Warranty

Comfile Technology provides a one year warranty on its products against defects in materials and workmanship. If you discover a defect, Comfile Technology will, at its option, repair the product, replace the product, or refund the purchase price. Simply return the product with a description of the problem and a copy of your invoice (if you do not have your invoice, please include your name and telephone number). This warranty does not apply if the product has been modified or damaged by accident, abuse, or misuse.

30-Day Money-Back Guarantee

If, within 30 days of having received your product, you find that it does not suit your needs, you may return it for a refund. Comfile Technology will refund the purchase price of the product, excluding shipping/handling costs. This does not apply if the product has been altered or damaged.

Copyright & Trademarks

Copyright © 2006,2010 by Comfile Technology Inc. All rights reserved. CUBLOC™ is a registered trademark of Comfile Technology Inc. WINDOWS is a trademark of Microsoft Corporation. XPORT is trademark of Lantronix inc. Other trademarks are of their respective companies.

Notice

This manual may be changed or updated without notice. Comfile Technology Inc. is not responsible for any actions taken outside the explanation of this manual. This product is protected by patents across the world. You may not change, copy, reproduce, or translate it without the consent of Comfile Technology Inc.

Disclaimer of Liability

Comfile Technology Inc. is not responsible for special, incidental, or consequential damages resulting from any breach of warranty, or under any legal theory, including lost profits, downtime, goodwill, damage to or replacement of equipment or property, and costs or recovering, reprogramming, or reproducing any data stored in or use with Comfile Technology products.
Preface

Comfile Technology has been developing PLC and BASIC controllers since 1997. Leveraging previous experience, we are providing a unique product that is powerful, flexible, and has the best features of both BASIC controllers and PLCs (Programmable Logic Controllers).

Ladder Logic, which is a traditional way of programming PLCs for its outstanding reliability and straightforward design, cannot easily cope with graphic interfaces and other functions that require complex code. In these situations, the BASIC programming approach greatly simplifies the work required to implement many complex features.

Cubloc is able to execute BASIC and Ladder Logic simultaneously through on-chip multitasking. By sharing data in common memory, users are able to integrate both BASIC and Ladder Logic to efficiently take advantage of both programming approaches.

Cubloc was created for beginners and advanced users alike. Its simplified commands and programming tools are an easy way to get started with microcontrollers, yet the device is powerful enough to handle serious automation applications with minimal time spent in the programming phase.

With our Plug-N-Play displays, development boards, and relay boards, you will be able to put an application together in matter or hours, instead of months.

Comfile Technology, Inc.
Notice

The Start Kit or Industrial Kit comes with the latest version of Cubloc Studio at the time the CD was created.

● Please be aware that the software may be upgraded often.
● Please check www.comfiletech.com to download the latest version of Cubloc Studio.
● Please run Setup->Firmware Download after installing a new version of Cubloc Studio as the newest firmware is distributed with Cubloc Studio.
● Please be sure to insert the Cubloc module correctly as inserting it improperly can damage the module.
● Please be aware that our 1 Year Warranty only covers defective items.
Table of Contents

CHAPTER 1: GETTING STARTED
What is Cubloc?.................................................................18
Cubloc Specifications.......................................................19
Ladder Logic and BASIC..................................................23
Multi-tasking of Ladder Logic and BASIC.............................25
Advantages of an On-Chip PLC/Embedded Computer.............27
Development Environment................................................29
Hints for Traditional PLC Users........................................30
Hints for Microcontroller Users.........................................31
Cubloc’s Internal Structure...............................................32
Cubloc Peripherals..........................................................33

CHAPTER 2: HARDWARE
Hardware Features..........................................................38
CB210............................................................................39
CB220 / CB320..............................................................41
Supplying power to the CB220 / CB320...............................43
CB280 / CB380..............................................................44
How to supply power to the CB280 and CB380.......................46
CB290............................................................................47
CB400............................................................................51
CB405............................................................................55
CB405RT......................................................................58
How to connect a battery to CB290 / CB405..........................61
Dimensions.......................................................................62

CHAPTER 3: CUBLOC STUDIO
About Cubloc Studio.......................................................68
Creating BASIC Code......................................................70
Debugging.......................................................................71
Menus.............................................................................72

CHAPTER 4: CUBLOC BASIC LANGUAGE
Cubloc BASIC Features...................................................76
Simple BASIC program...................................................77
Sub and Function...........................................................78
Variables........................................................................84
String.............................................................................86
About Variable Memory Space...........................................90
Arrays............................................................................91
<table>
<thead>
<tr>
<th>Subject</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bit and Byte Modifiers</td>
<td>92</td>
</tr>
<tr>
<td>Constants</td>
<td>95</td>
</tr>
<tr>
<td>Constant Arrays</td>
<td>96</td>
</tr>
<tr>
<td>Operators</td>
<td>98</td>
</tr>
<tr>
<td>Expressing Numbers</td>
<td>102</td>
</tr>
<tr>
<td>The BASIC Preprocessor</td>
<td>103</td>
</tr>
<tr>
<td>Conditional Directives</td>
<td>105</td>
</tr>
<tr>
<td>To Use Only Ladder Logic</td>
<td>108</td>
</tr>
<tr>
<td>To Use Only BASIC</td>
<td>108</td>
</tr>
<tr>
<td>Interrupts</td>
<td>109</td>
</tr>
<tr>
<td>More about Interrupts</td>
<td>110</td>
</tr>
<tr>
<td>Pointers using Peek, Poke, and MemAdr</td>
<td>112</td>
</tr>
<tr>
<td>Sharing Data</td>
<td>113</td>
</tr>
<tr>
<td><strong>CHAPTER 5: CUBLOC BASIC FUNCTIONS</strong></td>
<td>115</td>
</tr>
<tr>
<td>Math Functions</td>
<td>116</td>
</tr>
<tr>
<td>Type Conversion</td>
<td>118</td>
</tr>
<tr>
<td>String Functions</td>
<td>121</td>
</tr>
<tr>
<td><strong>CHAPTER 6: CUBLOC BASIC STATEMENTS &amp; LIBRARY</strong></td>
<td>129</td>
</tr>
<tr>
<td>AdIn( )</td>
<td>130</td>
</tr>
<tr>
<td>Alias</td>
<td>132</td>
</tr>
<tr>
<td>Bcd2Bin</td>
<td>133</td>
</tr>
<tr>
<td>BC1r</td>
<td>134</td>
</tr>
<tr>
<td>Beep</td>
<td>135</td>
</tr>
<tr>
<td>Bfree( )</td>
<td>136</td>
</tr>
<tr>
<td>Bin2Bcd</td>
<td>137</td>
</tr>
<tr>
<td>Blen( )</td>
<td>138</td>
</tr>
<tr>
<td>ByteIn( )</td>
<td>139</td>
</tr>
<tr>
<td>ByteOut</td>
<td>140</td>
</tr>
<tr>
<td>CheckBf( )</td>
<td>141</td>
</tr>
<tr>
<td>Compare</td>
<td>142</td>
</tr>
<tr>
<td>Count( )</td>
<td>143</td>
</tr>
<tr>
<td>CountReset</td>
<td>145</td>
</tr>
<tr>
<td>Dcd</td>
<td>146</td>
</tr>
<tr>
<td>Debug</td>
<td>147</td>
</tr>
<tr>
<td>Decr</td>
<td>150</td>
</tr>
<tr>
<td>Delay</td>
<td>151</td>
</tr>
<tr>
<td>Do...Loop</td>
<td>152</td>
</tr>
<tr>
<td>DTZero</td>
<td>154</td>
</tr>
<tr>
<td>EERead( )</td>
<td>155</td>
</tr>
<tr>
<td>EEWrite</td>
<td>156</td>
</tr>
<tr>
<td>EKeyPad()</td>
<td>157</td>
</tr>
</tbody>
</table>
CHAPTER 7: CUBLOC DISPLAY LIBRARY

CLC Module .............................................................................................................. 263
GHLCD Graphic LCD : GHB3224C ........................................................................ 266
Cls ............................................................................................................................. 269
Clear ......................................................................................................................... 269
CsrOn ....................................................................................................................... 269
CsrOff ..................................................................................................................... 269
Locate ...................................................................................................................... 269
Print ....................................................................................................................... 270
CLCDOOut ............................................................................................................. 271
Layer ....................................................................................................................... 272
GLayer ................................................................................................................... 273
Overlay .................................................................................................................. 273
Contrast .................................................................................................................. 274
Light ....................................................................................................................... 274
WMode ................................................................................................................... 274
Font ....................................................................................................................... 275
Style ....................................................................................................................... 276
CMode ................................................................................................................... 276
Line ......................................................................................................................... 277
LineTo .................................................................................................................... 277
Box ......................................................................................................................... 278
BoxClear ............................................................................................................... 278
BoxFill .................................................................................................................. 278
Circle ...................................................................................................................... 279
CircleFill ............................................................................................................... 279
Ellipse .................................................................................................................. 280
ElFill ...................................................................................................................... 280
GLocate ................................................................................................................ 281
GPrint .................................................................................................................... 281
DPrint .................................................................................................................... 282
Offset ..................................................................................................................... 283
Pset ......................................................................................................................... 284
Color ...................................................................................................................... 284
LineStyle ............................................................................................................... 284
DotSize ............................................................................................................... 284
Creating Ladder Logic Programs .................................................. 358
Editing Ladder Logic Text ........................................................... 360
Monitoring ...................................................................................... 364
Time Chart Monitoring .................................................................. 365
Watch Point ..................................................................................... 366
Registers ....................................................................................... 371
Ladder Symbols ............................................................................ 373
Using I/Os ...................................................................................... 375
Use of Aliases ................................................................................ 376
Starting Ladder Logic ................................................................... 377
Declaring the Device to Use .......................................................... 377
Using Ladder Logic Only ............................................................... 378
Ladder Logic Commands ............................................................... 379
LOAD, LOADN, OUT .................................................................... 381
NOT, AND, OR .............................................................................. 382
SETOUT, RSTOUT ...................................................................... 383
DEFCON ....................................................................................... 384
DF, DFN ....................................................................................... 385
LOOP .......................................................................................... 386
MCS, MCSCLR .. .......................................................................... 387
Step Control .................................................................................. 389
STEPSET ...................................................................................... 389
STEPOUT ..................................................................................... 390
TMON, TAMON ........................................................................... 391
TON, TAON .................................................................................. 393
TOFF, TAOFF .............................................................................. 394
CTU ............................................................................................. 395
CTD ............................................................................................. 395
UP/DOWN COUNTER .................................................................. 396
KCTU ........................................................................................... 397
KCTD ........................................................................................... 397
Comparison Logic ......................................................................... 398
Storing Words and Double Words .................................................. 399
Binary, Decimal, Hexadecimal ....................................................... 400
WBCD ........................................................................................... 401
WBIN ........................................................................................... 402
WBCNT, DWBCNT ...................................................................... 403
WMOV, DWMOV ........................................................................ 404
WXCHG, DWXCHG .................................................................... 405
FMOV ........................................................................................... 406
GMOV ........................................................................................... 407
WCMP, DWCMP ......................................................................... 408
WINC, DWINC, WDEC, DWDEC .................................................. 409
CHAPTER 12: CUTOUCH

What is Cutouch?................................................................. 431
Cutouch Specifications........................................................ 432
Hardware Requirements..................................................... 433
Cutouch Dimensions............................................................ 434
Cutouch I/O Ports ................................................................. 435
Backup Battery................................................................. 437
Cutouch Output ports ......................................................... 438
Cutouch Input ports ............................................................. 439
Cutouch A/D and TTL I/O Ports ......................................... 440
Cutouch jumper & connector .............................................. 441
Menu System Library........................................................ 442
MENU Commands.............................................................. 442
MenuSet................................................................................. 443
MenuTitle.............................................................................. 443
MenuCheck( ).......................................................................... 444
MenuReverse........................................................................ 444
Menu( )................................................................................. 445
WaitDraw.............................................................................. 445
Touch Pad Input Example.................................................... 446
Cutouch Sample Programs.................................................. 448

CHAPTER 13: CB405RT ......................................................... 463

CB405RT............................................................................... 464
Chapter 1: Getting Started
What is Cubloc?

Cubloc is different from the traditional PLCs that you may have encountered. Traditional PLCs are built into cases and have hardwired connections, but Cubloc is an "On-Chip" PLC/Industrial Controller, meaning you have more freedom and flexibility in the final product size and design.

Cubloc Modules are similar to traditional PLCs in that Ladder Logic can be used...but the small size allows developers to design custom PCBs for any application.

<table>
<thead>
<tr>
<th>Traditional PLC</th>
<th>Cubloc</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Traditional PLC Image" /></td>
<td><img src="image2.png" alt="Cubloc Image" /></td>
</tr>
</tbody>
</table>

There are different models, each with a unique program memory size and number of I/O ports. Please make a selection based on your product’s requirement.
## Cubloc Specifications

<table>
<thead>
<tr>
<th></th>
<th>CB210</th>
<th>CB220</th>
<th>CB280</th>
<th>CB290</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Picture</strong></td>
<td>![Image](90x430 to 132x462)</td>
<td>![Image](209x431 to 250x466)</td>
<td>![Image](272x432 to 321x471)</td>
<td><img src="37x488" alt="Image" /></td>
</tr>
<tr>
<td><strong>Program Memory</strong></td>
<td>80KB</td>
<td>80KB</td>
<td>80KB</td>
<td>80KB</td>
</tr>
<tr>
<td><strong>Data Memory</strong></td>
<td>2KB(BASIC)+ 1KB(Ladder Logic)</td>
<td>2KB(BASIC)+ 1KB(Ladder Logic)</td>
<td>2KB(BASIC)+ 1KB(Ladder Logic)</td>
<td>24KB(BASIC)+ 4KB(Ladder Logic)</td>
</tr>
<tr>
<td><strong>EEPROM</strong></td>
<td>4KB EEPROM</td>
<td>4KB EEPROM</td>
<td>4KB EEPROM</td>
<td>4KB EEPROM</td>
</tr>
<tr>
<td><strong>Program Speed</strong></td>
<td>36,000 inst./sec</td>
<td>36,000 inst./sec</td>
<td>36,000 inst./sec</td>
<td>36,000 inst./sec</td>
</tr>
<tr>
<td><strong>General Purpose I/O</strong></td>
<td>20 I/O lines (5V TTL) (input/output configurable)</td>
<td>16 I/O lines (5V TTL) (input/output configurable) + Spare I/O 6 (5V TTL)</td>
<td>49 I/O lines (5V TTL) (input/output configurable)</td>
<td>91 I/O lines (5V TTL) (input/output configurable)</td>
</tr>
<tr>
<td><strong>Serial Ports</strong></td>
<td>1 serial port (Channel 1: TTL 5V) - Configurable Baud rates: 2400bps to 230,400 bps</td>
<td>2 serial ports (Channel 0: RS232C 12V, Channel 1: TTL 5V) - Configurable Baud rates: 2400bps to 230,400 bps</td>
<td>2 serial ports (Channel 0: RS232C 12V, Channel 1: RS232C 12V &amp; TTL 5V) - Configurable Baud rates: 2400bps to 230,400 bps</td>
<td>2 serial ports (Channel 0: RS232C 12V, Channel 1: RS232C 12V &amp; TTL 5V) - Configurable Baud rates: 2400bps to 230,400 bps</td>
</tr>
<tr>
<td><strong>Analog Inputs</strong></td>
<td>6 Channel 10-bit ADCs</td>
<td>8 Channel 10-bit ADCs</td>
<td>8 Channel 10-bit ADCs</td>
<td>8 Channel 10-bit ADCs</td>
</tr>
<tr>
<td><strong>Analog Outputs</strong></td>
<td>- 3 Channel 16-bit PWMs (DACs) - Frequency: 35hz to 1.5Mhz</td>
<td>- 3 Channel 16-bit PWMs (DACs) - Frequency: 35hz to 1.5Mhz</td>
<td>- 6 Channel 16-bit PWMs (DACs) - Frequency: 35hz to 1.5Mhz</td>
<td>- 6 Channel 16-bit PWMs (DACs) - Frequency: 35hz to 1.5Mhz</td>
</tr>
<tr>
<td><strong>External Interrupts</strong></td>
<td>None</td>
<td>4 channels (in spare I/O)</td>
<td>4 Channels</td>
<td>4 Channels</td>
</tr>
<tr>
<td><strong>High Speed Counters</strong></td>
<td>None</td>
<td>2 Channel 32-bit Counters (up to 2Mhz)</td>
<td>2 Channel 32-bit Counters (up to 2Mhz)</td>
<td>2 Channel 32-bit Counters (up to 2Mhz)</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>DC 9V to 12V, 100mA or From USB</td>
<td>5 to 12V, 40mA (ports unloaded)</td>
<td>5V, 40mA (ports unloaded)</td>
<td>5V, 70mA (ports unloaded)</td>
</tr>
<tr>
<td><strong>RTC</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Data Memory Backup</strong></td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Optional</td>
</tr>
<tr>
<td><strong>Operating Temp.</strong></td>
<td>-40 °C to 120 °C</td>
<td>-40 °C to 120 °C</td>
<td>-40 °C to 120 °C</td>
<td>-40 °C to 120 °C</td>
</tr>
<tr>
<td><strong>Package</strong></td>
<td>I/O Board</td>
<td>24-pin DIP 600mil</td>
<td>64-pin Module</td>
<td>108-pin Module</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>2.9”L x 2.0”W x 0.4”H (75 x 53 x 12 mm)</td>
<td>1.2”L x 0.6”W x 0.4”H (30 x 15.3 x 11 mm)</td>
<td>1.4”L x 1”W x 0.4”H (35 x 25.4 x 11 mm)</td>
<td>2.4”L x 1.9”W x 0.5”H (59.4 x 47.8 x 13 mm)</td>
</tr>
<tr>
<td></td>
<td>CB320</td>
<td>CB380</td>
<td>CB405</td>
<td>CB400</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td><strong>Picture</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Program Memory</strong></td>
<td>200KB</td>
<td>200KB</td>
<td>200KB</td>
<td>200KB</td>
</tr>
<tr>
<td><strong>Data Memory</strong></td>
<td>6KB(BASIC)+</td>
<td>6KB(BASIC)+</td>
<td>51KB(BASIC)+4KB(Ladder Logic)+55KB(Heap)</td>
<td>6KB(BASIC)+1KB(Ladder Logic)</td>
</tr>
<tr>
<td><strong>EEPROM</strong></td>
<td>4KB EEPROM</td>
<td>4KB EEPROM</td>
<td>4KB EEPROM</td>
<td>4KB EEPROM</td>
</tr>
<tr>
<td><strong>Program Speed</strong></td>
<td>36,000 inst./sec</td>
<td>36,000 inst./sec</td>
<td>36,000 inst./sec</td>
<td>36,000 inst./sec</td>
</tr>
<tr>
<td><strong>General Purpose I/O</strong></td>
<td>16 I/O lines (5V TTL) (input/output configurable) + Spare I/O 6 (5V TTL)</td>
<td>49 I/O lines (5V TTL) (input/output configurable)</td>
<td>64 I/O lines (5V TTL) (input/output configurable)</td>
<td>83 I/O lines (5V TTL) (input/output configurable)</td>
</tr>
<tr>
<td><strong>Serial Ports</strong></td>
<td>2 serial ports (Channel 0: RS232C 12V, Channel 1: TTL 5V) - Configurable Baud rates: 2400bps to 230,400bps</td>
<td>2 serial ports (Channel 0: RS232C 12V, Channel 1: RS232C 12V &amp; TTL 5V) - Configurable Baud rates: 2400bps to 230,400bps</td>
<td>4 serial ports (Channel 0: RS232C 12V, Channel 1 to 3: RS232C TTL 5V) - Configurable Baud rates: 2400bps to 230,400bps</td>
<td>4 serial ports (Channel 0: RS232C 12V, Channel 1 to 3: RS232C TTL 5V) - Configurable Baud rates: 2400bps to 230,400bps</td>
</tr>
<tr>
<td><strong>Analog Inputs</strong></td>
<td>8 Channel 10-bit ADCs</td>
<td>8 Channel 10-bit ADCs</td>
<td>16 channel 10-bit ADCs</td>
<td>16 Channel 10-bit ADCs</td>
</tr>
<tr>
<td><strong>Analog Outputs</strong></td>
<td>- 6 Channel 16-bit PWMs (DACs) - Frequency: 35kHz to 1.5Mhz</td>
<td>- 6 Channel 16-bit PWMs (DACs) - Frequency: 35kHz to 1.5Mhz</td>
<td>- 12 Channel 16-bit PWMs (DACs) - Frequency: 35kHz to 1.5Mhz</td>
<td>- 12 Channel 16-bit PWMs (DACs) - Frequency: 35kHz to 1.5Mhz</td>
</tr>
<tr>
<td><strong>External Interrupts</strong></td>
<td>4 Channels (in Spare I/O)</td>
<td>4 Channels</td>
<td>4 Channels</td>
<td>4 Channels</td>
</tr>
<tr>
<td><strong>High Speed Counters</strong></td>
<td>2 Channel 32-bit Counters (up to 2MHz)</td>
<td>2 Channel 32-bit Counters (up to 2MHz)</td>
<td>2 Channel 32-bit Counters (up to 2MHz)</td>
<td>2 Channel 32-bit Counters (up to 2MHz)</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>5 to 12V, 40mA (ports unloaded)</td>
<td>5V, 40mA (ports unloaded)</td>
<td>5V, 50mA (ports unloaded)</td>
<td>5V, 40mA (ports unloaded)</td>
</tr>
<tr>
<td><strong>RTC</strong></td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Data Memory Backup</strong></td>
<td>None</td>
<td>None</td>
<td>Optional</td>
<td>None</td>
</tr>
<tr>
<td><strong>Operating Temp.</strong></td>
<td>-40 °C to 120 °C</td>
<td>-40 °C to 120 °C</td>
<td>-40 °C to 120 °C</td>
<td>-40 °C to 120 °C</td>
</tr>
<tr>
<td><strong>Package</strong></td>
<td>24-pin DIP 600mil</td>
<td>64-pin Module</td>
<td>80-pin Module</td>
<td>108-pin Module</td>
</tr>
<tr>
<td><strong>Size</strong></td>
<td>1.2”L x 0.6”W x 0.4”H (30 x 15.3 x 11 mm)</td>
<td>1.4”L x 1”W x 0.4”H (35 x 25.4 x 11 mm)</td>
<td>2.4”L x 1.9”W x 0.5”H (59.4 x 47.8 x 13 mm)</td>
<td>2.4”L x 1.9”W x 0.5”H (59.4 x 47.8 x 13 mm)</td>
</tr>
</tbody>
</table>

The main advantage of Cubloc is that it fills Ladder Logic’s weaknesses with the BASIC language. Ladder Logic is good enough to replace sequence...
diagrams, but to collect data, print graphics, and process complex tasks is asking a little bit too much. That is why we added the BASIC language. You can now run both Ladder Logic and/or BASIC!

```
DIM A AS INTEGER
IF IN(0) = 0 THEN
   OUT 2, A
END IF
GOTO LAB1
```

Image of Cubloc Studio is shown above.
There are other PLCs on the current market that support both Ladder Logic and BASIC. However, these PLCs do not multi-task. Because BASIC is part of their Ladder Logic, it does not run independently like Cubloc or Cutouch. This can prove to be costly since BASIC is not real-time oriented and can delay the Ladder Logic scans, possible causing missed inputs or other undesired behavior. Cubloc, on the other hand, doesn’t suffer from these weaknesses because it multitasks; guaranteeing accuracy and precise timing.

Cubloc is a brand new type of industrial controller. By being able to do things that traditional PLCs can’t, we have expanded the horizons of both PLCs and BASIC micro-computers.

Cubloc is fully backed by many Plug-N-Play peripherals such as our CuBASE industrial I/O Boards and Plug-N-Play Relay8 Boards. With these peripherals, controlling DC/AC devices is easy.

With 32-bit IEEE floating point math support and MODBUS ASCII/RTU support, the user will find that Cubloc and Cutouch are among the most versatile BASIC/PLC hybrid chips on the market today.
Ladder Logic and BASIC

Ladder Logic's greatest advantage is that all circuits are laid out in parallel; they are all processed as fast as the ladder scan time will allow. This allows for a more parallel execution path for unrelated functions.

As you can see above, both A and B circuits are in a waiting state, ready to turn the output On as soon as input is turned On. For example, if input P3 turned On, P9 would turn On.

In comparison, BASIC processes code in order, a type of "Sequential Processing."

These 2 types of programming languages have been used in different fields for a long time. Ladder Logic is used in automation controllers such as PLCs. On the other hand, BASIC and other programming languages such as C and Assembly have been used in PCs and MCUs.

Whether you are an experienced MCU or PLC user, you will be able to benefit by integrating both BASIC and Ladder Logic in your designs.
Another advantage of Ladder Logic is the ability to process input within a guaranteed slot of time. No matter how complex the circuit becomes, Ladder Logic is always ready to output when it receives input. This is the primary reason why it is used for machine control and other automation fields.

Ladder Logic is more logic oriented. It is not a complete programming language. To do complex processes, it has its limits. For example, to receive input from a keypad, display to 7 Segment or LCD, and process users' input is a difficult task for standard Ladder Logic.

But these things are rarely a problem for programming languages such as BASIC. BASIC is able to process floating point numbers, data communications, and other things beyond the scope of what Ladder Logic can do alone. Another advantage is that its syntax is very similar to the English language (IF, GOTO, etc...), allowing both beginners and experienced developers to learn in matter of hours instead of months. BASIC is a very common programming language, and many developers may be able to start programming a Cubloc with only a few glances at hardware-specific commands.

<table>
<thead>
<tr>
<th>Device</th>
<th>Ladder Logic</th>
<th>Programming Languages (BASIC, C, ASM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>Automation, Machine-Control</td>
<td>General Computing</td>
</tr>
<tr>
<td>Advantages</td>
<td>Sequencer, Bit Logic, Timers, Counters</td>
<td>Complex Math, Data Communication, Data Collection &amp; Process, Analysis, Graphic Interface</td>
</tr>
<tr>
<td>Basic Mechanism</td>
<td>Parallel</td>
<td>Sequential</td>
</tr>
</tbody>
</table>

Ladder Logic’s parallelism and BASIC's sequential language both have advantages. Ladder Logic makes controlling unrelated parallel tasks easy, which can be difficult with BASIC. On the other hand, BASIC can easily process complex sequential tasks and has a wider range of commands and interface abilities.

That is why we created "Cubloc," where the user is free to use both Ladder Logic and/or BASIC based on the application being created. After understanding the advantages of both Ladder Logic and BASIC, the user will be able to create more efficient final products while saving development time and reducing cost.
Multi-tasking of Ladder Logic and BASIC

There are many ways to implement both BASIC and Ladder Logic in one processor. The current products on the market use BASIC as part of Ladder Logic. These products support BASIC and Ladder Logic but these products have a few disadvantages.

The first disadvantage is that when BASIC is executing, the execution time of Ladder Logic also gets affected. For example, if BASIC creates an infinite loop, Ladder Logic will stop. Ladder Logic’s main advantage is that it can process input in a guaranteed scan time. If Ladder Logic cannot process within this guaranteed scan time because of BASIC, it might be better to not use BASIC at all.

The second disadvantage is that BASIC routines can only be started from Ladder Logic. BASIC is a powerful language and is able to process complex algorithms in a sequential manner. But if we can only use BASIC as part of Ladder Logic, we are not utilizing all of its capabilities.

The third disadvantage involves I/O. BASIC’s execution of I/O can create unwanted collisions with Ladder Logic. The reason is that Ladder Logic I/O is updated once per scan, while BASIC I/O is accessed immediately.

To address these problems, we have created a BASIC and Ladder Logic processor that supports real-time multi-tasking. BASIC runs BASIC and Ladder Logic runs Ladder Logic, without causing collisions.
Even if you only use BASIC, you will be able to build innumerable applications. In comparison to many other BASIC processors on the market today, Cubloc’s BASIC has a faster processing speed and the upper hand on its main features.

In the case of I/O, the user can specify the I/O used by BASIC and Ladder Logic, thereby eliminating I/O collision problems.

If you use Ladder, we recommend using some BASIC as a method of supervising the Ladder operations.

For example, there is a Master Control feature in Ladder Logic, allowing the user to set Control Zones. Control Zones are sections within the Ladder Logic containing portions of the control circuit. With the Master Control feature, the user can enable/disable Ladder Logic’s Control Zones easily.

In BASIC, the user may read or write to Ladder Logic’s data memory. In the above example, you can access Register M1 as _M(1) and write to it from BASIC.
Advantages of an On-Chip PLC/Embedded Computer

Cubloc's greatest advantages is that it is an "On-Chip" PLC. Normally, we think of a PLC as a block type case with input and output lines. These modules are usually mounted within yet another case, with external power supplies, additional output modules, and other wiring requirements.

This is usually fine for one or two applications, but doesn’t lend itself easily to larger scale production. Cubloc modules can be easily integrated into a custom product, providing all the features of a PLC yet the professional appearance and lower manufacturing cost of a custom design.
Cubloc is an On-Chip PLC, allowing an easy fit on a PCB. You may use the PLC almost like an MCU. You can design a customized PCB for your desired product, reducing its cost and size, and most importantly, making your product one-of-a-kind.

The following table shows a few differences between a traditional PLC and "On-Chip" PLC/Micro-computer, Cubloc.

<table>
<thead>
<tr>
<th></th>
<th>Traditional PLC</th>
<th>Cubloc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>Din Rail Attachment</td>
<td>PCB</td>
</tr>
<tr>
<td>Labor Costs</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Mass Production</td>
<td>Difficult</td>
<td>Easy</td>
</tr>
<tr>
<td>Final Product Cost</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Final Size</td>
<td>Large</td>
<td>Compact</td>
</tr>
</tbody>
</table>

If you are currently distributing a system using a traditional PLC, please review our products and consider the reduction in cost if you were to use Cubloc instead. We believe that you will end up with a more superior product at a fraction of the cost.
Development Environment

Cubloc Studio can be installed on a Windows 7, Vista, XP, 2000, or 98 operating system equipped computer. If you would like to use it in a Linux/Unix/Macintosh environment, you will need to install a virtual machine (such as VMware) that allows your computer to run the Windows operating system. An RS-232 port is also required, or you may use a USB-to-RS232C converter.

![RS232 Diagram](image)

Downloading and monitoring is possible when connected to the PC. When the Cubloc is disconnected from the PC, it goes into a stand-alone state. The main program is stored in Cubloc’s flash memory, and will be retained between power cycles. Each Cubloc can be programmed and/or erased more than 10,000 times.

![CB280 core module with Study Board](image)
Hints for Traditional PLC Users

For users with much experience in traditional PLCs, they will find BASIC to be a completely new language. Cubloc is a PLC with BASIC language capabilities added. If uncomfortable with BASIC, however, the user may program using only the Ladder Logic.

Even a Ladder Logic user may be able to incorporate new features into the final product by making use of BASIC, as BASIC offer additional capabilities and flexibility for communicating with other devices besides PLCs.

To use Cubloc, the user does not have to know BASIC. If the user does not require LCD display or keypad usage, he or she does not need to use BASIC at all, and can resort to using only Ladder Logic.

As you can realize, more emphasis on human interfaces is becoming apparent in our industrial world. Cubloc is able to overcome the deficiencies and disadvantages of traditional PLCs by being able to use both BASIC and Ladder Logic language.

We provide many BASIC user interface libraries which you can simply copy and paste to achieve the user interface structure desired.
Hints for Microcontroller Users

Microcontrollers (MCU), such as the PIC, AVR, and the 8051, are self-contained programmable computers. For mass-production, MCUs can cut costs and reduce the overall product size. But one disadvantage is that it can be difficult to learn everything necessary to program an unfamiliar controller. The hardware, commands, and even programming tools vary widely between controller families. This can be a drawback for low quantity or frequently-modified projects.

Even experienced engineers can feel that MCU programming is time-consuming. To make a final product, it takes many hours of programming and debugging with an MCU. Even after development, if bugs arise, it can be difficult to update the MCU.

In comparison, Comfile's Cubloc can cut the programmer's development time as much as 20 times, and provide an MCU-like chip that is upgradeable through an RS232 cable or even through the internet by using an XPORT. By providing a way to upgrade, the final product's value is increased.

If you have experience programming with MCUs, we guarantee you that development of your final product will be much easier with Cubloc. You will be able to spend more time designing the features of your final product, instead of spending hours relearning register locations and compiler syntax. Having Cubloc hardware on hand means that you can respond immediately to any equipment control needs.
Cubloc’s Internal Structure

The BASIC Interpreter controls a Flash storage area for the user’s BASIC programs. The Ladder Logic processor also has a Flash storage area for the user’s Ladder Logic program. I/O ports are shared between BASIC and Ladder Logic, allowing free access to both.

BASIC data memory can only be accessed by the BASIC Interpreter while Ladder Logic data memory can be accessed by both the BASIC Interpreter and the Ladder Logic Processor.

BASIC (1) and Ladder Logic (2) share the same Flash memory. The total available memory space is 80KB for some models and 200KB for others. BASIC and Ladder Logic can both use up to the entire memory area, if needed.

I/O ports (5) can be used both by BASIC and Ladder Logic. The user must specify I/O ports to use in both languages. All I/O ports can be used in Ladder Logic or BASIC.
Cubloc Peripherals

PROTO BOARD Series
Proto-boards for Cubloc can be used for testing and debugging your future products before starting PCB artwork or production. These proto-boards all include basic power and interface circuits.

BASE BOARD / CUSB Series
The CUBASE and CUSB series are especially geared for the industrial field applications. Simply attach our Plug-N-Play relays to CUBASE output ports for implementing solenoids, limit switches, etc.,. With 24V input ports and DIN rail mounting brackets, the CUBASE and CUSB series integrate quickly into any automation project. For even greater integration, the CUSB series contains a switching power supply for direct operation from AC power (except CUSB-22D, requires 24V power). The CUSB modules have integrated relays and optoisolated inputs, all accessible through screw-clamp terminals.
**STUDY BOARD**
The Study Board is geared for Cubloc first-timers. Connections for simple experiments including switches, LEDs, RS232 communication, I2C, piezo, ADC, toggle switches, and LCDs are included. We recommend the Start Kits, which include a study board, a Cubloc module, all necessary cables, and a manual.

![Study Board Image]

**LCD DISPLAY Module (CLCD, GHLCD Series)**
Various LCD displays are provided for use with Cubloc using the CUNET (I2C) protocol. With one line commands (PRINT, CLS, etc...), you can easily start printing to an LCD without complex commands.

![LCD Display Image]

CUNET is especially engineered for Cubloc displays, therefore, we recommend using CUNET supported LCDs for quick and easy development. Our Graphic Display GHLCD allows you to download black and white bitmap images to the onboard memory and display them on demand.
Seven Segment Display Modules (CSG Series)
Seven segment display modules can be easily implemented using Cubloc’s I2C protocol and native commands.

Cutouch Series
Cutouch is an integration of our graphic LCD, touch panel, and Cubloc core module. With BASIC, you can control the LCD and touch panel. With Ladder Logic, I/O ports can be controlled in real-time.
Chapter 2: Hardware
Hardware Features

Cubloc has the following features:

- (BASIC and/or Ladder Logic) 80KB or 200KB Flash Memory
- BASIC Execution Speed: 36,000 instructions per second
- LADDER Execution Speed: 10 millisecond scan time
- Data Memory for BASIC: 2KB to 51KB
- Data Memory for LADDER: 1KB to 4KB
- EEPROM Memory: 4KB
- 16 to 91 I/O pins (Ports)
- 8 to 16 10-bit ADC channels
- 3 to 12 PWM channels (DAC) from 8 to 16bit.
- UART (H/W RS232C ports) 2 to 4 channels
- RTC chip included (CB290)

Model Comparison Chart

<table>
<thead>
<tr>
<th>Feature</th>
<th>CB210</th>
<th>CB220</th>
<th>CB280</th>
<th>CB290</th>
<th>CB320</th>
<th>CB380</th>
<th>CB400</th>
<th>CB405</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prog. Memory</td>
<td>80KB</td>
<td>80KB</td>
<td>80KB</td>
<td>80KB</td>
<td>200KB</td>
<td>200KB</td>
<td>200KB</td>
<td>200KB</td>
</tr>
<tr>
<td>Data Memory:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- BASIC</td>
<td>2KB</td>
<td>2KB</td>
<td>2KB</td>
<td>24KB</td>
<td>6KB</td>
<td>6KB</td>
<td>6KB</td>
<td>51KB</td>
</tr>
<tr>
<td>- Ladder</td>
<td>1KB</td>
<td>1KB</td>
<td>1KB</td>
<td>4KB</td>
<td>1KB</td>
<td>1KB</td>
<td>1KB</td>
<td>4KB</td>
</tr>
<tr>
<td>- Heap</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>55KB</td>
</tr>
<tr>
<td>Battery Backup</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Yes</td>
</tr>
<tr>
<td>EEPROM</td>
<td>4KB</td>
<td>4KB</td>
<td>4KB</td>
<td>4KB</td>
<td>4KB</td>
<td>4KB</td>
<td>4KB</td>
<td>4KB</td>
</tr>
<tr>
<td>I/O ports</td>
<td>20</td>
<td>16</td>
<td>49 + 2</td>
<td>91 + 2</td>
<td>16 + 6</td>
<td>49 + 2</td>
<td>83 + 2</td>
<td>64 + 2</td>
</tr>
<tr>
<td>Package</td>
<td>I/O Board</td>
<td>24 pin DIP</td>
<td>64 pin Module</td>
<td>108 pin Module</td>
<td>24 pin DIP</td>
<td>64 pin Module</td>
<td>108 pin Module</td>
<td>80 pin Module</td>
</tr>
<tr>
<td>ADCs</td>
<td>6</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>PWMs</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>6</td>
<td>3</td>
<td>6</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>RS-232 Ch.</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>External</td>
<td>None</td>
<td>None</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Interrupts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-speed</td>
<td>None</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Counter Inputs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RTC</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
CB210

The CB210 has 20 digital I/O ports, 6 of which can be used for A/D input. It can be connected to a PC via USB for downloading and debugging and serial communication. It can be powered either by a 9V power supply, or through the USB port.
Please be aware of the following when using the CB210.

- Use Cubloc Studio V3.3.0 and above. Cubloc Studio can be downloaded from Comfile Technology’s website at http://www.ComfileTech.com/. A USB Driver is included in the download. You must install the USB Driver to use the CB210.
- Only PWMs 3, 4, and 5 are available. You cannot use PWM 0, 1, and 2.
- You can use ports 16 to 21 for digital I/O.
- You can use ports 16 to 21 for A/D input, but you must first configure the ports as input ports. For A/D input, you should supply 3.3V-5V power to AVREF port.
- The CB210 cannot handle currents over 300mA.
- An LED is connected to port 30.
CB220 / CB320

The CB220 and CB320 are a 24 pin wide DIP style packages. They have 16 I/O ports and an internal 5V power regulator. The CB220 and CB320 have 6 spare I/O ports.

<table>
<thead>
<tr>
<th>Port</th>
<th>Pin</th>
<th>I/O</th>
<th>Port Block</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOUT</td>
<td>1</td>
<td>OUT</td>
<td>Block 0</td>
<td>DOWNLOAD SERIAL OUTPUT</td>
</tr>
<tr>
<td>SIN</td>
<td>2</td>
<td>IN</td>
<td>Block 0</td>
<td>DOWNLOAD SERIAL INPUT</td>
</tr>
<tr>
<td>ATN</td>
<td>3</td>
<td>IN</td>
<td>Block 0</td>
<td>DOWNLOAD SERIAL INPUT</td>
</tr>
<tr>
<td>VSS</td>
<td>4</td>
<td>POWER</td>
<td></td>
<td>GROUND</td>
</tr>
<tr>
<td>P0</td>
<td>5</td>
<td>I/O</td>
<td>Block 0</td>
<td>ADC0 / SPI SS</td>
</tr>
<tr>
<td>P1</td>
<td>6</td>
<td>Input</td>
<td></td>
<td>ADC1 / SPI SCK</td>
</tr>
<tr>
<td>P2</td>
<td>7</td>
<td>I/O</td>
<td>Block 0</td>
<td>ADC2 / SPI MOSI</td>
</tr>
<tr>
<td>P3</td>
<td>8</td>
<td>I/O</td>
<td>Block 0</td>
<td>ADC3 / SPI MISO</td>
</tr>
<tr>
<td>P4</td>
<td>9</td>
<td>I/O</td>
<td>Block 0</td>
<td>ADC4</td>
</tr>
<tr>
<td>P5</td>
<td>10</td>
<td>I/O</td>
<td>Block 1</td>
<td>PWM0 / ADC5</td>
</tr>
<tr>
<td>P6</td>
<td>11</td>
<td>I/O</td>
<td>Block 1</td>
<td>PWM1 / ADC6</td>
</tr>
<tr>
<td>P7</td>
<td>12</td>
<td>I/O</td>
<td>Block 1</td>
<td>PWM2 / ADC7</td>
</tr>
<tr>
<td>P8</td>
<td>13</td>
<td>I/O</td>
<td>Block 1</td>
<td>CuNET SCL</td>
</tr>
<tr>
<td>P9</td>
<td>14</td>
<td>I/O</td>
<td>Block 1</td>
<td>CuNET SDA</td>
</tr>
<tr>
<td>P10</td>
<td>15</td>
<td>I/O</td>
<td>Block 1</td>
<td>RS232C Channel 1 RX</td>
</tr>
<tr>
<td>P11</td>
<td>16</td>
<td>I/O</td>
<td>Block 1</td>
<td>RS232C Channel 1 TX</td>
</tr>
<tr>
<td>P12</td>
<td>17</td>
<td>I/O</td>
<td>Block 2</td>
<td>High-speed Counter channel 0</td>
</tr>
<tr>
<td>P13</td>
<td>18</td>
<td>I/O</td>
<td>Block 2</td>
<td>High-speed Counter channel 1</td>
</tr>
<tr>
<td>P14</td>
<td>19</td>
<td>I/O</td>
<td>Block 2</td>
<td>PWM3</td>
</tr>
<tr>
<td>P15</td>
<td>20</td>
<td>I/O</td>
<td>Block 2</td>
<td>PWM4 / INT0</td>
</tr>
<tr>
<td>P18</td>
<td>21</td>
<td>I/O</td>
<td>Block 2</td>
<td>PWM5 / INT1</td>
</tr>
<tr>
<td>P20</td>
<td>22</td>
<td>I/O</td>
<td>Block 2</td>
<td>INT2</td>
</tr>
<tr>
<td>P21</td>
<td>23</td>
<td>I/O</td>
<td>Block 2</td>
<td>INT3</td>
</tr>
<tr>
<td>P22</td>
<td>24</td>
<td>I/O</td>
<td>Block 2</td>
<td>5V Output/Input</td>
</tr>
<tr>
<td>VDD</td>
<td>25</td>
<td>IN</td>
<td></td>
<td>RESET Input (LOW signal resets!)</td>
</tr>
<tr>
<td>RES</td>
<td>26</td>
<td>IN</td>
<td></td>
<td>GROUND</td>
</tr>
<tr>
<td>VIN</td>
<td>27</td>
<td>IN</td>
<td></td>
<td>5.5V to 12V Input Power</td>
</tr>
</tbody>
</table>
SIN, SOUT, ATN are RS-232 communication pins used to interface with a PC for downloading, debugging, monitoring, and serial communication. All Cubloc models have SOUT, SIN, ATN pins and are connected to a DE-9 connector (PC serial port) as shown below.

![Diagram showing DE-9 connector with pins labeled]

Other pins are mostly I/O ports. The user may select which ports (pins) to use as INPUT or OUTPUT. When set to INPUT, the pin enters a high-impedance state; when set to OUTPUT, the pin either outputs logic-low or logic-high. The maximum current (source/sink) available from the output ports is 25mA. The user is free to choose which I/O ports he/she will use for which purpose (such as ADC, PWM, etc...).
Supplying power to the CB220 / CB320

The CB220 and CB320 have an internal 5V power regulator that accepts a DC input between 5.5V and 12V.

It will produce a stable 5V at 100mA. When using the internal regulator, the supply voltage can be applied to pin 24, and 5V will appear on pin 21. If a 5V regulated power source is already available, the user may simply connect it to pin 21. If an application requires more than the 100mA of current, a separate power supply should be used.

Method 1

Method 2
**CB280 / CB380**

The CB280 and CB380 are packages of 64 pins of which 49 can be used for I/O. The CB280 and CB380 do not have an 5V regulator internal; you must supply a 5V regulated power source.

<table>
<thead>
<tr>
<th>Port</th>
<th>Pin</th>
<th>I/O</th>
<th>Port Block</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOUT</td>
<td>1</td>
<td>OUT</td>
<td>Block 0</td>
<td>DOWNLOAD SERIAL OUTPUT</td>
</tr>
<tr>
<td>SIN</td>
<td>2</td>
<td>IN</td>
<td>Block 0</td>
<td>DOWNLOAD SERIAL INPUT</td>
</tr>
<tr>
<td>ATN</td>
<td>3</td>
<td>IN</td>
<td>Block 0</td>
<td>DOWNLOAD SERIAL INPUT</td>
</tr>
<tr>
<td>VSS</td>
<td>4</td>
<td>POWER</td>
<td>Block 0</td>
<td>GROUND</td>
</tr>
<tr>
<td>P0</td>
<td>5</td>
<td>I/O</td>
<td>Block 0</td>
<td>SPI SS</td>
</tr>
<tr>
<td>P1</td>
<td>6</td>
<td>Input</td>
<td>Block 0</td>
<td>SPI SCK</td>
</tr>
<tr>
<td>P2</td>
<td>7</td>
<td>I/O</td>
<td>Block 0</td>
<td>SPI MOSI</td>
</tr>
<tr>
<td>P3</td>
<td>8</td>
<td>I/O</td>
<td>Block 0</td>
<td>SP MISO</td>
</tr>
<tr>
<td>P4</td>
<td>9</td>
<td>I/O</td>
<td>Block 0</td>
<td>PWM Channel 0</td>
</tr>
<tr>
<td>P5</td>
<td>10</td>
<td>I/O</td>
<td>Block 1</td>
<td>PWM Channel 1</td>
</tr>
<tr>
<td>P6</td>
<td>11</td>
<td>I/O</td>
<td>Block 1</td>
<td>PWM Channel 2</td>
</tr>
<tr>
<td>P7</td>
<td>12</td>
<td>I/O</td>
<td>Block 1</td>
<td>CuNET SCL</td>
</tr>
<tr>
<td>P8</td>
<td>13</td>
<td>I/O</td>
<td>Block 1</td>
<td>CuNET SDA</td>
</tr>
<tr>
<td>P9</td>
<td>14</td>
<td>I/O</td>
<td>Block 1</td>
<td>High-speed Counter Channel 0</td>
</tr>
<tr>
<td>P10</td>
<td>15</td>
<td>I/O</td>
<td>Block 1</td>
<td>High-speed Counter Channel 1</td>
</tr>
<tr>
<td>P11</td>
<td>16</td>
<td>I/O</td>
<td>Block 1</td>
<td></td>
</tr>
<tr>
<td>P12</td>
<td>17</td>
<td>I/O</td>
<td>Block 2</td>
<td>PWM Channel 3</td>
</tr>
<tr>
<td>P13</td>
<td>18</td>
<td>I/O</td>
<td>Block 2</td>
<td>PWM Channel 4 / INT Channel 0</td>
</tr>
<tr>
<td>P14</td>
<td>19</td>
<td>I/O</td>
<td>Block 2</td>
<td>PWM Channel 5 / INT Channel 1</td>
</tr>
<tr>
<td>P15</td>
<td>20</td>
<td>I/O</td>
<td>Block 2</td>
<td>INT Channel 2</td>
</tr>
<tr>
<td>P16</td>
<td>21</td>
<td>I/O</td>
<td>Block 2</td>
<td>INT Channel 3</td>
</tr>
<tr>
<td>P17</td>
<td>22</td>
<td>I/O</td>
<td>Block 2</td>
<td></td>
</tr>
<tr>
<td>Pin</td>
<td>Value</td>
<td>Description</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>-------</td>
<td>-------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P24</td>
<td>37</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P25</td>
<td>38</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P26</td>
<td>39</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P27</td>
<td>40</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P28</td>
<td>56</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P29</td>
<td>55</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P30</td>
<td>54</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P31</td>
<td>53</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P32</td>
<td>57</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P33</td>
<td>58</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P34</td>
<td>59</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P35</td>
<td>60</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P36</td>
<td>61</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P37</td>
<td>62</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P38</td>
<td>63</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P39</td>
<td>64</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P40</td>
<td>48</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P41</td>
<td>47</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P42</td>
<td>46</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P43</td>
<td>45</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P44</td>
<td>44</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P45</td>
<td>43</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P46</td>
<td>42</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P47</td>
<td>41</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P48</td>
<td>52</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VDD</td>
<td>17</td>
<td>IN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VSS</td>
<td>18</td>
<td>IN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RES</td>
<td>19</td>
<td>IN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TX1</td>
<td>33</td>
<td>RS232 Channel 1, +/- 12V Data Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RX1</td>
<td>34</td>
<td>RS232 Channel 1, +/- 12V Data Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVDD</td>
<td>35</td>
<td>ADC Power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TTLTX1</td>
<td>49</td>
<td>RS232 Channel 1, 5V (TTL level) Data Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TTLRX1</td>
<td>50</td>
<td>RS232 Channel 1, 5V (TTL level) Data Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVREF</td>
<td>51</td>
<td>ADC Reference Voltage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Block 3**

ADC0 : AD Channel 0
ADC1 : AD Channel 1
ADC2 : AD Channel 2
ADC3 : AD Channel 3
ADC4 : AD Channel 4
ADC5 : AD Channel 5
ADC6 : AD Channel 6
ADC7 : AD Channel 7

**Block 4**

**Block 5**

VDD: Power, 4.5V to 5.5V
VSS: GROUND
RES: RESET Input (LOW signal resets!), Normally HIGH or OPEN

TX1: RS232 Channel 1, +/- 12V Data Output
RX1: RS232 Channel 1, +/- 12V Data Input
TTLTX1: RS232 Channel 1, 5V (TTL level) Data Output
TTLRX1: RS232 Channel 1, 5V (TTL level) Data Input

AVREF: ADC Reference Voltage
How to supply power to the CB280 and CB380

The CB280 and CB380 do not have an internal 5V regulator; you must provide your own 5V power as shown below.

* Pin 20 and 36 are not used, please DO NOT CONNECT anything to these pins.
CB290

The CB290 is a package of 108 pins of which 91 can be used as I/O ports. It has a battery-backup-capable 28KB of memory and an RTC. The CB290 does not have an internal 5V regulator. Of the 91 I/O ports, 32 ports are output only, 32 ports are input only, and rest can be set as output or input as desired by the user program.

<table>
<thead>
<tr>
<th>Port</th>
<th>Pin</th>
<th>I/O</th>
<th>Port Block</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOUT</td>
<td>1</td>
<td>OUT</td>
<td></td>
<td>DOWNLOAD SERIAL OUTPUT</td>
</tr>
<tr>
<td>SIN</td>
<td>2</td>
<td>IN</td>
<td></td>
<td>DOWNLOAD SERIAL INPUT</td>
</tr>
<tr>
<td>ATN</td>
<td>3</td>
<td>IN</td>
<td></td>
<td>DOWNLOAD SERIAL INPUT</td>
</tr>
<tr>
<td>VSS</td>
<td>4</td>
<td>POWER</td>
<td></td>
<td>GROUND</td>
</tr>
<tr>
<td>P0</td>
<td>5</td>
<td>I/O</td>
<td>Block 0</td>
<td>SPI SS</td>
</tr>
<tr>
<td>P1</td>
<td>6</td>
<td>Input</td>
<td></td>
<td>SPI SCK</td>
</tr>
<tr>
<td>P2</td>
<td>7</td>
<td>I/O</td>
<td></td>
<td>SPI MOSI</td>
</tr>
<tr>
<td>P3</td>
<td>8</td>
<td>I/O</td>
<td></td>
<td>SPI MISO</td>
</tr>
<tr>
<td>P4</td>
<td>9</td>
<td>I/O</td>
<td></td>
<td>PWM Channel 0</td>
</tr>
<tr>
<td>P5</td>
<td>10</td>
<td>I/O</td>
<td></td>
<td>PWM Channel 1</td>
</tr>
<tr>
<td>P6</td>
<td>11</td>
<td>I/O</td>
<td></td>
<td>PWM Channel 2</td>
</tr>
<tr>
<td>P7</td>
<td>12</td>
<td>I/O</td>
<td>Block 1</td>
<td>ADC0 : AD Channel 0</td>
</tr>
<tr>
<td>P8</td>
<td>25</td>
<td>I/O</td>
<td></td>
<td>ADC1 : AD Channel 1</td>
</tr>
<tr>
<td>P9</td>
<td>26</td>
<td>I/O</td>
<td></td>
<td>ADC2 : AD Channel 2</td>
</tr>
<tr>
<td>P10</td>
<td>27</td>
<td>I/O</td>
<td></td>
<td>ADC3 : AD Channel 3</td>
</tr>
<tr>
<td>P11</td>
<td>28</td>
<td>I/O</td>
<td></td>
<td>ADC4 : AD Channel 4</td>
</tr>
<tr>
<td>P12</td>
<td>29</td>
<td>I/O</td>
<td></td>
<td>ADC5 : AD Channel 5</td>
</tr>
<tr>
<td>P13</td>
<td>30</td>
<td>I/O</td>
<td></td>
<td>ADC6 : AD Channel 6</td>
</tr>
<tr>
<td>P14</td>
<td>31</td>
<td>I/O</td>
<td></td>
<td>ADC7 : AD Channel 7</td>
</tr>
<tr>
<td>P15</td>
<td>32</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>P16</td>
<td>83</td>
<td>I/O</td>
<td>CUNET SCL</td>
<td></td>
</tr>
<tr>
<td>P17</td>
<td>84</td>
<td>I/O</td>
<td>CUNET SDA</td>
<td></td>
</tr>
<tr>
<td>P18</td>
<td>85</td>
<td>I/O</td>
<td>INT Channel 2</td>
<td></td>
</tr>
<tr>
<td>P19</td>
<td>86</td>
<td>I/O</td>
<td>INT Channel 3</td>
<td></td>
</tr>
<tr>
<td>P20</td>
<td>97</td>
<td>I/O</td>
<td>High-speed Counter Channel 0</td>
<td></td>
</tr>
<tr>
<td>P21</td>
<td>98</td>
<td>I/O</td>
<td>High-speed Counter Channel 1</td>
<td></td>
</tr>
<tr>
<td>P22</td>
<td>99</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P23</td>
<td>100</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P24</td>
<td>45</td>
<td>Output</td>
<td>Block 3</td>
<td></td>
</tr>
<tr>
<td>P25</td>
<td>46</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P26</td>
<td>47</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P27</td>
<td>48</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P28</td>
<td>49</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P29</td>
<td>50</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P30</td>
<td>51</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P31</td>
<td>52</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P32</td>
<td>65</td>
<td>Output</td>
<td>Block 4</td>
<td></td>
</tr>
<tr>
<td>P33</td>
<td>66</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P34</td>
<td>67</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P35</td>
<td>68</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P36</td>
<td>69</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P37</td>
<td>70</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P38</td>
<td>71</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P39</td>
<td>72</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P40</td>
<td>53</td>
<td>Output</td>
<td>Block 5</td>
<td></td>
</tr>
<tr>
<td>P41</td>
<td>54</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P42</td>
<td>55</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P43</td>
<td>56</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P44</td>
<td>57</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P45</td>
<td>58</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P46</td>
<td>59</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P47</td>
<td>60</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P48</td>
<td>73</td>
<td>Output</td>
<td>Block 6</td>
<td></td>
</tr>
<tr>
<td>P49</td>
<td>74</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P50</td>
<td>75</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P51</td>
<td>76</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P52</td>
<td>77</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P53</td>
<td>78</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P54</td>
<td>79</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P55</td>
<td>80</td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P56</td>
<td>13</td>
<td>Input</td>
<td>Block 7</td>
<td></td>
</tr>
<tr>
<td>P57</td>
<td>14</td>
<td>Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P58</td>
<td>15</td>
<td>Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P59</td>
<td>16</td>
<td>Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P60</td>
<td>17</td>
<td>Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P61</td>
<td>18</td>
<td>Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P62</td>
<td>19</td>
<td>Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P63</td>
<td>20</td>
<td>Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Block 8</td>
<td>Block 9</td>
<td>Block 10</td>
<td>Block 11</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>--------</td>
<td>----------</td>
<td>----------</td>
<td></td>
</tr>
<tr>
<td>P64 33</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P65 34</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P66 35</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P67 36</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P68 37</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P69 38</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P70 39</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P71 40</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P72 87</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P73 88</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P74 89</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P75 90</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P76 101</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P77 102</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P78 103</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P79 104</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P80 91</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P81 92</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P82 93</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P83 94</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P84 105</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P85 106</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P86 107</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P87 108</td>
<td>Input</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P88 81</td>
<td>N/C</td>
<td></td>
<td>N/C (Do not use this I/O</td>
<td></td>
</tr>
<tr>
<td>P89 82</td>
<td>I/O</td>
<td></td>
<td>PWM Channel 3</td>
<td></td>
</tr>
<tr>
<td>P90 95</td>
<td>I/O</td>
<td></td>
<td>PWM Channel 4 / INT Channel 0</td>
<td></td>
</tr>
<tr>
<td>P91 96</td>
<td>I/O</td>
<td></td>
<td>PWM Channel 5 / INT Channel 1</td>
<td></td>
</tr>
<tr>
<td>VDD 21,44 IN</td>
<td></td>
<td>Power, 4.5V to 5.5V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VSS 22,64 IN</td>
<td></td>
<td>GROUND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RES 23 IN</td>
<td></td>
<td>RESET Input (LOW signal resets!), Normally HIGH or OPEN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VBB 24 IN</td>
<td></td>
<td>Battery Backup</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TX1 41 IN</td>
<td></td>
<td>RS232 Channel 1, +/- 12V Data Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RX1 42 IN</td>
<td></td>
<td>RS232 Channel 1, +/- 12V Data Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVDD 43 IN</td>
<td></td>
<td>ADC Power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TTLTX1 61 IN</td>
<td></td>
<td>RS232 Channel 1, 5V (TTL level) Data Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TTLRX1 62 IN</td>
<td></td>
<td>RS232 Channel 1, 5V (TTL level) Data Input</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AVREF 63 IN</td>
<td></td>
<td>ADC Reference Voltage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The CB290's output-only pins P24 to P55 are in a high impedance state (High-Z) at power ON. You must use Set OutOnly On to enable the pins if you wish to use them.

