Micromite Plus Manual

MMBasic Ver 5.05.05

For updates to this manual and more details on MMBasic
go to http://geoffg.net/micromite.html

or http://mmbasic.com

The Micromite Plus is part of the Micromite family. The firmware runs on 64 and 100-pin PIC32 microcontrollers and implements all the features of the standard Micromite as described in the Micromite User Manual. It also has many additional features and they are described in this document.

The focus of this manual is to describe just the features that are **unique** to the Micromite Plus. For general Micromite programming you should refer to the Micromite User Manual in addition to this manual.

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Contributions

A very big thanks to Peter Mather (matherp) for his ongoing support including originally porting MMBasic to the MX470 (which became the Micromite Plus), introducing low cost LCD panels, writing the ILI9341 and ST7735S drivers, porting the M-Stack USB/CDC and FatFs drivers, pushing the implementation of CFunctions to new heights and the uncountable number of bugs that he has found and documented. Thank you very much Peter.

Also thanks to Phil Boyce (WhiteWizard) for his ongoing enthusiastic support and to the members of the Back Shed forum who have beta tested the Micromite firmware over the past few years and reported many, many bugs. Thanks guys.

Introduction

This section provides an introduction for users who are familiar with the Micromite and need a summary of the extra features in the Micromite Plus.

The Micromite Plus is an extension of the standard Micromite; all features of the standard Micromite are also supported in the Micromite Plus. This includes features of the BASIC language, input/output, communications, etc. Some commands have changed slightly (for example the CPU command) but for the main part Micromite programs will run unchanged on the Micromite Plus.

The following summarises the new features in the Micromite Plus as compared to the standard Micromite:

MX470 Processor

The Micromite Plus is based on the Microchip PIC32MX470 32 bit microcontroller. This chip is available in 64 and 100-pin surface mount packages and is two to three times faster than the MX170 chip used in the standard Micromite. In BASIC the space available for both programs and variables is doubled to approx 100 KB flash and 100 KB RAM.

The Micromite Plus uses a crystal for timekeeping. This allows the Micromite Plus to support USB communications and also ensures that its internal clocks are much more accurate.

I/O Pins

The 64-pin Micromite Plus has up to 45 free I/O pins and the 100-pin chip 77. Of these 28 pins (on either chip) can be analog inputs.

The Micromite Plus has two SPI ports and up to four serial COM ports. All serial COM ports are high speed (over 1,000,000 baud). The provision of two SPI ports means that one can be used for SPI LCD's, touch and SD card interfaces leaving the other entirely free for use in a BASIC program. If the SPI is not used for these features then both SPI interfaces can be used in BASIC programs.

USB

The Micromite Plus has a built in USB 2.0 interface which will work at all CPU frequencies at 20MHz or more. The USB is integrated in the chip and no other hardware or components are required. MMBasic uses the USB CDC protocol which allows the USB interface to be used as the console with a host computer running a terminal emulator such as Tera Term.

The USB console operates in parallel with the serial console, anything received from either of the inputs is placed in the input queue for the interpreter or the program to read and anything outputted by the program or interpreter will be sent to either devices.

The USB feature is optional, if nothing is connected to the USB interface MMBasic will ignore it.

SD Card

The Micromite Plus includes full support for SD cards. This includes opening files for reading, writing or random access and loading and saving programs. The firmware will work with cards up to 64GB formatted in FAT16 or FAT32 and the files created can also be read and written on personal computers running Windows, Linux or the Mac operating system.

Up to 10 files can be open simultaneously. Using the OPEN command files can be opened and read from using INPUT, LINE INPUT, or INPUT$() or written to using PRINT or WRITE with. A program can be saved using the SAVE command and reloaded or run using LOAD. Programs and files stored on the card can be listed with the FILES command and deleted using the KILL command. The current working directory can be changed using CHDIR and a new directory be created with MKDIR.

The LOAD IMAGE command can be used to load a bitmap image from the SD card and display it on an attached LCD display panel. This can be used to draw a logo or add a background on the display.

The SD card feature is entirely optional and MMBasic will operate normally if it is not used.

LCD Display Panels

Micromite Plus supports two additional LCD panels that use SPI controllers (the ST7735 and ILI9163) and also parallel LCD displays that use the SSD1963 controller.

SSD1963 based LCD panels are available in sizes from 4.3 inch to 9 inch for prices that range from US$30 to US$60 on eBay. They use a parallel interface so the Micromite Plus can transfer data much faster than via SPI resulting in a very quick screen update. These displays are also much larger, have more pixels and are brighter. MMBasic will drive them using 24-bit true colour for a full colour rendition (16 million colours).

All LCD panels that use the SSD1963 controller have a SD card socket and touch sensitive screen, both of which are fully supported by MMBasic on the Micromite Plus.

The LCD display panel feature is entirely optional and if not configured MMBasic will operate normally.

Additional LCD Panel Features

The Micromite Plus includes six fonts that are built in and provides for up to ten additional fonts that can be embedded in the program. It also provides a set of read only variables to return the coordinates of the next print position on the screen.

An optional PWM (Pulse Width Modulated) output is available for controlling the brightness of the LCD backlight. In addition the Micromite Plus will work with SSD1963 based LCD panels that are configured to use their controller to control the backlight.

Touch Input

The Micromite Plus extends the standard Micromite touch sensitive features with two new capabilities:

- Functions to detect if the touch is down or up, to return reference of the control currently being touched (see "Advanced Graphics" below) and also the last position or control touched.
- The ability to drive a connected Piezo buzzer to produce a click when a screen control is touched.

Advanced Graphics

The Micromite Plus incorporates a suite of advanced graphic controls that respond to touch, these include on screen switches, buttons, indicator lights, keyboard, etc. MMBasic will draw the control and animate it (ie, a switch will depress when touched). All that the BASIC program needs to do is invoke a single line command to specify the basic details of the control.

Using these advanced graphic controls it is easy to create a sophisticated control panel that includes WISWIG screen elements that are familiar to uses of modern computers (eg, check boxes, radio buttons, etc). A Micromite Plus using these controls could be used to create a professional control panel for anything from industrial machinery to a simple reticulation controller.

With some LCD displays the Micromite Plus supports transparent text (ie, the background image shows through the gaps in the text) and the BLIT command. The latter allows the background image to be saved and then restored allowing moving objects to be displayed over a background image.

Console Input/Output

You can attach a PS2 keyboard to the Micromite Plus and, if you are using a SSD1963 based LCD panel, display the output of the interpreter in the LCD. This turns the Micromite Plus into a completely self contained computer with its own keyboard, display and SD card for storage. Using the built in colour coded editor programs can be entered, edited and run without requiring another computer.

The keyboard interface supports the standard USA keyboard layout or special United Kingdom, French, German, Belgium, Italian or Spanish layouts.

Sound Output

Using the Micromite Plus you can play stereo WAV files stored on the SD card. You can also generate precise sine waves with selectable frequencies from 1Hz to 20KHz.

Miscellaneous

Other features of the Micromite Plus include:

- The ability to disable the serial console if it is not required. This allows the two I/O pins previously used by the console to be used as general I/O pins or as a fourth serial port (COM4:).
- The CPU command can vary the processor speed from 5 MHz to 120 MHz. The CPU command can also put the processor to sleep.
- The ability to specify the I/O pins used for connecting to a real time clock. When this option is specified MMBasic will automatically get the correct time on power up.

Micromite Family Summary

	Micromite		**Micromite Plus**	
	28-pin Thru Hole and SMD	44-pin Surface Mount	64-pin Surface Mount	100-pin Surface Mount
Maximum CPU Speed	48 MHz	48 MHz	120 MHz	120 MHz
Maximum BASIC Program Size	59 KB	59 KB	100 KB	100 KB
RAM Memory Size (used for variables, buffers, etc)	52 KB	52 KB	97 KB	97 KB
Clock Speed (MHz)	5 to 48	5 to 48	5 to 120	5 to 120
Serial Console for Programming and Control	✓	✓	✓	✓
Floating Point Resolution	Single	Single	Double	Double
USB Console (serial emulator over USB 2.0)			✓	✓
PS2 Keyboard and LCD Display Console			✓	✓
SD Card Interface (FAT16 or FAT32 up to 64GB)			✓	✓
Total Number of I/O pins	19	33	45	77
Number of Analog Inputs	10	13	28	28
Number of Serial I/O ports	2	2	3 or 4	3 or 4
Number of SPI Channels	1	1	2	2
Number of I^{2}C Channels	1	1	1 + RTC	1 + RTC
Maximum Number of 1-Wire I/O pins	19	33	45	77
Number of PWM or Servo Channels	5	5	5	5
Supports 2.2", 2.4" and 2.8" SPI LCD Displays	✓	✓	✓	✓
Supports twelve LCD Displays from 1.4" to 9"			✓	✓
Supports Resistive Touch Panels	✓	✓	✓	✓
Power Requirements	3.3V 30 mA	3.3V 30 mA	3.3V 80 mA	3.3V 80 mA

Suitable Microcontrollers

The microcontroller used in the Micromite Plus is available in two different frequency specifications (100MHz and 120MHz). The Micromite Plus will start up at 100MHz and if you have a 120MHz chip you can use the CPU command to step up to 120MHz. See http://microchip.com for the data sheets.

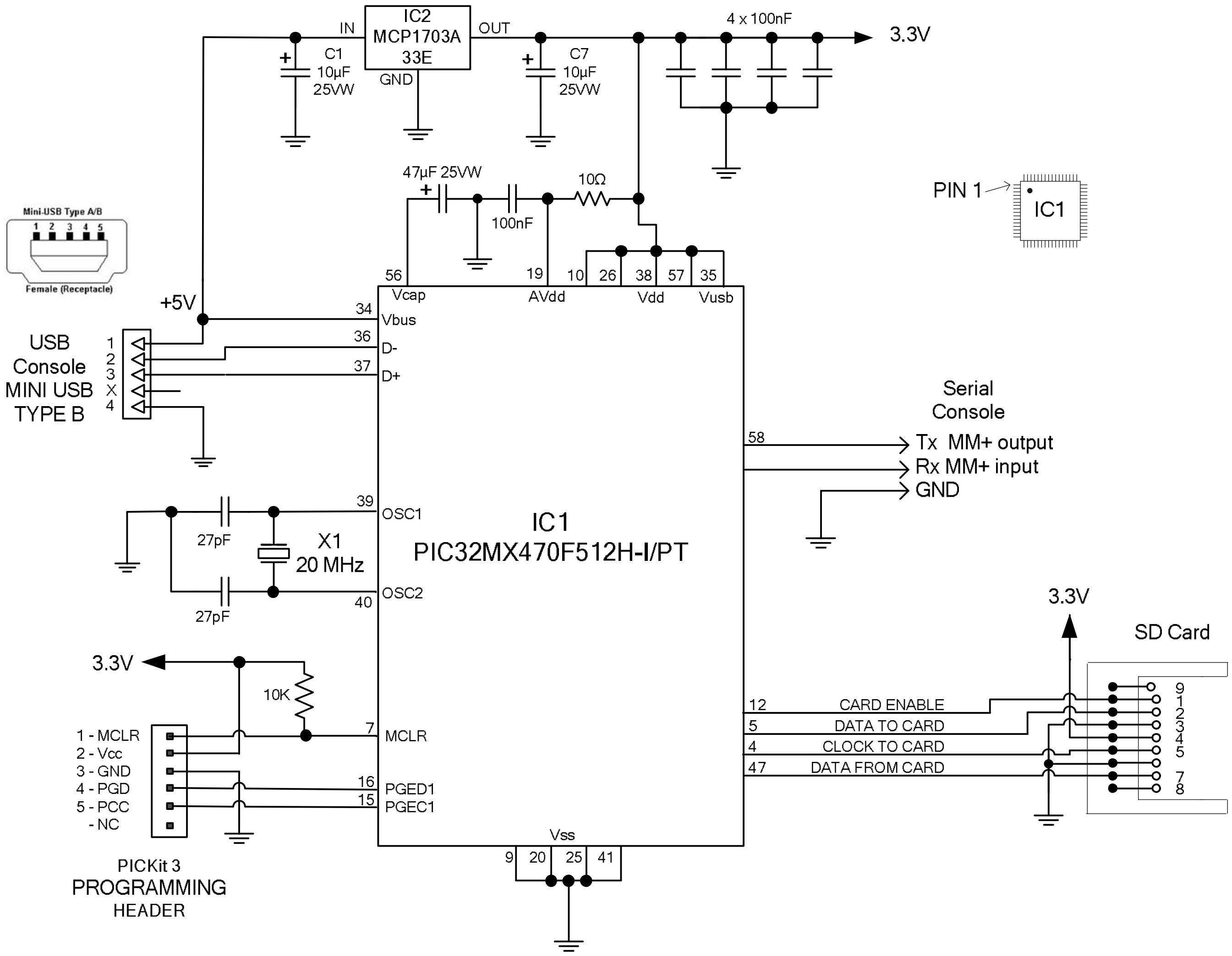
The recommended chips are:

PIC32MX470F512H-I/PT	64-pin TQFP package – maximum speed 100 MHz
PIC32MX470F512H-120/PT	64-pin TQFP package – maximum speed 120 MHz
PIC32MX470F512L-I/PF	100-pin TQFP package – maximum speed 100 MHz
PIC32MX470F512L-120/PF	100-pin TQFP package – maximum speed 120 MHz

All these chips are in a TQFP surface mount package with a lead pitch of 0.5 mm. They are reasonably easy to solder and can be mounted on a carrier board (for example futurlec.com part code 64PINTQFP) or the Explore64 which is a breadboard compatible PCB or the Explore100 which is designed to mate with a 5" display (see http://geoffg.net/micromite.html for examples).

