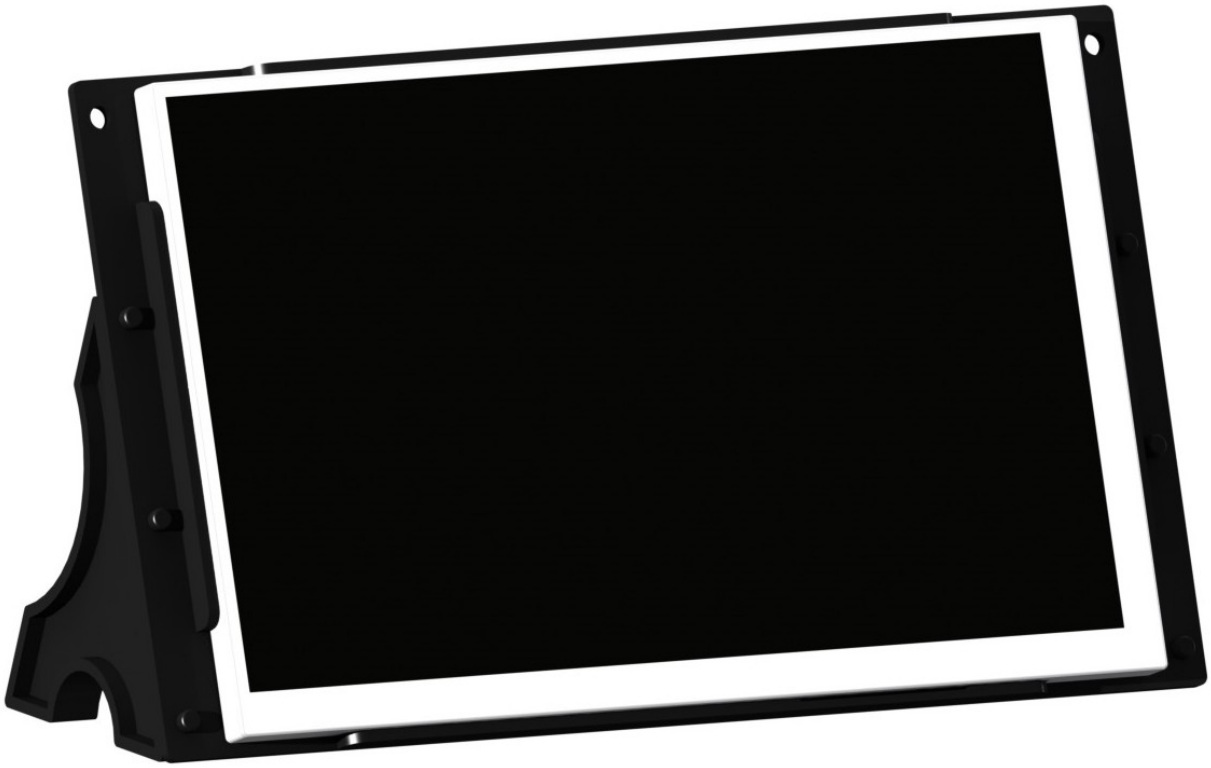
Serial High-Color Display

M Display



User's Manual

2015-11-09

"Everything for Embedded Control"

COMFILE TECHNOLOGY

Comfile Technology Inc.
www.cubloc.com

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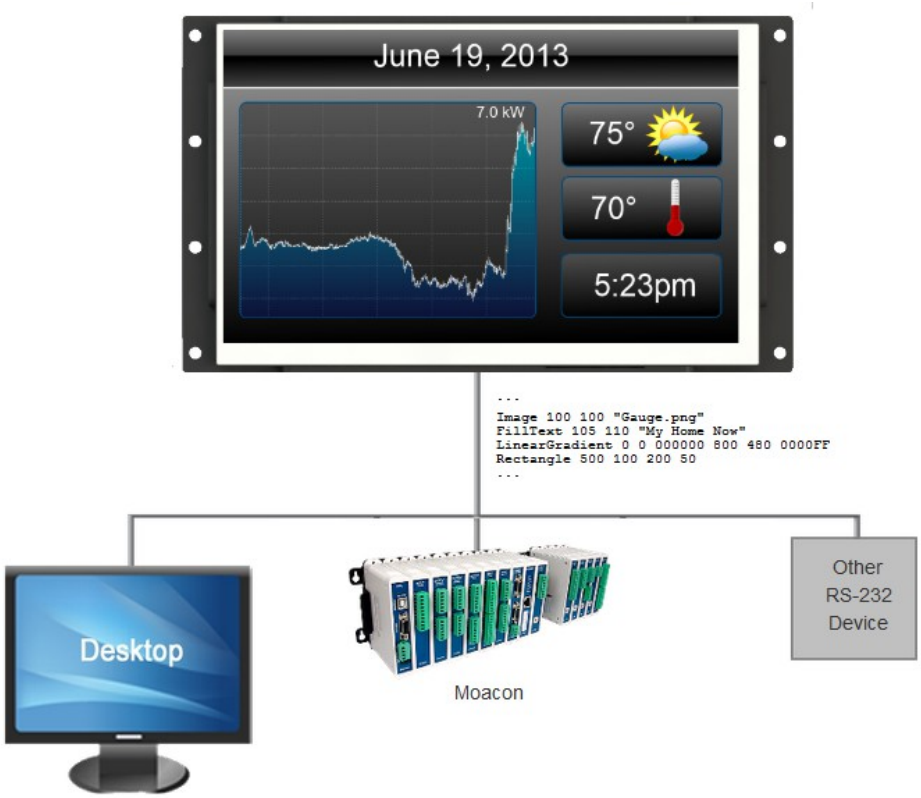


The M Display is a High-Color display that can render multi-layer vector graphics (lines, curves, etc…), raster graphics (PNG images), and TrueType fonts from any RS-232 capable device, by sending it UTF-8 or binary encoded commands.

The M Display is an excellent accessory for adding colorful, graphical output to the Moacon. A library is available for download from the M Display's support website.

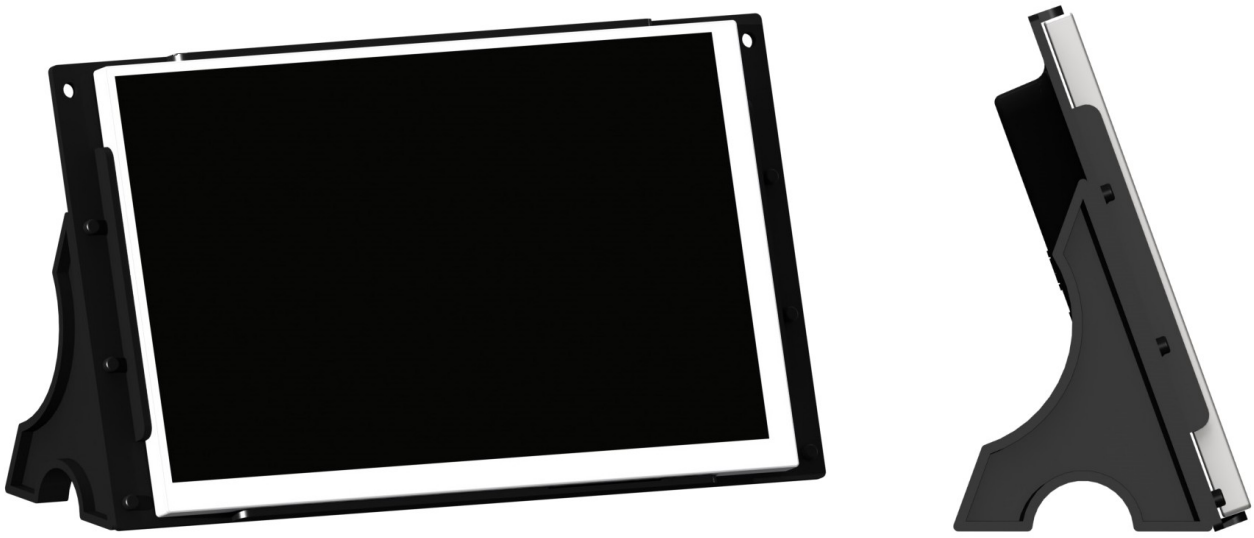
Features

- High-Color TFT display
- User-configurable screen orientation
- RS-232 interface
- Vector graphics (lines, rectangles, circles, curves, text, images, and many other drawing primitives)
- Solid colors and linear/radial gradients
- Alpha blending (transparency and partial transparency)
- TrueType font and Unicode Support
- PNG image file support
- Micro SD Card support (FAT32 File System) for storing user generated content (images, fonts, and scripts). 2GB SD Card included.
- Field upgradable firmware

Specifications

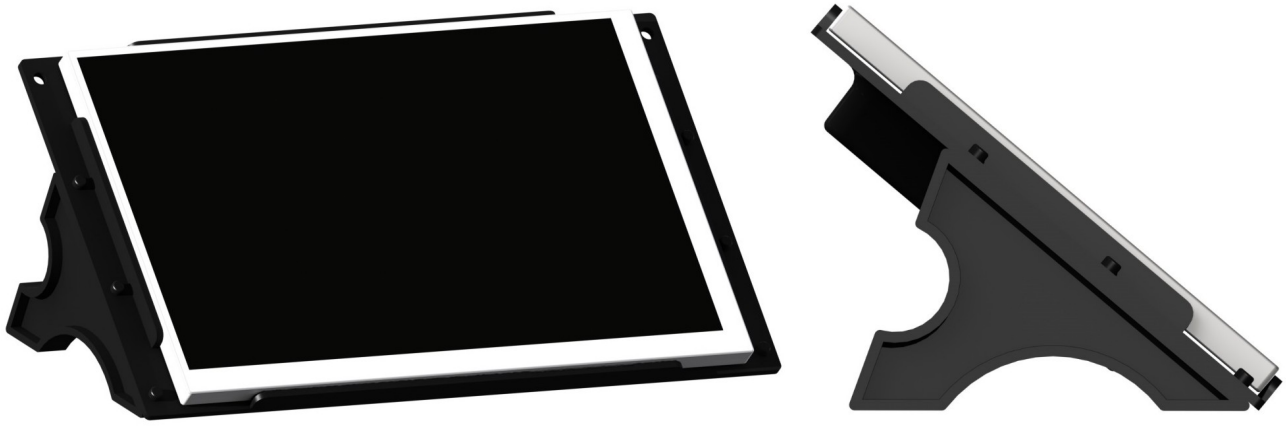
- 16-bit color, 800×480 (or 480 x 800: see Orientation), 7” TFT LCD
  4.3" (480x272), 5.6" (640x480), and 10.2" (800x480) displays are also available
- 4MB RAM
- 168MHz ARM MCU
- 1 RS-232 Serial Port (PC-Level)
- 1 MicroSD Card slot
- 1 USB Console/Firmware Update Port

Stand

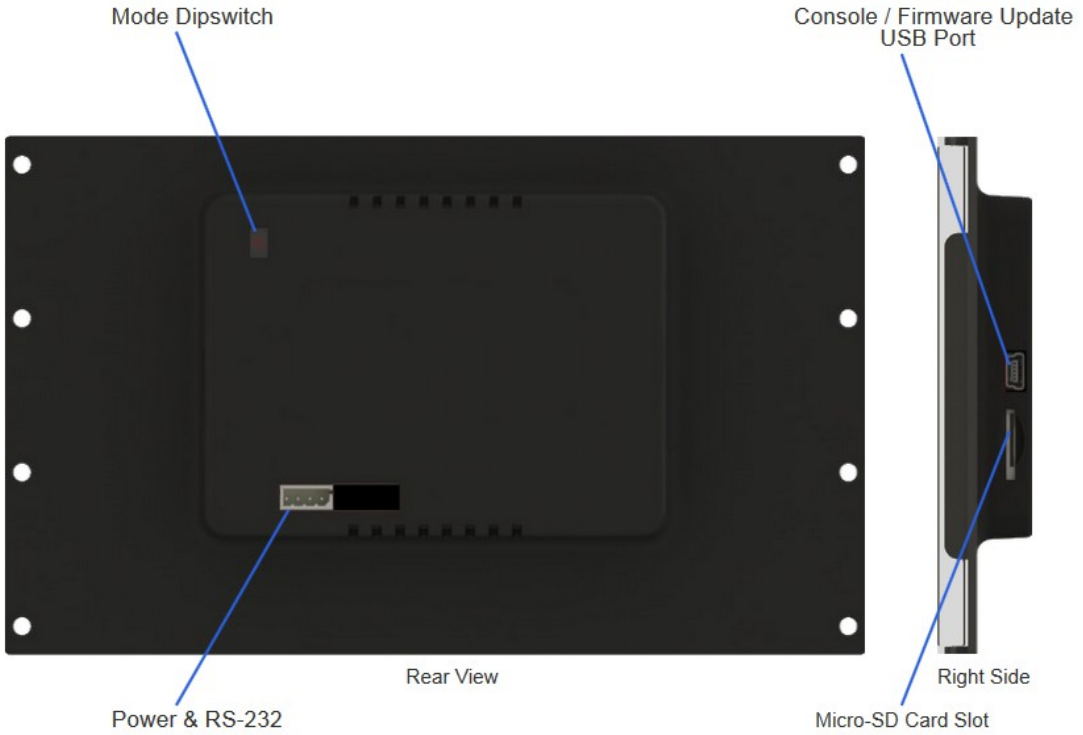


The M Display comes with an attractive and flexible stand that can be used to make desktop development more convenient and desktop display more appealing.

The legs can be removed and reversed to change the angle at which the display faces: Steep angle as shown above or a shallow angle as shown below.



Physical Connections



Mode Dipswitch

- **Dipswitch 1 –** Switches between *Demo Mode (On)* and *Serial Mode(Off)*
  - *Demo Mode (On)* – The M Display will display a simple demonstration on its screen.
  - *Command Mode (Off)* – The M Display will only display the result of serial commands received on its RS-232 port. Changes to serial and protocol settings will be persisted between power cycles.
- **Dipswitch 2** - Switches between *Firmware Update Mode (On)* and *Execution Mode* (Off).
  - *Firmware Update Mode* - This mode is used to update the M Display's firmware. The M Display will not respond to any serial commands while in this mode. In this mode, the USB port functions as a USB Device Firmware Upgrade (DFU) device and requires a DFU driver for PC connectivity. Please see the M Display support website to download the DFU driver and firmware updates.
  - *Execution Mode* - The M Display will respond to serial commands received on its RS-232 port. In this mode, the USB port functions as a virtual serial port and requires a virtual serial port driver for PC connectivity. The virtual serial port driver can be downloaded from the M Display support website. This USB virtual serial port is intended to be used as a console port for monitoring the status of the M Display. When powered on, the firmware version and serial and protocol settings will be output to this port. Any errors encountered while processing commands will also be output to this port.

Set both dipswitches to the off position to run the M Display in its default mode, as a serial display.

Power & RS-232

Contains pins for power, reset, and RS-232 communication. Pins are numbered from left to right.

- Pin 1 – RS-232 TX (PC Level)
- Pin 2 – RS-232 RX (PC Level)
- Pin 3 – Power (+5V)
- Pin 4 – Ground

Micro-SD Card Slot

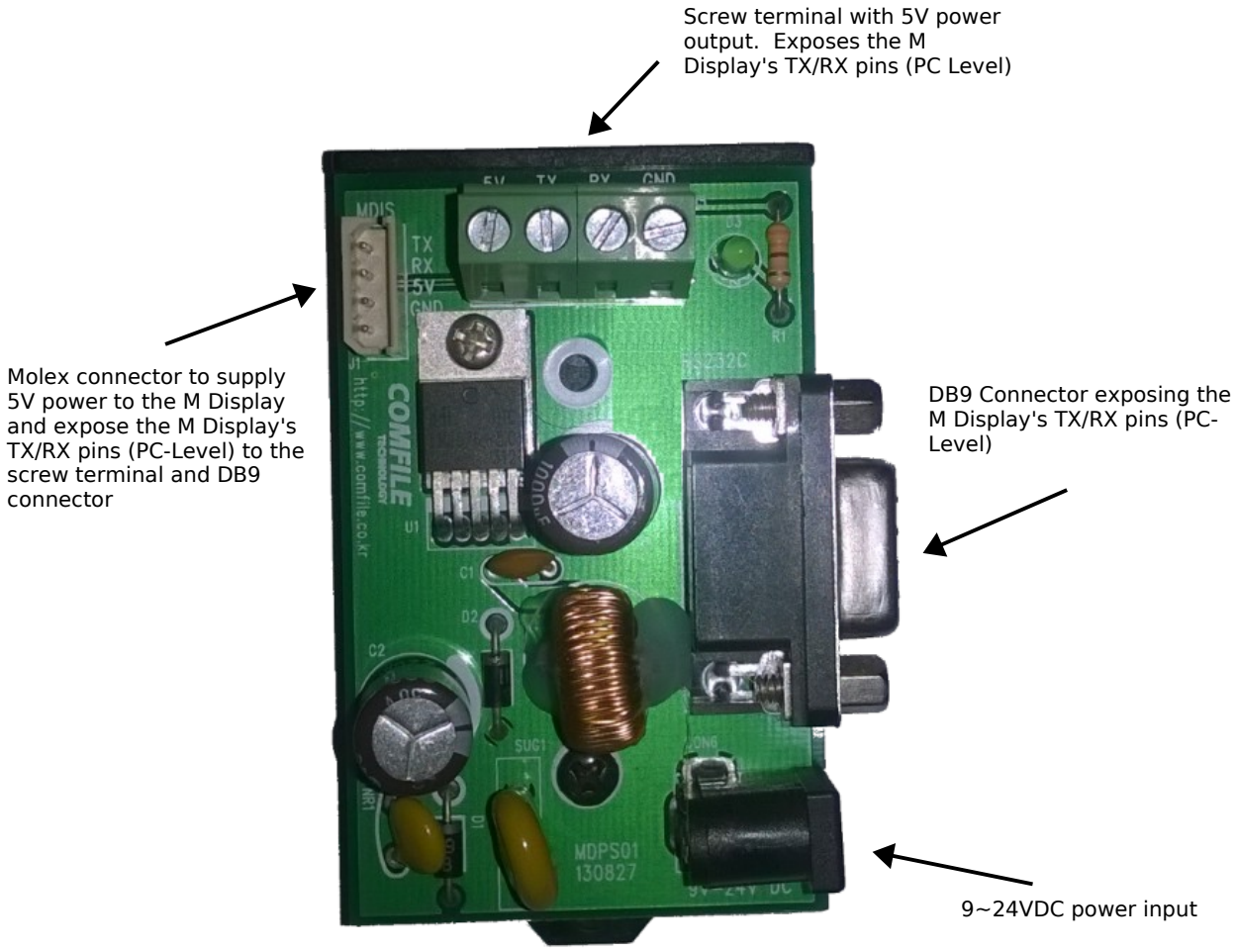
Accepts a FAT32 formatted Micro-SD Card for storing user content such as PNG images, fonts, and scripts. Long file names are not supported, so please limit file names to 8.3 format (8 character file name, 3 character file extension).