Set OutOnly On

This command only works with CB290 Rev. B. The revision number can be found on the bottom side of the CB290 module.

The Set Outonly command actually toggles virtual Port 88 to enable the output-only pins. If your program accidentally uses P88, you will see strange behavior on the output-only pins. Please do not access P88 in your Basic or Ladder Logic programs.
**CB400**

The CB400 is a package of 108 pins of which 80 can be used as I/O ports. It has more I/O ports than the CB405, but less memory.

<table>
<thead>
<tr>
<th>Name</th>
<th>Pin #</th>
<th>I/O</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOUT</td>
<td>1</td>
<td>OUT</td>
<td>DOWNLOAD SERIAL OUTPUT</td>
</tr>
<tr>
<td>SIN</td>
<td>2</td>
<td>IN</td>
<td>DOWNLOAD SERIAL INPUT</td>
</tr>
<tr>
<td>ATN</td>
<td>3</td>
<td>IN</td>
<td>DOWNLOAD SERIAL INPUT</td>
</tr>
<tr>
<td>VSS</td>
<td>4, 22, 64</td>
<td>POWER</td>
<td>GROUND</td>
</tr>
<tr>
<td>VDD</td>
<td>21, 44</td>
<td>POWER</td>
<td>4.5V to 5.5V Power Supply</td>
</tr>
<tr>
<td>AVREF</td>
<td>63</td>
<td>IN</td>
<td>ADC Reference Voltage</td>
</tr>
<tr>
<td>VBB</td>
<td>24</td>
<td>POWER</td>
<td>Battery Backup (Can’t be used)</td>
</tr>
<tr>
<td>RES</td>
<td>23</td>
<td>IN</td>
<td>RESET pin</td>
</tr>
<tr>
<td>TTLTXE</td>
<td>61</td>
<td>OUT</td>
<td>RS232 to TTL232 circuit, TX contact</td>
</tr>
<tr>
<td>TTLRXE</td>
<td>62</td>
<td>IN</td>
<td>RS232 to TTL232 circuit, RX contact</td>
</tr>
<tr>
<td>TXE</td>
<td>41</td>
<td>OUT</td>
<td>RS232 Output, +/- 12V</td>
</tr>
<tr>
<td>RXE</td>
<td>42</td>
<td>IN</td>
<td>RS232 Input, +/- 12V</td>
</tr>
</tbody>
</table>

The following I/O ports are described in blocks.
<table>
<thead>
<tr>
<th>Block</th>
<th>Name</th>
<th>Pin #</th>
<th>I/O</th>
<th>Function</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>P0</td>
<td>5</td>
<td>I/O</td>
<td>SPI SS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P1</td>
<td>6</td>
<td>Input</td>
<td>SPI SCK</td>
<td>Input Only</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>7</td>
<td>Input</td>
<td>SPI MOSI</td>
<td>Input Only</td>
</tr>
<tr>
<td></td>
<td>P3</td>
<td>8</td>
<td>Input</td>
<td>SPI MISO</td>
<td>Input Only</td>
</tr>
<tr>
<td></td>
<td>P4</td>
<td>9</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P5</td>
<td>10</td>
<td>I/O</td>
<td>PWM CHANNEL 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P6</td>
<td>11</td>
<td>I/O</td>
<td>PWM CHANNEL 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P7</td>
<td>12</td>
<td>I/O</td>
<td>PWM CHANNEL 2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>P8</td>
<td>13</td>
<td>I/O</td>
<td>TTL232 RX2</td>
<td>TTLRX channel 2</td>
</tr>
<tr>
<td></td>
<td>P9</td>
<td>14</td>
<td>I/O</td>
<td>TTL232 TX2</td>
<td>TTLTX channel 2</td>
</tr>
<tr>
<td></td>
<td>P10</td>
<td>15</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P11</td>
<td>16</td>
<td>I/O</td>
<td>PWM CHANNEL 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P12</td>
<td>17</td>
<td>I/O</td>
<td>PWM CHANNEL 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P13</td>
<td>18</td>
<td>I/O</td>
<td>PWM CHANNEL 8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P14</td>
<td>19</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P15</td>
<td>20</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>P16</td>
<td>25</td>
<td>I/O</td>
<td>AD CHANNEL 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P17</td>
<td>26</td>
<td>I/O</td>
<td>AD CHANNEL 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P18</td>
<td>27</td>
<td>I/O</td>
<td>AD CHANNEL 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P19</td>
<td>28</td>
<td>I/O</td>
<td>AD CHANNEL 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P20</td>
<td>29</td>
<td>I/O</td>
<td>AD CHANNEL 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P21</td>
<td>30</td>
<td>I/O</td>
<td>AD CHANNEL 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P22</td>
<td>31</td>
<td>I/O</td>
<td>AD CHANNEL 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P23</td>
<td>32</td>
<td>I/O</td>
<td>AD CHANNEL 7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>P24</td>
<td>33</td>
<td>I/O</td>
<td>Co-processor SCL</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>P25</td>
<td>34</td>
<td>I/O</td>
<td>Co-processor SDA</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>P26</td>
<td>35</td>
<td>I/O</td>
<td>Co-processor INT</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>P27</td>
<td>36</td>
<td>I/O</td>
<td>PWM3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P28</td>
<td>37</td>
<td>I/O</td>
<td>PWM4 / INT0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P29</td>
<td>38</td>
<td>I/O</td>
<td>PWM5 / INT1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P30</td>
<td>39</td>
<td>I/O</td>
<td>INT2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P31</td>
<td>40</td>
<td>I/O</td>
<td>INT3</td>
<td></td>
</tr>
</tbody>
</table>

* Communication line for connecting to the coprocessor (Please try to save these pins for future coprocessor communication ports.)
<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>P32</td>
<td>45</td>
<td>I/O</td>
<td>AD CHANNEL 8</td>
</tr>
<tr>
<td></td>
<td>P33</td>
<td>46</td>
<td>I/O</td>
<td>AD CHANNEL 9</td>
</tr>
<tr>
<td></td>
<td>P34</td>
<td>47</td>
<td>I/O</td>
<td>AD CHANNEL 10</td>
</tr>
<tr>
<td></td>
<td>P35</td>
<td>48</td>
<td>I/O</td>
<td>AD CHANNEL 11</td>
</tr>
<tr>
<td></td>
<td>P36</td>
<td>49</td>
<td>I/O</td>
<td>AD CHANNEL 12</td>
</tr>
<tr>
<td></td>
<td>P37</td>
<td>50</td>
<td>I/O</td>
<td>AD CHANNEL 13</td>
</tr>
<tr>
<td></td>
<td>P38</td>
<td>51</td>
<td>I/O</td>
<td>AD CHANNEL 14</td>
</tr>
<tr>
<td></td>
<td>P39</td>
<td>52</td>
<td>I/O</td>
<td>AD CHANNEL 15</td>
</tr>
<tr>
<td>5</td>
<td>P40</td>
<td>60</td>
<td>I/O</td>
<td>SCL</td>
</tr>
<tr>
<td></td>
<td>P41</td>
<td>59</td>
<td>I/O</td>
<td>SDA</td>
</tr>
<tr>
<td></td>
<td>P42</td>
<td>58</td>
<td>I/O</td>
<td>RX1</td>
</tr>
<tr>
<td></td>
<td>P43</td>
<td>57</td>
<td>I/O</td>
<td>TX1</td>
</tr>
<tr>
<td></td>
<td>P44</td>
<td>56</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P45</td>
<td>55</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P46</td>
<td>54</td>
<td>I/O</td>
<td>HCNT0</td>
</tr>
<tr>
<td></td>
<td>P47</td>
<td>53</td>
<td>I/O</td>
<td>HCNT1</td>
</tr>
<tr>
<td>6</td>
<td>P48</td>
<td>65</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P49</td>
<td>66</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P50</td>
<td>67</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P51</td>
<td>68</td>
<td>I/O</td>
<td>PWM Channel 9</td>
</tr>
<tr>
<td></td>
<td>P52</td>
<td>69</td>
<td>I/O</td>
<td>PWM Channel 10</td>
</tr>
<tr>
<td></td>
<td>P53</td>
<td>70</td>
<td>I/O</td>
<td>PWM Channel 11</td>
</tr>
<tr>
<td></td>
<td>P54</td>
<td>71</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P55</td>
<td>72</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>P56</td>
<td>80</td>
<td>I/O</td>
<td>RX3</td>
</tr>
<tr>
<td></td>
<td>P57</td>
<td>79</td>
<td>I/O</td>
<td>TX3</td>
</tr>
<tr>
<td></td>
<td>P58</td>
<td>78</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P59</td>
<td>77</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P60</td>
<td>76</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P61</td>
<td>75</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P62</td>
<td>74</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P63</td>
<td>73</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>P64</td>
<td>85</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P65</td>
<td>86</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P66</td>
<td>87</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P67</td>
<td>88</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P68</td>
<td>89</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P69</td>
<td>90</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P70</td>
<td>91</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P71</td>
<td>92</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P72</td>
<td>99</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-----</td>
<td>----</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P73</td>
<td>100</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P74</td>
<td>101</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P75</td>
<td>102</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P76</td>
<td>103</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P77</td>
<td>104</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P78</td>
<td>105</td>
<td>I/O</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P79</td>
<td>106</td>
<td>I/O</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>P80</th>
<th>93</th>
<th>I/O</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P81</td>
<td>94</td>
<td>I/O</td>
</tr>
<tr>
<td></td>
<td>P82</td>
<td>104</td>
<td>I/O</td>
</tr>
</tbody>
</table>
CB405

The CB405 is a package of 80 pins of which 64 can be used as I/O ports. It has a battery-backup-capable 55KB of memory. The CB405 does not have an internal 5V regulator.

<table>
<thead>
<tr>
<th>Name</th>
<th>Pin #</th>
<th>I/O</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOUT</td>
<td>1</td>
<td>OUT</td>
<td>DOWNLOAD SERIAL OUTPUT</td>
</tr>
<tr>
<td>SIN</td>
<td>2</td>
<td>IN</td>
<td>DOWNLOAD SERIAL INPUT</td>
</tr>
<tr>
<td>ATN</td>
<td>3</td>
<td>IN</td>
<td>DOWNLOAD SERIAL INPUT</td>
</tr>
<tr>
<td>VSS</td>
<td>4, 22, 64</td>
<td>POWER IN</td>
<td>GROUND</td>
</tr>
<tr>
<td>VDD</td>
<td>21, 44</td>
<td>POWER IN</td>
<td>4.5V to 5.5V Power Supply</td>
</tr>
<tr>
<td>AVDD</td>
<td>43</td>
<td>POWER IN</td>
<td>ADC power</td>
</tr>
<tr>
<td>AVREF</td>
<td>63</td>
<td>IN</td>
<td>ADC Reference Voltage</td>
</tr>
<tr>
<td>VBB</td>
<td>24</td>
<td>POWER IN</td>
<td>Battery Backup</td>
</tr>
<tr>
<td>RES</td>
<td>23</td>
<td>IN</td>
<td>RESET pin</td>
</tr>
<tr>
<td>TTLTXE</td>
<td>61</td>
<td>OUT</td>
<td>RS232 to TTL232 circuit, TX contact</td>
</tr>
<tr>
<td>TRLRXE</td>
<td>62</td>
<td>IN</td>
<td>RS232 to TTL232 circuit, RX contact</td>
</tr>
<tr>
<td>TXE</td>
<td>41</td>
<td>OUT</td>
<td>RS232 Output, +/- 12V</td>
</tr>
<tr>
<td>RXE</td>
<td>42</td>
<td>IN</td>
<td>RS232 Input, +/- 12V</td>
</tr>
</tbody>
</table>
The **following** I/O ports are described in blocks.

<table>
<thead>
<tr>
<th>Block</th>
<th>Name</th>
<th>Pin #</th>
<th>I/O</th>
<th>Function</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>P0</td>
<td>5</td>
<td>I/O</td>
<td>SPI SS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P1</td>
<td>6</td>
<td>Input</td>
<td>SPI SCK</td>
<td>Input Only</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>7</td>
<td>Input</td>
<td>SPI MOSI</td>
<td>Input Only</td>
</tr>
<tr>
<td></td>
<td>P3</td>
<td>8</td>
<td>Input</td>
<td>SPI MISO</td>
<td>Input Only</td>
</tr>
<tr>
<td></td>
<td>P4</td>
<td>9</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P5</td>
<td>10</td>
<td>I/O</td>
<td>PWM CHANNEL 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P6</td>
<td>11</td>
<td>I/O</td>
<td>PWM CHANNEL 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P7</td>
<td>12</td>
<td>I/O</td>
<td>PWM CHANNEL 2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>P8</td>
<td>13</td>
<td>I/O</td>
<td>TTL232 RX2</td>
<td>TTLRX channel 2</td>
</tr>
<tr>
<td></td>
<td>P9</td>
<td>14</td>
<td>I/O</td>
<td>TTL232 TX2</td>
<td>TTLTX channel 2</td>
</tr>
<tr>
<td></td>
<td>P10</td>
<td>15</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P11</td>
<td>16</td>
<td>I/O</td>
<td>PWM CHANNEL 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P12</td>
<td>17</td>
<td>I/O</td>
<td>PWM CHANNEL 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P13</td>
<td>18</td>
<td>I/O</td>
<td>PWM CHANNEL 8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P14</td>
<td>19</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P15</td>
<td>20</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>P16</td>
<td>25</td>
<td>I/O</td>
<td>AD CHANNEL 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P17</td>
<td>26</td>
<td>I/O</td>
<td>AD CHANNEL 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P18</td>
<td>27</td>
<td>I/O</td>
<td>AD CHANNEL 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P19</td>
<td>28</td>
<td>I/O</td>
<td>AD CHANNEL 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P20</td>
<td>29</td>
<td>I/O</td>
<td>AD CHANNEL 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P21</td>
<td>30</td>
<td>I/O</td>
<td>AD CHANNEL 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P22</td>
<td>31</td>
<td>I/O</td>
<td>AD CHANNEL 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P23</td>
<td>32</td>
<td>I/O</td>
<td>AD CHANNEL 7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>P24</td>
<td>33</td>
<td>I/O</td>
<td>Co-processor SCL</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>P25</td>
<td>34</td>
<td>I/O</td>
<td>Co-processor SDA</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>P26</td>
<td>35</td>
<td>I/O</td>
<td>Co-processor INT</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>P27</td>
<td>36</td>
<td>I/O</td>
<td>PWM3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P28</td>
<td>37</td>
<td>I/O</td>
<td>PWM4 / INT0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P29</td>
<td>38</td>
<td>I/O</td>
<td>PWM5 / INT1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P30</td>
<td>39</td>
<td>I/O</td>
<td>INT2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P31</td>
<td>40</td>
<td>I/O</td>
<td>INT3</td>
<td></td>
</tr>
</tbody>
</table>

* Communication line for connecting to the coprocessor (Please try to save these pins for future coprocessor communication ports.)
<table>
<thead>
<tr>
<th>Block</th>
<th>Name</th>
<th>Pin #</th>
<th>I/O</th>
<th>Function</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>P32</td>
<td>45</td>
<td>I/O</td>
<td>AD CHANNEL 8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P33</td>
<td>46</td>
<td>I/O</td>
<td>AD CHANNEL 9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P34</td>
<td>47</td>
<td>I/O</td>
<td>AD CHANNEL 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P35</td>
<td>48</td>
<td>I/O</td>
<td>AD CHANNEL 11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P36</td>
<td>49</td>
<td>I/O</td>
<td>AD CHANNEL 12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P37</td>
<td>50</td>
<td>I/O</td>
<td>AD CHANNEL 13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P38</td>
<td>51</td>
<td>I/O</td>
<td>AD CHANNEL 14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P39</td>
<td>52</td>
<td>I/O</td>
<td>AD CHANNEL 15</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>P40</td>
<td>60</td>
<td>I/O</td>
<td>SCL</td>
<td>CUNET clock pin</td>
</tr>
<tr>
<td></td>
<td>P41</td>
<td>59</td>
<td>I/O</td>
<td>SDA</td>
<td>CUNET data pin</td>
</tr>
<tr>
<td></td>
<td>P42</td>
<td>58</td>
<td>I/O</td>
<td>RX1</td>
<td>TTLRX channel 1</td>
</tr>
<tr>
<td></td>
<td>P43</td>
<td>57</td>
<td>I/O</td>
<td>TX1</td>
<td>TTLTX channel 1</td>
</tr>
<tr>
<td></td>
<td>P44</td>
<td>56</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P45</td>
<td>55</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P46</td>
<td>54</td>
<td>I/O</td>
<td>HCNT0</td>
<td>High-speed Counter 0</td>
</tr>
<tr>
<td></td>
<td>P47</td>
<td>53</td>
<td>I/O</td>
<td>HCNT1</td>
<td>High-speed Counter 1</td>
</tr>
<tr>
<td>6</td>
<td>P48</td>
<td>65</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P49</td>
<td>66</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P50</td>
<td>67</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P51</td>
<td>68</td>
<td>I/O</td>
<td>PWM CHANNEL 9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P52</td>
<td>69</td>
<td>I/O</td>
<td>PWM CHANNEL 10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P53</td>
<td>70</td>
<td>I/O</td>
<td>PWM CHANNEL 11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P54</td>
<td>71</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P55</td>
<td>72</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>P56</td>
<td>80</td>
<td>I/O</td>
<td>RX3</td>
<td>TTLRX channel 3</td>
</tr>
<tr>
<td></td>
<td>P57</td>
<td>79</td>
<td>I/O</td>
<td>TX3</td>
<td>TTLTX channel 3</td>
</tr>
<tr>
<td></td>
<td>P58</td>
<td>78</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P59</td>
<td>77</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P60</td>
<td>76</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P61</td>
<td>75</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P62</td>
<td>74</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P63</td>
<td>73</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
CB405RT

- CB405 core module
- equipped with a built-in accurate RTC (DS3231)
- equipped with a built-in 16-bit A/D converter (8 channels)

The CB405RT is a product, which adds an RTC and a 16-bit ADC to the original CB405. The external dimensions and pinout are the same as the CB405 with the exception that ports P32 to P37 are used for the 16-bit ADC and therefore cannot be used.

Refer chapter 13 for more information.

The following describes all pins excluding I/O ports.

<table>
<thead>
<tr>
<th>Name</th>
<th>Pin No.</th>
<th>I/O</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOUT</td>
<td>1</td>
<td>OUT</td>
<td>SERIAL OUTPUT for DOWNLOAD</td>
</tr>
<tr>
<td>SIN</td>
<td>2</td>
<td>IN</td>
<td>SERIAL OUTPUT for DOWNLOAD</td>
</tr>
<tr>
<td>ATN</td>
<td>3</td>
<td>IN</td>
<td>SERIAL OUTPUT for DOWNLOAD</td>
</tr>
<tr>
<td>VSS</td>
<td>4, 22, 64</td>
<td>POWER IN</td>
<td>GROUND</td>
</tr>
<tr>
<td>VDD</td>
<td>21, 44</td>
<td>POWER IN</td>
<td>Supplies 4.5V to 5.5V</td>
</tr>
<tr>
<td>HAD_Vref</td>
<td>43</td>
<td>IN</td>
<td>Supplies reference voltage to the 16-bit ADC</td>
</tr>
<tr>
<td>AVREF</td>
<td>63</td>
<td>IN</td>
<td>Supplies reference voltage to the 10-bit ADC</td>
</tr>
<tr>
<td>VBB</td>
<td>24</td>
<td>POWER IN</td>
<td>Battery connection pin for battery backup</td>
</tr>
<tr>
<td>RES</td>
<td>23</td>
<td>IN</td>
<td>RESET pin</td>
</tr>
<tr>
<td>TTLTXE</td>
<td>61</td>
<td>OUT</td>
<td>RS232 to TTL232 conversion circuit, TX connection terminal</td>
</tr>
<tr>
<td>TRLRXE</td>
<td>62</td>
<td>IN</td>
<td>RS232 to TTL232 conversion circuit, RX connection terminal</td>
</tr>
<tr>
<td>TXE</td>
<td>41</td>
<td>OUT</td>
<td>RS232 output terminal, connects with external RS232 port</td>
</tr>
<tr>
<td>RXE</td>
<td>42</td>
<td>IN</td>
<td>RS232 input terminal, connects with external RS232 port</td>
</tr>
</tbody>
</table>
The following describes the I/O ports, listed by their port blocks.

<table>
<thead>
<tr>
<th>Block</th>
<th>Name</th>
<th>Pin No.</th>
<th>I/O</th>
<th>Special Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>P0</td>
<td>5</td>
<td>I/O</td>
<td>SPI’s SS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P1</td>
<td>6</td>
<td>Input</td>
<td>SPI’s SCK</td>
<td>Input only pin</td>
</tr>
<tr>
<td></td>
<td>P2</td>
<td>7</td>
<td>Input</td>
<td>SPI’s MOSI</td>
<td>Input only pin</td>
</tr>
<tr>
<td></td>
<td>P3</td>
<td>8</td>
<td>Input</td>
<td>SPI’s MISO</td>
<td>Input only pin</td>
</tr>
<tr>
<td></td>
<td>P4</td>
<td>9</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P5</td>
<td>10</td>
<td>I/O</td>
<td>PWM CHANNEL 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P6</td>
<td>11</td>
<td>I/O</td>
<td>PWM CHANNEL 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P7</td>
<td>12</td>
<td>I/O</td>
<td>PWM CHANNEL 2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>P8</td>
<td>13</td>
<td>I/O</td>
<td>TTL232 RX2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P9</td>
<td>14</td>
<td>I/O</td>
<td>TTL232 TX2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P10</td>
<td>15</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P11</td>
<td>16</td>
<td>I/O</td>
<td>PWM CHANNEL 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P12</td>
<td>17</td>
<td>I/O</td>
<td>PWM CHANNEL 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P13</td>
<td>18</td>
<td>I/O</td>
<td>PWM CHANNEL 8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P14</td>
<td>19</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P15</td>
<td>20</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>P16</td>
<td>25</td>
<td>I/O</td>
<td>AD CHANNEL 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P17</td>
<td>26</td>
<td>I/O</td>
<td>AD CHANNEL 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P18</td>
<td>27</td>
<td>I/O</td>
<td>AD CHANNEL 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P19</td>
<td>28</td>
<td>I/O</td>
<td>AD CHANNEL 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P20</td>
<td>29</td>
<td>I/O</td>
<td>AD CHANNEL 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P21</td>
<td>30</td>
<td>I/O</td>
<td>AD CHANNEL 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P22</td>
<td>31</td>
<td>I/O</td>
<td>AD CHANNEL 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P23</td>
<td>32</td>
<td>I/O</td>
<td>AD CHANNEL 7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>P24</td>
<td>33</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P25</td>
<td>34</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P26</td>
<td>35</td>
<td>I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>P27</td>
<td>36</td>
<td>I/O</td>
<td>PWM3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P28</td>
<td>37</td>
<td>I/O</td>
<td>PWM4 / INT0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P29</td>
<td>38</td>
<td>I/O</td>
<td>PWM5 / INT1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P30</td>
<td>39</td>
<td>I/O</td>
<td>INT2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P31</td>
<td>40</td>
<td>I/O</td>
<td>INT3</td>
<td></td>
</tr>
</tbody>
</table>
This part has been changed from the original CB405.

<table>
<thead>
<tr>
<th>Block</th>
<th>Name</th>
<th>Pin No.</th>
<th>I/O</th>
<th>Special Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HADCH0</td>
<td>45</td>
<td>INPUT</td>
<td>16bit AD CHANNEL 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HADCH1</td>
<td>46</td>
<td>INPUT</td>
<td>16bit AD CHANNEL 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HADCH2</td>
<td>47</td>
<td>INPUT</td>
<td>16bit AD CHANNEL 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HADCH3</td>
<td>48</td>
<td>INPUT</td>
<td>16bit AD CHANNEL 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HADCH4</td>
<td>49</td>
<td>INPUT</td>
<td>16bit AD CHANNEL 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HADCH5</td>
<td>50</td>
<td>INPUT</td>
<td>16bit AD CHANNEL 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HADCH6 / P38</td>
<td>51</td>
<td>I/O</td>
<td>16bit AD CHANNEL 6</td>
<td>P38 usable</td>
</tr>
<tr>
<td></td>
<td>HADCH7 / P39</td>
<td>52</td>
<td>I/O</td>
<td>16bit AD CHANNEL 7</td>
<td>P39 usable</td>
</tr>
</tbody>
</table>

Note: Since ports P32 to P37 are internally connected to the RTC and the 16-bit ADC, if a program uses these ports, the RTC and ADC chip will not function properly. Also, if ports P38 and P39 are used for output, HADCH6 and HADCH7 cannot be used, respectively.

| 5 | P40  | 60 | I/O | SCL | CUNET clock |
|   | P41  | 59 | I/O | SDA | CUNET data  |
|   | P42  | 58 | I/O | RX1 | TTLRX channel 1 |
|   | P43  | 57 | I/O | TX1 | TTLTX channel 1 |
|   | P44  | 56 | I/O |     |             |
|   | P45  | 55 | I/O |     |             |
|   | P46  | 54 | I/O | HCNT0 | High-speed counter channel 0 |
|   | P47  | 53 | I/O | HCNT1 | High-speed counter channel 1 |

| 6 | P48  | 65 | I/O |     |             |
|   | P49  | 66 | I/O |     |             |
|   | P50  | 67 | I/O |     |             |
|   | P51  | 68 | I/O | PWM CHANNEL 9 |             |
|   | P52  | 69 | I/O | PWM CHANNEL 10 |         |
|   | P53  | 70 | I/O | PWM CHANNEL 11 |         |
|   | P54  | 71 | I/O |     |             |
|   | P55  | 72 | I/O |     |             |

| 7 | P56  | 80 | I/O | RX3 | TTLRX channel 3 |
|   | P57  | 79 | I/O | TX3 | TTLTX channel 3 |
|   | P58  | 78 | I/O |     |             |
|   | P59  | 77 | I/O |     |             |
|   | P60  | 76 | I/O |     |             |
|   | P61  | 75 | I/O |     |             |
|   | P62  | 74 | I/O |     |             |
|   | P63  | 73 | I/O |     |             |
How to connect a battery to CB290 / CB405

When a supercapacitor is connected to VBB, the memory can be maintained anywhere from a couple days to a couple weeks once powered off. The CB290/CB405 consumes about 15-20mA of current when idling. For a longer backup period, a battery pack can be used. A protection diode, as shown below, is necessary when using a battery, as the device normally attempts to charge a capacitor through VBB. Due to the relatively high standby current for battery backup, it is recommended to keep the device powered if possible and only maintain battery backup for short periods in the case of an emergency.

Power Features
- Operating Voltage : 4.5V to 5.5V
- Operating Clock : 18.432MHz
- I/O Port Source Current : 20mA
- I/O Port Sink Current : 25mA
- Operating Temperature : -40 to 125 Degrees(Celcius)
- Maintenance Temperature: -60 to 140 Degrees(Celcius)
- Operating Humidity : 5 to 95% RH
  (Keep the board's surface dry when in use)

Additional Information
If a Cubloc module is supplied with power above the recommended voltage, the device can be destroyed. Also please be careful to avoid electrostatic discharge, as it too can destroy the device. Please be aware that P1 is an input-only pin. To reduce accidental power drain, please set unused pins to input. All I/O ports are set to input as default at power on. When not using SIN, SOUT, and ATN, please do not connect them to anything.
Dimensions

CB220

15.24mm (600 mil)

30mm (1181 mil)

CB280

2mm (78.74 mil)

25.4mm (1000 mil)

34.9mm (1374 mil)

CB380

18.415mm (725 mil)

2mm (78.74 mil)
Please refer to the diagram below for PCB design. The numbers are offsets based on location 0, 0 (from the top left corner of the module’s internal PCB; not the external plastic case).
Chapter 3: Cubloc Studio
About Cubloc Studio

After installing Cubloc Studio and executing it, you will see the following screen.

You will see that, at first, Cubloc Studio will default to the BASIC editor.

If you press F2, the screen will change to the Ladder Logic editor and if you press F1, it will switch back to the BASIC editor.
Source files are saved as two files under the file extensions .CUL and .CUB. If you need to backup or move source files, you must keep BOTH of these files together.

When opening a file, you will only see .CUL files. (.CUB files are not displayed, but they are in the same folder). When you open a .CUL file, Cubloc Studio automatically opens CUB file.

The source code can only be saved on the PC. Source code downloaded to the Cubloc module can not be uploaded back to the PC.

**IMPORTANT**
All Cubloc modules implement code obfuscation. By obfuscating the downloaded program data, the code is safe from any attempt to read part of the chip’s memory and copy the source code.

When you press the RUN button (or CTRL-R), Save, Compile, Download, and Execute are all automatically processed. Ladder Logic and BASIC both are compiled with one RUN button. If an error is found during compilation, the cursor will relocate to the error position.
Creating BASIC Code

You can create BASIC code as shown below. Cubloc Studio's text editor is similar to most text editors, and performs syntax highlighting of certain commands.

```
Const Device = CB280
Const iorst = 7
Const 10dio = 6
Const loclk = 5
Dim I As Integer
Dim adr As Byte
High iorst
Shiftout loclk,10dio,0,6h8c,8
Shiftout loclk,10dio,0,0,8
Low iorst
Delay 1
High iorst
Shiftout loclk,10dio,0,6h80,8
Shiftout loclk,10dio,0,6h50,8
Low iorst
Do
  High iorst
  adr = 4h81
  Shiftout loclk,10dio,0,adr,8
  I = Shiftin(loclk,10dio,4,8)
  Debug Hex I,Cr
  Low iorst
  Delay 1000
Loop
```
Debugging

As shown in the screenshot above, the Debug statement can be used to monitor your BASIC program while it’s running. Be aware that you cannot debug and monitor Ladder Logic simultaneously. You must remove all Debug statements or comment them out with an apostrophe before attempting to use Ladder Logic monitoring. Another option is to use the command Set Debug Off which will automatically ignore any Debug statements.
Menus

File Menu

<table>
<thead>
<tr>
<th>Menu</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>New</td>
<td>Create new file.</td>
</tr>
<tr>
<td>Open</td>
<td>Open file.</td>
</tr>
<tr>
<td>Ladder Import</td>
<td>Import Ladder Logic part of a Cubloc program.</td>
</tr>
<tr>
<td>Save</td>
<td>Save current file.</td>
</tr>
<tr>
<td>Save As</td>
<td>Save current file under a different name.</td>
</tr>
<tr>
<td>Save Object</td>
<td>Save current program as an object file. Use this to protect your source code. An object file is a strictly binary format file so others cannot easily reverse engineer it. You can use &quot;Download from Object File&quot; to download an object file to Cubloc.</td>
</tr>
<tr>
<td>Print Ladder</td>
<td>Print Ladder Logic section only.</td>
</tr>
<tr>
<td>Print BASIC</td>
<td>Print BASIC section only.</td>
</tr>
<tr>
<td>Print Setup</td>
<td>Setup printer for printing Ladder Logic editor.</td>
</tr>
<tr>
<td>Download from Object file</td>
<td>Download an object file to the Cubloc module.</td>
</tr>
<tr>
<td>BMP download for CT1721C</td>
<td>Download Bitmap to CT1721C</td>
</tr>
<tr>
<td>Touch calibration for CT1721C</td>
<td></td>
</tr>
<tr>
<td>BMP download for CT1820</td>
<td></td>
</tr>
<tr>
<td>Touch calibration for CT1820</td>
<td></td>
</tr>
<tr>
<td>Store Current Time to CT1820 RTC</td>
<td></td>
</tr>
</tbody>
</table>
**Device Menu**

If a Const Device statement does not exist in your source code, you can use the "Device" menu to create a Const Device statement at the very beginning of your source code. If a Const Device statement already exists, using the "Device" menu will simply replace the Const Device statement.

**Run Menu**

<table>
<thead>
<tr>
<th>Menu</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Download &amp; Run</td>
<td>Compile BASIC and Ladder Logic, download to Cubloc module if there are no errors, and restart the program automatically. To disable automatic restart, please go to Setup-&gt;Studio Option to change.</td>
</tr>
<tr>
<td>Ladder Logic Run</td>
<td>Continue execution of Ladder Logic while monitoring</td>
</tr>
<tr>
<td>Ladder Logic Stop</td>
<td>Stop execution of Ladder Logic while monitoring</td>
</tr>
<tr>
<td>Reset</td>
<td>Reset the Cubloc module.</td>
</tr>
<tr>
<td>Ladder Monitor on</td>
<td>Start Ladder Logic monitoring</td>
</tr>
<tr>
<td>BASIC Debug Terminal</td>
<td>Open BASIC Debug Terminal Window. This window opens automatically when there’s a Debug statement in the source code.</td>
</tr>
<tr>
<td>Clear Cubloc’s Flash</td>
<td>Clear Cubloc’s Flash Memory.</td>
</tr>
</tbody>
</table>
### Memory

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write enable fuse off</td>
<td>This will turn off the download function for a Cubloc Core module to protect against noisy environments where the flash memory can be affected. Once you choose this menu, you will be unable to download new programs to your Cubloc module. You will be able to download again after a Firmware Download.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run with Firmware download</td>
<td>View relays in use by Ladder Logic after compilation.</td>
</tr>
<tr>
<td>View Relay Usage</td>
<td>See, at a glance, the status of relays in a separate window.</td>
</tr>
<tr>
<td>View Watch window</td>
<td>See, at a glance, the status of relays in a separate window.</td>
</tr>
<tr>
<td>Check Syntax</td>
<td>Check the source code’s syntax</td>
</tr>
</tbody>
</table>

### Setup Menu

- PLC Setup Wizard...
- PC interface setup...
- Editor environment setup...
- Ladder Logic Environment Options...
- Use English menu
- Firmware download

### Menu

<table>
<thead>
<tr>
<th>Menu</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLC Setup Wizard</td>
<td>Wizard to automatically generate BASIC code.</td>
</tr>
<tr>
<td>PC Interface Setup</td>
<td>Setup the RS232 COM PORT for Download/Monitor. Select COM1 through COM4.</td>
</tr>
<tr>
<td>Editor Environment Setup</td>
<td>Configuration options for the BASIC editor.</td>
</tr>
<tr>
<td>Ladder Logic Environment Options</td>
<td>Configuration options for Ladder Logic.</td>
</tr>
<tr>
<td>Use English menu</td>
<td>Change the language of the menus to English</td>
</tr>
<tr>
<td>Firmware Download</td>
<td>Download Firmware to Cubloc. Please use this to download firmware to Cubloc manually.</td>
</tr>
</tbody>
</table>
Chapter 4: Cubloc BASIC Language

**IMPORTANT**
The device being used must be declared before using BASIC or Ladder Logic. Below is an example of declaring the Cubloc CB220 module.

```plaintext
Const Device = CB220 ' Use CB220.
```

This should be the first line of a program. When this command is not used, the CB220 model will be assumed.

```plaintext
Const Device = CT1720 ' Use CT171.
Const Device = CB280 ' Use CB280.
```
Cubloc BASIC Features

**Cubloc BASIC supports functions and subroutines.** The user is able to create subroutines and functions to organize their programs. Using subroutines and functions allows the user to reuse code, and organize programs for better readability.

```
Function SUM( A As Integer, B As Integer) As Integer
    Dim RES As Integer
    RES = A + B
    SUM = RES
End Function
```

**Calculations can be done within conditional statements such as If, While, etc...**

```
If ((A + 1) = 100) Then GoTo ABC

If ((A + 1) = 100) And (B / 100 = 20) OR C = 3 Then GoTo ABC
```

**Hardware RS-232 Communication**

Cubloc uses a hardware RS-232 UART instead of software RS-232 UART allowing real-time processing to continue during RS-232 operations.

**A graphic LCD library is provided.**

Cubloc provides a complete graphic LCD library for the Comfile GHLCD product. Boxes, lines, circles, and other graphics commands are easily implemented in a few lines of code.

**Various Communication Protocols are supported.**

**CUNET**: Display peripherals such as character LCDs  
**RS232**: up to 4 channels  
**MODBUS**: built-in slave functions  
**I2C**: I2C commands supported (**I2CRead** **I2CWrite**)  
**SPI**: SPI commands supported (**ShiftIn**, **ShiftOut**)  
**PAD**: Keypad, touchpad supported.
Simple BASIC program

Below is an example of a simple BASIC program with a Do...Loop statement.

```
Dim A As Byte
Do
    ByteOut 0, A
    A=A+1
Loop
```

This program outputs the increasing binary value of A to Ports P0-P7. The next program uses a function to accomplish the same task:

```
Dim A As Byte
Do
    ByteOut 0, A
    A=ADD_VALUE(A)
Loop
End

Function ADD_VALUE(B As Byte) As Byte
    ADD_VALUE = B + 1
End Function
```

By placing A=A+1 in a function, the user will be able to separate one big program into small manageable pieces. As you can see here, the main program ends at the End command, and functions are added afterwards.
Sub and Function

For subroutines, you can either use **Sub** or **Function**. Function can return a value, but **Sub** can't.

```vba
Sub SubName (Param1 As DataType [,ParamX As DataType][,...])
    Statements
    [Exit sub] ' Exit during sub-routine
End Sub

Function FunctionName (Param1 As DataType [,,...])[As ReturnDataType]
    Statements
    [Exit Function] ' Exit during sub-routine
End Function
```

To return values using **Function**, simply store the final value as the name of the function as shown below:

```vba
Function ADD_VALUE(B As Byte) As Byte
    ADD_VALUE = B + 1 ' Return B+1.
End Function
```

**DEMO PROGRAM**

![Demo Program Image]
Global and Local Variables

When you declare variables inside a subroutine or a function, it is considered a "Local" variable. Local variables are created when the subroutine or function is called, and removed when the subroutine or function exits. This means that local variables will temporarily allocate data memory for the duration of the call. Local variables may only be referred to or used inside the subroutine or function in which they were declared.

On the other hand, global variables may be used anywhere in your program.

In the program above, A is declared as a global variable and K is declared as a local variable. A can be used anywhere in the program but K can only be used inside the subroutine DELAYTIME.

Arrays cannot be declared as local variables. **Arrays must be declared as global variables.**
Calling Subroutines

Once the subroutine is created, they can be used like any other statement.

For a subroutine, you do not need parenthesis around the parameters. Use commas to separate multiple parameters.

The example below shows how this is done:

```vbnet
DELAYTIME 100
' Call subroutine
End

Sub DELAYTIME(DL As Integer)
    Dim K As Integer
    ' Declare K as Local Variable
    For K=0 To DL
        Next
End Sub
```

For a function, you need parenthesis around the parameters. Parenthesis are required even when there are no parameters.

```vbnet
Dim K As Integer
    K = SUMAB(100,200) ' Call subroutine and store return value in K
Debug Dec K,cr
End

Function SUMAB(A AS INTEGER, B AS INTEGER) As Integer
    SUMAB = A + B
End Function
```
Subroutine Position

Subroutines must be created after the main program. To do this, simply put `End` at the end of your main program as shown below. `End` is only required if you have subroutines.

```plaintext
Dim A As Integer
LOOP1:
    A = A + 1
    Debug DP(A),CR
    DELAYTIME
    Goto Loop1
End ' End of main program

Sub DELAYTIME()
    Dim K As Integer
    For K=0 To 10
        Next
End Sub
```

Subroutines and functions are created after the `End` statement. `Gosub` subroutines must be within the main program like shown below:

```plaintext
Dim A As Integer
    :
    Gosub ABC
    :
    ABC:
    :
End

Sub DEF(B as Byte)
    :
End Sub

Function GHI(C as Byte)
    :
End Function
```

* The `End` statement is used to differentiate between the BASIC main program and the program's subroutines. The `END` statement in Ladder Logic is used to indicate the final Ladder Logic rung.*
Subroutine Parameters and Return Values

Functions may use any data type, except arrays, as parameters and return values:

```
Dim A(10) As Integer

Function ABC(A AS Single) as Single ' Return Single value
End Function

Function ABC(A AS String * 12) as String * 12 ' Return String value
End Function

Function ABC(A AS long) ' Long value as a parameter
End Function ' When return value is not declared,
Long ' will be used as return value.
```

Arrays cannot be used as parameters. The following is not allowed.

```
Function ARRAYUSING(A(10) AS Integer) ' Arrays may not be used as
End Function ' parameters.
```

But you may use one element of an array as a parameter:

```
Dim b(10) as Integer
K = ARRAYUSING(b(10)) ' Use 10th element of array b as a parameter.

Function ARRAYUSING(A AS Integer) as Integer
End Function
```

All subroutine parameters are passed by value, not by reference. If the parameter value is changed within a subroutine, it will not affect the variable passed to the subroutine.

```
Dim A As Integer
Dim K As Integer
A = 100
K = ADDATEN(A)
Debug Dec? A, Dec? K,CR ' A is 100 and K is 110
End

Sub ADDATEN(V As Integer)
    V = V + 10 ' A does not change when V is changed.
    ADDATEN = V
End Sub
```
In contrast, some languages allow values to be passed by reference in which the actual memory address is passed to the subroutine. **Cubloc BASIC only supports passing by value.**

### Too many characters in one line?
If you run out of room, you can use an underscore character (\_) to go to the next line as shown here:

```plaintext
ST = "COMFILE TECHNOLOGY"
ST = "COMFILE _ TECHNOLOGY"
```

### Comments
Use an apostrophe/single-quote (') to add comments. Comments are discarded during at compile time, and will not consume any program memory.

```plaintext
ADD_VALUE = B + 1   ' Add 1 to B.(Comment)
```

### Nested Subroutines
Nested subroutines are supported in Cubloc.

```plaintext
A=Floor(SQR(F))   ' Do Floor() on Sqr(F).
```

### Colons
Colons cannot be used to append commands in Cubloc BASIC, as is possible in some other languages.

```plaintext
A=1: B=1 : C=1   ' Incorrect.
A=1               ' Correct.
B=1
C=1
```
Variables

There are 5 types of variables in Cubloc BASIC.

- **Byte**
  8 bit positive number, 0 to 255

- **Integer**
  16 bit positive number, 0 to 65535

- **Long**
  32 bit positive/negative number,
  \((-2147483648\) to \(+2147483647\))

- **Single**
  32 bit floating point number,
  \((-3.402823E+38\) to \(+3.402823E+38\))

- **String**
  character string, 0 TO 127 bytes

*For storing negative numbers, please use LONG or SINGLE.
Use the **Dim** statement for declaring variables as shown below:

| Dim A As Byte   | ' Declare A as Byte.               |
| Dim B As Integer, C As Byte | ' Comma may **NOT** be used.         |
| Dim ST1 As String * 12 | ' Declare a String of 12 bytes.        |
| Dim ST2 As String       | ' String is 64 bytes default.        |
| Dim AR(10) As Byte      | ' Declare AR as a Byte Array.        |
| Dim AK(10,20) As Integer | ' Declare AK as a 2-Dimensional Array |
| Dim ST(10) As String*10 | ' Declare a String Array             |
Var Statement (Same as Dim)
*Var* can be used in the place of *Dim* to declare variables. Below are examples of how to use *Var*:

- A Var Byte ' Declare A as BYTE.
- ST1 Var String * 12 ' Declare ST1 as String of 12 bytes.
- AR Var Byte(10) ' Declare AR as Byte Array of 10.
- AK Var Integer(10,20) ' Declare AK as 2-D Integer Array
- ST Var String *12 (10) ' Declare String Array
String

A String can be a maximum of 127 bytes in size. When the size is not declared, a default size of 64 bytes will be assumed.

```
Dim ST As String * 14 ' For maximum usage of 14 bytes
Dim ST2 As String ' Set as 64 byte String variable
```

When declaring a String as 14 bytes, an additional byte is allocated by the processor to store a NULL terminating character. When storing "COMFILE TECHNOLOGY" in a 14 byte String, the last 4 characters (bytes) will be truncated.

```
Dim ST As String * 14
ST = "COMFILE TECHNOLOGY" ' "LOGY" is not stored
```

![Image showing truncated string]

In Cubloc BASIC, only the double-quote character (" ) can be used for String constants and Strings; a single-quote characters ( ' ) can not be used.

```
ST = "COMFILE " TECHNOLOGY" ' (" ) cannot be used inside the String.
ST = "COMFILE ' TECHNOLOGY" ' (') cannot be used inside the String.
ST = "COMFILE , TECHNOLOGY" ' (, ) cannot be used inside the String.
```

Furthermore, Cubloc BASIC does not support character escape sequences. Use CHR(\&H22) to include a double-quote character (" ) in a String. Commas and single-quotes also cannot be directly declared in a String. Use CHR(\&H27) to included a single-quote character ( ' ) and CHR(\&H2C) to included a comma (, ).
Example for printing to an LCD:

Print Chr(&H22), "COMFILE TECHNOLOGY",Chr(&H22)  ' (")
Print Chr(&H27), "COMFILE " TECHNOLOGY",Chr(&H27)  ' (') Apostrophe

DEMO PROGRAM

Const Device = CB280
Dim $1 As String
Dim $2 As String * 10

$1 = "COMFILE TECHNOLOGY"
$2 = "KOREA SOCCER"

Debug $1,Cr
Debug $2,Cr
Concatenate Multiple Strings

To concatenate multiple strings together, use the + operator as shown below:

```vba
Dim a1 As String * 30
Dim a2 As String * 30
a1 = "Comfile "
a2 = "Technology "
a1 = a1 + a2 + ", Inc"
Debug a1, cr
```

The above program will show "Comfile Technology, Inc" on the debug screen.

**DEMO PROGRAM**
How to Access Individual Characters within a String

You can treat strings as a Byte array. Simply append "_A" after the name of your string variable as shown below:

```vbnet
Dim ST1 As String * 12 ' ST1_A Array is created at the same time.
ST1 = "123"
ST1_A(0) = ASC("A") ' Store A in the first character of ST1.
```

When you declare `Dim St1 as String * 12, St1_A(12)` is also declared automatically by the Real-Time Operating System (RTOS). The string and the array use the same memory space. Whether you use the string or the array, you are still accessing same memory location.

The example below shows how to convert blank characters to z.

```vbnet
Const Device = CB280
Dim A As Integer
Dim st As String * 30
st = "COM FILE "
Debug st, Cr
For A = 0 To 12
    If st_A(A) = ASC(" ") Then
        st_A(A) = ASC("z")
    End If
Next
Debug st, Cr
```

This feature cannot be used with String arrays.
About Variable Memory Space

In the CB220 and CB280, 2KB (2048 bytes) of data memory is available. However, the memory is not dedicated entirely to variables. Some data memory is reserved for use by peripherals like the DISPLAY and the RS232 buffers. An additional 80 bytes are used for the Debug statement.

Subroutines, functions, and interrupt routines, when executing, also consume data memory, especially if they declare local variables. Of the available 2048 bytes, about 1800 bytes can be used for global variables. Space must be reserved for subroutines which may reduce the memory available for global variables. However, this can often save memory, as the local variables will be destroyed after the subroutine completes, releasing the memory to be used again.

When the user creates buffers with SET DISPLAY or OPENCOM, data memory will be consumed to allocate buffers.

Initializing Memory

In Cubloc BASIC, data memory is not cleared when powered on. The user should initialize variables or use the RamClear statement to initialize all data memory to 0. If data memory is not cleared, the values in memory could potentially be anything. If the contents of memory are to be predictable, you must either initialize each variable, or use the Ramclear statement.

In the case of battery backed-up modules, the variables will remember their values after a power cycle (powering off and on).
Arrays

Cubloc BASIC supports arrays of up to 8 dimensions. Each dimension can contain up to 65,535 items.

```
Dim A(20) As Byte       ' Declare an array of 20 Bytes
Dim B(200) As Integer   ' Declare an array of 200 Integers
Dim C(200) As Long      ' Declare an array of 200 Longs
Dim D(20,10) As Single  ' 2-dimensional Single array (20 x 10)
Dim ST1(10) As String * 12 ' Declare String array
```

Be sure to make note of how much memory is used when using multidimensional arrays.

```
' 13 * 10 = 130 Bytes of Data Memory
Dim ST1(10) As String * 12

' 4 * 10 * 20 = 800 Bytes of Data Memory
Dim D(20,10) As Single
```
Bit and Byte Modifiers

A variable’s bits and bytes can be accessed individually by using the commands shown below:

```vba
Dim A As Integer
A.LowByte = &H12 ' Store &H12 at A’s lowest byte
```

### Bit

<table>
<thead>
<tr>
<th>Modifier</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOWBIT</td>
<td>Variable’s bit 0</td>
</tr>
<tr>
<td>BIT0 to 31</td>
<td>Variable’s bit 0 through 31</td>
</tr>
</tbody>
</table>

```vba
A.BIT2 = 1 ' Make bit 2 of A equal to 1.
```

![Byte Diagram]

### Nibble

A nibble is 4 bits. The user can access individual nibbles to make processing certain data formats easier.

<table>
<thead>
<tr>
<th>Modifier</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOWNIB</td>
<td>Variable’s NIBBLE 0</td>
</tr>
<tr>
<td>NIB0 to 7</td>
<td>Variable’s NIBBLE 0 to 7</td>
</tr>
</tbody>
</table>

```vba
A.NIB3 = 7 ' Store 7 in Nibble 3 of A
```

![Nibble Diagram]
Byte
To access specific bytes of a variable, the following can be used.

<table>
<thead>
<tr>
<th>LOWBYTE, BYTE0</th>
<th>BYTE 0 of Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYTE1</td>
<td>BYTE 1 of Variable</td>
</tr>
<tr>
<td>BYTE2</td>
<td>BYTE 2 of Variable</td>
</tr>
<tr>
<td>BYTE3</td>
<td>BYTE 3 of Variable</td>
</tr>
</tbody>
</table>

A.Byte1 = &HAB  'Store &HAB in byte 1 of variable A

<table>
<thead>
<tr>
<th>LONG</th>
<th>BYTE3</th>
<th>BYTE2</th>
<th>BYTE1</th>
<th>BYTE0</th>
</tr>
</thead>
</table>

Word
To specify a certain Word of a variable, the following can be used:
(A Word is 16 bits)

<table>
<thead>
<tr>
<th>LOWWORD, WORD0</th>
<th>Word 0 of variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>WORD1</td>
<td>Word 1 of variable</td>
</tr>
</tbody>
</table>

A.Word1 = &HABCD  'Store &HABCD in word 1 of variable A

<table>
<thead>
<tr>
<th>LONG</th>
<th>WORD1</th>
<th>WORD0</th>
</tr>
</thead>
</table>

* Tip: Need to access 5 bits of a variable?
NewVariable = Variable AND 0x1F.
This will mask the last 5 bits of the variable.
DEMO PROGRAM

Const Device = CE200
Dim A As Long
A = $H12345678
Debug Hex A.EYTE0, Cr
Debug Hex A.EYTE1, Cr
Debug Hex A.EYTE2, Cr
Debug Hex A.EYTE3, Cr
A.WORD1 = $HABCD
Debug Hex A, Cr
Constants

Constants can be used to declare a constant value (a value that cannot be changed) within the program. This essentially allows a number to be assigned a name, often improving readability and debugging of the source code.

The **CONST** statement can be used to declare constants in Cubloc BASIC:

```plaintext
Const PI As Single = 3.14159
Const WRTTIME As Byte = 10
Const MSG1 As String = "ACCESS PORT"
```

When the constant is not given a type, the compiler will find an appropriate type for it as shown below:

```plaintext
Const PI = 3.14159        ' Declare as SINGLE
Const WRTTIME = 10        ' Declare as Byte
Const MYROOM = 310         ' Declare as Integer since it’s over 255.
Const MSG1 = "ACCESS PORT" ' Declare as String
```

**Con (Another CONST method)**

The **Con** statement can be also used to declare constants as shown below:

```
PI    Con  3.14159        ' Declare as Single.
WRTTIME    Con  10        ' Declare as Byte
MYROOM    Con  310        ' Declare as Integer
MSG1    Con   "ACCESS PORT" ' Declare as String
```
Constant Arrays...

In constant arrays, the user is able to store a list of values before the program begins. A program requiring a large number of constant values can be simplified as shown below:

```
Const Byte DATA1 = (31, 25, 102, 34, 1, 0, 0, 0, 0, 0, 65, 64, 34)
I = 0
A = DATA1(I)   ' Store 31 in A.
I = I + 1
A = DATA1(I)   ' Store 25 in A.
Const Byte DATA1 = ("CUBLOC SYSTEMS")
```

String data can be stored in Byte constant arrays. Each Byte contains the ASCII code of each character in the String. In the example above, If DATA1(0) is read, the ASCII code of ‘C’ is returned. Likewise if DATA1(1) is read, ASCII code of ‘U’ is returned.

Integer and floating point (Single) numbers can also be stored in arrays as shown below:

```
Const Integer DATA1 = (6000, 3000, 65500, 0, 3200)
Const Long DATA2 = (12345678, 356789, 165500, 0, 0)
Const Single DATA3 = (3.14, 0.12345, 1.5443, 0.0, 32.0)
```

For multiple-line constant arrays, end each line with a comma, or an underscore character as shown:

1) 
```
Const Byte DATA1 = (31, 25, 102, 34, 1, 0, 0, 0, 0, 0, 65, 64, 34,
12, 123, 94, 200, 0, 123, 44, 39, 120, 239,
132, 13, 34, 20, 101, 123, 44, 39, 12, 39)
```

2) 
```
Const Byte DATA2 = (31, 25, 102, 34, 1, 0, 65, 64, 34_
, 101, 123, 44, 39, 12, 39)
```

String constant arrays are deprecated.
Please make note of the following differences between arrays and constant arrays.

<table>
<thead>
<tr>
<th></th>
<th>Array</th>
<th>Constant Array</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Storage Location</strong></td>
<td>Data Memory (SRAM)</td>
<td>Program Memory (FLASH)</td>
</tr>
<tr>
<td><strong>When Allocated</strong></td>
<td>During Program run</td>
<td>During Download</td>
</tr>
<tr>
<td><strong>Can be Changed</strong></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Purpose</strong></td>
<td>Store changing values</td>
<td>Store constant values</td>
</tr>
<tr>
<td><strong>When Powered Off</strong></td>
<td>Lost</td>
<td>Retained</td>
</tr>
</tbody>
</table>

**DEMO PROGRAM**

```
Const Device = CR280
Const Byte DATA1 = (31, 25, 102, 34, 1, 0, 0, 0, 0, 0, 65, 64, 34, 12, 123, 94, 200, 0, 123, 44, 39, 120, 239, 132, 13, 34, 20, 101, 123, 44, 39, 12, 39)

Debug Dec DATA1(3), Cr
Debug Dec DATA1(6), Cr
Debug Dec DATA1(1), Cr
```
Operators

When evaluating expressions in a programming language, it is important to understand the order of operations, also known as operator precedence. The following table describes Cubloc BASIC's operator precedence.