Typical Circuit

Note that the pin numbers refer to the 64-pin chip. For the 100-pin chip refer to the table in the next section.



Note that the only required components are:

- The capacitor on pin 56 (Vcap). This must be a tantalum (47 µF) or multilayer ceramic (10 µF) type.
- The 20 MHz crystal and its two 27pF load capacitors.
- The 10 KΩ pullup resistor on pin 7 (MCLR).

Micromite Plus Connections

The tick column ANA means ANALOG, DIG means digital I/O and 5V means a 5 V tolerant pin. Pins marked SSD1963 xxx are required for a SSD1963 based display - see the "SSD1963 Based LCD Displays" section for more details. Otherwise the notation is similar as described for the 28-pin version.

64-pin Micromite Plus

		ANA	DIG	5V	5V	DIG	ANA		
DIGITAL INPUT ONLY	33		✓	✓	✓	✓		32	PWM 2B
USB +5V	*34*				✓	✓		31	
POWER (+2.3 to +3.6V)	*35*					✓	✓	30	
USB D-	*36*					✓	✓	29	COM1: ENABLE
USB D+	*37*					✓	✓	28	SSD1963 RESET
POWER (+2.3 to +3.6V)	*38*					✓	✓	27	SSD1963 RS (data/command)
20MHz CRYSTAL)	*39*							*26*	*POWER (+2.3 to +3.6V)*
20MHz CRYSTAL)	*40*							*25*	*GROUND*
GROUND	*41*					✓	✓	24	SSD1963 WR
PWM 1B	42		✓	✓		✓	✓	23	COUNT
I^{2}C DATA	43		✓	✓		✓	✓	22	
I^{2}C CLOCK	44		✓	✓		✓	✓	21	
SPI 1 IN (MISO)	45		✓	✓				*20*	*ANALOG GROUND*
	46		✓	✓				*19*	*ANALOG POWER (+2.3 to +3.6V)*
SPI 2 IN (MISO)	47		✓			✓	✓	18	
PWM 1A	48		✓			✓	✓	17	COM3: Rx
COUNT	49	✓	✓			✓	✓	16	COM3: Tx
SPI 1 CLOCK	50	✓	✓			✓	✓	15	COM1: Tx
COUNT | WAKEUP | IR	51	✓	✓			✓	✓	14	
COUNT	52		✓	✓		✓	✓	13	COM2: Rx
PWM 2A	53		✓	✓		✓	✓	12	
KEYBOARD CLOCK	54		✓	✓		✓	✓	11	COM2: Tx
KEYBOARD DATA	55		✓	✓				*10*	*POWER (+2.3 to +3.6V)*
47µF TANT CAPACITOR (+)	*56*							*9*	*GROUND*
POWER (+2.3 to +3.6V)	*57*					✓	✓	8	SPI 1 OUT (MOSI)
COM4: Tx | CONSOLE Tx (OUT)	58		✓	✓				*7*	*RESET Normally 10KΩ to V+*
COM1: Rx	59		✓	✓		✓	✓	6	CONSOLE Rx (IN) | COM4: Rx
SSD1963 D0	60		✓	✓		✓	✓	5	SPI 2 OUT (MOSI) |
SSD1963 D1	61		✓	✓		✓	✓	4	SPI 2 CLOCK
SSD1963 D2	62	✓	✓			✓	✓	3	SSD1963 D7
PWM 1C | SSD1963 D3	63		✓	✓		✓	✓	2	SSD1963 D6
SSD1963 D4	64	✓	✓			✓	✓	1	SSD1963 D5

100-pin Micromite Plus

		ANA	DIG	5V	5V	DIG	ANA		
DIGITAL INPUT ONLY	51		✓	✓	✓	✓		50	
	52		✓	✓	✓	✓		49	
	53		✓	✓	✓	✓		48	
USB +5V	*54*			✓	✓	✓		47	
POWER (+2.3 to +3.6V)	*55*							*46*	*POWER (+2.3 to +3.6V)*
USB D-	*56*							*45*	*GROUND*
USB D+	*57*					✓	✓	44	
	58		✓	✓		✓	✓	43	COM1: ENABLE
	59		✓	✓		✓	✓	42	SSD1963 RESET
	60		✓	✓		✓	✓	41	
	61		✓	✓	✓	✓		40	
POWER (+2.3 to +3.6V)	*62*				✓	✓		39	
20MHz CRYSTAL)	*63*				✓	✓		38	
20MHz CRYSTAL)	*64*							*37*	*POWER (+2.3 to +3.6V)*
GROUND	*65*							*36*	*GROUND*
I^{2}C CLOCK	66		✓	✓		✓	✓	35	
I^{2}C DATA	67		✓	✓		✓	✓	34	COUNT
PWM 1B	68		✓	✓		✓	✓	33	
	69		✓	✓		✓	✓	32	
SPI 1 CLOCK	70		✓	✓				*31*	*ANALOG GROUND*
SPI 1 IN (MISO)	71		✓	✓				*30*	*ANALOG POWER (+2.3 to +3.6V)*
SPI 1 OUT (MOSI)	72		✓	✓		✓		29	
	73		✓			✓		28	
PWM 1A	74		✓			✓	✓	27	
GROUND	*75*					✓	✓	26	COM3: Rx
COUNT	76	✓	✓			✓	✓	25	COM3: Tx
	77	✓	✓			✓	✓	24	COM1: Tx
COUNT | WAKEUP | IR	78	✓	✓			✓	✓	23	
PWM 1C	79		✓	✓		✓	✓	22	COM2: Rx
	80		✓	✓		✓	✓	21	
COUNT	81		✓	✓		✓	✓	20	COM2: Tx
PWM 2A	82		✓	✓	✓	✓		19	SSD1963 WR
KEYBOARD CLOCK	83		✓	✓	✓	✓		18	SSD1963 RS (data/command)
KEYBOARD DATA	84		✓	✓	✓	✓		17	
47µF TANT CAPACITOR (+)	*85*							*16*	*POWER (+2.3 to +3.6V)*
POWER (+2.3 to +3.6V)	*86*							*15*	*GROUND*
COM4: Tx | CONSOLE Tx (OUT)	87		✓	✓		✓	✓	14	
COM1: Rx	88		✓	✓	✓			*13*	*RESET Normally 10KΩ to V+*
COM4: Rx | CONSOLE Rx (IN)	89		✓	✓		✓	✓	12	SPI 2 OUT (MOSI)
	90		✓	✓		✓	✓	11	SPI 2 IN (MISO)
	91		✓	✓		✓	✓	10	SPI 2 CLOCK
	92		✓	✓	✓	✓		9	PWM 2B
SSD1963 D0	93		✓	✓	✓	✓		8	
SSD1963 D1	94		✓	✓	✓	✓		7	
	95		✓	✓	✓	✓		6	
	96		✓	✓		✓	✓	5	SSD1963 D7
	97		✓	✓		✓	✓	4	SSD1963 D6
SSD1963 D2	98	✓	✓			✓	✓	3	SSD1963 D5
SSD1963 D3	99		✓	✓				*2*	*POWER (+2.3 to +3.6V)*
SSD1963 D4	100	✓	✓		✓	✓		1	

Programming the Firmware

Programming the 64 and 100-pin Micromite Plus is similar to programming the 28-pin standard Micromite described in the Micromite User Manual.

Refer to the following table for the pin connections to a PICkit 3 programmer:

PICkit 3 Pins	Description	64-pin Micromite Plus Pin Numbers	100-pin Micromite Plus Pin Numbers
	47µF Tantalum Capacitor to GND	56	85
1 - MCLR	Master Reset (active low)	7	13
2 - Vcc	Power Supply (3.3V)	10, 19, 26, 35, 38, and 57	2, 16, 30, 37, 46, 55, 62 and 86
3 - GND	Ground	9, 20, 25 and 41	15, 31, 36, 45, 65 and 75
4- PGD	Programming Data	16	25
5 - PGC	Programming Clock	15	24
6 - NC	Not used		

Notes:

- A pullup resistor of 10 K is required between the MCLR pin and Vcc.
- A crystal is not required to program these chips and will be ignored if it is present.
- The microcontroller being programmed can be powered by the PICkit 3 but it is recommended that a separate power supply be used. When the PICkit 3 supplies the power pin 2 (Vcc) on the PICkit 3 will become an output supplying the power to the chip being programmed.

SPI Based LCD Displays

The Micromite Plus includes support for three types of colour LCD display panels using a SPI interface. These are the:

- Standard 2.2”, 2.4" and 2.8” 240x320 pixel display with an ILI9341 controller as described in the Micromite User Manual.
- A 1.8" 128 x160 pixel display with a ST7735 controller
- A 1.44" 128 x128 pixel display using the ILI9163 controller.

On eBay you can find suitable displays by searching for the controller name (ILI9341, ST7735 or ILI9163).

ILI9341 Based Displays

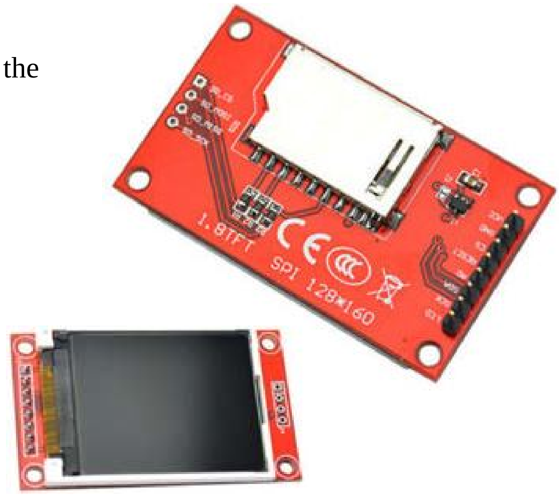
The ILI9341 based displays are illustrated on the right.

They use an SPI interface and have the following basic specifications:

- A 2.2, 2.4 or 2.8 inch display
- Resolution of 240 x 320 pixels and a colour depth of 262K/65K
- A ILI9341 controller with a SPI serial interface

There is a version which uses a TFT panel that requires the colours to be inverted. This is supported by the Micromite Plus by specifying the controller type as ILI9341_I.

ST7735 Based Displays



The ST7735 based displays also use a SPI interface and are smaller than the ILI9341 based displays. ST7735 displays have the following basic specifications:

- A 1.8 inch display
- Resolution of 128 x 160 pixels and a colour depth of 262K/65K
- A ST7735 controller with a SPI serial interface

These do not come with a touch controller.

A typical ST7735 based display is illustrated on the right. On eBay you can find suitable displays by searching for the controller name (ST7735).

ILI9163 Based Displays

ILI9163 based displays have a 1.44 inch display with 128x128 pixels. They have an SPI interface and use the same connections as ST7735 based displays.