Console / Firmware Update USB Port

This USB port functions as either a console port, or a firmware update port depending on the state of the Mode Dipswitch. See the Mode Dispswitch explanation for details.

Power Adapter

The M Display comes with a power adapter. It accepts a 9 ~24VDC input and will supply the M Display and potentially other devices through its 5V output. It also exposes the M Display's RS-232 TX/RX pins (PC Level) to a screw terminal and a DB9 connector.



There is no RS-232 level converter in this power adapter; the TX and RX pins are all the same node.

Initialization

When the M Display is powered on, it will default to the following settings:

Serial: 115200bps, No Parity, 1 Stop Bit
Protocol: UTF-8
Checksum: Disabled
Orientation: 0 degrees (e.g. 800x480 landscape for 7" & 10.2" model)
Boot Image: None

To change these settings, insert an SD card, and add a file named “init.txt” to the root of the SD card. In that text file, you can add the following commands to change the settings above.

Serial

Syntax

```
Serial baudRate parity stopBits
```

Description

Sets the serial communication settings.

Arguments

Argument	Type	Description
baudRate	UInt32	The baud rate in bits per second
parity	Text	“odd” “even”, or “none”
stopBits	Real Number	0.5, 1.0, 1.5, or 2.0

Protocol

Syntax

```
Protocol protocol
```

Description

Sets the serial communication protocol.

Arguments

Argument	Type	Description
protocol	Text	“UTF-8” or “Binary”

EnableChecksum

Syntax

```
EnableChecksum
```

Description

Enables checksum verification for the serial communication protocol.

Orientation

Syntax

```
Orientation orientation
```

Description

Changes the display orientation effectively rotating the screen by *orientation* degrees.

Arguments

Argument	Type	Description
protocol	UInt16	0, 90, 180, or 270

BootImage

Syntax

```
BootImage filePath
```

Description

Displays an image when the M Display powers on.

Arguments

Argument	Type	Description
filePath	Text	Path to the image file to display when the M display is powered on.

EnableTrace

Syntax

```
EnableTrace
```

Description

Each command and response will be echoed on the M Display's USB console port. See the M Display Console manual on the M Display's support website for more information.

Communication Protocol

Communication is based on a command/response protocol – the host issues a command, and the M Display responds with a response.

Responses will contain one of the following status codes indicating the success or failure of a command.

Status Code (Hexadecimal)	Description
0000	Success
0001	Unknown command
0002	Wrong number of command arguments
0003	Invalid command argument
0004	Error reading from a file
0005	Memory allocation error
0006	Serial communication error
0007	Checksum error
FFFF	Unspecified error

The M Display can communicate using a either a UTF-8 protocol or a binary protocol further defined in the sections to follow. The protocol to use is configured in the initialization sequence. See Initialization.

UTF-8 Protocol

The UTF-8 protocol is an ASCII compatible, text based protocol that transmits all information as a series of UTF-8 code points. Each command and its arguments (i.e. the payload) is encapsulated in a frame starting with a Newline character (\n – Hexadecimal 0A) and ending with a Carriage Return character (\r – Hexadecimal 0D).

<\n><payload (n-bytes)><\r>

Command

The payload consists of a one-word command name followed by zero or more arguments, each separated by a space.

Example

```
\nDrawLine 0 0 100 100\r
```

Arguments may be any one of the following types.

Argument Type	Format/Notation	Description
Real Number	Decimal Fraction (3.4E +/- 38)	Base 10, 32-bit floating point number
UInt8	Decimal (0 ~ 255)	Base 10, 8-bit unsigned integer
Int16	Decimal (-32,768 ~ 32,767)	Base 10, 16-bit singed integer
UInt16	Decimal (0 ~ 65,535)	Base 10, 16-bit unsigned integer
UInt32	Decimal (0 ~ 4,294,967,295)	Base 10, 32-bit unsigned integer
Color*	Hexadecimal (AARRGGBB). Example: Opaque Fuschia = 00FF00FF	Base 16, 32-bit unsigned integer used to represent a color with Alpha(AA, 00 = opaque, FF = transparent), Red(RR), Green(GG), and Blue(BB) components.
Text	UTF-8 See (Textual Command Arguments)	A string of characters in UTF-8 format

See the Command Reference to find the specification of each command and its arguments.

** Note that although the notation for color arguments allows users to specify a 24-bit RGB component, the LCD is only capable of displaying 16-bit (565) RGB colors.*

Response

Responses consist of a one-word response (“Ack” or “Nak”) followed by a 4-digit hexadecimal status code, separated by a space.

Example

Positive Response

```
\nAck 0000\r
```

Negative Response (Unknown command)

```
\nNak 0001\r
```

Textual Command Arguments

Arguments are separated by spaces, so to send a command with a textual argument that must contain a space (e.g. a text message containing a space) the argument must be enclosed in double quotes (Decimal 34, Hexadecimal 22).

The following command will only display the word '*Hello*' because it recognizes the argument *World* as an additional argument, and additional arguments are ignored.

```
FillText 100 100 Hello World
```

The following command will display '*Hello World*' as the entire phrase is enclosed within double quotes.

```
Fillext 100 100 "Hello World"
```

To display a double quote character ('"', Decimal 34, Hexadecimal 22), it must be escaped with backslash character (Decimal 92, Hexadecimal 5C). The following command will display '*Double quotes (") must be escaped*'.

```
FillText 100 100 "Double Quotes (\") must be escaped"
```

To display a backslash character, it too must be escaped with a preceding backslash character. The following command will display '*Backslashes (\) must also be escaped*'.

```
FillText 100 100 "Backslashes (\\) must also be escaped"
```

Optional Checksum

If the checksum feature is enabled via the EnableChecksum command, a 4-byte hexadecimal number is appended to the end of the payload for both commands and responses. The checksum is simply a sum of all bytes in the payload,

including spaces.

Example – Command

All bytes in the payload are added together (D + r + a + w+ L + I + n + e + space + 0 + space + 0 + space + 1 + 0 + 0 + space + 1 + 0 + 0 + space = Hexadecimal 0538) and appended to the end of the payload.

```
DrawLine 0 0 100 100 0538
```

Example – Positive Response

All bytes in the payload are added together (A + c + k + space + 0 + 0 + 0 + 0 + space = Hexadecimal 020F) and appended to the end of the payload.

```
Ack 0000 020F
```

Binary Protocol

The binary protocol sends commands and responses as pure binary data. **Multi-byte values are transmitted least significant byte first (i.e. Little Endian)**.

Each command and its arguments (i.e. the payload) is encapsulated in a frame starting with a 2-byte start sequence, <DLE><STX> (Hexadecimal 1002) and ending with a 2-byte end sequence, <DLE><ETX> (Hexadecimal 1003)

<DLE><STX><payload (n bytes)><DLE><ETX>

If the payload contains a <DLE> byte (Hexadecimal 10), the byte must be escaped by prepending a <DLE> just before it.

Command

The payload consists of a 1-byte command code followed by zero or more arguments.

Arguments may be any one of the following types.

Argument Type	Description
Real Number*	Real number multiplied by 10 to form a 16-bit integer. Example: 123.4 = 1234.
UInt8	8-bit unsigned integer
Int16	16-bit signed integer
UInt16	16-bit unsigned integer
UInt32	32-bit unsigned integer
Color**	32-bit unsigned integer used to represent a color with Alpha(AA, 00 = opaque, FF = transparent), Red(RR), Green(GG), and Blue(BB) components.
Text	Null-terminated UTF-8 encoded character string

See the Command Reference to find the specification of each command and its arguments.

** For the binary protocol, Real Number arguments are multiplied by 10 so fractions can be used without requiring floating point formats. This can be conveniently implemented on the host by treating the LCD as having a resolution of 8000x4800 rather than 800x480. However, be careful to distinguish vector graphics coordinate arguments (Real Numbers) from as raster graphics coordinate arguments (Int16/UInt16). Raster graphics coordinate arguments are **not** real numbers as they must specify whole pixels, so should **not** be multiplied by 10.*

*** Note that although the notation for color arguments allows users to specify a 24-bit RGB component, the LCD is only capable of displaying 16-bit (565) RGB colors.*

Example 1

In this example, we'll look at constructing the binary equivalent of the the UTF-8 command `DrawLine 0 0 100 100`. The DrawLine command has the following specification:

- DrawLine command code – Hexadecimal 11
- *x1* – 16-bit Real Number
- *y1* – 16-bit Real Number
- *x2* – 16-bit Real Number
- *y2* – 16-bit Real Number

So, the command would be transmitted as follows.

Field	DLE	STX	DrawLine	0	0	1000*	1000*	DLE	ETX
Bytes (Hex)	10	02	11	00-00	00-00	E8-03	E8-03	10	03

**Note that real number arguments are multiplied by 10 so that they can be transmitted as 16- bit integers.*

Example 2

Consider the command `DrawLine 0 0 104 104`. Multiplying by 10 for real number arguments 104 becomes 1040. The binary representation for the number 1040 is 10-04 (Little Endian). Notice that the 1st byte is equivalent to the DLE character (Hexadecimal 10). Therefore it must be escaped by prepending a DLE byte as shown below.

Field	DLE	STX	DrawLine	0	0	1040*	1040*	DLE	ETX
Bytes (Hex)	10	02	11	00-00	00-00	**10**-10-04	**10**-10-04	10	03

**Note that real number arguments are multiplied by 10 so that they can be transmitted as 16- bit integers.*

Example 3
Text arguments must be null-terminating. Consider the command `DrawText 100 100 Hello`. The string "Hello" is encoded in UTF-8 as 48-65-6C-6C-6F, but to know where the string ends, a null character (Hexadecimal 00) is appended to the string.

Field	DLE	STX	DrawText	1000*	1000*	Hello	DLE	ETX
Bytes (Hex)	10	02	14	E8-03	E8-03	48-65-6C-6C-6F-**00**	10	03

**Note that real number arguments are multiplied by 10 so that they can be transmitted as 16- bit integers.*

Response

Responses consist of a 1-byte response code, <ACK> (Hexadecimal 06) or <NAK> (Hexadecimal 15), followed by 16-bit status code

Example
Positive Response

Field	DLE	STX	ACK	Success	DLE	ETX
Bytes (Hex)	10	02	06	00-00	10	03

Negative Response (Unknown command)

Field	DLE	STX	NAK	Unknown Command	DLE	ETX
Bytes (Hex)	10	02	15	01-00	10	03

Optional Checksum

If the checksum feature is enabled via the EnableChecksum command, a 16-bit integer checksum is appended to the end of the payload for both commands and responses. The checksum is simply a sum of all bytes in the payload.

Example – Command
Consider the command `DrawLine 0 0 100 100`. All bytes in the payload are added together (Hexadecimal: 11 + 00 + 00 + 00 + 00 + E8 + 03 + E8 + 03 = 01E7) and appended to the end of the payload.

Field	DLE	STX	DrawLine	0	0	1000*	1000*	Checksum	DLE	ETX
Bytes (Hex)	10	02	11	00-00	00-00	E8-03	E8-03	E7-01	10	03

**Note that real number arguments are multiplied by 10 so that they can be transmitted as 16- bit integers.*

Example – Positive Response
All bytes in the payload are added together (Hexadecimal: 06 + 00 + 00 + 00 + 00 = 0006) and appended to the end of the payload.

Field	DLE	STX	ACK	Success	Checksum	DLE	ETX
Bytes (Hex)	10	02	06	00-00-00-00	06-00	10	03

Coordinate System

For the 7" and 10.2" models, the M Display features an 800 x 480 (or 480 x 800: see Orientation) pixel display. The X-axis increases from left to right while the Y-axis increases from top to bottom. The origin (0, 0) is the top-left corner of the display.

Coordinates are in units of pixels and are always relative to the active layer's origin. So the command…

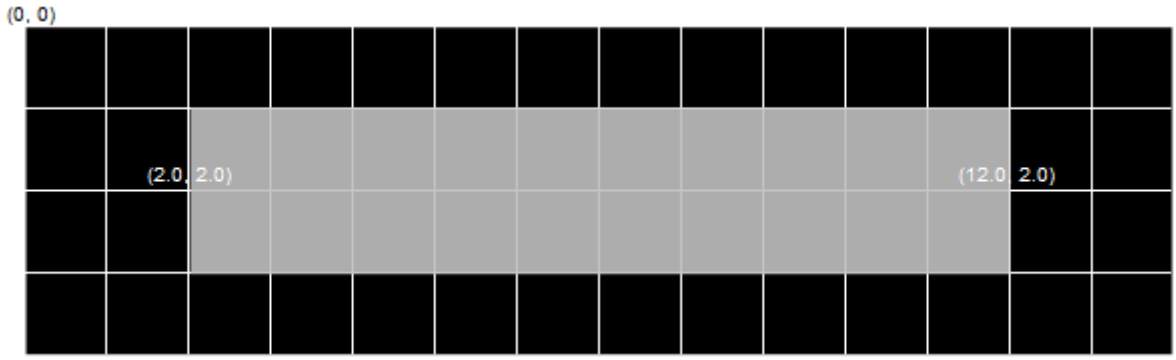
```
DrawLine 0.0 0.0 800.0 480.0
```

…will draw a diagonal line from the top-left corner of the screen to the bottom-right corner of the screen. However, notice that commands for drawing vector graphics can accept real number arguments. This means it's possible to specify coordinates of sub-pixels (e.g. half of a pixel). So, that might beg the question "How does half of a pixel appear?".

To answer that question, consider the commands…

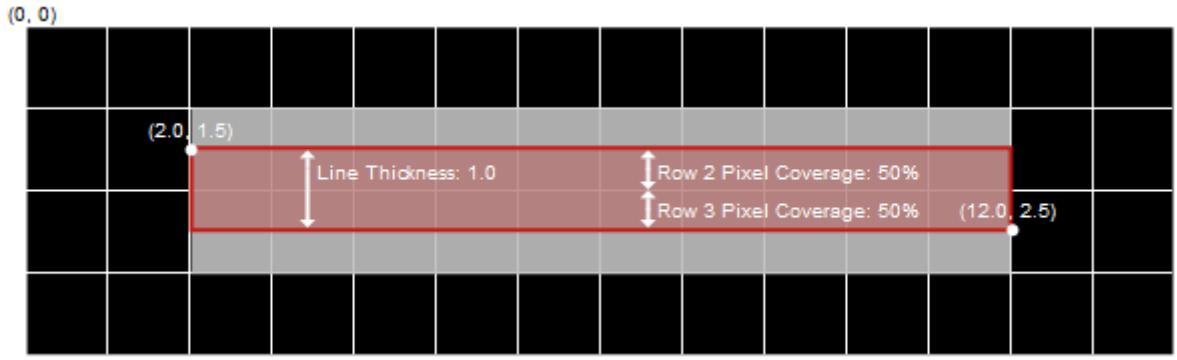
```
Color FFFFFF
LineEnd Butt
LineWidth 1.0
DrawLine 2.0 2.0 12.0 2.0
```

One might expect this to draw a bright white horizontal line, 10.0-pixels long, and exactly 1.0-pixel thick. However the line actually appears blurred. Zoomed in, one can see the line is actually 2.0-pixels thick and light-gray in color as shown below.



To understand why this is, one must understand that pixels are not dimensionless; rather they have a width and height. The most common displays have a pixel array of 72 DPI (dots per inch) meaning each pixel is approximately 0.013 inches square (pixels aren't actually square, but, it helps this explanation to think of them as square).

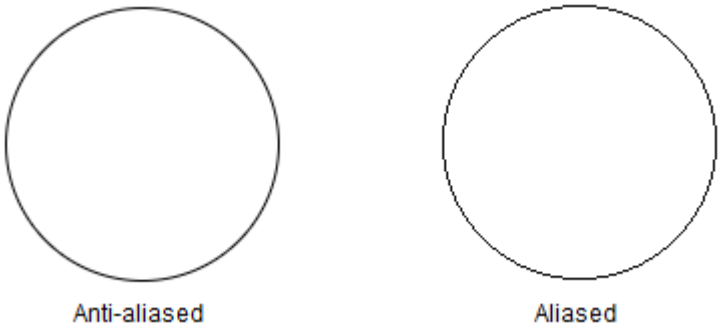
To draw a 1.0-pixel thick horizontal line from (2.0, 2.0) to (12.0, 2.0), that really means drawing a 10.0-pixel wide, 1.0-pixel tall rectangle centered on the line between (2.0, 2.0) and (12.0, 2.0). Therefore, the rectangle's top-left corner is (2.0, 1.5) and bottom-right corner is (12.0, 2.5). This is illustrated on the graph below. The outline of the actual line is shows in red. (NOTE: Observe that the ends of the line are clipped exactly at the x-coordinates due to the "Butt" line ending)



One can see that the line partially covers the pixels in rows 2 and 3. That is why the line appears to be two-pixels wide. The pixels in row 2 and 3 are each only half-covered (i.e. the pixel coverage is 50%). Since a single pixel is the smallest individual unit of color, the graphics engine approximates the 50% pixel coverage by making the pixel half as bright (i.e. 50% transparent). That is why, on a black background, the line appears gray instead of white.

In summary, sub-pixels are approximated by varying the pixel's brightness according to the percentage of pixel's area covered by the shape.

All this is necessary in order to support anti-aliasing, and ensure the visuals appear smooth and professional.



If an application requires a horizontal line that is exactly 1.0-pixel thick and not approximated on the pixel grid, simply shift the line as necessary to achieve 100% pixel coverage.

In the following example, the horizontal line in the previous illustrations is shifted up by 0.5 pixels to get 100% pixel coverage on row 2.

```
Color FFFFFF
LineEnd Butt
LineWidth 1.0
DrawLine 2.0 1.5 12.0 1.5
```

Now, because the pixel coverage is 100%, the pixels will be lit at 100% brightness (i.e. 100% opaque), resulting in a bright white horizontal line with a thickness of exactly 1.0 pixel.

Graphics

The M Display can display 3 types of graphics: Vector Graphics, Raster Graphics, and Fonts for text.

Vector Graphics

The majority of the M Display's command repertoire is used to draw vector graphics. Vector graphics consist of geographical primitives (lines, curves, rectangles, circles, etc…) that can be used in isolation or in combination with other visuals to create buttons, graphs, charts, panels, or just about any other visual that can be imagined.

Vector graphics commands can be broken down into 2 categories: stroked visuals and filled visuals. Stroked visuals draw an outline around the shape, and filled visuals have their interior filled with a specific color or pattern.

The following draws two rectangles: one stroked, and one filled. Commands that draw stroked shapes begin with "Draw" and commands that draw filled shapes begin with "Fill". There are also path drawing commands ArcTo, ClearPath, ClosePath, CurveTo, LineTo, MoveTo that can be used to create arbitrary shapes.