<table>
<thead>
<tr>
<th>Operator</th>
<th>Explanation</th>
<th>Type</th>
<th>Precendence</th>
</tr>
</thead>
<tbody>
<tr>
<td>^</td>
<td>To the power of</td>
<td>Math</td>
<td>First</td>
</tr>
<tr>
<td>*, /, MOD</td>
<td>Multiply, Divide, MOD</td>
<td>Math</td>
<td></td>
</tr>
<tr>
<td>+, -</td>
<td>Add, Subtract</td>
<td>Math</td>
<td></td>
</tr>
<tr>
<td>&lt;&lt;, &gt;&gt;</td>
<td>Left Shift, Right Shift</td>
<td>Logic</td>
<td></td>
</tr>
<tr>
<td>&lt;, &gt;, &lt;=, =&gt;</td>
<td>Less than, Larger than, Less or Equal to, Larger or Equal to.</td>
<td>Comparison</td>
<td></td>
</tr>
<tr>
<td>=, &lt;&gt;</td>
<td>Same, Different</td>
<td>Comparison</td>
<td></td>
</tr>
<tr>
<td>AND, XOR, OR, NOT</td>
<td>Boolean AND, XOR, OR, &amp; NOT</td>
<td>Logic</td>
<td>Last</td>
</tr>
</tbody>
</table>

Within each row in the table above, the operators are evaluated from left to right. Operators can be used in conditional statements as shown below.

\[
\text{IF A+1 = 10 THEN GOTO ABC}
\]

\[
\frac{1}{2} \Rightarrow 1/2
\]

\[
\frac{5}{3+4} \Rightarrow 5 / (3+4)
\]

\[
\frac{2+6}{3+4} \Rightarrow (2+6) / (3+4)
\]

Use parenthesis to explicitly control the order of operations in an expression.
When multiple operators are used, the expression will be evaluated in the following order:

1) Operator(s) inside parenthesis
2) Negative Sign (–)
3) Exponent (^)
4) Multiplication, Division, Remainder (*, /, MOD)
5) Addition/Subtraction (+,-)
6) Bit-wise Left Shift, Bit-wise Right Shift (<<, >>)

Operators used in Cubloc BASIC may differ slightly from common mathematical operators. Please refer to the table below:

<table>
<thead>
<tr>
<th>Operator</th>
<th>Math</th>
<th>Basic</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add</td>
<td>+</td>
<td>+</td>
<td>3+4+5, 6+A</td>
</tr>
<tr>
<td>Subtract</td>
<td>-</td>
<td>-</td>
<td>10-3, 63-B</td>
</tr>
<tr>
<td>Multiply</td>
<td>X</td>
<td>*</td>
<td>2 * 4, A * 5</td>
</tr>
<tr>
<td>Division</td>
<td>/</td>
<td></td>
<td>1234/3, 3843/A</td>
</tr>
<tr>
<td>To the power of</td>
<td>^</td>
<td></td>
<td>5^3, A^2</td>
</tr>
<tr>
<td>MOD</td>
<td>Remainder of</td>
<td>mod</td>
<td>102 mod 3</td>
</tr>
</tbody>
</table>
When numbers of different types are mixed in an expression, the final result is cast to the type of the assigned variable.

```vba
Dim F1 As Single
Dim A As Long
F1 = 1.1234
A = F1 * 3.14 ' A gets 3 even though result is 3.525456.
```

Please be sure to include a decimal point(.) when using floating point numbers even if your computer’s language setting uses a different character for its decimal separator.

```vba
F1 = 3.0/4.0 ' Write 3/4 as 3.0/4.0 for floating values
F1 = 200.0 + Floor(A) * 12.0 + SQR(B) '200 as 200.0, 12 as 12.0...
```

The **And**, **Xor**, and **Or** operators are used for both logical and bit-wise operations.

```vba
If A=1 And B=1 Then C=1 ' if A=1 and B=1 ...(Logical Operation)
If A=1 Or B=1 Then C=1 ' if A=1 or B=1...(Logical Operation)
A = B And &HF 'Set the upper 4 bits to zero. (Bit-wise Operation)
A = B Xor &HF 'Invert the lower 4 bits. (Bit-wise Operation)
A = B Or &HF 'Set the lower 4 bits to 1. (Bit-wise Operation).
```
Strings can be compared with the = operator.

```
Dim ST1 As String * 12
Dim ST2 As String * 12
ST1 = "COMFILE"
ST2 = "CUBLOC"
If ST1=ST2 Then ST2 = "OK" ' Check if ST1 is same as ST2.
```

When comparing Strings, Cubloc BASIC compares the ASCII value of each character in the String. Therefore, String comparisons are case-sensitive; "COMFILE" does not equal "comfile".

**DEMO PROGRAM**
Expressing Numbers

There are three possible ways to represent numbers in Cubloc BASIC: binary, decimal and hexadecimal. The binary and hexadecimal representations are useful when interfacing to digital devices. The decimal representation is the standard human readable format.

Examples:

Binary : &B10001010, &B10101, 0b1001001, 0b1100
Decimal : 10, 20, 32, 1234
Hexadecimal : &H, &H1234, &HABC
              0xABCD, 0x1234 ← Similar to C
              $1234, $ABCD ← Similar to Assembly Language
The BASIC Preprocessor

The BASIC preprocessor is a macro processor that is used automatically by the compiler to transform your program before compilation. It is called a macro processor because it allows you to define macros, which are brief abbreviations for longer constructs.

Cubloc BASIC uses a preprocessor similar to the C language. Preprocessor directives like `#include` and `#define` can be used to include files and process code before compiling.

`#include "filename"`

Reuse code by including source files. For files in the same directory as the current source file, you can write the following:

```
#include "MYLIB.cub"
```

For files in other directories, you will need to include the full path name as shown here:

```
#include "c:\mysource\CUBLOC\lib\mylib.cub"
```

Using include files, you can store all of your common subroutines in a separate file. In this case, please make sure to `#include` the subroutine file at the very end of your program, after the `End` statement.

`#define name constants`

By using `#define`, you can assign names to values before compiling.

```
#define motorport 4
Low motorport
```

In the example above, `motorport` will be compiled as 4. You can also use `CONST` for similar tasks. However, `CONST` will use data memory; `#define` will only use program memory.

```
CONST motorport = 4
Low motorport
```

The following example uses `#define` for replacing a line of code:
#define FLAGREG1 2
#define f_led FLAGREG1.BIT0
#define calc (4+i)*256
f_led = 1
If f_led = 1 Then f_led = 0
j = calc

NOTE
The "name" argument in a define statement is not case-sensitive. For example, #define ALPHA 0 and #define alpha 0 do not define different constants. They both define the same constant.

DEMO PROGRAM
Conditional Directives

A conditional directive is a directive that instructs the preprocessor to select whether or not to include a part of code before compilation. Preprocessor conditional directives can test arithmetic expressions, or whether a name is defined as a macro.

Here are some reasons to use a conditional.

- A program may need to use different code depending on the module it is to run on. In some cases the code for one module may be different on another module. With a conditional directive, a BASIC program may be programmed to compile on any of the Cubloc/Cutouch modules without making changes to the source code.
- If you want to be able to compile the same source file into two different programs. For example one version might be compiled with debugging statements, and one without.

```plaintext
#if constant
#endif
```

The preprocessor directive `#if` will compare a constant declared with `CONST` to another constant. If the `#if` statement is true, the statements inside the `#if...#endif` block will be compiled, otherwise the statements will be discarded.

```plaintext
Const Device = CB280

Delay 500

' Device only returns the decimal number
#if Device = 220
  Debug "CB220 module used!"
#endif
```

The above example illustrates how, depending on the type of Cubloc/Cutouch declared, you can decide to include a command in the final compilation of your program. Using conditional directives, you will be able to write applications for different Cubloc/Cutouch modules with just one source file.
Using the preprocessor directive `#elseif` or `#else`, you can create more complex `#if...#endif` expressions.

```
Const Device = CB220

Delay 500

' Device only returns the decimal number
If Device = 220
  Debug "CB220 module used!"
elseif device = 280
  Debug "CB280 module used!"
elseif device = 290
  Debug "CB290 module used!"
elseif device = 1720
  Debug "CT1720 module used!"
endif
```

`#else` may only be used ONCE in an `#if` expression. Also, you can only compare constants declared with the `CONST` statement in a `#if` directive.

```
#define LOWMODEL 0
#ifdef LOWMODEL
  Low 0
#endif
```

In the above example, since `LOWMODEL` is defined, the statement `LOW 0` is compiled.

`#else #elseifdef` may be used for more complex expressions as shown below:

```
#ifdef LOWMODEL
  Low 0
elseifdef HIGHMODEL
  High 0
#else
  Low 1
#endif
```
ifndef name endif

ifndef is the opposite of the ifdef directive. If a constant has not been defined, the statements inside a ifndef...endif block will be compiled, otherwise the statements will be discarded.

```c
#define LOWMODEL 0
ifndef LOWMODEL
Low 0
endif
```

elseifndef and else may be used for more complex expressions as shown below:

```c
ifndef LOWMODEL
Low 0
elseifndef HIGHMODEL
High 0
else
Low 1
endif
```

Finally, the directives may be mixed as shown below:

```c
if MODELNO = 0
Low 0
elseifdef HIGHMODEL
High 0
else
Low 1
endif
```

Nested if directives are not supported; if may not be used inside another if.
To Use Only Ladder Logic

If you do not need to use BASIC, you can program in Ladder Logic alone. But you will need a few lines of BASIC to get started, as shown below:

```
Const Device = CB280    ' Select device
UsePin 0,In,START      ' Declare pins to use
UsePin 1,Out,RELAY
Alias M0 = MOTORSTATE  ' Set Aliases
Alias M1 = RELAY1STATE
Set Ladder On          ' Start Ladder.
```

Device model, aliases, and pin I/O mode must be set in BASIC. Ladder Logic must be started in BASIC with the `Set Ladder On` statement.

To Use Only BASIC

Ladder Logic is off as default.

```
Set Ladder On          ' If using only BASIC, don't use this statement
Ladderscan             ' Or this one
```
Interrupts

Interrupts are external events that stop a program's normal flow (interrupting the program) and immediately execute some other subroutine, called an interrupt service routine (ISR). The On...GoSub statement can be used to tell a program to listen for an interrupt and execute an ISR. When the interrupt occurs, the main program stops execution and jumps to the ISR designated by the On...GOSUB statement. Once the ISR is finished, the Return statement is used to return execution back to the main program.

External key input can occur at any time and data can be received via RS-232 at any time. Since the main program cannot wait forever to receive these inputs, we need interrupts. If a key is pressed or serial data is received while the main program is running, an interrupt occurs and the main program jumps to the appropriate ISR.

While an ISR is running, subsequent interrupts of the same type are ignored. For example, if an RS-232 receive interrupt occurs during execution of previous RS-232 receive ISR, the new RS-232 receive interrupt will be ignored. On the other hand, if a timer interrupt occurs (See the On Timer statement) during execution of an RS-232 receive ISR, it will immediately interrupt the RS-232 receive ISR, execute the timer's ISR, and then return to the RS-232 receive ISR.

<table>
<thead>
<tr>
<th>Interrupt Type</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>On Timer</td>
<td>Initiates an interrupt on a periodic basis</td>
</tr>
<tr>
<td>On Int</td>
<td>Initiates an interrupt when an external input is received.</td>
</tr>
<tr>
<td>On Recv</td>
<td>Initiates an interrupt when data is received via RS-232</td>
</tr>
<tr>
<td>On LadderInt</td>
<td>Initiates an interrupt when Ladder Logic requests an interrupt</td>
</tr>
<tr>
<td>On Pad</td>
<td>Initiates an interrupt when Pad receives data</td>
</tr>
</tbody>
</table>
More about Interrupts...

The Cubloc and CuTouch have a Real-Time Operating System (RTOS) which controls interrupt events. This is slightly different from the microcontroller’s hardware interrupts.

1. When interrupt A occurs, while interrupt A’s ISR is executing, another interrupt A cannot occur. But interrupt B can occur. Here A and B are different types of interrupts. (e.g. On Timer and On Recv)

2. When interrupt B occurs while executing interrupt A’s ISR, interrupt B’s ISR will be executed immediately and execution will return to interrupt A’s ISR to finish.

3. At the end of an ISR, be sure to include a Return statement. Otherwise, the program may malfunction.

4. If no interrupt is required for your program, you can increase the execution speed of the Cubloc by setting turning off all interrupts using the Set OnGlobal Off. By default, Set OnGlobal is set to On.

5. In the case of On Recv, data received during an On Recv ISR will simply be stored in the serial port’s receive buffer. Therefore the data will not be lost. After the current On Recv ISR is finished, if there’s new data in the receive buffer, another On Recv interrupt will be immediately generated. The BClr statement can be used if you do not want to process another On Recv interrupt.

6. If you declare an interrupt more than once, only the last one declared will be in effect.

IMPORTANT!!!!!!

Please pay attention when creating the interrupt service routine (ISR). It must require less time to execute than the interval itself. If interval is set to 10ms, the ISR must execute within 10 ms. Otherwise, collisions can occur.

It is quite common for a microcontroller to make use of interrupts, but with the Cubloc, interrupts should be used sparingly.

The Cubloc does not handle hardware interrupts directly. When an interrupt occurs, the handler jumps to the BASIC interrupter. Because the BASIC interpreter is slower than directly processed machine code, extra latency
can be added to the interrupt service routine and prevent the main routine from operating smoothly.

Therefore, we recommend using interrupts sparingly with the Cubloc. If interrupts are used, keep the interrupt service routine very light and fast. For example, writing to a serial port or using the Delay command is not recommended.

**If you need a device that can handle interrupts with speed and ease, please consider the Moacon.** The Moacon is an ARM based modular industrial controller from Comfile Technology designed for high speed, interrupt intensive applications.
Pointers using Peek, Poke, and MemAdr

The following is an example that uses the EEWrite statement and the EERead statement to read and write floating point data:

```vb
Const Device = CB280
Dim f1 As Single, f2 As Single
f1 = 3.14
EEWrite 0,f1,4
f2 = EERead(0,4)
Debug Float f2,cr
```

When you run this program, the debug window will show 3.00000 instead of 3.14. The reason is that the EEWrite statement automatically converts floating point values to whole numbers.

In order to store floating point values, we can use Peek and Poke to read the data directly:

```vb
Const Device = CB280
Dim F1 As Single, F2 As Single
F1 = 3.14
EEWrite 10,Peek(MemAdr(F1),4),4
Poke MemAdr(F2),EERead(10,4),4
Debug Float F2,CR
```

The debug window will now show 3.14.

We use MemAdr(F1) to find the memory address of F1 and then use the Peek statement to directly access the memory and write 4 bytes. We store that value in the EEPROM. Next, we use MemAdr(F2) and Poke to read 4 bytes directly.

Warning: Please use caution when using these command as incorrectly manipulating memory can affect the entire program. Peek and Poke may only access data memory.
Sharing Data

The Cubloc has separate BASIC and Ladder Logic data memory areas.

Ladder Logic data memory can be accessed from BASIC easily by using system variables. Using these system variables, data can be easily read from or written to Ladder Logic data memory.

<table>
<thead>
<tr>
<th>System Variable (Array)</th>
<th>Access Units</th>
<th>Ladder Logic Register</th>
</tr>
</thead>
<tbody>
<tr>
<td>_P</td>
<td>Bits _P(0) to _P(127)</td>
<td>P Register</td>
</tr>
<tr>
<td>_M</td>
<td>Bits _M(0) to _M(511)</td>
<td>M Register</td>
</tr>
<tr>
<td>_WP</td>
<td>Words _WP(0) to _WP(7)</td>
<td>P Register (Word Access)</td>
</tr>
<tr>
<td>_WM</td>
<td>Words _WM(0) to _WM(31)</td>
<td>M Register (Word Access)</td>
</tr>
<tr>
<td>_T</td>
<td>Words _T(0) to _T(99)</td>
<td>T Register (Timer)</td>
</tr>
<tr>
<td>_C</td>
<td>Words _C(0) to _C(49)</td>
<td>C Register (Counter)</td>
</tr>
<tr>
<td>_D</td>
<td>Words _D(0) to _D(99)</td>
<td>D Register (Data)</td>
</tr>
</tbody>
</table>

Registers P and M can be accessed in units of bits, and registers C, T, and D can be accessed in units of words. To access P and M registers in units of words, use _WP and _WD. For example, _WP(0) represents P0 through P15.

The following is an example program:

```plaintext
_D(0) = 1234
_D(1) = 3456
_D(2) = 100
For I = 0 To 99
   _M(I) = 0
Next
IF _P(3) = 1 Then _M(127) = 1
```

Accessing BASIC variables from Ladder Logic is not possible, but you can use Ladder interrupts to request a BASIC routine to change a Ladder Logic variable.
Use Ladder Logic pins in BASIC using the Alias Command

The **Alias** command can be used to set aliases for Ladder Logic registers (except the D register). Aliases, although declared in BASIC, can only be used in Ladder Logic.

```plaintext
UsePin 0, In, START
UsePin 1, Out, RELAY

Alias M0 = MOTORSTATE
Alias M1 = RELAY1STATE
Alias T1 = SUBTIMER
```
Chapter 5: Cubloc BASIC Functions
Math Functions

**Sin, Cos, Tan**
Return sine, cosine, and tangent values. Cubloc uses radians as units. Use a Single for most precise results.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A=Sin B</td>
<td>' Return the sine of B.</td>
</tr>
<tr>
<td>A=Cos B</td>
<td>' Return the cosine of B.</td>
</tr>
<tr>
<td>A=Tan B</td>
<td>' Return the tangent of B.</td>
</tr>
</tbody>
</table>

**ASin, ACos, ATan**
Return arc sine, arc cosine, and arc tangent values. Cubloc uses radians as units. Use a Single for the most precise results.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A=ASin B</td>
<td>' Return the arc sine of B.</td>
</tr>
<tr>
<td>A=ACos B</td>
<td>' Return the arc cosine of B.</td>
</tr>
<tr>
<td>A=ATan B</td>
<td>' Return the arc tangent of B.</td>
</tr>
</tbody>
</table>

**Sinh, Cosh, Tanh**
Return hyperbolic sine, hyperbolic cosine, and hyperbolic tangent values.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A=Sinh B</td>
<td>' Return the hyperbolic sine of B.</td>
</tr>
<tr>
<td>A=Cosh B</td>
<td>' Return the hyperbolic cosine of B.</td>
</tr>
<tr>
<td>A=Tanh B</td>
<td>' Return the hyperbolic tangent of B.</td>
</tr>
</tbody>
</table>

**Sqr**
Return Square Root of a value.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A=Sqr B</td>
<td>' Return the square root of B</td>
</tr>
</tbody>
</table>

**Exp**
Return e^x.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A=Exp X</td>
<td>' Returns e^x.</td>
</tr>
</tbody>
</table>

**Log, Log10**
Return Log or Log10 of a value.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A=Log B</td>
<td>or</td>
</tr>
<tr>
<td>A=Log10 B</td>
<td></td>
</tr>
</tbody>
</table>

For the natural logarithm (Ln), simply do: A=Log B
**Abs**  Return the absolute value of a Long.

```vba
Dim A As Long, B As Long
B = -1234
A = Abs B  ' Return |B|.
Debug Dec A  ' Print 1234
```

**FAbs**  Return the absolute value of a Single.

```vba
Dim A As Single, B As Single
B = -1234.0
A = Fabs B  ' Return |B|.
Debug Float A  ' Print 1234.00
```

**Floor**  Round down to the nearest whole number.

```vba
Dim A As Single, B As Single
B = 3.5
A = Floor B  ' Floor 3.5 gives 3.
Debug Float A  ' Print 3.0
```
Type Conversion

Type conversion can be used to convert the variable to the desired representation.

**Hex**

Converts the variable to a string representation of a hexadecimal value (16 bit). Hex8 means to convert to 8 decimal places. (1 to 8 can be used for decimal places)

```
Debug Hex A    ' If A is 123ABC, 123ABC is printed
Debug Hex8 A   ' If A is 123ABC, bb123ABC is printed,
                ' b is a blank space in this case.
Debug Hex5 A   ' If A is 123ABC, 23ABC is printed, first character
                ' is cut.
```
Dec
Converts an integer variable to a string representation of a decimal (10 bit).
Dec8 means to convert to 8 decimal places. (1 to 11 can be used for
decimal places)

```
Debug Dec A    ' If A is 1234, 1234 is printed.
Debug Dec10 A  ' If A is 1234, bbbbb1234 is printed, ' b is a blank space in this case.
Debug Dec3 A   ' If A is 1234, 234 is printed, first ' character is cut
```

? Include the name of the variable by using question mark (?). This question
mark can only be used with HEX or DEC.

```
Debug Dec ? A   ' If A is 1234, "A=1234" will be printed.
Debug Hex ? A   ' If A is &HABCD, "A=ABCD" will be printed.
Debug Hex ? B   ' If B is a variable within a subroutine ' (for example: subroutine CONV) with a value of '
                &HABCD "B_@_CONV=ABCD" will be printed
```
**Float**

Use `Float` to convert floating point values to `String`.

```plaintext
Const Device = cb280
Dim F1 As Single
F1 = 3.14
Debug Float F1,cr  ' Print "3.14000".

Dim ST As String * 15
ST = Float F1  ' First store in a String.
ST = Left(ST,3)  ' Convert to 3 decimal places
Debug ST  ' Print "3.14".
```

You can also store a value in `String` before printing with `Debug` statements or displaying to the LCD as shown below.
String Functions

String functions are provided to assist the user in accessing and modifying data within a String.

**DP(value, numberOfDigits, zeroPrint)**

*DP* converts a variable into a decimal string representation.

If *zeroPrint* is set to 1, zeros are printed instead of blank spaces.

```vbnet
Dim A as Integer
Debug DP(A,10,0) ' Convert A into decimal String representation. ' Set display decimalPlaces to 10. ' If A is 1234, " 1234" will be displayed. ' (notice the 6 blank spaces)
Debug DP(A,10,1) ' If A is 1234, 0000001234 will be displayed.
```
**HP(value, numberOfDigits, zeroPrint)**

HP converts a variable into a hexadecimal string representation. If ZeroPrint is set to 1, zeroes are substituted for blank spaces.

Debug HP(A,4,0)  ' Convert A into HEX String representation  
                 ' Set display decimal places to 4.  
                 ' If A is ABC, bABC will be displayed.  
                 ' (b stand for blank spaces.)

Debug HP(A,4,1)  ' If A is ABC, 0ABC will be displayed.
FP (value, wholeNumberDigits, fractionalNumberDigits)

FP converts floating point variables into a formatted string with user defined whole and fractional number of digits.

```
Dim A as Single
A = 3.14
Debug Float A    ' 3.1400000 Prints all digits.
Debug FP(A,3,2)  ' 3.14 Print user defined digits.
```

With the FP function, the user can control the number of digits to be used for string data when using Debug or displaying to an LCD.

Cubloc floating-point values are stored in accordance to the IEEE724 format. The output of FP and Float may differ but the value stored in the variable will be the same.
**Left(stringValue, numberOfCharacters)**
Returns a specified number of characters from the left side of a String.

```vbnet
Dim ST1 As String * 12
ST1 = "CUBLOC"
Debug Left(ST1,4)  ' "CUBL" is printed.
```

**Right(stringValue, numberOfCharacters)**
Returns a specified number of characters from the right side of a String.

```vbnet
Dim ST1 As String * 12
ST1 = "CUBLOC"
Debug Right(ST1,4)  ' "BLOC" is printed.
```

**Mid(stringValue, location, numberOfCharacters)**
Returns a specified number of characters from a string starting at a specified location.

```vbnet
Dim ST1 As String * 12
ST1 = "CUBLOC"
Debug Mid(ST1,2,4)  ' "UBLO" is printed.
```
**Len(stringValue)**
Return the length of the given string.

```vba
Dim ST1 As String * 12
ST1 = "CUBLOC"
Debug Dec Len(ST1)  ' 6 is printed since there are 6 characters in ST1.
```

**String(asciiCode, length)**
Creates a string of a specified length with the given ASCII code repeated for the length of the string.

```vba
Dim ST1 As String * 12
ST1 = String(&H41,5)
Debug ST1  ' AAAAA is printed.
           ' &H41 is ASCII code for character A.
```

**SPC(numberOfSpaces)**
Create a specified amount of blank space

```vba
Dim ST1 As String * 12
ST1 = SPC(5)
Debug "A",ST1,"A"  ' A     A is printed.
                  ' Note the 5 blank spaces between each A.
```
LTrim(stringValue)
Removes all blank spaces from the left side of the given String.

Dim ST1 As String * 12
ST1 = "  COMFILE"
ST1 = LTrim(ST1)
Debug "AAA",ST1 ' AAACOMFILE is printed.

RTrim(stringValue)
Removes all blank spaces from the right side of the given String.

Dim ST1 As String * 12
ST1 = "COMFILE  
ST1 = RTrim(ST1)
Debug ST1,"TECH" ' COMFILETECH is printed.
' Blank spaces on the right are removed.
Val(stringValue)
Parses a given String into its equivalent decimal value.

```vbnet
Dim ST1 As String * 12
Dim i As Integer
ST1 = "123"
i = Val(ST1) ' 123 is stored in variable I as a number.
```

ValSng(stringValue)
Parses a given String into its equivalent floating point value.

```vbnet
Dim ST1 As String * 12
Dim F As Single
ST1 = "3.14"
F = ValSng(ST1) ' 3.14 is stored in variable F as a floating point number.
```

ValHex(String variable)
Parses a given String in hexadecimal format into its numeric equivalent.

```vbnet
Dim ST1 AS String * 12
Dim i AS Long
ST1 = "ABCD123"
i = ValHex(ST1) '&HABCD123 is stored in variable I
```
**Chr(asciiCode)**
Return the character represented by the given ASCII code.

```
Dim ST1 AS String * 12
ST1 = Chr(&H41)
Debug ST1 ' Print A. &H41 is the ASCII code for character A.
```

**ASC(stringValue)**
Return ASCII code of the first character in the given String.

```
Dim ST1 AS String * 12
Dim i AS Integer
ST1 = "123"
i = Asc(ST1) ' &H31 is stored in variable i. ASCII code of 1 is &H31 or 0x31.
```

**Caution:**
A variable must be used when using string functions.

```
Debug Left("INTEGER",4) ' A String constant cannot be used.
ST1 = "INTEGER"
Debug Left(ST1,4) ' The String must be stored as a variable first.
```
Chapter 6: Cubloc BASIC Statements & Library
AdIn( )

\[ \text{variable} = \text{AdIn} (\text{channel}) \]

\[ \text{variable} : \text{Variable to store results (No String or Single)} \]
\[ \text{channel} : \text{AD Channel Number (not I/O Pin Number)} \]

Cubloc has several 10bit Analog to Digital Converters (ADCs) and 16bit Pulse Width Modulators (PWMs). The user can use an ADC to convert analog signals to digital, or use a PWM to convert digital signals to analog.

The AdIn command reads the analog signal's amplitude and stores the result in a variable. Depending on the model, the number of ADC ports may vary. For the CB280, there are 8 AD ports (P24 to P31). An ADC port must be set to input before use.

When a voltage between 0 and AVREF is applied, that voltage is converted to a value from 0 to 1023. AVREF can accept voltages from 2V to 5V. The default reference is 5V. If an AVREF of 3V is used, voltages from 0 and 3V are converted to a value from 0 to 1023.

(*Note: CB220 AVREF is fixed to 5V)

![Graph showing the relationship between input voltage and return value](image)

```
Dim A As Integer
Input 24 ' Set port 24 to input.
A=AdIn(0) ' Do a A/D conversion on channel 0 and ' store result in A
```
The CB220 and CB280 ADC ports are shown below:

Please refer to the following table for ADC channels.

<table>
<thead>
<tr>
<th>A/D channel</th>
<th>CB220</th>
<th>CB280</th>
<th>CB290</th>
<th>CT17xx</th>
<th>CB405</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>I/O 0</td>
<td>I/O 24</td>
<td>I/O 8</td>
<td>I/O 0</td>
<td>I/O 16</td>
</tr>
<tr>
<td>1</td>
<td>I/O 1</td>
<td>I/O 25</td>
<td>I/O 9</td>
<td>I/O 1</td>
<td>I/O 17</td>
</tr>
<tr>
<td>2</td>
<td>I/O 2</td>
<td>I/O 26</td>
<td>I/O 10</td>
<td>I/O 2</td>
<td>I/O 18</td>
</tr>
<tr>
<td>3</td>
<td>I/O 3</td>
<td>I/O 27</td>
<td>I/O 11</td>
<td>I/O 3</td>
<td>I/O 19</td>
</tr>
<tr>
<td>4</td>
<td>I/O 4</td>
<td>I/O 28</td>
<td>I/O 12</td>
<td>I/O 4</td>
<td>I/O 20</td>
</tr>
<tr>
<td>5</td>
<td>I/O 5</td>
<td>I/O 29</td>
<td>I/O 13</td>
<td>I/O 5</td>
<td>I/O 21</td>
</tr>
<tr>
<td>6</td>
<td>I/O 6</td>
<td>I/O 30</td>
<td>I/O 14</td>
<td>I/O 6</td>
<td>I/O 22</td>
</tr>
<tr>
<td>7</td>
<td>I/O 7</td>
<td>I/O 31</td>
<td>I/O 15</td>
<td>I/O 7</td>
<td>I/O 23</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I/O 32</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I/O 33</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I/O 34</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I/O 35</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I/O 36</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I/O 37</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I/O 38</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>I/O 39</td>
</tr>
</tbody>
</table>

The ADIn statement does a single conversion per call. TADIn is a macro that returns the average of 10 conversions, giving the user more precise results. If you need more precision rather than speed, we recommend the using TADIn instead of ADIn. It is also possible to create your own averaging or filtering code for better precision.
Alias

Alias registerName = aliasName

- `registerName`: Register name such as P0, M0, T0 (Do not use D registers)
- `aliasName`: An Alias for the register chosen (up to 32 characters)

Aliases may be given to Ladder registers. Aliases can be used to make a program easier to read, understand, and debug. Please note that Aliases, although declared in BASIC, can only be used in Ladder Logic.

```
Alias M0 = Rstate
Alias M0 = Kstate
Alias P0 = StartSw
```
**Bcd2Bin**

\[
\text{variable} = \text{Bcd2Bin}(\text{bcdValue})
\]

- **variable**: Variable to store results (Returns LONG)
- **bcdValue**: BCD value to convert to binary

Bcd2Bin converts a BCD (Binary Coded Decimal) number into a normal binary number, Cubloc BASIC's default number format. BCD is a way of expressing values as decimals.

For example, the number 3451 in binary is as shown below:

```
\[
\begin{array}{cccc}
3 & 4 & 5 & 1 \\
0 & 0 & 0 & 0 \\
D & 1 & 0 & 1 \\
7 & 0 & 1 & 1 \\
B & 1 & 0 & 1 \\
\end{array}
\]
```

The following is 3451 converted to BCD code. As you can see, each 4 bits represent one of the digits.

```
\[
\begin{array}{cccc}
3 & 4 & 5 & 1 \\
0 & 0 & 1 & 1 \\
0 & 1 & 0 & 0 \\
0 & 1 & 0 & 1 \\
0 & 0 & 0 & 1 \\
\end{array}
\]
```

This command is useful when the user needs to convert a variable for a device such as a 7 segment display, or a real-time clock.

```vbs
Dim A As Integer
A=Bcd2Bin(&h1234)
Debug Dec A   ' Print 1234
```

See also **Bin2Bcd**.
BClr

BClr channel, buffertype

channel : RS232 Channel (0 to 3)
buffertype : 0=Receive, 1=Send, 2=Both

BClr clears the specified RS-232 channel’s input buffer, output buffer, or both buffers. Use this statement if your code is about to receive data and there may be unneeded data already in the buffer.

| BClr 1,0 | ' Clear RS232 Channel 1’s rx buffer |
| BClr 1,1 | ' Clear RS232 Channel 1’s tx buffer |
| BClr 1,2 | ' Clear RS232 Channel 1’s rx & tx buffers |
**Beep**

`Beep port, length`

- `port`: Port number (0 to 255)
- `length`: Pulse output period (1 to 65535)

`Beep` is used to create a beep sound. A piezo or a speaker can be connected to the specified port. A short beep will be generated. This is useful for creating button-press sound effects or alarm sounds. When this command is used, the specified port is automatically set to output.

```
Beep 2, 100  ' Output Beep on P2 for a period of 100
```
**Bfree( )**

variable = Bfree(channel, bufferType)

- **variable**: Variable to store results (No String or Single)
- **channel**: RS232 Channel number (0 to 3)
- **bufferType**: 0=Receive Buffer, 1=Send Buffer

This function will return the number of free bytes in a receive or send buffer. When sending data, this command can be used to avoid overflowing the buffer. When receiving data, this command can help the program wait for a specified amount of data to be received before taking action.

```vbscript
Dim A As Byte
OpenCom 1,19200,0, 100, 50
If BFree(1,1)>10 Then
    Put "TECHNOLOGY"
End If
```

If the size of the buffer is set to 50, up to 49 bytes can be returned. When the buffer is empty, BFree will return 1 less than the buffer size.
**Bin2Bcd**

\[ \text{variable} = \text{Bin2Bcd( binValue)} \]

- \text{variable} : Variable to store results (Returns Long)
- \text{binValue} : Binary value to be converted

**Bin2Bcd** converts a binary value to BCD (Binary Coded Decimal).

```
i = 123456
j = bin2Bcd(i)
Debug Hex j  \ ' Print 123456
```

See also Bcd2Bin.
**BLen( )**

\[ \text{variable} = \text{BLen(channel, bufferType)} \]

- **variable**: Variable to store results (No String or Single)
- **channel**: RS-232 channel number (0 to 3)
- **bufferType**: 0=receive buffer, 1=send buffer

BLen returns the current number of bytes in the specified RS-232 channel’s buffer. If the buffer is empty, 0 will be returned. When receiving data, this function can be used to check how much data has been received before using `Get` or `GetStr` to read the data received.

If the receive buffer is full, it will not be able to receive any more data. To avoid this, use receive interrupts (See `On Recv`) or increase the buffer size.

```vbnet
Dim A As Byte
OpenCom 1,19200,0,100,50
On Recv DATARECV_RTN
    ' When data is received through RS232, jump to DATARECV_RTN
    Do
        Loop
    ' infinite loop
DATARECV_RTN:
    If BLen(1,0) > 0 Then
        ' If there is at least 1 byte...
        A = Get(1)
    ' Read 1 Byte
End If
Return
    ' End Interrupt routine
```
ByteIn

\[ \text{variable} = \text{ByteIn} (\text{portBlock}) \]

\text{variable} : Variable to store results (No String or Single)

\text{portBlock} : I/O Port Block Number (0 to 15)

ByteIn reads from an I/O port block (a group of 8 I/O ports). Ports 0 to 7 are block 0 and ports 8 to 15 are block 1. The port block numbers vary for the different models of Cubloc. When using this command, all I/O ports within the port block have their I/O mode set to input and their input is stored in a variable.

\[ \text{Dim A As Byte} \]
\[ A = \text{ByteIn}(0) \quad \text{' Read from Port Block 0 and store in variable A.} \]

The CB220 and CB280 port block groupings are shown below. Please refer to the pin/port tables for the specific Cubloc module you are using.
**ByteOut**

*ByteOut*  * portBlock, value  
  * portBlock : I/O Port Block Number (0 to 15).  
  * value : Value to be output (0 to 255).

*ByteOut* outputs a value to a port block (a group of 8 I/O ports.  Refer to *ByteIn*). When using this command, all I/O ports within the specified port block are set to output.

```
ByteOut 1,255  
' Output 255 to Port Block 1.  
' Ports 8 through 15 are set to HIGH.
```

**NOTE:** I/O Port 1 only supports input. Therefore, *ByteOut* 0 will not set Port 1 to Output.
CheckBf( )

\[ variable = \text{CheckBf}(\text{channel}) \]

- \textit{variable} : Variable to store results (No String or Single)
- \textit{channel} : RS232 Channel (0 to 3)

The command \texttt{CheckBf()} can be used to check the current data in the receive buffer without modification. Unlike \texttt{Get}, it will not erase the data after reading. Only 1 byte can be read at a time.

\[
\text{A = CheckBf(1) \quad \text{'} Check current data in the receive buffer}
\]
**Compare**

*Compare channel, target#, port, targetState*

- **channel**: High-speed counter channel
- **target#**: Target # of pulses (CH0: 0 to 65535, CH1: 0 to 255)
- **port**: Output port (DO NOT USE input-only ports)
- **targetState**: Target output port state

When the high-speed counter value reaches a set target point (target#), the processor will set an I/O Port to logic low or logic high.

If targetState is set to 1 and the target number of pulses (target#) have been received, the output port (port) will output logic high. Likewise, if the targetState is set to 0 and the target number of pulses (target#) have been received, the output port (port) will output logic low.

<table>
<thead>
<tr>
<th>Channel</th>
<th>Compare Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCOUNT Channel 0</td>
<td>0 to 65535</td>
</tr>
<tr>
<td>HCOUNT Channel 1</td>
<td>0 to 255</td>
</tr>
</tbody>
</table>

The high-speed counter itself supports up to 32-bits, but the Compare is limited since this command was designed to not affect the overall multitasking of Cubloc's main processor. Note: For channel 0, please use the Set Count0 On command before using Compare.

```vbnet
Dim i As Integer
Set Count0 On
Compare 0, 10, 61, 1
Do
  i = Count(0)
  Debug Goxy, 0, 0, dec4 i, Cr
  Delay 100
Loop
```

The above uses high-speed counter channel 0 with a target of 10 pulses. When the counter value becomes 11, the output port (port 61) will output logic high.
Count( )

variable = Count(channel)

variable : Variable to store results. (No String or Single)
channel : Counter channel number (0 to 1)

Return the counted value from the specified counter channel. Please set the counter input ports to input before use of this command (refer to the pin/port table for the appropriate Cubloc module). Data types up to 32 bits in size can be counted (Byte, Integer, and Long). The maximum pulse frequency is 2MHz.

Cubloc’s counter is hardware driven, meaning it runs independently from the main program. It is able to count reliably in real-time regardless of how busy the Cubloc processor is.

The Cubloc has 2 counter inputs. Counter channel 0 uses the same resources as PWM0 through PWM2, so you cannot use both at the same time. However, counter channel 1 can be used while PWM channel 0 is running. The Set Count0 On command must be executed before using counter channel 1. Counter channel 1 requires no additional settings.

Dim R As Integer
Input 15 ' Set port 15 as input. (Counter Channel 1)
R = Count(1) ' Read current counter value.

Set Count0 On ' Activate counter channel 0
 ' (PWM0,1, and 2 becomes deactivated.)
Input 14 ' Set port 14 as input (Counter Channel 0)
R = Count(0) ' Read current Counter value.
As illustrated below, counter 0 uses the same resources as PWM0 through PWM2, so please be careful not to use both at the same time.

```
Const Device = CB280
Dim A as Integer
Input 15
Low 5
Freqout 0,2000
Low 0
On Timer(100) Gosub GetFreq
Do
Loop

GetFreq:
A = Count(1)
Debug goxy,10,2
Debug dec5 A
Countreset 1
Reverse 0
Return
```
CountReset

*CountReset channel*

channel : Counter channel (0 to 1)

Resets the specified counter to 0.

<table>
<thead>
<tr>
<th>CountReset 0</th>
<th>' Clear Channel 0</th>
</tr>
</thead>
<tbody>
<tr>
<td>CountReset 1</td>
<td>' Clear channel 1</td>
</tr>
</tbody>
</table>
Dcd

\[ \text{variable} = \text{Dcd source} \]

\[ \text{variable} : \text{Variable to store results. (No String or Single)} \]

\[ \text{source : source value} \]

Dcd is the opposite of Ncd. It returns the bit position (counting from one) of the most significant bit that is a 1.

\[ I = \text{Dcd} \ 15 \quad \text{' Result is 4 since 15 = 0b00001111} \]
Cubloc supports RS-232 debugging with the `Debug` command. The user can insert `Debug` commands as desired within a program. The result of the `Debug` command is displayed on the Debug Terminal, which will automatically appear after the program is downloaded from Cubloc Studio.

```plaintext
Dim A As Integer  
A = 123  
Debug Dec A
```

Use `Dec` or `Hex` to convert numbers to strings for the `Debug` command. If you do not use `Dec` or `Hex`, numbers will be printed as raw ASCII, usually providing no useful output.

If you insert a question mark (?) before `Dec` or `Hex`, the variable’s name will be printed before the value.

```plaintext
Debug Dec? A,Cr  
Debug Hex? A,Cr
```
You can also specify the number of characters to print.

```
Debug  Hex8  A
```

The HEX command will accept 1 through 8. HEX8 will print as an 8 digit hexadecimal number. The DEC command will accept 1 through 10.

You are free to mix strings and numbers:

```
Debug  "CHECK VALUE " Hex?  A, Cr
```

The Debug command is useful for printing strings and numbers in a user-friendly format. During the execution of a Cubloc BASIC program, when the Debug command is encountered, the resulting values are immediately displayed on the debug terminal.
If you insert a **Debug** statement into a program and the debug terminal displays output, it verifies that the program has executed to that point. By using **Debug** commands, you will be able to detect the location of bugs in your program, and monitor variables changes in real time.

You can send data to the download port of Cubloc by entering text in the upper text box of the debug terminal. This is useful for interactive communication with the Cubloc.

**Warning**
The **Debug** command may not be used while monitoring in Ladder Logic. Likewise, Ladder Logic monitoring can not be used while debugging using **Debug** statements.

The following is a chart of commands that can be used with the **Debug** command. You can control the debug terminal's output like an output screen or LCD.

<table>
<thead>
<tr>
<th>Command</th>
<th>Code</th>
<th>Explanation</th>
<th>Example Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLR</td>
<td>0</td>
<td>Clear Debug screen</td>
<td>Debug CLR</td>
</tr>
<tr>
<td>HOME</td>
<td>1</td>
<td>Move cursor to the upper left corner of the Debug screen</td>
<td>Debug HOME</td>
</tr>
<tr>
<td>GOXY</td>
<td>2</td>
<td>Move cursor to X, Y</td>
<td>Debug GOXY, 4, 3</td>
</tr>
<tr>
<td>CSLE</td>
<td>3</td>
<td>Move cursor one to the left.</td>
<td></td>
</tr>
<tr>
<td>CSRI</td>
<td>4</td>
<td>Move cursor one to the right</td>
<td></td>
</tr>
<tr>
<td>CSUP</td>
<td>5</td>
<td>Move cursor one up</td>
<td></td>
</tr>
<tr>
<td>CSDN</td>
<td>6</td>
<td>Move cursor one down</td>
<td></td>
</tr>
<tr>
<td>BELL</td>
<td>7</td>
<td>Make beeping sound</td>
<td></td>
</tr>
<tr>
<td>BKSP</td>
<td>8</td>
<td>BACK SPACE</td>
<td></td>
</tr>
<tr>
<td>LF</td>
<td>10</td>
<td>LINE FEED</td>
<td>Debug &quot;ABC&quot;,LF</td>
</tr>
<tr>
<td>CLRRI</td>
<td>11</td>
<td>Erase all characters on the right of cursor to the end of line.</td>
<td></td>
</tr>
<tr>
<td>CLRDN</td>
<td>12</td>
<td>Erase all characters on the bottom of cursor</td>
<td></td>
</tr>
<tr>
<td>CR</td>
<td>13, 10</td>
<td>Carriage Return (go to next line)</td>
<td>Debug &quot;ABC&quot;,CR</td>
</tr>
</tbody>
</table>

You must use above commands within a **Debug** statement:

```
Debug Goxy,5,5,Dec I
Debug Clr,"TEST PROGRAM"
```
Decr

Decr variable

variable : Variable to decrement. (No String or Single)

Decrements variable by 1.

Decr A ' Decrement A by 1.
**Delay**

*Delay time*

\[ time : Time interval (variable or constant up to Long type value) \]

Delay delays program execution for the specified time in milliseconds. The Delay command is best used for small amounts of time. We recommend not using it for time measurements and other time-critical applications, as the actual delay time can vary depending on other running tasks.

```
Delay 10   ' Delay for about 10 ms.
Delay 200  ' Delay for about 200 ms.
```

Delay is implemented as the following subroutine.

```
Sub Delay(dl As long)
    d1 var Long
    d2 var Integer
    For d1 = 0 To dl
        For d2 = 0 To 1
            Nop
            Nop
            Nop
        Next
    Next
End Sub
```
Do...Loop

Do...Loop will infinitely loop the enclosed commands unless Do While or Do Until is used to conditionally terminate the loop. An Exit Do statement can also be used within the DO...LOOP to exit from the loop.

```
Dim K As Integer
Do
    K=Adin(0) ' Read AD input from channel 0
    Debug Dec K,Cr
    Delay 1000
Loop
```

In the above example, the program will loop indefinitely inside Do and Loop. An Exit Do or GOTO statement must be used to get out of the infinite loop.

```
Do While [Condition]
    Commands
    [Exit Do]
Loop
```

Do...While will loop indefinitely until the While condition is met.

```
Do Until [Condition]
    Commands
    [Exit Do]
Loop
```

Do...Until will loop indefinitely until Until condition is met.
DEMO PROGRAM

```
Const Device = CB280
Dim A As Integer
A = 4
Do While A < 10
    Debug Dec A, Cr
    Incr A
Loop
```

```
Const Device = CB280
Dim A As Integer
A = 4
Do
    Debug Dec A, Cr
    Incr A
    Loop Until A > 9
```
DTZero

DTZero variable

variable : Variable for decrement. (No String or Single)

DTZero decrement variable by 1 as long as variable is greater than 0. If variable is 0, DTZero does nothing. This differs from the Decr command, which will underflow the variable and wrap around to the type's highest value.

DTZero A ' Decrement A by 1 unless A is 0
EERead( )

variable = EERead (Address, ByteLength)

- variable : Variable to store result (No String or Single)
- address : 0 to 4095
- byteLength : Number of bytes to read (1 to 4)

Read data from the specified address in the EEPROM.

Dim A As Integer
Dim B As Integer
A = 100
EEWrite 0,A,2  ' Store 2 bytes of A in Address 0.
B = EERead(0,2)   ' Read 2 bytes from Address 0 and store in B.
EEWrite

*EEWrite address, data, byteLength*

- **address**: 0 to 4095
- **data**: Data to write to EEPROM (up to Long type values)
- **byteLength**: Number of Bytes to write (1 to 4)

Store data in the specified address in EEPROM. This is very useful for storing configuration or calibration data.

```
Dim A As Integer
Dim B As Integer
A = 100
EEWrite 0, A, 2 ' Store A in Address 0.
B = EERead(0, 2) ' Read from Address 0 and store in B.
```

When writing to the EEPROM, it takes about 3 to 5 milliseconds. When reading from the EEPROM, it takes less than 1 millisecond. There is a physical limit of around 100,000 writes to each location within the EEPROM.

If you are using the EEPROM for data acquisition or data that requires a lot of writes, we recommend using a module with battery-backup memory, such as the CB290 or CB405, instead. One alternative is an RS-232 Compact Flash (CF) or Secure Digital (SD) memory interface module.

The following table compares SRAM and EEPROM.

<table>
<thead>
<tr>
<th>Type</th>
<th>Battery Backup SRAM</th>
<th>EEPROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life of Data</td>
<td>Depends on battery capacity</td>
<td>40 Years</td>
</tr>
<tr>
<td>Maximum Writes</td>
<td>Infinite</td>
<td>About 100,000</td>
</tr>
<tr>
<td>Writing Time</td>
<td>0 ms</td>
<td>3 to 5 ms</td>
</tr>
<tr>
<td>General use</td>
<td>Store often-used variable information over a power outage. Example: daily production counter.</td>
<td>Important data that needs to survive even a backup battery failure. Example: Product Serial Number</td>
</tr>
</tbody>
</table>
**EKeyPad()**

variable = EKeyPad( portblockIn, portblockOut)

- **variable**: Variable to store results (Returns Byte)
- **portblockIn**: Port Block to receive input (0 to 15)
- **portblockOut**: Port Block to output (0 to 15)

**EKeyPad** extends **KeyPad** to read up to 64 key inputs. Two port blocks are used to read a keypad matrix of up to 8x8 lines. The input port block and the output port block must be selected separately.

A pullup resistor (2.2K to 10K) should be connected between each input port and 5V. For ports not used within the input port block, a pullup resistor must be used. Unused ports may not be used for other purposes when using this command.

Ports not used within the output port block can be left unconnected. Unconnected ports may not be used for other purposes. The following is an example showing port block 0 as the input port block and port block 1 as the output port block:

![Keypad Diagram](image)

If no keys are pressed, 255 will be returned. Otherwise, the pressed key’s scan code will be returned.
For...Next

For...Next will loop the commands within itself for a set number of times.

For Variable = StartingValue To EndingValue [Incremental Step]
  Commands
  [Exit For]
Next

In the below example, an Incremental Step is not set. By default each loop increments by 1.

```vbnet
Dim K As Long
For K=0 To 10
  Debug Dp(K),CR
Next

For K=10 To 0 Step -1
  Debug Dp(K),CR
Next
```

An Exit For command can be used within the For...Next loop to exit at any time.

```vbnet
For K=0 To 10
  Debug Dp(K),CR
  If K=8 Then Exit For
    ' If K equals 8 exit the For...Next loop.
Next
```

When choosing a variable to use for the For...Next loop, please make sure the chosen variable is able to cover the desired range. Byte variables can cover 0 to 255. For larger values, a variable with a larger range must be chosen.

```vbnet
Dim K As Byte
For K=0 To 255
  Debug Dp(K),CR
Next
```

When using a negative Step, please choose a Long variable type if the loop will go below 0.

```vbnet
Dim LK As Long
For LK=255 To 0 Step -1
  Debug Dp(LK),CR
Next
```
DEMO PROGRAM

Const Device = CB280
Dim A As Integer
For A = 1 To 9
    Debug "3 * "
    Debug Dec A
    Debug " = "
    Debug Dec 3*A, Cr
Next

Const Device = CB280
Dim A As Integer, B As Integer
For A = 2 To 9
    For B = 1 To 9
        Debug Dec A," * "
        Debug Dec B
        Debug " = "
        Debug Dec A*B, Cr
    Next
    Debug Cr
Next
FreePin

FreePin  I/O

I/O : I/O port number

This command will reassign an I/O port back to BASIC, if it had previously been assigned to Ladder Logic with UsePin.
**FreqOut**

FreqOut channel, freqValue

channel : PWM channel (0 to 15)

freqValue : Frequency value between 1 and 65535

FreqOut output the specified frequency to the specified PWM channel. Please make sure to specify the PWM channel, not the I/O port number. For the CB220 and CB280, ports 5, 6, and 7 correspond to PWM Channel 0, 1, and 2, respectively.

The following chart shows several example freqValues and their corresponding frequencies. The highest possible frequency can be achieved by setting freqValue to 1 and the lowest possible can be achieved by setting freqValue to 65535. A freqValue of 0 does not produce any output.

<table>
<thead>
<tr>
<th>FreqValue</th>
<th>Frequency</th>
<th>FreqValue</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1152 KHz</td>
<td>200</td>
<td>11.52 KHz</td>
</tr>
<tr>
<td>2</td>
<td>768 kHz</td>
<td>1000</td>
<td>2.3 KHz</td>
</tr>
<tr>
<td>3</td>
<td>576 KHz</td>
<td>2000</td>
<td>1.15 KHz</td>
</tr>
<tr>
<td>4</td>
<td>460.8KHz</td>
<td>3000</td>
<td>768 Hz</td>
</tr>
<tr>
<td>5</td>
<td>384 KHz</td>
<td>4000</td>
<td>576 Hz</td>
</tr>
<tr>
<td>10</td>
<td>209.3 KHz</td>
<td>10000</td>
<td>230 Hz</td>
</tr>
<tr>
<td>20</td>
<td>109.7 KHz</td>
<td>20000</td>
<td>115.2 Hz</td>
</tr>
<tr>
<td>30</td>
<td>74.4 KHz</td>
<td>30000</td>
<td>76.8 Hz</td>
</tr>
<tr>
<td>100</td>
<td>22.83 KHz</td>
<td>65535</td>
<td>35.16 Hz</td>
</tr>
</tbody>
</table>

You can calculate freqValue using the following formula:

freqValue = 2,304,000 / Desired Frequency

Before using this command, please set the specified PWM port to output mode and set to a logic high or logic low state. To stop the output, use the PWMOff command.

The following is an example:

```vbs
Const Device = CB280
Dim i As Integer
Low 5 ' Set Port 5 to low and output.
i = 1
FreqOut 0,10 ' Produce a 209.3Khz wave
Do ' Infinite loop
   Loop
```

Since FreqOut uses the same resources as the PWM, there are some restrictions to consider. PWM channels 0, 1, and 2 use the same timer. If
PWM channel 0 is used for a FreqOut command, PWM channels 0, 1, and 2 cannot be used for a PWM command.

Likewise, PWM Channels 3, 4, and 5 are linked. If FreqOut is used on PWM channel 3, PWM Channels 3, 4, and 5 cannot be used for a PWM command.

You can produce different frequencies on PWM channels 0 and 3.

To summarize, two different frequencies can be produced at one time, and when using the FreqOut command, a PWM command cannot be used on the same channel.

The following is a chart that correlates freqValue to musical notes:

<table>
<thead>
<tr>
<th>Note</th>
<th>Octave 2</th>
<th>Octave 3</th>
<th>Octave 4</th>
<th>Octave 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20945</td>
<td>10473</td>
<td>5236</td>
<td>2618</td>
</tr>
<tr>
<td>Bb</td>
<td>19770</td>
<td>9885</td>
<td>4942</td>
<td>2471</td>
</tr>
<tr>
<td>B</td>
<td>18660</td>
<td>9330</td>
<td>4665</td>
<td>2333</td>
</tr>
<tr>
<td>C</td>
<td>17613</td>
<td>8806</td>
<td>4403</td>
<td>2202</td>
</tr>
<tr>
<td>Db</td>
<td>16624</td>
<td>8312</td>
<td>4156</td>
<td>2078</td>
</tr>
<tr>
<td>D</td>
<td>15691</td>
<td>7846</td>
<td>3923</td>
<td>1961</td>
</tr>
<tr>
<td>Eb</td>
<td>14811</td>
<td>7405</td>
<td>3703</td>
<td>1851</td>
</tr>
<tr>
<td>E</td>
<td>13979</td>
<td>6990</td>
<td>3495</td>
<td>1747</td>
</tr>
<tr>
<td>F</td>
<td>13195</td>
<td>6597</td>
<td>3299</td>
<td>1649</td>
</tr>
<tr>
<td>Gb</td>
<td>12454</td>
<td>6227</td>
<td>3114</td>
<td>1557</td>
</tr>
<tr>
<td>G</td>
<td>11755</td>
<td>5878</td>
<td>2939</td>
<td>1469</td>
</tr>
<tr>
<td>Ab</td>
<td>11095</td>
<td>5548</td>
<td>2774</td>
<td>1387</td>
</tr>
</tbody>
</table>

FreqOut 0,5236  ' Note A in Octave 4 (440Hz)
FreqOut 0,1469  ' Note G in Octave 5
Get( )

\[ \text{variable} = \text{Get(channel, length)} \]

- **variable**: Variable to store results (Cannot use String or Single)
- **channel**: RS-232 Channel (0 to 3)
- **length**: Length of data to receive in bytes (1 to 4)

Read data from the RS-232 port. The `Get` command actually reads from the receive buffer. If there is no data in the receive buffer, it will quit without waiting for data and return 0. The `Blen` command can be used to check if there is any data in the receive buffer before trying to read data.

The length of data to be read must be between 1 and 4. If receiving a single Byte, it would be 1. If receiving a Long, it would be 4. For larger amounts of data, use `GetStr` or `GetA`.

**TIPS**

Use `Sys(1)` after `Get` or `GetStr` to verify how much data was actually read. If 5 bytes are received but only 4 bytes are verified, 1 byte is lost.

```vbs
Const Device = CB280
Dim A as Byte
OpenCom 1,115200,3,50,10
On Recv1 GoSub GOTDATA
Do
    Do While In(0) = 0
        Loop
        ' Wait for a button press (Connect P0)
    Put 1,Asc("H"),1
    Put 1,Asc("E"),1
    Put 1,Asc("L"),1
    Put 1,Asc("L"),1
    Put 1,Asc("O"),1
    Put 1,13,1    ' HELLO + Chr (13) + Chr (10)
    Put 1,10,1
    Do While In(0) = 1
        Loop
    Loop

GOTDATA:
    A=Get(1,1)
    Debug A
    Return
```
GetA

GetA channel, arrayName, byteLength

channel : RS-232 Channel (0 to 3)
arrayName : Array to store received data (Byte type only)
byteLength : Number of bytes to store (1 to 65535)

The command GetA can be used to store received RS-232 data in a Byte array. Data will be stored starting from the first element of the array. Check the receive buffer with BLen before reading to avoid overflowing the buffer.