ILI9163 based displays use an SPI interface and have the following basic specifications:

- A 1.44 inch display
- Resolution of 128 x 128 pixels
- A ILI9163 controller with a SPI serial interface

A typical ILI9163 based display is illustrated on the right. On eBay you can find suitable displays by searching for the controller name (ILI9163).

Be warned, apparently some displays with a red PCB have a fault and will not work with the Micromite Plus. So, you should choose a display with a black PCB (as illustrated) as these have been tested and work correctly

Connecting SPI Based LCD Panels

The SPI based display controllers share the second SPI channel (SPI2) interface on the Micromite Plus with the touch controller (if present) and the SD Card interface if implemented. If any of these features are enabled SPI2 will also be unavailable to BASIC programs (which can use the first SPI channel instead).

The following table lists the connections required between the ILI9341, ST7735 and ILI9163 based LCD display board and the Micromite Plus:

ILI9341 Display	ST7735 or ILI9163 Display	Description	Micromite Plus 64-pin version	Micromite Plus 100-pin version
T_IRQ		Touch Interrupt	Configurable (see Touch Support)	
T_DO		Touch Data Out (MISO)	Pin 47	Pin 11
T_DIN		Touch Data In (MOSI)	Pin 5	Pin 12
T_CS		Touch Chip Select	Configurable (see Touch Support)	
T_CLK		Touch SPI Clock	Pin 4	Pin 10
SDO (MISO)		Display Data Out (MISO)	Pin 47	Pin 11
LED	LED	Power supply for the backlight (see below)		
SCK	SCK	Display SPI Clock	Pin 4	Pin 10
SDI (MOSI)	SDA	Display Data In (MOSI)	Pin 5	Pin 12
D/C	A0	Display Data/Command Control	Configurable	
RESET	RESET	Display Reset (when pulled low)	Configurable	
CS	CS	Display Chip Select	Optional - Configurable	
GND	GND	Ground		
VCC	VCC	5V supply (the controller draws less than 10mA)		

Where a Micromite Plus connection is listed as "configurable" the specific pin should be specified with the OPTION LCDPANEL or OPTION TOUCH commands (see below).

The backlight power (the LED connection) should be supplied from the main 5V supply via a current limiting resistor. A typical value for this resistor on the ILI9341 based LCD display is 18Ω for a current of about 63mA and on the ST7735 or ILI9163 display is 39Ω for a current of about 30mA. The value of this resistor can be varied to reduce the power consumption or to provide a brighter display.

Important: Care must be taken with display panels that share the SPI port between a number of devices (display controller, touch, etc). In this case all the Chip Select signals must be configured in MMBasic or disabled by a permanent connection to 3.3V. If this is not done any unconnected Chip Select pins will float causing the wrong controller to respond to commands on the SPI bus.

Configuring an SPI Based LCD Panel

To use the display MMBasic must be configured using the OPTION LCDPANEL command which is normally entered at the command prompt. Every time the Micromite is restarted MMBasic will automatically initialise the display. This command can also be embedded in a program with certain conditions – see the section "Special Functions and the Library" in the *Micromite User Manual* for more details.

The syntax is:

```
      OPTION LCDPANEL controller, orientation, D/C pin, reset pin [,CS pin]
```

Where:

'controller' can be either ILI9341, ILI9341_I, ST7735 or ILI9163. The ILI9341_I designation works the same as the ILI9341 but the colours are inverted, this is required by some TFT panels using the ILI9341controller.

'orientation' can be LANDSCAPE, PORTRAIT, RLANDSCAPE or RPORTRAIT. These can be abbreviated to L, P, RL or RP. The R prefix indicates the reverse or "upside down" orientation.

'C/D pin' and 'reset pin' are the Micromite I/O pins to be used for these functions. Any free pin can be used.

'CS pin' can also be any I/O pin but is optional. If a touch controller is not used this parameter can be left off the command and the CS pin on the LCD display wired permanently to ground. If the touch controller is used this pin must then be specified and connected to a Micromite I/O pin.

To test the display you can enter the command GUI TEST LCDPANEL. You should see an animated display of colour circles being rapidly drawn on top of each other. Press the space bar on the console’s keyboard to stop the test.

Important: The above test may not work if the display has a touch controller and the touch controller has not been configured (ie, the touch Chip Select pin is floating). In this case configure the touch controller (see below) and then retry GUI TEST LCDPANEL.

To verify the configuration you can use the command OPTION LIST to list all options that have been set including the configuration of the LCD panel.

Examples

For the 64-pin Micromite Plus the following allocations are recommended:

- Pin 44 for the display Chip Select
- Pin 43 for the display Data/Command control
- Pin 42 for the display reset control
- Pin 45 for the touch Chip Select
- Pin 46 for the touch IRQ input
- Pin 52 is the SD card Chip Select

The corresponding configuration commands are:

```
      OPTION LCDPANEL ILI9341, L, 44, 43, 42
      OPTION TOUCH 45, 46
      OPTION SDCARD 52
```

These match the pin allocations on the TFT Backpack+ PCB board offered by CircuitGizmos. See: http://circuitgizmos.com/gizmo-store/#!/TFT-Backpack+-PCB-Peter-Mather/p/65473479

SSD1963 Based LCD Displays

In addition to the SPI based controllers the Micromite Plus supports colour LCD displays using the SSD1963 controller. These use a parallel interface, are available in sizes from 4.3" to 9" and have better specifications than the smaller displays. Typically they cost about US$30 for the 4.3" version to US$50 for the 7" version. All these displays have an SD card socket which is fully supported by MMBasic on the Micromite Plus.

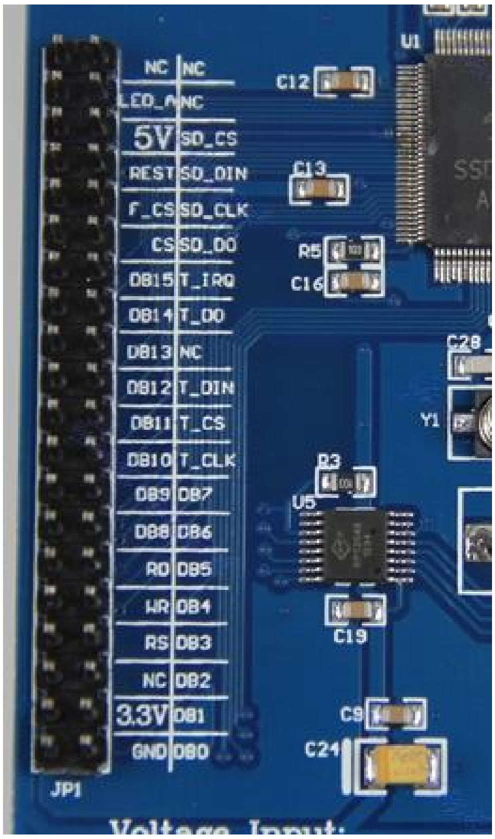
On eBay you can find suitable displays by searching for the controller name (SSD1963).

Because the SSD1963 controller uses a parallel interface the Micromite Plus can transfer data much faster than an SPI interface resulting in a very quick screen update. These displays are also much larger, have more pixels and are brighter. MMBasic drives them using 24-bit true colour for a full colour rendition (16 million colours).

The characteristics of these displays are:

- A 4.3, 5, 7, 8 or 9 inch display
- Resolution of 480 x 272 pixels (4.3" version) or 800 x 480 pixels (5”, 7", 8" or 9" versions).
- An SSD1963 display controller with a parallel interface (8080 format).
- A touch controller (SPI interface).
- A full sized SD card socket.

There are a number of different designs using the SSD1963 controller but fortunately most Chinese suppliers have standardised on a single connector as illustrated below. It is strongly recommended that any display purchased has a matching connector – this provides some confidence that the manufacturer has followed the standard that the Micromite Plus is designed to use.



Connecting an SSD1963 Based LCD Panel

The SSD1963 controller uses a parallel interface while the touch controller and SD card use an SPI interface. The touch and SD card features are optional but if they are used they will use the second SPI port (SPI2).

The following table lists the connections required between the display board and the Micromite Plus to support the SSD1963 interface and the LCD display. The touch controller and SD card interfaces are listed further below.

SSD1963 Display	Description	64-pin Micromite+	100-pin Micromite+
DB0	Parallel Data Bus bit 0	Pin 60	Pin 93
DB1	Parallel Data Bus bit 1	Pin 61	Pin 94
DB2	Parallel Data Bus bit 2	Pin 62	Pin 98
DB3	Parallel Data Bus bit 3	Pin 63	Pin 99
DB4	Parallel Data Bus bit 4	Pin 64	Pin 100
DB5	Parallel Data Bus bit 5	Pin 1	Pin 3
DB6	Parallel Data Bus bit 6	Pin 2	Pin 4
DB7	Parallel Data Bus bit 7	Pin 3	Pin 5
CS	Chip Select (active low)	Ground (ie, always selected)	
WR	Write (active low)	Pin 24	Pin 19
RD	Read (active low)	Configurable	
RS	Command/Data	Pin 27	Pin 18
RESET	Reset the SSD1963	Pin 28	Pin 42
LED_A	Backlight control for an unmodified display panel	Configurable	
5V	5V power for the backlight on some displays (most displays use the 3.3V supply for this).		
3.3V	Power supply.		
GND	Ground		

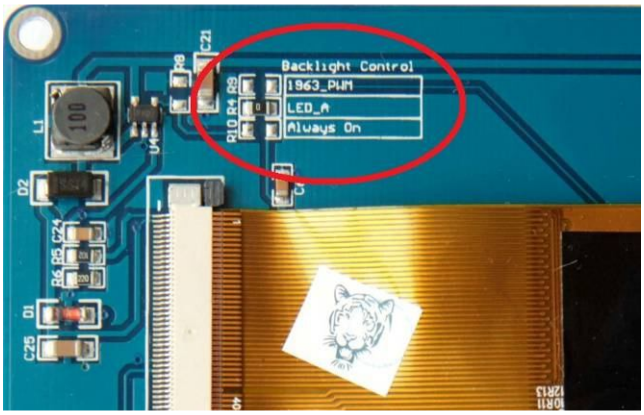
The following table lists the connections required to support the touch controller interface:

SSD1963 Display	Description	64-pin Micromite+	100-pin Micromite+
T_CS	Touch Chip Select	Configurable	
T_IRQ	Touch Interrupt	Configurable	
T_DIN	Touch Data In (MOSI)	Pin 5	Pin 12
T_CLK	Touch SPI Clock	Pin 4	Pin 10
T_DO	Touch Data Out (MISO)	Pin 47	Pin 11

The following table lists the connections required to support the SD card connector:

SSD1963 Display	Description	64-pin Micromite+	100-pin Micromite+
SD_CS	SD Card Chip Select	Configurable	
SD_DIN	SD Card Data In (MOSI)	Pin 5	Pin 12
SD_CLK	SD Card SPI Clock	Pin 4	Pin 10
SD_DO	SD Card Data Out (MISO)	Pin 47	Pin 11

Where a Micromite connection is listed as "configurable" the specific pin should be specified in the appropriate OPTION command (see below).



Most SSD1963 based LCD panels have three pairs of solder pads on the PCB which are grouped under the heading "Backlight Control" as illustrated on the right. Normally the pair marked "LED-A" are shorted together with a zero ohm resistor and this allows control of the backlight's brightness with a PWM (pulse width modulated) signal on the LED-A pin of the display panel's main connector.

The Micromite Plus fully supports this form of control and if you do not want to be bothered with the details you can specify the I/O pin used to drive the LED-A pin in the OPTION LCDPANEL command (below).

However, it is better to use the SSD1963 controller to generate this signal as it frees up one I/O pin and it allows the brightness to be controlled with a finer degree of resolution (1% instead of 5% steps). To use the SSD1963 for brightness control the zero ohm resistor should be removed from the pair marked "LED-A" and used to short the nearby pair of solder pads marked "1963-PWM". The Micromite Plus can then control the brightness via the SSD1963 controller.

In either case the BACKLIGHT command will work the same and can be used to dynamically change the display's brightness.