The following example shows two different rectangles: one stroked and one filled.

```
# Clear the active layer
Clear

# Draw a stroked rectangle
LineWidth 2
Color 00FF00
DrawRectangle 50 50 100 100

# Draw a filled rectangle
Color FF00FF
FillRectangle 200 50 100 100
```

- The color of the stroke or the fill can be specified with the Color, LinearGradient, or RadialGradient commands.
- The characteristics of the stroke can be specified with the LineWidth, LineEnd, and LineJoin commands.

Vector graphics can be mathematically transformed (rotated, scaled, translated, etc…) without loosing any definition. This makes them particularly useful for rendering dynamic content such as gauge needles and graphs.

Raster Graphics

Raster graphics are simply arrays of plotted pixels. They are mostly used for displaying photographs and other file-based images. The M Display supports two commands for drawing raster graphics: Image and SetPixel. Image can be used to read a PNG file from the SD Card and plot it to the screen at a given location. SetPixel is used to plot one or more pixels at a specified location and can be used to plot images on the screen without needing to read from the SD Card.

The following example shows an image of a gauge being displayed from a PNG file on the SD Card.

```
# Clear the active layer
Clear

# Display the image
Image 229 115 "/gauge.png"
```

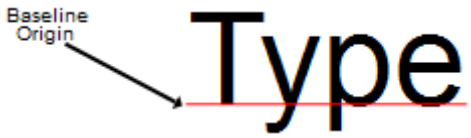
Fonts and Text

The M Display supports the TrueType font format. TrueType fonts are actually a specialized class of vector graphics, and can, therefore, be scaled, stroked, and filled just like vector graphics.

The shape of the characters (a.k.a. glyphs) are stored in a TrueType font file. The M Display can read these glyphs from a TrueType font file, and draw the characters at a specified location on the screen.

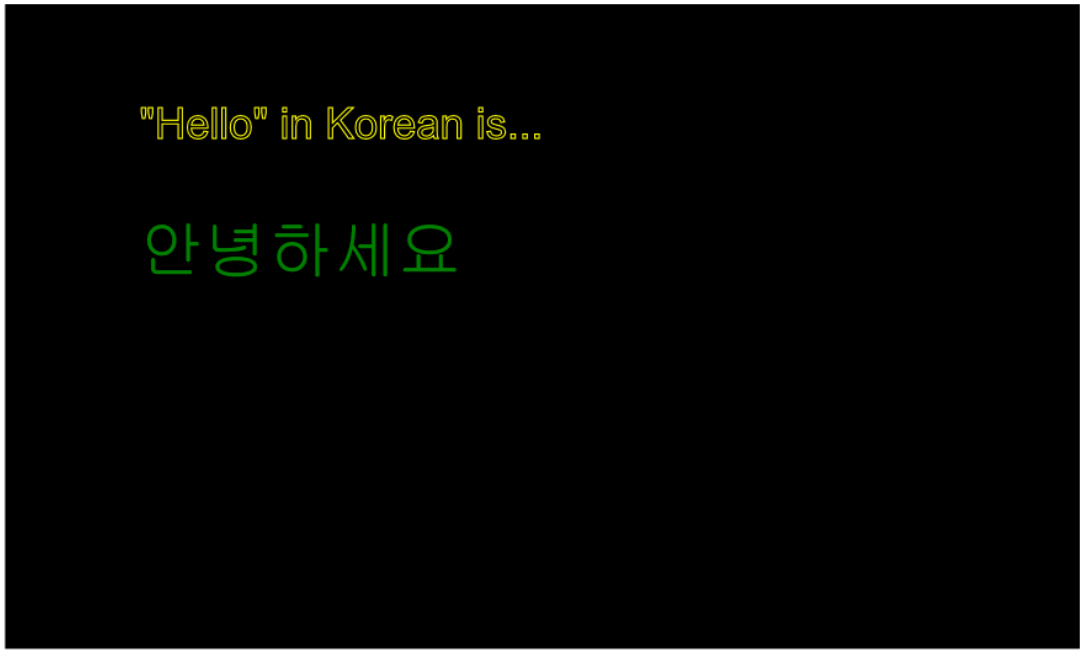
By default the M Display has a Sans-Serif font file loaded in its internal memory. This font contains glyphs for ASCII and Extended ASCII characters. Additional fonts can be loaded from the SD Card at runtime with the LoadFont command.

Text is positioned relative to its baseline origin as illustrated below.



This example shows how to stroke and fill text.

```
# Clear the active layer
Clear

# Draw yellow text in the default font
Color FFFF00
DrawText 100 100 "\"Hello\" in Korean is..."

# Load font with Korean glyphs
LoadFont "/gulim.ttf"

# Draw green text in the gulim font
Color 00FF00
FontSize 48
FillText 100 200 "안녕하세요"
```



- The color of the stroke or the fill can be specified with the Color, LinearGradient, or RadialGradient commands.
- The characteristics of the stroke can be specified with the LineWidth, LineJoin, and LineCap commands.
- The size of the font is specified with the FontSize command.

When loading a font from the SD Card, every time text is displayed, the glyphs have to be read from the file. This may be fine for infrequent text updates, but for highly dynamic text, it may be too slow. Therefore, the LoadFont command has an additional parameter that can be used to cache the font in memory if enough memory is available. This can greatly improve performance for applications that require frequent text updates.

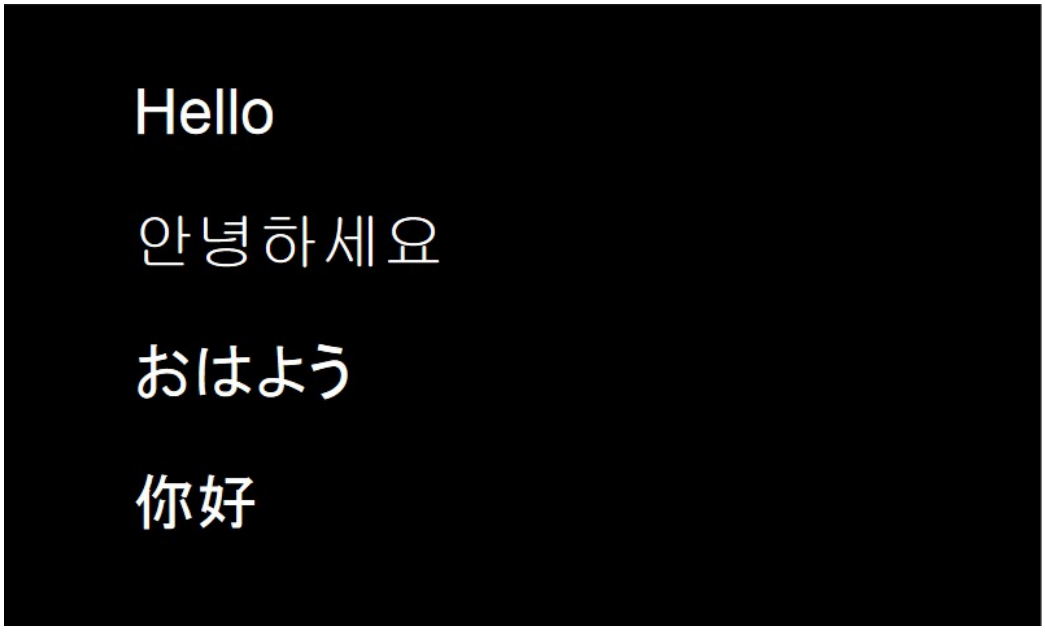
To ensure fonts fit in memory, however, the size of the font file must be reduced to an absolute minimum. To help users reduce the size of font files, Comfile Technology has created a SubsetFont Utility that can be used to remove unneeded glyphs from font files so they can be used more efficiently with the M Display. Please see the M Display's support site to obtain this utility.

Internationalization and Multilingual Support

Unicode is supported as long as all text is encoded in UTF-8. Therefore, it is possible to render just about any written language as long as the active font contains the glyphs. The M Display does not have a text layout engine, however, so combining marks, right-to-left text, and other advanced layout features are not supported. The M display will simply render glyphs in sequential order from left to right.

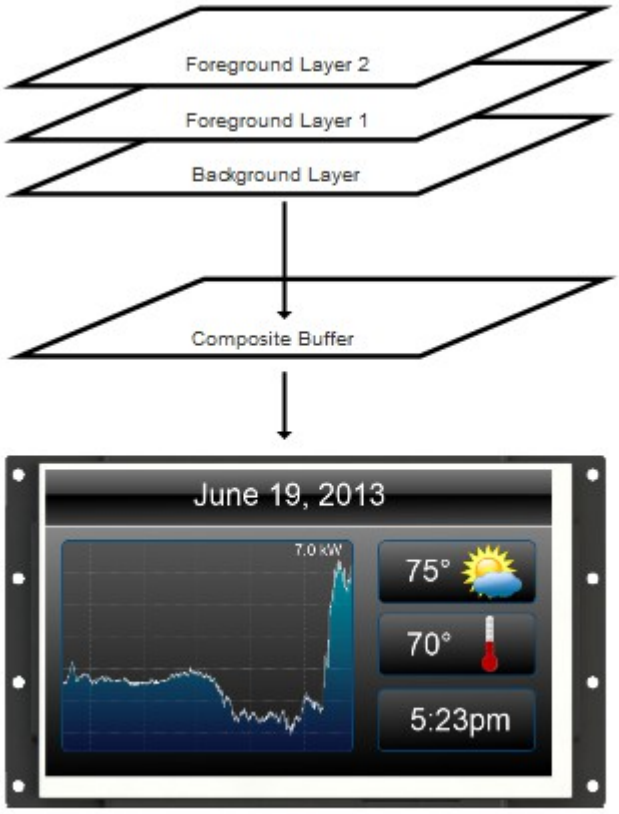
The example below shows how to load a font for English, Korean, Japanese, and Chinese, and display text in each of those languages.

```
# English text using default font
FontSize 48
FillText 100 200 "Hello"

# Load font with Korean glyphs
LoadFont "/korean.ttf"
FillText 100 200 "안녕하세요"

# Load font with Japanese glyphs
LoadFont "/japan.ttf"
FillText 100 200 "おはよう"

# Load font with Chinese glyphs
LoadFont "/china.ttf"
FillText 100 200 "你好"
```



Layers

Layers are independent visuals superimposed on one another to create a composite visual. They are useful for separating a visual into logical parts that can be updated independently without impacting other visuals that they may overlap.



At power on, the M Display creates a background layer as the default drawing surface. Additional foreground layers can be created with the CreateLayer command.

The user can draw, independently, to the background layer or any foreground layer. Using the painter's algorithm (background layer rendered first, foreground layer-1 rendered second…foreground layer-*n* rendered last) the layers are combined into a single frame buffer, the composite buffer. Then on every vertical refresh of the LCD, any changes to the composite buffer are flushed to the screen.

The flushing of the composite buffer to the LCD can be controlled with the DisableFlush and EnableFlush commands. This can be useful to prevent the M Display from displaying part of a composite visual until the entire visual has been completely drawn. It can also improve performance when drawing many visuals, as the M Display doesn't have to waste resources updating the LCD multiple times.

Using Layers to Update Text

Using layers is particularly useful when updating text. Consider the desire to update text on green background.

Attempt 1

If one issues a FillText command and attempts to update the text with a second FillText command, the the second text will be superimposed on the first text as shown below.

```
# Green Rectangle
Color 000800
FillRectangle 0 0 200 75

# White Text
Color FFFFFF
FillText 50 50 "123"
FillText 50 50 "456"
```

Attempt 2

If a Clear command is used in between the two FillText commands, the background will be erased and a black box will appear, which is also not desirable.

```
# Green Rectangle
Color 000800
FillRectangle 0 0 200 75

# White Text
Color FFFFFF

# Display "123"
FillText 50 50 "123"

# Clear the box containing the text (black on background layer)
Clear 40 20 70 40

# Display "456"
FillText 50 50 "456"
```

Attempt 3

However, by separating the green background and the text onto different layers, clearing the foreground layer will erase the text without impacting the green background layer.

```
# Green Rectangle
Color 000800
FillRectangle 0 0 800 480

# New 70x40 layer, positioned at 40,20 to contain text
```

```
CreateLayer 40 20 70 40 1
Layer 1

# White text
Color FFFFFF

# Display "123"
# Coordinates are relative to new layer's top-left corner (i.e. 40,20)
FillText 0 40 "123"

# Erase "123" (Transparent for foreground layer)
Clear

# Display "456"
FillText 0 40 "456"
```

That's better! One could have simply displayed a new green-filled rectangle to clear the text in this example, but that method falls short for backgrounds that may be images. Images are stored on the SD card and reading from the SD card is orders of magnitude slower than drawing with the CPU. Re-displaying the background image from the SD card for each and every text update, especially if the image were full-screen, would be much too slow to be practical, and this is why the layering feature was created.

Layers and Memory

Creating layers requires memory to hold the state of its pixels. The M Display has 4MB of memory that is shared by all layers, cached fonts, and any other loadable content. When the M Display is first powered on, it creates an 800x480x16-bits = 768KB background layer and an 800x480x16-bits = 768KB composition layer. These layers only need 16-bits per pixel because they are opaque layers. That leaves approximately 2~2.5MB of memory for any foreground layers, cached fonts, and other loadable content.

Foreground layers will reside “on top” of the background layer, and will therefore need an additional byte for the alpha (transparency) component. This byte, in addition to the 16 bits required for the RGB components, results in for a total of 24 bits per pixel. So, as an example, an 800×480 foreground layer will need 800x480x24-bits = 1,152KB of memory.

As can be seen, layers can potentially consume a lot of memory. So, be sure to create layers sparingly, and keep them to as small an area as possible to avoid running out of memory.

Command Reference

ArcTo (Hexadecimal 00)

Syntax

```
ArcTo x y horizontalRadius [verticalRadius [rotationAngle [largeArc [sweep]]]]
```

Description

Draws an elliptical or circular arc on the active layer from the current point (see MoveTo) to x,y.

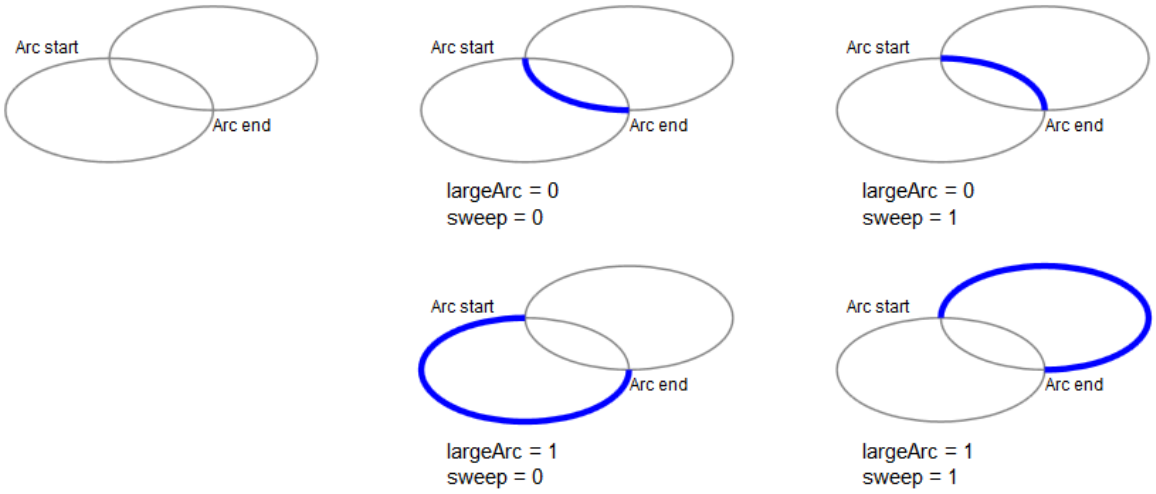
- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.
- The stroke's end cap is specified with the LineCap command.
- The appearance of the joint with preceding and subsequent strokes is specified with the LineJoin command.

Arguments

Argument	Type	Description
x	Real Number	The X-Coordinate of the point to draw the arc to
y	Real Number	The Y-Coordinate of the point to draw the arc to
horizontalRadius	Real Number	The horizontal radius of the ellipse that forms the arc
verticalRadius	Real Number	(Optional) The vertical radius of the ellipse that forms the arg. If omitted, the this value will be equal to the horizontal radius forming a circular arc.
rotationAngle	Real Number	(Optional) The angle in degrees to rotate the ellipse that forms the arc. Default is 0 degrees.
largeArc	UInt8	(Optional) 0 - Draw the smaller arc, non-zero - draw the larger arc. Default is non-zero.
sweep	UInt8	(Optional) 0 - Draws arc starting at the current point in a counter-clockwise direction, non-zero - Draws the arc starting at the current point in a clockwise direction. Default is non-zero.

Understanding the *largeArc* and *sweep* Arguments

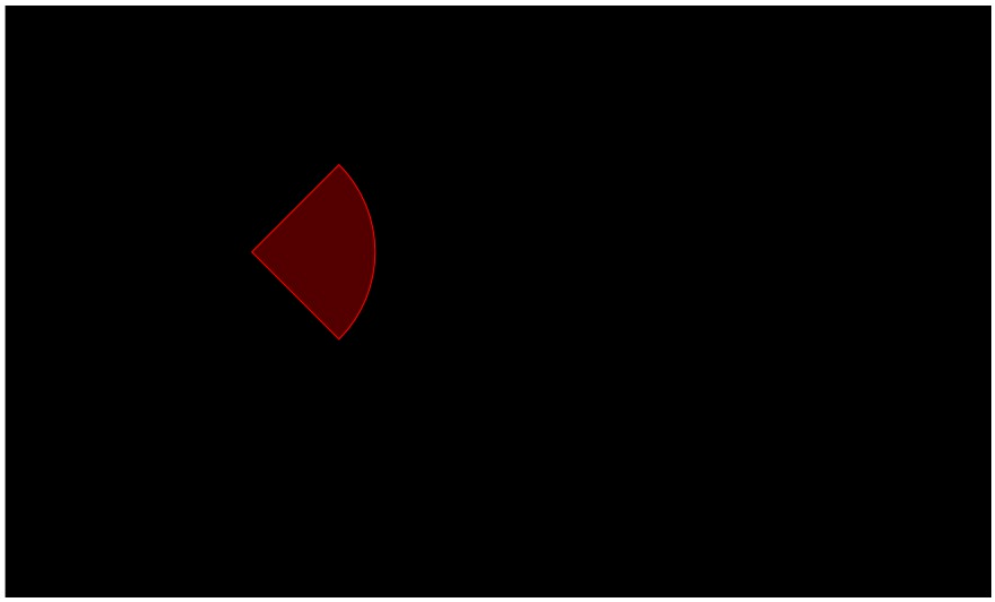
The following illustrates the affect of the *largeArc* and *sweep* arguments.



Example

This example demonstrates how to use ArcTo to draw a fraction of a pie chart.

```
# Clear the active layer
Clear

# Create a fraction of a pie
MoveTo 200 200
LineTo 270.7 129.29
ArcTo 270.7 270.7 100 100 0 0 1
ClosePath

# Fill the pie with partially transparent red
Color AAFF0000
FillPath

# Draw a border around the pie in bright red
LineWidth 1
Color FF0000
DrawPath
```



Backlight (Hexadecimal 01)

Syntax

```
Backlight brightness
```

Description

Sets the brightness of the LCD backlight. The default brightness is 255.