Const Device = CB280
Dim A(10) As Byte
OpenCom 1,115200,3,50,10
Set Until 1,8, 10 '10 is a required dummy value, it will be ignored
On Recv1 Gosub GOTDATA
Do
    Do While In(0) = 0
        Loop ' Wait until press button (Connect P0)
    PutStr 1,"CUBLOC",Cr
    Do While In(0) = 1
        Loop
    Loop
GOTDATA:
    GetA 1,A,8
    Debug A(0),A(1),A(2),A(3),A(4),A(5),A(6),A(7)
    Return

In order to run the program above, please connect Rx to Tx as shown below.
GetA2

GetA2 channel, arrayName, byteLength, stopChar
   channel : RS-232 Channel (0 to 3)
   arrayName : Array to store received data (Byte type only)
   byteLength : Number of Bytes to store (1 to 65535)
   stopChar : Stop character ASCII code

GetA2 is the same as GetA except it will stop reading data at the when it encounters stopChar, even if the data received is less than byteLength. If stopChar is not found, then it will operate just like GetA.

stopChar is included in the received data.

You can use the Sys(1) command to check the number of bytes read:

```
Dim A(10) As Byte
OpenCom 1,19200,0,50,10
GetA2 1,A,20,10   ' Read until stop character ASCII code 10 is found
       ' or 20 bytes have been read
```
**GetCrc**

GetCrc variable, arrayName, byteLength

- **variable:** String variable to store results (Integer type)
- **arrayName:** Array with data (Must be a Byte array)
- **byteLength:** number of bytes to calculate CRC

GetCrc calculates a Circular Redundancy Check (CRC) when using MODBUS RTU Master Mode. GetCrc will return a 16-bit integer CRC value of the specified array, arrayName. You can set the number of bytes to use for the CRC calculation from the array starting at 0.

```plaintext
Const Device = CB280
OpenCom 1,115200,3,80,20
Set Modbus 1,9
Dim A(20) As Byte
Dim B As Integer
RamClear
UsePin 0,Out
UsePin 9,Out

Set Ladder On

A(0) = 9
A(1) = 2
A(2) = 3
A(3) = 0
A(4) = 10
A(5) = 23

GetCrc B,A,6 ' Store in variable B the CRC for 6 bytes of array A
Debug Hex B,Cr
```

**NOTE:** Please use byte arrays when using this function.
GetPad( )

variable = GetPad(length)

variable: Variable to store results
length: Length of data to receive

Reads length bytes from the pad buffer allocated with Set Pad.

Const Device = CB280

Dim X As Integer
Dim Y As Integer

Set Pad 0,4,20 'Mode 0, Packet size 4 bytes, Buffer 20 bytes
On Pad GoSub ABC 'Define ABC as interrupt service routine

Do 'Run forever
Loop

ABC:
  X = GetPad(2) 'First 2 bytes is the x coordinate
  Y = GetPad(2) 'Second 2 bytes is y coordinate
  Debug Dec X, Cr 'Print x coordinate
  Debug Dec Y, Cr 'Print y coordinate
  Return
GetStr( )

\[ \text{variable} = \text{GetStr}(\text{channel, length}) \]

- \text{variable} : String Variable to store results
- \text{channel} : RS-232 Channel
- \text{length} : Length of data to receive

Same as \text{Get}, except the variable to store results can only be a \text{String} and the length of data is not limited to 4 bytes.

```vbnet
Const Device = CB280
Dim A As String * 10
OpenCom 1,115200,3,50,10
Set Until 1,8, 10 '10 is a required dummy value, it will be ignored
On Recv1 GoSub GOTDATA
Do
    Do While In(0) = 0
        Loop ' Wait until press button (Connect P0)
    PutStr 1,"CUBLOC",Cr
    Do While In(0) = 1
        Loop
    Loop
GOTDATA:
    A = GetStr(1,8)
    Debug A
    Return
```

In order to run the program above, please connect Rx to Tx as shown below.
GetStr2( )

variable = GetStr(channel, byteLength, stopChar)

variable : String variable to store results
channel : RS-232 Channel
byteLength : Length of data to receive
stopChar : Stop character ASCII code

Same as the GetStr command, except it will stop reading data when it encounters stopChar, even if the data received is less than byteLength. If stopChar is not found, then it will operate just like GetStr.
GoSub...Return
The GoSub command can call a subroutine. The Return command must be used at the end of the subroutine.

GoSub ADD_VALUE

ADD_VALUE:
   A = A + 1
Return
**GoTo**

The GoTo command will instruct the current program to jump to a specified label. This is part of every BASIC language, but its use should be limited in an effort to adopt a structural programming paradigm. Be especially careful when using GoTo within a GoSub or subroutine since improperly terminating a subroutine can have undesired effects.

```basic
If I = 2 Then
    GoTo LAB1
End If

LAB1:
    I = 3
```

**About Labels...**

A label can be set with a colon (:) to specify a point for GoTo or GoSub to begin execution.

ADD_VALUE:

LINKPOINT:

Labels cannot use reserved keywords, numbers, or include blank spaces. The following labels are not permitted:

Ladder:       'Reserved keyword
123:          'Number.
About 10:      'Blank space.
Heap Memory Access

Heap memory access is a special feature only available on the CB405 module. The user may use 55KB of heap memory from address 0 through 56831 (&H0000 through &HDDFF). The heap can be used to store large data for graphics, temperature tables, etc. With a backup battery, the heap can be used for data logging and other persistent uses.

There are five heap-related functions:

<table>
<thead>
<tr>
<th>Function</th>
<th>Syntax</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>HeapClear</td>
<td>HeapClear</td>
<td>Erase the entire heap.</td>
</tr>
<tr>
<td>HRead</td>
<td>variable = HRead(address, length)</td>
<td>Read the designated number of bytes set by length from heap address, address, and store into variable.</td>
</tr>
<tr>
<td>HWrite</td>
<td>HWrite address, variable, length</td>
<td>Store length number of bytes of variable to the heap address, address.</td>
</tr>
<tr>
<td>HeapW</td>
<td>HeapW address, variable</td>
<td>Store one byte, variable, to the heap address, address.</td>
</tr>
<tr>
<td>Heap</td>
<td>variable = Heap(address)</td>
<td>Read one byte from the heap address, address, and store into variable.</td>
</tr>
</tbody>
</table>
**HRead( )**

variable = HRead(address, byteLength)

- **variable**: Variable to store results
- **address**: Heap address
- **byteLength**: Number of bytes to read, constant or variable (1 to 4)

Read the designated number of bytes set by length from heap address, address, and store into variable.

**HWrite**

HWrite address, data, byteLength

- **address**: Heap address
- **data**: Constant or variable with data (whole numbers only)
- **byteLength**: Number of bytes to write

Store length number of bytes of variable to the heap address, address.

```
Dim A As Integer
Dim B As Integer
A = 100
HWrite 0, A, 2 ' Write integer A to address 0.
B = HRead(0, 2) ' Read from address 0 and store in B.
```

**NOTE**

EERead and EEWrite have same syntax as HRead and HWrite.

<table>
<thead>
<tr>
<th>Function</th>
<th>Memory Type</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>EERead, EEWrite</td>
<td>EEPROM</td>
<td>Retains data during power cycles without a battery. The EEWrite command takes about 5ms.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4KB of available memory</td>
</tr>
<tr>
<td>HRead, HWrite</td>
<td>SRAM</td>
<td>Retains data during power cycles with a backup battery. Without a backup battery, data is lost. HWrite command takes about 20 microseconds to execute, much faster compared to EEWrite.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>55KB of available memory</td>
</tr>
</tbody>
</table>
HeapClear

Set all 55KB of the heap to zero.

Heap( )

\[
\text{variable} = \text{Heap} \left( \text{address} \right) \\
\text{variable} : \text{Variable to store results} \\
\text{address} : \text{Heap address}
\]

Returns 1 byte of data from the specified heap address.

HeapW

\[
\text{HeapW} \text{ address, data} \\
\text{address} : \text{Heap memory address} \\
\text{data} : \text{Constant or variable with data (Byte only)}
\]

Write 1 byte of data to the specified heap address.

Heap Memory Addressing

The heap is divided into byte unit addresses. When a \texttt{Long} variable is stored, 4 bytes are stored, and 4 memory addresses are used.

\[
\begin{array}{c}
0 & \&HCD \\
1 & \&HAB \\
2 & \&H34 \\
3 & \&H12 \\
\end{array}
\]

As you can see in the above table, when a \texttt{Long} variable is stored in heap address 0, four memory addresses are taken.

\[
\begin{array}{c}
\text{HWrite 0, \&H1234ABCD, 4} \\
\text{HWrite 1, \&H6532, 2} \\
\end{array}
\]

' Write \&HCD to address 0 and \&HAB to address 1

' Overwrite address 1 with \&H32 and write \&H5 to address 2
Const Device = CB405
Dim A As Byte
Dim i As Long, J As Long

i = &HABCD1234
HeapClear
HWrite 0, i, 4
Do
    HeapW 56830, 100
    HeapW 56831, 123
    Debug Dec Heap(56830), Cr
    Debug Dec Heap(56831), Cr
    J = HRead(0, 4)
    Debug Hex J, Cr
    Delay 100
Loop
High

port : I/O port number

Set the port to a logic high state, 5V.

Output 8  ' Set Port 8 to output state.
High 8    ' Set Port 8 to HIGH (5V).

When a port is set to high, the port is internally connected to VDD (5V). If it’s set to Low, the port is internally connected to VSS (0V). This allows either source or sink interfacing to external components (up to 25ma for source or sink).
**I2CStart**

*I2CStart*

Sets I2C SDA and SCL to start mode. After this command, SDA and SCL go low.

**I2CStop**

*I2CStop*

Set I2C SDA and SCL to stop mode. After this command, SDA and SCL go high.
**I2CRead( )**

```
variable = I2CRead(dummy)
```

*variable*: Variable to store results. *(No String or Single)*

*dummy*: Dummy value.

Read a byte from the I2C ports set by SET I2C command. Use any value for the dummy value.

```
A = I2CRead(0)
```

This command will send an ACK signal back to the slave I2C device. After reading a byte, an SCL pulse will be sent while SDA is kept low.
**I2CReadNA( )**

Variable = I2CReadNA (dummy)

- **variable**: Variable to store results. *(No String or Single)*
- **dummy**: Dummy value. *(Normally 0)*

Functions the same as the **I2CRead** command but without acknowledgment.

\[
A = \text{I2CReadNA}(0)
\]
I2CWrite( )

variable = I2CWrite data

variable : Acknowledge (0=Acknowledgment, 1=No Acknowledgment)
data : data to send (Byte value : 0 to 255)

Sends one byte of data through I2C. This command creates an ACK pulse and returns 0 if there is an acknowledgment and 1 if there isn’t. No acknowledgment indicates that there was a communication error (possibly due to incorrect wiring). The following is an example illustrating how this can be used to trigger an error processing function:

If I2CWrite(DATA)=1 Then GoTo ERR_PROC

If you don’t need to check for an ACK, you can just use any variable to receive the ACK status as shown below:

A = I2CWrite(DATA)

One byte of data transfer takes approximately 60 microseconds.

Please refer to Chapter 8 "About I2C..." for a detailed description of I2C communications.
If...Then...ElseIf...EndIf

You can use If...Then...ElseIf...Else...EndIf conditional statements to control execution of your program.

If Condition1 Then [Expression1]
  [Expression2]
[ElseIf Condition2 Then
  [Expression3]]
[Else
  [Expression4]]
[End If]

Usage 1

If A<10 Then B=1

Usage 2

If A<10 Then B=1 Else C=1

Usage 3

If A<10 Then B=1
' When using more than 1 line, do not put any Expressions after "Then".
End If

Usage 4

If A<10 Then
  B=1
Else
  C=1
End If

Usage 5

If A<10 Then B=1
ElseIf A<20 Then C=1
End If

Usage 6

If A<10 Then B=1
ElseIf A<20 Then C=1
ElseIf A<40 Then C=2
Else
  D=1
End If
**In()**

\[ variable = \text{In}(\text{port}) \]

- **variable**: The variable to store result (No String or Single)
- **port**: I/O port number (0 to 255)

Read the current state of the specified port. This function reads the state of the I/O port and stores it in the specified variable. When this command is executed, Cubloc will automatically set the port to input and read from the port. You do not need to use the Input command to set the port beforehand when using this command.

```
Dim A As Byte
A = In(8)    ' Read the current state of port 8
            ' and store in variable A(0 or 1)
```

**TIP**

By default, all I/O ports are set to a high-Z (high impedance) input state at power ON. When a port is set to output, it will either output a high or low signal; high is 5V and low is 0V or GND (ground).
Incr

Incr variable

variable : Variable to increment. (No String or Single)

Increment the variable by 1.

Incr A

'Increment A by 1.'
Input

Input port

port : I/O port number (0 to 255)

Sets the specified port to a high-Z (high impedance) input state. All I/O ports of Cubloc modules are set to a high-Z input state by default at power on.

High impedance means that the value of resistance is so high that it’s neither high nor low; it won’t affect a circuit attached to the port.

Input 8

'Set port 8 to a high-Z input state.'
The command `KeyIn` removes the input signal's contact bounce before reading an input. You can use `KeyIn` only with active low inputs as shown below. For active high inputs, please use `KeyInH`. When a button press is detected, `KeyIn` will return 0; otherwise, it will return 1.

If you use 10 for the debouncing time, the Cubloc will debounce for 10 ms. Contact bounce usually stops after 10ms, so a 10ms debouncing time will suffice for most applications.

```plaintext
A = KeyIn(1,10)  'Read from port 1 after waiting 10ms for debouncing.
```
KeyInH

\[
\text{variable} = \text{KeyInH}(\text{port, debouncingTime})
\]

\begin{itemize}
\item \text{variable} : Variable to store results (No String or Single)
\item \text{port} : Input port (0 to 255)
\item \text{debouncingTime} : Debouncing time (0 to 65535)
\end{itemize}

\text{KeyInH} is for active high inputs. For active low inputs, the \text{KeyIn} command should be used.

When a button press is detected, \text{KeyInH} will return 1; otherwise, it will return 0.

\begin{verbatim}
A = KeyInH(1,100) 'Read from port 1 after waiting 100ms for debouncing.
\end{verbatim}
Keypad

\[ \text{variable} = \text{Keypad(portBlock)} \]

- \text{variable} : Variable to store results (Returns Byte, No String or Single)
- \text{portBlock} : Port block (0 to 15)

Use this command to read input from a matrix keypad. One port block can be used to read a 4 by 4 keypad input. The keypad rows should be connected to the lower 4 bits of the Port Block, and the keypad columns should be connected to upper 4 bits of the port block.

Pullup resistors (2.2K to 10K) should be connected to the lower 4 bits of the port block. A resistor should be connected even if a row is not being used.

Please refer to the diagram below:

\[
\begin{array}{cccc}
0 & 1 & 2 & 3 \\
4 & 5 & 6 & 7 \\
8 & 9 & 10 & 11 \\
12 & 13 & 14 & 15 \\
\end{array}
\]

\[
A = \text{Keypad(0)} \quad \text{' Read the status of keypad connected to Port Block 0}
\]

If no keys are pressed, 255 will be returned. Otherwise, the pressed key's scan code will be returned.
**Low**

*Low port*

*port : I/O port number (0 to 255)*

This command sets the port's I/O mode to output and outputs logic low or 0V (GND).

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output 8</td>
<td>'Set port 8's I/O mode to output</td>
</tr>
<tr>
<td>LOW 8</td>
<td>'Set logic low (0V) on port 8.</td>
</tr>
</tbody>
</table>

When a port is set to logic high, the port is internally connected to VDD (5V). If it is set to a logic low, the port is internally connected to VSS (0V). This allows either source or sink interfacing to external components (up to 25mA for source or sink).
MemAdr( )

\[ \text{variable} = \text{MemAdr}(\text{targetVariable}) \]

\[ \text{variable} : \text{Variable to store results (No String or Single)} \]

\[ \text{targetVariable} : \text{Variable whose physical memory address should be returned} \]

The `MemAdr` command will return the memory location of the specified target variable. This can be useful when used with the `Peek` and `Poke` commands; operations similar to C pointer manipulation can be performed.

```
Dim A as Single
Dim Adr as Integer
Adr = MemAdr(A) 'Return the physical address of A.
```

`MemAdr` does not work with arrays.
Ncd

\[ \text{variable} = \text{Ncd } \text{bitPosition} \]

\[ \text{variable} : \text{Variable to store results. (No String or Single)} \]

\[ \text{bitPosition} : \text{Position of bit (0 to 31)} \]

The \text{ncd} command is used to return a value with the specified bit set to 1.

\[
\begin{align*}
I &= \text{Ncd } 0 \ 'Result is 00000001 = 1 \\
I &= \text{Ncd } 1 \ 'Result is 00000010 = 2 \\
I &= \text{Ncd } 2 \ 'Result is 00000100 = 4 \\
I &= \text{Ncd } 3 \ 'Result is 00001000 = 8 \\
I &= \text{Ncd } 4 \ 'Result is 00010000 = 16 \\
I &= \text{Ncd } 5 \ 'Result is 00100000 = 32 \\
I &= \text{Ncd } 6 \ 'Result is 01000000 = 64 \\
I &= \text{Ncd } 7 \ 'Result is 10000000 = 128
\end{align*}
\]
**Nop**

*Nop*

This command does nothing, but consumes one command cycle. It is useful for tuning small intervals.

<table>
<thead>
<tr>
<th>Low 8</th>
<th>Nop</th>
</tr>
</thead>
<tbody>
<tr>
<td>High 8</td>
<td>'Output very short pulse to port 8. (About 50 micro Sec)</td>
</tr>
<tr>
<td>Nop</td>
<td></td>
</tr>
<tr>
<td>Low 8</td>
<td></td>
</tr>
</tbody>
</table>
On Int

On Int0 GoSub label
On Int1 GoSub label
On Int2 GoSub label
On Int3 GoSub label

This command must be called before accepting external interrupts. Cubloc has 4 external interrupt ports. The interrupt ports can be set to sense input on the rising edge, falling edge, or both.

Set OnIntx command must be used with this command in order for the interrupt to work.

*CB220 has no external interrupt inputs.

```
Dim A As Integer
On Int0 GoSub GETINT0
Set Int0 0 'Falling Edge Input
Do
Loop

GETINT0:
A=A+1 'Record number of interrupts
Return
```
On LadderInt GoSub
*On LadderInt GoSub label*

If Register F40 turns on in Ladder Logic, and the **On LadderInt GoSub** command is used, then the processor will jump to the routine (**label**) specified by **On LadderInt**.

This can be used when a Ladder Logic program needs to trigger a specific procedure in BASIC.

Please use the **SetOut** and **DIFU** command to write 1 to the register F40. When the BASIC interrupt routine is finished, register F40 can be cleared by writing a zero to it.

During the interrupt service routine (ISR) execution, writing a 1 to register F40 will not allow another interrupt to occur. If register F40 is cleared from BASIC, it signals the end of the ISR and can process another interrupt.

```
UsePin 0, In
Set Ladder On
Set Display 0, 0, 16, 77, 50
On LadderInt GoSub msg1_rtn
Dim i As Integer
Low 1

Do
  i = i + 1
  ByteOut 1, i
  Delay 200
Loop
msg1_rtn:
Locate 0, 0
Print "On LadderInt", Dec i
Reverse 1
Return
```

When P0 turns on, register F40 turns on and the msg1_rtn interrupt routine in BASIC is executed. In the ISR, a **String** is printed to the LCD.
Although there is only one register, F40, with which call an ISR in BASIC from Ladder Logic, we can use data register D to process many different types of interrupts.

Given the ladder above, when P0 turns on, D0 gets 3 and the interrupt routine is executed. If P2 turns on, D0 gets 2 and the interrupt routine is executed. In the ISR, the user can then process the type of interrupt based on the value stored in D0.

```plaintext
msg1_rtn:
  If _D(0)=3 Then
    Locate 0,0
    Print "ON Ladderint",Dec i
  End If
  If _D(0)=2 Then
    Locate 0,0
    Print "TEST PROGRAM",Dec i
  End If
  Return
```

For a short version of the ladder above the user can use an INTON command, which accomplishes both WMOV and SETOUT in one command.

The following is an equivalent shortened version of the ladder above:

```plaintext
<table>
<thead>
<tr>
<th>P0</th>
<th>INTON 3,D0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WMOV 3,D0</td>
</tr>
<tr>
<td>P2</td>
<td>SETOUT F40</td>
</tr>
<tr>
<td></td>
<td>WMOV 2,D0</td>
</tr>
<tr>
<td></td>
<td>SETOUT F40</td>
</tr>
<tr>
<td>P1</td>
<td>INTON 2,D0</td>
</tr>
</tbody>
</table>
```
On Pad

On Pad GoSub label

The On Pad interrupt will jump to the specified label when the keypad/touchpad port receives a packet (packets sizes are assigned by the Set Pad command). Please be sure to use a Return command after the label.

Const Device = Ct1720
Dim TX1 As Integer, TY1 As Integer
Contrast 450
Set Pad 0,4,5
On Pad GoSub GETTOUCH
Do
Loop

GETTOUCH:
   TX1 = GetPad(2)
   TY1 = GetPad(2)
   CircleFill TX1,TY1,10
   PulsOut 18,300
   Return
On Recv

On Recv0  GoSub label
On Recv1  GoSub label
On Recv2  GoSub label
On Recv3  GoSub label

When data is received on one of Cubloc's RS-232 channels, this command will jump to the specified label (Recv0 for channel 0, Recv1 for channel 1, etc...). The processor will automatically check for received data and trigger interrupts when this command is used.

Dim A(5) As Byte
OpenCom 1,19200,0, 100, 50
On Recv1 DATARECV_RTN      ' Jump to DATARECV_RTN when RS232 channel 1 receives any data

Do
Loop      ' Infinite Loop

DATARECV_RTN:
  If BLen(1,0) > 4 Then
    A(0) = Get(1,1)  ' Read 1 Byte.
    A(1) = Get(1,1)  ' Read 1 Byte.
    A(2) = Get(1,1)  ' Read 1 Byte.
    A(3) = Get(1,1)  ' Read 1 Byte.
    A(4) = Get(1,1)  ' Read 1 Byte.
  End If
Return      ' End of interrupt routine

**IMPORTANT**

When a Recv interrupt service routine (ISR) is being executed, subsequent Recv interrupts will not be received. After the ISR is finished executing, if there is still data being received, another Recv interrupt will be generated, and the ISR will execute again.
On Timer()
On Timer( interval ) GoSub label

interval : Interrupt interval 1=10ms, 2=20ms......65535=655350ms
1 to 65535 can be used

On Timer can be used to repeatedly execute an interrupt routine on a specified interval. Set the desired interval in increments of 10 milliseconds, and a label to jump to when interrupt occurs.

On Timer(100) GoSub TIMERTN
Dim i As Integer

I = 0

Do
Loop

TIMERTN:
Incr i  ' i is incremented by 1 every second.
Return

IMPORTANT

Be aware that the interrupt service routine (ISR) must require less time to execute than the interval itself. If the interval is set to 10ms, the ISR must execute within 10 ms; otherwise collisions can occur.
OpenCom

OpenCom channel, baudRate, protocol, recvSize, sendSize

channel : RS232 Channel (0 to 3)
baudRate : BaudRate (Do not use a variable)
protocol : Protocol (Do not use a variable)
recvSize : Receive buffer size (Max. 1024, Do not use a variable)
sendSize : Send buffer size (Max. 1024, Do not use a variable)

This command must be used to enable RS-232 communication.

The Cubloc has 2 or 4 channels for RS-232C communication, depending on the model. Channel 0 is typically used for monitoring and downloading, but it can also be used for RS-232 communication if monitoring is not needed. Downloading will still work regardless.

You may use any value between 2400 to 230400, but we are recommed one of the following values.

2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, 76800, 115200, 230400

For the protocol parameter, please refer to the table below:

<table>
<thead>
<tr>
<th>Bit7</th>
<th>Bit6</th>
<th>Bit5</th>
<th>Bit4</th>
<th>Bit3</th>
<th>Bit2</th>
<th>Bit1</th>
<th>Bit0</th>
<th>Parity</th>
<th># of Bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0 = NONE</td>
<td>Stop Bit</td>
<td>0</td>
<td>0 = 5 bit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1 = Reserve*</td>
<td>1=2 Stop Bits</td>
<td>Bit</td>
<td>0 = 6 bit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0 = Even</td>
<td>1 = 7 bit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0 = Odd</td>
<td>1 = 8 bit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following table shows typical settings based on the previous table:

<table>
<thead>
<tr>
<th>Bits</th>
<th>Parity</th>
<th>Stop Bit</th>
<th>Value to Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>NONE</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>EVEN</td>
<td>1</td>
<td>19 (Hex = 13)</td>
</tr>
<tr>
<td>8</td>
<td>ODD</td>
<td>1</td>
<td>27 (Hex = 1B)</td>
</tr>
<tr>
<td>7</td>
<td>NONE</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>EVEN</td>
<td>1</td>
<td>18 (Hex = 12)</td>
</tr>
<tr>
<td>7</td>
<td>ODD</td>
<td>1</td>
<td>26 (Hex = 1A)</td>
</tr>
</tbody>
</table>

OpenCom 1, 19200, 3, 30, 20 'Set to 8-N-1
The send and receive buffer size can be set with the OpenCom command. Each buffer can be as large as 1024 bytes, but be aware that the send and receive buffers consume data memory. So the larger the buffers, the fewer number of variables can be used in the program. Receive buffer sizes from 30 to 100 and send buffer sizes from 30 to 50 will suffice for most programs.

For the CB220 module, pins 1 and 2 can be used for channel 0. Ports 10 and 11 can be used for channel 1.

For the CB280 module, there are dedicated RS-232 ports. For channel 1, there are 2 types of outputs: +/-12V and TTL (+5/0V).

Please make sure to use only one of them at a time.

*If necessary, the Set RS232 command can reset the RS-232 channel's configuration during program execution.
CB400/CB405 RS232 How-to

The following is a table of the 5V TTL signal pins for the CB405:

<table>
<thead>
<tr>
<th>Channel</th>
<th>I/O Port</th>
<th>5V TTL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P42</td>
<td>RX</td>
</tr>
<tr>
<td></td>
<td>P43</td>
<td>TX</td>
</tr>
<tr>
<td>2</td>
<td>P8</td>
<td>RX</td>
</tr>
<tr>
<td></td>
<td>P9</td>
<td>TX</td>
</tr>
<tr>
<td>3</td>
<td>P56</td>
<td>RX</td>
</tr>
<tr>
<td></td>
<td>P57</td>
<td>TX</td>
</tr>
</tbody>
</table>

The CB400/CB405 has an internal MAX232 that can be used to convert any of the 5V TTL signals to +/- 12V level signals. The following is an example for connecting channel 3:

This allows any +/- 12V RS232 device to connect to TXE and RXE.
Out

Out port, value

  port : I/O port number (0 to 255)
  value : Value to output to the specified I/O port (1 or 0)

This command outputs a 1 (logic high) or a 0 (logic low) to the specified Port. When you execute this command, the Cubloc will automatically set the port's I/O mode to output. If using the Out command it is not necessary to use the Output command to set the port beforehand.

```
Out 8,1  'Output a logic high signal on port 8.
        '(This is same as using command High 8)
Out 8,0  'Output a logic low signal on port 8.
        '(This is same as using Low 8)
```
Output

Output port

port : I/O port number (0 to 255)

Set the port's I/O mode to output. All Cubloc module's I/O ports are set to High-Z input by default at power on.

Output 8 'Set port 8's I/O mode to output.

You can also use the High or Low commands to set a port's I/O mode to output. When using the Output command, the port's output (logic high or logic low) is not clearly defined. Therefore, it recommended to use the High or Low commands to set a port's I/O mode so the port's output is properly initialized.

Low 8 'Set port 8's I/O mode to output and output a logic low.
**OutStat( )**

*variable = OutState(port)*

- **variable**: Variable to store results. *(No String or Single)*
- **port**: I/O port number *(0 to 255)*

Reads the current output value for the specified port. This command is different from the `In` command; it reads a port's current output, not input.

```vba
Dim A As Byte
A = OutStat(0) 'Read from port 0 and store the output in A.
```

---

**Pause**

*Pause value*

Same as `Delay`
**Peek( )**

\[\text{variable} = \text{Peek}(\text{address, length})\]

- **variable**: Variable to store result (No String or Single)
- **address**: RAM address.
- **length**: Number of bytes to read (1 to 4)

Reads the specified length of data starting from the specified data memory address.

**Poke**

\[\text{Poke address, value, length}\]

- **address**: RAM address
- **value**: The value to write
- **length**: Number of bytes to write (1 to 4)

Write the specified length of data starting at the specified data memory address.

```plaintext
Const Device = CB280
Dim F1 As Single, F2 As Single
F1 = 3.14
EEWrite 10, Peek(MemAdr(F1),4),4
Poke MemAdr(F2), EERead(10,4),4

Debug Float F2, CR
```
**PulsOut**

*PulsOut port, period*

- **port**: Output port (0 to 255)
- **period**: Pulse period (1 to 65535)

This is a subroutine that outputs a pulse. To create a high pulse, the output port must be set to logic low beforehand. To create a Low pulse, the output Port must be set to logic high before hand.

If you set the pulse period to 10, you will create a pulse of about 2.6ms. Likewise, a Pulse Period of 100 will be about 23ms.

---

**Low 2**

```
PulsOut 2, 100 '23mS high pulse
```

**High 2**

```
PulsOut 2, 100 '23mS low pulse
```

---

PulsOut is a premade system subroutine.

```
Sub PulsOut(pt As Byte, ln As Word)
    Dim dl1 as integer
    Reverse pt
    For dl1=0 to ln
        Reverse pt
    Next
End Sub
```
Put

Put channel, data, byteLength

channel : RS-232 channel (0 to 3)
data : Data to send (up to Long type value)
byteLength : Length of data in bytes (1 to 4)

This command sends data on the specified RS-232 channel. For data, variables and constants can be used. To send a String, please use the PutStr command instead.

**IMPORTANT**
The `OpenCom` command must be used beforehand

```
OpenCom 1,19200,0,50,10
Dim A As Byte
A = &HA0
Put 1,A,1 ' Send &HA0 (0xA0) ' to RS232 Channel 1.
```

The data is first stored in the send buffer set by OpenCom. The Cubloc BASIC Interpreter will automatically keep transmitting the data until the send buffer is empty.

If the send buffer is full when the `Put` command is executed, `Put` will overwrite the data currently in the buffer. The `BFree` command can be used to check the send buffer beforehand to prevent overwriting existing data in the send buffer.

```
If BFree(1,1) > 2 Then ' If send buffer has at least 2 bytes free
    Put 1,A,2
End If
```

`Bfree` is used to check how much free space the send buffer has before writing any data to it.

**TIP**
After using `Put` or `PutStr`, the function `Sys(0)` can be used to verify that the data has been stored in the send buffer.

```
OpenCom 1,19200,0,50,10
PutStr 1,"COMFILE"
Debug Dec Sys(0) ' If output is 7, all data has been stored ' in the send buffer
```

*Please refer to the `On Recv` interrupt service routine for receiving data using the hardware serial buffer.*
**PutA**

*PutA channel, array, byteLength*

- **channel**: RS-232 channel. (0 to 3)
- **array**: The Byte array to send
- **byteLength**: Number of bytes to send (1 to 65535)

The command **PutA** is used to send a Byte array on the specified RS-232 channel. The array data will be sent starting from the first element of the array.

```vb
Dim A(10) As Byte
OpenCom 1,19200,0,50,10
PutA 1,A,10 ' Send 10 Bytes of Array A
```

**IMPORTANT**

If **byteLength** is larger than the array, Cubloc will send random values.

*Please refer to the On Recv interrupt routine for receiving data using the hardware serial buffer.*
PutA2

*PutA2 channel, array, byteLength, stopChar*

  channel: RS-232 channel. (0 to 3)
  array: The byte array to send
  byteLength: Number of bytes to send (1 to 65535)
  stopChar: Stop character ASCII code

Same as the PutA command, except it will stop transmission when the specified stop character in encountered in the array (stopChar will be the last character to be sent).
**PutStr**

*PutStr channel, data...*

- **channel**: RS-232 channel. (0 to 3)
- **data**: String data (String variable, String constant or Constant)

Sends String data on the specified RS-232 channel.

```
OpenCom 1,19200,0,50,10
PutStr 1,"COMPILE TECHNOLOGY", Dec I, Cr
```

Similar to the **Put** command, **PutStr** puts data to be sent in the RS-232 port's send buffer. Afterward, the Cubloc BASIC interpreter takes care of the actual sending. Use the **BFree** command to prevent overloading the send buffer.
Pwm

Pwm channel, duty, period

*channel: PWM channel (0 to 15)*
*duty: Duty cycle (must be less than the period)*
*period: Maximum of 65535*

Outputs a pulse waveform whose shape is determined by the values of duty and period. Be aware that the PWM channel is different from the I/O port number. For the CB280, ports 5, 6, and 7 are used for PWM 0, 1, and 2. Before using Pwm, make sure to set the ports' I/O mode to output, and set their output to a known state (logic low or logic high).

Depending on the value of period, a PWM signal of up to 16 bit precision is generated. A period of 1024 is a 10 bit pulse and a period of 65535 is a 16 bit pulse. The pulse's actual frequency in Hz can be computed with the following formula.

\[ \text{Frequency} = \frac{2,304,000}{\text{period}} \]

*duty* must to be less than *period*. The pulse's output will remain active for a fraction of the period given by *duty/period*.

Pwm is independently hardware driven within the Cubloc. Once the Pwm command is executed, it will keep running until the PwmOff command is called.

```
Low 5       ' Set port 5 output and output LOW signal.
Pwm 0,200,1024 ' Output 10-bit pulse with duty of 200 and
               ' width of 1024
```

**IMPORTANT**
PWM channels 0, 1, and 2 must use the same value for period since they share the same resources, but their duty cycles can be different. PWM channels 3, 4, and 5 also must use the same value for period, but again, their duty cycles can be different.
**PwmOff**

*PwmOff channel*

channel: PWM channel (0 to 15)

Stops the PWM output on the specified PWM channel.

The following illustrates the PWM channels available on each module:

For CB220, 3 PWM channels are provided on ports P5, P6, and P7.

Please refer to the table below for PWM channels and their corresponding I/O ports.
RamClear

Clear Cubloc BASIC’s RAM. BASIC’s data memory can hold garbage values at power on. RamClear can be used to initialize all data memory to zero.

*There are Cubloc modules that support battery backup of the RAM. If you don’t use the RamClear command in these modules, Cubloc will retain the values in RAM between power cycles.
Reset

Restarts the Cubloc BASIC program from the beginning. It does not clear the data memory, so any variables that have been declared will retain their values. RamClear should be used if this behavior is not desirable.
Reverse

Reverse port

port : I/O port number. (0 to 255)

Reverse the specified port output:  logic-high to logic-low, or logic-low to logic-high.

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output 8</td>
<td>' Set Port 8 to output.</td>
</tr>
<tr>
<td>Low 8</td>
<td>' Set output to logic low.</td>
</tr>
<tr>
<td>Reverse 8</td>
<td>' Reverse from logic low to logic high.</td>
</tr>
</tbody>
</table>
Rnd( )

variable = Rnd(0)

The command Rnd returns a random number from 0 through 32767. The number passed to Rnd has no effect, but is required.

```
Dim A As Integer
A = Rnd(0)
```

Internally, this function is pseudorandom; it creates a random number based on previous values. When powered off and turned back on again, the same pattern of random values is generated. Thus, this function is not a true random number generator.
Select...Case

Select Case variable
   [Case value [,value],…
      [Statement 1]]
   [Case value [,value],…
      [Statement 2]]
   [Case Else
      [Statement 3]]

End Select

If variable meets the value or expression following Case, the code beneath Case is executed.

Select Case A
   Case 1
      B = 0
   Case 2
      B = 2
   Case 3, 4, 5, 6
      B = 3
   Case Is < 1
      B = 3
   Case Else
      B = 4
End Select

Select Case K
   Case Is < 10
      R = 0
   Case Is < 40
      R = 1
   Case Is < 80
      R = 2
   Case Is < 100
      R = 3
   Case Else
      R = 4
End select
Set Debug

Set Debug On|Off

Set Debug is set to On by default.

You can use this command to control debugging functions in BASIC.

When you don’t need any debugging features, you can use this command to turn off all Debug commands instead of modifying every instance of the Debug command. When this command is used, no Debug command will be compiled; they are simply discarded from the program.

Debug Command How-to

When used correctly, the Debug command can help the user identify and fix bugs in a program. During a program's execution, variables can be monitored and verified, an LCD can be simulated, and do other tasks can be performed to increase development productivity.

1. How to Check if program is being reset

Sometimes, due to programming errors, a program can be automatically reset. This condition can be verified using Debug.

Simply put a Debug statement at the beginning of your program, such as 'Debug "=========Reset========="' as shown below:

```
Const Device = CB280
Debug "=========Reset========="
Do
  High 0
  Delay 200
  Low 0
  Delay 200
Loop
```

If the program is being reset, the "=========Reset=========" line will be printed more than once.
2. How to check if a particular point of the program is being executed

Simply insert a `Debug` command at the point in question, as shown below:

```plaintext
Const Device = CB280
Do
  High 0
  Delay 200
  Low 0
  Delay 200
Loop
Debug "This Part!"
```

(The debug statement above will never execute, as the program will execute the `Do...Loop` indefinitely)
3. How to simulate an LCD

You can simulate an LCD using the Debug terminal. Simply use GoXY, XX, YY to access a particular location on the terminal as shown below:

Use the command Debug Clr to clear the debug window. At any time during development, you can remove all Debug statements from the program’s compilation by using the command Set Debug Off.
Set I2C

Set I2C dataPort, clockPort

dataPort : SDA, data send/receive port. (0 to 255)
clockPort : SCL, clock send/receive port. (0 to 255)

The Set I2C command sets the data port (SDA) and clock port (SCL), for I2C communication. Once this command is executed, both ports' I/O modes become output, and their outputs become logic high. For I2C communication please use ports capable of both input and output and 4.7K resistors as shown below.

I2C communication requires ports capable of both input and output, but some ports are only capable of either input or output. Please check the port specifications in the data sheet for the model you are using.
Set Int

Set Int x mode

x : 0 to 3, External interrupt channel
mode : 0=Falling edge, 1=Rising edge, 2=Changing edge

This command must be used with the On Int command in order to receive external interrupts. The mode of interrupt can be set to trigger on either the falling edge, rising edge, or changing edge.

Set Int0 0  ' Set external interrupt 0 to trigger on the falling edge.
Set Ladder

*Set Ladder On|Off*

Ladder is set to **Off** by default. Use this command to turn enable Ladder Logic.

The following is an example of a simple BASIC program for starting Ladder logic:

```plaintext
Const Device = CB280 'Device Declaration

UsePin 0,In,START  'Port Declaration
UsePin 1,In,RESETKEY
UsePin 2,In,BKEY
UsePin 3,Out,MOTOR

Alias M0=RELAYSTATE  'Aliases
Alias M1=MAINSTATE

Set Ladder On  'Start Ladder

Do
   Loop  'BASIC program will run in infinite loop.
```

222
Set Modbus

Set Modbus mode, slaveAddress, returnInterval

mode : 0=ASCII, 1=RTU
slaveAddress : Slave address (1 to 254)
returnInterval : Return interval (1 to 255)

Cubloc supports the Modbus protocol in combination with Ladder Logic functions. Modbus can be used on RS-232 channel 1 only.

To enable Modbus slave mode, use the Set Modbus command. This command will enable the Modbus slave. It must come after an OpenCom command to set up RS-232 communication on RS-232 channel 1. The baud rate, stop bit, and parity settings can be set with OpenCom.

OpenCom 1,115200,3,80,80  ' Please set receive buffer
' to at least 50.
Set Modbus 0,1,100  ' ASCII mode, Slave address = 1

After this command, Cubloc responds automatically. Cubloc supports Modbus commands 1, 2, 3, 4, 5, 6, 15, and 16.

<table>
<thead>
<tr>
<th>Command</th>
<th>Command Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>01, 02</td>
<td>Bit Read</td>
</tr>
<tr>
<td>03, 04</td>
<td>Word Write</td>
</tr>
<tr>
<td>05</td>
<td>1 Bit Write</td>
</tr>
<tr>
<td>06</td>
<td>1 Word Write</td>
</tr>
<tr>
<td>15</td>
<td>Multiple Bit Write</td>
</tr>
<tr>
<td>16</td>
<td>Multiple Word Write</td>
</tr>
</tbody>
</table>

Please refer to Chapter 9 for detailed description of Modbus with ASCII and RTU examples.

The return interval is Cubloc's delay time for responding to the master Modbus device. If the return interval is set to be too fast, the master device might not be able to receive all data. The default setting is 1, which is about 200 micro-seconds. A value of 100 is about 4.5ms and a value of 255 is about 11ms.
Set OnGlobal

Set OnGlobal On|OFF

OnGlobal is On by default.

This command turns on or off the ability to process ALL interrupts.

When OnGlobal is set to Off and then set to On, all interrupt settings in effect before OnGlobal was set to Off will be still be in effect.

Set OnGlobal Off  ' Turn ALL interrupts OFF.

If you don’t use any interrupts, you can turn off all interrupts using Set OnGlobal Off to increase Cubloc's execution speed.
Set OnInt

Set OnIntx  On|Off
    x : 0 to 3, External interrupt channel

At power on, Set OnIntx is On by default.

This command turns on or off the ability to receive individual external interrupts. x corresponds to the interrupt number supported by the device. For example OnInt1 is used for interrupt 1.

When Set OnIntx is On for a specific interrupt, the interrupt service routine (ISR) set using the On Intx command will be executed when the corresponding interrupt occurs. If Set OnIntx is Off, then the ISR will not be executed when the corresponding external interrupt occurs. See also the Set Intx command which controls external interrupts.

```
Set OnInt0 On
Set OnInt1 On
Set OnInt1 Off
Set OnInt2 Off
Set OnInt3 On
```
Set OnLadderInt

Set OnLadderInt  On|Off

At power on, Set OnLadderInt is On by default.

This command turns on or off the ability to receive Ladder Logic interrupts.

When Set OnLadderInt is On, the interrupt service routine (ISR) set using the On LadderInt command will be executed when the corresponding interrupt occurs. If Set OnGlobal is Off, then the ISR will not be executed when the Ladder Logic interrupt occurs. See also the On LadderInt command.
Set OnPad

Set OnPad On|Off

At power on, Set OnPad is On by default.

This command turns on or off the ability to receive On Pad interrupts.

When Set OnPad is On, the interrupt service routine (ISR) set using the On Pad command will be executed when the corresponding interrupt occurs. If Set OnPad is Off, then the ISR will not be executed when the interrupt occurs. See also the Set Pad and On Pad commands.
Set OnRecv

At power on, Set OnRecv is On by default.

This command turns on or off the ability to receive OnRecv interrupts. An OnRecv interrupt occurs after data is received on the serial port AND stored in serial port's the receive buffer.

When Set OnRecv is On, the interrupt service routine (ISR) set using the OnRecv command will be executed when the corresponding interrupt occurs. If Set OnRecv is Off, then the ISR will not be executed when the interrupt occurs. See also the OnRecv command.
Set OnTimer

*Set OnTimer  On|Off*

At power on, Set OnTimer is On by default.

This command turns on or off the ability to receive On Timer interrupts. An interrupt occurs at every time interval set by the On Timer command.

When Set OnTimer is On, the interrupt service routine (ISR) set using the On Timer command will be executed when the corresponding interrupt occurs. If Set OnTimer is Off, then the ISR will not be executed when the interrupt occurs. See also the On Timer command.
**Set OutOnly**

*Set OutOnly On|Off*

The CB290/CT1721 output ports are in a high impedance (High-Z) state at power on in order to prevent the output of data prior to initialization.

Set OutOnly On must be used to enable the CB290 / CT1721's output-only ports.

Const Device = CB290
Set OutOnly On
Low 24

<table>
<thead>
<tr>
<th>Model</th>
<th>Output only port</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB290</td>
<td>P24 to P55</td>
</tr>
<tr>
<td>CT1720 / CT1721</td>
<td>P24 to P55</td>
</tr>
</tbody>
</table>
Set Pad

Set Pad mode, packetSize, bufferSize

mode : Bit mode (0 to 255)
packetSize : Packet size (1 to 255)
bufferSize : Receive buffer size (1 to 255)

The Cubloc has a dedicated port for keypad / touchpad inputs similar to a PC’s keyboard or mouse port. This port can be used with the Set Pad command to create interrupts when input is received on a keypad, touchpad, etc.,. This port is as an SPI slave.

To use pad communication, you must use a Set Pad command at the beginning of your program. Pad communication uses 4 wires. SCK is used as the clock signal, SS as the slave select, MOSI as the master out/slave in, and MISO as master in/slave out.

I/O ports P0 through P3 can be used for pad communication.
The `packetSize` parameter sets the packet size need to cause an interrupt. For example, the Cutouch panel requires 4 bytes to be received before an interrupt is generated.

The `bufferSize` parameter is the total size of the receive buffer. The buffer size must be at least 1 more than the packet size. A larger buffer will essentially give you more time to process the interrupt service routine. The buffer size is usually set to 5 or 10 times the packet size.

The `mode` parameter will set the receiving mode of the received data. Please refer to the following table:

<table>
<thead>
<tr>
<th>Mode</th>
<th>Value</th>
<th>Bit Pattern</th>
<th>Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSB First</td>
<td>&amp;H20</td>
<td>0010 xxxx</td>
<td></td>
</tr>
<tr>
<td>MSB First</td>
<td>&amp;H00</td>
<td>0000 xxxx</td>
<td></td>
</tr>
<tr>
<td>SCK Low-Edge Triggered</td>
<td>&amp;H08</td>
<td>xxxx 1xxx</td>
<td></td>
</tr>
<tr>
<td>SCK High-Edge Triggered</td>
<td>&amp;H00</td>
<td>xxxx 0xxx</td>
<td></td>
</tr>
<tr>
<td>Sampling after SCK</td>
<td>&amp;H04</td>
<td>xxxx x1xx</td>
<td>&quot;0&quot; ↑ &quot;1&quot; ↑ ↑</td>
</tr>
<tr>
<td>Sampling before SCK</td>
<td>&amp;H00</td>
<td>xxxx x0xx</td>
<td>&quot;0&quot; ↑ ↑ &quot;1&quot; ↑ ↑</td>
</tr>
</tbody>
</table>
The receiving modes can be added together. For example, for MSB first, High-Edge Triggered SCK, and sampling after SCK:

0x00 + 0x00 + 0x04 = 0x04

Here are some common examples:

For pad communications, you can use Comfile’s keypads and touch screens.

The Set Pad command will automatically set the I/O mode of ports P0 through P3; the user doesn’t have to set them.
Set RS232

Set RS232 channel, baudRate, protocol
channel : RS-232 Channel (0 to 3)
baudRate : baudRate (Do not use a variable)
protocol : Protocol (Do not use a variable)

You can only use the OpenCom command once to open a serial port. Set RS232 is used to change the baud rate and/or protocol of a serial port at run time.

For the protocol parameter, please refer to the table below:

<table>
<thead>
<tr>
<th>Bit 7</th>
<th>Bit 6</th>
<th>Bit 5</th>
<th>Bit4</th>
<th>Bit3</th>
<th>Bit2</th>
<th>Bit1</th>
<th>Bit0</th>
<th># of Bits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Parity</td>
<td>0</td>
<td>0 = NONE</td>
<td>Stop Bit</td>
<td>Bit</td>
<td>0 = 5 bit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>1 = Reserve*</td>
<td>0=</td>
<td>1 Stop Bit</td>
<td>0</td>
<td>1 = 6 bit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>0 = Even</td>
<td>1=</td>
<td>2 Stop Bits</td>
<td>1</td>
<td>0 = 7 bit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1 = Odd</td>
<td></td>
<td></td>
<td>1</td>
<td>1 = 8 bit</td>
</tr>
</tbody>
</table>

The following table shows typical settings based on the previous table:

<table>
<thead>
<tr>
<th>Bits</th>
<th>Parity</th>
<th>Stop Bit</th>
<th>Value to Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>NONE</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>EVEN</td>
<td>1</td>
<td>19 (Hex = 13)</td>
</tr>
<tr>
<td>8</td>
<td>ODD</td>
<td>1</td>
<td>27 (Hex = 1B)</td>
</tr>
<tr>
<td>7</td>
<td>NONE</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>EVEN</td>
<td>1</td>
<td>18 (Hex = 12)</td>
</tr>
<tr>
<td>7</td>
<td>ODD</td>
<td>1</td>
<td>26 (Hex = 1A)</td>
</tr>
</tbody>
</table>

OpenCom 1, 19200, 3, 30, 20 'Open Rs232 channel 1
Set RS232 1, 115200, 19 'Change the baud rate & parity
Set RS485

**Set RS485 channel, portNumber**

channel : RS-232 channel (0 to 3)

portNumber : Transmit enable port number

RS485 allows you to link multiple Cublocs up to a distance of 1.2km. With RS485, there must be 1 master and the rest must be slave devices. You can use a chip such as the SN75176B or use an RS232 to RS485 converter module.

With RS485, transmitting and receiving data cannot occur simultaneously. RS485 is known for being stable under noisy conditions.

You can refer to the following circuit schematic for connecting TTL signals from a CB280 to the RS485 chip, SN75176B:

RS485 communication needs a "Transmit Enable" signal to control when the device is sending or receiving. There can only be one device transmitting while all the other devices are in receiving mode.

Example:

When the PC is transmitting, all the slave devices can only receive data.
The **Set RS485** command allows the Cubloc or Cutouch to control the data line whenever it wants to send or receive data. While the data is being sent, the transmit enable pin will output active high. This will be done automatically by the Cubloc RTOS.

*NOTE:* If you are using an RS232-to-RS485 converter and it supports automatic mode, then you don’t need to use this command.

```
Set RS485 1,48  ' Set P48 as the transmit enable pin
```

When using the **Set RS485** command, the port chosen may not be used for other purposes.

1: Please refer to the diagram on the left when connecting multiple Cublocs or Cutouchs using RS485.

Please use a 120 Ohm terminating resistor for the device at the end.

The two 560 Ohm pull-up and pull-down resistors are required for proper communication.
Set Spi

Set Spi clk, mosi, miso, mode

 clk: port for clock output
 mosi: port for data (Master output, Slave Input)
 miso: port for data (Master input, Slave output)
 mode: communication mode
  bit 3: 0 = MSB start, 1 = LSB start
  bit 2: 0 = wait at clock LOW, 1 = wait at clock HIGH
  bit 1: Output sample point; 0 = before rising edge, 1 = after rising edge
  bit 0: Input sample point; 0 = before rising edge, 1 = after rising edge

Ex) Set Spi 9,8,7,0

Const Device = CB280
Dim Dtin As Byte
Set Spi 9,8,7,0
Dtin = Spi(Dtout,32)
Set Until

Set Until channel, packetLength[, stopChar]
  channel : RS232 channel. (0 to 3)
  packetLength : Length of packet (0 to 255)
  stopChar : Character to catch
  charCheck: (Optional) Whether to use stopChar
    0 = Check Char (default)
    1 = Don’t Check Char

This is a conditional statement you can put right after the On Recv command. Normally, the On Recv interrupt is generated when a single byte is received via the specified serial port. Set Until can be used to only generate an interrupt when either packetLength bytes are received, or stopChar is detected.

packetLength is used to interrupt stopChar never arrives. To interrupt only on packetLength, set charCheck to 1.

You MUST use this command with the On Recv command.

The following is an example:

```vba
Dim A(5) As Byte
OpenCom 1,19200,0, 100, 50
On Recv1 DATARECV_RTN
Set Until 1,99,"S"
```

As you can see above, the packet size is 99 bytes. In other words, if character "S" is not received within 99 bytes, an interrupt will occur.

The stop character may also be written in decimal form as shown below:

```vba
Set Until 1,100,4
```

In the following example, an interrupt be generated only when the packet length is greater than or equal to 5. charCheck is 1 so stopChar is ignored.

```vba
Set Until 1,5,0,1
```
ShiftIn( )

variable = ShiftIn(clock, data, mode, bitLength)

variable : Variable to store results. (No String or Single)
clock : Clock port. (0 to 255)
data : Data port. (0 to 255)
mode : 0 = LSB first (Least Significant Bit first), after rising edge
1 = MSB first (Most Significant Bit first), after rising edge
2 = LSB first (Least Significant Bit first), after falling edge
3 = MSB first (Most Significant Bit first), after falling edge
4 = LSB first (Least Significant Bit first), before rising edge
5 = MSB first (Most Significant Bit first), before rising edge
bitLength : Length of bits (1 to 16)

The ShiftIn command receives a shift input. It uses 2 ports, CLOCK and DATA, to communicate.

The ShiftIn and ShiftOut commands can be used to communicate with SPI, Microwire, and similar communication protocols. When using EEPROM, ADC, or DAC devices that require SPI communication, this command can be used.

Dim A AS Byte
A = ShiftIn(3,4,0,8) ' Port 3 is CLOCK, port 4 is DATA, ' mode is 0, 8 bits to be received.
**ShiftOut**

*ShiftOut* clock, data, mode, variable, bitLength

- **clock**: Clock port. (0 to 255)
- **data**: Data port. (0 to 255)
- **mode**: 0 = LSB first (Least Significant Bit first)
  1 = MSB first (Most Significant Bit first)
  2 = MSB first (Most Significant Bit first), create ACK (For I2C)
- **variable**: Variable to store data (up to 65535)
- **bitLength**: Bit length (1 to 16)

This command performs a shift output. There are 3 modes. Mode 2 is for the I2C protocol. In I2C communication, an ACK signal is required for every 8 bits.

```
ShiftOut 3,4,0,&H55,8 ' Port 3 = Clock, 
   ' Port 4 = Data, Mode = 0, send 0x55 
   ' 8 bits to be sent,
```

![ShiftOut Diagram](image)
**Spi**

\[ \text{InData} = \text{Spi}(\text{OutData}, \text{Bits}) \]

- **InData**: Input data
- **OutData**: Input data
- **Bits**: Number of bits (1 to 32)

This command sends and receives data simultaneously. In contrast, the ShiftOut and ShiftIn commands only support either sending data (ShiftOut) or receiving data (ShiftIn), but not both. The Spi command can be used on any I/O port.

The Set Spi command must be used prior to the Spi command to ensure the I/O ports are defined prior to sending or receiving data.
StepAccel

StepAccel channel, port, freqBase, freqTop, FreqAccel, qty

channel : StepPulse channel (StepAccel supports only 0)
port : Output port
freqBase : The starting stepper frequency (Up to FreqTop)
freqTop : The frequency after acceleration is finished (Up to 3.3KHz)
FreqAccel : The acceleration in steps per second
qty : # of pulses to output (up to 2147483647)

This command outputs a set number of pulses at a set frequency (up to 3.3kHz) with acceleration. The StepAccel command supports only 1 channel, so 0 must be used for the channel parameter.

You can use any of the available I/O ports on the Cubloc. When the StepAccel command is executed, the specified port's I/O mode is automatically set to output. Even after the command has finished generating pulses, the port's I/O mode remains output.

The output frequency can be set from 1hz to 3.3KHz.

This command will run in the background independently, so system resources can be used for other tasks.
StepPulse

StepPulse channel, port, freq, qty

\[
\begin{align*}
\text{channel} & : \text{StepPulse channel (0 or 1)} \\
\text{port} & : \text{Output port} \\
\text{freq} & : \text{Output frequency (Up to 15kHz)} \\
\text{qty} & : \# \text{ of pulses to output (up to 2147483647)}
\end{align*}
\]

This command outputs a set number of pulses at a set frequency (up to 15kHz). FreqOut and Pwm can also output pulses, but the number of pulses cannot be controlled and only the dedicated PWM ports can be used. With StepPulse, any output port can be used, and the number of pulses and pulse frequency can be controlled.

Depending on the Cubloc module used, the number of available channels may change. Please refer to the following table for module specific information.

<table>
<thead>
<tr>
<th>Module</th>
<th>Channels</th>
<th>Channel</th>
<th>PWM Channels that cannot be used during use of the command</th>
</tr>
</thead>
<tbody>
<tr>
<td>CB220, 280, 290, CT17XX</td>
<td>1</td>
<td>0</td>
<td>Channel 0: PWM 3, 4, 5</td>
</tr>
<tr>
<td>CB400, CB405</td>
<td>2</td>
<td>0 or 1</td>
<td>Channel 0: PWM 3, 4, 5, Channel 1: 6, 7, 8</td>
</tr>
</tbody>
</table>

StepPulse uses the Cubloc processor’s PWM counters. When using this command, PWM3, PWM4, and PWM5 cannot be used.

For the CB400/CB405, when using channel 1, PWM6, PWM7, and PWM8 cannot be used. With the CB2XX series, only channel 0 may be used. With the CB400/CB405, StepPulse can be used on 2 different channels simultaneously.

You can use any of the available I/O ports on the Cubloc. When the StepPulse command is executed, the specified port's I/O mode is automatically set to output. Even after the command has finished generating pulses, the port's I/O mode remains output.

The output frequency can be set from 1hz to 15kHz.

This command will run in the background independently, so system resources can be used for other tasks.
StepStat( )

variable = StepStat (Channel)

variable : Variable to store results
channel : StepPulse channel(0 or 1)

StepStat allows you to monitor how many pulses have been generated since the last StepPulse command.