Generally 7 inch and larger displays have a separate pin on the connector (marked 5V) for powering the backlight from a 5V supply. If this pin is not provided the backlight power will be drawn from the 3.3V pin. Note that the power drawn by the backlight can be considerable. For example, a 7 inch display will typically draw 330 mA from the 5V pin.

The current drawn by the backlight can cause a voltage drop on the LCD display panel’s ground pin which can in turn shift the logic levels as seen by the display controller resulting in corrupted colours or text. An easy way of diagnosing this effect is to reduce the CPU speed to (say) 40MHz. If this fixes the problem it is a strong indication that this is the cause. Soldering power and ground wires direct to the LCD display panel’s PCB is one workaround.

Care must be taken with display panels that share the SPI port between a number of devices (SD card, touch, etc). In this case all the Chip Select signals must configured in MMBasic or disabled by a permanent connection to 3.3V. If this is not done the pin will float causing the wrong controller to respond to commands on the SPI bus.

On the Micromite Plus the second SPI channel (SPI2) is used to communicate with the touch controller and the SD Card interface. If any of these features are enabled SPI2 will be unavailable to BASIC programs (which can use the first SPI channel instead).

Configuring an SSD1963 Based LCD Panel

To use the display MMBasic must be configured using the OPTION LCDPANEL command which is normally entered at the command prompt. Every time the Micromite is restarted MMBasic will automatically initialise the display. This command can also be embedded in a program with certain conditions – see the section "Special Functions and the Library" in the *Micromite User Manual* for more details.

The syntax is:

```
      OPTION LCDPANEL controller, orientation [,LCD-A pin] [,RD pin]
```

Where:

'controller' can be either:

• SSD1963_4	For a 4.3 inch display
• SSD1963_5	For a 5 inch display
• SSD1963_5A	For an alternative version of the 5 inch display if SSD1963_5 does not work
• SSD1963_7	For a 7 inch display
• SSD1963_7A	For an alternative version of the 7 inch display if SSD1963_7 does not work.
• SSD1963_8	For 8 inch or 9 inch displays.

'orientation' can be LANDSCAPE, PORTRAIT, RLANDSCAPE or RPORTRAIT. These can be abbreviated to L, P, RL or RP. The R prefix indicates the reverse or "upside down" orientation.

'LCD-A pin' can also be any I/O pin but is optional. This can be used to control the brightness of the backlight if the internal SSD1963 controller is not used (see the notes above).

'RD pin' can also be any I/O pin and is connected to the RD (read) pin of the LCD display panel. This is optional and if specified will allow the use of transparent text, the SAVE IMAGE command and the BLIT command (transparent text is displayed when the background colour is specified as -1).

This command only needs to be run once. From then on MMBasic will automatically initialise the display on startup or reset. In some circumstances it may be necessary to interrupt power to the LCD panel while the Micromite is running (eg, to save battery power) and in that case the GUI RESET LCDPANEL command can be used to reinitialise the display.

If the LCD panel is no longer required the command OPTION LCDPANEL DISABLE can be used which will return the I/O pins for general use.

To verify the configuration you can use the command OPTION LIST to list all options that have been set including the configuration of the LCD panel.

To test the display you can enter the command GUI TEST LCDPANEL. You should see an animated display of colour circles being rapidly drawn on top of each other. Press the space bar on the console’s keyboard to stop the test.

8 and 9 inch Displays

The controller configuration SSD1963_8 has only been tested with the 8 and 9 inch displays made by EastRising (available at www.buydisplay.com). These must be purchased as a TFT LCD panel with 8080 interface, 800x480 pixel LCD, SSD1963 display controller and XPT2046 touch controller. Note that the EastRising panels use a non-standard interface connector pin-out so you will need to refer to their data sheets when connecting these to the Micromite Plus. A suitable adapter can be purchased from: https://www.rictech.nz/micromite-products

100-Pin Micromite Plus Example

The Explore 100 board with the 100-pin Micromite Plus uses the following pin allocations:

- Pin 48 is the SSD1963 LED_A control
- Pin 6 is the SSD1963 RD pin (required for transparent text and the SAVE IMAGE command)
- Pin 1 is the touch Chip Select
- Pin 40 is the touch IRQ input
- Pin 39 is the touch click output (see the next chapter)
- Pin 47 is the SD card Chip Select

The corresponding configuration commands are:

```
OPTION LCDPANEL SSD1963_5, LANDSCAPE, 48, 6
OPTION TOUCH 1, 40, 39
OPTION SDCARD 47
```

Because the RD pin is specified for the SSD1963 display programs will be able to display transparent text and use the BLIT command.

64-Pin Micromite Plus Example

For the Explore 64 board (64-pin Micromite Plus) the following allocations are recommended:

- Pin 12 for the SSD1963 LED_A control
- Pin 51 for the touch Chip Select
- Pin 33 for the touch IRQ input
- Pin 50 for the touch click output (see the next chapter)
- Pin 52 is the SD card Chip Select

The corresponding configuration commands are:

```
OPTION LCDPANEL SSD1963_5, LANDSCAPE, 12
OPTION TOUCH 51, 33, 50
OPTION SDCARD 52
```

Because the RD pin is not specified programs will not be able to use transparent text and the BLIT command.

Touch Support

The Micromite User Manual describes how to setup and calibrate a resistive touch sensitive panel. This section concentrates on the additional features offered by the Micromite Plus.

Configuring Touch

To configure the Micromite Plus for a touch panel the OPTION TOUCH command is used:

```
      OPTION TOUCH T_CS pin, T_IRQ pin [, click pin]
```

Where:

'T_CS pin' and 'T_IRQ pin' are the Micromite I/O pins to be used for chip select and touch interrupt respectively (any free pins can be used).

'click pin' is exclusive to the Micromite Plus and specifies an I/O pin that will be driven briefly high when a screen control is touched. This can be used to drive a small Piezo buzzer which will produce a click sound providing an audible feedback when a GUI element on the screen is activated (see the section "Graphical User Interface Commands").

A typical buzzer that can be used is Altronics Part Number S6108 or S6104

Note that most I/O pins on the Micromite Plus are capable of driving 15mA (pins 50, 44 and 6 on the 64-pin chip can drive 30mA). However many buzzers require more that this so a transistor might be necessary to buffer the Micromite Plus output and drive the buzzer.

The OPTION TOUCH command is normally entered at the command prompt. Every time the Micromite is restarted MMBasic will then automatically initialise the touch controller. This command can also be embedded in a program with certain conditions – see the section "Special Functions and the Library" in the *Micromite User Manual* for more details.

Calibrating the Touch Screen

Calibrating the touch screen is done using the GUI CALIBRATE command. When run this command will present a series of four targets on the screen that must be touched.

This process is fully described in the Micromite User Manual.

Touch Functions

To detect if and where the screen is touched you can use the following functions in a BASIC program.

Note that the first two functions are common across all versions of the Micromite, the remainder are unique to the Micromite Plus.

□ TOUCH(X)
Returns the X coordinate of the currently touched location or -1 if the screen is not being touched.

□ TOUCH(Y)
Returns the Y coordinate of the currently touched location or -1 if the screen is not being touched.

□ TOUCH(DOWN)
Returns true if the screen is currently being touched (this is much faster than TOUCH(X or Y)).

□ TOUCH(UP)
Returns true if the screen is currently NOT being touched (also faster than TOUCH(X or Y))

□ TOUCH(LASTX)
Returns the X coordinate of the last location that was touched.

□ TOUCH(LASTY)
Returns the Y coordinate of the last location that was touched.

□ TOUCH(REF)
Returns the reference number of the control that is currently being touched or zero if no control is being touched. See the section Advanced Graphics for more details.

□ TOUCH(LASTREF)
Returns the reference number of the control that was last touched.

The GUI BEEP Command

The Piezo buzzer specified in the OPTION TOUCH command can also be driven by a BASIC program using the command:

```
GUI BEEP msec
```

Where 'msec' is the number of milliseconds that the beeper should be driven. A time of 3ms produces a click while 100ms produces a short beep.

Touch Interrupts

On the Micromite Plus the GUI INTERRUPT command is used to setup a touch interrupt. The syntax is:

```
GUI INTERRUPT down [, up]
```

Where 'down' is the subroutine to call when a touch down has been detected. And optionally 'up' is the subroutine to call when the touch has been lifted from the screen ('up' and 'down' can point to the same subroutine if required).

As an example, the following program will print out the X and Y coordinates of any touch on the screen:

```
GUI INTERRUPT MyInt
DO : LOOP

SUB MyInt
  PRINT TOUCH(X) TOUCH(Y)
END SUB
```

Specifying the number zero (single digit) as the argument will cancel both up and down interrupts. ie:

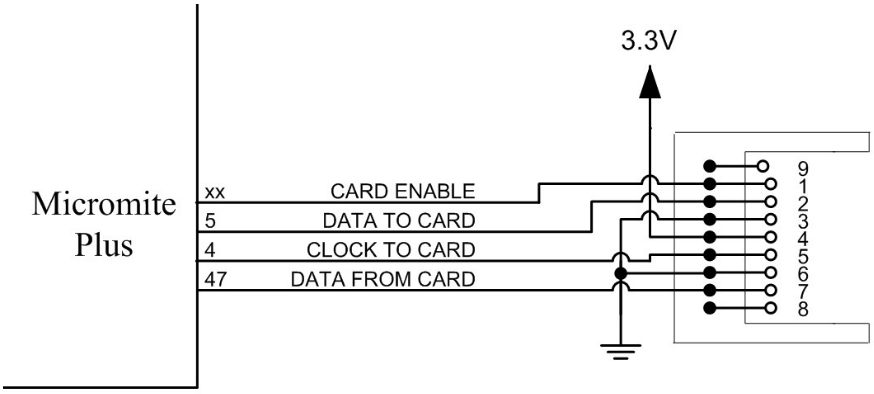
```
GUI INTERRUPT 0
```

SD Card Support

The Micromite Plus has full support for SD cards. This includes opening files for reading, writing or random access and loading and saving programs.

The firmware will work with cards up to 128 GB formatted in FAT16, FAT32 or exFAT and the files created can also be read/written on personal computers running Windows, Linux or the Mac operating system. Note that exFAT is limited as functions returning a directory path will return just the drive letter.

The basic circuit diagram for connecting the SD card connector to the 64-pin Micromite Plus is illustrated below. Note that the pin number used for Card Enable is selected when configuring the interface.



Care must be taken with display panels that share the SPI port between a number of devices (SD card, touch, etc). In this case all the Chip Select signals must configured in MMBasic or alternatively disabled by a permanent connection to 3.3V. If this is not done any floating Chip Select signal lines will cause the wrong controller to respond to commands on the SPI bus.

Configuring the SD Card

To use the SD card MMBasic must be configured using the OPTION SDCARD command which is normally entered at the command prompt. Every time the Micromite is restarted MMBasic will automatically initialise the SD card. This command can also be embedded in a program with certain conditions – see the section "Special Functions and the Library" in the *Micromite User Manual* for more details.

The syntax is:

```
      OPTION SDCARD CS-pin [, CD-pin [,WP pin]]
```

Where:

'CS-pin' is the I/O pin number that will be used as chip select (pin 1 on the SD card connector).

'CD-pin' is optional and is the I/O pin number that will be used to connect to the card detect pin on the SD card connector. The Micromite will provide a weak pullup on this pin which is normally pulled high but, when a card is inserted, it will be connected to ground and the signal line pulled low. On some connectors this signal is not provided and in that case the Micromite Plus would need to be restarted if the SD card was changed.

'WP-pin' is optional and is the I/O pin number that will be used to connect to the write protect pin on the SD card connector. The Micromite will provide a weak pullup on this pin which is normally pulled high but, when a card is write protected, it will be connected to ground and the signal line pulled low.

The state of the 'CD-pin' and 'WP-pin' can also be read using the PIN() function which is useful for checking the status of an SD card before opening it..

Some SD card connectors reverse the polarity of the 'CD-pin' or 'WP-pin' signal - ie, they are open (and therefore the signal is high) when the card is inserted or write protected. In this case the pin numbers used for 'CD-pin' and 'WP-pin' can be a negative number. This will tell MMBasic to invert the polarity of these signals.