Arguments

Argument	Type	Description
brightness	UInt8	The brightness of the backlight ranging from 0-off to 255-brightest.

BevelButton (Hexadecimal 02)

Syntax

```
BevelButton topLeftX topLeftY width height buttonColor topLeftColor bottomRightColor [text]
```

Description

Draws a rectangular button with a beveled border to the active layer.

Arguments

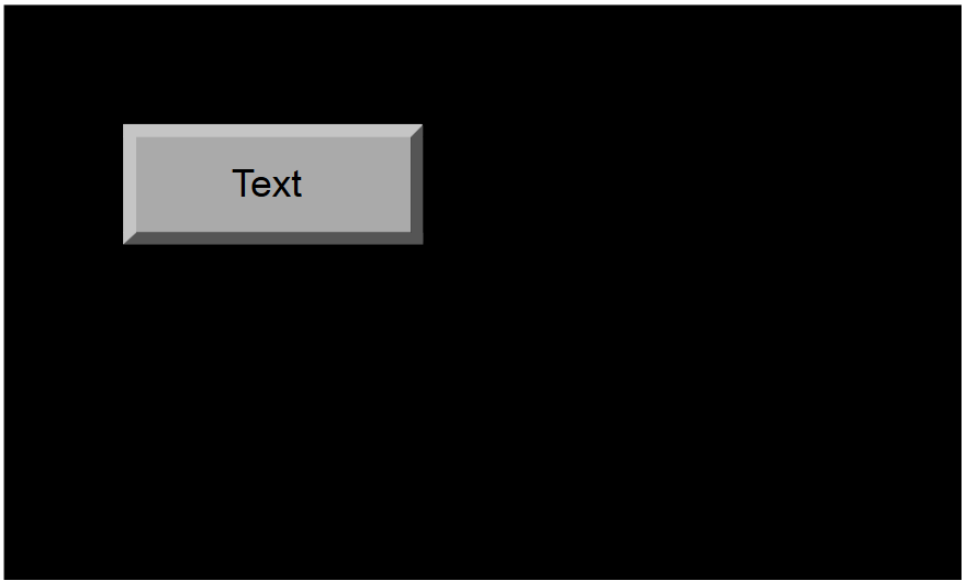
Argument	Type	Description
topLeftX	Real Number	The X-Coordinate of the top-left corner of the button.
topLeftY	Real Number	The Y-Coordinate of the top-left corner of the button.
width	Real Number	The width of the button.
height	Real Number	The height of the button.
buttonColor	Color	The color of the body of the button.
topLeftColor	Color	The color of the top and left bevel border.
bottomRightColor	Color	The color of the bottom and right bevel border.
text	Text	(Optional) The text label to display in the center of the button. If omitted, no text will be displayed

- The color of the text is specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the border is specified with the LineWidth command.
- The size of the font for the text label is specified with the FontSize command.

Example

This example displays a gray beveled button with black text.

```
# Clear the active layer
Clear

# Black Text
Color 0

# Border width of 10 pixels
LineWidth 10

# Gray beveled button
BevelButton 100 100 250 100 AAAAAA C5C5C5 555555 "Text"
```


Text

Button (Hexadecimal 03)

Syntax

```
Button topLeftX topLeftY width height cornerRadius buttonColor borderColor [text]
```

Description

Draws a rectangular or rounded-rectangular button to the active layer.

Arguments

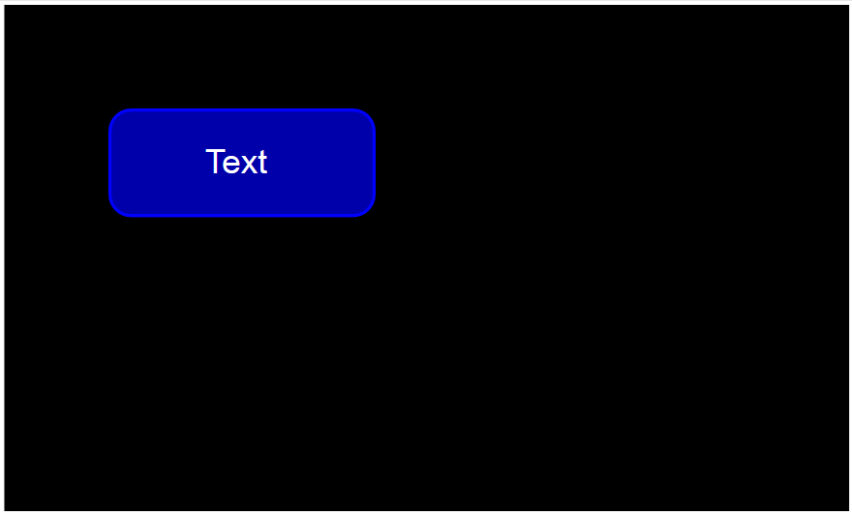
Argument	Type	Description
topLeftX	Real Number	The X-Coordinate of the top-left corner of the button.
topLeftY	Real Number	The Y-Coordinate of the top-left corner of the button.
width	Real Number	The width of the button.
height	Real Number	The height of the button.
cornerRadius	Real Number	The radius of curvature for the corners of the button.
buttonColor	Color	The color of the body of the button.
borderColor	Color	The color of the button's border.
text	Text	(Optional) The text label to display in the center of the button. If omitted, no text will be displayed

- The color of the text is specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the border is specified with the LineWidth command.
- The size of the font for the text label is specified with the FontSize command.

Example

This example draws a blue rounded-rectangular button with white text.

```
# Clear the active layer
Clear

# white text
Color FFFFFF

# Border width of 1 pixel
LineWidth 3

# Blue button with 20 pixel radius rounded corners
Button 100 100 250 100 20 0000AA 0000FF "Text"
```



Clear (Hexadecimal 04)

Syntax

```
Clear [x y width height]
```

Description

Clears the active layer. If *x*, *y*, *width*, and *height* are omitted the entire layer will be cleared. Otherwise, just the rectangle bound by x,y width,height will be cleared.

Foreground layers are transparent when cleared in order to reveal pixels in the layers beneath them. The background layer is black when cleared as there are no layers beneath it.

Arguments

Argument	Type	Description
x	Int16	The X-Coordinate of the top-left corner of the area to be cleared
y	Int16	The Y-Coordinate of the top-left corner of the area to be cleared
width	UInt16	The width of the area to be cleared
height	UInt16	The height of the area to be cleared

ClearPath (Hexadecimal 05)

Syntax

```
ClearPath
```

Description

Clears the current path drawn with any of the path drawing commands (e.g. ArcTo, ClearPath, ClosePath, CurveTo, LineTo, MoveTo).

ClosePath (Hexadecimal 32)

Syntax

```
ClosePath
```

Description

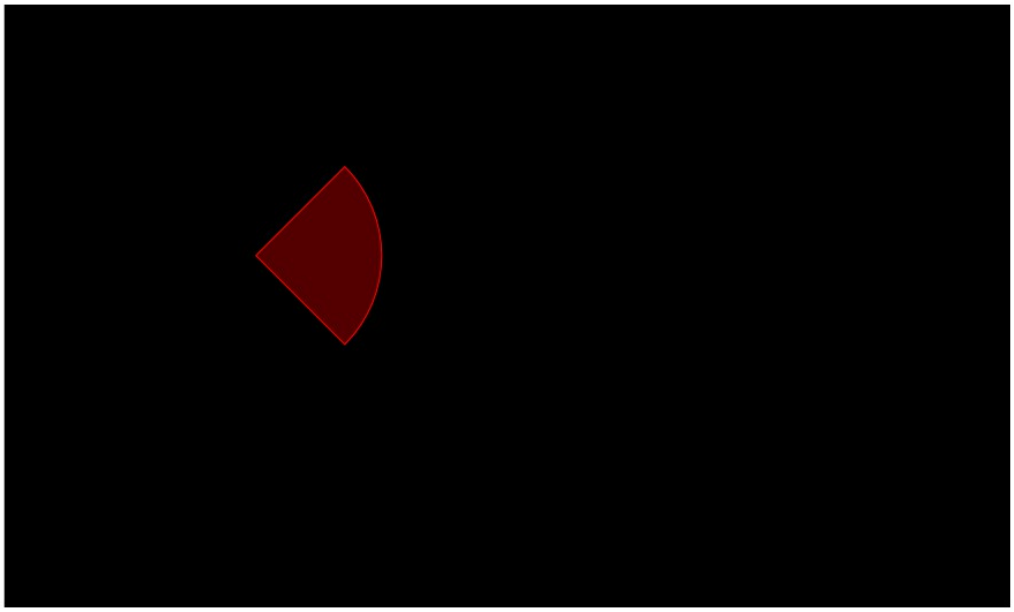
Draws a line from the current point on the path to the path's origin creating an enclosed polygon.

- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.
- The stroke's end cap is specified with the LineCap command.
- The appearance of the joint with preceding and subsequent strokes is specified with the LineJoin command.

Example

This example demonstrates use ClosePath to enclose a section of a pie.

```
# Clear the active layer
Clear

# Create a fraction of a pie
MoveTo 200 200
LineTo 270.7 129.29
ArcTo 270.7 270.7 100 100 0 0 1

# Enclose the pie by drawing a line back to the center
ClosePath

# Fill the pie with partially transparent red
Color AAFF0000
FillPath

# Draw a border around the pie in bright red
LineWidth 1
Color FF0000
DrawPath
```



Color (Hexadecimal 07)

Syntax

```
Color color
```

Description

Specifies the solid color to use in subsequent drawing and filling commands. The color is global and applies to all layers.

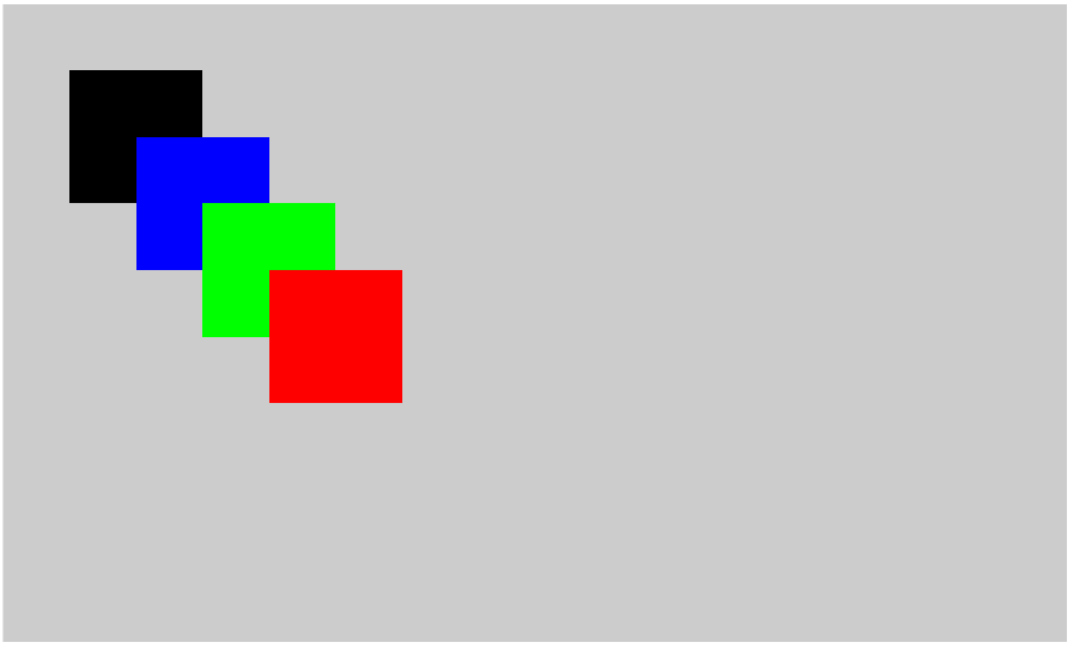
Arguments

Argument	Type	Description
color	Color	The solid color to use for all subsequent commands.

Example 1

This example will display a black, blue, green, and red rectangle on a gray background.

```
# Clear the active layer
Clear

# Opaque gray background
Color CCCCCC
FillRectangle 0 0 800 480

# Opaque black rectangle
Color 0
FillRectangle 50 50 100 100

# Opaque blue rectangle
Color FF
FillRectangle 100 100 100 100

# Opaque green rectangle
Color FF00
FillRectangle 150 150 100 100

# Opaque red rectangle
Color FF0000
FillRectangle 200 200 100 100
```



Example 2

This example will display a partially transparent fuchsia filled rectangle on a partially transparent green filled rectangle.

```
# Clear the active layer
Clear

# Partially transparent green rectangle
Color A900FF00
FillRectangle 50 50 100 100

# Partially transparent fuchsia rectangle
Color A9FF00FF
FillRectangle 100 100 100 100
```

CreateLayer (Hexadecimal 08)

Syntax

```
CreateLayer x y width height layerID
```

Description

Creates a new layer on top of all existing layers. This command dynamically allocates memory to hold the layer's frame buffer, so be aware that creating too may layers or too large of a layer can result in memory errors.

Arguments

Argument	Type	Description
x	Int16	The X-Coordinate of the top-left corner of the layer to be created
y	Int16	The Y-Coordinate of the top-left corner of the layer to be created
width	UInt16	The width of the layer to be created
height	UInt16	The height of the layer to be created
layerID	UInt8	The ID to give the layer. This is a text value that must be unique. ID “0” is already assigned to the background layer so it cannot be used.

Coordinates are relative to the the screen's origin (0, 0).

CurveTo (Hexadecimal 09)

Syntax

```
CurveTo x y control0X control0Y [control1X control1Y]
```

Description

Draws a quadratic or cubic bezier curve from the current point (see MoveTo) to x,y.

- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.
- The stroke's end cap is specified with the LineCap command.
- The appearance of the joint with preceding and subsequent strokes is specified with the LineJoin command.

Arguments

Argument	Type	Description
x	Real Number	The X-Coordinate of the point to draw the curve to
y	Real Number	The Y-Coordinate of the point to draw the curve to
control0X	Real Number	The X-Coordinate of the first control point
control0Y	Real Number	The Y-Coordinate of the first control point
control1X	Real Number	(Optional) The X-Coordinate of the second control point. If this argument is specified, the curve will be drawn as a cubic bezier. If omitted, the curve will be drawn as a quadratic bezier.
control1Y	Real Number	(Optional) The Y-Coordinate of the second control point. If this argument is specified, the curve will be drawn as a cubic bezier. If omitted, the curve will be drawn as a quadratic bezier.

Example

This example draws a cyan curve from (200, 200) to (400, 200).

```
# Clear the active layer
Clear

# Create the vertices for the path
MoveTo 200 200
CurveTo 400 200 300 300 300 200

# Draw the path in a cyan, with a line width of 5 pixels
LineWidth 5
Color 00FFFF
DrawPath
```

Delay (Hexadecimal 0A)

Syntax

```
Delay milliseconds
```

Description

Pauses execution for the specified number of milliseconds. This is particularly useful for use with the RunScript command so one can control the rate at which visuals are displayed.

Arguments

Argument	Type	Description
milliseconds	UInt32	The number of milliseconds to pause for.

DestroyLayer (Hexadecimal 0B)

Syntax

```
DestroyLayer layerID
```

Description

Destroys the layer specified by *layerID* and releases any memory held by its frame buffer.

Arguments

Argument	Type	Description
layerID	UInt8	The ID of the layer to be destroyed

DisableFlush (Hexadecimal 0C)

Syntax

```
DisableFlush
```

Description

Disables flushing all layers' frame buffers to the screen.

If you have many items to draw, use this to prevent displaying each item on the screen until all items have been drawn. Using this command in combination with EnableFlush can improve performance and prevent display anomalies while drawing.

DisableLayer (Hexadecimal 34)

Syntax

```
DisableLayer layerId
```

Description

Disables a layer so it is no longer displayed, effectively hiding the layer. The layer still exists and the contents of the memory are not cleared. Use EnableLayer to undo this command and show the layer on the screen.

Arguments

Argument	Type	Description
layerID	UInt8	The ID of the layer to be disabled

DrawArc (Hexadecimal 0D)

Syntax

```
DrawArc centerX centerY horizontalRadius [verticalRadius] startAngle sweep
```

Description

Draws a circular or elliptical arc to the active layer.

- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.
- The stroke's end cap is specified with the LineCap command.

Arguments

Argument	Type	Description
centerX	Real Number	The X-Coordinate of the center of the ellipse that forms the arc.
centerY	Real Number	The Y-Coordinate of the center of the ellipse that forms the arc.
horizontalRadius	Real Number	The horizontal radius of the ellipse that forms the arc.
verticalRadius	Real Number	(Optional) The vertical radius of the ellipse that forms the arc. If omitted it will be equal to horizontal radius producing a circular arc.
startAngle	Real Number	The angle (in degrees) at which to start drawing
sweep	Real Number	The number of degrees to sweep the arc. Positive numbers sweep in the clockwise direction. Negative numbers sweep in the counter-clockwise direction.

Example

This example draws a green circular arc with a stroke width of 1.0, and fuchsia elliptical arc with a stroke width of 3.0.

```
# Clear the active layer
Clear

# Draw green circular arc with a stroke width of 1.0
LineWidth 1.0
Color 00FF00

# Width omitted for circular arc
DrawArc 100 100 50 45.0 235.0

# Draw fuchsia elliptical arc with a stroke width of 3.0
LineWidth 3.0
Color FF00FF
DrawArc 300 100 100 50 110 270
```

DrawCircle (Hexadecimal 0E)

Syntax

```
DrawCircle centerX cenerY radius
```

Description

Draws a square-bound circle to the active layer.

- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.