StepStat will return double the number of pulses remaining to be generated. If there are 500 pulses left to output, StepStat will return 1000.

You can also check the output status of pulses using _F(56) or F56 in Ladder Logic. When channel 0 is generating pulses, _F(56) will be logic high, 1. When channel 1 is generating pulses, _F(57) will be logic high, 1. If no pulses are being generated the F registers will be logic low, 0.

StepStop

StepStop channel

channel : StepPulse channel (0 or 1)

The StepStop command immediately stops pulse output on the specified channel.
Demo Program

Const Device = CB280
Do
  Do While In(0) = 1
  Loop

  StepPulse 0, 5, 5000, 300

  Do While In(0) = 0
  Loop
Loop

When the port 0 switch is pressed, port 5 will output 300 pulses at the speed of 5kHz. The following is a circuit diagram for the code above:
A stepper motor controller can be created using a stepper motor and stepper motor driver as shown below.

Connect 3 Cubloc I/O ports to the stepper motor driver. The DISABLE and DIRECTION pins are only to enable and set the direction of the stepper motor.

Please refer to your stepper motor specifications for how many pulses are required to move the stepper motor one rotation.
Sys( )

\[
\text{variable} = \text{Sys(address)}
\]

variable : Variable to store results. (No String or Single)
address : Address. (0 to 255)

Use the Sys(0) and Sys(1) commands are used to read the status of the RS-232 buffers for both channel 0 and channel 1.

Sys(0) returns the actual number of bytes written to the RS-232 transmit buffer after executing commands Put or PutStr.

Sys(1) returns the actual number of bytes read from the RS-232 receive buffer after executing commands Get or GetStr.

Sys(5) returns the value of the system timer which increments approximately every 10ms. The value can only be read; not changed. The timer will increment up to 65,535 and then reset to 0. This timer can be used in applications that require and extra timer.

Sys(6) returns the address of the top of the stack in data memory. At power on, this value is 0. As variables are declared or subroutines and functions are called, this value will increase. This can be used provide an indication of a program’s data memory usage at runtime.

All other values are undefined.
TADIn()

variable = TADIn(Channel)

variable : Variable to store results. (No String or Single)
channel : AD channel number (Not Port number, 0 to 15)

This command is similar to ADIn, but returns the average of 10 values read with the ADIn command. When working under noisy environments, using TADIn could help in obtaining more precise results.

TADIn is a pre-made function:

```vbnet
Function TADIn(num As Byte) As Integer
    Dim ii As Integer, ta As Long
    ta = 0
    For ii = 0 To 9
        ta = ta + ADIn(num)
    Next
    TADIn = ta / 10
End Function
```
The CT1721C, CB290 has an internal Real Time Clock (RTC) chip. You can use the `Time` and `TimeSet` commands to write and read time values to and from the RTC. Time information such as the current time of day, day of the week, and year can be written to the RTC, and read from it in real-time.

If a backup battery is used, time is kept current even when the module powers off.

The following is a chart showing the addresses of the RTC and its corresponding values.

* You cannot use these commands for the CB220 nor CB280 since they do not have an RTC.

<table>
<thead>
<tr>
<th>Address</th>
<th>Value</th>
<th>Range</th>
<th>Bit Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Second</td>
<td>0 to 59</td>
<td>2nd digit place</td>
</tr>
<tr>
<td>1</td>
<td>Minute</td>
<td>0 to 59</td>
<td>2nd digit place</td>
</tr>
<tr>
<td>2</td>
<td>Hour</td>
<td>0 to 23</td>
<td>2nd digit place</td>
</tr>
<tr>
<td>3</td>
<td>Date</td>
<td>01 to 31</td>
<td>2nd digit place</td>
</tr>
<tr>
<td>4</td>
<td>Weekday</td>
<td>0 to 6</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Month</td>
<td>1 to 12</td>
<td>2nd digit place</td>
</tr>
<tr>
<td>6</td>
<td>Year</td>
<td>00 to 99</td>
<td>2nd digit place</td>
</tr>
</tbody>
</table>

Please refer to the chart below for the weekdays' corresponding numerical values:

<table>
<thead>
<tr>
<th>Day</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunday</td>
<td>0</td>
</tr>
<tr>
<td>Monday</td>
<td>1</td>
</tr>
<tr>
<td>Tuesday</td>
<td>2</td>
</tr>
<tr>
<td>Wednesday</td>
<td>3</td>
</tr>
<tr>
<td>Thursday</td>
<td>4</td>
</tr>
<tr>
<td>Friday</td>
<td>5</td>
</tr>
<tr>
<td>Saturday</td>
<td>6</td>
</tr>
</tbody>
</table>
System Real Time Clock RTC

This feature will allow you to use the system timer of a Cubloc as an RTC. You can use `Time` and `TimeSet` commands to access the following addresses:

<table>
<thead>
<tr>
<th>Address</th>
<th>Returning Value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Seconds</td>
<td>0 to 59</td>
</tr>
<tr>
<td>11</td>
<td>Minutes</td>
<td>0 to 59</td>
</tr>
<tr>
<td>12</td>
<td>Hours</td>
<td>0 to 65535</td>
</tr>
<tr>
<td>13</td>
<td>Continuous Seconds</td>
<td>0 to 65535</td>
</tr>
</tbody>
</table>

Address 10 will increment its value by 1 every second. When its value becomes 60, address 11 will increment its value by 1. When address 11’s value becomes 60, address 12 will increment its value by 1. When address 12’s value becomes 65535, it will reset back to 0. At power on, all addresses are set to 0. The `TimeSet` command can be used to set the time at the beginning of user’s program.

The system RTC (addresses 10 to 13)'s values are stored as raw binary values, unlike the CB290's and CB405's on-chip RTC. There is no need to convert the values using `BCD2Bin` and `Bin2BCD`.

The system RTC uses the processor’s system timer so there can be a slight time difference ( < 1%) after a 24 hour period.

```vbnet
Const Device = CB405
Dim i As Integer
Cls
TimeSet 10, 58
TimeSet 13, 254
Do
    i = Time(10)
    Debug Goxy, 0, 0, dec4 i, Cr
    Debug Goxy, 0, 1, dec4 Time(13)
    Delay 100
Loop
```

Address 13 will increment its value by 1 every second, just like address 10, except when it reaches 65,535 it will reset to 0. Addresses 10 through 13 must be used with Cubloc Studio version 2.0.X and above.
**TimeSet**

*TimeSet address, value*

*address : Address of time value (0 to 6)*

*value : Time value. (0 to 255)*

Use the `TimeSet` command to store new time values.

<table>
<thead>
<tr>
<th>Address</th>
<th>Value</th>
<th>Range</th>
<th>Bit Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Second</td>
<td>0 to 59</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; digit place 1&lt;sup&gt;st&lt;/sup&gt; digit place</td>
</tr>
<tr>
<td>1</td>
<td>Minute</td>
<td>0 to 59</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; digit place 1&lt;sup&gt;st&lt;/sup&gt; digit place</td>
</tr>
<tr>
<td>2</td>
<td>Hour</td>
<td>0 to 23</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; digit place 1&lt;sup&gt;st&lt;/sup&gt; digit place</td>
</tr>
<tr>
<td>3</td>
<td>Date</td>
<td>01 to 31</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; digit place 1&lt;sup&gt;st&lt;/sup&gt; digit place</td>
</tr>
<tr>
<td>4</td>
<td>Day</td>
<td>0 to 6</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; digit place 1&lt;sup&gt;st&lt;/sup&gt; digit place</td>
</tr>
<tr>
<td>5</td>
<td>Month</td>
<td>1 to 12</td>
<td>10 1&lt;sup&gt;st&lt;/sup&gt; digit place</td>
</tr>
<tr>
<td>6</td>
<td>Year</td>
<td>00 to 99</td>
<td>2&lt;sup&gt;nd&lt;/sup&gt; digit place 1&lt;sup&gt;st&lt;/sup&gt; digit place</td>
</tr>
</tbody>
</table>

The following is an example showing how to set the time, and output the current time to the debug window:

```
Const Device=CB290
Dim i As Byte
TimeSet 0,0   'Sec
TimeSet 1,&H32 'Min
TimeSet 2,&H11 'Hour
TimeSet 3,&H1  'Date
TimeSet 4,&H5  'Day of the week
TimeSet 5,&H6  'Month
TimeSet 6,&H5  'Year

Do
    i = Time(6)
    Debug "Year ","200",Hex i, " "
    i = Time(5)
    Select Case i
    Case 0
        Debug "January"
    Case 1
        Debug "February"
    Case 2
        Debug "March"
    Case 3
        Debug "April"
    Case 4
        Debug "May"
    Case 5
        Debug "June"
    Case 6
    Do
```

251
Debug "July"
Case 7
  Debug "August"
Case 8
  Debug "September"
Case 9
  Debug "November"
Case 10
  Debug "December"
End Select
i = Time(3)
Debug " ", Hex2 i  'Print date
Debug " "

i = Time(4)
Select Case i
Case 0
  Debug "Sunday 
Case 1
  Debug "Monday 
Case 2
  Debug "Tuesday 
Case 3
  Debug "Wednesday 
Case 4
  Debug "Thursday 
Case 5
  Debug "Friday 
Case 6
  Debug "Saturday 
End Select
Debug Cr

i = Time(2)
Debug Hex2 i,":"  
i = Time(1)
Debug Hex2 i,":"  
i = Time(0)
Debug Hex i,Cr
Delay 1000

Debug Terminal Screenshot:
**UDelay**

*UDelay* time

\[ time : Interval \ (1 \ to \ 65535) \]

*UDelay* is a more precise delay. The delay is initialized to about 70 micro-seconds. Every unit added to it will add 14 to 18 micro-seconds. For example, *UDelay* 0 would be about 70 micro-seconds. *UDelay* 1 would be about 82 to 84 micro-seconds.

```
UDelay 100   ' Delay about 1630 micro-seconds.
```

When an interrupt occurs or Ladder Logic code is being executed at the same time, this delay function might be affected. During this delay, BASIC interrupts are enabled and could cause further delay when using this command.

To prevent interference from Ladder Logic or BASIC interrupts, consider stopping Ladder Logic and all interrupts before using this command.
UsePin

UsePin port, In/Out[, aliasName]
    port : I/O port number. (0 to 255)
    In/Out : "In" or "Out"
    aliasName : Alias for the port (Optional)

This command is used to set a port's I/O mode and alias for Ladder Logic programs. This is required before the ports can be used in Ladder Logic.

UsePin 0,In,START
UsePin 1,Out,RELAY
UsePin 2,In,BKEY
UsePin 3,Out,MOTOR

Use the FreePin command to return reassign the port back to BASIC.
UTMax

UTMax variable

variable : Variable to increment. (No String or Single)

Increment the variable by 1 until the variables maximum is reached. When the maximum is reached, the variable is no longer incremented. The maximum here refers to the variable's type’s maximum value. For Byte the maximum would be 255, and for Integer the maximum would be 65535.

UTMax A

' Increment A by 1
Wait

Wait  

\[time\]  

\textit{time: interval variable or constant (in milliseconds) 10 to 2,147,483,640}

Wait for the specified time in milliseconds.

This command will generate a delay using the system clock. This delay function is accurate to 10ms. It is much more precise than the Delay command.

| Wait 10  | ' Delay 10 ms. |
| Wait 15  | ' Delay 10 ms. |
| Wait 110 | ' Delay 110 ms. |
| Wait 115 | ' Delay 110 ms. |
**WaitTx**

*WaitTx channel*

`channel : RS-232 channel, (0 to 3)`

This *WaitTx* command will wait until the send buffer is flushed.

**Without WaitTx, the following is necessary:**

```plaintext
OpenCom 1,19200,0, 100, 50
PutStr 1,"ILOVEYOU",CR

Do While BFree(1,1)<49  ' Wait until all data has been sent
  Loop
```

Using *WaitTx*, the process of sending data is simpler as shown below:

```plaintext
OpenCom 1,19200,0, 100, 50
PutStr 1,"ILOVEYOU",CR

WaitTx 1  ' Wait until all data has been sent
```

When this command is waiting, other interrupts may be called. In other words, this command will not affect other parts of the Cubloc system.
Chapter 7: Cubloc Display Library
The Cubloc integrated display functions make it easy to control Comfile LCD products such as the GHLCD or CLCD. Drawing lines, circles, boxes, and printing strings can all be done with a single line of code.

## Character LCD : CLCD

The CLCD products are blue or green LCDs that can display characters and numbers. A control board on the back of the device receives data and controls the attached LCD panel.

The CLCD receives data via RS-232 or the CuNet I2C communication protocol.
Set Display

Set Display type, method, baud, bufferSize

type : 0=RS-232LCD, 1= GHB3224, 2=CLCD

method : Communication method 0=CUNET, 1=RS-232 CH1

baud : Slave address when method = 0,
baudRate when method = 1

bufferSize : Send buffer size (up to 128)

This command is used to initialize the display settings. It can only be used once. All displays will communicate using the method set here. This command configures the type of LCD, the communication method, the baud rate, and the buffer size. CLCDs will use method 0.

Method = 1 (RS232 Channel 1)

This method only supports the use of RS-232 channel 1 for display. For the CB220, port 11(TX) is used.

For the CB280, pin 33 or pin 49 can be used. Pin 49 outputs a 12V level signal and pin 33 outputs a 5V level signal.
The following baud rates are supported:

2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, 76800, 115200, 230400.

The recommended buffer size is around 50 to 128. If the send buffer size too small, data will not be displayed correctly. If the send buffer size is too big, it will take up unnecessary memory.

```
Set Display 0,1,19200,50  ' Set Baud rate to 19200 and
                       ' send buffer to 50.
```

The `Set Display` command can only be used once at the beginning of the program.

**Method = 0 (Use CUNET)**

CUNET is an implementation of the I2C protocol that is part of the Cubloc.

For the CB220, use I/O port 8 (Clock) and I/O port 9 (Data).

```
| SOUT | 1 |
| SIRN | 2 |
| ATN  | 3 |
| VSS  | 4 |
| P0   | 5 |
| P1   | 6 |
| P2   | 7 |
| P3   | 8 |
| P4   | 9 |
| P5   | 10|
| P6   | 11|
| P7   | 12|
|VIN   | 24|
|VSS   | 23|
|RES   | 22|
|VDD   | 21|
|P15   | 20|
|P14   | 19|
|P13   | 18|
|P12   | 17|
|P11   | 16|
|P10   | 15|
|P9    | 14|
|SDA   | 13|
|SCL   | 12|
```

CUNET can be used with displays that support it. CUNET does not use baud rate settings, it uses slave address settings instead.

```
Set Display 2,0,1,50  ' CLCD, Slave address of 1, Send buffer of 50
```

Although multiple devices can be connected via I2C, for CUNET displays only ONE device may be attached.
**CLCD Module**

On the back of the CLCD, a control board is attached. This control board receives CuNET signals and prints to the CLCD.

![CLCD Module Image](image)

The CLCD can also communicate using RS-232. There are two RS-232 connectors, one for 3-pin 5V level signals and the other for 4-pin +/- 12V level signals.

![RS-232 Connectors](image)

Use the CLCD DIP switches to set the I2C slave address. The 4th DIP switch is not used.

<table>
<thead>
<tr>
<th>DIP Switch</th>
<th>RS232 Baud rate</th>
<th>I2C Slave Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON 1 2 3</td>
<td>2400</td>
<td>0</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>4800</td>
<td>1</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>9600</td>
<td>2</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>19200</td>
<td>3</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>28800</td>
<td>4</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>38400</td>
<td>5</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>57600</td>
<td>6</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>115200</td>
<td>7</td>
</tr>
</tbody>
</table>
CuNET and RS-232 communication can both be used. If both are connected, please make sure when one of them is processing, the other is not.

The following is the CLCD command table:

<table>
<thead>
<tr>
<th>Command</th>
<th>Example (hex)</th>
<th>Bytes</th>
<th>Execution Time</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESC 'C'</td>
<td>1B 43</td>
<td>2</td>
<td>15mS</td>
<td>Clear screen. A 15ms delay must be executed after this command.</td>
</tr>
<tr>
<td>ESC 'S'</td>
<td>1B 53</td>
<td>2</td>
<td>15mS</td>
<td>Cursor On (Default)</td>
</tr>
<tr>
<td>ESC 's'</td>
<td>1B 73</td>
<td>2</td>
<td>15mS</td>
<td>Cursor Off</td>
</tr>
<tr>
<td>ESC 'B'</td>
<td>1B 42</td>
<td>2</td>
<td>15mS</td>
<td>Backlight On (Default)</td>
</tr>
<tr>
<td>ESC 'b'</td>
<td>1B 62</td>
<td>2</td>
<td>15mS</td>
<td>Backlight Off</td>
</tr>
<tr>
<td>ESC 'H'</td>
<td>1B 48</td>
<td>2</td>
<td></td>
<td>Locate 0,0</td>
</tr>
<tr>
<td>ESC 'L' X Y</td>
<td>1B 4C xx yy</td>
<td>4</td>
<td>100 uS</td>
<td>Change the position of the cursor.</td>
</tr>
<tr>
<td>ESC 'D' 8byte</td>
<td>1B 44 Code 8bytes</td>
<td>11</td>
<td>100 uS</td>
<td>Character codes 8 through 15 are 8 custom characters that the user is free to create and use.</td>
</tr>
</tbody>
</table>

If the data received is not a command, the CLCD will display it on the screen.

When using RS-232, the maximum baud rate settings for 12V (4-pin) levels is 38400. For TTL 5V levels (3-pin), a baud rate up to 115200 can be used.

The following is an example of code using the CB280 to connect to a CLCD module using the CUNET protocol. When you execute this program, the CLCD will display incrementing numbers.

```vbnet
Const Device = CB280
Set Display 2,0,1,50 ' Set the SLAVE ADDRESS to 1 by manipulating the DIP switch.
Dim i As Integer
Delay 100 ' Delay for start up of CLCD
Cls
Delay 200 ' Delay for initializing and clearing CLCD
CsrOff
Locate 5,2
Print "Start!!!"
Delay 500
Cls
Delay 100
Do
  Incr i
  Locate 0,0
  Print "COMFILE"
  Delay 100
  Delay 200
  Cls
  CsrOff
  Locate 5,2
  Print "Start!!!"
  Delay 500
 Cls
  Delay 100
  Do
```

264
* The slave address specified in the Set Display command should match that of the CLCD.
The GHLCD is an LCD that features the ability to display characters and graphics on three different layers. Unlike the CLCD, the GHLCD supports many different commands for easily drawing lines, circles, and boxes. There are also commands to copy, cut, and paste graphics, and a BMP downloader for downloading images to the GHLCD.

The GHB3224C model is a blue and white STN type LCD with a display area of 320 by 240 pixels. There are 3 layers. The first layer is for text and the other 2 layers can be used for graphics.

* GHB3224C Library is 99% compatible with Cutouch modules.
The text layer is a 40x15 grid as illustrated below. Each character size is 8 by 16 pixels.

The GHLCD series features a 320 by 240 pixels for graphics.

Please note that graphics or characters will appear randomly when trying to print outside the specified range of pixels shown here.
GHB3224C supports CuNET.

The GHB3224C model supports CuNET. When using Cubloc with the GHCLD, using CuNET instead of serial communications will free up the serial port for other uses.

GHB3224C CuNET settings:

Set Display 1,0,1,50  'GHLCD, CUNET, Set Address to 1,
                   'Send buffer to 50.

*Warning : The CuNET slave address and display slave address must match. The display lave address can be set with the DIP switch.
Cls

Cls
Initialize the LCD and clear all layers.
(Leave a small amount of delay to give the LCD time to initialize.)

```
Cls
Delay 200
```

Clear

Clear layer
Erase the specified layer(s).

```
Clear 1  ' Erase (Text) Layer 1.
Clear 2  ' Erase (Graphic) Layer 2.
Clear 0  ' Erase all layers. Same as CLS.
```

CsrOn

CsrOn
Turn the cursor on. (Default is OFF).

CsrOff

CsrOff
Turn the cursor off.

Locate

Locate x,y

\[
\begin{align*}
x & : x \text{ coordinate of LCD} \\
y & : y \text{ coordinate of LCD}
\end{align*}
\]

Set the position of the text cursor. After the CLS command, the LCD defaults to position 0,0.

```
Locate 1,1  ' Move cursor to 1,1
Print "COMFILE"
```
Print

Print text

_text : String, String variable, or String constant containing text to be printed_

This command prints characters on the text layer. To print characters to the graphic layer, the GPrint command can be used.

_locate 1,1  
Print "COMFILE"

To connect multiple Strings, you can use a comma as shown below:

_Print "ABC","DEF","GHI"  
' Same as PRINT "ABCDEFGHI"._

Use CR for carriage return (new line).

_Print "California",CR  
' Print California and go to the next line._
**CLCDOut**

*CLCDOut x, y, text*
- *x*: x coordinate of LCD
- *y*: y coordinate of LCD
- *text*: String, String variable, or String constant containing text to be printed

The `CLCDOut` command was added to Cubloc Studio in v3.1.2. This command combines the Locate and Print commands into one statement.

```
CLCDOUT 3,2, "COMFILE" ' Print "Comfile" at position 3,2
```

Using the Locate and Print command separately can occasionally result in characters being printed to the wrong location. The `CLCDOut` command was created to address this problem.

```
Const Device = CB280
Dim I As Integer
Set Display 2,0,0,80

Do
  CLCDOUT 1,1,"COMFILE",Dec I
  Incr I
  Delay 200
Loop
```

This command can only be used with CLCD modules manufactured after December 2010. Users of existing CLCD modules manufactured before December 2010 should contact Comfile Technology for an upgrade.

This command is not supported by the GHLCD devices.

After executing this command, the Print command’s behavior is undefined. After the first `CLCDOut` command is executed, `CLCDOut` should be used exclusively, instead of `Print`, from that point on.
Layer

Layer layer1Mode, layer2Mode, layer3Mode

Layer1Mode : Set layer 1 mode (0=off, 1=on, 2=flash)
Layer2Mode : Set layer 2 mode (0=off, 1=on, 2=flash)
Layer3Mode : Set layer 3 mode (0=off, 1=on, 2=flash)

Set the mode of the specified layer. The flash mode will flash the layer at 16Hz. When the LCD is powered on, layer 1 and 2 defaults to on and Layer 3 defaults to off.

This command can be used to hide the process of drawing lines, circles, etc.,. Set the layer to off when drawing, then set the layer on when drawing is complete.
GLayer

GLayer layerNumber

LayerNumber : Set the graphic layer. (0,1,2)

There are 3 layers on the GHLCD GHB3224 series. Any of the layers may be used as a graphic layer. Graphic commands such as Line, Circle, and Box can be used to draw on a graphic layer. Normally, layer 1 is used for text while layer 2 is used for graphics. Layers 2 and 3 have slightly different characteristics. We recommend layer 2 for graphics that require a lot of erasing.

Layer 1 can also be used as a graphic layer. In this case, you can even erase text characters with graphic commands. To set Layer 3 to a graphic layer, use the command Layer 3 On.

Overlay

Overlay overlayMode

overlayMode : Logical mode (0=OR, 1=AND, 2=XOR)

This command determines the drawing logic mode between layer 1 and layer 2. Usually, layer 1 is for text and layer 2 is for graphics. By using this command, the user can specify the overlay mode when layer 1 and layer 2 are displaying on the same position. The default is XOR, which will invert when layer 1 and layer 2 print to the same positions. OR will allow graphics on both layers to overlap. AND will display graphics only where they overlap.
Contrast

Contrast value

value : Contrast value (1 to 1024)

This command controls the contrast of the LCD. Use this command with care, the contrast setting is sensitive. You will most likely need to adjust the contrast wheel on the back of the LCD after using this command.

Contrast 450
Delay 500

Please add a 500ms delay after each call to this command to prevent an overrun in the graphics buffer.

Light

Light value

value : Backlight 0=Off, 1=On

This command is used to turn the backlight on and off. The default is on.

Note: This command is obsolete for all devices manufactured after December 2012 due to a change in the backlight hardware.

WMode

WMode value

value : 0=Fast, 1=Slow

This command is used to select the method for refreshing the screen. To draw graphics or text, data must be written to memory. Slow mode only writes to memory between screen refreshes, so the screen redraws at a slower rate, but produces no imperfections in the display. Fast mode writes to memory at any time, so the screen refreshes at a faster rate, but can cause imperfections in the display, such as flickering and noise.
Font

Font fontSize, eFontWidth

fontSize : 0 to 8 Font Selection
eFontWidth : 0 = fixed width, 1=variable width

This command sets the size and width of the font used to print characters. The GHB3224 LCD has 4 different font sizes and 2 different widths.

<table>
<thead>
<tr>
<th>Font Size</th>
<th>Font</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,1</td>
<td>10 x 16</td>
</tr>
<tr>
<td>2,3,4,5</td>
<td>16 x 16</td>
</tr>
<tr>
<td>6,7</td>
<td>24 x 24</td>
</tr>
<tr>
<td>8</td>
<td>48 x 48</td>
</tr>
</tbody>
</table>

Const Device = CB290
Cls
Delay 100
Font 0,0
Glocate 10,10
GPrint "FONT 0,0 :ABCDEFGHIJKLMN"
Font 2,0
Glocate 10,30
GPrint "FONT 2,0 :ABCDEFGHIJKLMN"
Font 6,0
Glocate 10,50
GPrint "FONT 6,0 :ABCDEFGHIJKLMN"
Font 8,0
Glocate 10,72
GPrint "FONT 8,0 "
Font 0,1
Glocate 10,120
GPrint "FONT 0,1 :ABCDEFGHIJKLMN"
Font 2,1
Glocate 10,140
GPrint "FONT 2,1 :ABCDEFGHIJKLMN"
Font 6,1
Glocate 10,160
GPrint "FONT 6,1 :ABCDEFGHIJ"
Font 8,1
Glocate 10,185
GPrint "FONT 8,1 "

275
**Style**

*Style* *bold, inverse, underline*

- **bold**: 0=Normal, 2 or 3=Bold
- **inverse**: 0=Normal, 1=Inverse
- **underline**: 0=Normal, 1=Underline

This command is used to add bold, inverse, or underline decorations to your fonts.

---

**CMode**

*CMode value*

- **value**: 0=Box type, 1=Underline type

This command sets the type of cursor to use. The default is the underline type.

- 0 : BOX Type
- 1 : Under Line Type
**Line**

*Line*  $x_1, y_1, x_2, y_2$

This command draws a line from $x_1, y_1$ to $x_2, y_2$.

```
Line 10,20,100,120  ' Draw a line
```

**LineTo**

*LineTo*  $x, y$

This command draws a line from the last point to $x, y$.

```
LineTo 200,50
  ' Continue drawing a line from the last point
```
**Box**

Box \( x_1, y_1, x_2, y_2 \)

This command draws a rectangle with the upper-left coordinates of \( x_1, y_1 \) and the bottom right coordinates of \( x_2, y_2 \).

Box \( 10,20,200,100 \)  

' Draw a box

**BoxClear**

BoxClear \( x_1, y_1, x_2, y_2 \)

This command clears a rectangle with upper-left coordinates of \( x_1, y_1 \) and bottom-right coordinates of \( x_2, y_2 \).

BoxClear \( 10,20,200,100 \)  

' Clear box

**BoxFill**

BoxFill \( x_1, y_1, x_2, y_2, \text{logic} \)

\[ \text{logicOperator} : 0=\text{OR}, 1=\text{AND}, 2=\text{XOR} \]

This command draws a rectangle with upper-left coordinates of \( x_1, y_1 \) and bottom-right coordinates of \( x_2, y_2 \) and fill by logically combining with other BoxFill areas.

0 - OR will display BoxFill areas that overlap and BoxFill areas that don't overlap.
1 - AND will display only the BoxFill areas that overlap.
2 - XOR will display only the BoxFill areas that don't overlap.

BoxFill \( 10,20,200,100,0 \)  

' Draw and fill box
Circle

Circle $x, y, r$

This command draws a circle with center coordinates of $x, y$ and radius $r$.

```plaintext
Circle 200,100,50  ' Draw circle
```

CircleFill

CircleFill $x, y, r$

Draw and fill a circle with $x, y$ as the center and with $r$ as the radius.

```plaintext
CircleFill 200,100,50

' Draw and fill circle
```
**Ellipse**

*Ellipse* $x, y, r1, r2$

This command draws an ellipse with center $x$, $y$, horizontal radius $r1$, and vertical radius $r2$.

```
Ellipse 200,100,100,50  ' Draw ellipse
```

**ElFill**

*ElFill* $x, y, r1, r2$

This command draws and fills an ellipse with center $x$, $y$, horizontal radius $r1$, and vertical radius $r2$.

```
ElFill 200,100,100,50  
  ' Draw and fill ellipse
```
GLocate

GLocate x, y
This command specifies the graphical text position on the current graphic layer.

GLocate 128,32   ' locate new position
GPrint "CUTOUCH"

GPrint

GPrint string
This command prints a string on the graphic layer. You have more freedom printing text in the graphic layer, as you can use GLocate to specify the exact position. Then you can use the GPrint command to print a string at the specified location.

GPrint "CUBLOC IS FASTER",CR
   ' Print String and go to next line(CR)
DPrint

\textit{DPrint} \textit{string}

\texttt{DPrint} is similar to \texttt{GPrint}, except it over-writes the current graphics.

\texttt{DPrint "WE LOVE CUBLOC", CR \ ' Print String and go to next line}

This command prints faster than \texttt{GPrint} since it simply overwrites the background. When trying to display animations or numbers that change rapidly, such as a moving ball or the current time, \texttt{DPrint} will allow smoother transitions.

\texttt{DPrint} can only be used with X-Axis values that are a multiple of 8. For example, you can use \texttt{GLocate 8,2} or \texttt{GLocate 16,101} but not \texttt{GLocate 10,30}.
**Offset**

*Offset* \( x, y \)

This command offsets printed characters on the graphic layer. \( x \) is the spacing between characters, and \( y \) is the spacing between lines. The default value is 0. Both \( x \) and \( y \) can be set independently.

Offset 0,0 ` Default offset

```
0     319
0
239
```

CUBLOC IS FUN
COMFILE TECHNOLOGY

Offset 3,3 ` Set \( x \) and \( y \) offset to 3.

```
0     319
0
239
```

CUBLOC IS FUN
COMFILE TECHNOLOGY
**Pset**

*PSet x, y*

This command draws a dot at coordinates *x*, *y*.

```
PSet 200,100 ' Draws a dot
```

**Color**

*Color value*

*value*: 0 = *white*, 1 = *black*

This command sets the current drawing color. The default value is 0 (white).

```
Color 0 ' Set color to white.
```

**LineStyle**

*LineStyle value*

This command sets the line style used when drawing lines and shapes. You can make dotted lines by increasing *value*. The default value is 0, a solid line.

```
LineStyle 1 ' Use dotted lines
```

**DotSize**

*DotSize value, style*

*value*: the size of the dot
*style*: the style of the dot: 0 = rectangular, 1 = circular

This command sets the dot size used when drawing lines and shapes. Value sets the size of the dot, and style makes the dot either rectangular (0), or circular (1).

```
DotSize 1,1 ' Set dot size to 1 and dot style to circular.
```
Paint

Paint \( x, y \)

This command fills the area enclosing \( x, y \).

\[
\text{Paint } 100,100 \quad \text{' Fill the area enclosing ' } 100,100
\]

Arc

Arc \( x, y, r, \text{start}, \text{end} \)

This command draws an arc. \( x, y \) specifies the arc's center, \( r \) specifies the arc's radius, \( \text{start} \) specifies the angle at which to start drawing, and \( \text{end} \) specifies the angle at which to stop drawing.

\[
\text{Arc } 150, 150, 100, 200, 290 \quad \text{' Draw an arc ' } 200 \text{ to } 290 \text{ degrees.}
\]
**DefChr**

*DefChr code, data*

- **code**: Custom character code (&hDB30 to &hDBFF)
- **data**: 32byte bitmap data

This command creates custom characters. A character of size 16x16 pixels can be created and stored in the LCD memory. Then the character can be used just like any other regular character using the `Print` or `GPrint` and `DPrint`. A total of 207 custom characters can be stored in the memory. The characters are not preserved when powered off.

```
DefChr &HDB30,&HAA,&HAA,&HAA,&HAA,&HAA,&HAA,&HAA,_,
   &HAA, &HAA, &HAA, &H55, &HAA, &HAA, &HAA, &HAA,_,
   &HAA, &HAA, &HAA, &HAA, &HAA, &HAA, &HAA,_,
   &HAA, &HAA, &HAA, &HAA, &HAA, &HAA, &HAA, &HAA
```

```
Print Chr(&HDB30)
```

**Bmp**

*Bmp x, y, fileNumber, layer*

- **x, y**: Coordinates where bitmap should display
- **fileNumber**: Bitmap File number
- **layer**: Layer on which to display the bitmap.

The GHB3224 has flash memory for storing bitmap files. The BMP Downloader is used to download bitmaps to the LCD. Once the bitmaps files are stored in flash memory, this command can be used to display them on the LCD.

*The GHB3224 has 102,400 bytes of flash memory for storing bitmap files which can store approximately 10 320x240 full screen images.*
Graphic Data Push and Pop Commands

The GHB3224 has a separate stack for storing graphic data. The current screen can be pushed and popped on and off the stack. By saving and restoring the screen to the stack, copy, cut, and paste features can be implemented.

The GPush and GPop can be used for precise cutting of the current screen while HPush and HPop can be used for higher speed operations with less precision.

The stack is LIFO (last in first out), so it will pop the last screen that was pushed onto the stack.

There is approximately 32KB of stack memory on the GHB3224 which can store approximately 3 to 4 full screens. Please refer to the picture below for a depiction of how the stack works:
**GPush**

*GPush* $x_1, y_1, x_2, y_2, \text{layer}$

Push the rectangular area with upper-left coordinates $x_1, y_1$ and lower-right coordinates $x_2, y_2$ onto the stack.

```
GPush 10,20,200,100,2
```

![Diagram](image1)

**GPop**

*GPop* $x, y, \text{layer, logic}$

- logic =0 : OR
- logic =1 : AND
- logic =2 : XOR
- logic =3 : Clear screen then pop

This command pops a screen from stack and displays it on the specified layer at coordinates $x,y$. The logic parameter specifies how the popped screen should be combined with the data currently displayed on the specified layer.

```
GPop 120,20,2,0
```

![Diagram](image2)
**GPaste**

`GPaste x, y, layer, logic`

- `logic =0 : OR`
- `logic =1 : AND`
- `logic =2 : XOR`
- `logic =3 : Clear screen then pop`

This command pastes a screen from the stack and displays it on the specified layer at coordinates x,y. The logic parameter specifies how the popped screen should be combined with the data currently displayed on the specified layer.

This command is identical to `GPop` except it will not remove the screen from stack. Therefore, you can use this command if the current item in the stack must be used again.
**HPush**

*HPush* $x_1, y_1, x_2, y_2, \text{layer}$

The *HPush*, *HPop*, and *HPaste* commands are similar to *GPush*, *GPop*, and *GPaste* except the x coordinate in multiples of 8 as shown below:

The 320 pixels is divided into 40 columns, each 8 pixels wide.

```
HPush 6,20,12,100,2
```

**HPop**

*HPop* $x, y, \text{layer}$

This command is the same as *GPop*, except the x coordinate must be from 0 to 39.

```
HPop 10,20,2,0
```

**HPaste**

*HPaste* $x, y, \text{layer}$

This command is the same as *GPaste* except the x coordinate must be from 0 and 39.
**GHB3224C DIP Switch Settings**

On the back of the GHB3224B, there are DIP switches to set the RS232 baud rate and I2C slave address. GHB3224 DIP Switch number 4 is not used.

<table>
<thead>
<tr>
<th>DIP Switch</th>
<th>RS232 Baud Rate</th>
<th>I2C Slave Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON 1 2 3</td>
<td>2400</td>
<td>0</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>4800</td>
<td>1</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>9600</td>
<td>2</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>19200</td>
<td>3</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>28800</td>
<td>4</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>38400</td>
<td>5</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>57600</td>
<td>6</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>115200</td>
<td>7</td>
</tr>
</tbody>
</table>

Only one communication method (either CuNET or RS232) can be used at a time.
A seven segment display can be used to display numbers. Eight LEDs are used for most seven segment displays as shown below, allowing decimal points to be displayed as well.

Using a seven segment display requires specialized circuits to control and refresh the segment matrix. This increases in complexity with each digit added. In the interest of convenience and simplicity, we have developed an easy to use seven segment display called the CSG module.

As you can see above, the front has a 4 digit seven segment display and the back has two I2C connections. After connecting the CSG to a Cubloc, you can use the commands in the following table to easily and quickly display the numbers you want.

<table>
<thead>
<tr>
<th>Command</th>
<th>Explanation</th>
<th>Example Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSGDecSlaveAdr, Data</td>
<td>Output decimal value.</td>
<td>CSGDec 0, 1</td>
</tr>
<tr>
<td>CSGHexSlaveAdr, Data</td>
<td>Output hex as decimal value</td>
<td>CSGHex 0, 1</td>
</tr>
<tr>
<td>CSGNPutSlaveAdr, Digit, Data</td>
<td>Control digit places</td>
<td>CSGNPut 0, 0, 8</td>
</tr>
<tr>
<td>CSGXPuIntSlaveAdr, Digit, Data</td>
<td>Control digit places and output data as binary number</td>
<td>CSGXPuInt 0, 0, 9</td>
</tr>
</tbody>
</table>
CSGDec

The CSGDec command is used to print decimal values to the display.

```
Const Device = CB280
Set I2c 9,8 '← must be used before the CSGDec command
Dim b As Integer
b=8
Do
    CSGDec 0,b '← CSGDec command
    Delay 100
    b = b + 1
    If b=0 Then b=200
Loop
```

To use CSG commands, the Set I2C command must be used beforehand.

**Slave Address**

The I2C slave address can be set using the DIP switches on the back of the CSG module. A total of 4 addresses can be set per I2C line pair.

**CSG DIP Switch:**

<table>
<thead>
<tr>
<th>DIP Switch</th>
<th>Slave Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON 1 2 3</td>
<td>0</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>1</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>2</td>
</tr>
<tr>
<td>ON 1 2 3</td>
<td>3</td>
</tr>
</tbody>
</table>
To display more than 4 digits, use 2 CSG modules as shown below and set different slave addresses for each.

![CSG Modules](Image)

**CSGNPut**

CSGNPut slaveAddress, digit, data  

slaveAddress : CSG module I2C slave address  
digit : Digit position (0 to 3)  
data : Data (&H30 to &H39, &H41 to &H46)

This command displays the desired digit on the specified CSG module. The most significant bit of the data parameter controls the decimal point.

You can use &H30 through 39 and &H41 through &H46 only.

&H30 displays "0"  
&H31 displays "1"  
&H39 displays "9"  
&H41 displays "A"  
&H42 displays "b"  
&H46 displays "F"
CSGXPut

CSGXPut slaveAddress, digit, data
- **slaveAddress**: CSG module I2C slave address
- **digit**: Digit (0 through 3)
- **data**: Bit array with each position corresponding to an LED segment

This command turns on the LED at the specified position. When displaying anything other than numbers, this command can be used to control each LED segment individually.

To print an "L", positions D, E, and F must be turned on, corresponding to but positions 3, 4, and 5. Therefore the bit value would be 0011 1000, which in hexadecimal is &H38.

CSGXPut 0, 0, &H38 'Display an 'L'

CSGDec

CSGDec slaveAddress, data
- **slaveAddress**: CSG I2C slave address
- **data**: Decimal value

This command prints a decimal value to the CSG.

CSGHex

CSGHex slaveAddress, data
- **slaveAddress**: CSG slave address
- **data**: Hexadecimal value to display

This command prints a hexadecimal value to the CSG.
Chapter 8: Interfacing
Input/Output Circuits

How to connect LEDs
Connect an LED as shown below, and output a logic high to the connected I/O port to turn the LED ON.

![LED circuit diagram]

How to connect push buttons
Connect a push button as shown below, and set the connected port's I/O mode to input. When the button is pressed, the Cubloc will read logic high; otherwise it will read logic low.

![Push button circuit diagram]

How to connect a potentiometer
Connect the potentiometer as shown below to an A/D I/O port and use the ADIn command to read the position of the potentiometer.

![Potentiometer circuit diagram]

The Cubloc core module uses 5V power. When using a larger voltage, please use an appropriate voltage converter or regulator.
How to Connect an Output Relay.
The following diagram shows how to connect an output relay to a Cubloc I/O port. A photocoupler can be used to separate isolate 24V and 5V circuits and protect against noise. Noise coming from 24V circuit will not affect the 5V circuit and vice-versa.

How to Connect an NPN TR Output
This circuit diagram shows an NPN TR photocoupler separating the 5V circuit from the LOAD.

How to Connect a DC24V Input
Use a double polarity photocoupler to convert 24V signals to 5V signals. When input is received, the Cubloc will receive a logic high(5V) signal.
How to connect an AD Input

To connect an AD input to the CB280, the AVDD and AVREF pins must be connected to a 5V source. AVDD supplies power to the ADC of the Cubloc and AVREF is the reference voltage that the ADC uses to do conversions. If a 5V source is connected to the AVREF pin, input voltages from 0 to 5V will be converted and if a 3V source is connected to the AVREF pin, input voltages from 0 to 3V will be converted.

The CB220’s AVDD and AVREF are internally connected to 5V.

The following is the simplest AD input circuit using a potentiometer. When you turn the knob, the voltage will be converted by the Cubloc ADC to a digital value from 0 to 1023.
The following illustrates a 4-20mA signal connected to the ADC input port. You can use a 230 Ohm and 20 Ohm resistor in series instead of a 250 Ohm resistor.

For an input voltage from 0 to 10V, use 2 resistors as shown below. This is called a voltage divider.

**How to use a PWM as Digital-to-Analog converter**

The Cubloc has 6 PWM ports. If you use a simple circuit like that shown below, you can make a digital-to-analog converter.
RS-232 HOWTO

A PC's RS-232 interface typically use +/-12V signals, while the Cubloc's RS-232 interface uses 5V signals. To avoid the need to make a separate circuit to convert the +/-12V signals from the PC to the 5V signals of the Cubloc, and vise-versa, the Cubloc was built with both a +/-12V RS-232 interface (channel 0 – the download port) and a 5V RS-232 interface (channel 1).

The +/-12V RS-232 interface (channel 0) is provided on pins 1 and 2. For the CB220/320 a 5V RS-232 interface is provided on pins 10 and 11.

For the CB280/380, RS-232 channel 1 can make use of either 5V or +/-12V signals, but the pins are different. For a 5V interface, use pins 49 and 50. For a +/-12V interface use pins 33 and 34.

Downloading programs to the Cubloc is very easy, since the PC's RS-232 interface can connect directly to pins 1 and 2 of the Cubloc. For RS-422 and RS-485, 5V signals are provided on RS-232 channel 1.
For the CB280, a +/-12V RS-232 interface is provided in addition to the 5V interface, but only one can be used at a time.

The following shows a simple circuit diagram to convert a 12V RS-232 interface to a 5V RS-232 interface using a MAX232 chip.

The MAX232 is a very useful chip for converting between 5V and +/-12V RS-232 signals.
CUNET

CUNET is a communication protocol for Cubloc peripherals such as the CLCD, GHLCD, CSG modules. With just 2 pins, SCL and SDA, up to 127 devices can be communicated with simultaneously. CUNET uses Cubloc’s I2C protocol to perform the communication.

To use CUNET, please be sure to add pull up resistors (4.7K each) to the SCL and SDA lines. SCL and SDA pins are in an open-collector configuration, protecting against outside noise. It automatically removes pulses less than 50ns.

When using CUNET, the connector’s pin 1 must be connected to ground, pin 2 to 5V or RESET, pin 3 to SCL, and pin 4 to SDA. This 4 pin configuration is standard for all CUNET interfaces.

When using CUNET, the Cubloc core module will act as the master and the connected device will act as the slave. All CUNET devices will respond to the Cubloc while in an idle state.

CUNET is a master-slave protocol. Slaves cannot initiate communication with the master. For externally-initiated communication, you must use PAD communication. PAD can receive inputs from other external devices without the need for the Cubloc to initiate communication. Please refer to the On Pad command for more detailed information.
When the device is to be powered from the CUNET bus, pin 2 of the CUNET device should be connected to 5V on the main module:

![Diagram of CUNET connection](image)

Pin 2 of a CUNET device can be connected to RESET on the main module when a separate power supply is powering the CUNET device. (Active-low to RESET causes the Cubloc to reset)

![Diagram of CUNET connection with RESET](image)

CUNET cables can be up to 3 feet in length. For longer distances (up to approximately 1 mile), the Phillips I2C long distance interface chip (P82B96 or P82B715) can be used.
Cubloc Study Board Circuit Diagram

The Cubloc Study Board is useful for first timers and developers of the Cubloc. Simple experiments can be created using switches, LED, RS-232 communication, I2C, piezo, ADC, toggle switches, and LCDs.

When 9V is supplied, the 5V voltage regulator inside the Study Board will provide 5V to the main module and all peripherals. DC adapter polarity can be used either way. For normal operation, please use a 9V adapter with at least 200mA of current.
(1) To use RS-232 channel 1, please connect wires to the appropriate pins on the interface labeled RS-232C in the upper right hand corner.

(2) For the CB280, connect RS-232 channel 1 as shown below:

(3) When using CuNET, all jumpers must be shorted. If using pin 8 and 9 for general I/O, all jumpers should be left open.
About I²C...

The Cubloc provides an easy set of commands to communicate using the I²C protocol. I²C communication is a widely used protocol, primarily for communicating with ADC, EEPROM, DAC, and external I/O chips.

I²C uses two lines, SDA and SCL, and devices must operate in either master or slave mode. The Cubloc can only be used as a master.

Be sure to configure I²C using the Set I²C command before using any other I²C commands.

I²C’s START, STOP

When SCL(Clock) and SDA(Data) are logic high, I²C is in an idle state. If a START command is executed during the idle state, I²C begins.

When SCL and SDA are both logic low, I²C is in a busy state. If a STOP command is executed during the busy state, I²C stops.

There is also a Repeated Start in I²C. If a START command is executed during a busy state, I²C restarts.
Using an EEPROM through I²C

We will go through an example showing I²C communication between a Cubloc and a 24LC32 EEPROM. The following is a diagram from the EEPROM’s data sheet. It shows how to send data to the EEPROM.

![Diagram of EEPROM communication](image)

The first bit is for the Start command. The 4 upper bits of CONTROL BYTE must be 1010 and the 3 lower bits are for selecting the chip’s address. The user may change the EEPROM chip’s address by configuring the chip.

For a read, 1 can be written into R/W and for a write, 0 can be written into R/W. A is for acknowledgment of the 8 bits (1 byte) sent. Then HIGH ADDRESS, LOW ADDRESS and DATA can be sent. When all data is sent, the Stop command can be transmitted.

It takes about 5ms for each EEPROM write.

The following is an EEPROM write sequence in Cubloc’s BASIC code:

```
Set I2C 9,8    ' Set P9 as SDA, P8 as SCL
I2CStart
If I2CWrite(&b10100000) = 1 Then ERR_PROC    ' Chip Address = A0
If I2CWrite(adr.Byte1) = 1 Then ERR_PROC    ' Write address to write to
If I2CWrite(adr.LowByte) = 1 Then ERR_PROC
If I2CWrite(data) = 1 Then ERR_PROC    ' Write byte
I2CStop
Delay 5    ' Wait for the write operation to finish
```

Next, we will look at how to read 1 byte from the EEPROM. Although it might look more complex than writing 1 byte, we will soon find out that they are very similar.
Read Point is where the actual data will be read from the EEPROM. The first part of the command is for setting the address to read data from.

Set I2C 9,8
I2CStart
If I2CWrite(&b10100000) = 1 Then ERR_PROC ' Chip Address = A0
If I2CWrite(adr.Byte1) = 1 Then ERR_PROC ' Write address to read from
If I2CWrite(adr.LowByte) = 1 Then ERR_PROC
I2CStart
If I2CWrite(&b10100001) = 1 Then ERR_PROC ' Repeat start
If I2CWrite(&b10100001) = 1 Then ERR_PROC ' Read command.
Data = I2CRead(0) ' Store result to data
I2CStop

And now, we will look at how to read multiple bytes from the EEPROM. If we don't send a STOP command, we can keep reading from the EEPROM since it automatically increments its address. In this way, we can set the starting address only once, and then read the rest of the data much faster.

Set I2C 8,9
I2CStart
If I2CWrite(&b10100000) = 1 Then ERR_PROC ' Chip address = A0
If I2CWrite(adr.Byte1) = 1 Then ERR_PROC ' Write address to read from
If I2CWrite(adr.LowByte) = 1 Then ERR_PROC
I2CStart
If I2CWrite(&b10100001) = 1 Then ERR_PROC ' Repeat start
If I2CWrite(&b10100001) = 1 Then ERR_PROC ' Read command.
For i = 0 To 10
    adata(i) = I2CRead(0) ' Read 10 bytes continuously,
    ' adata is an array
Next
I2CStop
**I²C example**

The following example shows a CB280 and 24LC32 EEPROM connected. A value will be written to a specified address of the EEPROM and then read back to display on the DEBUG window of Cubloc Studio.

```vba
Const Device = cb280
Dim adr As Integer
Dim data As Byte
Dim a As Byte
data = &ha1
adr = &h3
Set I2C 3,2
Do
    ' Write 1 Byte
    I2CStart
    If I2CWrite(&b10100000)= 1 Then Goto err_proc
    a=I2CWrite(adr.byte1)
    a=I2CWrite(adr.lowbyte)
    a=I2CWrite(data)
    I2CStop
    Delay 1000

    ' Read 1 Byte
    I2CStart
    a=I2CWrite(&b10100000)
    a=I2CWrite(adr.Byte1)
    a=I2CWrite(adr.LowByte)
    I2CStart
    a=I2Cwrite(&b10100001)
    a=I2CRead(0)
    I2CStop

    ' Print Results
    Debug Hex a,cr
    Delay 500
Loop

err_proc:
    Debug "Error !"
    Do
    Loop
```
More About I²C... (Advanced)

I²C is a common protocol used by many devices today. Cubloc uses I²C as one of its primary communication protocols.

CuNET is built upon the I²C protocol. The main advantage of CuNET is that it’s hardware controlled for LCDs. (Not CSG modules or I/O ports)

I²C commands such as I2CWrite and I2CRead are software commands. An advantage of I²C is that it does not require receive interrupts like serial communications; the clock line is controlled by the master device. This allows the Cubloc to multi-task, not creating any situations where the processor can "freeze" indefinitely while attempting to communicate. The Cubloc can simply request data when it wants to; it does not have to wait for the I²C slave device to respond.

As a result, a Cubloc CB280 module can interface with up to 24 separate I²C buses! (That’s buses, you can add multiple I²C devices per I²C bus!)

The Cubloc simulates a master I²C device. Therefore, all other connected I²C devices must operate as slaves.

*Note: The I/O port used for I²C communication must be an Input/Output port, not Input Only or Output Only.

Even though the maximum range for a typical I²C bus is around 12 feet, a long distance extender chip such as the P82B715 can be used to extend the bus to almost ¾ of a mile. A P82B96 can also be used as a buffer to protect the I²C devices from electrical surges and interference.
Extend to almost ¾ of a mile using the P82B715.

By using the P82B96, ground and power can be isolated on each end.

Please refer to Phillips website for more information on the specific chips discussed here: [http://www.standardics.nxp.com/](http://www.standardics.nxp.com/).
If you are using I²C **within 12 feet**, we recommend using the following protection circuit:

If the I²C devices are connected with no buffers, electrical interference can cause damage either the Cubloc or the I²C slave device. By using diodes as shown below, you can protect against most of the electrical interference. If the devices are in a heavy, industrial environment, we recommend using P82B96 chips as buffers.
Chapter 9: MODBUS
About Modbus...

Modbus is a protocol developed by Modicon as an interface to their PLCs.

It is usually used with devices like touchscreens, HMI devices, and SCADA software; most of which now support Modbus.

In Modbus, there are master and slave devices. The master provides command while the slave receives and responds to commands. The slave can only send data to the master when requested; it cannot initiate communication on its own.

Each slave has a unique address called a slave address. The master, using those slave addresses, can talk to one slave at a time.

For 1 to 1 connections, RS-232 can be used. For 1 to N connections, RS-485 can be used.

The master sends messages in units of "frames". Each frame contains the slave address, command, data, and checksum codes. The slave receives a frame, analyzes it, performs the requested function, and responds. When responding to the master, slaves also respond in frames.

There are two Modbus transmission modes, ASCII and RTU. RTU is binary and can be implemented in fewer bytes than ASCII, making it a little more compact. ASCII uses a Longitudinal Redundancy Check (LRC) for error checking while RTU uses a Cyclic Redundancy Check (CRC).

The table below shows a Modbus frame in both ASCII and RTU:

<table>
<thead>
<tr>
<th>Field</th>
<th>Hex</th>
<th>ASCII</th>
<th>RTU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td></td>
<td>: (colon)</td>
<td>None</td>
</tr>
<tr>
<td>Slave Address</td>
<td>0X03</td>
<td>0 3</td>
<td>0X03</td>
</tr>
<tr>
<td>Command</td>
<td>0X01</td>
<td>0 1</td>
<td>0X01</td>
</tr>
<tr>
<td>Start Address HI</td>
<td>0X00</td>
<td>0 0</td>
<td>0X00</td>
</tr>
<tr>
<td>Start Address LO</td>
<td>0X13</td>
<td>1 3</td>
<td>0X13</td>
</tr>
<tr>
<td>Length HI</td>
<td>0X00</td>
<td>0 0</td>
<td>0X00</td>
</tr>
<tr>
<td>Length LO</td>
<td>0X25</td>
<td>2 5</td>
<td>0X25</td>
</tr>
<tr>
<td>Error Check</td>
<td></td>
<td>LRC (2 Bytes)</td>
<td>CRC(2 Bytes)</td>
</tr>
<tr>
<td>Ending Code</td>
<td></td>
<td>CR LF</td>
<td>None</td>
</tr>
<tr>
<td>Total Bytes</td>
<td></td>
<td>17 Bytes</td>
<td>8 Bytes</td>
</tr>
</tbody>
</table>

ASCII uses a colon (:) to mark the start of a start of a frame and ends the frame with a Carriage Return (CR) or a Line Feed(LF).
RTU requires no special characters to mark the start and end of a frame. It uses 4 bytes of silence (a delay) to indicate the start and finish.

### Cubloc support

**NOTE:** Starting with Cubloc Studio v3.3.1, the CB400, CB405 and CB405RT no longer support Modbus ASCII. However, Modbus RTU is still supported, so please use Modbus RTU instead.

Cubloc supports Modbus functions 1, 2, 3, 4, 5, 6, 15, and 16.

<table>
<thead>
<tr>
<th>Function Code</th>
<th>Function Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>01, 02</td>
<td>Bit Read</td>
</tr>
<tr>
<td>03, 04</td>
<td>Word Write</td>
</tr>
<tr>
<td>05</td>
<td>1 Bit Write</td>
</tr>
<tr>
<td>06</td>
<td>1 Word Write</td>
</tr>
<tr>
<td>15</td>
<td>Multiple Bit Write</td>
</tr>
<tr>
<td>16</td>
<td>Multiple Word Write</td>
</tr>
</tbody>
</table>

In Modbus, there are addresses that correspond to Cubloc registers. Cubloc’s registers P, M, F, C, T, and D can be accessed using the addresses in the following table:

<table>
<thead>
<tr>
<th>Bit Units</th>
<th>Word Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>Address</td>
</tr>
<tr>
<td>Register</td>
<td>Register</td>
</tr>
<tr>
<td>0000H P</td>
<td>5000H T</td>
</tr>
<tr>
<td>1000H M</td>
<td>6000H C</td>
</tr>
<tr>
<td>2000H Not Used</td>
<td>7000H D</td>
</tr>
<tr>
<td>3000H Not Used</td>
<td>8000H WP</td>
</tr>
<tr>
<td>4000H F</td>
<td>9000H WM</td>
</tr>
<tr>
<td>0A000H WF</td>
<td></td>
</tr>
</tbody>
</table>
**Function Code 01: Read Coil Status**

**Function Code 02: Read Input Status**

These functions are used to read the bit status of a PLC’s Register. The following is an example that reads registers P20 through P56 from slave address of 3.