This command only needs to be run once. When the Micromite is restarted MMBasic will automatically initialise the SD card interface. If the SD card is no longer required the command OPTION SDCARD DISABLE can be used which will disable the SD card and return the I/O pins for general use.

To verify the configuration you can use the command OPTION LIST to list all options that have been set including the configuration of the SD Card.

Specific Examples

On the Explore 64 module (http://www.rictech.nz/pages/5/Products) the SD Card Chip Select (CS) signal is on pin 12 and the Card Detect (CD) signal is on pin 14. So, to enable the SD Card on this module the command is: OPTION SDCARD 12, 14

On the CGMICROBOARD2 module (www.circuitgizmos.com/products/cgmicroboard2/cgmicroboard2.shtml) the SD Card Chip Select (CS) signal is on pin 49 and pin 30 is used for Card Detect). So, to enable the SD Card on this module the command is: OPTION SDCARD 49, 30

The SnadPIC 100-pin PIC32 Module is useful if you are experimenting with the 100-pin Micromite Plus: http://www.microcontroller-board.com/snadpic-board-32/14-snadpic-pic32mx470f512l-development-board.html#/crystal_oscillator-20mhz/crystal_rtcc-no_without_crystal_r

This is the company's standard PIC32 experimental board modified to suit the Micromite Plus firmware (it has a 20M Hz crystal and does not include a RTC crystal). If you are purchasing this board make sure that you specify these two details and the words "For Micromite" in the comments field.

On this module the SD Card Chip Select (CS) signal is on pin 14 and the Card Detect (CD) signal is on pin 18. So, to enable the SD Card on this module the command is: OPTION SDCARD 14, 18

Note that on the 100-pin Micromite Plus pin 18 is used for driving a SSD1963 based LCD panel and will conflict with its allocation as Card Detect. In this case the zero ohm resistor J3 on the underside of the SnadPIC board must be removed so that SD Card Detect is no longer on pin 18. Another pin may be selected via the CD pin on the top of the board.

MMBasic Support

MMBasic on the Micromite Plus supports the standard BASIC commands for working with storage systems.

Note that:

- Long file/directory names are supported in addition to the old 8.3 format.
- The maximum file/path length is 127 characters.
- Upper/lowercase characters and spaces are allowed although the file system is not case sensitive.
- Directory paths are allowed in file/directory strings. (ie, OPEN "\dir1\dir2\file.txt" FOR …).
- Either forward or back slashes can be used in paths. Eg \dir\file.txt is the same as /dir/file.txt.
- The current Micromite time is used for file create and last access times.
- Up to ten files can be simultaneously open.
- The CPU speed must be 30MHz or higher.
- Except for INPUT, LINE INPUT and PRINT the # in #fnbr is optional and may be omitted.

□ OPEN fname$ FOR mode AS #fnbr
Opens a file for reading or writing. 'fname$' is the file name in 8.3 format. 'mode' can be INPUT, OUTPUT, APPEND or RANDOM. '#fnbr' is the file number (1 to 10).

□ PRINT #fnbr, expression [[,;]expression] … etc
Outputs text to the file opened as #fnbr.

□ INPUT #fnbr, list of variables
Read a list of comma separated data into the variables specified from the file previously opened as #fnbr.

□ LINE INPUT #fnbr, variable$
Read a complete line into the string variable specified from the file previously opened as #fnbr.

□ CLOSE #fnbr [,#fnbr] …
Close the file(s) previously opened with the file number '#fnbr'.

Programs can be loaded from or saved to the SD card using two commands.

□ RUN fname$
Load a BASIC program from the SD Card and run it (fname$ must be a string constant).

□ LOAD fname$ [, R]
Load a BASIC program from the SD Card. The optional suffix ",R" will cause the program to be run after it has been loaded (in this case fname$ must be a string constant).

□ SAVE fname$
Save the current program to the SD card.

Images can be loaded from or saved to the SD card using two commands.

□ LOAD IMAGE fname$
Load a BMP file and display it on the LCD screen.

□ SAVE IMAGE fname$
Save the current LCD screen image as a BMP file (the LCD panel must be capable of transparent text).

Basic file and directory manipulation can be done from within a BASIC program.

□ FILES [wildcard]
Search the current directory and list the files/directories found.

□ KILL fname$
Delete a file in the current directory.

□ MKDIR dname$
Make a sub directory in the current directory.

□ CHDIR dname$
Change into to the directory $dname. $dname can also be ".." (dot dot) for up one directory or "\" for the root directory.

□ RMDIR dir$
Remove, or delete, the directory ‘dir$’ on the SD card.

□ SEEK #fnbr, pos
Will position the read/write pointer in a file that has been opened for RANDOM access to the 'pos' byte.

Also there are a number of functions that support the above commands.

□ INPUT$(nbr, #fnbr)
Will return a string composed of ‘nbr’ characters read from a file previously opened for INPUT with the file number ‘#fnbr’. If less than ‘nbr’ characters are available the function will return with what it has (including an empty string if no characters are available).

□ DIR$(fspec, type)
Will search an SD card for files and return the names of entries found.

□ CWD$
Will return the current working directory. For a card formatted exFAT will return just “A:/”.

□ EOF(#fnbr)
Will return true if the file previously opened for INPUT with the file number ‘#fnbr’ is positioned at the end of the file.

□ LOC(#fnbr)
For a file opened as RANDOM this will return the current position of the read/write pointer in the file.

□ LOF(#fnbr)
Will return the current length of the file in bytes.

XModem Transfer

In addition to the standard method of XModem transfer which copies to or from the program memory the Micromite Plus can also copy to and from a file on the SD card. The syntax is:

```
XMODEM SEND filename$
```

or

```
XMODEM RECEIVE filename$
```

Where ‘filename$’ is the file to save or send. As is common throughout MMBasic ‘filename$’ can be a string expression, variable or constant. If it is a constant the string must be quoted (eg, XMODEM SEND "PRBAS") In the case of receiving a file, any file on the SD card with the same name will be automatically overwritten.

Load and Save Image

The LOAD IMAGE command can be used to load a bitmap image from the SD card and display it on the attached LCD display panel. This can be used to draw a logo or add a background on the display. The syntax of the command is:

```
LOAD IMAGE filename$ [, StartX, StartY]
```

Where ‘filename$’ is the image to load and ‘StartX’/’StartY’ are the coordinates of the top left corner of the image (these default to the top left corner of the display if not specified). The image must be in BMP format and MMBasic will add “.BMP” to the file name if an extension is not specified. All types of the BMP format are supported including black and white and true colour 24-bit images.

The LOAD IMAGE command can display full colour, full screen images which look gorgeous. With high resolution displays it will take some time to read the image from the SD Card (about 2 seconds for an 800x480 image).

The x and y parameters are optional and if they are not used will default to zero which positions the top left of the image at the top left point of the screen. For example, if the file TIGER.BMP is an 800x600 image this command will fill the screen with the image:

```
LOAD IMAGE "TIGER.BMP"
```

The current image on the LCD screen can be saved to a file using the following command:

```
SAVE IMAGE filename$
```

This will save the image as a 24-bit true colour BMP file (the extension .BMP) will be added if an extension is not supplied.

Example of Sequential I/O

In the example below a file is created and two lines are written to the file (using the PRINT command). The file is then closed.

```
OPEN "fox.txt" FOR OUTPUT AS #1
PRINT #1, "The quick brown fox"
PRINT #1, "jumps over the lazy dog"
CLOSE #1
```

You can read the contents of the file using the LINE INPUT command. For example:

```
OPEN "fox.txt" FOR INPUT AS #1
LINE INPUT #1,a$
LINE INPUT #1,b$
CLOSE #1
```

LINE INPUT reads one line at a time so the variable `a$` will contain the text "The quick brown fox" and `b$` will contain "jumps over the lazy dog".

Another way of reading from a file is to use the INPUT$() function. This will read a specified number of characters. For example:

```
OPEN "fox.txt" FOR INPUT AS #1
ta$ = INPUT$(12, #1)
tb$ = INPUT$(3, #1)
CLOSE #1
```

The first INPUT$() will read 12 characters and the second three characters. So the variable `ta$` will contain "The quick br" and the variable `tb$` will contain "own".

Files normally contain just text and the print command will convert numbers to text. So in the following example the first line will contain the line "123" and the second "56789".

```
nbr1 = 123 : nbr2 = 56789
OPEN "numbers.txt" FOR OUTPUT AS #1
PRINT #1, nbr1
PRINT #1, nbr2
CLOSE #1
```

Again you can read the contents of the file using the LINE INPUT command but then you would need to convert the text to a number using VAL(). For example:

```
OPEN "numbers.txt" FOR INPUT AS #1
LINE INPUT #1, a$
LINE INPUT #1, b$
CLOSE #1
x = VAL(a$) : y = VAL(b$)
```

Following this the variable `x` would have the value 123 and `y` the value 56789.

Random File I/O

For random access the file should be opened with the keyword RANDOM. For example:

```
OPEN "filename" FOR RANDOM AS #1
```

To seek to a record within the file you would use the SEEK command which will position the read/write pointer to a specific byte. The first byte in a file is numbered one so, for example, the fifth record in a file that uses 64 byte records would start at byte 257. In that case you would use the following to point to it:

```
SEEK #1, 257
```

When reading from a random access file the INPUT$() function should be used as this will read a fixed number of bytes (ie, a complete record) from the file. For example, to read a record of 64 bytes you would use:

```
dat$ = INPUT$(64, #1)
```

When writing to the file a fixed record size should be used and this can be easily accomplished by adding sufficient padding characters (normally spaces) to the data to be written. For example:

```
PRINT #1, dat$ + SPACE$(64 – LEN(dat$);
```

The SPACE$() function is used to add enough spaces to ensure that the data written is an exact length (64bytes in this example). The semicolon at the end of the print command suppresses the addition of the carriage return and line feed characters which would make the record longer than intended.

Two other functions can help when using random file access. The LOC() function will return the current byte position of the read/write pointer and the LOF() function will return the total length of the file in bytes.

The following program demonstrates random file access. Using it you can append to the file (to add some data in the first place) then read/write records using random record numbers. The first record in the file is record number 1, the second is 2, etc.

```
RecLen = 64
OPEN "test.dat" FOR RANDOM AS #1
DO
   abort: PRINT
   PRINT "Number of records in the file =" LOF(#1)/RecLen
   INPUT "Command (r = read,w = write, a = append, q = quit): ", cmd$
   IF cmd$ = "q" THEN CLOSE #1 : END
   IF cmd$ = "a" THEN
      SEEK #1, LOF(#1) + 1
   ELSE
      INPUT "Record Number: ", nbr
      IF nbr < 1 or nbr > LOF(#1)/RecLen THEN PRINT "Invalid record" : GOTO abort
      SEEK #1, RecLen * (nbr - 1) + 1
   ENDIF
   IF cmd$ = "r" THEN
      PRINT "The record = " INPUT$(RecLen, #1)
   ELSE
      LINE INPUT "Enter the data to be written: ", dat$
      PRINT #1,dat$ + SPACE$(RecLen - LEN(dat$));
   ENDIF
LOOP
```

Random access can also be used on a normal text file. For example, this will print out a file backwards:

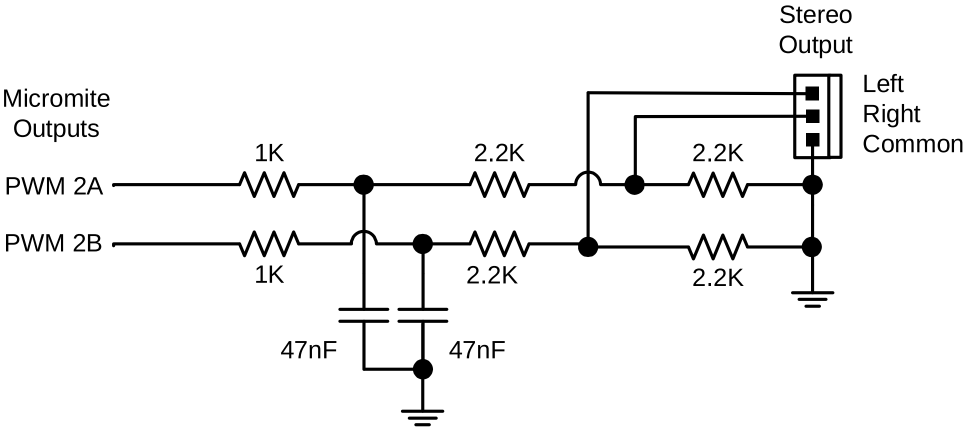
```
OPEN "file.txt" FOR RANDOM AS #1
FOR i = LOF(#1) TO 1 STEP -1
   SEEK #1, i
   PRINT INPUT$(1, #1);
NEXT i
CLOSE #1
```

Sound Output

The Micromite Plus can play stereo WAV files located on the SD card or generate precise sine waves using the PLAY command.