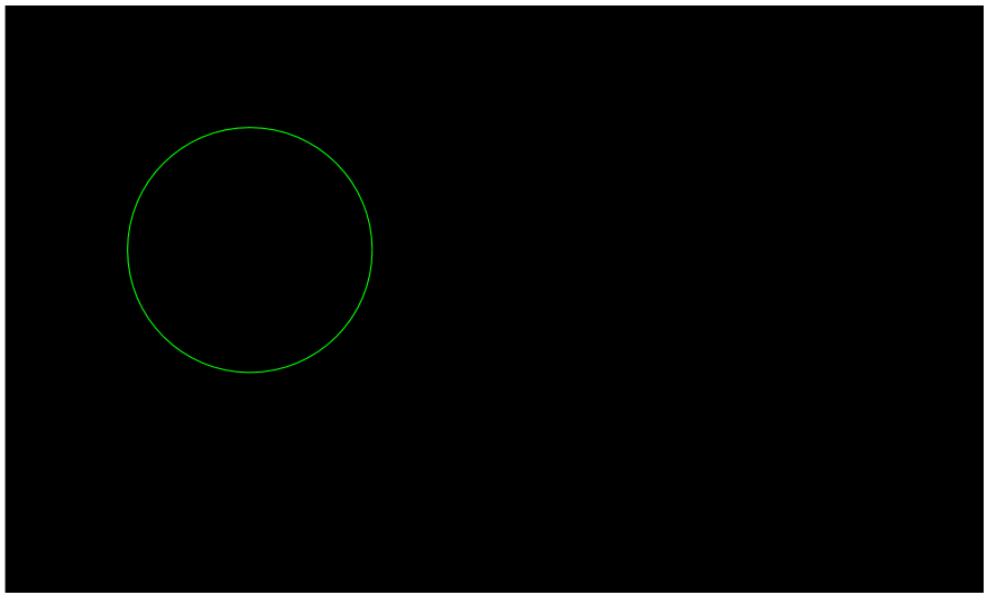
Arguments

Argument	Type	Description
centerX	Real Number	The X-Coordinate of the circle's center
centerY	Real Number	The Y-Coordinate of the circle's center
radius	Real Number	The radius of the circle

Example

This example draws circle with a radius of 100 centered at (200, 200).

```
# Clear the active layer
Clear

# Set line width
LineWidth 1.0

# Draw a green circle
Color 00FF00
DrawCircle 200 200 100
```



DrawCurve (Hexadecimal 0F)

Syntax

```
DrawCurve fromX fromY control0X control0Y [control1X control1Y] toX toY
```

Description

Draws a quadratic or cubic bezier curve from the point (*fromX*, *fromY*) to point (*toX*, *toY*) on the active layer.

- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.
- The stroke's end cap is specified with the LineCap command.

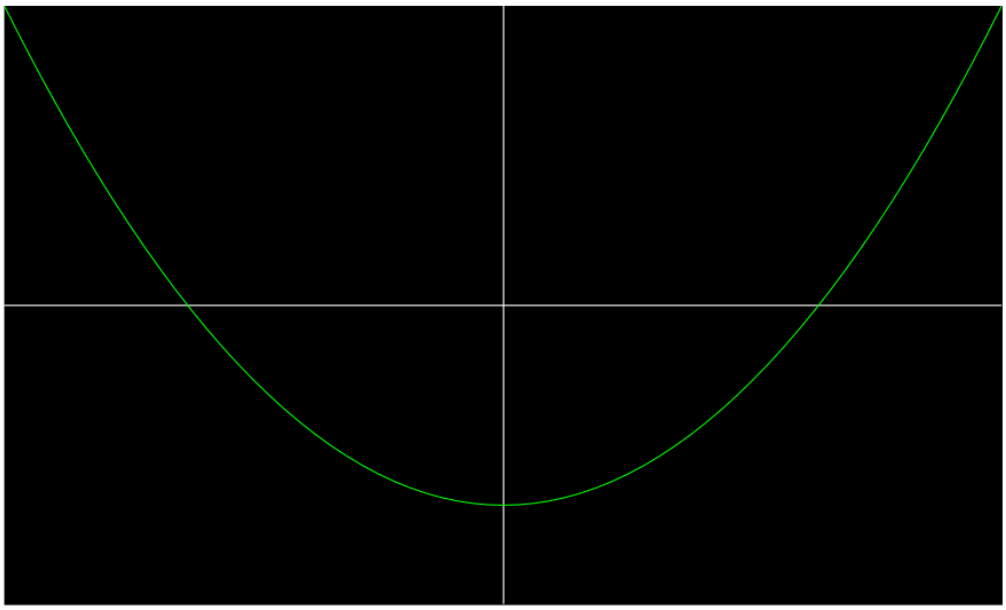
Arguments

Argument	Type	Description
fromX	Real Number	The X-Coordinate of the point to start drawing from
fromY	Real Number	The Y-Coordinate of the point to start drawing from
control0X	Real Number	The X-Coordinate of the first control point
control0Y	Real Number	The Y-Coordinate of the first control point
control1X	Real Number	(Optional) The X-Coordinate of the second control point. If this argument is specified, the curve will be drawn as a cubic bezier. If omitted, the curve will be drawn as a quadratic bezier.
control1Y	Real Number	(Optional) The Y-Coordinate of the second control point. If this argument is specified, the curve will be drawn as a cubic bezier. If omitted, the curve will be drawn as a quadratic bezier.
toX	Real Number	The X-Coordinate of the point to draw the curve to
toY	Real Number	The Y-Coordinate of the point to draw the curve to

Example 1

This example draws a green parabola between the two top corners of the screen

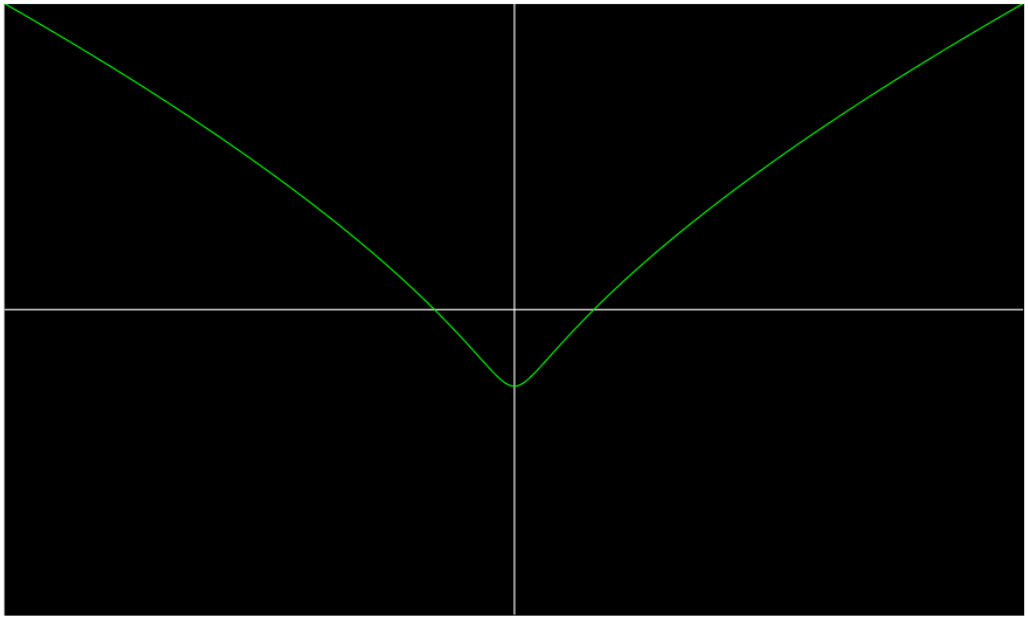
```
# Clear the active layer
Clear

# Draw X and Y axes
Color FFFFFF
DrawLine 0 240 799 240
DrawLine 400 0 400 479

# Draw quadratic bezier curve (parabola)
Color 00FF00
DrawCurve 0 0 400 800 799 0
```



Example 2

This example draws a green cubic bezier curve between the two top corners of the screen.

```
# Clear the active layer
Clear

# Draw X and Y axes
Color FFFFFF
DrawLine 0 240 799 240
DrawLine 400 0 400 479

# Draw cubic bezier curve
Color 00FF00
DrawCurve 0 0 700 400 100 400 799 0
```



DrawEllipse (Hexadecimal 10)

Syntax

```
DrawEllipse centerX centerY horizontalRadius verticalRadius
```

Description

Draws a rectangle-bound ellipse to the active layer.

- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.

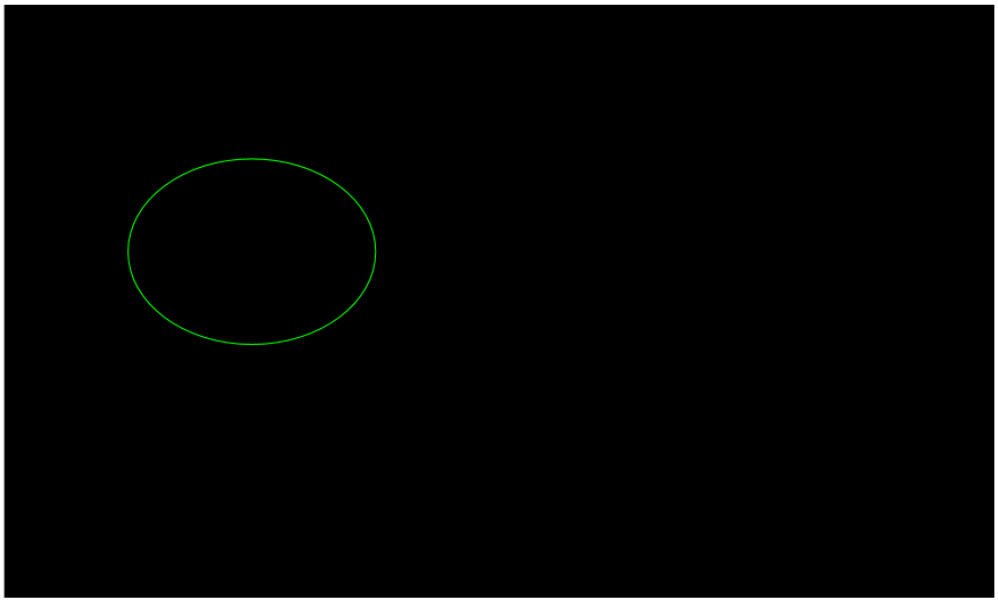
Arguments

Argument	Type	Description
centerX	Real Number	The X-Coordinate of the ellipse's center
centerY	Real Number	The Y-Coordinate of the ellipse's center
horizontalRadius	Real Number	The radius of the ellipse in the direction of the x-axis
verticalRadius	Real Number	The radius of the ellipse in the direct of the y-axis

Example

This example draws an ellipse with a horizontal radius of 100, vertical radius of 75, centered at 200,200.

```
# Clear the active layer
Clear

# Set line width
LineWidth 1.0

# Draw a green circle
Color 00FF00
DrawEllipse 200 200 100 75
```



DrawLine (Hexadecimal 11)

Syntax

```
DrawLine x1 y1 x2 y2
```

Description

Draws a line on the active layer from point (x1, y1) to line (x2, y2) including both points.

- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.
- The stroke's end cap is specified with the LineCap command.

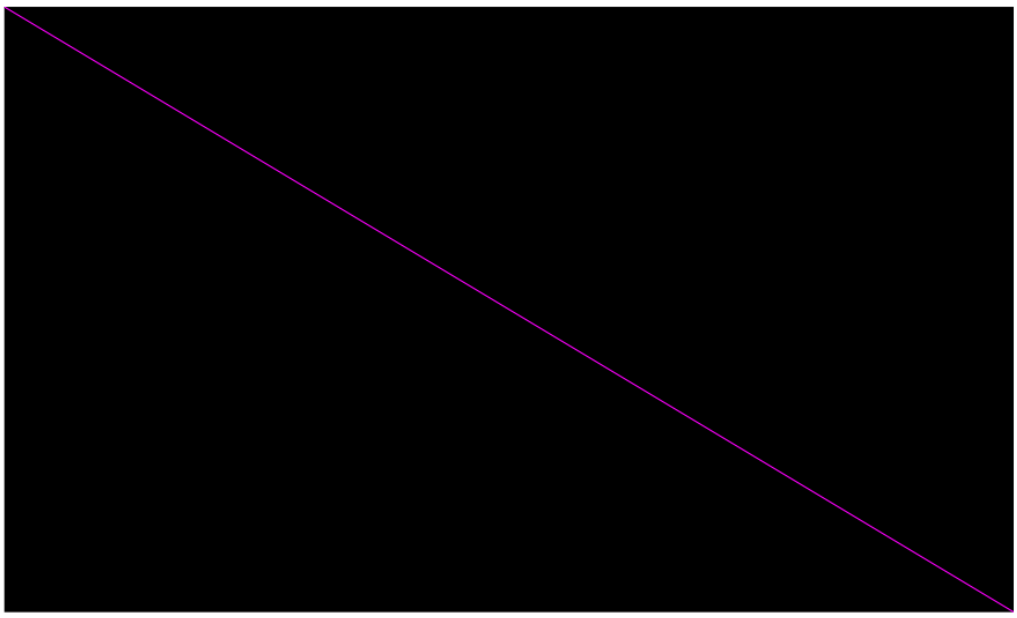
Arguments

Argument	Type	Description
x1	Real Number	The X-Coordinate of the point from which to begin drawing
y1	Real Number	The Y-Coordinate of the point from which to begin drawing
x2	Real Number	The X-Coordinate of the point at which to end drawing
y2	Real Number	The Y-Coordinate of the point at which to end drawing

Example

This example draws a fuchsia line from point 0,0 to point 799,479

```
# Clear the active layer
Clear

# Set the line width
LineWidth 1.0

# Set the color of the line
Color FF00FF

# Draw the line
DrawLine 0 0 799 479
```



DrawPath (Hexadecimal 12)

Syntax

```
DrawPath
```

Description

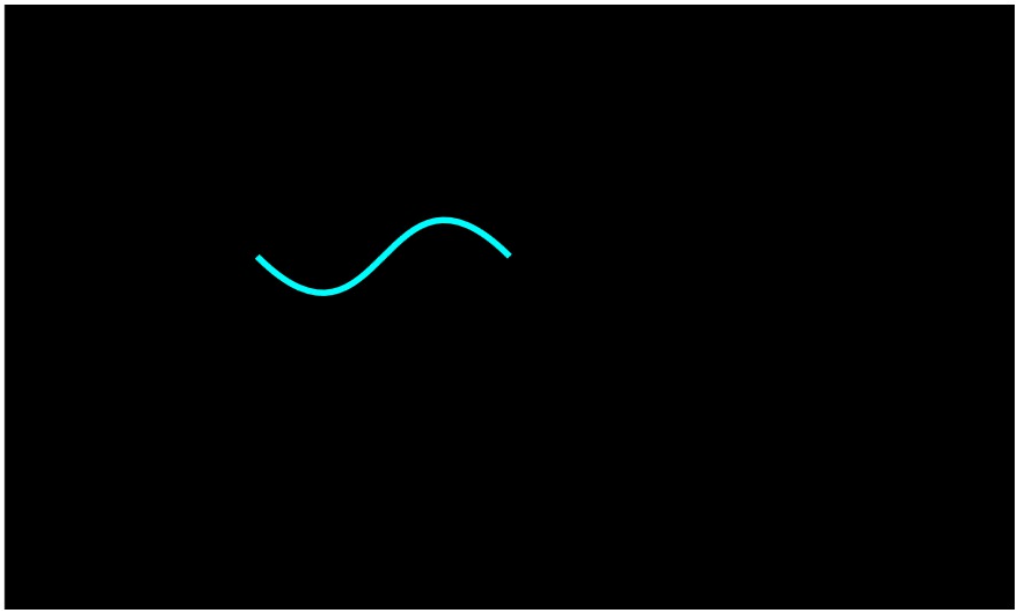
Displays the outline of the path drawn with the path drawing commands (e.g. ArcTo, ClearPath, ClosePath, CurveTo, LineTo, MoveTo) on the active layer.

- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.
- The stroke's end cap is specified with the LineCap command.

Example

This example draws a cyan curve from (200, 200) to (400, 200).

```
# Clear the active layer
Clear

# Create the vertices for the path
MoveTo 200 200
CurveTo  400 200 300 300 300 200

# Draw the path in a cyan, with a line width of 5 pixels
LineWidth 5
Color 00FFFF
DrawPath
```



DrawRectangle (Hexadecimal 13)

Syntax

```
DrawRectangle x y width height [topLeftCornerRadius [topRightCornerRadius
bottomLeftCornerRadius bottomRightCornerRadius]]
```

Aliases

```
DrawRect
```

Description

Draws a rectangle or rounded-rectangle on the active layer.

- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.

Arguments

Argument	Type	Description
x	Real Number	The X-Coordinate of the point to be the rectangle's top-left corner
y	Real Number	The Y-Coordinate of the point to be the rectangle's top-left corner
width	Real Number	The width of the rectangle.
height	Real Number	The height of the rectangle.
topLeftCornerRadius	Real Number	(Optional) The radius of the quarter circle that forms the top-left corner. If omitted, a value with sharp (90 degree) corners will be drawn. If *topRightCornerRadius* , *bottomLeftCornerRadius* , and *bottomRightCornerRadius* are omitted, this value will be used for all corner radii.
topRightCornerRadius	Real Number	(Optional) (Optional) The radius of the quarter circle that forms the top-right corner
bottomLeftCornerRadius	Real Number	(Optional) The radius of the quarter circle that forms the bottom-left corner
bottomRightCornerRadius	Real Number	(Optional) The radius of the quarter circle that forms the bottom-right corner

Example

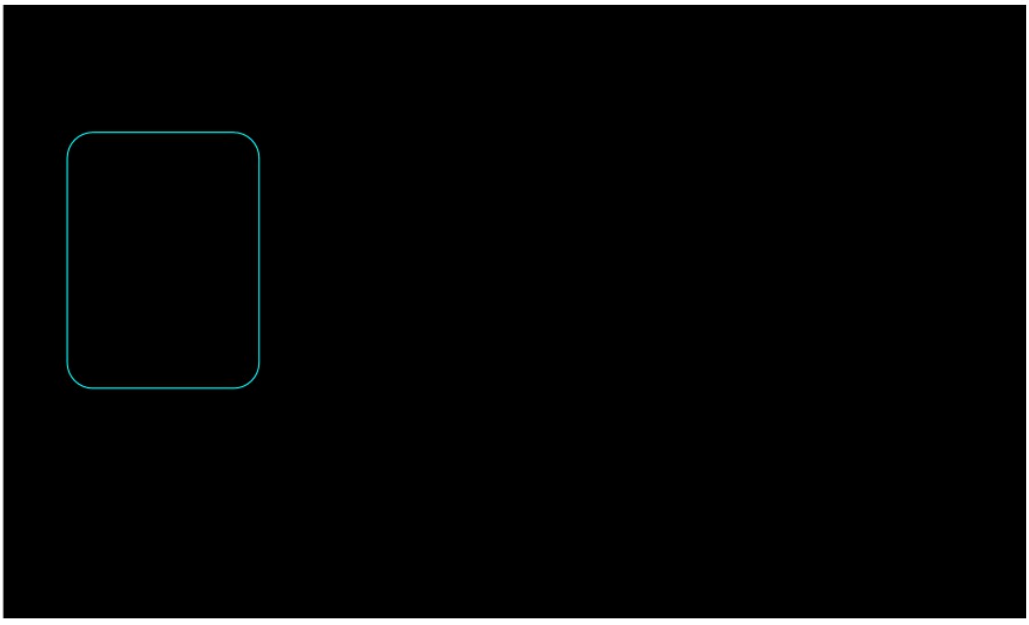
This example will draw a cyan rectangular perimeter 150 pixels wide, 200 pixels tall, positioned so it's top left corner is at 50,100.

```
#Clear the current layer
Clear

# Draw a cyan rectangular perimeter
Color 00FFFF
DrawRectangle 50 100 150 200
```

Example

This example will draws an opaque rounded rectangle 150 pixels wide, 200 pixels tall, with a corner radius of 20 pixels positioned so it's top left corner is at 50,100.

```
#Clear the current layer
Clear

# Set Line Width
LineWidth 1.0

# Draw a cyan rounded rectangular perimeter
Color FFFF
DrawRectangle 50 100 150 200 20
```



DrawText (Hexadecimal 14)

Syntax

```
DrawText baselineX baselineY text [angle]
```

Description

Draws outlined text on the active layer.