**Query:**

<table>
<thead>
<tr>
<th>Field</th>
<th>RTU</th>
<th>Bytes</th>
<th>ASCII</th>
<th>Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>: (colon)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slave Address</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Function Code</td>
<td>0X01</td>
<td>1</td>
<td>0 1</td>
<td>2</td>
</tr>
<tr>
<td>Start Address HI</td>
<td>0X00</td>
<td>1</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Start Address LO</td>
<td>0X14</td>
<td>1</td>
<td>1 4</td>
<td>2</td>
</tr>
<tr>
<td>Length HI</td>
<td>0X00</td>
<td>1</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Length LO</td>
<td>0X25</td>
<td>1</td>
<td>2 5</td>
<td>2</td>
</tr>
<tr>
<td>Error Check</td>
<td>CRC</td>
<td>2</td>
<td>LRC</td>
<td>2</td>
</tr>
<tr>
<td>Ending Code</td>
<td>CR LF</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For Modbus ASCII, the LRC is the 2’s complement of the 8-bit sum of all packet values except the colon, CR, and LF.

For the table above, 0x03 + 0x01 + 0x13 + 0x25 = 0x3C.

To find the 2’s complement of 0x3C, we can write it in binary first.

0011 1100

Then invert the bits.

1100 0011

Then add one:

1100 0011 + 0000 0001 = 1100 0100 = 0xC4

The LRC is therefore 0xC4.

The table below illustrates this frame in Modbus ASCII.

<table>
<thead>
<tr>
<th>ASCII</th>
<th>Hex</th>
<th>:</th>
<th>0</th>
<th>3</th>
<th>0</th>
<th>1</th>
<th>0</th>
<th>0</th>
<th>1</th>
<th>3</th>
<th>0</th>
<th>0</th>
<th>2</th>
<th>5</th>
<th>C</th>
<th>4</th>
<th>CR</th>
<th>LF</th>
</tr>
</thead>
<tbody>
<tr>
<td>:</td>
<td>3A</td>
<td>30</td>
<td>33</td>
<td>30</td>
<td>31</td>
<td>30</td>
<td>30</td>
<td>31</td>
<td>33</td>
<td>30</td>
<td>30</td>
<td>32</td>
<td>35</td>
<td>43</td>
<td>34</td>
<td>13</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>
The response frame to the query above would be:

Response:

<table>
<thead>
<tr>
<th>Field</th>
<th>RTU</th>
<th>Bytes</th>
<th>ASCII</th>
<th>Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td></td>
<td></td>
<td>: (colon)</td>
<td>1</td>
</tr>
<tr>
<td>Slave Address</td>
<td>0X03</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Function Code</td>
<td>0X01</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Byte Count</td>
<td>0X05</td>
<td>1</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Data 1</td>
<td>0X53</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Data 2</td>
<td>0X6B</td>
<td>1</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Data 3</td>
<td>0X01</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Data 4</td>
<td>0XF4</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Data 5</td>
<td>0X1B</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Error Check</td>
<td>CRC</td>
<td>2</td>
<td>LRC</td>
<td>2</td>
</tr>
<tr>
<td>Ending Code</td>
<td></td>
<td></td>
<td>CR LF</td>
<td>2</td>
</tr>
</tbody>
</table>

If you look at the response to the query, you can see that bits 20 through 27 make up one byte.

Data 1's least significant bit corresponds to P20 and Data 1's most significant bit corresponds to P27. Likewise, Data 2 corresponds to P28 through P35, Data 3 to P36 through P43, Data 4 to P44 through P51, and Data 5 to P52 through P59. We don't need P57 through P59, so the most significant 3 bits of Data 5 can be disregarded.
Function Code 03: Read Holding Registers
Function Code 04: Read Input Registers

These functions can read 1 word (16 bits), and is usually used for counters, timers, and data registers. The following shows an example that reads slave address 3’s registers D0 through D2.

Query:

<table>
<thead>
<tr>
<th>Field</th>
<th>RTU</th>
<th>Bytes</th>
<th>ASCII</th>
<th>Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td></td>
<td></td>
<td>: (colon)</td>
<td>1</td>
</tr>
<tr>
<td>Slave Address</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Function Code</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Start Address HI</td>
<td>0X70</td>
<td>1</td>
<td>7 0</td>
<td>2</td>
</tr>
<tr>
<td>Start Address LO</td>
<td>0X00</td>
<td>1</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Length HI</td>
<td>0X00</td>
<td>1</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Length LO</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Error Check</td>
<td>CRC</td>
<td>2</td>
<td>LRC</td>
<td>2</td>
</tr>
<tr>
<td>Ending Code</td>
<td></td>
<td></td>
<td>CR LF</td>
<td>2</td>
</tr>
</tbody>
</table>

The query above asked for a length of 3. And since 1 word is 2 bytes, we will get 6 bytes total in the response.

Response:

<table>
<thead>
<tr>
<th>Field</th>
<th>RTU</th>
<th>Bytes</th>
<th>ASCII</th>
<th>Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td></td>
<td></td>
<td>: (colon)</td>
<td>1</td>
</tr>
<tr>
<td>Slave Address</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Function Code</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Byte Count</td>
<td>0X06</td>
<td>1</td>
<td>0 6</td>
<td>2</td>
</tr>
<tr>
<td>Data 1 LO</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Data 1 HI</td>
<td>0XE8</td>
<td>1</td>
<td>E 8</td>
<td>2</td>
</tr>
<tr>
<td>Data 2 LO</td>
<td>0X01</td>
<td>1</td>
<td>0 1</td>
<td>2</td>
</tr>
<tr>
<td>Data 2 HI</td>
<td>0XF4</td>
<td>1</td>
<td>F 4</td>
<td>2</td>
</tr>
<tr>
<td>Data 3 LO</td>
<td>0X05</td>
<td>1</td>
<td>0 5</td>
<td>2</td>
</tr>
<tr>
<td>Data 3 HI</td>
<td>0X33</td>
<td>1</td>
<td>3 3</td>
<td>2</td>
</tr>
<tr>
<td>Length LO</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Error Check</td>
<td>CRC</td>
<td>2</td>
<td>LRC</td>
<td>2</td>
</tr>
<tr>
<td>Ending Code</td>
<td></td>
<td></td>
<td>CR LF</td>
<td>2</td>
</tr>
</tbody>
</table>
**Function Code 05: Force Single Coil**

This function can be used to remotely set a register's value in units of bits. To turn on a bit register, 0xFF00 must be set. To turn off a bit register, 0x0000 must be sent. Any other values will be ignored. The following is an example showing slave address 3’s P1 register being turned on.

**Query:**

<table>
<thead>
<tr>
<th>Field</th>
<th>RTU</th>
<th>Bytes</th>
<th>ASCII</th>
<th>Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td></td>
<td>0X03</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Slave Address</td>
<td></td>
<td>0X05</td>
<td>0 5</td>
<td>2</td>
</tr>
<tr>
<td>Function Code</td>
<td></td>
<td>0X10</td>
<td>0 1</td>
<td>2</td>
</tr>
<tr>
<td>Start Address HI</td>
<td></td>
<td>0X00</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Start Address LO</td>
<td></td>
<td>0XFF</td>
<td>F F</td>
<td>2</td>
</tr>
<tr>
<td>Length HI</td>
<td></td>
<td>0X00</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Length LO</td>
<td></td>
<td>CRC</td>
<td>LRC</td>
<td>2</td>
</tr>
<tr>
<td>Error Check</td>
<td></td>
<td>CR LF</td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

The response is typically an echo of the request indicating that the operation was successful.

**Response:**

<table>
<thead>
<tr>
<th>Field</th>
<th>RTU</th>
<th>Bytes</th>
<th>ASCII</th>
<th>Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td></td>
<td>0X03</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Slave Address</td>
<td></td>
<td>0X05</td>
<td>0 5</td>
<td>2</td>
</tr>
<tr>
<td>Function Code</td>
<td></td>
<td>0X10</td>
<td>0 1</td>
<td>2</td>
</tr>
<tr>
<td>Start Address HI</td>
<td></td>
<td>0X00</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Start Address LO</td>
<td></td>
<td>0XFF</td>
<td>F F</td>
<td>2</td>
</tr>
<tr>
<td>Length HI</td>
<td></td>
<td>0X00</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Length LO</td>
<td></td>
<td>CRC</td>
<td>LRC</td>
<td>2</td>
</tr>
<tr>
<td>Error Check</td>
<td></td>
<td>CR LF</td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>
Function Code 06: Preset Single Registers

PLC’s can remotely control the status of its registers in word (2 bytes) units through this function code.

The following is an example showing slave address 3’s D1 being written.

**Query:**

<table>
<thead>
<tr>
<th>Field</th>
<th>RTU</th>
<th>Bytes</th>
<th>ASCII</th>
<th>Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td></td>
<td>1</td>
<td>: (colon)</td>
<td>1</td>
</tr>
<tr>
<td>Slave Address</td>
<td>0X03</td>
<td>2</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Function Code</td>
<td>0X06</td>
<td>2</td>
<td>0 6</td>
<td>2</td>
</tr>
<tr>
<td>Start Address HI</td>
<td>0X70</td>
<td>2</td>
<td>0 7</td>
<td>2</td>
</tr>
<tr>
<td>Start Address LO</td>
<td>0X01</td>
<td>2</td>
<td>0 1</td>
<td>2</td>
</tr>
<tr>
<td>Length HI</td>
<td>0X12</td>
<td>2</td>
<td>1 2</td>
<td>2</td>
</tr>
<tr>
<td>Length LO</td>
<td>0X34</td>
<td>2</td>
<td>3 4</td>
<td>2</td>
</tr>
<tr>
<td>Error Check</td>
<td>CRC</td>
<td>2</td>
<td>LRC</td>
<td>2</td>
</tr>
<tr>
<td>Ending Code</td>
<td></td>
<td>2</td>
<td>CR LF</td>
<td>2</td>
</tr>
</tbody>
</table>

The response is typically an echo of the request indicating that the operation was successful.

**Response:**

<table>
<thead>
<tr>
<th>Field</th>
<th>RTU</th>
<th>Bytes</th>
<th>ASCII</th>
<th>Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td></td>
<td>: (colon)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Slave Address</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Function Code</td>
<td>0X06</td>
<td>1</td>
<td>0 6</td>
<td>2</td>
</tr>
<tr>
<td>Start Address HI</td>
<td>0X70</td>
<td>1</td>
<td>0 1</td>
<td>2</td>
</tr>
<tr>
<td>Start Address LO</td>
<td>0X01</td>
<td>1</td>
<td>7 0</td>
<td>2</td>
</tr>
<tr>
<td>Length HI</td>
<td>0X12</td>
<td>1</td>
<td>1 2</td>
<td>2</td>
</tr>
<tr>
<td>Length LO</td>
<td>0X34</td>
<td>1</td>
<td>3 4</td>
<td>2</td>
</tr>
<tr>
<td>Error Check</td>
<td>CRC</td>
<td>2</td>
<td>LRC</td>
<td>2</td>
</tr>
<tr>
<td>Ending Code</td>
<td></td>
<td>CR LF</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
Function Code 15: Force Multiple Coils

PLC’s can remotely control the status of its registers in units of multiple bits through this function code. The following is an example showing slave address 3’s P20 through P30 being turned on/off.

Query:

<table>
<thead>
<tr>
<th>Field</th>
<th>RTU</th>
<th>Bytes</th>
<th>ASCII</th>
<th>Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td></td>
<td>: (colon)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Slave Address</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Function Code</td>
<td>0X0F</td>
<td>1</td>
<td>0 F</td>
<td>2</td>
</tr>
<tr>
<td>Start Address HI</td>
<td>0X00</td>
<td>1</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Start Address LO</td>
<td>0X14</td>
<td>1</td>
<td>1 4</td>
<td>2</td>
</tr>
<tr>
<td>Length HI</td>
<td>0X00</td>
<td>1</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Length LO</td>
<td>0X0B</td>
<td>1</td>
<td>0 B</td>
<td>2</td>
</tr>
<tr>
<td>Byte Count</td>
<td>0X02</td>
<td>1</td>
<td>0 2</td>
<td>2</td>
</tr>
<tr>
<td>Data 1</td>
<td>0XD1</td>
<td>1</td>
<td>D 1</td>
<td>2</td>
</tr>
<tr>
<td>Data 2</td>
<td>0X05</td>
<td>1</td>
<td>0 5</td>
<td>2</td>
</tr>
<tr>
<td>Error Check</td>
<td>CRC</td>
<td>2</td>
<td>LRC</td>
<td>2</td>
</tr>
<tr>
<td>Ending Code</td>
<td></td>
<td>CR LF</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

The following table shows how Data in the above query is divided. P20 corresponds to the least significant bit of the first byte sent, and P27 corresponds to the most significant bit. There will be a total of 2 bytes sent in this manner. Unused bits can be set to zero.

<table>
<thead>
<tr>
<th>Bit</th>
<th>1</th>
<th>1</th>
<th>0</th>
<th>1</th>
<th>0</th>
<th>0</th>
<th>1</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>0</th>
<th>1</th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>.</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Response:

<table>
<thead>
<tr>
<th>Field</th>
<th>RTU</th>
<th>Bytes</th>
<th>ASCII</th>
<th>Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td></td>
<td>: (colon)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Slave Address</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Function Code</td>
<td>0X0F</td>
<td>1</td>
<td>0 F</td>
<td>2</td>
</tr>
<tr>
<td>Start Address HI</td>
<td>0X00</td>
<td>1</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Start Address LO</td>
<td>0X14</td>
<td>1</td>
<td>1 4</td>
<td>2</td>
</tr>
<tr>
<td>Length HI</td>
<td>0X00</td>
<td>1</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Length LO</td>
<td>0X0B</td>
<td>1</td>
<td>0 B</td>
<td>2</td>
</tr>
<tr>
<td>Error Check</td>
<td>CRC</td>
<td>2</td>
<td>LRC</td>
<td>2</td>
</tr>
<tr>
<td>Ending Code</td>
<td></td>
<td>CR LF</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
Function Code 16: Preset Multiple Registers

PLC’s can remotely control the status of registers in units of multiple words through this function code. The following is an example showing slave address 3’s D0 through D2 being written.

Query:

<table>
<thead>
<tr>
<th>Field</th>
<th>RTU</th>
<th>Bytes</th>
<th>ASCII</th>
<th>Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td></td>
<td></td>
<td>: (colon)</td>
<td>1</td>
</tr>
<tr>
<td>Slave Address</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Function Code</td>
<td>0X10</td>
<td>1</td>
<td>1 0</td>
<td>2</td>
</tr>
<tr>
<td>Start Address HI</td>
<td>0X70</td>
<td>1</td>
<td>7 0</td>
<td>2</td>
</tr>
<tr>
<td>Start Address LO</td>
<td>0X00</td>
<td>1</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Length HI</td>
<td>0X00</td>
<td>1</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Length LO</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Byte Count</td>
<td>0X06</td>
<td>1</td>
<td>0 6</td>
<td>2</td>
</tr>
<tr>
<td>Data 1 HI</td>
<td>0XD1</td>
<td>1</td>
<td>D 1</td>
<td>2</td>
</tr>
<tr>
<td>Data 1 LO</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Data 2 HI</td>
<td>0X0A</td>
<td>1</td>
<td>0 A</td>
<td>2</td>
</tr>
<tr>
<td>Data 2 LO</td>
<td>0X12</td>
<td>1</td>
<td>1 2</td>
<td>2</td>
</tr>
<tr>
<td>Data 3 HI</td>
<td>0X04</td>
<td>1</td>
<td>0 4</td>
<td>2</td>
</tr>
<tr>
<td>Data 3 LO</td>
<td>0X05</td>
<td>1</td>
<td>0 5</td>
<td>2</td>
</tr>
<tr>
<td>Error Check</td>
<td>CRC</td>
<td>2</td>
<td>LRC</td>
<td>2</td>
</tr>
<tr>
<td>Ending Code</td>
<td></td>
<td></td>
<td>CR LF</td>
<td>2</td>
</tr>
</tbody>
</table>

Response:

<table>
<thead>
<tr>
<th>Field</th>
<th>RTU</th>
<th>Bytes</th>
<th>ASCII</th>
<th>Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td></td>
<td></td>
<td>: (colon)</td>
<td>1</td>
</tr>
<tr>
<td>Slave Address</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Function Code</td>
<td>0X10</td>
<td>1</td>
<td>1 0</td>
<td>2</td>
</tr>
<tr>
<td>Start Address HI</td>
<td>0X70</td>
<td>1</td>
<td>7 0</td>
<td>2</td>
</tr>
<tr>
<td>Start Address LO</td>
<td>0X00</td>
<td>1</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Length HI</td>
<td>0X00</td>
<td>1</td>
<td>0 0</td>
<td>2</td>
</tr>
<tr>
<td>Length LO</td>
<td>0X03</td>
<td>1</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Error Check</td>
<td>CRC</td>
<td>2</td>
<td>LRC</td>
<td>2</td>
</tr>
<tr>
<td>Ending Code</td>
<td></td>
<td></td>
<td>CR LF</td>
<td>2</td>
</tr>
</tbody>
</table>
Error Check

If there is an error in the data from the master, the slave will send back an error code.

<table>
<thead>
<tr>
<th>Field</th>
<th>Hex</th>
<th>ASCII</th>
<th>Bytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Header</td>
<td>0x00</td>
<td>: (colon)</td>
<td>1</td>
</tr>
<tr>
<td>Slave Address</td>
<td>0x03</td>
<td>0 3</td>
<td>2</td>
</tr>
<tr>
<td>Function Code</td>
<td>0x81</td>
<td>8 1</td>
<td>2</td>
</tr>
<tr>
<td>Error Code</td>
<td>0x09</td>
<td>0 9</td>
<td>2</td>
</tr>
<tr>
<td>Error Check</td>
<td></td>
<td>LRC</td>
<td>2</td>
</tr>
<tr>
<td>Ending Code</td>
<td></td>
<td>CR LF</td>
<td>2</td>
</tr>
</tbody>
</table>

The list of possible error codes is as follows:

<table>
<thead>
<tr>
<th>Code</th>
<th>Error Name</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>ILLEGAL FUNCTION</td>
<td>When a non-supported function code is received.</td>
</tr>
<tr>
<td>02</td>
<td>ILLEGAL DATA ADDRESS</td>
<td>When an incorrect address is received.</td>
</tr>
<tr>
<td>03</td>
<td>ILLEGAL DATA VALUE</td>
<td>When bad data is received.</td>
</tr>
<tr>
<td>09</td>
<td>LRC UNMATCH</td>
<td>When LRC is incorrect.</td>
</tr>
</tbody>
</table>

The error check is only for MODBUS ASCII; there is no error check in RTU. Modbus RTU uses a CRC to check for errors in transmission.
Using Modbus with HMI / SCADA Addresses
The following describes the address mechanism to be used from HMI / SCADA software.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coil</td>
<td>1–999</td>
</tr>
<tr>
<td>Input Status</td>
<td>10001 – 19999</td>
</tr>
<tr>
<td>Input Register</td>
<td>30001 – 39999</td>
</tr>
<tr>
<td>Holding Register</td>
<td>40001 – 49999</td>
</tr>
</tbody>
</table>

To determine the appropriate address to use from HMI / SCADA software, refer to the following table.

<table>
<thead>
<tr>
<th>Word Region (Holding/Input Registers)</th>
<th>Relevant Function Codes: 3,4,6,16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of the Cubloc to be addressed</td>
<td>Address to be entered in the HMI / SCADA software</td>
</tr>
<tr>
<td>D area (D0 ~ D511)</td>
<td>40001 ~ 40512</td>
</tr>
<tr>
<td>T area (T0 ~ T255)</td>
<td>41001 ~ 41256</td>
</tr>
<tr>
<td>C area (C 0~ C255)</td>
<td>42001 ~ 42256</td>
</tr>
<tr>
<td>WM area (WM0 ~ WM255)</td>
<td>43001 ~ 43256</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bit Region (Coil, Input Status)</th>
<th>Relevant Function Codes : 1,2,4,15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area of the Cubloc to be addressed</td>
<td>Address to be entered in the HMI / SCADA software</td>
</tr>
<tr>
<td>P area (P0 ~ P127)</td>
<td>1 ~128 or 10001 ~10128</td>
</tr>
<tr>
<td>M area (M0 ~ M2047)</td>
<td>4097 ~ 6144 or 14097 ~ 16144</td>
</tr>
</tbody>
</table>
Modbus ASCII Master

There are no special commands needed to set the Cubloc as a Modbus master. One simply needs to use Cubloc's RS-232 commands like Get and Put.

The following is an example illustrating the Cubloc running as a Modbus ASCII master:

```
'Master Source

Const Device = cb280
    Dim RDATA As String * 80
    Dim a As Byte, ct As Byte
    Dim b As String * 17
    Dim Port As Integer

OpenCom 1,115200,3,80,80
On Recv1 Gosub GETMODBUS
Set Until 1,60,10
' Data Receive Interrupt routine
    ' When Ending Code (10)
    ' on Channel 1 is discovered,
    ' create an interrupt

Do
    For Port=2 To 4
        BitWrite Port, 1  'Turn P0,P1,P2 ON!
        Delay 100
    Next
    For Port=2 To 4
        BitWrite Port, 0  'Turn P0,P1,P2 OFF!
        Delay 100
    Next
Loop

GETMODBUS:
    If BLen(1,0) > 0 Then  ' If buffer empty then
        A=BLen(1,0)  ' Store the buffer length in A!
        Debug "GOT RESPONSE: ":
        B=GetStr(1,A)  ' Store received data in B
        Debug B
    End If
    Return
End

Sub BitWrite(K As Integer, D As Integer)
    Dim LRC As Integer
    PutStr 1,":0305"
    PutStr 1,Hp(k,4,1)
    If D=0 Then
        PutStr 1,"0000"
    End If
End
```
LRC = -(3+5+K.Byte1+K.Byte0)  'Calculate LRC
Else
    PutStr 1,"00FF"
    LRC = -(3+5+K.Byte1+K.Byte0+0xFF)  ' LRC
End If
PutStr 1,Hex2(LRC),13,10  'Send

End Sub
Modbus ASCII Slave

When the slave finishes processing the data sent by the master, the return packet from the slave will cause a jump to the label GETMODBUS. The Set Until command is used to check for the ending code LF (10).

The GetStr command is used to store all received data in RDATA. The data in RDATA can be analyzed for any communication errors.

If the slave is not connected, the program will never jump to GETMODBUS.
Chapter 10: Application Notes
NOTE 1. Switch Input

Let’s say you are developing some kind of machine controlled by a Cubloc. The first thing you need is a user interface. Our task today is to build a machine that will receive input from a switch and process it to perform a task.

We will make a "start" and "stop" button that will turn a lamp on and off.

![Switch Diagram]

As you can see above, ports P0 and P4 will be connected to a pull-down resistor (resistor attached to ground). The CB220 will read these switches as logic-low or "off" when the switch is not pressed. To find out if these switches are pressed or unpressed, we can use Cubloc BASIC command `In`.

```cul
Const Device = cb220
Dim a As Byte
Do
    If In(0) = 1 Then a = 1
    If In(4) = 1 Then a = 0
    Out 14,a
Loop
```

When the switch is pressed, a "bouncing" effect occurs from the switch’s mechanical spring.
The above picture shows how bouncing can confuse Cubloc controller with alternating high and low signal levels. To get rid of this bouncing effect, a capacitor and resistor can be added to filter it out.

A simpler method is to use the `KeyInH` command instead of `In` which will remove the bouncing effect through software.

```vbnet
Const Device = cb220
Dim a As Byte
Do
    If KeyInH(0, 20) = 1 Then a = 1
    If KeyInH(4, 20) = 1 Then a = 0
    Out 14, a
Loop
```

The 2\textsuperscript{nd} parameter of `KeyInH(0, 20)` a delay before reading the input so the signal bounce has time to settle. This delay is called the debouncing time. The software will wait for 20ms before reading the input.

In industrial environments, there can be a lot of electromagnetic noise which can affect switch signals. To prevent this noise from affecting the circuit, a circuit diagram similar to one shown below can be used. Using a photocoupler, the user is able to raise the voltage and minimize the effect the noise has on the switch input.
NOTE 2. Keypad Input

This application demonstrates interfacing to a 4x4 keypad and displaying the results on a 4 digit seven segment module (CSG module).

The CSG module is a 4 digit seven segment LED module that can be connected via CUNET or the I2C interface to display numbers and custom characters.

Const Device = CB280
Set I2c 9,8
Dim i As Byte
Do
   CsgDec 0,i
   i = i + 1
Loop

<Filename: csgprint.cul>
If you connect the CSG to the CuNet connector and execute the program above, the CSG module will show incrementing numbers.

The key matrix can be easily read using the Keypad command. If you look carefully at the keypad, you will see that the scan code does not match the actual key pressed. In order to read the correct key, we will use a Byte array (KEYTABLE) to map the scan codes to the appropriate key.

Const Device = CB280
Set I2c 9,8
Dim i As Integer
Dim K As Integer
Const Byte KEYTABLE = (1,4,7,10,2,5,8,0,3,6,9,11,12,13,14,15)
Do
    i = Keypad(0)
    If i < 16 Then
        i = KEYTABLE(i)
        Csgdec 0,i
    End If
Loop

And now we will make a simple program that receives input. When a number key input is received, it is displayed to the CSG module as a 4 digit number. The number is stored in the variable K, which is in BCD format. We then use the BCD2Bin command to convert the BCD value back into binary.

Const Device = CB280
Set I2c 9,8
Dim i As Integer
Dim K As Integer
Dim M As Integer
K = 0
Const Byte KEYTABLE = (1,4,7,10,2,5,8,0,3,6,9,11,12,13,14,15)
Do
    i = Keypad(0)
    If i < 16 Then
        i = KEYTABLE(i)
        If i < 10 Then
            K = K << 4
            K = K + i
            Csghex 0,K
        End If
    ' WAIT UNTIL KEY DEPRESS
    Do While KeyPad(0) < 255
        Loop
M = BCD2Bin(K)
Debug Dec M, CR
End If
Loop

When there is no input, the returned scan code is 255. Using the statement
Do While keypad(0) < 255, we wait until a key is released which will
return a scan code of 255. This is to allow the processor to stop reading
input while a key is being pressed. Otherwise, the processor might receive
multiple key inputs since the Cubloc's execution speed is very fast.

Using _D(0) = M, you can pass the scan code to Ladder Logic's D0 register.
If you need to use a keypad in Ladder Logic, you can make minor
modifications to this code to quickly get your results.
NOTE 3. Temperature Sensor

There are many uses for devices that sense temperature. Refrigerators, heaters, air conditioners, automobiles, etc. all make use of devices that sense temperature.

There are several different kinds of temperatures sensors. There are PT100, NTC, and PTC thermistors, and other chip-type sensors such as the DS1620.

We will take a look at the NTC thermistor and interface it with the Cubloc.

The NTC thermistor is a temperature-sensitive resistor. Depending on the temperature, the value of resistance will change. By reading the value of this resistance, we can determine the temperature.

A common NTC thermistor resembles a diode. With this thermistor, we can sense temperatures between -30 and 250 degrees Celsius.

You can acquire an R-T (Resistance – Temperature) conversion table from the maker of the thermistor. The following is a diode-type 10Kohm NTC thermistor R-T conversion chart and table.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Minimum</th>
<th>Average</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>31260.0</td>
<td>32610.0</td>
<td>33987.7</td>
</tr>
<tr>
<td>1</td>
<td>29725.7</td>
<td>30993.7</td>
<td>32286.7</td>
</tr>
<tr>
<td>2</td>
<td>28275.6</td>
<td>29466.8</td>
<td>30680.6</td>
</tr>
<tr>
<td>3</td>
<td>26904.5</td>
<td>28023.9</td>
<td>29163.6</td>
</tr>
<tr>
<td>4</td>
<td>25607.8</td>
<td>26660.0</td>
<td>27730.3</td>
</tr>
<tr>
<td>5</td>
<td>24381.0</td>
<td>25370.2</td>
<td>26375.7</td>
</tr>
<tr>
<td>6</td>
<td>23220.0</td>
<td>24150.1</td>
<td>25094.9</td>
</tr>
<tr>
<td>7</td>
<td>22120.9</td>
<td>22995.7</td>
<td>23883.7</td>
</tr>
<tr>
<td>8</td>
<td>21080.1</td>
<td>21903.1</td>
<td>22737.7</td>
</tr>
<tr>
<td>9</td>
<td>20094.1</td>
<td>20868.5</td>
<td>21653.3</td>
</tr>
<tr>
<td>10</td>
<td>19159.9</td>
<td>19888.7</td>
<td>20626.7</td>
</tr>
<tr>
<td>11</td>
<td>18274.4</td>
<td>18960.5</td>
<td>19654.6</td>
</tr>
<tr>
<td>12</td>
<td>17434.8</td>
<td>18080.8</td>
<td>18733.8</td>
</tr>
<tr>
<td>13</td>
<td>16638.5</td>
<td>17246.9</td>
<td>17861.4</td>
</tr>
<tr>
<td>14</td>
<td>15883.1</td>
<td>16456.1</td>
<td>17034.4</td>
</tr>
<tr>
<td>15</td>
<td>15166.2</td>
<td>15706.0</td>
<td>16250.4</td>
</tr>
<tr>
<td>16</td>
<td>14485.7</td>
<td>14994.4</td>
<td>15506.9</td>
</tr>
<tr>
<td>17</td>
<td>13839.6</td>
<td>14318.9</td>
<td>14801.5</td>
</tr>
<tr>
<td>18</td>
<td>13225.9</td>
<td>13677.7</td>
<td>14132.2</td>
</tr>
<tr>
<td>19</td>
<td>12642.8</td>
<td>13068.7</td>
<td>13496.9</td>
</tr>
<tr>
<td>20</td>
<td>12088.7</td>
<td>12490.3</td>
<td>12893.6</td>
</tr>
<tr>
<td>21</td>
<td>11561.9</td>
<td>11940.6</td>
<td>12320.7</td>
</tr>
</tbody>
</table>
For connecting the sensor to the Cubloc, please refer to the following circuit diagram. To protect against voltage surges, a zener diode is recommended, especially if the thermistor is attached to a long probe wire.

As you can see in the circuit diagram, we will be using an ADC (Analog-to-Digital) converter to read the voltage across the sensor. The A/D converter will convert the voltage into a value between 0 and 1024.

The most important part of this application note is the following table which converts the temperature and voltage to an A/D value between 0 and 1024. (Only some of the temperatures are shown.)
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>32610.0</td>
<td>4.851234752</td>
</tr>
<tr>
<td>1</td>
<td>30993.7</td>
<td>4.8437193</td>
</tr>
<tr>
<td>2</td>
<td>29466.8</td>
<td>4.835887094</td>
</tr>
<tr>
<td>3</td>
<td>28023.9</td>
<td>4.827728362</td>
</tr>
<tr>
<td>4</td>
<td>26660.0</td>
<td>4.819233234</td>
</tr>
<tr>
<td>5</td>
<td>25370.2</td>
<td>4.810391755</td>
</tr>
<tr>
<td>6</td>
<td>24150.1</td>
<td>4.801193902</td>
</tr>
<tr>
<td>7</td>
<td>22995.7</td>
<td>4.79162959</td>
</tr>
<tr>
<td>8</td>
<td>21903.1</td>
<td>4.781688696</td>
</tr>
<tr>
<td>9</td>
<td>20868.5</td>
<td>4.771361072</td>
</tr>
<tr>
<td>10</td>
<td>19888.7</td>
<td>4.760636561</td>
</tr>
<tr>
<td>11</td>
<td>18960.5</td>
<td>4.749505017</td>
</tr>
<tr>
<td>12</td>
<td>18080.8</td>
<td>4.73956327</td>
</tr>
<tr>
<td>13</td>
<td>17246.9</td>
<td>4.725980424</td>
</tr>
<tr>
<td>14</td>
<td>16456.1</td>
<td>4.713567319</td>
</tr>
<tr>
<td>15</td>
<td>15706.0</td>
<td>4.700707114</td>
</tr>
<tr>
<td>16</td>
<td>14994.4</td>
<td>4.68739003</td>
</tr>
<tr>
<td>17</td>
<td>14318.9</td>
<td>4.673606431</td>
</tr>
<tr>
<td>18</td>
<td>13677.7</td>
<td>4.659346849</td>
</tr>
<tr>
<td>19</td>
<td>13068.7</td>
<td>4.64602011</td>
</tr>
<tr>
<td>20</td>
<td>12490.3</td>
<td>4.629362861</td>
</tr>
<tr>
<td>21</td>
<td>11940.6</td>
<td>4.613620595</td>
</tr>
<tr>
<td>22</td>
<td>11418.2</td>
<td>4.597366883</td>
</tr>
<tr>
<td>23</td>
<td>10921.6</td>
<td>4.580592903</td>
</tr>
<tr>
<td>24</td>
<td>10449.3</td>
<td>4.563291365</td>
</tr>
<tr>
<td>25</td>
<td>10000.0</td>
<td>4.545454545</td>
</tr>
<tr>
<td>26</td>
<td>9572.5</td>
<td>4.527075313</td>
</tr>
<tr>
<td>27</td>
<td>9165.6</td>
<td>4.508146964</td>
</tr>
<tr>
<td>28</td>
<td>8778.3</td>
<td>4.488663246</td>
</tr>
<tr>
<td>29</td>
<td>8409.4</td>
<td>4.468618396</td>
</tr>
<tr>
<td>30</td>
<td>8058.1</td>
<td>4.448007162</td>
</tr>
<tr>
<td>31</td>
<td>7723.3</td>
<td>4.426824842</td>
</tr>
<tr>
<td>32</td>
<td>7404.3</td>
<td>4.405067304</td>
</tr>
<tr>
<td>33</td>
<td>7100.2</td>
<td>4.382731022</td>
</tr>
<tr>
<td>34</td>
<td>6810.2</td>
<td>4.359813102</td>
</tr>
<tr>
<td>35</td>
<td>6533.7</td>
<td>4.336311306</td>
</tr>
<tr>
<td>36</td>
<td>6269.8</td>
<td>4.312224084</td>
</tr>
<tr>
<td>37</td>
<td>6018.0</td>
<td>4.287550592</td>
</tr>
<tr>
<td>38</td>
<td>5777.7</td>
<td>4.262290722</td>
</tr>
<tr>
<td>39</td>
<td>5548.3</td>
<td>4.236445118</td>
</tr>
<tr>
<td>40</td>
<td>3606.1</td>
<td>3.914475937</td>
</tr>
<tr>
<td>41</td>
<td>3472.1</td>
<td>3.881948015</td>
</tr>
<tr>
<td>42</td>
<td>3343.7</td>
<td>3.848917708</td>
</tr>
<tr>
<td>43</td>
<td>3220.8</td>
<td>3.815397329</td>
</tr>
<tr>
<td>44</td>
<td>3103.1</td>
<td>3.781399998</td>
</tr>
<tr>
<td>45</td>
<td>2990.2</td>
<td>3.746939622</td>
</tr>
<tr>
<td>46</td>
<td>2882.1</td>
<td>3.712030877</td>
</tr>
<tr>
<td>47</td>
<td>2778.4</td>
<td>3.676689176</td>
</tr>
<tr>
<td>48</td>
<td>2679.0</td>
<td>3.640930651</td>
</tr>
<tr>
<td>49</td>
<td>2583.6</td>
<td>3.604721114</td>
</tr>
<tr>
<td>50</td>
<td>1220.4</td>
<td>2.748157207</td>
</tr>
<tr>
<td>51</td>
<td>1181.9</td>
<td>2.7084025</td>
</tr>
<tr>
<td>52</td>
<td>1144.8</td>
<td>2.668747011</td>
</tr>
<tr>
<td>53</td>
<td>1109.0</td>
<td>2.629210536</td>
</tr>
<tr>
<td>54</td>
<td>1074.5</td>
<td>2.589812422</td>
</tr>
<tr>
<td>55</td>
<td>1041.3</td>
<td>2.550571543</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>-------</td>
<td>-----------------</td>
</tr>
<tr>
<td>87</td>
<td>1009.2</td>
<td>2.511506263</td>
</tr>
<tr>
<td>88</td>
<td>978.3</td>
<td>2.472634416</td>
</tr>
<tr>
<td>89</td>
<td>948.5</td>
<td>2.433973277</td>
</tr>
<tr>
<td>90</td>
<td>919.8</td>
<td>2.395539544</td>
</tr>
<tr>
<td>91</td>
<td>892.0</td>
<td>2.357349316</td>
</tr>
<tr>
<td>92</td>
<td>865.3</td>
<td>2.319418079</td>
</tr>
<tr>
<td>93</td>
<td>839.4</td>
<td>2.281760687</td>
</tr>
<tr>
<td>94</td>
<td>814.5</td>
<td>2.244391354</td>
</tr>
<tr>
<td>95</td>
<td>790.4</td>
<td>2.207323646</td>
</tr>
<tr>
<td>96</td>
<td>767.1</td>
<td>2.170570465</td>
</tr>
<tr>
<td>97</td>
<td>744.7</td>
<td>2.134144055</td>
</tr>
<tr>
<td>98</td>
<td>723.0</td>
<td>2.098055989</td>
</tr>
<tr>
<td>99</td>
<td>702.0</td>
<td>2.062317177</td>
</tr>
<tr>
<td>100</td>
<td>681.8</td>
<td>2.026937858</td>
</tr>
<tr>
<td>101</td>
<td>662.2</td>
<td>1.99192761</td>
</tr>
<tr>
<td>102</td>
<td>643.3</td>
<td>1.957295352</td>
</tr>
<tr>
<td>103</td>
<td>625.0</td>
<td>1.92304935</td>
</tr>
<tr>
<td>104</td>
<td>607.3</td>
<td>1.889197225</td>
</tr>
<tr>
<td>105</td>
<td>590.2</td>
<td>1.855745964</td>
</tr>
<tr>
<td>106</td>
<td>573.7</td>
<td>1.822701928</td>
</tr>
<tr>
<td>107</td>
<td>557.7</td>
<td>1.790070865</td>
</tr>
<tr>
<td>108</td>
<td>542.2</td>
<td>1.757857926</td>
</tr>
<tr>
<td>109</td>
<td>527.2</td>
<td>1.726067674</td>
</tr>
<tr>
<td>239</td>
<td>33.5</td>
<td>0.162295782</td>
</tr>
<tr>
<td>240</td>
<td>33.0</td>
<td>0.159800146</td>
</tr>
<tr>
<td>241</td>
<td>32.5</td>
<td>0.157350769</td>
</tr>
<tr>
<td>242</td>
<td>32.0</td>
<td>0.154946682</td>
</tr>
<tr>
<td>243</td>
<td>31.5</td>
<td>0.152586936</td>
</tr>
<tr>
<td>244</td>
<td>31.0</td>
<td>0.150270604</td>
</tr>
<tr>
<td>245</td>
<td>30.5</td>
<td>0.147996779</td>
</tr>
<tr>
<td>246</td>
<td>30.0</td>
<td>0.145764577</td>
</tr>
<tr>
<td>247</td>
<td>29.6</td>
<td>0.143573131</td>
</tr>
<tr>
<td>248</td>
<td>29.1</td>
<td>0.141421596</td>
</tr>
<tr>
<td>249</td>
<td>28.7</td>
<td>0.139309144</td>
</tr>
<tr>
<td>250</td>
<td>28.2</td>
<td>0.137234968</td>
</tr>
</tbody>
</table>

NTC THERMISTOR READ TABLE
10K DIODE TYPE

Const Device = cb280


Dim a As Integer,b As Integer
By using the TADIn command for AD conversion, the Cubloc will automatically calculate the average of 10 A/D conversion reads for more precise results. The sample program shown here will be able to sense between 0 and 100 degrees. A minor modification to the code would allow a larger temperature range.

The formula for acquiring the A/D conversion value from the R-T table is as follows:

\[ V = \frac{5}{(1000 + \text{THR})} \times \text{THR} \]

THR is the resistance value. 1000 is for a 1K Ohm resistor and 5 is for 5 volts. The 10 bit A/D converter of the Cubloc will return a value between 0 and 1024. Therefore, to get the A/D value, you must multiply the result, \( V \), by 204.8. A chart can be made by plotting this formula in a spreadsheet.
NOTE 4. Sound Bytes

This application note will demonstrate a few examples that generate sound with the Cubloc. Sound can be generated using the Cubloc's I/O port or PWM channel. With a PWM channel, sounds of varying frequency can be generated.

The example above shows the CB220's PWM channel 0 of CB220 being used with the `FreqOut` command to produce a sound.

With commands like `FreqOut` and `Delay`, simple sounds can be created.

By changing the frequencies, a simple program can be made that plays musical notes.
To express one note, 2 characters are used: the first character is for the frequency of the note and second character is for the length of the note.

```
Const Device = CB220

Dim PLAYSTR As String
Low 5
PLAYSTR = "G5E3E3G3E3C5"
PLAY 0,PLAYSTR

Do
Loop
End

Sub PLAY(CH As Byte, NOTE As String)
    Dim PL As Byte
    Dim CHAR As Byte
    Const Integer PLAYTABLE = (5236,4665,4403,3923,3495,3299,2939,
                                2618,2333,2202,1961,1747,1649,1469,0)
    For PL=1 To Len(NOTE) Step 2
        CHAR = Asc(Mid(NOTE,PL,1)) - &H41
        FreqOut CH,PLAYTABLE(CHAR)
        CHAR = Asc(Mid(NOTE,PL+1,1)) - &H30
        Delay CHAR*100
    Next
    PwmOff CH
End Sub
```

When using the PWM port for other purposes, the FreqOut command cannot be used. To get around this limitation, any regular I/O port can be used to create sound.

The following example shows how to make an alert sound with I/O port P4. This program uses the Reverse and UDelay commands to alternate the I/O port between logic-high and logic-low.
Const Device = CB220

Low 4
Do
SOUND 4,110,60
SOUND 4,80,60
SOUND 4,40,160
Loop
End

Sub SOUND(PN As Byte, FR As Byte, LN As Byte)
    Dim SI As Byte, SJ As Byte
    For SJ = 0 To LN
        Reverse PN
        UDelay FR
        Reverse PN
        UDelay FR
    Next
End Sub
NOTE 5. RC Servo Motor

RC servo motors (or "servos" for short) are used by many hobbyists to make remote control cars, planes, etc.,. In recent years, they have been used for robot arms, legs, and wheels.

With the Cubloc's PWM outputs, a servo can be easily added to any project.

A servo typically has three wires. The black wire is ground and red wire is for power. The other yellow wire is for receiving a PWM signal. A typical pulse rate is approximately 60 pulses per second.

![Diagram of servo connections]

The servo will move to a location set by the PWM's pulse and duty cycle, and will hold its position.

![Diagram of servo movement]

Every RC servo motor is different, but as an example, pulses of 1ms, 1.5ms, and 2ms might stop a RC servo motor to -45 degrees, 0 degrees, and +45 degrees respectively.
When the code above is executed, a 1ms pulse will be generated from I/O port P5 and the RC servo motor will position itself to -45 degrees.

When the code above is executed, a 1.5ms pulse will be generated from I/O port P5 and the RC servo will position itself to 0 degrees.

By simply changing the duty value of PWM command, the RC servo can easily be controlled. For the CB220, 3 RC servos can be controlled simultaneously while the CB280 and CB290 can control up to 6 RC servos. The CB400/CB405 can control up to 12 servos.

Warning: When the RC servo is in operation, it will need about 500mA of current. Please make sure to use a power supply of at least 500mA.
NOTE 6. Digital Thermometer

The DS1620 is a digital thermometer. The chip has an internal temperature conversion table so the user does not have to make a separate table. Temperatures between -55 and 125 degrees Celsius can be measured by the DS1620 in units of 0.5 degrees.

```
Const Device = CB220
Const iorst = 7
Const ioclk = 6
Const iodq = 5
Dim i As Integer
Delay 100
High iorst ' init ds1620
ShiftOut ioclk, iodq, 0, 12, 8
ShiftOut ioclk, iodq, 0, 3, 8
Low iorst
High iorst

ShiftOut ioclk, iodq, 0, &hEE, 8
Low iorst
Do
    High iorst
    ShiftOut ioclk, iodq, 0, &hAA, 8
    i = ShiftIn(ioclk, iodq, 4, 9)
    i = i
    debug dec i, cr
Low iorst
Delay 100
Loop
```

The final value received must be divided by 2 to obtain the correct temperature.
NOTE 7. DS1302 RTC

The DS1302 RTC (Real Time Clock) is a chip that acts as an electronic time keeper. It has the ability to keep time and date in real-time. We will show you how to implement this clock chip into your application.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
<th>I/O Direction</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>RST</td>
<td>Reset</td>
<td>Input</td>
<td>Data transfer when High</td>
</tr>
<tr>
<td>SCLK</td>
<td>System Clock</td>
<td>Input</td>
<td>Clock signal</td>
</tr>
<tr>
<td>I/O</td>
<td>Data</td>
<td>Input / Output</td>
<td>Data input/output</td>
</tr>
</tbody>
</table>

Const Device = CB220  
Const iorst = 7  
Const iodio = 6  
Const ioclk = 5  
Dim i As Integer  
Dim adr As Byte  
High iorst  
ShiftOut ioclk,iodio,0,&h8e,8  
ShiftOut ioclk,iodio,0,0,8  
Low iorst  
Delay 1  
High iorst  
ShiftOut ioclk,iodio,0,&h80,8  
ShiftOut ioclk,iodio,0,&h50,8  
Low iorst  

Do  
  High iorst  
  adr = &h81  
  ShiftOut ioclk,iodio,0,adr,8  
  i = ShiftIn(ioclk,iodio,4,8)  
  Debug Hex i,cr  
  Low iorst  
  Delay 1000  
Loop
The code above will read address 0, the seconds value, and display it in the debug window. At the beginning of the program, writes are enabled to the DS1302 chip and address 0 is set to 50 seconds. Within the `Do Loop`, data is read from the DS1302. The DS1302 has 6 addresses as shown below:

- ADDRESS 0 (sec)
- ADDRESS 1 (min)
- ADDRESS 2 (hour)
- ADDRESS 3 (date)
- ADDRESS 4 (month)
- ADDRESS 5 (day)
- ADDRESS 6 (year)

These addresses can be used to read and write to the DS1302. Please note that the data is in BCD code format.
NOTE 8. MCP3202 12 Bit A/D Conversion

The Cubloc has a 10 bit A/D converter. For greater resolution, meaning greater precision, you can use a chip like the MCP3202. The MCP3202 is a 12 bit A/D converter that supports the SPI protocol. Here we will show you how to implement this 12 bit A/D converter into your project.

---

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
<th>I/O Direction</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS</td>
<td>Chip Select</td>
<td>Input</td>
<td>Low for data communication</td>
</tr>
<tr>
<td>CLK</td>
<td>Clock</td>
<td>Input</td>
<td>Clock signal</td>
</tr>
<tr>
<td>DI</td>
<td>Data Input</td>
<td>Input</td>
<td>Data input from MCP3202</td>
</tr>
<tr>
<td>DO</td>
<td>Data Output</td>
<td>Output</td>
<td>Data output from MCP3202</td>
</tr>
</tbody>
</table>

Const Device = CB220
Const iodi = 7
Const iodo = 6
Const iclk = 5
Const iocs = 4
Dim i As Byte
Dim ad As Integer
Do
  Low iocs
  i = &b1011 'Channel 0
  i = &h1111 'Channel 1
  Shiftout iclk,iodi,0,i,4
  ad = Shiftin(iclk,iodo,3,12)
  High iocs
  Debug Dec ad,cr
  Delay 100
Loop
The MCP3202 will convert voltage coming into CH0 and CH1 to a digital value and retain it. SPI communication can then be used to read the value from the MCP3202.

The voltage measured on the MCP320 CH0 and CH1 pins must not be greater than the voltage supplied to the MCP3202. The result of the A/D conversion is displayed in the debug window.
NOTE 9. Reading from and Writing to an EEPROM

Typically EEPROMs store between 0.5 to 64KB of data. Data is retained even after powering off. For example, if you wanted to retain a temperature setting for a temperature controller, you could simply store the value of the temperature in the EEPROM in case of a power outage.

The Cubloc has an internal EEPROM of 4KB. This EEPROM can be used to store small amounts of data. If a larger EEPROM is needed, the 24LC512 can be used to store up to 64KB of data.

The following example will demonstrate how to access the 24LC32 4KB EEPROM using the I2C protocol. Serial EEPROMs usually support either SPI or I2C. I2C EEPROM part numbers begin with 24XXXX and SPI EEPROM part numbers begin with 93XXX.

Const Device = CB220
Dim adr As Integer
Dim data As Byte
Dim a As Byte
Data = &ha6
adr = &h3
Set I2C 7,6
Do
I2CStart
If I2CWrite(&b10100000)= 1 Then Goto err_proc
a=I2CWrite(adr.byte1)
a=I2CWrite(adr.lowbyte)
a=I2CWrite(data)
I2CStop
Delay 1000
I2CStart
This example program will write a number to the EEPROM and read it back. When this program runs correctly, numbers will increment in the debug window. This program can be easily modified to support other EEPROMs.

Note: Typically, EEPROMs need a delay of about 5ms after a write operation.
MEMO
Chapter 11: Ladder Logic

**WARNING**
If you do not use the `SET LADDER ON` command in BASIC, Ladder Logic will not be executed.
Ladder Logic Basics

The following is an example of an electrical circuit with one switch and a lamp.

If you take out the power, the following results:

If you express the above circuit using Ladder Logic, the following results:

As you can see, Ladder Logic is basically an easy way to model electrical circuits in software. The switch corresponds to the input port P0 and the lamp corresponds to the output port P9.

There are many ways to connect other devices such as timers, counters, etc.,. The following is an example illustrating OR and AND logic using Ladder Logic:
In this circuit diagram, P0 and P3 are ORed and that result is ANDed with P2.
If you express the circuit diagram above in Ladder Logic, it will be as follows:

In Cubloc Studio, the right side is not shown. In Cubloc Ladder Logic, P0, P1, P2 are called "Registers". 
Creating Ladder Logic Programs

The screen below shows you how Ladder Logic programs are created in Cubloc Studio.

The red box shown above is the Ladder Logic cursor. You may use the keyboard’s up, down, left, and right keys or the mouse to control the red box. After moving to the desired position, you can use the keys F3 through F12 to place the desired symbol. You can also enter text for each symbol.
1. Press F3 to make a contact.

|   |   |   |   |   |   |   |   |  F3 |  F4 |  F5 |   |   |   |   |  F6 |   |   |   |   |  F7 |   |   |   |   |  F8 |   |   |   |   |  F9 |  F10 |  F11 |  F12 |  NOT |  END |
|---|---|---|---|---|---|---|---|----|----|----|---|---|---|---|----|---|---|---|---|----|---|---|---|---|----|----|----|----|----|----|----|
| 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 2 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

2. Type "START" and press ENTER.

|   |   |   |   |   |   |   |   |  F3 |  F4 |  F5 |   |   |   |   |  F6 |   |   |   |   |  F7 |   |   |   |   |  F8 |   |   |   |   |  F9 |  F10 |  F11 |  F12 |  NOT |  END |
|---|---|---|---|---|---|---|---|----|----|----|---|---|---|---|----|---|---|---|---|----|---|---|---|---|----|----|----|----|----|----|----|----|
| 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 2 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

3. Press F5 couple times and you will see that it creates a line.

|   |   |   |   |   |   |   |   |  F3 |  F4 |  F5 |   |   |   |   |  F6 |   |   |   |   |  F7 |   |   |   |   |  F8 |   |   |   |   |  F9 |  F10 |  F11 |  F12 |  NOT |  END |
|---|---|---|---|---|---|---|---|----|----|----|---|---|---|---|----|---|---|---|---|----|---|---|---|---|----|----|----|----|----|----|----|----|
| 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 2 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

4. Press F7, type "RELAY", and press ENTER.

|   |   |   |   |   |   |   |   |  F3 |  F4 |  F5 |   |   |   |   |  F6 |   |   |   |   |  F7 |   |   |   |   |  F8 |   |   |   |   |  F9 |  F10 |  F11 |  F12 |  NOT |  END |
|---|---|---|---|---|---|---|---|----|----|----|---|---|---|---|----|---|---|---|---|----|---|---|---|---|----|----|----|----|----|----|----|----|
| 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 2 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

5. Go to the next rung (line) and press END.

|   |   |   |   |   |   |   |   |  F3 |  F4 |  F5 |   |   |   |   |  F6 |   |   |   |   |  F7 |   |   |   |   |  F8 |   |   |   |   |  F9 |  F10 |  F11 |  F12 |  NOT |  END |
|---|---|---|---|---|---|---|---|----|----|----|---|---|---|---|----|---|---|---|---|----|---|---|---|---|----|----|----|----|----|----|----|----|
| 1 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 2 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

At the very end of the Ladder Logic program, you must always put an END command.
Editing Ladder Logic Text

Editing Text
To edit existing text, place the cursor in the desired location and press ENTER. A text box will appear for editing the text.

Erasing a Cell
To erase a cell, select it with the cursor, and...

Erasing a Rung (one line)
A rung is a row in Ladder.

You can press CTRL-D to erase a rung. This actually moves the rung to a buffer.
**Rung Recovery**
To recover an erased rung (recall it from the buffer), press CTRL-U.

```plaintext
1          RELAY
START     ( )
IN2       OUT2
2         ( )
              END
3                       
```

**Cell Insert and Delete**
Select an empty cell on a rung.

- If you press the DEL key, the cell is erased and items on the right are pulled one cell to the left.

```plaintext
1          TON T0,100
START     [ ]
              [ ]
```

- If you press the INS key, a blank cell is inserted and items on the right are moved one cell to the right.

```plaintext
1          TON T0,100
START     [ ]
              [ ]
```

**Rung Copy**
When the same style of rung is needed, you can press CTRL-A and it will copy the rung above and pasted it one rung below.

```plaintext
1          TON T0,100
START     [ ]
2          [ ]
            [ ]
```
Comments
You can enter comments by adding an apostrophe (').

"This is Sample Program"

You can use a semi-colon (;) to drop to the next line.
For example:
"This is Sample Program; Date 24-Sep-2007 Comfile Technology"
Ladder Logic Block Copy and Paste

You can make a block of ladder logic and copy and paste to different parts of the program.

Click and drag the mouse to select the block you wish to copy. Press CTRL-C to copy and CTRL-V to paste. Similar to text editing, you can press CTRL-X and CTRL-V to cut and paste also.

NOTE: Please be aware that the Ladder Logic editor does not support undo.
Monitoring

Cubloc Studio supports real-time monitoring of Ladder Logic.

Status of contacts that are ON will be displayed in green. Timer and counter values will be displayed in decimal.

The monitoring speed can be controlled by going to "Setup" -> "Ladder Logic Environment Options..." and adjusting the "Monitoring Speed" slider. If the monitoring speed is too fast, it can negatively affect Cubloc's communications as monitoring consumes Cubloc's resources. We recommend a monitoring speed of 5.

NOTE: Please be sure to stop monitoring before editing or downloading.
With Time Chart Monitoring, Ladder Logic contacts can be analyzed in a time chart. The minimum width of the time chart is 40ms. The "Zoom" control can be used to measure the width of each pulse after stopping.

Up to 8 Registers can be monitored at one time.

To use the Time Chart Monitor, you must turn Debug off in BASIC. To do this, simply add the `Set Debug Off` command at the very beginning of the BASIC program.

NOTE: While using the Time Chart Monitor, Ladder Monitoring may not be used.
Watch Point

The Watch Point feature is useful when, in a long Ladder Logic program, two registers cannot be viewed simultaneously in the same screen due to their location in the ladder. Two apostrophes (""") are used to add a watch point.

Examples:  
"P0  "P1  "D0

NOTE: To set a watch point it’s two apostrophes (""), not a quotation mark(""") that must be used.
Options Window

If you select "Auto Run when download", the program will automatically reset itself after downloading. This can become a problem for machines that are sensitive to resets. To precisely control when to reset a program turn this option off.

In the "Help" menu, Cubloc Studio upgrade and version information can be found.
PLC Setup Wizard

To use Ladder Logic in Cubloc, you must create some minimal BASIC code. Although very simple, this can be hard for first-timers. You can use the PLC Setup Wizard and setup the I/Os you will be using and create the BASIC source automatically.

As you can see in above screen, device name, I/O mode, alias, and other features can be set simply by clicking.

You can set aliases for registers, turn Modbus on, and set the Modbus baud rate. You can always review the current BASIC code generated in real-time by navigating to the "Output BASIC code review" tab.
To get values for A/D, PWM, or COUNT, read from the D registers. For ADC0, the AD value is stored in D(10). Reading from register D(10) will return the AD value for ADC0.

To output PWM3, simply write to register D(29).

For HIGH COUNT1, simply read from register D(39). If necessary, the register for storing and writing values can be changed by modifying the BASIC code.

When finished making changes, click the "Replace Basic Code" button to produce the final BASIC code. Please be aware that any existing BASIC code will be overwritten.

Changes can also be saved to a file by clicking the "Save As..." button. Click the "Load..." button to restore from a saved file.
Usage of Ladder Register

With this feature, the aliases of all registers can be seen. A great deal of time can be saved using this feature while debugging and developing the final product. Go to Run->View Register Usage to open this window.
Registers

CB220, CB280 Registers
The following is a chart showing the registers for the CB220 and CB280.