The sound is played on the PWM 2 outputs as a stereo signal with the left channel on the PWM 2A pin and the right on PWM 2B. The PWM and SERVO commands for controller 2 cannot be used while the sound is being generated (however PWM/SERVO controller 1 is still available).

The audio signal is superimposed on an 80 KHz square wave as a pulse width modulated (PWM) signal. This means that a low pass filter is required to recover the audio signal as shown below. This is a simple example which relies on capacitor coupling into the following amplifier (most have this) and has an output level of about 1V peak to peak (650mV RMS).



This is suitable for general use, however more sophisticated designs can be implemented if required to improve the frequency response and reject more of the carrier frequency. This circuit is also suitable for generating a DC output signal using the PWM commands although in that case both the 47 nF capacitors should be increased to 4.7 µF.

Playing WAV Files

The PLAY WAV command will play a WAV file residing on an SD card to the sound output. It can be used to add sound effects to programs and provide informative announcements.

The syntax of the command is:

```
   PLAY WAV file$ [, interrupt]
```

'file$' is the name of the WAV file to play. It must be on a connected SD card and the extension of .wav will be appended if missing. The audio will play in the background (ie, the program will continue without pause). 'interrupt' is optional and is the name of a subroutine which will be called when the file has finished playing.

The WAV file must be PCM encoded in stereo with unsigned 8-bit sampling. The sample rate can be 8 KHz or 16 kHz. To convert a file to this format a program or website such as http://audio.online-convert.com/convert-to-wav can be used (for this website set 8-bit resolution, set sampling rate to 8000 or 16000, set “Audio Channels” to stereo. Click “Normalise audio”. Set PCM unsigned 8-bit in ADVANCED OPTIONS).

Generating Sine Waves

The PLAY TONE command also uses the sound output and will generate sine waves with selectable frequencies for the left and right channels. This feature is intended for generating attention catching sounds but, because the frequency is very accurate, it can be used for many other applications. For example, signalling DTMF tones down a telephone line or testing the frequency response of loudspeakers.

The syntax of the command is:

```
   PLAY TONE left [, right [, dur]]
```

'left' and 'right' are the frequencies in Hz to use for the left and right channels. The tone plays in the background (the program will continue running after this command) and 'dur' specifies the number of milliseconds that the tone will sound for.

If the duration is not specified the tone will continue until explicitly stopped or the program terminates. The frequency can be from 1 Hz to 20 KHz and is very accurate (it is based on the Micromite Plus crystal oscillator). The frequency can be changed at any time by issuing a new PLAY TONE command.

Using PLAY

It is important to realise that the PLAY command will generate the audio in the background. This means that the commands following the PLAY command will be executed immediately and **not** when the audio has finished. This has some subtle inferences. For example, take the following program:

```
PLAY TONE 500, 500, 2000
END
```

You would expect the 500Hz tone to sound for 2 seconds but in practice it will not make any sound at all. This is because MMBasic will execute the PLAY TONE command (which will start generating the sound in the background) and then it will immediately continue on and execute the END command… which will terminate the program and the background sound. This happens so fast that nothing is heard.

Similarly the following program will not work either:

```
PLAY TONE 500, 500, 2000
PLAY TONE 300, 300, 5000
```

This is because the first command will set a 500Hz the tone playing but then the second PLAY command will immediately replace that with a 300Hz tone and following that the program will run off the end terminating the program and the background audio resulting in nothing being heard.

If you want MMBasic to wait while the PLAY command is doing its thing you should use suitable PAUSE commands. For example:

```
PLAY TONE 500, 500
PAUSE 2000
PLAY TONE 300, 300
PAUSE 5000
```

This also applies to the PLAY WAV command.

Utility Commands

There are a number of commands that can be used to manage the sound output:

`PLAY PAUSE` Temporarily halt (pause) the currently playing file or tone.

`PLAY RESUME` Resume playing a file or tone that was previously paused.

`PLAY STOP` Terminate the playing of the file or tone. The sound output will also be automatically stopped when the program ends.

`PLAY VOLUME L, R` Set the volume to between 0 and 100 with 100 being the maximum volume. The volume will reset to the maximum level when a program is run.

`PLAY CLOSE` Turn off the PWM output.
In order to suppress the audible "pops" that can occur when the PWM output waveform is turned on and off the PLAY command will leave the PWM signal running even if a sound is not being outputted (ie, finished playing or paused). This normally will not affect the normal running of the Micromite but if you want to turn it off (for example, when entering sleep) you can use this command.

Basic Drawing Features

The Micromite User Manual describes the basic drawing commands which are common across all versions of the Micromite. This section concentrates on the additional features offered by the Micromite Plus.

All coordinates and measurements on the screen are done in terms of pixels with the X coordinate being the horizontal position and Y the vertical position. The top left corner of the screen has the coordinates X=0 and Y=0 and the values increase as you move down and to the right of the screen.

Read Only Variables

In the Micromite Plus there are six read only variables which provide useful information about the display currently connected. The variables specific to the Micromite Plus are MM.HPOS and MM.VPOS, the others are supported by all Micromites:

- MM. HRES
  Returns the width of the display (the X axis) in pixels.
- MM. VRES
  Returns the height of the display (the Y axis) in pixels.
- MM.FONTHEIGHT
  Returns the height of the current font (in pixels). All characters in a font have the same height.
- MM.FONTWIDTH
  Returns the width of a character in the current font (in pixels). All characters in a font have the same width.
- MM.HPOS
  Returns the X coordinate of the text cursor (ie, the horizontal location (in pixels) of where the next character will be printed on the LCD panel)
- MM.VPOS
  Returns the Y coordinate of the text cursor (ie, the vertical location (in pixels) of where the next character will be printed on the LCD panel)

Colours

Colour is specified as a true colour 24 bit number where the top eight bits represent the intensity of the red colour, the middle eight bits the green intensity and the bottom eight bits the blue.

MMBasic will automatically translate all colours to the format required by the individual display controller which, in the case of the ILI9341, ST7735 and ILI9163 controllers, is 65K colours in the 565 format. In LCD panels using the SSD1963 controller colours are displayed using the full 24-bit colour range (16 million colours).

Fonts

The Micromite Plus has six built in fonts plus it can use embedded fonts to a maximum of 16 fonts.

The built in fonts are:

Font Number	Size (width x height)	Character Set	Description
1	8 x 13	All 95 characters	A small font where a dense display is required.
2	12 x 20	All 95 characters	General use on 480 x 272 displays
3	16 x 24	All 95 characters	General use on 800 x 480 displays
4	16 x 24 BOLD	All 95 characters	A bold version of font #3
5	24 x 32	All 95 characters	Large font, very clear
6	32 x 50	0 to 9 plus some symbols	Numbers plus decimal point, positive, negative, equals, degree and colon symbols. Very clear.

In all fonts (including font #6) the back quote character (60 hex or 96 decimal) has been replaced with the degree symbol (º).

Embedded Fonts

Both the standard Micromite and the Micromite Plus support embedded fonts. These are fully described in the Micromite User Manual. Note that because of the way the fonts are managed you cannot redefine fonts 1 or 6.

Drawing Commands

Compared to the standard Micromite the Micromite Plus has two additional basic drawing commands:

- □ `TRIANGLE X1, Y1, X2, Y2, X3, Y3, `*`C, FILL`*
  Draws a triangle with the corners at X1, Y1 and X2, Y2 and X3, Y3. C is the colour of the triangle and FILL is the fill colour. FILL can omitted or be -1 for no fill.
- □ `ARC x, y, r1, r2, a1, a2, c`
  Draws an arc with the centre at x and y, r1 and r2 are the inner and outer radius defining the thickness of the arc (if they are the same the arc will be one pixel thick), a1 and a2 are the start and end angles in degrees and c is the colour.

The other basic drawing commands are the same as in the standard Micromite. Refer to the Micromite User Manual for a description of these.

Rotated Text

As described in the *Micromite User Manual* the alignment of the text in the TEXT command can be specified by using one or two characters in a string expression for the third parameter of the command. In the Micromite Plus you can also specify a third character to indicate the rotation of the text. This character can be one of:

N for normal orientation

V for vertical text with each character under the previous running from top to bottom.

I the text will be inverted (ie, upside down)

U the text will be rotated counter clockwise by 90º

D the text will be rotated clockwise by 90º

This extra feature applies in the TEXT and GUI CAPTION commands.

As an example, the following will display the text "LCD Display" vertically down the left hand margin of the display panel and centred vertically:

```
TEXT 0, 250, "LCD Display", "LMV", 5
```

Positioning is relative to the top left corner of the character when viewed normally so inverted 100,100 will have the top left pixel of the first character at 100,100 and the text will then be above y=101 and to the left of x=101. Similarly “R” in the alignment string is viewed from the perspective of the character in whatever orientation it is in (not the screen).

Transparent Text

If the display is capable of transparent text the TEXT command will allow the use of -1 for the background colour. This means that the text is drawn over the background with the background image showing through the gaps in the letters. Displays capable of transparent text are any that use the ILI9341 controller or an SSD1963 controller. The latter must have the RD pin specified in the OPTION LCDPANEL command. On the Micromite eXtreme the VGA output also supports transparency (see the *Micromite eXtreme Manual*).

BLIT Command

If the display is capable of transparent text (see the above subheading) programs can also use the BLIT command. This allows a portion of the image currently showing on the display to be copied to a memory buffer and later copied back to the display. This is useful when something needs to be drawn over the background and later removed without damaging the image in the background. Examples include a game where a character is moving about in front of a landscape or the moving needle of a photorealistic gauge.

The available commands are:

```
BLIT READ #b, x, y, w, h
BLIT WRITE #b, x, y, w, h
BLIT CLOSE #b
```

#b is the buffer number in the range of 1 to 8. x and y are the coordinates of the top left corner and w and h are the width and height of the image. READ will copy the display image to the buffer, WRITE will copy the buffer to the display and CLOSE will free up the buffer and reclaim the memory used.

These commands can be used to copy a portion of the display to another location (by copying to a buffer then writing somewhere else) but a simpler method is to use an alternative version of the BLIT command as follows:

```
BLIT x1, y1, x2, y2, w, h
```

This will copy a portion of the image at x1/y1 to the location x2/y2. w and h specify the width and height of the image to be copied. The source and destination areas can overlap and the BLIT command will perform the copy correctly.

This form of the BLIT command is particularly useful for creating graphs that can scroll horizontally or vertically as new data is added.