- The font size is specified with the FontSize command.
- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.
- The stroke's end cap is specified with the LineCap command.

Unicode characters are supported, but the font rendering engine does not contain a text layout features, so combining marks, bi-directional text, and other such layout features are not supported.

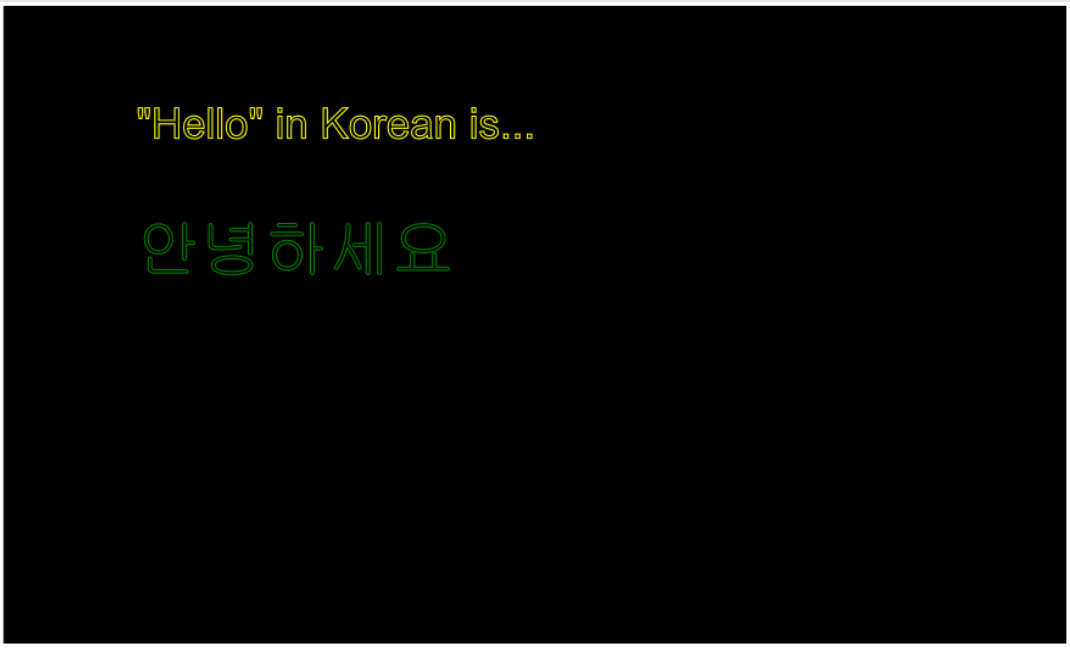
Arguments

Argument	Type	Description
baselineX	Real Number	The X-Coordinate of the text's baseline
baselineY	Real Number	The Y-Coordinate of the text's baseline
text	Text	The text to display.
angle	Real Number	(Optional) Angle, in degrees, to rotate the text

Example

This example draws ”"Hello” in Korean is…” in yellow with a size of 32 pixels and “안녕하세요” in green with a size of 48 pixels.

```
# Clear the active layer
Clear

# Draw yellow text in the default font
Color FFFF00
DrawText 100 100 "\"Hello\" in Korean is..."

# Load font with Korean glyphs
LoadFont "/gulim.ttf"

# Draw green text in the gulim font
Color 00FF00
FontSize 48
DrawText 100 200 "안녕하세요"
```



DrawTextCenter (Hexadecimal 37)

Syntax

```
DrawTextCenter baselineX baselineY text [angle]
```

Description

Draws outlined text on the active layer, center-aligned to *baselineX*, *baselineY*.

- The font size is specified with the FontSize command.
- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.
- The stroke's end cap is specified with the LineCap command.

Unicode characters are supported, but the font rendering engine does not contain a text layout features, so combining marks, bi-directional text, and other such layout features are not supported.

Arguments

Argument	Type	Description
baselineX	Real Number	The X-Coordinate of the text's baseline
baselineY	Real Number	The Y-Coordinate of the text's baseline
text	Text	The text to display.
angle	Real Number	(Optional) Angle, in degrees, to rotate the text

DrawTextRight (Hexadecimal 36)

Syntax

```
DrawTextRight baselineX baselineY text [angle]
```

Description

Draws outlined text on the active layer, right-aligned to *baselineX*, *baselineY*.

- The font size is specified with the FontSize command.
- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.
- The stroke's end cap is specified with the LineCap command.

Unicode characters are supported, but the font rendering engine does not contain a text layout features, so combining marks, bi-directional text, and other such layout features are not supported.

Arguments

Argument	Type	Description
baselineX	Real Number	The X-Coordinate of the text's baseline
baselineY	Real Number	The Y-Coordinate of the text's baseline
text	Text	The text to display.
angle	Real Number	(Optional) Angle, in degrees, to rotate the text

EnableFlush (Hexadecimal 33)

Syntax

```
EnableFlush
```

Description

Enables flushing all layers' frame buffers to the screen.

If you have many items to draw, use DisableFlush to prevent displaying each item on the screen until all items have been drawn. Once all items have been drawn use this command to make them appear on the screen. Using this command in combination with DisableFlush can improve performance and prevent display anomalies while drawing.

EnableLayer (Hexadecimal 35)

Syntax

```
EnableLayer layerId
```

Description

Enables a layer effectively showing it on the screen. This command will undo a previous DisableLayer command.

Arguments

Argument	Type	Description
layerID	UInt8	The ID of the layer to be enabled

FillCircle (Hexadecimal 16)

Syntax

```
FillCircle centerX centerY radius
```

Description

Draws a filled circle to the active layer.

The fill color is specified with the Color, LinearGradient, or RadialGradient command.

Arguments

Argument	Type	Description
centerX	Real Number	The X-Coordinate of the circle's center.
centerY	Real Number	The Y-Coordinate of the circle's center.
radius	Real Number	The radius of the circle.

Example

This example displays green-filled circle of radius 50, centered at (100, 100).

```
# Clear the active layer
Clear

# Draw a green circle
Color 00FF00
FillCircle 100 100 50
```

FillEllipse (Hexadecimal 17)

Syntax

```
FillEllipse centerX centerY horizontalRadius verticalRadius
```

Description

Draws a filled ellipse on the active layer.

The fill color is specified with the Color, LinearGradient, or RadialGradient command.

Arguments

Argument	Type	Description
centerX	Real Number	The X-Coordinate of the bounding-rectangle's top-left corner
centerY	Real Number	The Y-Coordinate of the bounding-rectangle's top-left corner
horizontalRadius	Real Number	The radius of the ellipse in the X-axis direction
verticalRadius	Real Number	The radius of the ellipse in the Y-axis direction

Example

This example draws a green-filled ellipse at 100,100 with a horizontal radius of 50 pixels and vertical radius of 75 pixels.

```
# Clear the active layer
Clear

# Draw a green oval
Color 00FF00
FillEllipse 100 100 50 75
```

FillPath (Hexadecimal 18)

Syntax

```
FillPath
```

Description

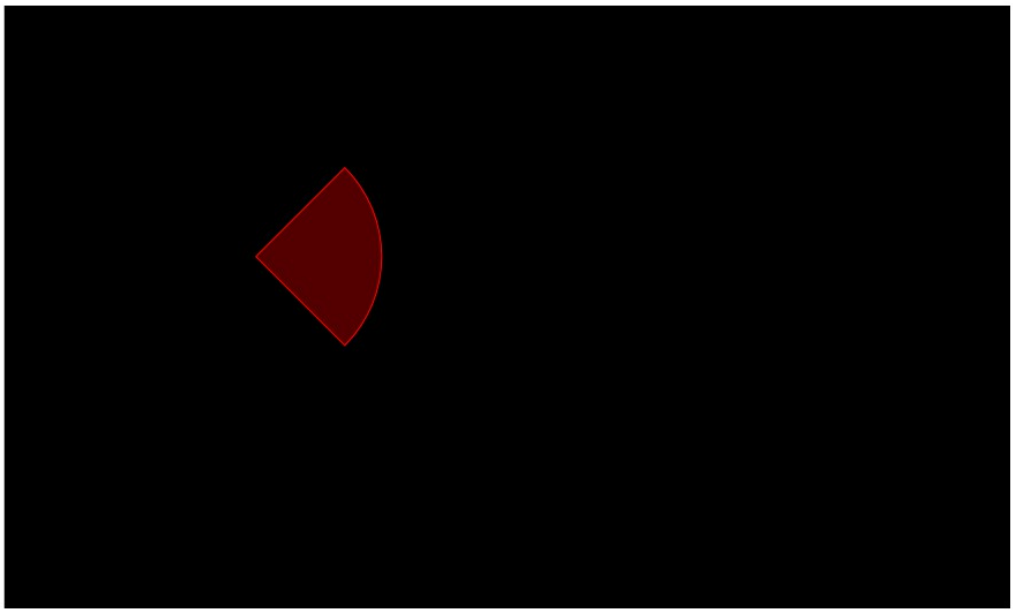
Fills the path drawn with the path drawing commands (e.g. ArcTo, ClearPath, ClosePath, CurveTo, LineTo, MoveTo) on the active layer.

The fill color can be specified with the Color, LinearGradient, or RadialGradient commands.

Example

This example demonstrates using the FillPath command to display a fraction of a pie chart.

```
# Clear the active layer
Clear

# Create a fraction of a pie
MoveTo 200 200
LineTo 270.7 129.29
ArcTo 270.7 270.7 100 100 0 0 1
ClosePath

# Fill the pie with partially transparent red
Color AAFF0000
FillPath

# Draw a border around the pie in bright red
LineWidth 1
Color FF0000
DrawPath
```



FillRectangle (Hexadecimal 19)

Syntax

```
FillRectangle topLeftX topLeftY width height [topLeftCornerRadius [topRightCornerRadius
bottomLeftCornerRadius bottomRightCornerRadius]]
```

Aliases

```
FillRect
```

Description

Draws a filled rectangle or filled rounded-rectangle on the active layer.

The fill color is specified with the Color, LinearGradient, or RadialGradient command.

Arguments

Argument	Type	Description
topLeftX	Real Number	The X-Coordinate of the rectangle's top-left corner.
topLeftY	Real Number	The Y-Coordinate of the rectangle's top-left corner.
width	Real Number	The width of the rectangle.
height	Real Number	The height of the rectangle.
topLeftCornerRadius	Real Number	(Optional) The radius of the quarter circle that forms the top-left corner. If omitted, a value with sharp (90 degree) corners will be drawn. If *topRightCornerRadius* , *bottomLeftCornerRadius* , and *bottomRightCornerRadius* are omitted, this value will be used for all corner radii.
topRightCornerRadius	Real Number	(Optional) The radius of the quarter circle that forms the top-right corner
bottomLeftCornerRadius	Real Number	(Optional) The radius of the quarter circle that forms the bottom-left corner
bottomRightCornerRadius	Real Number	(Optional) The radius of the quarter circle that forms the bottom-right corner

Example 1

This example will display a partially transparent fuchsia filled rectangle on a partially transparent green filled rectangle.

```
# Clear the active layer
Clear

# Partially transparent green rectangle
Color A900FF00
FillRectangle 50 50 100 100

# Partially transparent fuchsia rectangle
Color A9FF00FF
FillRectangle 100 100 100 100
```

Example 2

This example will display a partially transparent fuchsia-filled rounded rectangle with a corner radius of 10 pixels on a partially transparent green-filled rounded rectangle with a corner radius of 20 pixels.

```
# Clear the active layer
Clear

# Partially transparent green rounded rectangle
Color A900FF00
FillRectangle 50 50 100 100 20

# Partially transparent fuchsia rounded rectangle
Color A9FF00FF
FillRectangle 100 100 100 100 10
```

FillText (Hexadecimal 1A)

Syntax

```
FillText baselineX baselineY text [angle]
```

Description

Draws filled text on the active layer.

- The font size is specified with the FontSize command.
- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.
- The stroke's end cap is specified with the LineCap command.
- The appearance of the joint with preceding and subsequent strokes is specified with the LineJoin command.

Unicode characters are supported, but the font rendering engine does not contain a text layout features, so combining marks, bi-directional text, and other such layout features are not supported.

Arguments

Argument	Type	Description
baselineX	Real Number	The X-Coordinate of the text's baseline
baselineY	Real Number	The Y-Coordinate of the text's baseline
text	Text	The text to display.
angle	Real Number	(Optional) Angle, in degrees, to rotate the text

Example

This example draws ”"Hello” in Korean is…” in yellow with a size of 32 pixels and “안녕하세요” in green with a size of 48 pixels.

```
# Clear the active layer
Clear

# Draw yellow text in the default font
Color FFFF00
FillText 100 100 "\"Hello\" in Korean is..."

# Load font with Korean glyphs
LoadFont "/gulim.ttf"

# Draw green text in the gulim font
Color 00FF00
FontSize 48
FillText 100 200 "안녕하세요"
```

FillTextCenter (Hexadecimal 39)

Syntax

```
FillTextCenter baselineX baselineY text [angle]
```

Description

Draws filled text on the active layer, center-aligned to *baselineX*, *baselineY*.

- The font size is specified with the FontSize command.
- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.
- The stroke's end cap is specified with the LineCap command.
- The appearance of the joint with preceding and subsequent strokes is specified with the LineJoin command.

Unicode characters are supported, but the font rendering engine does not contain a text layout features, so combining marks, bi-directional text, and other such layout features are not supported.

Arguments

Argument	Type	Description
baselineX	Real Number	The X-Coordinate of the text's baseline
baselineY	Real Number	The Y-Coordinate of the text's baseline
text	Text	The text to display.
angle	Real Number	(Optional) Angle, in degrees, to rotate the text

FillTextRight (Hexadecimal 38)

Syntax

```
FillTextRight baselineX baselineY text [angle]
```

Description

Draws filled text on the active layer, right-aligned to *baselineX*, *baselineY*.

- The font size is specified with the FontSize command.
- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.
- The stroke's end cap is specified with the LineCap command.
- The appearance of the joint with preceding and subsequent strokes is specified with the LineJoin command.

Unicode characters are supported, but the font rendering engine does not contain a text layout features, so combining marks, bi-directional text, and other such layout features are not supported.

Arguments

Argument	Type	Description
baselineX	Real Number	The X-Coordinate of the text's baseline
baselineY	Real Number	The Y-Coordinate of the text's baseline
text	Text	The text to display.
angle	Real Number	(Optional) Angle, in degrees, to rotate the text

FontSize (Hexadecimal 1B)

Syntax

```
FontSize size
```

Description

Selects the size to display with the DrawText and FillText commands. The default size at power on is 32 pixels.

Arguments

Argument	Type	Description
size	Real Number	The size of the text in pixels

Example

This example draws "Default Font Size" in yellow with the default font size and "Font Size 48" in green with a size of 48 pixels.

```
# Clear the active layer
Clear

# Yellow text at default font size
Color FFFF00
DrawText 100 100 "Default Font Size"

# Green text at font size of 48
Color 00FF00
FontSize 48
DrawText 100 200 "Font Size 48"
```

GlossyButton (Hexadecimal 1C)

Syntax

```
GlossyButton topLeftX topLeftY width height cornerRadius buttonColor borderColor [text]
```

Description

Draws a button with a glossy appearance on the active layer.

- Coordinates are relative to the active's origin.
- The color of the text is specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the border is specified with the LineWidth command.
- The size of the font for the text label is specified with the FontSize command.

Arguments

Argument	Type	Description
topLeftX	Real Number	The X-Coordinate of the top-left corner of the button.
topLeftY	Real Number	The Y-Coordinate of the top-left corner of the button.
width	Real Number	The width of the button.
height	Real Number	The height of the button.
cornerRadius	Real Number	The radius of curvature for the corners of the button.
buttonColor	Color	The primary shade of color to use for the body of the button.
borderColor	Color	The color of the button's border.
text	Text	(Optional) The text label to display in the center of the button. If omitted, no text will be displayed

Example

This example draws a blue glossy button.

```
# Clear the active layer
Clear

# White text
Color FFFFFF

# Border width of 2
LineWidth 2

# Draw a blue glossy button
GlossyButton 100 100 200 50 10 336699 336699 "Text"
```

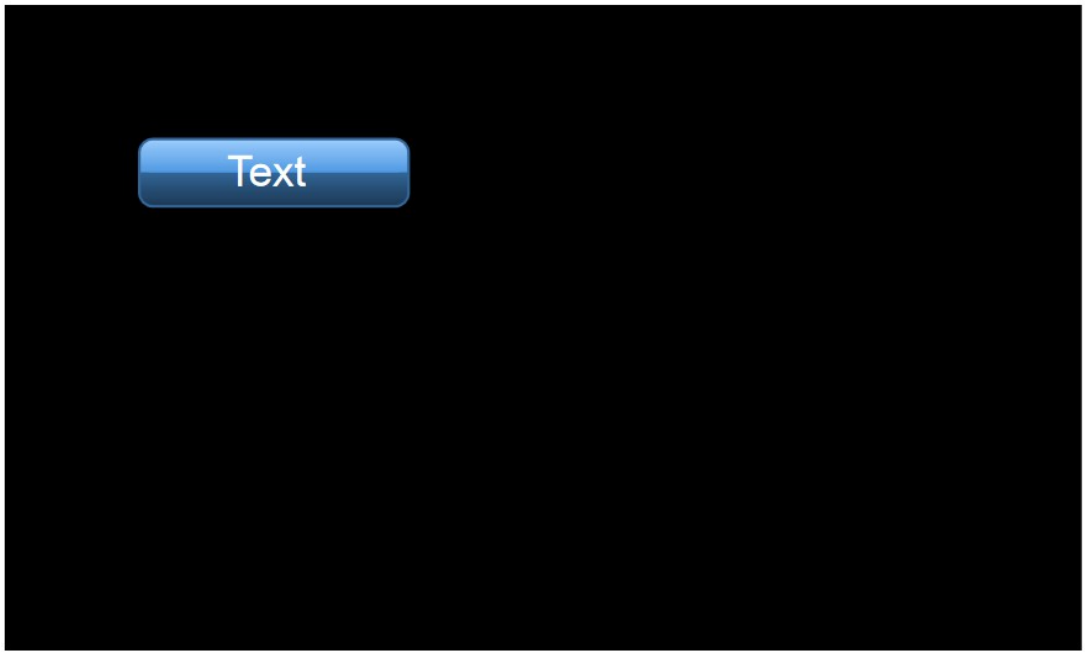


Image (Hexadecimal 1D)

Syntax

```
Image x y filePath
```

Description

Reads a PNG file from the SD Card and displays it on the active layer.