<table>
<thead>
<tr>
<th>Register Name</th>
<th>Range</th>
<th>Units</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input/Output Register P</td>
<td>P0 to P127</td>
<td>1 bit</td>
<td>Interface w/ External devices</td>
</tr>
<tr>
<td>Internal Registers M</td>
<td>M0 to M511</td>
<td>1 bit</td>
<td>Internal Registers</td>
</tr>
<tr>
<td>Special Register F</td>
<td>F0 to F127</td>
<td>1 bit</td>
<td>System Status</td>
</tr>
<tr>
<td>Timer T</td>
<td>T0 to T99</td>
<td>16 bit (1 Word)</td>
<td>For Timers</td>
</tr>
<tr>
<td>Counter C</td>
<td>C0 to C49</td>
<td>16 bit (1Word)</td>
<td>For Counters</td>
</tr>
<tr>
<td>Step Enable S</td>
<td>S0 to S15</td>
<td>256 steps (1 Byte)</td>
<td>For Step Enabling</td>
</tr>
<tr>
<td>Data Memory D</td>
<td>D0 to 99</td>
<td>16bit (1 Word)</td>
<td>For Storing Data</td>
</tr>
</tbody>
</table>

P, M, and F registers are in bit units whereas T, C, and D are in word units. To access P, M, and F registers in word units, use WP, WM, and WF respectively.

<table>
<thead>
<tr>
<th>Register Name</th>
<th>Range</th>
<th>Units</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP</td>
<td>WP0 to 7</td>
<td>16 bit (1 Word)</td>
<td>Register P Word Access</td>
</tr>
<tr>
<td>WM</td>
<td>WM0 to WM31</td>
<td>16 bit (1 Word)</td>
<td>Register M Word Access</td>
</tr>
<tr>
<td>WF</td>
<td>WF0 to WF7</td>
<td>16 bit (1 Word)</td>
<td>Register F Word Access</td>
</tr>
</tbody>
</table>

WP0 consists of registers P0 through P15. P0 is the least significant bit of WP0 and P15 is the most significant bit. These registers are often used with commands like WMOV.
CB290 and CB405 Registers

The following is a chart showing the registers for the CB290 and CB405. The CB290 and CB405 have more M, C, T, and D registers than the CB220 and CB280.

<table>
<thead>
<tr>
<th>Register Name</th>
<th>Range</th>
<th>Units</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input/Output Register P</td>
<td>P0 to P127</td>
<td>1 bit</td>
<td>Interface w/ External devices</td>
</tr>
<tr>
<td>Internal Registers M</td>
<td>M0 to M2047</td>
<td>1 bit</td>
<td>Internal Registers</td>
</tr>
<tr>
<td>Special Register F</td>
<td>F0 to F127</td>
<td>1 bit</td>
<td>System Status</td>
</tr>
<tr>
<td>Timer T</td>
<td>T0 to T255</td>
<td>16 bit (1 Word)</td>
<td>For Timers</td>
</tr>
<tr>
<td>Counter C</td>
<td>C0 to C255</td>
<td>16 bit (1 Word)</td>
<td>For Counters</td>
</tr>
<tr>
<td>Step Enable S</td>
<td>S0 to S15</td>
<td>256 steps (1 Byte)</td>
<td>For Step Enabling</td>
</tr>
<tr>
<td>Data Memory D</td>
<td>D0 to 511</td>
<td>16 bit (1 Word)</td>
<td>For Storing Data</td>
</tr>
</tbody>
</table>

P, M, and F Registers are in bit units whereas T, C, and D are in word units. To access P, M, and F registers in word units, use WP, WM, and WF respectively.

<table>
<thead>
<tr>
<th>Register Name</th>
<th>Range</th>
<th>Units</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP</td>
<td>WP0 to 7</td>
<td>16 bit (1 Word)</td>
<td>Register P Word Access</td>
</tr>
<tr>
<td>WM</td>
<td>WM0 to WM63</td>
<td>16 bit (1 Word)</td>
<td>Register M Word Access</td>
</tr>
<tr>
<td>WF</td>
<td>WF0 to WF7</td>
<td>16 bit (1 Word)</td>
<td>Register F Word Access</td>
</tr>
</tbody>
</table>

WP0 contains P0 through P15. P0 is the least significant bit of WP0 and P15 is the most significant bit. These registers are often used with commands like WMOV.
Ladder Symbols

Contact A, Contact B

Contact A is "Normally Open" and closes when a signal is received. On the other hand, Contact B is "Normally Closed" and opens when a signal is received.

Input, Output Register Symbol

Input/Output registers are the most basic symbols among the registers in Ladder Logic.

Function Registers

Function registers include timers, counters, and other mathematical operation registers.
Internal Registers

Internal registers (M) only operate within the program. Unless connected to an actual external port, they are only used internally. M registers can be used as input or output symbols.

P Registers Not Used as I/O Ports

Cubloc supports P registers from P0 to P127. P registers are directly connected to I/O ports one to one. However, most models of Cubloc have less than 128 I/O ports. Those P registers not connected to an I/O port can be used as internal registers (M registers).
Using I/Os

Cubloc I/O ports can be used by both BASIC and Ladder Logic. Without defined settings, all I/O ports are controlled in BASIC. The UsePin command must be used to set the I/O ports for use in Ladder Logic.

```
UsePin 0,IN
UsePin 1,OUT
```

The above code sets P0 as input and P1 as output for use in Ladder Logic.

Those ports declared with the UsePin command will be re-flashed during a ladder scan. Re-flashing means that, prior to a ladder scan, those ports declared as IN with the UsePin command will have their input read and copied to the port's corresponding P register. After the ladder scan, those ports declared as OUT with the UsePin command will have the corresponding P register's value written to the port's output.

```
INPUT REFRESH
  
LADDER SCAN
  
OUTPUT REFRESH
```

In BASIC, the commands In and Out can be used to control I/O ports. This method directly accesses the I/O ports when reading and writing. In order to avoid collisions between the two, I/O ports should be used in either BASIC or Ladder Logic, but not both. Once a port is declared with the UsePin command, it can only be used in Ladder Logic and cannot be directly accessed in BASIC, except through the ladder registers.

```
UsePin 0,IN, START
UsePin 1,OUT, RELAY
```

Aliases (such as START or RELAY as shown above) can be assigned using the UsePin command to improve readability.
Use of Aliases

When creating Ladder Logic using "Register numbers" such as P0, P1, and M0, aliases can be used to help simplify programs.

In order to use an alias, they must be declared in BASIC.

```
Alias M0 = MAINMOTOR
Alias M2 = STATUS1
Alias M4 = MOTORSTOP
```

Aliases can be declared using either the UsePin or the Alias commands.
Starting Ladder Logic

Cubloc executes BASIC first. To enable Ladder Logic, use the command Set Ladder On. After this command is executed, Ladder Logic will begin running and perform ladder scans every 10 milliseconds.

If the Set Ladder On command is not used, Ladder Logic will not run and no ladder scans will be performed.

Set Ladder On

Declaring the Device to Use

The type of device being used must be declared in BASIC at the beginning of every program using the Const Device command. The following are examples illustrate this for the CB220 and the CB280.

Const Device = CB220     ' Use the CB220.

or

Const Device = CB280     ' Use the CB280.
Using Ladder Logic Only

If only using Ladder Logic a minimal amount of BASIC code is required. The BASIC code must contain, at a minimum, a device declaration, the `Set Ladder On` command, and a `Do...Loop` to keep the program executing. Port declarations, and aliases must also be declared in BASIC.

The following example illustrates such a program.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Const Device = CB280</td>
<td>'Device Declaration</td>
</tr>
<tr>
<td>UsePin 0, In, START</td>
<td>'Port Declaration</td>
</tr>
<tr>
<td>UsePin 1, In, RESETKEY</td>
<td></td>
</tr>
<tr>
<td>UsePin 2, In, BKEY</td>
<td></td>
</tr>
<tr>
<td>UsePin 3, Out, MOTOR</td>
<td></td>
</tr>
<tr>
<td>Alias M0=RELAYSTATE</td>
<td>'Aliases</td>
</tr>
<tr>
<td>Alias M1=MAINSTATE</td>
<td></td>
</tr>
<tr>
<td>Set Ladder On</td>
<td>'Start Ladder</td>
</tr>
<tr>
<td>Do</td>
<td></td>
</tr>
<tr>
<td>Loop</td>
<td>'BASIC program will run in infinite loop.</td>
</tr>
</tbody>
</table>
# Ladder Logic Commands

## Low-Level Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOAD</td>
<td><img src="image" alt="Symbol" /></td>
<td>Contact A (Open by default)</td>
</tr>
<tr>
<td>LOADN</td>
<td><img src="image" alt="Symbol" /></td>
<td>Contact B (Closed by default)</td>
</tr>
<tr>
<td>OUT</td>
<td><img src="image" alt="Symbol" /></td>
<td>Output</td>
</tr>
<tr>
<td>NOT</td>
<td><img src="image" alt="Symbol" /></td>
<td>NOT (Invert the result)</td>
</tr>
<tr>
<td>STEPSET</td>
<td><img src="image" alt="Symbol" /></td>
<td>Step Controller Output (Step Set)</td>
</tr>
<tr>
<td>STEPOUT</td>
<td><img src="image" alt="Symbol" /></td>
<td>Step Controller Output (Step Out)</td>
</tr>
<tr>
<td>MCS</td>
<td><img src="image" alt="Symbol" /></td>
<td>Master Control Start</td>
</tr>
<tr>
<td>MCSCLR</td>
<td><img src="image" alt="Symbol" /></td>
<td>Master Control Stop</td>
</tr>
<tr>
<td>DIFU</td>
<td><img src="image" alt="Symbol" /></td>
<td>Set ON for 1 scan time when a logic-high signal is received</td>
</tr>
<tr>
<td>DIFD</td>
<td><img src="image" alt="Symbol" /></td>
<td>Set ON for 1 scan time when logic-low signal is received</td>
</tr>
<tr>
<td>SETOUT</td>
<td><img src="image" alt="Symbol" /></td>
<td>Set and Hold Output ON</td>
</tr>
<tr>
<td>RSTOUT</td>
<td><img src="image" alt="Symbol" /></td>
<td>Set and Hold Output OFF</td>
</tr>
<tr>
<td>END</td>
<td><img src="image" alt="Symbol" /></td>
<td>End of Ladder Logic</td>
</tr>
<tr>
<td>GOTO</td>
<td><img src="image" alt="Symbol" /></td>
<td>Jump to the Specified Label</td>
</tr>
<tr>
<td>LABEL</td>
<td><img src="image" alt="Symbol" /></td>
<td>Label Declaration</td>
</tr>
<tr>
<td>CALLS</td>
<td><img src="image" alt="Symbol" /></td>
<td>Call a Subroutine</td>
</tr>
<tr>
<td>SBRT</td>
<td><img src="image" alt="Symbol" /></td>
<td>Declare a Subroutine</td>
</tr>
<tr>
<td>RET</td>
<td><img src="image" alt="Symbol" /></td>
<td>End Subroutine</td>
</tr>
<tr>
<td>TND</td>
<td><img src="image" alt="Symbol" /></td>
<td>Conditional Exit Command</td>
</tr>
</tbody>
</table>
# High-Level Commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Commands</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WMOV</td>
<td>s,d</td>
<td>Move Word</td>
</tr>
<tr>
<td>DWMOV</td>
<td>s,d</td>
<td>Move Double Word</td>
</tr>
<tr>
<td>WXCHG</td>
<td>s,d</td>
<td>Swap Word</td>
</tr>
<tr>
<td>DWXCHG</td>
<td>s,d</td>
<td>Swap Double Word</td>
</tr>
<tr>
<td>FMOV</td>
<td>s,d,n</td>
<td>Move Data Multiple Times (Fill Data)</td>
</tr>
<tr>
<td>GMOV</td>
<td>s,d,n</td>
<td>Move a Group of Data</td>
</tr>
<tr>
<td><strong>Increment/Decrement Commands</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WINC</td>
<td>d</td>
<td>Increment a Word by 1</td>
</tr>
<tr>
<td>DWINC</td>
<td>d</td>
<td>Increment a Double Word by 1</td>
</tr>
<tr>
<td>WDEC</td>
<td>d</td>
<td>Decrement a Word by 1</td>
</tr>
<tr>
<td>DWDEC</td>
<td>d</td>
<td>Decrement a Double Word by 1</td>
</tr>
<tr>
<td><strong>Math Commands</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WADD</td>
<td>s1,s2,d</td>
<td>Word Add</td>
</tr>
<tr>
<td>DWADD</td>
<td>s1,s2,d</td>
<td>Double Word Add</td>
</tr>
<tr>
<td>WSUB</td>
<td>s1,s2,d</td>
<td>Word Subtract</td>
</tr>
<tr>
<td>DWSUB</td>
<td>s1,s2,d</td>
<td>Double Word Subtract</td>
</tr>
<tr>
<td>WMUL</td>
<td>s1,s2,d</td>
<td>Word Multiplication</td>
</tr>
<tr>
<td>WDIV</td>
<td>s1,s2,d</td>
<td>Word Division</td>
</tr>
<tr>
<td>DWDIV</td>
<td>s1,s2,d</td>
<td>Double Word Division</td>
</tr>
<tr>
<td><strong>Logical Commands</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WAND</td>
<td>s1,s2,d</td>
<td>Word AND</td>
</tr>
<tr>
<td>DWAND</td>
<td>s1,s2,d</td>
<td>Double Word AND</td>
</tr>
<tr>
<td>WOR</td>
<td>s1,s2,d</td>
<td>Word OR</td>
</tr>
<tr>
<td>DWOR</td>
<td>s1,s2,d</td>
<td>Double Word OR</td>
</tr>
<tr>
<td>WXOR</td>
<td>s1,s2,d</td>
<td>Word XOR</td>
</tr>
<tr>
<td>DWXOR</td>
<td>s1,s2,d</td>
<td>Double Word XOR</td>
</tr>
<tr>
<td><strong>Bit Shift Commands</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WROL</td>
<td>d</td>
<td>Shift Word 1 bit to the Left</td>
</tr>
<tr>
<td>DWROL</td>
<td>d</td>
<td>Shift Double Word 1 bit to the Left</td>
</tr>
<tr>
<td>WROR</td>
<td>d</td>
<td>Shift Word 1 bit to the Right</td>
</tr>
<tr>
<td>DWOR</td>
<td>d</td>
<td>Shift Double Word 1 bit to the Right</td>
</tr>
</tbody>
</table>
LOAD, LOADN, OUT

LOAD is for contacts that are open by default and LOADN is for contacts that are closed by default.

<table>
<thead>
<tr>
<th>Registers that can be used</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOAD</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>LOADN</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>OUT</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
</tbody>
</table>

P0

P1

P2

P3
NOT, AND, OR

NOT inverts the results. On the first rung in the example above, if P0 is ON then P5 will be OFF.

AND is performed on two registers when they are placed horizontally beside each other on the same rung. On the second rung in the example above, both registers P0 and P1 must be ON in order for P5 to be ON.

An OR operation is performed when two registers are placed vertically beside each other on the same rung. On the third rung in the example above, when either P0 or P1 is ON, P5 will be ON.

When two or more AND or OR operations are used on a single rung, as illustrated in the following example, it is called a BLOCK AND or a BLOCK OR.
SETOUT, RSTOUT

SETOUT turns a register ON, and holds it on even if its input condition changes. Contrary to SETOUT, RSTOUT turns a register OFF and holds it OFF even if its input condition changes.

On the first rung in the example below, SETOUT will turn P5 ON when P0 turns ON, and will hold P5 ON even if P0 turns OFF. In the second rung of the example below, RSTOUT will turn P5 OFF when P1 is ON, and will hold P5 OFF even when P1 turns OFF.

```
<table>
<thead>
<tr>
<th>P0</th>
<th>P1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
```

SETOUT P5

RSTOUT P5

<table>
<thead>
<tr>
<th>Registers that can be used</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>SETOUT</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSTOUT</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P0

P1

P5
DEFCON

DEFCON  name, value

Defines a named constant

DEFCON provides a convenient way to reuse a value within a ladder diagram. If the value changes, only the constant’s declaration, the DEFCON statement, would need to change.

Please note you cannot use reserved words as constant names. For example DEFCON WMOV 100 is not legal since WMOV is a reserved command name.
DF, DFN

DF turns an output ON for the duration of one ladder scan when the input changes from OFF to ON.

Conversely, DFN turns an output ON for the duration of one ladder scan when the input changes from ON to OFF.
**LOOP**

**LO**OP *label, register*

Repeatedly jumps to *label* until the value in register reaches 0. *register* is automatically decremented with each iteration.

In the example above, D0 is initialized to 5. This will be the number of times to repeat the loop. D1 is initialized to 0. This is the number we wish to change. D1 is incremented with each iteration and D0 is decremented with each iteration. Therefore, when D0 reaches 0, LOOP no longer jumps to NT1 and D1 will contain the value 5.
MCS, MCSCLR

MCS and MCSCLR are used to conditionally execute rungs in a ladder. Rungs between MCS x and MCSCLR x are executed only when the input to MCS x is ON. If the input to MCS x is OFF, the rungs between MCS x and MCSCLR x will not be executed. Using this command, an block of Ladder Logic can be conditionally executed.

In the example above, when M0 turns ON, the rungs between MCS 0 and MCSCLR are executed normally. If M0 is OFF, P5 and P6 will not be processed.

MCS numbers can be assigned from 0 to 7. MCS numbers should be used incrementally from 0 to 7. MCS 1 must be nested inside MCS 0 and MCS 2 must be nested inside MCS 1. When MCS 0 is OFF, none of the MCS's nested inside of MCS 0 will be executed.

When the input to an MCS is OFF, all outputs within that MCS block will turn OFF, timers within the MCS block will be reset, and counters within the MCS block will stop counting.

The following table describes the behavior of various commands nested within an MCS block:

<table>
<thead>
<tr>
<th>Command</th>
<th>When MCS is ON</th>
<th>When MCS is OFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUT</td>
<td>Normal Operation</td>
<td>OFF</td>
</tr>
<tr>
<td>SETOUT</td>
<td>Normal Operation</td>
<td>State is retained</td>
</tr>
<tr>
<td>RSTOUT</td>
<td>Normal Operation</td>
<td>State is retained</td>
</tr>
<tr>
<td>Timer</td>
<td>Normal Operation</td>
<td>Reset to default value</td>
</tr>
<tr>
<td>Counter</td>
<td>Normal Operation</td>
<td>State is retained, but counting is stopped</td>
</tr>
<tr>
<td>Other Commands</td>
<td>Normal Operation</td>
<td>Not executed</td>
</tr>
</tbody>
</table>
The following example shows MCS 1 nested within MCS 0.

MCS numbers can be used repeatedly, but cannot be nested within one another.
Step Control
S Registers are used for step control. Step control arguments must follow the following format.

S7:126

Step control can be performed in two ways: "Normal Step" and "Reverse Step". STEPSET is used for "Normal Step".

STEPSET

STEPSET turns ON the current step, but only if the previous step is ON. STEPSET is processed one step at a time, in sequence, according to the step number. For example, in the ladder above, when P1 turns ON, S0:2 is turned ON, but only if S0:1 is ON. After S0:2 turns ON, S0:1 is turns OFF. When P2 turns ON, S0:0 is turned ON and all other steps are turned OFF. S0:0, or step 0, is used to reset. All other steps are processed in order.
STEPOUT

STEPOUT differs from STEPSET in two ways. First, it is not evaluated in sequence, and second, when a step is turned ON, it remains in that state regardless of its input condition. When using STEP OUT and a step is turned ON, all other steps are turned OFF, so only one step is ON at any given time.

In the ladder above, when P1 turns ON, S0:2 will turn ON. When P0 turns on S0:1 turns ON, and S0:2 turns OFF and S0:1 turns ON. When P0 turns OFF, S0:1 is unchanged as each step, when turned ON, remains ON regardless of its input condition. Finally when P2 turns ON, S0:0 turns ON and S0:1 turns OFF.
TMON, TAMON

Cubloc Studio 3.3.1 and later

TMON  *arg*,  *timeout*
TAMON  *arg*,  *timeout*

Implements a timer that turns *arg* ON when the input turns ON, and remains ON until *timeout* elapses. After *timeout* elapses, *arg* will remain on regardless of the input.

<table>
<thead>
<tr>
<th>Type of Timer</th>
<th>Time units</th>
<th>Maximum Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMON</td>
<td>0.01 sec</td>
<td>655.35 sec</td>
</tr>
<tr>
<td>TAMON</td>
<td>0.1 sec</td>
<td>6553.5 sec</td>
</tr>
</tbody>
</table>

Usable Registers

<table>
<thead>
<tr>
<th>arg</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Y</th>
<th>A</th>
<th>B</th>
<th>00</th>
</tr>
</thead>
</table>

If the input (P0) turns OFF, the output (T0) still remains ON.
After the timeout elapses, the output (T0) will turn OFF even if the input (P0) remains ON.

If the input (P0) turns ON after the timeout has elapsed, the output (T0) will turn ON again.

If the input (P0) turns OFF and then ON before the timeout has elapsed, the output (T0) will still remain ON only for the specified timeout.
TON, TAON

TON and TAON provide the capability to delay the effect of an input changing from OFF to ON for a specified amount of time. When the input turns ON, a timer begins incrementing from its initial value to the specified value. When the specified value is reached, the output is turned ON. TON increments every 0.01 seconds and TAON increments every 0.1 seconds.

<table>
<thead>
<tr>
<th>Type of Timer</th>
<th>Time units</th>
<th>Maximum Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>TON</td>
<td>0.01 sec</td>
<td>655.35 sec</td>
</tr>
<tr>
<td>TAON</td>
<td>0.1 sec</td>
<td>6553.5 sec</td>
</tr>
</tbody>
</table>

For TON and TAON there are 2 parameters. The first parameter can be any value from T0 through T99, and the second parameter can be any numeric constant or data register, such as D0.

In the ladder above, when START turns ON, timer T0 increases from 0 to 100 in increments of 0.01 seconds. When 100 is reached, T0 will turn ON. Here, 100 is equal to a time of 1 second for TON, and 10 seconds for TAON.

When START turns OFF, the timer is reset to its initial value and T0 will turn OFF. TON and TAON will reset their values upon powering OFF. Using KTON and KTAON, the battery backup feature can be used to retain the timer’s values between power cycles. The example below illustrates how to reset TAON.
TOFF, TAOFF

TOFF and TAOFF provide the capability to delay the effect of an input changing from ON to OFF for a specified amount of time. When input turns ON, the output turns ON immediately, but when the input turns OFF, the output is kept ON for the set amount of time, and then turned OFF. TOFF increases in increments of 0.01 seconds and TAOFF increases in increments 0.1 seconds.

<table>
<thead>
<tr>
<th>Type of Timer</th>
<th>Time units</th>
<th>Maximum Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOFF</td>
<td>0.01 sec</td>
<td>655.35 sec</td>
</tr>
<tr>
<td>TAOFF</td>
<td>0.1 sec</td>
<td>6553.5 sec</td>
</tr>
</tbody>
</table>

For TON and TAON there are 2 parameters. The first parameter can be any value from T0 through T99, and the second parameter can be any numeric constant or data register, such as D0.

<table>
<thead>
<tr>
<th>Usable Registers</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOFF, TAOFF</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
</tbody>
</table>

In the ladder above, when START turns ON, the timer T0 immediately turns ON. When START turns OFF, the timer will start decreasing from 100 to 0. When 0 is reached, T0 will turn OFF. Here, 100 is equal to a time of 1 second for TOFF, and 10 seconds for TAOFF.
**CTU**

This CTU command is an UP counter. When an input is received the counter is incremented by one. When the counter reaches a specified value, the specified register will turn ON. There is also a reset input so the counter can be reset as needed.

---

**CTD**

This CTD command is a DOWN counter. When an input is received the counter is decremented by one. When the counter reaches 0, the specified register will turn ON. There is also a reset input so the counter can be reset as needed.
UP/DOWN COUNTER

Below is a simple example of how an UP counter can be used to make an UP/DOWN Counter.

P0 is for counting UP, P2 is for counting DOWN, and P1 is for resetting the counter. When the counter reaches 100, C0 turns ON.
**KCTU**

This command is exactly same as the CTU command, except this command will be able to remember its count when the module is powered off. By comparison, the CTU command will lose its count when the module is powered off. This command can only be used with modules that support battery backup such as the CB290, CB405, and CuTouch.

When using this command for the very first time, use the RESET signal to initialize the counter. Otherwise the counter could start at some random value.

**KCTD**

This command is exactly same as the CTD command, except this command will be able to remember its count when the module is powered off. By comparison, the CTD command will lose its count when the module is powered off. This command can only be used with modules that support battery backup such as the CB290, CB405, and CuTouch.
Comparison Logic

Compare 2 word(16 bit) or 2 double word(32 bit) values and turn on an output when the conditions are satisfied.

<table>
<thead>
<tr>
<th>Comparison Command</th>
<th>Data Types</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>=, s1, s2</td>
<td>Word(16 bit)</td>
<td>Turns on when s1 and s2 are equal.</td>
</tr>
<tr>
<td>&lt;&gt; , s1, s2</td>
<td>Word(16 bit)</td>
<td>Turns on when s1 and s2 are not equal.</td>
</tr>
<tr>
<td>&gt;, s1, s2</td>
<td>Word(16 bit)</td>
<td>Turns on when s1 &gt; s2.</td>
</tr>
<tr>
<td>&lt;, s1, s2</td>
<td>Word(16 bit)</td>
<td>Turns on when s1 &lt; s2.</td>
</tr>
<tr>
<td>&gt;=, s1, s2</td>
<td>Word(16 bit)</td>
<td>Turns on when s1 &gt;= s2.</td>
</tr>
<tr>
<td>&lt;=, s1, s2</td>
<td>Word(16 bit)</td>
<td>Turns on when s1 &lt;= s2.</td>
</tr>
<tr>
<td>D=, s1, s2</td>
<td>DWord(32 bit)</td>
<td>Turns on when s1 and s2 are equal.</td>
</tr>
<tr>
<td>D&lt;&gt; , s1, s2</td>
<td>DWord(32 bit)</td>
<td>Turns on when s1 and s2 are not equal.</td>
</tr>
<tr>
<td>D&gt;, s1, s2</td>
<td>DWord(32 bit)</td>
<td>Turns on when s1 &gt; s2.</td>
</tr>
<tr>
<td>D&lt;, s1, s2</td>
<td>DWord(32 bit)</td>
<td>Turns on when s1 &lt; s2.</td>
</tr>
<tr>
<td>D&gt;=, s1, s2</td>
<td>DWord(32 bit)</td>
<td>Turns on when s1 &gt;= s2.</td>
</tr>
<tr>
<td>D&lt;=, s1, s2</td>
<td>DWord(32 bit)</td>
<td>Turns on when s1 &lt;= s2.</td>
</tr>
</tbody>
</table>

You can mix comparison logic as shown below:

When either D0=T1 or D1<100 and if C0>=99, M0 will turn ON. In other words, either D0 has to equal to value of T1 or D1 has to be less than 100 while C0 must be greater than or equal to 99.
Storing Words and Double Words

A byte is 8 bits, a word is 16 bits, and a double word is 32 bits.

Memory is divided into bytes, so words and double words must be split across multiple bytes. Therefore, there are two ways to store words and double words: Least significant byte first (Little Endian) or most significant byte first (Big Endian). Cubloc stores its data in Little Endian.

In the memory map to the right, 1234H is stored in memory address 0 and 12345678H is stored in memory address 5. Note how 34H (the least significant byte of 1234H is stored first in memory address 0, and 78H, the least significant byte of 12345678H is stored first in memory address 5.

The Registers C, T, D are in word units. To store double words data, 2 words are required, therefore 2 registers are required. Below is an example of storing a double word, 12345678H. D1 gets 1234H and D0 gets 5678H.
Binary, Decimal, Hexadecimal

To program well, we need to know binary, decimal, and hexadecimal numbers. The following chart shows the relationships between these notations.

<table>
<thead>
<tr>
<th>Decimal</th>
<th>Binary</th>
<th>Hexadecimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0000</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0001</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0010</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>0011</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>0100</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>0101</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>0110</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>0111</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>1000</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>1001</td>
<td>9</td>
</tr>
<tr>
<td>10</td>
<td>1010</td>
<td>A</td>
</tr>
<tr>
<td>11</td>
<td>1011</td>
<td>B</td>
</tr>
<tr>
<td>12</td>
<td>1100</td>
<td>C</td>
</tr>
<tr>
<td>13</td>
<td>1101</td>
<td>D</td>
</tr>
<tr>
<td>14</td>
<td>1110</td>
<td>E</td>
</tr>
<tr>
<td>15</td>
<td>1111</td>
<td>F</td>
</tr>
</tbody>
</table>

In Cubloc’s Ladder Logic, we express binary and hexadecimal numbers in the following manner:

- Binary: 00101010B
- Hexadecimal: 0ABCDH

We put a B at the end of the binary number and an H at the end for hexadecimal numbers. To clearly identify that a hexadecimal value is a number, we can put a 0 in front of the hexadecimal number.
(E.g.: 0ABH, 0A1H, 0BCDH)

*BASIC is slightly different from Ladder Logic in the way binary and hexadecimal numbers are expressed. &B100010 is used for binary and &HAB is used for hexadecimal.
WBCD s, d

Converts the 16 bit binary value in \texttt{s} to a BCD (Binary Coded Decimal) value and stores the result in \texttt{d}.

Values shown are in hexadecimal

<table>
<thead>
<tr>
<th>Usable Registers</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Y</th>
<th>A</th>
<th>B</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{s, d}</td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
</tbody>
</table>

\[ \begin{array}{c}
\text{D0} \quad 1234 \\
\quad 04D2H
\end{array} \quad \rightarrow \quad \begin{array}{c}
\quad \rightarrow \quad \text{D2} \\
\quad 4660 \\
\quad 1234H
\end{array} \]
WBIN

WBIN  s, d

Converts the 16 bit BCD value in s to binary and stores the result in d. Values shown are in hexadecimal.

<table>
<thead>
<tr>
<th>Usable Register</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>s, d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

D2  4660 1234H → D4  1234 04D2H
WBCNT, DWBCNT

Cubloc Studio 3.3.1 and later

WBCNT  s, d
DWBCNT  s, d

Counts the number of active bits (1s) in s in stores the result in d. WBCNT operates words (16 bits) and DWBCNT operates on double words (32 bits).

Values shown are in hexadecimal

<table>
<thead>
<tr>
<th>Usable Register</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
</tbody>
</table>
WMOV, DWMOV

WMOV  s, d  
DWMOV  s, d

The WMOV command moves 16 bit data from s to d. DWMOV is used for 32 bit data.

<table>
<thead>
<tr>
<th>Usable Register</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>s (Source)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>d (Destination)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

When the input START turns ON, D0 will get 100. When IN0 turns ON, D2 will get 1234H.
**WXCHG, DWXCHG**

**WXCHG**  s, d
**DWXCHG**  s, d

These commands swap data between s and d. WXCHG is for swapping word values and DWXCHG is swapping double word values.

<table>
<thead>
<tr>
<th>Usable Registers</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>O</td>
<td></td>
</tr>
</tbody>
</table>

When START turns ON, D0 gets 100 and D1 gets 123. When IN0 turns ON, D0 and D1 swap their data. The result is as shown below:

<table>
<thead>
<tr>
<th>D0</th>
<th>123</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>100</td>
</tr>
<tr>
<td>D2</td>
<td></td>
</tr>
<tr>
<td>D3</td>
<td></td>
</tr>
<tr>
<td>D4</td>
<td></td>
</tr>
</tbody>
</table>
**FMOV**

FMOV s, d, n

This command stores s in d, n number of times, in subsequent memory locations. This command is usually used for initializing or clearing memory.

<table>
<thead>
<tr>
<th>Usable Registers</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>n</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The result of the ladder above is shown below:

```
D0  100
D1  100
D2  100
D3  100
D4  100
D5  100
```

*NOTE: n must be less than 255.*
**GMOV**

GMOV s, d, n

This command takes \( n \) values, starting from \( s \), and copies them to \( d \). To avoid collisions, source and destination memory should not overlap.

<table>
<thead>
<tr>
<th>Usable Registers</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>s</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ACTION: GMOV D0, D10, 5

The result of the ladder above is shown below:

<table>
<thead>
<tr>
<th>D0</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>34</td>
</tr>
<tr>
<td>D2</td>
<td>56</td>
</tr>
<tr>
<td>D3</td>
<td>78</td>
</tr>
<tr>
<td>D4</td>
<td>90</td>
</tr>
<tr>
<td>D5</td>
<td></td>
</tr>
<tr>
<td>D6</td>
<td></td>
</tr>
<tr>
<td>D7</td>
<td></td>
</tr>
<tr>
<td>D8</td>
<td></td>
</tr>
<tr>
<td>D9</td>
<td></td>
</tr>
<tr>
<td>D10</td>
<td>12</td>
</tr>
<tr>
<td>D11</td>
<td>34</td>
</tr>
<tr>
<td>D12</td>
<td>56</td>
</tr>
<tr>
<td>D13</td>
<td>78</td>
</tr>
<tr>
<td>D14</td>
<td>90</td>
</tr>
<tr>
<td>D15</td>
<td></td>
</tr>
<tr>
<td>D16</td>
<td></td>
</tr>
</tbody>
</table>

*NOTE:* \( n \) must be less than 255.
WCMP, DWCMP

Cubloc Studio 3.3.1 and later

WCMP arg1, arg2
DWCMP arg1, arg2

Compares arg1 and arg2. WCMP operates on words (16 bits) and DWCMP operates on double words (32 bits).

Flags:
F73 (zero flag) - ON if s1 and s2 are equal
F66 (less than flag) - ON if s1 is less than s2
F67 (greater than flag) - ON if s1 is greater than s2
WINC, DWINC, WDEC, DWDEC

WINC d
DWINC  d
WDEC  d
DWDEC  d

WINC increments the word value in d by one.
DWINC increments the double word value in d by one.
WDEC decrements the word value in d by one.
DWDEC decrements the double word value in d by one.

<table>
<thead>
<tr>
<th>Usable Registers</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
</tbody>
</table>

The result of the ladder above is shown below:

<table>
<thead>
<tr>
<th>D0</th>
<th>99</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td></td>
</tr>
<tr>
<td>D3</td>
<td></td>
</tr>
</tbody>
</table>
**WADD, DWADD**

WADD s1, s2, d  
DWADD s1, s2, d

These commands adds $s_1$ and $s_2$ and store the result in $d$. WADD adds word values and DWADD adds double word values.

<table>
<thead>
<tr>
<th>Usable Registers</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>s1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>s2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**WSUB, DWSUB**

WSUB s1, s2, d  
DWSUB s1, s2, d

These commands subtracts $s_2$ from $s_1$ and store the result in $d$. WADD subtracts word values and DWADD subtracts double word values.

<table>
<thead>
<tr>
<th>Usable Registers</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>s1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>s2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

```
<table>
<thead>
<tr>
<th>START</th>
<th>WMOV 100, D0</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACTION</td>
<td>WSUB D0, 5, D1</td>
</tr>
</tbody>
</table>
```

In the ladder above, D1 will get 95.
**WMUL**

**WMUL s1, s2, d**

These commands multiply \( s_1 \) and \( s_2 \) and store the result in \( d \). WMUL multiplies word values.

<table>
<thead>
<tr>
<th>Usable Registers</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>s1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>s2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

In the ladder above, the result of \( 1234H \times 1234H \) is stored as the double word \( 14B5A90H \) in D1.

```
START

WMUL, 1234H, D0

ACTION

WMUL, D0, 1234H, D1
```

In the ladder above, the result of \( 123456H \times 1234H \) is stored as \( 4B60AD78H \) in D2.

```
START

DWMUL 123456H, D0

ACTION

DWMUL D0, 1234H, D2
```

In the ladder above, the result of \( 123456H \times 1234H \) is stored as \( 4B60AD78H \) in D2.
**WDIV, DWDIV**

WDIV s1, s2, d  
DWDIV s1, s2, d

These commands divide s1 and s2 and store the result in d and the remainder in d+1. WDIV divides word values and DWDIV divides double word values.

<table>
<thead>
<tr>
<th>Usable Registers</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>s1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>s2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

**ACTION**  

<table>
<thead>
<tr>
<th>WDIV D0,D2,D4</th>
</tr>
</thead>
</table>

| D0 | 1234H |
| D1 |      |
| D2 | 3    |
| D3 |      |
| D4 | 611H |
| D5 | 1    |

**ACTION**  

<table>
<thead>
<tr>
<th>DWDIV D0,D2,D4</th>
</tr>
</thead>
</table>

| D0 | 5678H |
| D1 | 1234H |
| D2 | 7     |
| D3 | 0     |
| D4 | 0C335H|
| D5 | 299H  |
| D6 | 5     |
| D7 | 0     |

412
**WOR, DWOR**

WOR s1, s2, d  
DWOR s1, s2, d

These commands logically OR $s_1$ and $s_2$ and store the result in $d$. WOR divides word values and DWOR divides double word values.

<table>
<thead>
<tr>
<th>Usable Registers</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>s1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>s2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

The result of above ladder diagram:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D0</td>
<td>1200H</td>
</tr>
<tr>
<td>D1</td>
<td>34H</td>
</tr>
<tr>
<td>D2</td>
<td>1234H</td>
</tr>
</tbody>
</table>
WXOR, DWXOR

WXOR s1, s2, d
DWXOR s1, s2, d

These commands logically XOR \( s_1 \) and \( s_2 \) and store the result in \( d \). WXOR divides word values and DWXOR divides double word values.

<table>
<thead>
<tr>
<th>Usable Registers</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>s1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>s2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>d</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

The following is result of above LADDER:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D0</td>
<td>1234H</td>
</tr>
<tr>
<td>D1</td>
<td>0FFH</td>
</tr>
<tr>
<td>D2</td>
<td>12CBH</td>
</tr>
</tbody>
</table>

When you want to invert specific bits, you can use XOR logical operation.
WAND, DWAND

WAND s1, s2, d
DWAND s1, s2, d

These commands logically AND s1 and s2 and store the result in d. WAND divides word values and DWAND divides double word values.

<table>
<thead>
<tr>
<th>Registers that may be used</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>s1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>s2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

The results of execution of LADDER above:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D0</td>
<td>1234H</td>
</tr>
<tr>
<td>D1</td>
<td>0FFH</td>
</tr>
<tr>
<td>D2</td>
<td>34H</td>
</tr>
</tbody>
</table>

You can use AND operation when you want to use specific bits only.
WROL, DWROL

WROL d
DWROL d

This commands rotates the bits in d 1 bit to the left (least significant bit to most significant bit). Bits on the far left are appended on the far right. WROL operates on word values and DWROL operates on double word values.

<table>
<thead>
<tr>
<th>Registers that may be used</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
</tbody>
</table>

If D0 has 8421H, the following results:

<table>
<thead>
<tr>
<th>D0</th>
<th>0843H</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td></td>
</tr>
</tbody>
</table>
WROR, DWROR

WROR d
DWROR  d

This commands rotates the bits in \( d \) 1 bit to the right (most significant bit to least significant bit). Bits on the far right are appended on the far left. WROR operates on word values and DWROR operates on double word values.

<table>
<thead>
<tr>
<th>Registers that may be used</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
</tbody>
</table>

If D1 has 8421H, the following results:

<table>
<thead>
<tr>
<th>D0</th>
<th>D1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0C210H</td>
</tr>
</tbody>
</table>
WRCL, DWRCL

WRCL  arg
DWRCL  arg

Shifts arg one bit to the left and fills the carry bit (F72). WRCL operates on words (16 bits) and DWRCL operates on double words (32 bits).

<table>
<thead>
<tr>
<th>Usable Registers</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>arg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Example:

**BEFORE**

```
  1 0 1 0 1 1 0 0
CARRY (F72)
  0
```

**AFTER**

```
  1
CARRY (F72)
  0 1 0 1 1 0 0 0
```

The most significant bit is moved to the carry flag, while the least significant bit is populated with a 0.
WRCR, DWRCR

Cubloc Studio 3.3.1 and later

WRCR arg
DWRCR arg

Shifts arg one bit to the right and fills the carry bit (F72). WRCR operates on words (16 bits) and DWRCR operates on double words (32 bits).

Example:

BEFORE

<table>
<thead>
<tr>
<th>MSB</th>
<th>LSB</th>
<th>CARRY (F72)</th>
</tr>
</thead>
<tbody>
<tr>
<td>101011100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Shift to the right

AFTER

<table>
<thead>
<tr>
<th>MSB</th>
<th>LSB</th>
<th>CARRY (F72)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0110110</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Shift to the right

The least significant bit is moved to the carry flag, while the most significant bit is populated with a 0.
WINV, DWINV

Cubloc Studio 3.3.1 and later

WINV arg
DWINV arg

Toggles, inverts, each bit in arg making each 1 a 0, and each 0 a 1. WINV operates words (16 bits) and DWINV operates on double word (32 bits).

<table>
<thead>
<tr>
<th>Usable Registers</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>arg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

```
**WNEG, DWNEG**

Cubloc Studio 3.3.1 and later

WNEG arg
DWNEG arg

Toggles the sign (+/-) of arg. WNEG operates words (16 bits) and DWNEG operates on double word (32 bits).

### Usable Registers

<table>
<thead>
<tr>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

`arg`
The GOTO command causes a jump to label. The LABEL command is used to name a position in the program to jump to.

In the ladder above, when START turns ON, the program will jump to label SK_1

In the ladder below, when D0 equals C0, the program will jump to SK_1.
The CALLS command calls a subroutine with the specified label. SBRT marks the subroutine's starting point and RET marks the subroutine's end.

Please be aware that when adding sub-routines to your program, RET must be appended to the end of main program, before the first subroutine. END must be placed at the very end of the main program after the last subroutine.
INTON

INTON s,d

INTON is the same as the WMOV command except it triggers an interrupt in BASIC.

<table>
<thead>
<tr>
<th>Usually registers</th>
<th>P</th>
<th>M</th>
<th>F</th>
<th>S</th>
<th>C</th>
<th>T</th>
<th>D</th>
<th>Constants</th>
</tr>
</thead>
<tbody>
<tr>
<td>s (Source)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>d (Destination)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>O</td>
<td>O</td>
<td>O</td>
<td></td>
</tr>
</tbody>
</table>

INTON 3.D0

INTON 2.D0
TND

TND is a conditional exit command. TND is typically used to abort a ladder scan.

In the ladder above, when P0 turns ON the ladder scan will be aborted.

It can also be used to exit from subroutines when a certain condition is met. In the ladder above, when P1 turns ON, the subroutine will be aborted, but the ladder scan will continue.
## Special Registers

Cubloc contains a set of special registers that can be used to obtain the Cubloc's current status or for timing functions and applications.

<table>
<thead>
<tr>
<th>Special Register</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>F0</td>
<td>Always OFF</td>
</tr>
<tr>
<td>F1</td>
<td>Always ON</td>
</tr>
<tr>
<td>F2</td>
<td>Turn on 1 SCAN time at POWER UP (Set Ladder On).</td>
</tr>
<tr>
<td>F3</td>
<td>Reserved</td>
</tr>
<tr>
<td>F4</td>
<td>Reserved</td>
</tr>
<tr>
<td>F5</td>
<td>Reserved</td>
</tr>
<tr>
<td>F6</td>
<td>Reserved</td>
</tr>
<tr>
<td>F7</td>
<td>Reserved</td>
</tr>
<tr>
<td>F8</td>
<td>1 SCAN every 10ms</td>
</tr>
<tr>
<td>F9</td>
<td>1 SCAN every 100ms</td>
</tr>
<tr>
<td>F10</td>
<td>Reserved</td>
</tr>
<tr>
<td>F11</td>
<td>Reserved</td>
</tr>
<tr>
<td>F12</td>
<td>Reserved</td>
</tr>
<tr>
<td>F13</td>
<td>Reserved</td>
</tr>
<tr>
<td>F14</td>
<td>Reserved</td>
</tr>
<tr>
<td>F15</td>
<td>Reserved</td>
</tr>
<tr>
<td>F16</td>
<td>Repeat ON/OFF every 1 Scan time. Period 2 Scan times.</td>
</tr>
<tr>
<td>F17</td>
<td>Repeat ON/OFF every 2 Scan times. Period 4 Scan times.</td>
</tr>
<tr>
<td>F18</td>
<td>Repeat ON/OFF every 4 Scan times. Period 8 Scan times.</td>
</tr>
<tr>
<td>F19</td>
<td>Repeat ON/OFF every 8 Scan times. Period 16 Scan times.</td>
</tr>
<tr>
<td>F20</td>
<td>Repeat ON/OFF every 16 Scan times. Period 32 Scan times.</td>
</tr>
<tr>
<td>F21</td>
<td>Repeat ON/OFF every 32 Scan times. Period 64 Scan times.</td>
</tr>
<tr>
<td>F22</td>
<td>Repeat ON/OFF every 64 Scan times. Period 128 Scan times.</td>
</tr>
<tr>
<td>F23</td>
<td>Repeat ON/OFF every 128 Scan times. Period 256 Scan times.</td>
</tr>
<tr>
<td>F24</td>
<td>Repeat ON/OFF every 10ms (20ms period)</td>
</tr>
<tr>
<td>F25</td>
<td>Repeat ON/OFF every 20ms (40ms period)</td>
</tr>
<tr>
<td>F26</td>
<td>Repeat ON/OFF every 40ms (80ms period)</td>
</tr>
<tr>
<td>F27</td>
<td>Repeat ON/OFF every 80ms (160ms period)</td>
</tr>
<tr>
<td>F28</td>
<td>Repeat ON/OFF every 160ms (320ms period)</td>
</tr>
<tr>
<td>F29</td>
<td>Repeat ON/OFF every 320ms (640ms period)</td>
</tr>
<tr>
<td>F30</td>
<td>Repeat ON/OFF every 640ms (1.28s period)</td>
</tr>
<tr>
<td>F31</td>
<td>Repeat ON/OFF every 2.56 seconds (5.12s period)</td>
</tr>
<tr>
<td>F32</td>
<td>Repeat ON/OFF every 5.12 seconds (10.24s period)</td>
</tr>
<tr>
<td>F33</td>
<td>Repeat ON/OFF every 10.24 seconds (20.48s period)</td>
</tr>
<tr>
<td>F34</td>
<td>Repeat ON/OFF every 20.48 seconds (40.96s period)</td>
</tr>
<tr>
<td>F35</td>
<td>Repeat ON/OFF every 40.96 seconds (81.92s period)</td>
</tr>
<tr>
<td>F36</td>
<td>Repeat ON/OFF every 81.92 seconds (163.84s period)</td>
</tr>
<tr>
<td>F37</td>
<td>Repeat ON/OFF every 163.84 seconds (327.68s period)</td>
</tr>
<tr>
<td>F38</td>
<td>Repeat ON/OFF every 327.68 seconds (655.36s period)</td>
</tr>
<tr>
<td>F39</td>
<td>Repeat ON/OFF every 655.36 seconds (1310.72s period)</td>
</tr>
<tr>
<td>F40</td>
<td>Call LADDERINT in BASIC</td>
</tr>
<tr>
<td>F41</td>
<td>Reserved</td>
</tr>
<tr>
<td>Special Register</td>
<td>Explanation</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>F42</td>
<td>Reserved</td>
</tr>
<tr>
<td>F56</td>
<td>StepPulse Channel 0 Status</td>
</tr>
<tr>
<td>F57</td>
<td>StepPulse Channel 1 Status</td>
</tr>
<tr>
<td>F65 (F_ERR)</td>
<td>Error</td>
</tr>
<tr>
<td>F66 (F_&lt;)</td>
<td>&lt; Result of WCMP, DWCMP</td>
</tr>
<tr>
<td>F67 (F_&gt; )</td>
<td>&gt; Result of WCMP, DWCMP</td>
</tr>
<tr>
<td>F72 (F_CARRY)</td>
<td>Carry Flag</td>
</tr>
<tr>
<td>F73 (F_ZERO)</td>
<td>Zero Flag</td>
</tr>
</tbody>
</table>

* Turning F40 ON will create a LadderInt in BASIC. Please refer to the On LadderInt GoSub command for details.

* Turning F2 ON causes one ladder scan immediately when the Set Ladder On command is executed in BASIC.

* Reserved registers should not be used.
Chapter 12: Cutoch
Preface

The Cutouch is a fully integrated graphical touchscreen device containing a Cubloc embedded computer. In recent years, touchscreens have found increasing use in the field of industrial automation. However, most touchscreen devices require connection to an external PLC, and require learning yet another complex interface description method. In addition, the cost of touchscreen interfaces has remained relatively high.

The Cutouch is a complete touchscreen controller featuring both a graphical user interface and direct I/O, reducing complexity and cost.

The embedded BASIC language can be used to draw graphics and print characters to the LCD, and process touchscreen coordinates. BASIC makes it easy to interface to various types of sensors, read analog values, process text, perform mathematical operations, and perform custom RS-232 communication; tasks that are difficult to accomplish with a traditional PLC. Ladder Logic is also available and can execute alongside BASIC to perform sequential processing and real-time logic as done traditional PLCs.

The Cutouch has reprogrammable flash memory for BASIC and Ladder Logic programs. An RS-232 serial port is used to download and debug code using a Windows PC, but once disconnected from the PC, the Cutouch will operate as a stand-alone device.

If you are thinking about developing a device that uses a touchscreen, consider the Cutouch. The integrated approach saves time, and lets you concentrate on solutions instead of problems.

Comfile Technology Inc.
What is Cutouch?

The Cutouch is quite different from traditional touchscreens. Traditional touchscreens are not a complete integrated product for solution development. They are usually only capable of displaying graphics and capturing touch input. Most touchscreens require an external controller in order to affect the real world through I/O.

The Cutouch combines a traditional PLC with a touchscreen graphical LCD. By integrating user input, display output, and control, developers can now use one device as a complete control system.
## Cutouch Specifications

<table>
<thead>
<tr>
<th>Processor</th>
<th>Cutouch CT1721</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microprocessor</td>
<td>Dual Core Atmega128 @ 18.432Mhz</td>
</tr>
<tr>
<td>Program Memory (Flash)</td>
<td>80KB</td>
</tr>
<tr>
<td>Data Memory (RAM)</td>
<td>24KB(BASIC)+4KB(Ladder Logic)</td>
</tr>
<tr>
<td>EEPROM</td>
<td>4KB EEPROM</td>
</tr>
<tr>
<td>Program Speed</td>
<td>36,000/sec</td>
</tr>
<tr>
<td>General Purpose I/O</td>
<td>- 82 I/O lines (TTL &amp; 24V DC)</td>
</tr>
</tbody>
</table>

| Serial Ports for Communication | - 2 High-speed hardware-independent serial ports  
- Configurable Baud rates: 2400bps to 230,400 bps |
| Analog Inputs | 8 channel 10-bit ADCs  
Configurable Voltage: **0 to 5V OR 0 to 10V** |
| Analog Outputs | - 6 Channel 16-bit PWMs (DACs)  
- Output Voltage Range: **0 to 5V**  
- Configurable Frequencies: **35Hz to 1.5Mhz** |
| External Interrupts | 4 Channels |
| High Speed Counters | 2 Channel 16-bit Counters |

### Power
- Required Power: **24V DC**  
- Current Consumption w/ ports unloaded:  
  @ 24V w/ Backlight ON: 170mA  
  @ 24V w/ Backlight OFF: 70mA  
  @ 12V w/ Backlight ON: 340mA  
  @ 12V w/ Backlight OFF: 130mA

### RTC (Real Time Clock)
- Yes

### Timers
- 1 User Configurable Timer  
- Configurable Interval Units = 10ms

### RTC Back-up
- *Yes, a 1 Farad rechargeable Super-Capacitor is included.*

### Data Memory Back-up
- No

### Operating Temperature
- 0 °C to 70 °C

### Package
- Integrated Touch-screen Panel w/ 2mm Headers and 2.5mm RCABLE Headers
Hardware Requirements

The Cubloc Studio software used to develop programs for the Cutouch will run on a computer with Windows 7, Vista, 2000, or 98 installed. If you would like to use it in Linux/Unix/Macintosh environment, virtual machine software, such as Vmware, will be needed to host the Windows operating system.

An RS-232 port is also required, or you may use a USB-to-RS232C converter. Programs can be downloaded, monitored, and debugged when connected to a PC via RS-232.

When the Cutouch is disconnected from the PC, it functions as a stand-alone device. The main program is stored in the Cutouch’s flash memory, and will be retained even between power cycles. Programs can be downloaded and erased thousands of times.
Cutouch Dimensions
## Cutouch I/O Ports

<table>
<thead>
<tr>
<th>Name</th>
<th>I/O</th>
<th>Port Block</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td>I/O</td>
<td>Block 0</td>
<td>ADC0</td>
</tr>
<tr>
<td>P1</td>
<td>I/O</td>
<td></td>
<td>ADC1</td>
</tr>
<tr>
<td>P2</td>
<td>I/O</td>
<td></td>
<td>ADC2</td>
</tr>
<tr>
<td>P3</td>
<td>I/O</td>
<td></td>
<td>ADC3</td>
</tr>
<tr>
<td>P4</td>
<td>I/O</td>
<td></td>
<td>ADC4</td>
</tr>
<tr>
<td>P5</td>
<td>I/O</td>
<td></td>
<td>ADC5</td>
</tr>
<tr>
<td>P6</td>
<td>I/O</td>
<td></td>
<td>ADC6</td>
</tr>
<tr>
<td>P7</td>
<td>I/O</td>
<td></td>
<td>ADC7</td>
</tr>
<tr>
<td>P8</td>
<td>I/O</td>
<td>Block 1</td>
<td>PWM0</td>
</tr>
<tr>
<td>P9</td>
<td>I/O</td>
<td></td>
<td>PWM1</td>
</tr>
<tr>
<td>P10</td>
<td>I/O</td>
<td></td>
<td>PWM2</td>
</tr>
<tr>
<td>P11</td>
<td>I/O</td>
<td></td>
<td>PWM3</td>
</tr>
<tr>
<td>P12</td>
<td>I/O</td>
<td></td>
<td>PWM4 / INT0</td>
</tr>
<tr>
<td>P13</td>
<td>I/O</td>
<td></td>
<td>PWM5 / INT1</td>
</tr>
<tr>
<td>P14</td>
<td>I/O</td>
<td></td>
<td>INT2</td>
</tr>
<tr>
<td>P15</td>
<td>I/O</td>
<td></td>
<td>INT3 (RS485 Transmit enable)</td>
</tr>
<tr>
<td>P16</td>
<td>I/O</td>
<td></td>
<td>High-speed Counter 0</td>
</tr>
<tr>
<td>P17</td>
<td>IN</td>
<td></td>
<td>High-speed Counter 1</td>
</tr>
<tr>
<td>P18</td>
<td>OUTPUT</td>
<td></td>
<td>BUZZER</td>
</tr>
<tr>
<td>P19~P23</td>
<td></td>
<td>Block 3</td>
<td>8 Output only port –NPN TR</td>
</tr>
<tr>
<td>P24~31</td>
<td>OUTPUT</td>
<td>Block 4</td>
<td>8 Output only port – NPN TR</td>
</tr>
<tr>
<td>P32~39</td>
<td>OUTPUT</td>
<td>Block 5</td>
<td>8 Output only port – NPN TR</td>
</tr>
<tr>
<td>P40~47</td>
<td>OUTPUT</td>
<td>Block 6</td>
<td>8 Output only port – NPN TR</td>
</tr>
<tr>
<td>P48~55</td>
<td>INPUT</td>
<td>Block 7</td>
<td>8 Input only port- DC24V</td>
</tr>
<tr>
<td>P56~63</td>
<td>INPUT</td>
<td>Block 8</td>
<td>8 Input only port - DC24V</td>
</tr>
<tr>
<td>P64~71</td>
<td>INPUT</td>
<td>Block 9</td>
<td>8 Input only port - DC24V</td>
</tr>
<tr>
<td>P72~79</td>
<td>INPUT</td>
<td>Block 10</td>
<td>8 Input only port - DC24V</td>
</tr>
<tr>
<td>P80~87</td>
<td>INPUT</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N/C = No Connection

The Cutouch CT1720 I/O Ports are TTL 5V.

The Cutouch Add-On Board allows opto-isolated 24V DC inputs and 24V TR outputs for J1 through J4.

The Cutouch CT1721 is a combination of the CT1720 plus the Add-On Board.

* Please be careful to not input more than 5V into a Cutouch TTL ports as it can damage the product.
There are extra RS232 headers as shown below:

The Download Channel is a 4-pin connector and RS-232 Channel 1 is a 3 pin connector. They can be connected to a PC as shown below:
Backup Battery

The Cutouch will maintain data in its volatile memory when powered off by using a backup battery. If backup is not needed, the program should clear the memory at the beginning of the program. Use RamClear to clear all data memory at the start of your program.

*The Cutouch comes with a self-charging 1.0F super-capacitor that can last about a day (up to 30hrs). You can replace it with a 10.0F super-capacitor to extend the duration to about 300 hours (12.5 days). Adding a battery can provide additional backup time depending on capacity. To add a backup battery, please connect to the ports labeled “External Battery,” under the super-capacitor (not visible when the back cover is in place).