Backlight Control

The brightness of the backlight on a SSD1963 LCD panel can be controlled with the BACKLIGHT command:

```
      BACKLIGHT percent
```

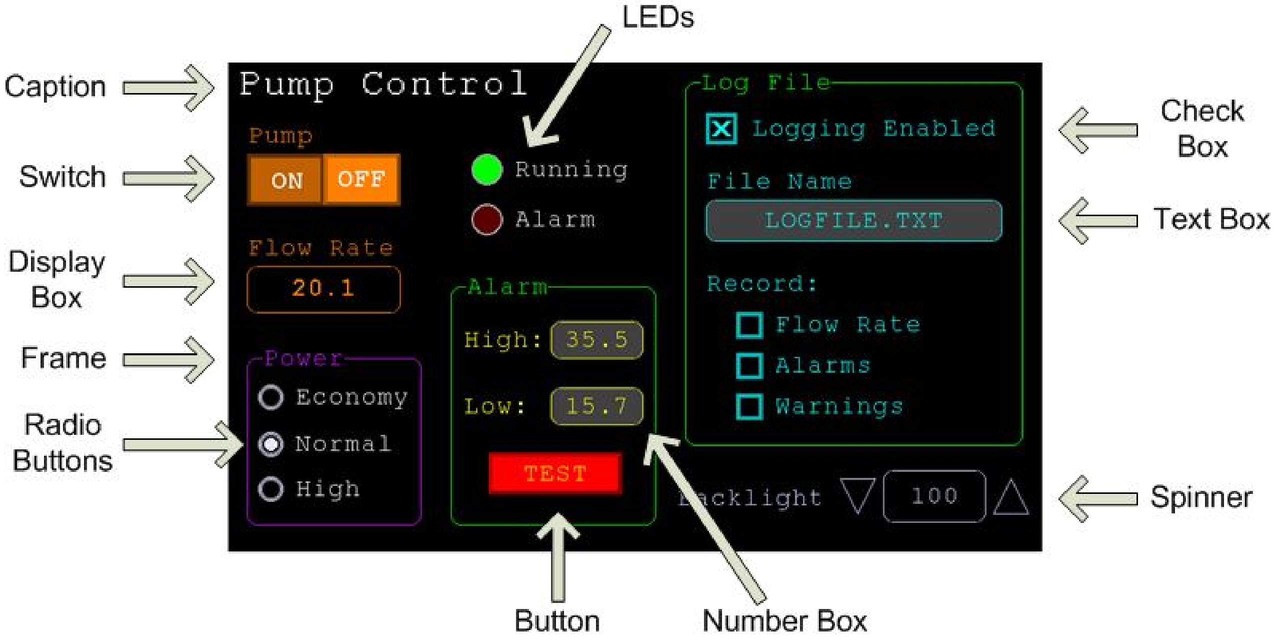
Where 'percent' is the degree of brightness ranging from 0 (fully off) to 100 (full brightness). This can be changed as often as required and makes a huge difference to the power requirements of the display. For example, a brightness of 50% will halve the current consumption (compared to 100%) while only making a small difference to the perceived visual brightness.

Load Image

As previously described in the "SD Card Support" section the LOAD IMAGE command can be used to load a bitmap image from the SD card and display it on the LCD display. This can be used to draw a logo or add an ornate background to the graphics drawn on the display.

Advanced Graphics

The Micromite Plus incorporates a suite of advanced graphic controls that respond to touch, these include on screen switches, buttons, indicator lights, keyboard, etc. MMBasic will draw the control and animate it (ie, a switch will appear to depress when touched). All that the BASIC program needs to do is invoke a single line command to specify the basic details of the control.



Each control has a reference number called '#ref' in the description of the control. By default this can be any number between 1 and 100 and the upper limit can be changed with the OPTION CONTROL command. The reference number is used to identify a control. For example, a check box can be created thus:

```
GUI CHECKBOX #10, "Test", 100, 100, 50, rgb(BLUE)
```

And the program can check its value by using its reference number in the CtrlVal() function:

```
IF CtrlVal(#10) THEN ...
```

The # character is optional but serves to remind the programmer that this is not an ordinary number.

In the following commands any arguments that are in italic font (eg, *`Width, Height`*) are optional and if not specified will take the value of the previous command that did specify them. This means for example, that a number of radio buttons with the same size and colour can be specified with only the first button having to list all the details. Note that with the colour specification this is different to the Basic Drawing Commands which default to the last COLOUR command.

All strings used in GUI controls and the MsgBox can display multiple lines by using the tilde character (~) to separate each line in the string. For example, a push button's caption can be "ALARM~TEST" and this would be displayed as two lines. For all controls the font used for the caption will be whatever is set with the FONT command and the colours will be whatever was set by the last COLOUR command.

If the display is capable of transparent text these commands will allow the use of -1 for the background colour. This means that the text is drawn over the background with the background image showing through the gaps in the letters. Displays capable of transparent text are any that use the ILI9341 controller or an SSD1963 controller. The latter must have the RD pin specified in the OPTION LCDPANEL command.

The advanced graphics controls are:

Frame

`GUI FRAME #ref, caption$, StartX, StartY,` *`Width, Height, Colour`*

This will draw a frame which is a box with round corners and a caption. A frame does not respond to touch but is useful when a group of controls need to be visually brought together. It can also used to surround a group of radio buttons and MMBasic will arrange for the radio buttons surrounded by the frame to be exclusive – that is, when one radio button is selected any other button that was selected and within the frame will be automatically deselected.

LED

`GUI LED #ref, caption$, CenterX, CenterY`*`, Diameter, Colour`*

This will draw an indicator light (it looks like a panel mounted LED). When its value is set to one it will be illuminated and when it is set to zero it will be off (a dull version of its colour attribute). The LED can be made to flash by setting its value to the number of milliseconds that it should remain on before turning off.

The caption will be drawn to the right of the LED and will use the colours set by the COLOUR command. The LED control is not animated when touched but its reference number can be found using TOUCH(REF) and TOUCH(LASTREF) in the touch interrupts and any required animation can be done in MMBasic.

Check Box

`GUI CHECKBOX #ref, caption$, StartX, StartY`*`, Size, Colour`*

This will draw a check box which is a small box with a caption. Both the height and width are specified with the 'Size' parameter. When touched an X will be drawn inside the box to indicate that this option has been selected and the control's value will be set to 1. When touched a second time the check mark will be removed and the control's value will be zero. The caption will be drawn to the right of the Check Box and will use the colours set by the COLOUR command.

Push Button

`GUI BUTTON #ref, caption$, StartX, StartY`*`, Width, Height, FColour, BColour`*

This will draw a momentary button which is a square switch with the caption on its face. When touched the visual image of the button will appear to be depressed and the control's value will be 1. When the touch is removed the value will revert to zero. Caption can be a single string with two captions separated by a vertical bar (|) character (eg, "UP|DOWN"). When the button is up the first string will be used and when pressed the second will be used.

Switch

`GUI SWITCH #ref, caption$, StartX, StartY`*`, Width, Height, FColour, BColour`*

This will draw a latching switch with the caption on its face. When touched the visual image of the button will appear to be depressed and the control's value will be 1. When touched a second time the switch will be released and the value will revert to zero. Caption can be a single string with two captions separated by a | character (eg, "ON|OFF"). When this is used the switch will appear to be a toggle switch with each half of the caption used to label each half of the toggle switch.

Radio Button

`GUI RADIO #ref, caption$, CenterX, CenterY`*`, Radius, Colour`*

This will draw a radio button with a caption. When touched the centre of the button will be illuminated to indicate that this option has been selected and the control's value will be 1. When another radio button is selected the mark on this button will be removed and its value will be zero. Radio buttons are grouped together when surrounded by a frame and when one button in the group is selected all others in the group will be deselected. If a frame is not used all buttons on the screen will be grouped together.

The caption will be drawn to the right of the button and will use the colours set by the COLOUR command.

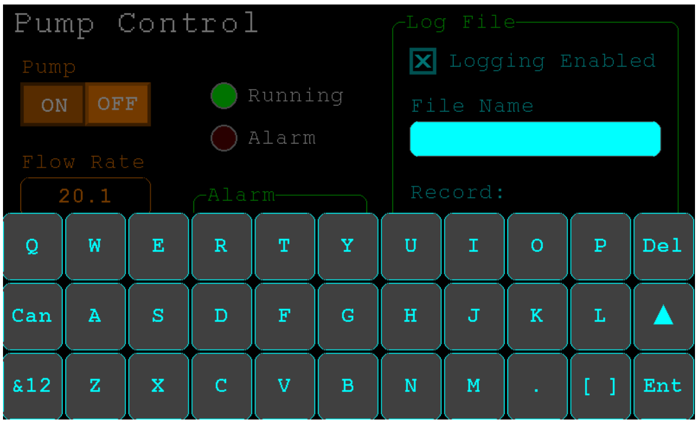
Display Box

`GUI DISPLAYBOX #ref, StartX, StartY`*`, Width, Height, FColour, BColour`*

This will draw a box with rounded corners. Any string can be displayed in the box by using the CtrlVal(r) = command. This is useful for displaying text, numbers and messages. This control is not animated when touched but its reference number can be found using TOUCH(REF) and TOUCH(LASTREF) in the touch interrupts and any required animation can be done in MMBasic.

Text Box

`GUI TEXTBOX #ref, StartX, StartY, `*`Width, Height, FColour, BColour`*



This will draw a box with rounded corners. When the box is touched a QWERTY keyboard will appear on the screen as shown on the right. Using this virtual keyboard any text can be entered into the box including upper/lower case letters, numbers and any other characters in the ASCII character set. The new text will replace any text previously in the box.

`Ent` is the enter key, `Can` is the cancel key and will close the text box and return it to its original state, the triangle is the shift key, the `[ ]` key will insert a space and the `&12` key will select an alternate key selection with numbers and special characters (there are two sets of special characters and the shift key will switch between them).

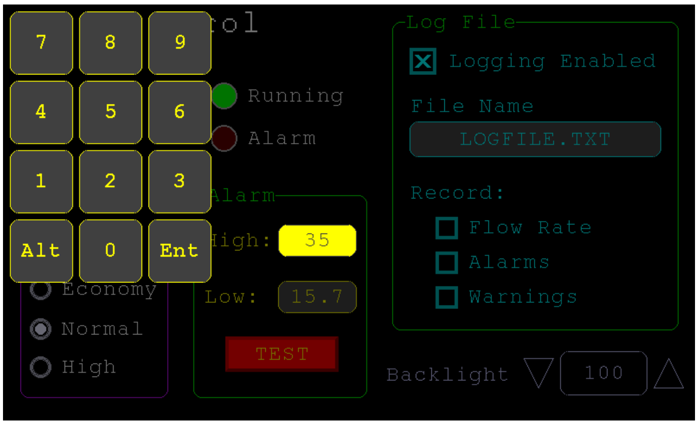
The displayed string can be set by assigning a string to the box using the CtrlVal(r) = command. The value of the control can also be set to a string starting with two hash characters (##) and in that case the string (without the leading two hash characters) will be displayed in the box with reduced brightness. This can be used to give the user a hint as to what should be entered (called "ghost text"). Reading the value of the control displaying ghost text will return an empty string. When a key is pressed the ghost text will vanish and be replaced with the entered text.

MMBasic will try to position the virtual keyboard on the screen to not obscure the text box that caused it to appear. A pen down interrupt will be generated when the keyboard is deployed and a key up interrupt will be generated when the Enter or Cancel keys are touched and the keyboard is hidden.

If necessary the virtual keyboard can be forced to appear without the control being touched with the command GUI TEXTBOX ACTIVATE and it can be dismissed by the program (same as touching the cancel button) with the command: GUI TEXTBOX CANCEL.

Number Box

`GUI NUMBERBOX #ref, StartX, StartY, `*`Width, Height, FColour, BColour`*



This will draw a box with rounded corners. When the box is touched a numeric keypad will appear on the screen as shown on the right. Using this virtual keypad any number can be entered into the box including a floating point number in exponential format. The new number will replace the number previously in the box.

The Alt key will select an alternative key selection and the other special keys are the same as with the text box.

The displayed number can also be set by assigning a number (float or integer) to the box using the CtrlVal(r) = command. Similar to the Text Box, the value of the control can set to a literal string with two leading hash characters (eg, "##Hint") and in that case the string (without the leading two characters) will be displayed in the box with reduced brightness. Reading this will return zero and when a key is pressed the ghost text will vanish.

MMBasic will try to position the virtual keypad on the screen to not obscure the number box that caused it to appear. A pen down interrupt will be generated when the keypad is deployed and a key up interrupt will be generated when the Enter key is touched and the keypad is hidden. Also, when the Enter key is touched the entered text will be evaluated as a number and the NUMBERBOX control redrawn to display this number.

Formatted Number Box

```
GUI FORMATBOX #ref, Format, StartX, StartY, Width, Height, FColour, BColour
```

This will draw a box with rounded corners. When the box is touched a numeric keypad will appear similar to a Number Box. The difference is that the Formatted Number Box will require the user to enter numbers according to a specific format for dates, time, etc. Invalid keys on the keypad will be disabled and the user will guided in their entry with guide text. This means that the programmer can be assured that the entry made by the user will always be in a fixed format.