Arguments

Argument	Type	Description
x	Int16	X-Coordinate of the point to be the image's top-left corner
y	Int16	Y-Coordinate of the point to be the image's top-left corner
filePath	Text	Path to image file on SD card

Example

This example draws reads the file “gauge.png” located at root of the SD card's file system and positions it so it's top-left corner is at 229,115.

```
# Clear the active layer
Clear

# Draw the image
Image 229 115 "/gauge.png"
```

Layer (Hexadecimal 1E)

Syntax

```
Layer layerID
```

Description

Sets the active layer.

Arguments

Argument	Type	Description
layerID	UInt8	The ID of the layer to become the active layer. The background layer's ID is 0.

LineCap (Hexadecimal 1F)

Syntax

```
LineCap cap
```

Description

Sets the type of end cap for all subsequent strokes

Arguments

Argument	Type	Description
cap	Text (UTF-8 protocol) UInt8 (binary protocol)	The type of end cap to use. UTF-8 protocol valid values are “Butt”, “Round”, and “Square” . Binary protocol valid values are 0, 1, and 2 for Butt, Round, and Square respectively.

Example

This example shows the appearance of each kind of end cap.

```
# Clear the active layer
Clear

# Draw white lines with a thickness of 10
Color FFFFFF
LineWidth 10

# Draw three lines, each with a different end cap
LineCap Butt
DrawLine 100 100 200 100

LineCap Round
DrawLine 100 150 200 150

LineCap Square
DrawLine 100 200 200 200

# Draw red lines to illustrate the endpoints
LineCap Butt
LineWidth 1
Color FF0000
DrawLine 100 90 100 210
DrawLine 200 90 200 210
```

LineJoin (Hexadecimal 20)

Syntax

```
LineJoin join
```

Description

Sets the type join to use for interconnected strokes.

Arguments

Argument	Type	Description
join	Text(UTF-8 protocol) UInt8 (Binary protocol)	The type of join to use. UTF-8 protocol valid values are “Miter”, “Round”, and “Bevel” . Binary valid values are 0, 1, and 2 for Miter, Round and Bevel respectively.

Example

This example shows the appearance of each kind of line join.

```
# Clear the active layer
Clear

# Set the line width
LineWidth 10.0

# Draw polyline with round join
ClearPath
MoveTo 100 100
LineTo 150 50
LineTo 200 100
LineJoin Round
DrawPath

# Draw polyline with miter join
ClearPath
MoveTo 250 100
LineTo 300 50
LineTo 350 100
LineJoin Miter
DrawPath

# Draw polyline with round join
ClearPath
MoveTo 400 100
LineTo 450 50
LineTo 500 100
LineJoin Bevel
DrawPath
```

LineTo (Hexadecimal 21)

Syntax

```
LineTo x y
```

Description

Adds a line to the current path from the current point (See MoveTo) to x,y.

- The color of the stroke can be specified with the Color, LinearGradient, or RadialGradient commands.
- The width of the stroke is specified with the LineWidth command.
- The stroke's end cap is specified with the LineCap command.
- The appearance of the joint with preceding and subsequent strokes is specified with the LineJoin command.

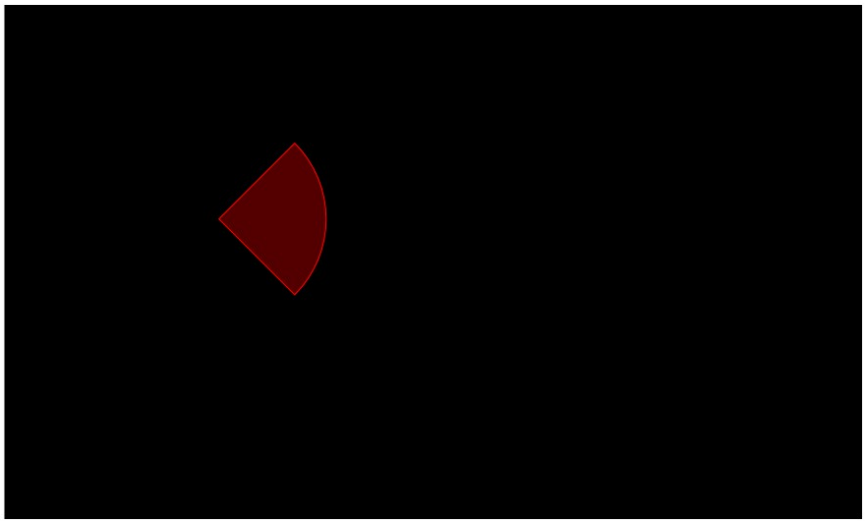
Arguments

Argument	Type	Description
x	Real Number	The X-Coordinate of the point to draw the line to
y	Real Number	The Y-Coordinate of the point to draw the line to

Example

This example uses the LineTo command to draw the edges of a fraction of a pie chart.

```
# Clear the active layer
Clear

# Create a fraction of a pie
MoveTo 200 200
LineTo 270.7 129.29
ArcTo 270.7 270.7 100 100 0 0 1
ClosePath

# Fill the pie with partially transparent red
Color AAFF0000
FillPath

# Draw a border around the pie in bright red
LineWidth 1
Color FF0000
DrawPath
```



LineWidth (Hexadecimal 22)

Syntax

```
LineWidth width
```

Description

Sets the width of the line (i.e. stroke) when drawing outlined and stroked shapes.

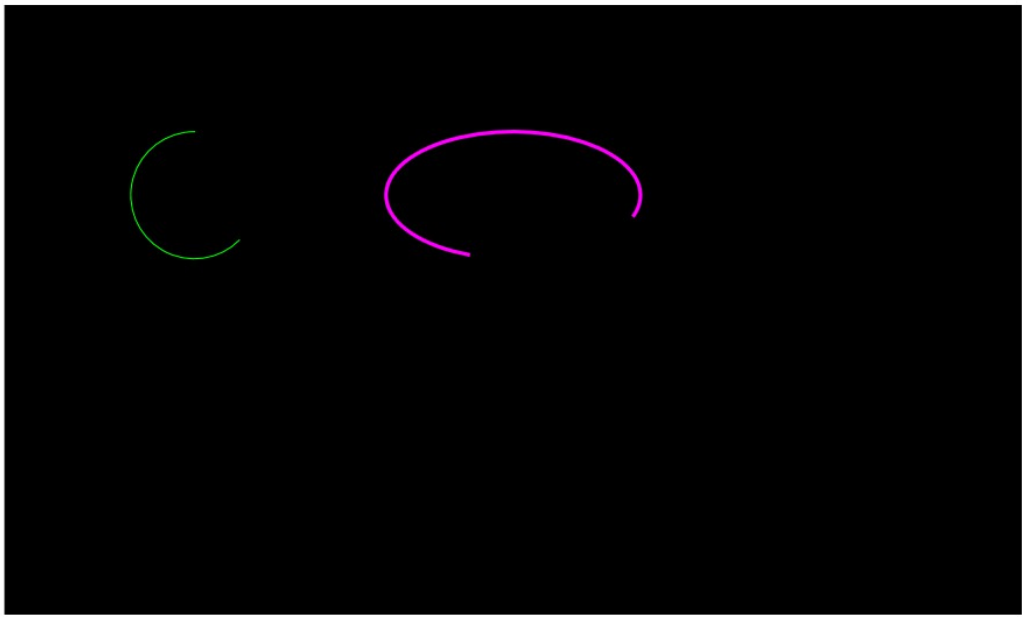
Arguments

Argument	Type	Description
width	Real Number	The width of the line in pixels

Example

This example draws a green circular arc with a stroke width of 1.0, and fuchsia elliptical arc with a stroke width of 3.0.

```
# Clear the active layer
Clear

# Draw green circular arc with a stroke width of 1.0
LineWidth 1.0
Color 00FF00

# Width omitted for circular arc
DrawArc 100 100 50 45.0 235.0

# Draw fuchsia elliptical arc with a stroke width of 3.0
LineWidth 3.0
Color FF00FF
DrawArc 300 100 100 50 110 270
```



LinearGradient (Hexadecimal 23)

Syntax

```
LinearGradient startX startY startColor endX endY endColor
```

Description

Sets the color pattern used to draw and fill shapes in subsequent commands. *startColor* blends with *endColor* starting at *startX*,*startY* and finishing at *endX*,*endY*.

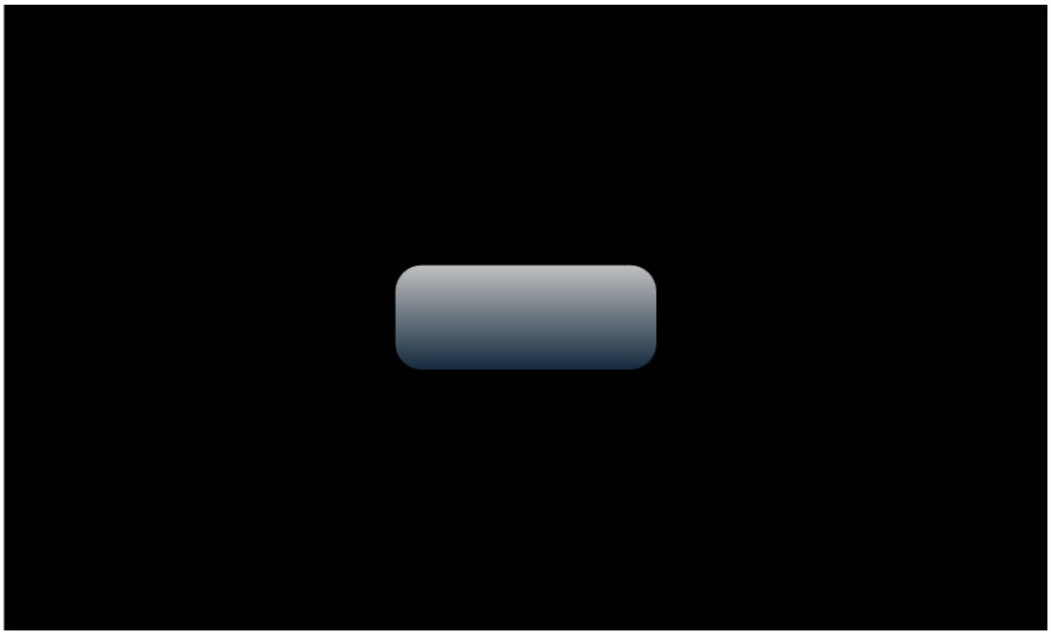
Arguments

Argument	Type	Description
startX	Real Number	The X-Coordinate of the point at which to start the gradient.
startY	Real Number	The Y-Coordinate of the point at which to start the gradient.
startColor	Color	The color to use at the start of the gradient
endX	Real Number	The X-Coordinate of the point at which to end the gradient.
endY	Real Number	The Y-Coordinate of the point at which to end the gradient.
endColor	Color	The color to use at the end of the gradient

Example

This example draws a rounded rectangle with a linear gradient fill starting with light-gray to navy blue.

```
# Clear the active layer
Clear

# Draw a rounded rectangle with a linear gradient fill
LinearGradient 400 200 C0C0C0 400 280 336699
FillRoundedRectangle 300 200 200 80 20
```



LoadFont (Hexadecimal 24)

Syntax

```
LoadFont filePath [cacheInMemory]
```

Description

Selects the active font to be used by all subsequent DrawText and FillText commands from a TrueType font file on the SD card. The *cacheInMemory* argument can be used to optionally load the font into memory so every time text is displayed it does not need to read the font data from disk. Caching the font in memory will improve performance when displaying text, but could consume too much memory, causing memory errors, if the font is too large.

To revert back to the default font use the UnloadFont command.

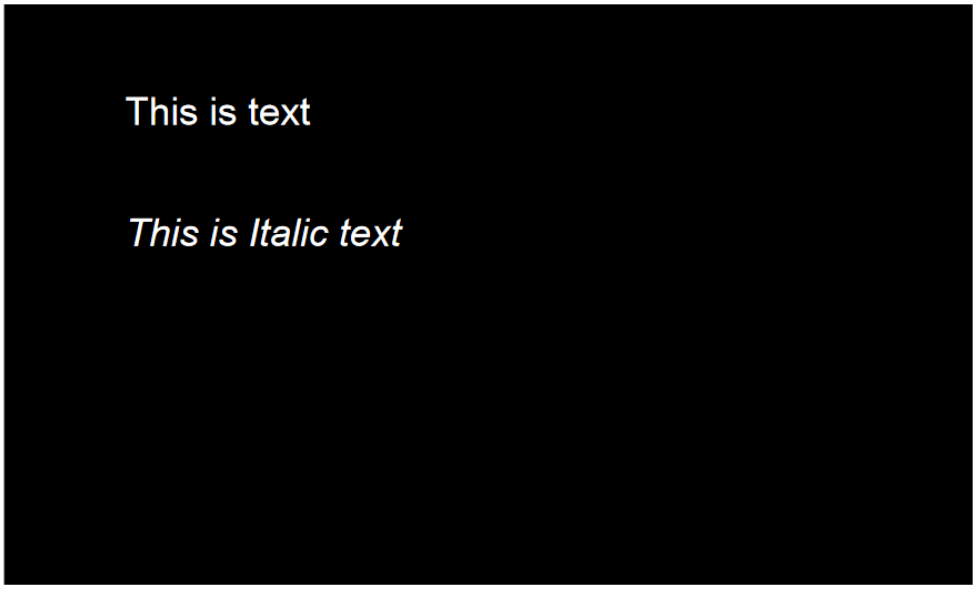
Arguments

Argument	Type	Description
filePath	Text	Path to the TrueType font file on the SD Card
cacheInMemory	UInt8	0 - (default) Font will be streamed from disk. Non-zero - Font will be loaded into memory.

Example

This example draws “This is text” at 100 100 in a normal typeface (font.ttf) and “This is Italic text” in an italic typeface (fonti.ttf).

```
# Clear the active layer
Clear

# Display font in white
Color FFFFFF

#Load Font (stream from disk)
LoadFont "/font.ttf"
FillText 100 100 "This is text"

#Load Font (cache in memory)
LoadFont "/fonti.ttf" 1
Fillext 100 200 "This is Italic text"
```



MoveLayer (Hexadecimal 25)

Syntax

```
MoveLayer topLeftX topLeftY
```

Description

Repositions the active layer. The background layer cannot be repositioned, and will return an Invalid Argument status code if this command is executed while the active layer is the background layer.

Arguments

Argument	Type	Description
topLeftX	Int16	The X-coordinate of the active layer's new top left corner.
topLeftY	Int16	The Y-coordinate of the active layer's new top left corner.

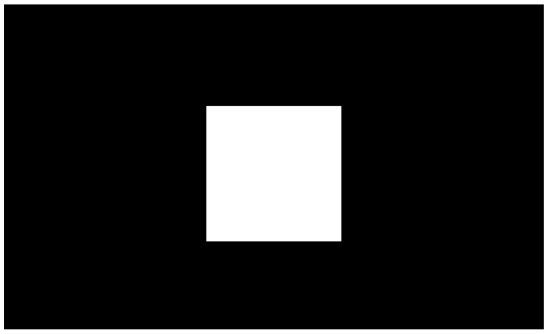
Example

This example moves layer 1 from (100, 100) to (150, 150).

```
# Clear the active layer
Clear

# Create layer 1 at (100, 100)
CreateLayer 100 100 200 200 1

# Change the active layer to layer 1
Layer 1

# Fill a rectangle that covers the entire layer
FillRectangle 0 0 200 200

# Move the entire layer to (300, 150)
MoveLayer 300 150
```

After the *FillRectangle* command:

After the *MoveLayer* command:



MoveTo (Hexadecimal 26)

Syntax

```
MoveTo x y
```

Description

When drawing a path, moves the current point to x,y to begin drawing.

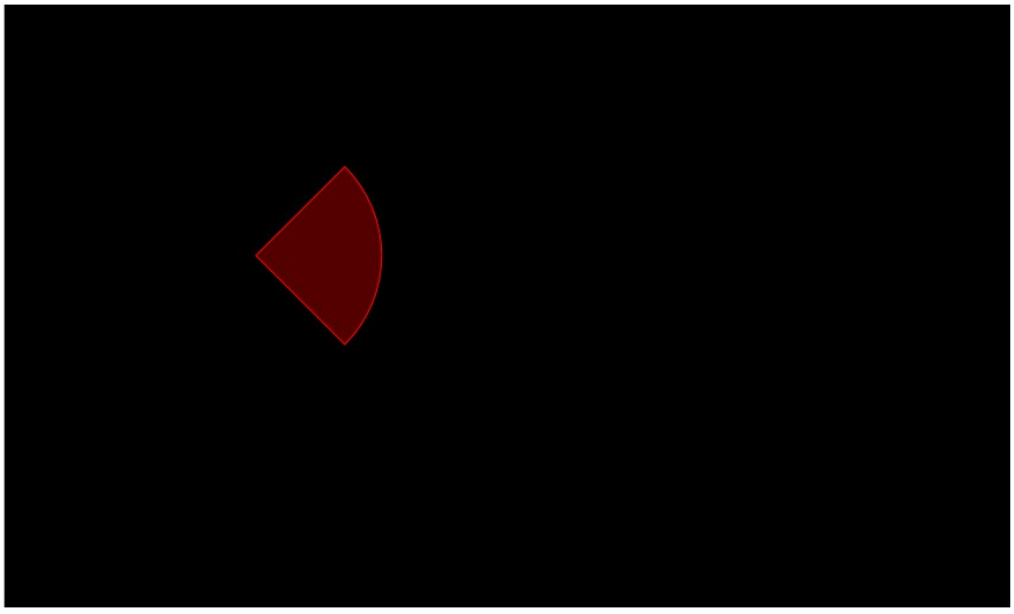
Arguments

Argument	Type	Description
x	Real Number	The X-Coordinate of the point to move to
y	Real Number	The Y-Coordinate of the point to move to

Example

This example demonstrates using to MoveTo draw a fraction of a pie chart centered at (200, 200).

```
# Clear the active layer
Clear

# Create a fraction of a pie
MoveTo 200 200
LineTo 270.7 129.29
ArcTo 270.7 270.7 100 100 0 0 1
ClosePath

# Fill the pie with partially transparent red
Color AAFF0000
FillPath

# Draw a border around the pie in bright red
LineWidth 1
Color FF0000
DrawPath
```



Ping (Hexadecimal 27)

Syntax

```
Ping
```

Description

Responds with an acknowledgment. Use this command for testing communication.

RadialGradient (Hexadecimal 28)

Syntax

```
RadialGradient startX startY startColor radius endColor
```

Description

Sets the color pattern used to draw and fill shapes in subsequent commands to a radial gradient. *startColor* blends with *endColor* outward radially starting at *startX*,*startY* for a distance of *radius*.