```
Const Device = CT1720
Dim TX1 As Integer, TY1 As Integer
TX1 = 0
TY1 = 0        ' Clear just this variable
RamClear       ' Clear all RAM
```

In Ladder Logic, all registers S, M, C, T, and D are retained by the backup battery. Register P is cleared by default when the device is powered on. If you only want to clear parts of a register, rather than all registers, use the following method:

```
Const Device = CT1720
Dim i As Integer
For i=0 to 32      ' Clear only Register M0 to M32
    M(i) = 0
Next
Set Ladder On
```
Cutouch Output ports

CT1721C has 32 NPN TR output ports. (Sink DC output)
Cutouch Input ports

CT1721C has 32 opto-isolated DC input.
Cutouch A/D and TTL I/O Ports

CT1721C has 8 A/D ports.

CT1721C has 16 TTL I/O ports and 2 High speed Counter.
Cutoch jumper & connector

This battery supports Data Sram memory only.
Menu System Library

The Cutouch supports extra commands easily create and manipulate menus. With the menu system library, a menu system as shown below can be made in less than 5 minutes.

![Menu System Library Preview](image)

**MENU Commands**

The Cutouch has enough memory to support approximately 100 menu buttons. The MenuSet command is used to set the x and y coordinates, as well as the style of the menu. The MenuTitle command can be used to name the menu. When touch input is received, the MenuCheck command can be used to determine which menu button was pressed.

```
0
```

```
99
```

Each menu button's position and style can be changed using the MenuSet command. Up to 100 buttons can be displayed on a single screen. Each button can be assigned a different function on a different screen, resulting in virtually unlimited menus and buttons.
**MenuSet**

*MenuSet index, style, x1, y1, x2, y2*

- **index**: Menu index number
- **style**: Button style; 0=none, 1=box, 2=box with shadow
- **x1, y1, x2, y2**: Menu button position

The *index* value must be a number from 0 through 99. *Style* is the shape of the button, where 0 is for no box, 1 is for a box, and 2 is for a shadowed box.

```
0 1 2
```

*x1, y1, x2, y2* are the x and y axis positions of the left upper and lower right corners. When this command is executed, the set part of the screen becomes part of the button’s area.

**MenuTitle**

*MenuTitle index, x, y, string*

- **index**: Menu index number
- **x, y**: Title location based on left upper corner of button
- **string**: Name of the menu

*MenuSet* only draws the box itself. Use the *MenuTitle* command to set the name of the menu like shown here:

```
MenuTitle 0,13,13,"Gas Left"
MenuTitle 1,16,13,"Initialize"
MenuTitle 2,13,13,"Total Cost"
```

- Gas left
- Initialize
- Total cost
MenuCheck( )

variable = MenuCheck( index, touchX, touchX)

variable : Variable to store results (1 if selected, 0 if unselected)
index : Menu index number
touchX : x coordinate of the touch
touchY : y coordinate of the touch

Use this command to determine which menu button has been touched. touchX and touchY are the x and y coordinates of where the user touched the screen. If the coordinates of the touch match the coordinates of the button, 1 is returned, otherwise 0 is returned.

If MenuCheck(0,TX1,TY1) = 1 Then
    MenuReverse 0
    Beep 18,180
End If

MenuReverse

MenuReverse index

index : Menu index number

This command causes the menu button identified by index to have its colors reversed. This is useful to provide visual feedback to a user, indicating that a menu button has been touched.
Menu( )

Variable = Menu( index, position)

  variable : Variable to store results (1 = selected, 0 = unselected)
  index : Menu index
  position : Position (0=x1, 1=y1, 2=x2, 3=y2)

To find the current coordinates of Menu buttons set using the MenuSet command, use Menu() function to return the current status of the specified menu. 0 will read x2, 1 will read y1, 2 will read x2, and 3 will read y2.

If Menu(0,1) < 100 THEN  ' If Menu button 0’ s Y1 is less than 100

WaitDraw

WaitDraw

This command will wait for a drawing command to finish before resuming execution.

ElFill  200,100,100,50  ' Fill an ellipse
WaitDraw  ' Wait until drawing is finished.

This command is especially useful for animations, and if graphics are displayed at a high rate.

The Cutouch has an internal buffer for receiving graphic commands from the internal Cubloc controller. If this buffer fills up and data is sent to it, the existing data in the buffer can be overwritten. In order to avoid these situations, use the WaitDraw command to wait until the buffer has enough space before sending graphic commands.

If graphics need to be drawn repeatedly, WaitDraw can be used to prevent overrunning the buffer, which may appear as noise on the LCD.

This command can only be used with the Cutouch.
Touch Pad Input Example

Set Pad, On Pad, and GetPad can all be used to determine which menu buttons were touched by the user.

All Pad commands are used for receiving and processing touch input. We can use On Pad interrupts to capture touch events. The following is an example program that uses the touch pad:

```vba
' DEMO FOR Cutouch
Const Device = CT1720
Dim TX1 As Integer, TY1 As Integer
Set Pad 0,4,5 ' (1) Activate Touch PAD Input
On Pad GoSub abc ' (2) Declare pad interrupts
Do
Loop

abc:
TX1 = GetPad(2) ' (3) Interrupt Service routine
TY1 = GetPad(2)
CircleFill TX1,TY1,10 ' (4) Draw a circle where it was touched

Return
```

(1) SET PAD 0, 4, 5: This command will activate the pad inputs. (Syntax: Set Pad mode, packetSize, bufferSize). The Cutouch has a separate touch controller that will sense touch input and send it back to the CPU using the SPI protocol. This touch controller will create a pad signal that is equal to mode = 0 (Most significant bit, rising edge sampling). Input packets are 4 bytes each ( x and y coordinates each get 2 bytes). Buffer size is 5; one more than the actual packet size.

(2) On Pad GoSub abc: This command is for PAD interrupt declaration. When a pad event occurs, the program will jump to label abc.

(3) This is the interrupt service routine. When a pad event occurs, this part of the code will be executed, until Return. GetPad will read the data received from touch pad, 2 bytes for the x coordinate and 2 bytes for the y coordinate.

(4) Draw a circle where touch input was received.
When this program is executed, a circle will appear wherever the screen is touched. This program can be used as a skeleton for touch programs.
The following is an example combining menu and pad commands. When a menu button is pressed, a beep will sound and the menu button will colors reversed.

DEM FOR Cutouch

Const Device = CT1720
Dim TX1 As Integer, TY1 As Integer
Dim k As Long
Contrast 550
Set Pad 0,4,5
On Pad GoSub abc
MenuSet 0,2,8,16,87,63
MenuTitle 0,13,13,"Start"
MenuSet 1,2,96,16,176,63
MenuTitle 1,13,13,"End"
MenuSet 2,2,184,16,264,63
MenuTitle 2,13,13,"Restart"
Low 18
Do
Loop

abc:
    TX1 = GetPad(2)
    TY1 = GetPad(2)
    CircleFill TX1,TY1,10
    If MenuCheck(0,TX1,TY1) = 1 Then
        MenuReverse 0
        PulsOut 18,300  ' Send out beep to piezo
    End If
    If MenuCheck(1,TX1,TY1) = 1 Then
        MenuReverse 1
        PulsOut 18,300
    End If
    If MenuCheck(2,TX1,TY1) = 1 Then
        MenuReverse 2
        PulsOut 18,300
    End If
Return
Cutouch Sample Programs

SAMPLE 1
Let’s make a simple counter that will print to the screen. The source files used here are in the Cubloc Studio installation directory. (Usually C:\Program Files\Comfile Tools\CublocStudio)

```cul
Const Device = Ct1720
Dim i As Integer
Contrast 550 ' LCD CONTRAST SETTING

Do
    Locate 15,6
    Print DEC5 i
    Incr i
    Delay 200
Loop
```

Please adjust the screen’s contrast accordingly using the Contrast command.

* Depending on the model, the contrast may be able to be adjusted using a knob on the back of the Cutouch, providing the ability to change the contrast manually.
SAMPLE 2
The following sample program will display a "RESET" button and will increment the number displayed on the screen every time the button is pressed.

```
Const Device = Ct1720
Dim i As Integer
Dim TX1 As Integer, TY1 As Integer
Contrast 550
Set Pad 0,4,5
On Pad GoSub GETTOUCH
MenuSet 0,2,120,155,195,200
MenuTitle 0,20,14,"RESET"

Do
    Locate 15,6
    Print DEC5 i
    Incr i
    Delay 200
Loop

GETTOUCH:
    TX1 = GetPad(2)
    TY1 = GetPad(2)
    If MenuCheck(0,TX1,TY1) = 1 Then
        PulsOut 18,300
        I = 0
    End If
    Return
```

The SET PAD command activates touch input. The ON PAD command jumps to a label when touch input is received. The MENUSET command sets the desired touch input area and the MENUTITLE command sets the name of the button itself. PulsOut outputs a BEEP sound to the piezo speaker.
SAMPLE 3
This sample draws a circle wherever the screen is touched.

<Filename : CT003.CUL>

Const Device = Ctl720
Dim TX1 As Integer, TY1 As Integer
Contrast 550
Set Pad 0,4,5
On Pad Gosub GETTOUCH
Do
Loop

GETTOUCH:
    TX1 = Getpad(2)
    TY1 = Getpad(2)
    Circlefill TX1,TY1,10
    Pulsout 18,300
    Return
SAMPLE 4
This sample make a virtual keypad that accept numerical input.

```
Const Device = Ct1720
Dim TX1 As Integer, TY1 As Integer
Dim I As Integer
Contrast 550
Set Pad 0,4,5
MenuSet
MenuSet 0,2,165,50,195,75
MenuTitle 0,11,4,"1"
MenuSet 1,2,205,50,235,75
MenuTitle 1,11,4,"2"
MenuSet 2,2,245,50,275,75
MenuTitle 2,11,4,"3"
MenuSet 3,2,165,85,195,110
MenuTitle 3,11,4,"4"
MenuSet 4,2,205,85,235,110
MenuTitle 4,11,4,"5"
MenuSet 5,2,245,85,275,110
MenuTitle 5,11,4,"6"
MenuSet 6,2,165,120,195,145
MenuTitle 6,11,4,"7"
MenuSet 7,2,205,120,235,145
MenuTitle 7,11,4,"8"
MenuSet 8,2,245,120,275,145
MenuTitle 8,11,4,"9"
MenuSet 9,2,165,155,195,180
MenuTitle 9,11,4,"0"
MenuSet 10,2,205,155,275,180
MenuTitle 10,17,4,"ENTER" I =0
Do
Loop
GETTOUCH:
    TX1 = GetPad(2)
    TY1 = GetPad(2)
    If MenuCheck(0,TX1,TY1) = 1 Then
```
I = I << 4
I = I + 1
PulsOut 18,300
Elseif MenuCheck(1,TX1,TY1) = 1 Then
I = I << 4
I = I + 2
PulsOut 18,300
Elseif MenuCheck(2,TX1,TY1) = 1 Then
I = I << 4
I = I + 3
PulsOut 18,300
Elseif MenuCheck(3,TX1,TY1) = 1 Then
I = I << 4
I = I + 4
PulsOut 18,300
Elseif MenuCheck(4,TX1,TY1) = 1 Then
I = I << 4
I = I + 5
PulsOut 18,300
Elseif MenuCheck(5,TX1,TY1) = 1 Then
I = I << 4
I = I + 6
PulsOut 18,300
Elseif MenuCheck(6,TX1,TY1) = 1 Then
I = I << 4
I = I + 7
PulsOut 18,300
Elseif MenuCheck(7,TX1,TY1) = 1 Then
I = I << 4
I = I + 8
PulsOut 18,300
Elseif MenuCheck(8,TX1,TY1) = 1 Then
I = I << 4
I = I + 9
PulsOut 18,300
Elseif MenuCheck(9,TX1,TY1) = 1 Then
I = I << 4
PulsOut 18,300
Elseif MenuCheck(10,TX1,TY1) = 1 Then
I = 0
PulsOut 18,300
End If
Locate 3,3
Print HEX4 I
Return

The final value "I" is stored in BCD format. The Bcd2Bin command can be used to convert it back to a binary number.
SAMPLE 5

This sample uses CUCANVAS to make some menus. To create the virtual keypad shown in the previous page, it would take a long time to manually code it and place buttons. CUCANVAS can save time.

Run CUCANVAS and press the "Add Form" button in the upper right hand corner. Enter a desired name for the new form ("NumKey" is used in this example).

On the left side of CUCANVAS, there a toolbar with an arrow, box, filled box, circle, filled circle, line, text, and menu box. Select the last button, menu box, and draw a small box on the screen.

The 0 on the button means the menu number is 0. In the actual screen, this number will not be displayed. Type "1" in the Title field on the top. There is now a "1" button.
A keypad like the one shown below can be created in less than 5 minutes by creating each button in the same way the "1" button was made.
Now for the fun part. Simply click "Generate" on the menu bar, and click "View Basic Code." CUCANVAS will generate a subroutine that includes the buttons just created. Simply copy (Ctrl+C) and paste (CTRL+V) this code to Cubloc Studio. A complete menu has just been created in a matter of minutes. The "To Clipboard" button will also copy the generated code to the clipboard.

Instead of copying and pasting repetitive menu creations, include files can be used. Click the "Save to File" button and save the code as an include (*.inc) file.
Include files make it easy to change the interface of a program without a lot of cut and paste operations within the main code.

The following program is exactly same as SAMPLE 4 except an include file is used for the virtual keypad:

```cul
Const Device = Ct1720
Dim TX1 As Integer, TY1 As Integer
Dim I As Integer
Contrast 550
Set Pad 0,4,5
On Pad GoSub GETTOUCH

NUMKEY ' Execute the Sub-routine in INCLUDE file
I = 0
Do
Loop

GETTOUCH:
TX1 = GetPad(2)
TY1 = GetPad(2)
If MenuCheck(0,TX1,TY1) = 1 Then
I = I << 4
I = I + 1
PulsOut 18,300
Elseif MenuCheck(1,TX1,TY1) = 1 Then
I = I << 4
I = I + 2
PulsOut 18,300
Elseif MenuCheck(2,TX1,TY1) = 1 Then
I = I << 4
I = I + 3
PulsOut 18,300
Elseif MenuCheck(3,TX1,TY1) = 1 Then
I = I << 4
I = I + 4
PulsOut 18,300
Elseif MenuCheck(4,TX1,TY1) = 1 Then
I = I << 4
I = I + 5
PulsOut 18,300
Elseif MenuCheck(5,TX1,TY1) = 1 Then
I = I << 4
I = I + 6
PulsOut 18,300
Elseif MenuCheck(6,TX1,TY1) = 1 Then
I = I << 4
I = I + 7
PulsOut 18,300
Elseif MenuCheck(7,TX1,TY1) = 1 Then
I = I << 4
```

456
We must place the #include command at the end of the code, as the generated code is in the form of a subroutine, which must come after the End statement in the main program.

CUCANVAS can be downloaded at www.cubloc.com. CUCANVAS is free to use with Cutouch products.
SAMPLE 6
This sample demonstrates how to set up a paging and menu system.

Switching between screens is quite simple. Maintain a variable that keeps track which screen is currently being displayed. While switching to a new screen, always update this variable. Use the variable to determine which set of Menucheck tests should be run for a particular screen. Subroutines are very useful for compartmentalizing the code.

```
Const Device = CT1720
Ramclear

Set Pad 0,4,5
On Pad Gosub ProcessTouch

Dim TX1 As Integer
Dim TY1 As Integer

Dim CurrentScreen As Byte
 #define _MAINMENU 0
 #define _SUBMENU1 1
 #define _SUBMENU2 2
 #define _SUBMENU3 3
 #define _SUBMENU4 4

MAIN
CurrentScreen = _MAINMENU

Do
    If CurrentScreen = _MAINMENU Then
        Set Onpad Off
        DisplayTime
        Set Onpad On
    endif
    Delay 250
Loop

ProcessTouch:
    TX1 = GetpadX()
    TY1 = GetpadY()

    Select Case CurrentScreen
        Case _MAINMENU
            ProcessMainMenu
        Case _SUBMENU1
            ProcessSubMenu1
        Case _SUBMENU2
```

458
Sub ProcessSubMenu2
Case _SUBMENU3
  ProcessSubMenu3
Case _SUBMENU4
  ProcessSubMenu4
End Select
Return
End

Sub ProcessMainMenu()
  If Menucheck(0,TX1,TY1) = 1 Then
    FlashMenu 0
    CurrentScreen = _SUBMENU1
   Cls
    SUBMENU1
  Elselseif Menucheck(1,TX1,TY1) = 1 Then
    FlashMenu 1
    CurrentScreen = _SUBMENU2
   Cls
    SUBMENU2
  Elselseif Menucheck(2,TX1,TY1) = 1 Then
    FlashMenu 2
    CurrentScreen = _SUBMENU3
   Cls
    SUBMENU3
  Elselseif Menucheck(3,TX1,TY1) = 1 Then
    FlashMenu 3
    CurrentScreen = _SUBMENU4
   Cls
    SUBMENU4
  Endif
End Sub

Sub ProcessSubMenu1()
  If Menucheck(0,TX1,TY1) = 1 Then
    FlashMenu 0
    Beeper 1
  Elselseif Menucheck(1,TX1,TY1) = 1 Then
    FlashMenu 1
    CurrentScreen = _MAINMENU
   Cls
    MAIN
  Endif
End Sub

Sub ProcessSubMenu2()
  If Menucheck(0,TX1,TY1) = 1 Then
    FlashMenu 0
Elseif Menucheck(1,TX1,TY1) = 1 Then
  FlashMenu 1
  CurrentScreen = _MAINMENU
 Cls
  MAIN
Endif
End Sub

Sub ProcessSubMenu3()
  If Menucheck(0,TX1,TY1) = 1 Then
    FlashMenu 0
    Beeper 3

  Elseif Menucheck(1,TX1,TY1) = 1 Then
    FlashMenu 1
    CurrentScreen = _MAINMENU
    Cls
    MAIN
Endif
End Sub

Sub ProcessSubMenu4()
  If Menucheck(0,TX1,TY1) = 1 Then
    FlashMenu 0
    Beeper 4

  Elseif Menucheck(1,TX1,TY1) = 1 Then
    FlashMenu 1
    CurrentScreen = _MAINMENU
    Cls
    MAIN
Endif
End Sub

Sub Beeper(Num As Byte)
  Dim i As Byte

  For i = 1 To Num
    High 18
    Delay 100
    Low 18
    Delay 200
  Next
End Sub

Sub FlashMenu(Num As Byte)
  Menureverse Num
  Delay 150
  Menureverse Num
End Sub
Sub DisplayTime()
    Glocate 16,220
    Font 0,0
    Dprint Dp(Bcd2bin(Time(2)),2,1)," ",Dp(Bcd2bin(Time(1)),2,1)," ",Dp(Bcd2bin(Time(0)),2,1)
End Sub

#include "CT1721treemenu.inc"

Use CuCanvas to Generate your menus.

SUB MAIN()
    FONT 6,1
    STYLE 0,0,0
    GLOCATE 96,24
    GPRINT "Main Menu"
    FONT 0,1
    MENUSET 0,2,40,96,144,128
    MENUTITLE 0,20,8,"Submenu 1"
    MENUSET 1,2,168,96,280,128
    MENUTITLE 1,24,8,"Submenu 2"
    MENUSET 2,2,40,152,144,184
    MENUTITLE 2,24,8,"Submenu 3"
    MENUSET 3,2,168,152,280,184
    MENUTITLE 3,24,8,"Submenu 4"
    LINESTYLE 0
    DOTSIZE 0,0
    COLOR 1
    BOX 80,16,232,56
    FONT 4,0
END SUB

SUB SUBMENU1()
    FONT 6,1
    STYLE 0,0,0
    GLOCATE 96,24
    GPRINT "Submenu 1"
    LINESTYLE 0
    DOTSIZE 0,0
    COLOR 1
    BOX 80,16,232,56
    FONT 2,1
    MENUSET 0,2,88,88,224,120
    MENUTITLE 0,22,8,"Beep 1 time"
    MENUSET 1,2,0,208,72,239
    MENUTITLE 1,10,7,"<BACK"
    FONT 4,0
END SUB
SUB SUBMENU2()
  FONT 6,1
  STYLE 0,0,0
  GLOCATE 96,24
  GPRINT "Submenu 2"
  LINESTYLE 0
  DOTSIZEx 0,0
  COLOR 1
  BOX 80,16,232,56
  FONT 2,1
  MENUST Ex 0,2,88,88,224,120
  MENUTITLE 0,16,8,"Beep 2 times"
  MENUST Ex 1,2,0,208,72,239
  MENUTITLE 1,10,7,"<BACK"
  FONT 4,0
END SUB

SUB SUBMENU3()
  FONT 6,1
  STYLE 0,0,0
  GLOCATE 96,24
  GPRINT "Submenu 3"
  LINESTYLE 0
  DOTSIZEx 0,0
  COLOR 1
  BOX 80,16,232,56
  FONT 2,1
  MENUSTEx 0,2,88,88,224,120
  MENUTITLE 0,16,8,"Beep 3 times"
  MENUSTEx 1,2,0,208,72,239
  MENUTITLE 1,10,7,"<BACK"
  FONT 4,0
END SUB

SUB SUBMENU4()
  FONT 6,1
  STYLE 0,0,0
  GLOCATE 96,24
  GPRINT "Submenu 4"
  LINESTYLE 0
  DOTSIZEx 0,0
  COLOR 1
  BOX 80,16,232,56
  FONT 2,1
  MENUSTEx 0,2,88,88,224,120
  MENUTITLE 0,16,8,"Beep 4 times"
  MENUSTEx 1,2,0,208,72,239
  MENUTITLE 1,10,7,"<BACK"
  FONT 4,0
END SUB
Chapter 13: CB405RT
CB405RT

- CB405 core module
- equipped with a built-in accurate RTC (DS3231)
- equipped with a built-in 16-bit A/D converter (8 channels)

The CB405RT is a product, which adds an RTC and a 16-bit ADC to the original CB405. The external dimensions and pinout are the same as the CB405 with the exception that ports P32 to P37 are used for the 16-bit ADC and therefore cannot be used.

The CB405RT has a built-in realtime clock (DS3231), which automatically compensates for clock errors due to temperature changes, sporting improved accuracy over the existing RTC.

When a supercapacitor is connected to VBB, data memory is preserved even when the power supply is interrupted. Since the supercapacitor is charged automatically when the device is powered, the supercapacitor can compensate for the power supply if interrupted, eliminating the need for batteries.
CB405RT-Related Commands

CB405RT-related commands can be used on in Cubloc Studio V2.6.B or in later versions.

First, the RTC-related commands

**RTCRead( )**

\[\text{variable} = \text{RTCRead( address )}\]

- **variable**: variable to store the result (Byte type)
- **address**: RTC’s address

If you see the address table of RTC chip (DS3231) below, you will notice that the time data are stored from addresses 0 through 6. The rest of the addresses are related to the alarm and RTC chipsetting; thus, we recommend those interested to refer to the DS3231 databook.

**RTCRead** command literally reads data from the RTC chip.

<table>
<thead>
<tr>
<th>ADDRESS</th>
<th>BIT 7 MSB</th>
<th>BIT 6</th>
<th>BIT 5</th>
<th>BIT 4</th>
<th>BIT 3</th>
<th>BIT 2</th>
<th>BIT 0 LSB</th>
<th>FUNCTION</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>00h</td>
<td>0</td>
<td>10 Seconds</td>
<td>Seconds</td>
<td>Seconds</td>
<td>00–59</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01h</td>
<td>0</td>
<td>10 Minutes</td>
<td>Minutes</td>
<td>Minutes</td>
<td>00–59</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>02h</td>
<td>012/24 AM/PM</td>
<td>10 Hour</td>
<td>Hour</td>
<td>Hours</td>
<td>00–23</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>03h</td>
<td>0010 Day</td>
<td>Day</td>
<td>Day</td>
<td>01–31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>04h</td>
<td>0010 Month</td>
<td>Month</td>
<td>Month/ Century</td>
<td>01–12 + Century</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>05h</td>
<td>0010 Month</td>
<td>Month</td>
<td>Month/ Century</td>
<td>01–12 + Century</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>06h</td>
<td>10 Year</td>
<td>Year</td>
<td>Year</td>
<td>00–99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>07h</td>
<td>A1M1</td>
<td>10 Seconds</td>
<td>Seconds</td>
<td>Alarm 1 Seconds</td>
<td>00–59</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08h</td>
<td>A1M2</td>
<td>10 Minutes</td>
<td>Minutes</td>
<td>Alarm 1 Minutes</td>
<td>00–59</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>09h</td>
<td>A1M3</td>
<td>12/24 AM/PM</td>
<td>10 Hour</td>
<td>Alarm 1 Hours</td>
<td>01–12 + AM/PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0Ah</td>
<td>A1M4</td>
<td>10 Date</td>
<td>Day</td>
<td>Alarm 1 Date</td>
<td>01–31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0Bh</td>
<td>A2M2</td>
<td>10 Minutes</td>
<td>Minutes</td>
<td>Alarm 2 Minutes</td>
<td>00–59</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0Ch</td>
<td>A2M3</td>
<td>12/24 AM/PM</td>
<td>10 Hour</td>
<td>Alarm 2 Hours</td>
<td>01–12 + AM/PM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0Dh</td>
<td>A2M4</td>
<td>10 Date</td>
<td>Day</td>
<td>Alarm 2 Date</td>
<td>01–31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0Eh</td>
<td>000000</td>
<td>0</td>
<td>EN3kHz</td>
<td>BSY</td>
<td>A2F</td>
<td>A1F</td>
<td>Control</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>0Fh</td>
<td>000000</td>
<td>0</td>
<td>0</td>
<td>DATA</td>
<td>DATA</td>
<td>DATA</td>
<td>Aging Offset</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>10h</td>
<td>SIGN</td>
<td>DATA</td>
<td>DATA</td>
<td>DATA</td>
<td>DATA</td>
<td>DATA</td>
<td>MSB of Temp</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>11h</td>
<td>SIGN</td>
<td>DATA</td>
<td>DATA</td>
<td>DATA</td>
<td>DATA</td>
<td>DATA</td>
<td>MSB of Temp</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>12h</td>
<td>DATA</td>
<td>DATA</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>LSB of Temp</td>
<td>—</td>
<td></td>
</tr>
</tbody>
</table>
CAUTION:
To use CB405RT, in the beginning of the program, one must replace Const Device = CB405 with #Include "CB405RT".

```
#include "CB405RT"    ' Use "#include" instead of the "Const Device" statement.

Dim i As Integer

Wait 100
RTCwrite 0,&h20    ' Sec
RTCwrite 1,&h59    ' Min
RTCwrite 2,&h23    ' Hour 24h
RTCwrite 3,&h7    ' day 1-7, 1=Sun, 2=Mon, 3=Tue, 4=Wed, 5=Thu,
                 ' 6=FRI, 7=SAT
RTCwrite 4,&h31    ' Date
RTCwrite 5,&h12    ' Month
RTCwrite 6,&h08    ' Year

Do
    i = RTCread(0)
    Debug Goxy,1,1,Hex2 i, " Sec"
    i = RTCread(1)
    Debug Goxy,1,2,Hex2 i, " Min"
    i = RTCread(2) And &h3f
    Debug Goxy,1,3,Hex2 i, " Hour"
    i = RTCread(3)
    Debug Goxy,1,4,Hex2 i, " Day"
    i = RTCread(4)
    Debug Goxy,1,5,Hex2 i, " Date"
    i = RTCread(5)
    Debug Goxy,1,6,Hex2 i, " Month"
    i = RTCread(6)
    Debug Goxy,1,7,Hex2 i, " Year"
    Wait 500
Loop
```
When the above example program is executed, the following debug window will appear.
RTCWrite

RTCWrite address, data

  address : RTC chip’s address
  data    : the variable or constant to store

This command writes a new data value to the specified address of the RTC chip.

In other RTC chips, clock inaccuracies can occur due to temperature changes. The RTC chips, which work properly at room temperature, begin to tick abnormally as their crystals oscillations are affected by temperature.

The DS3231 is an RTC chip that avoids such problems. It has a thermistor (i.e., a temperature sensor) along with a 32 KHz crystal. The oscillation frequency is adapted based on the temperature sensed by the thermistor. As a result, the crystal oscillations don’t fluctuate and the clock keeps better time.

But be aware that although the DS3231 keeps great time under varying temperatures, it is still not 100% perfect and should be verified for time critical applications.
**HADIn()**

```c
variable = HADIn( channel )
```

- **variable**: Variable to store the result (Integer or Long type)
- **channel**: AD channel

This function stores the result of 16-bit A/D conversion at the specified variable.

```c
#include "CB405RT"
Do
  Debug Goxy,1,1,Dec5 HADIn(0)
  Wait 500
Loop
```

For the above example program to work, a 5V source should be connected to HAD_Vref and a volume resistance should be connected to the HAD_CH0 as shown below. Note that only voltages ranging from 1V to 5V can be connected to HAD_Vref and only voltages ranging from 0V to HAD_Vref can be applied to HAD_CH0 through HAD_CH7.

![Diagram of HAD_Vref and HAD_CH0 connections](image)

The 16-bit ADC gives a result ranging from 0V to Vref expressed as one of the 65536 equally divided intervals. It is capable of much more accurate measurement compared to a 10-bit ADC.
HADIn2( )

\[ \text{variable} = \text{HADIn2(\text{channel combination})} \]

\text{variable} : \text{Variable to store the result (Integer or Long type)}

\text{channel} : \text{Combination: AD channel combination code}

This command is for a differential A/D input. Two channels are paired up, and the A/D converter converts the difference between the two voltages.

<table>
<thead>
<tr>
<th>Channel combination code</th>
<th>+ Input</th>
<th>- Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>CH0</td>
<td>CH1</td>
</tr>
<tr>
<td>1</td>
<td>CH2</td>
<td>CH3</td>
</tr>
<tr>
<td>2</td>
<td>CH4</td>
<td>CH5</td>
</tr>
<tr>
<td>3</td>
<td>CH6</td>
<td>CH7</td>
</tr>
<tr>
<td>4</td>
<td>CH1</td>
<td>CH0</td>
</tr>
<tr>
<td>5</td>
<td>CH3</td>
<td>CH2</td>
</tr>
<tr>
<td>6</td>
<td>CH5</td>
<td>CH4</td>
</tr>
<tr>
<td>7</td>
<td>CH7</td>
<td>CH6</td>
</tr>
</tbody>
</table>

```
#include "CB405RT"
Do
  Debug Goxy,1,1,Dec5 Hadin2(0)
  Wait 500
Loop
```

**TIP**

For a more accurate measurement, one should start with a reliable power source. A Linear power source (e.g., using 7805, etc.) is better for A/D input than a switching power source circuit (e.g., using LM2576). Also, when the A/D input pins are extended and exposed outside the board, a protection circuit (where additional chips such as the isolation circuit, etc. are involved) should be added to protect the core module from external noise. Keep in mind that, especially when a voltage over 5V could be applied to the A/D input port, repairable damage can occur to the module.
# Appendix A: ASCII CODE

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>00H</td>
<td>NUL</td>
<td>20H</td>
<td>SPACE</td>
<td>40H</td>
<td>@</td>
<td>60H</td>
<td>`</td>
</tr>
<tr>
<td>01H</td>
<td>SOH</td>
<td>21H</td>
<td>!</td>
<td>41H</td>
<td>A</td>
<td>61H</td>
<td>a</td>
</tr>
<tr>
<td>02H</td>
<td>STX</td>
<td>22H</td>
<td>&quot;</td>
<td>42H</td>
<td>B</td>
<td>62H</td>
<td>b</td>
</tr>
<tr>
<td>03H</td>
<td>ETX</td>
<td>23H</td>
<td>#</td>
<td>43H</td>
<td>C</td>
<td>63H</td>
<td>c</td>
</tr>
<tr>
<td>04H</td>
<td>EOT</td>
<td>24H</td>
<td>$</td>
<td>44H</td>
<td>D</td>
<td>64H</td>
<td>d</td>
</tr>
<tr>
<td>05H</td>
<td>ENQ</td>
<td>25H</td>
<td>%</td>
<td>45H</td>
<td>E</td>
<td>65H</td>
<td>e</td>
</tr>
<tr>
<td>06H</td>
<td>ACK</td>
<td>26H</td>
<td>&amp;</td>
<td>46H</td>
<td>F</td>
<td>66H</td>
<td>f</td>
</tr>
<tr>
<td>07H</td>
<td>BEL</td>
<td>27H</td>
<td>'</td>
<td>47H</td>
<td>G</td>
<td>67H</td>
<td>g</td>
</tr>
<tr>
<td>08H</td>
<td>BS</td>
<td>28H</td>
<td>(</td>
<td>48H</td>
<td>H</td>
<td>68H</td>
<td>h</td>
</tr>
<tr>
<td>09H</td>
<td>HT</td>
<td>29H</td>
<td>)</td>
<td>49H</td>
<td>I</td>
<td>69H</td>
<td>i</td>
</tr>
<tr>
<td>0AH</td>
<td>LF</td>
<td>2AH</td>
<td>*</td>
<td>4AH</td>
<td>J</td>
<td>6AH</td>
<td>j</td>
</tr>
<tr>
<td>0BH</td>
<td>VT</td>
<td>2BH</td>
<td>+</td>
<td>4BH</td>
<td>K</td>
<td>6BH</td>
<td>k</td>
</tr>
<tr>
<td>0CH</td>
<td>FF</td>
<td>2CH</td>
<td>,</td>
<td>4CH</td>
<td>L</td>
<td>6CH</td>
<td>l</td>
</tr>
<tr>
<td>0DH</td>
<td>CR</td>
<td>2DH</td>
<td>-</td>
<td>4DH</td>
<td>M</td>
<td>6DH</td>
<td>m</td>
</tr>
<tr>
<td>0EH</td>
<td>SO</td>
<td>2EH</td>
<td>.</td>
<td>4EH</td>
<td>N</td>
<td>6EH</td>
<td>n</td>
</tr>
<tr>
<td>0FH</td>
<td>SI</td>
<td>2FH</td>
<td>/</td>
<td>4FH</td>
<td>O</td>
<td>6FH</td>
<td>o</td>
</tr>
<tr>
<td>10H</td>
<td>DLE</td>
<td>30H</td>
<td>0</td>
<td>50H</td>
<td>P</td>
<td>70H</td>
<td>p</td>
</tr>
<tr>
<td>11H</td>
<td>DC1</td>
<td>31H</td>
<td>1</td>
<td>51H</td>
<td>Q</td>
<td>71H</td>
<td>q</td>
</tr>
<tr>
<td>12H</td>
<td>DC2</td>
<td>32H</td>
<td>2</td>
<td>52H</td>
<td>R</td>
<td>72H</td>
<td>r</td>
</tr>
<tr>
<td>13H</td>
<td>DC3</td>
<td>33H</td>
<td>3</td>
<td>53H</td>
<td>S</td>
<td>73H</td>
<td>s</td>
</tr>
<tr>
<td>14H</td>
<td>DC4</td>
<td>34H</td>
<td>4</td>
<td>54H</td>
<td>T</td>
<td>74H</td>
<td>t</td>
</tr>
<tr>
<td>15H</td>
<td>NAK</td>
<td>35H</td>
<td>5</td>
<td>55H</td>
<td>U</td>
<td>75H</td>
<td>u</td>
</tr>
<tr>
<td>16H</td>
<td>SYN</td>
<td>36H</td>
<td>6</td>
<td>56H</td>
<td>V</td>
<td>76H</td>
<td>v</td>
</tr>
<tr>
<td>17H</td>
<td>ETB</td>
<td>37H</td>
<td>7</td>
<td>57H</td>
<td>W</td>
<td>77H</td>
<td>w</td>
</tr>
<tr>
<td>18H</td>
<td>CAN</td>
<td>38H</td>
<td>8</td>
<td>58H</td>
<td>X</td>
<td>78H</td>
<td>x</td>
</tr>
<tr>
<td>19H</td>
<td>EM</td>
<td>39H</td>
<td>9</td>
<td>59H</td>
<td>Y</td>
<td>79H</td>
<td>y</td>
</tr>
<tr>
<td>1AH</td>
<td>SUB</td>
<td>3AH</td>
<td>:</td>
<td>5AH</td>
<td>Z</td>
<td>7AH</td>
<td>z</td>
</tr>
<tr>
<td>1BH</td>
<td>ESC</td>
<td>3BH</td>
<td>;</td>
<td>5BH</td>
<td>[</td>
<td>7BH</td>
<td>{</td>
</tr>
<tr>
<td>1CH</td>
<td>FS</td>
<td>3CH</td>
<td>&lt;</td>
<td>5CH</td>
<td>\</td>
<td>7CH</td>
<td></td>
</tr>
<tr>
<td>1DH</td>
<td>GS</td>
<td>3DH</td>
<td>=</td>
<td>5DH</td>
<td>]</td>
<td>7DH</td>
<td>}</td>
</tr>
<tr>
<td>1EH</td>
<td>RS</td>
<td>3EH</td>
<td>&gt;</td>
<td>5EH</td>
<td>^</td>
<td>7EH</td>
<td>~</td>
</tr>
<tr>
<td>1FH</td>
<td>US</td>
<td>3FH</td>
<td>?</td>
<td>5FH</td>
<td>_</td>
<td>7FH</td>
<td>DEL</td>
</tr>
</tbody>
</table>
Appendix B: Note for BASIC STAMP users

When using Parallax’s Basic Stamp compatible development board, please be aware of the following:

There is a capacitor on the Basic Stamp compatible development boards which may cause a download error in Cubloc Studio. Please short (or take out) the extra capacitor connected to the DTR pin of the board as shown below. The Cubloc already has this capacitor on the chip itself.
## Ladder Logic Special Registers

<table>
<thead>
<tr>
<th>Special Register</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>F0</td>
<td>Always OFF</td>
</tr>
<tr>
<td>F1</td>
<td>Always ON</td>
</tr>
<tr>
<td>F2</td>
<td>Turn on 1 SCAN time at POWER UP (Set Ladder On).</td>
</tr>
<tr>
<td>F3</td>
<td>Reserved</td>
</tr>
<tr>
<td>F4</td>
<td>Reserved</td>
</tr>
<tr>
<td>F5</td>
<td>Reserved</td>
</tr>
<tr>
<td>F6</td>
<td>Reserved</td>
</tr>
<tr>
<td>F7</td>
<td>Reserved</td>
</tr>
<tr>
<td>F8</td>
<td>1 SCAN every 10ms</td>
</tr>
<tr>
<td>F9</td>
<td>1 SCAN every 100ms</td>
</tr>
<tr>
<td>F10</td>
<td>Reserved</td>
</tr>
<tr>
<td>F11</td>
<td>Reserved</td>
</tr>
<tr>
<td>F12</td>
<td>Reserved</td>
</tr>
<tr>
<td>F13</td>
<td>Reserved</td>
</tr>
<tr>
<td>F14</td>
<td>Reserved</td>
</tr>
<tr>
<td>F15</td>
<td>Reserved</td>
</tr>
<tr>
<td>F16</td>
<td>Repeat ON/OFF every 1 Scan time.</td>
</tr>
<tr>
<td>F17</td>
<td>Repeat ON/OFF every 2 Scan times.</td>
</tr>
<tr>
<td>F18</td>
<td>Repeat ON/OFF every 4 Scan times.</td>
</tr>
<tr>
<td>F19</td>
<td>Repeat ON/OFF every 8 Scan times.</td>
</tr>
<tr>
<td>F20</td>
<td>Repeat ON/OFF every 16 Scan times.</td>
</tr>
<tr>
<td>F21</td>
<td>Repeat ON/OFF every 32 Scan times.</td>
</tr>
<tr>
<td>F22</td>
<td>Repeat ON/OFF every 64 Scan times.</td>
</tr>
<tr>
<td>F23</td>
<td>Repeat ON/OFF every 128 Scan times.</td>
</tr>
<tr>
<td>F24</td>
<td>Repeat ON/OFF every 10ms</td>
</tr>
<tr>
<td>F25</td>
<td>Repeat ON/OFF every 20ms</td>
</tr>
<tr>
<td>F26</td>
<td>Repeat ON/OFF every 40ms</td>
</tr>
<tr>
<td>F27</td>
<td>Repeat ON/OFF every 80ms</td>
</tr>
<tr>
<td>F28</td>
<td>Repeat ON/OFF every 160ms</td>
</tr>
<tr>
<td>F29</td>
<td>Repeat ON/OFF every 320ms</td>
</tr>
<tr>
<td>F30</td>
<td>Repeat ON/OFF every 640ms</td>
</tr>
<tr>
<td>F31</td>
<td>Repeat ON/OFF every 2.56 seconds</td>
</tr>
<tr>
<td>F32</td>
<td>Repeat ON/OFF every 5.12 seconds</td>
</tr>
<tr>
<td>F33</td>
<td>Repeat ON/OFF every 10.24 seconds</td>
</tr>
<tr>
<td>F34</td>
<td>Repeat ON/OFF every 20.48 seconds</td>
</tr>
<tr>
<td>F35</td>
<td>Repeat ON/OFF every 40.96 seconds</td>
</tr>
<tr>
<td>F36</td>
<td>Repeat ON/OFF every 81.92 seconds</td>
</tr>
<tr>
<td>F37</td>
<td>Repeat ON/OFF every 163.84 seconds</td>
</tr>
<tr>
<td>F38</td>
<td>Repeat ON/OFF every 327.68 seconds</td>
</tr>
<tr>
<td>F39</td>
<td>Repeat ON/OFF every 655.36 seconds</td>
</tr>
<tr>
<td>F40</td>
<td>Call LADDERINT in BASIC</td>
</tr>
<tr>
<td>F41</td>
<td>Reserved</td>
</tr>
<tr>
<td>F42</td>
<td>Reserved</td>
</tr>
<tr>
<td>F65 (F.ERR)</td>
<td>Error</td>
</tr>
<tr>
<td>F66 (F.&lt;)</td>
<td>&lt; Result of WCMP, DWCMP</td>
</tr>
<tr>
<td>F67 (F.&gt;)</td>
<td>&gt; Result of WCMP, DWCMP</td>
</tr>
<tr>
<td>F72 (F.CARRY)</td>
<td>Carry Flag</td>
</tr>
<tr>
<td>F73 (F.ZERO)</td>
<td>Zero Flag</td>
</tr>
</tbody>
</table>
Index

AdIn................................................................. 130
Alias............................................................... 132
AND................................................................. 382
Arc................................................................. 285
ASC................................................................. 128
Bcd2Bin......................................................... 133
BClr............................................................... 134
Beep............................................................... 135
Bfree.............................................................. 136
Bin2Bcd......................................................... 137
Bit................................................................. 92
BLen.............................................................. 138
Bmp.............................................................. 286
Box............................................................... 278
BoxClear....................................................... 278
BoxFill......................................................... 278
Byte............................................................ 93
ByteIn......................................................... 139
ByteOut....................................................... 140
CALLS.......................................................... 423
CheckBf....................................................... 141
Chr............................................................. 128
Circle.......................................................... 279
CircleFill..................................................... 279
CLCDOOut.................................................... 271
Clear.......................................................... 269
Cls............................................................ 269
CMode......................................................... 276
Color.......................................................... 284
Compare..................................................... 142
Con........................................................... 95
Constant Arrays.......................................... 96
Constants.................................................... 95
Contrast...................................................... 274
Count( )....................................................... 143
CountReset.................................................. 145
CSGDec....................................................... 295
CSGHex....................................................... 295
CSGNPut..................................................... 294
CSGXPut..................................................... 295
CsrOff....................................................................................................................... 269
CsrOn.......................................................................................................................... 269
CTD.............................................................................................................................. 395
CTU.............................................................................................................................. 394
Dcd............................................................................................................................... 146
Debug.......................................................................................................................... 147
Dec............................................................................................................................... 119
Decr............................................................................................................................. 150
DefChr......................................................................................................................... 286
DEFCON...................................................................................................................... 384
Delay............................................................................................................................ 151
DF................................................................................................................................. 385
DFN............................................................................................................................... 385
Do...Loop...................................................................................................................... 152
DotSize......................................................................................................................... 284
DP................................................................................................................................. 121
DPrint........................................................................................................................... 282
DTZero......................................................................................................................... 154
DWADD....................................................................................................................... 410
DWAND....................................................................................................................... 415
DWBCNT...................................................................................................................... 403
DWCMP....................................................................................................................... 408
DWDEC......................................................................................................................... 409
DWDIV.......................................................................................................................... 412
DWINC.......................................................................................................................... 409
DWINV.......................................................................................................................... 420
DWMOV......................................................................................................................... 404
DWNEG......................................................................................................................... 421
DWOR............................................................................................................................ 413
DWRCL......................................................................................................................... 418
DWRCR.......................................................................................................................... 419
DWROL.......................................................................................................................... 416
DWROR.......................................................................................................................... 417
DWSUB.......................................................................................................................... 410
DWXCHG..................................................................................................................... 405
DWXOR.......................................................................................................................... 414
EEPROM....................................................................................................................... 156
EERead( )..................................................................................................................... 155
EEWrite......................................................................................................................... 156
EKeyPad()..................................................................................................................... 157
ElFill............................................................................................................................. 280
Ellipse.......................................................................................................................... 280
Float............................................................................................................................... 120
<table>
<thead>
<tr>
<th>Function</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Font</td>
<td>275</td>
</tr>
<tr>
<td>For...Next</td>
<td>158</td>
</tr>
<tr>
<td>FP</td>
<td>123</td>
</tr>
<tr>
<td>FreePin</td>
<td>160</td>
</tr>
<tr>
<td>FreqOut</td>
<td>161</td>
</tr>
<tr>
<td>Get( )</td>
<td>163</td>
</tr>
<tr>
<td>GetA</td>
<td>164</td>
</tr>
<tr>
<td>GetA2</td>
<td>165</td>
</tr>
<tr>
<td>GetCrc</td>
<td>166</td>
</tr>
<tr>
<td>GetPad( )</td>
<td>167</td>
</tr>
<tr>
<td>GetStr( )</td>
<td>168</td>
</tr>
<tr>
<td>GetStr2()</td>
<td>169</td>
</tr>
<tr>
<td>GLayer</td>
<td>273</td>
</tr>
<tr>
<td>GLocate</td>
<td>281</td>
</tr>
<tr>
<td>GMOV</td>
<td>407</td>
</tr>
<tr>
<td>GoSub...Return</td>
<td>170</td>
</tr>
<tr>
<td>GOTO</td>
<td>422</td>
</tr>
<tr>
<td>GoTo</td>
<td>171</td>
</tr>
<tr>
<td>GPaste</td>
<td>289</td>
</tr>
<tr>
<td>GPop</td>
<td>288</td>
</tr>
<tr>
<td>GPrint</td>
<td>281</td>
</tr>
<tr>
<td>GPush</td>
<td>288</td>
</tr>
<tr>
<td>HADIn( )</td>
<td>469</td>
</tr>
<tr>
<td>HADIn2( )</td>
<td>470</td>
</tr>
<tr>
<td>Heap( )</td>
<td>174</td>
</tr>
<tr>
<td>HeapClear</td>
<td>174</td>
</tr>
<tr>
<td>HeapW</td>
<td>174</td>
</tr>
<tr>
<td>Hex</td>
<td>118</td>
</tr>
<tr>
<td>High</td>
<td>176</td>
</tr>
<tr>
<td>HP</td>
<td>122</td>
</tr>
<tr>
<td>HPaste</td>
<td>290</td>
</tr>
<tr>
<td>HPop</td>
<td>290</td>
</tr>
<tr>
<td>HPush</td>
<td>290</td>
</tr>
<tr>
<td>HRead</td>
<td>173</td>
</tr>
<tr>
<td>HWrite</td>
<td>173</td>
</tr>
<tr>
<td>I2CRead</td>
<td>178</td>
</tr>
<tr>
<td>I2CReadNA</td>
<td>179</td>
</tr>
<tr>
<td>I2CStart</td>
<td>177</td>
</tr>
<tr>
<td>I2CStop</td>
<td>177</td>
</tr>
<tr>
<td>I2CWrite</td>
<td>180</td>
</tr>
<tr>
<td>If...Then...Elseif...Else...EndIf</td>
<td>181</td>
</tr>
<tr>
<td>In</td>
<td>182</td>
</tr>
</tbody>
</table>

477
Incr........................................................................................................183
Input........................................................................................................184
INTON.................................................................................................424
KCTD.................................................................................................397
KCTU.................................................................................................397
KeyIn.................................................................................................185
KeyInH...............................................................................................186
Keypad...............................................................................................187
Label.................................................................................................171
LABEL...............................................................................................422
Layer.................................................................................................272
Left......................................................................................................124
Len......................................................................................................125
Light.................................................................................................274
Line.................................................................................................277
LineStyle..........................................................................................284
LineTo...............................................................................................277
LOAD.................................................................................................381
LOADN...............................................................................................381
Locate...............................................................................................269
LOOP.................................................................................................386
Low......................................................................................................188
LTrim.................................................................................................126
MCS.................................................................................................387
MCSCLR...........................................................................................387
MemAdr............................................................................................189
menu buttons......................................................................................442
Menu( )...........................................................................................445
MenuCheck( )..................................................................................444
MenuReverse....................................................................................444
MenuSet...........................................................................................443
MenuTitle..........................................................................................443
Mid.................................................................................................124
monitoring........................................................................................364
multi-tasking.....................................................................................25
Ncd.................................................................................................190
Nibble...............................................................................................92
Nop.................................................................................................191
NOT.................................................................................................382
Offset...............................................................................................283
On Int...............................................................................................192
On LadderInt GoSub........................................................................193
On Pad...............................................................................................195
<table>
<thead>
<tr>
<th>Function</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>On Recv</td>
<td>196</td>
</tr>
<tr>
<td>On Timer()</td>
<td>197</td>
</tr>
<tr>
<td>OpenCom</td>
<td>198</td>
</tr>
<tr>
<td>Operators</td>
<td>98</td>
</tr>
<tr>
<td>OR</td>
<td>382</td>
</tr>
<tr>
<td>Out</td>
<td>201</td>
</tr>
<tr>
<td>OUT</td>
<td>381</td>
</tr>
<tr>
<td>Output</td>
<td>202</td>
</tr>
<tr>
<td>OutStat( )</td>
<td>203</td>
</tr>
<tr>
<td>Overlay</td>
<td>273</td>
</tr>
<tr>
<td>Paint</td>
<td>285</td>
</tr>
<tr>
<td>Pause</td>
<td>203</td>
</tr>
<tr>
<td>Peek</td>
<td>112, 204</td>
</tr>
<tr>
<td>PLC Setup Wizard</td>
<td>368</td>
</tr>
<tr>
<td>Poke</td>
<td>112, 204</td>
</tr>
<tr>
<td>Print</td>
<td>270p.</td>
</tr>
<tr>
<td>Pset</td>
<td>284</td>
</tr>
<tr>
<td>PulsOut</td>
<td>205</td>
</tr>
<tr>
<td>Put</td>
<td>206</td>
</tr>
<tr>
<td>PutA</td>
<td>207</td>
</tr>
<tr>
<td>PutA2</td>
<td>208</td>
</tr>
<tr>
<td>PutStr</td>
<td>209</td>
</tr>
<tr>
<td>Pwm</td>
<td>210</td>
</tr>
<tr>
<td>PwmOff</td>
<td>211</td>
</tr>
<tr>
<td>RamClear</td>
<td>212</td>
</tr>
<tr>
<td>Reset</td>
<td>213</td>
</tr>
<tr>
<td>RET</td>
<td>423</td>
</tr>
<tr>
<td>Reverse</td>
<td>214</td>
</tr>
<tr>
<td>Right</td>
<td>124</td>
</tr>
<tr>
<td>Rnd( )</td>
<td>215</td>
</tr>
<tr>
<td>RSTOUT</td>
<td>383</td>
</tr>
<tr>
<td>RTCRead( )</td>
<td>465</td>
</tr>
<tr>
<td>RTCWrite</td>
<td>468</td>
</tr>
<tr>
<td>RTrim</td>
<td>126</td>
</tr>
<tr>
<td>SBRT</td>
<td>423</td>
</tr>
<tr>
<td>Select...Case</td>
<td>216</td>
</tr>
<tr>
<td>Set Debug</td>
<td>217</td>
</tr>
<tr>
<td>Set Display</td>
<td>261</td>
</tr>
<tr>
<td>Set I2C</td>
<td>220</td>
</tr>
<tr>
<td>Set Int</td>
<td>221</td>
</tr>
<tr>
<td>Set Ladder</td>
<td>222</td>
</tr>
<tr>
<td>Set Modbus</td>
<td>223</td>
</tr>
<tr>
<td>Set OnGlobal</td>
<td>224</td>
</tr>
</tbody>
</table>
Set OnInt.................................................................................................................. 225
Set OnLadderInt........................................................................................................ 226
Set OnPad.................................................................................................................. 227
Set OnRecv................................................................................................................. 228
Set OnTimer............................................................................................................... 229
Set OutOnly............................................................................................................... 230
Set Pad......................................................................................................................... 231
Set RS232.................................................................................................................. 234
Set RS485.................................................................................................................. 235
Set Spi......................................................................................................................... 237
Set Until...................................................................................................................... 238
SETOUT...................................................................................................................... 383
ShiftIn( )................................................................................................................... 239
ShiftOut...................................................................................................................... 240
SPC............................................................................................................................. 125
Special Registers...................................................................................................... 426, 473
Spi............................................................................................................................... 241
StepAccel.................................................................................................................... 242
STEPOUT.................................................................................................................... 390
StepPulse..................................................................................................................... 243
STEPSET...................................................................................................................... 389
StepStat( )................................................................................................................. 244
StepStop..................................................................................................................... 244
String.......................................................................................................................... 86
STRING( ).................................................................................................................. 125
String........................................................................................................................... 125
Style.............................................................................................................................. 276
Sys( ).......................................................................................................................... 247
TADIN......................................................................................................................... 131
TADIn()....................................................................................................................... 248
TAMON......................................................................................................................... 391
TAOFF......................................................................................................................... 394
TAON............................................................................................................................ 393
Time( )......................................................................................................................... 249
TimeSet....................................................................................................................... 251
TMON............................................................................................................................ 391
TND............................................................................................................................... 425
TOFF............................................................................................................................ 394
TON............................................................................................................................... 393
UDelay......................................................................................................................... 253
UsePin.......................................................................................................................... 254
UTMax........................................................................................................................ 255
Val................................................................................................................................. 127
<table>
<thead>
<tr>
<th>Function</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ValHex</td>
<td>127</td>
</tr>
<tr>
<td>ValSng</td>
<td>127</td>
</tr>
<tr>
<td>WADD</td>
<td>410</td>
</tr>
<tr>
<td>Wait</td>
<td>256</td>
</tr>
<tr>
<td>WaitDraw</td>
<td>445</td>
</tr>
<tr>
<td>WaitTx</td>
<td>257</td>
</tr>
<tr>
<td>WAND</td>
<td>405, 415</td>
</tr>
<tr>
<td>WBCD</td>
<td>401</td>
</tr>
<tr>
<td>WBCNT</td>
<td>403</td>
</tr>
<tr>
<td>WBIN</td>
<td>402</td>
</tr>
<tr>
<td>WCMP</td>
<td>408</td>
</tr>
<tr>
<td>WDEC</td>
<td>409</td>
</tr>
<tr>
<td>WDIV</td>
<td>412</td>
</tr>
<tr>
<td>WINC</td>
<td>409</td>
</tr>
<tr>
<td>WINV</td>
<td>420</td>
</tr>
<tr>
<td>WMode</td>
<td>274</td>
</tr>
<tr>
<td>WMOV</td>
<td>404</td>
</tr>
<tr>
<td>WMUL</td>
<td>411</td>
</tr>
<tr>
<td>WNEG</td>
<td>421</td>
</tr>
<tr>
<td>WOR</td>
<td>413</td>
</tr>
<tr>
<td>Word</td>
<td>93</td>
</tr>
<tr>
<td>WRCL</td>
<td>418</td>
</tr>
<tr>
<td>WRCR</td>
<td>419</td>
</tr>
<tr>
<td>WROL</td>
<td>416</td>
</tr>
<tr>
<td>WROR</td>
<td>417</td>
</tr>
<tr>
<td>WSUB</td>
<td>410</td>
</tr>
<tr>
<td>WXCHG</td>
<td>405</td>
</tr>
<tr>
<td>WXOR</td>
<td>414</td>
</tr>
<tr>
<td>#define</td>
<td>103</td>
</tr>
<tr>
<td>#endif</td>
<td>105</td>
</tr>
<tr>
<td>#if</td>
<td>105</td>
</tr>
<tr>
<td>#ifdef</td>
<td>106</td>
</tr>
<tr>
<td>ifndef</td>
<td>106</td>
</tr>
<tr>
<td>#include</td>
<td>103</td>
</tr>
</tbody>
</table>