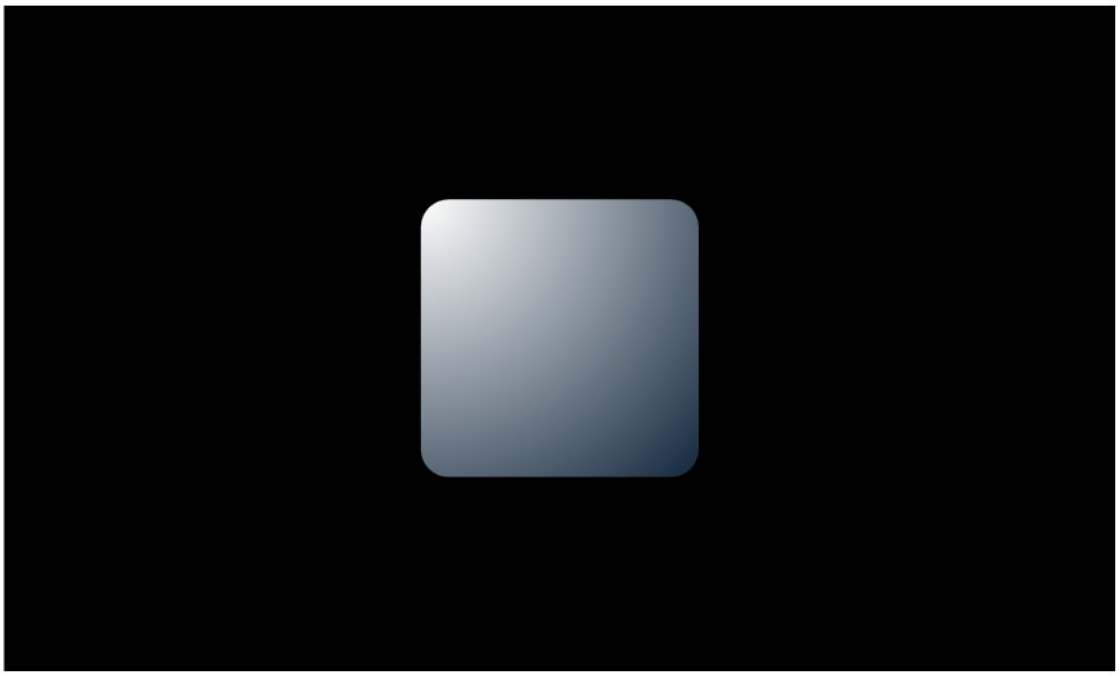
Arguments

Argument	Type	Description
startX	Real Number	The X-Coordinate of the point at which to start the gradient.
startY	Real Number	The Y-Coordinate of the point at which to start the gradient.
startColor	Color	The color to use at the start of the gradient
radius	Real Number	The radius of the gradient from *startX*,*startY*
endColor	Color	The color to use at the end of the gradient

Example

This example draws a rounded rectangle with a radial gradient fill starting with light-gray to navy blue.

```
# Clear the active layer
Clear

# Draw a rounded rectangle with a radial gradient fill
RadialGradient 300 140 C0C0C0 280 336699
FillRoundedRectangle 300 140 200 20 20
```



RunScript (Hexadecimal 29)

Syntax

```
RunScript filePath
```

Description

Reads a script file from the SD card and executes each command, in order, line-by-line. Using RunScript within a script file is not supported.

- Lines preceded by a '#' character are ignored and can be used to add comments to a script file.
- The script file should be encoded as UTF-8.
- This command is acknowledged only after all commands have executed.

Arguments

Argument	Type	Description
filePath	Text	Path to the script file on the SD Card

Example

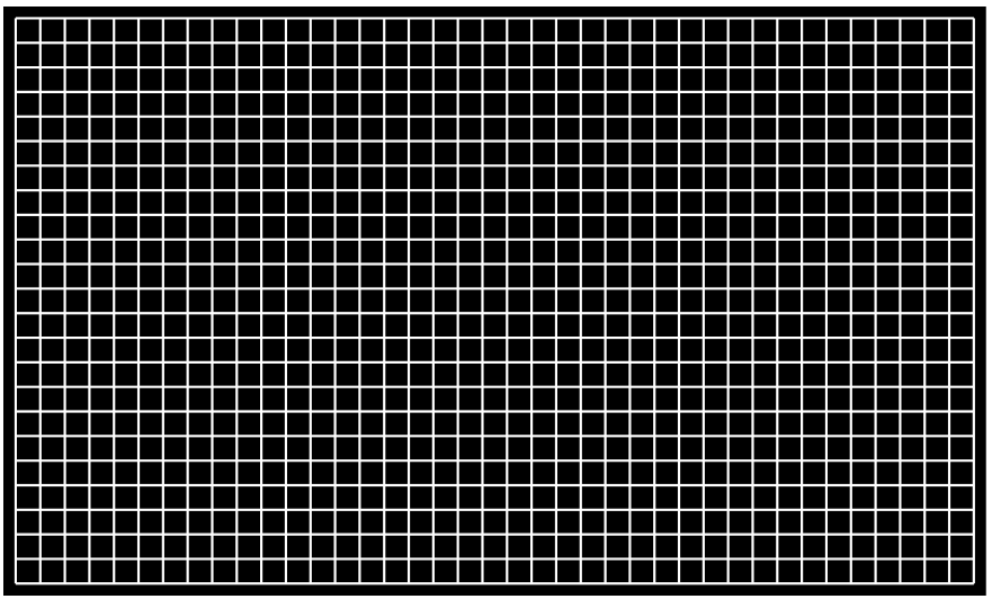
Assuming the following script is stored as "Grid.txt" in a folder called "Scripts" (e.g. "/Scripts/Grid.txt") …

```
# Clear the active layer
Clear

# Don't draw anything until all commands have executed
DisableFlush

# Set line width
LineWidth 2.0

# White lines
Color FFFFFF

# Vertical lines
DrawLine 10 10 10 470
DrawLine 30 10 30 470
DrawLine 50 10 50 470
DrawLine 70 10 70 470
DrawLine 90 10 90 470
DrawLine 110 10 110 470
DrawLine 130 10 130 470
DrawLine 150 10 150 470
DrawLine 170 10 170 470
DrawLine 190 10 190 470
DrawLine 210 10 210 470
DrawLine 230 10 230 470
DrawLine 250 10 250 470
DrawLine 270 10 270 470
DrawLine 290 10 290 470
DrawLine 310 10 310 470
DrawLine 330 10 330 470
DrawLine 350 10 350 470
DrawLine 370 10 370 470
DrawLine 390 10 390 470
DrawLine 410 10 410 470
DrawLine 430 10 430 470
DrawLine 450 10 450 470
DrawLine 470 10 470 470
DrawLine 490 10 490 470
DrawLine 510 10 510 470
DrawLine 530 10 530 470
DrawLine 550 10 550 470
DrawLine 570 10 570 470
```

```
DrawLine 590 10 590 470
DrawLine 610 10 610 470
DrawLine 630 10 630 470
DrawLine 650 10 650 470
DrawLine 670 10 670 470
DrawLine 690 10 690 470
DrawLine 710 10 710 470
DrawLine 730 10 730 470
DrawLine 750 10 750 470
DrawLine 770 10 770 470
DrawLine 790 10 790 470

# Horizontal lines
DrawLine 10 10 790 10
DrawLine 10 30 790 30
DrawLine 10 50 790 50
DrawLine 10 70 790 70
DrawLine 10 90 790 90
DrawLine 10 110 790 110
DrawLine 10 130 790 130
DrawLine 10 150 790 150
DrawLine 10 170 790 170
DrawLine 10 190 790 190
DrawLine 10 210 790 210
DrawLine 10 230 790 230
DrawLine 10 250 790 250
DrawLine 10 270 790 270
DrawLine 10 290 790 290
DrawLine 10 310 790 310
DrawLine 10 330 790 330
DrawLine 10 350 790 350
DrawLine 10 370 790 370
DrawLine 10 390 790 390
DrawLine 10 410 790 410
DrawLine 10 430 790 430
DrawLine 10 450 790 450
DrawLine 10 470 790 470

# Display the result
EnableFlush
```

… then the following command will execute that script and draw the grid as shown below.

```
RunScript "/Scripts/Grid.txt"
```



Reset (Hexadecimal 2A)

Syntax

```
Reset
```

Description

Initiates a software reset, causing the M Display to restart.

SetPixel (Hexadecimal 2C)

Syntax

```
SetPixel x y color0 [color1 ... colorn]
```

Description

Plots pixels to the active layer in contiguous horizontal line starting at (*x*, *y*). By sending a sequence of SetPixel commands images and other graphics can be plotted pixel-by-pixel.

Arguments

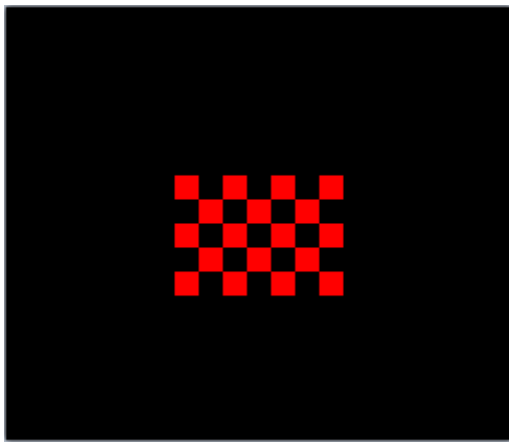
Argument	Type	Description
x	Int16	X-Coordinate of the starting point
y	Int16	Y-Coordinate of the starting point
color0 …colorn	Color	A list of colors to be displayed in horizontal succession (*color0* at x,y to *colorn* at x+n,y).

Example

This example draws a small checkerboard pattern in the upper left quadrant of the screen.

```
# Clear the active layer
Clear

# First row. Even pixels red.
SetPixel 100 100 FF0000 000000 FF0000 000000 FF0000 000000 FF0000

# Second row. Odd pixels red.
SetPixel 101 100 FF0000 000000 FF0000 000000 FF0000

# Third row. Even pixels red.
SetPixel 100 100 FF0000 000000 FF0000 000000 FF0000 000000 FF0000

# Fourth row. Odd pixels red.
SetPixel 101 100 FF0000 000000 FF0000 000000 FF0000

# Fifth row. Even pixels red.
SetPixel 100 100 FF0000 000000 FF0000 000000 FF0000 000000 FF0000
```

Zoomed in 1200%:



UnloadFont (Hexadecimal 2D)

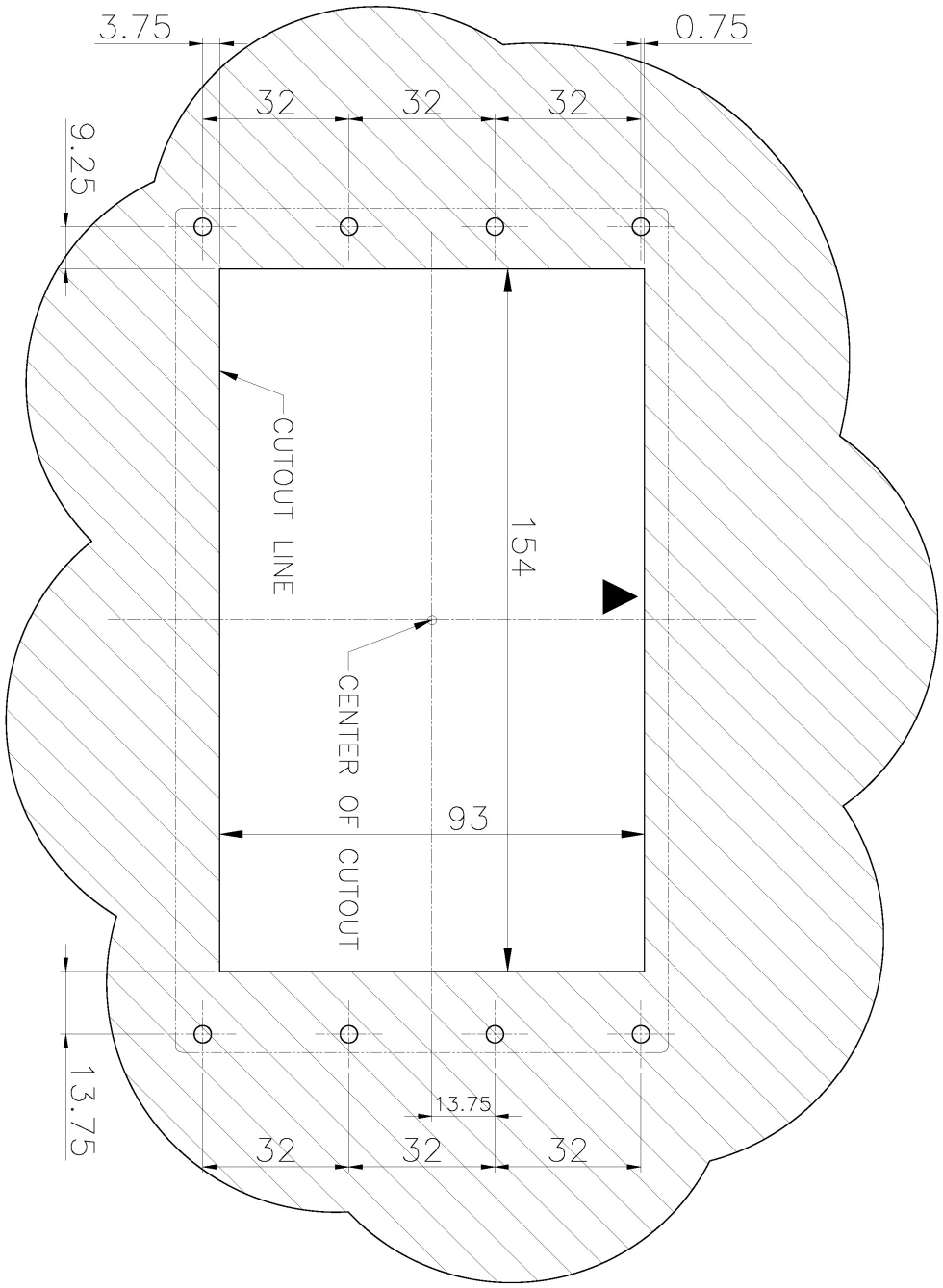
Syntax

```
UnloadFont
```

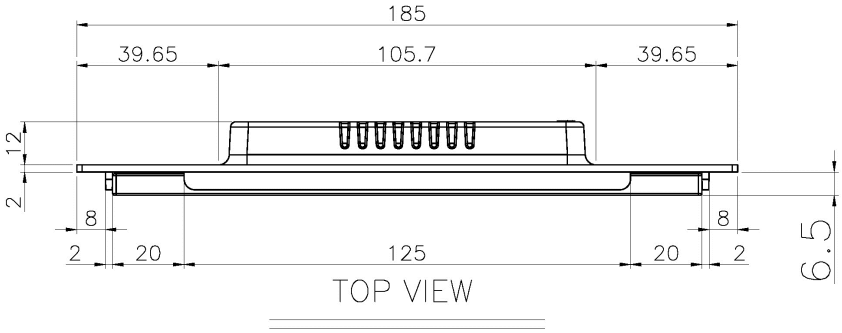
Description

Unloads the active font, reverting to the default font.

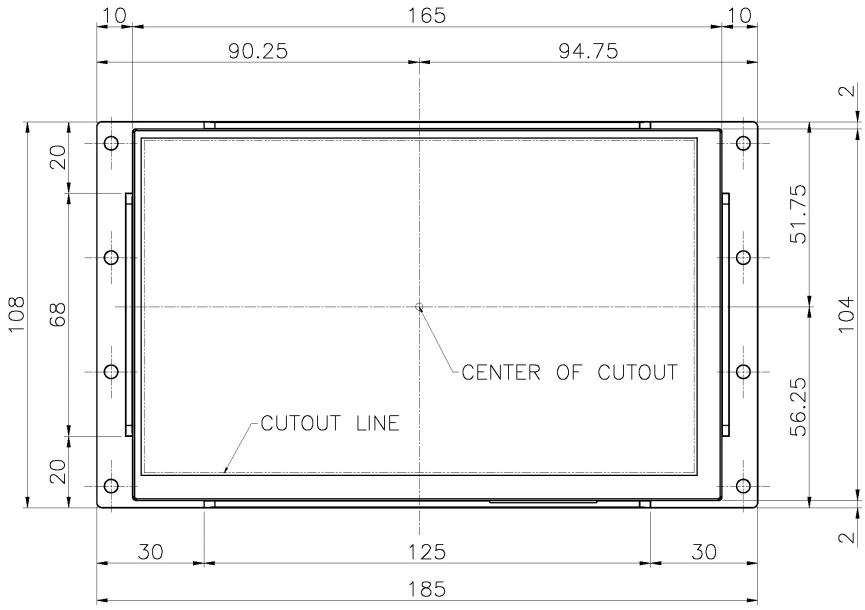
Dimensions



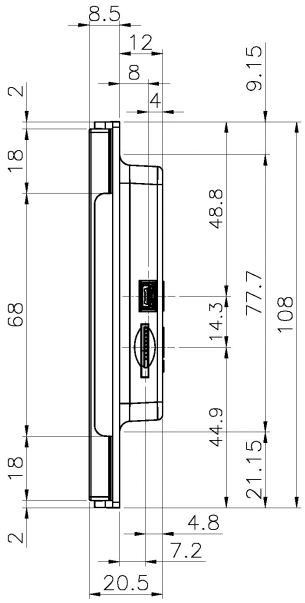
MDP070N PANEL CUTOUT – FRONT VIEW



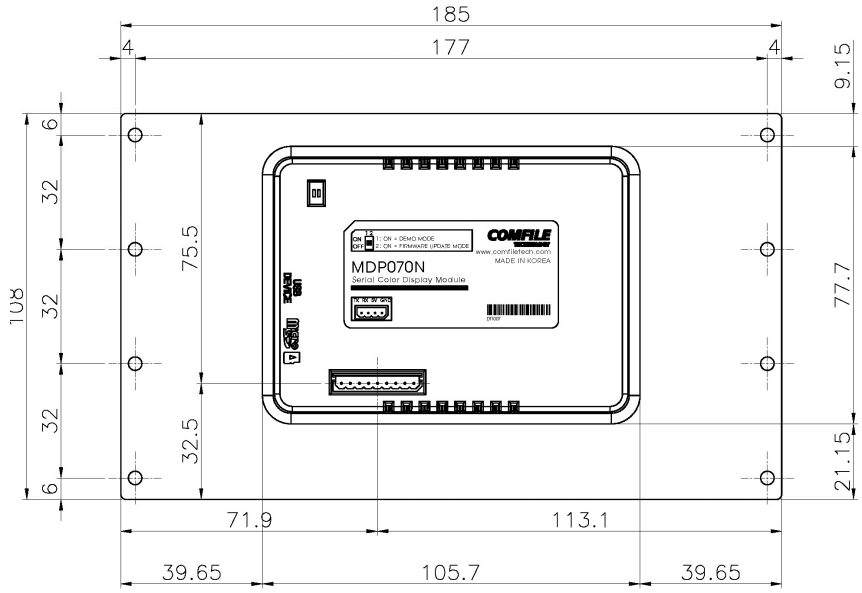
TOP VIEW



FRONT VIEW



SIDE VIEW



BACK VIEW

Unit: mm

MDP070N OUTLINE DIMENSIONS

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