The type of entry is controlled by the 'Format' argument as follows:

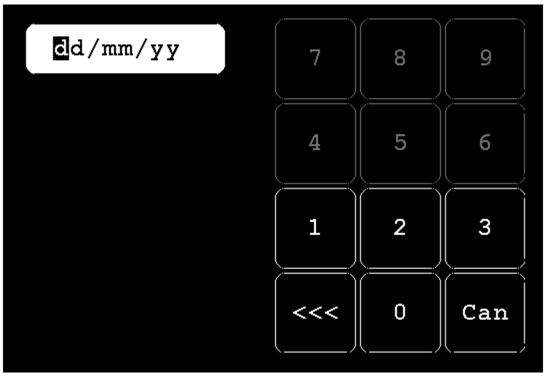
DATE1	Date in UK/Aust/NZ format (dd/mm/yy)
DATE2	Date in USA format (mm/dd/yy)
DATE3	Date in international format (yyyy/mm/dd)
TIME1	Time in 24 hour notation (hh:mm)
TIME2	Time in 24 hour notation with seconds (hh:mm:ss)
TIME3	Time in 12 hour notation (hh:mm AM/PM)
TIME4	Time in 12 hour notation with seconds (hh:mm:ss AM/PM)
DATETIME1	Both date (UK fmt) and time (12 hour) (dd/mm/yy hh:mm AM/PM)
DATETIME2	Both date (UK fmt) and time (24 hour) (dd/mm/yy hh:mm)
DATETIME3	Both date (USA fmt) and time (12 hour) (mm/dd/yy hh:mm AM/PM)
DATETIME4	Both date (USA fmt) and time (24 hour) (mm/dd/yy hh:mm)
LAT1	Latitude in degrees, minutes and seconds (d°` mm' ss" N/S)
LAT2	Latitude with seconds to one decimal place (dd° mm' ss.s" N/S)
LONG1	Longitude in degrees, minutes and seconds (ddd° mm' ss" E/W)
LONG2	Longitude with seconds to one decimal place (ddd° mm' ss.s" E/W)
ANGLE1	Angle in degrees and minutes (ddd° mm')

For example:

```
GUI FORMATBOX #1, DATE1, 300, 150, 200, 50
```

would create a data entry box and when it is touched a keypad will appear as shown on the right . Note that:

- The display box is filled with a guide string to prompt the user as to the data required.
- Because the day of the month can only start with a digit from 0 to 3 all other keys are disabled. This also happens with other numbers that have a limited range.
- The value of the control retrieved via CtrlVal(#1) is a string. As an example, if the user entered the date for the 8th of May 2020 the returned string would be "08/05/20" (ie, the UK/Aust/NZ format as specified by DATE1).



The value of the control can be pulled apart using the string functions or, in some cases, the string can be used directly. For example, if using the above format box to get a date from the user the Micromite's internal clock could then be directly set as follows:

```
DATE$ = CtrlVal(#1)
```

The RTC SETTIME command will accept a single string argument in the format of *dd/mm/yy hh:mm* so similarly the RTC time could be set as follows if the formatted box used DATETIME2 for 'Format':

```
RTC SETTIME CtrlVal(#1)
```

You can use the USA style DATETIME4 to get the date/time. In that case you would use this to set the RTC:

```
RTC SETTIME MID$(CtrlVal(#1),4,3) + LEFT$(CtrlVal(#1),2) + RIGHT$((CtrlVal(#1),9)
```

MMBasic will try to position the virtual keypad on the screen so as to not obscure the format box that caused it to appear. A pen down interrupt will be generated when the keypad is deployed and a key up interrupt will be generated when all the required data has been entered and the keypad is hidden.

Spin Box

```
GUI SPINBOX #ref, StartX, StartY, Width, Height, FColour, BColour, Step,
         Minimum, Maximum
```

This will draw a box with up/down icons on either end. When these icons are touched the number in the box will be incremented or decremented by the 'StepValue', holding down the touch will repeat at a fast rate. 'Minimum' and 'Maximum' set a limit on the value that can be entered. 'StepValue', 'Minimum' and 'Maximum' are optional and if not specified 'StepValue' will be 1 and there will be no limit on the number entered. A pen down interrupt will be generated every time up/down is touched or when automatic repeat occurs.

Caption

```
GUI CAPTION #ref, text$, StartX, StartY, Alignment, FColour, BColour
```

This will draw a text string on the screen. It is similar to the basic drawing command TEXT, the difference being that MMBasic will automatically dim this control if a keyboard or number pad is displayed.

'Alignment' is zero to three characters (a string expression or variable is also allowed) where the first letter is the horizontal alignment around X and can be L, C or R for LEFT, CENTER, RIGHT and the second letter is the vertical alignment around Y and can be T, M or B for TOP, MIDDLE, BOTTOM. A third character can be used to indicate the rotation of the text. This can be 'N' for normal orientation, 'V' for vertical text with each character under the previous running from top to bottom, 'I' the text will be inverted (ie, upside down), 'U' the text will be rotated counter clockwise by 90º and 'D' the text will be rotated clockwise by 90º. The default alignment is left/top with no rotation.

If the colours are not specified this control will use the colours set by the COLOUR command.

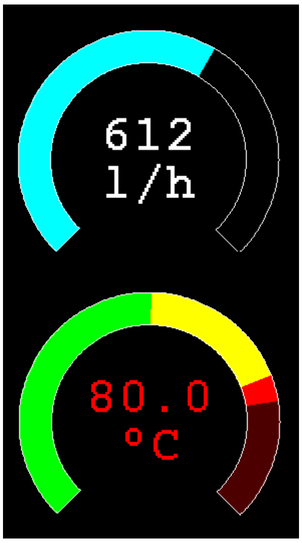
Circular Gauge

```
GUI GAUGE #ref, StartX, StartY, Radius, FColour, BColour, min, max,
nbrdec, units$, c1, ta, c2, tb, c3, tc, c4
```

This will define a graphical circular analogue gauge with a digital display in the centre showing the value and units. If specified the gauge will be coloured to provide a graphical indication of the signal level (eg, green for OK, yellow for warning, etc).

'StartX' and 'StartY' are the coordinates of the centre of the gauge while 'Radius' is the distance from the centre to the outer edge.

'min' is the value associated with the minimum value of the gauge and 'max' is the maximum value. When CtrlVal() is used to assign a value (floating point or integer) to the gauge the analogue portion of the gauge will be drawn to a length proportional to the range between 'min' and 'max'. At the same time the digital value will be drawn in the centre of the gauge using the current font settings (set with the FONT command). 'nbrdec' specifies the number of decimal places to be used in this display. Under the digital value the 'units$' will be displayed (this can be skipped or a zero length string used if not required).



Normally the analogue graph is drawn using the colour specified in 'Fcolour' however a multi colour gauge can be created using 'c1' to 'c4' for the colours and 'ta' to 'tc' for the thresholds used to determine when the colour will change.

Specifically, 'c1' is the colour to be used for values up to 'ta'. 'c2' is the colour to be used for values between 'ta' and 'tb', 'c3' is used for values between 'tb' and 'tc' and c4 is used for values above 'tc'. Colours and thresholds not required can be left off then list. For example, for a two colour gauge only 'c1', 'ta' and 'c2' need to be specified.

When colours and thresholds are specified the background of the gauge will be drawn with a dull version of the gauge colour at that level ("ghost colouring") so that the user can appreciate how close to the various thresholds the actual value is. Also the digital value displayed in the centre will also change to the colour specified by the current value.

If only one colour is required for the whole analogue graph it can be specified by just using 'c1' and leaving all the following parameters off.

Bar Gauge

`GUI BARGAUGE #ref, StartX, StartY, *width, height, FColour, BColour, min, max, c1, ta, c2, tb, c3, tc, c4*`

This will define either a horizontal or vertical bar gauge. The gauge can be coloured to provide a graphical indication of the signal level (eg, green for OK, yellow for warning, etc) and many bar graphs can be packed close together so that a number of values can be displayed simultaneously using a small amount of screen space (as shown in the image which consists of ten bar gauges).

If the width is less that the height the bar gauge will be drawn vertically with the analogue graph growing from the bottom towards the top. Otherwise, if the width is more that the height, it will be drawn horizontally with the analogue graph growing from the left towards the right. In both cases 'StartX' and 'StartY' reference the top left coordinate of the bar graph while 'width' is the horizontal width and 'height' the vertical height.

The bar graph does not have a digital display of its value but other than that the parameters are the same as for the circular gauge (described above).

'min' and 'max' specify the range of values for the bar and, if specified, 'c1' to 'c4' and 'ta' to 'tc' specify the colours and thresholds for the analogue bar image. Note that unlike the circular bar gauge a "ghost image" of the colours is not shown in the background.

As with the circular gauge, if only one colour is required for the whole gauge it can be specified by just using 'c1' and leaving all the following parameters off.

Area

`GUI AREA #ref, StartX, StartY, *Width, Height*`

This will define an invisible area of the screen that is sensitive to touch and will set TOUCH(REF) and TOUCH(LASTREF) accordingly when touched or released. It can be used as the basis for creating a custom control which is defined and managed by the BASIC program.

Interacting with Controls

Using the following commands and functions the characteristics of the on screen controls can be changed and their value retrieved.

- = CTRLVAL(#ref)
  This is a function that will return the current value of a control. For controls like check boxes or switches it will be the number one (true) indicating that the control has been selected by the user or zero (false) if not. For controls that hold a number (eg, a SPINBOX) the value will be the number (normally a floating point number). For controls that hold a string (eg, TEXTBOX) the value will be a string. For example:
  ```
  PRINT "The number in the spin box is: " CTRLVAL(#10)
  ```

- CTRLVAL(#ref) =
  This command will set the value of a control. For off/on controls like check boxes it will override any touch input and can be used to depress/release switches, tick/untick check boxes, etc. A value of zero is off or unchecked and non zero will turn the control on. For a LED it will cause the LED to be illuminated or turned off. It can also be used to set the initial value of spin boxes, text boxes, etc. For example:
  ```
  CTRLVAL(#10) = 12.4
  ```

- GUI FCOLOUR colour, #ref1 [, #ref2, #ref3, etc]
  This will change the foreground colour of the specified controls to 'colour'. This is especially handy for a LED which can change colour.

- GUI BCOLOUR colour, #ref1 [, #ref2, #ref3, etc]
  This will change the background colour of the specified controls to 'colour'.

- = TOUCH(REF)
  This is a function that will return the reference number of the control currently being touched. If no control is currently being touched it will return zero.

- = TOUCH(LASTREF)
  This is a function that will return the reference number of the control that was last touched.

- GUI DISABLE #ref1 [, #ref2, #ref3, etc]
  This will disable the controls in the list. Disabled controls do not respond to touch and will be displayed dimmed.   The keyword ALL can be used as the argument and that will disable all controls on the currently displayed page. For example:
  `GUI DISABLE ALL`

- GUI ENABLE #ref1 [, #ref2, #ref3, etc]
  This will undo the effects of GUI DISABLE and restore the controls in the list to normal operation. The keyword ALL can be used as the argument for all controls on the currently displayed page.

- GUI HIDE #ref1 [, #ref2, #ref3, etc]
  This will hide the controls in the list. Hidden controls will not respond to touch and will be replaced on the screen with the current background colour. The keyword ALL can be used as the argument.

- GUI SHOW #ref1 [, #ref2, #ref3, etc]
  This will undo the effects of GUI HIDE and restore the controls in the list to being visible and capable of normal operation. The keyword ALL can be used as the argument for all controls.

- GUI DELETE #ref1 [, #ref2, #ref3, etc]
  This will delete the controls in the list. This includes removing the image of the control from the screen using the current background colour and freeing the memory used by the control. The keyword ALL can be used as the argument and that will cause all controls to be deleted.

MsgBox()

The MsgBox() function will display a message box on the screen and wait for user input. While the message box is displayed all controls will be disabled so that the message box has the complete focus.

The syntax is:

```
r = MsgBox(message$, button1$ [, button2$ [, button3$ [, button4$]]])
```

All arguments are strings. 'message$' is the message to display. This can contain one or more tilde characters (~) which indicate a line break. Up to 10 lines can be displayed inside the box. 'button1$' is the caption for the first button, 'button2$' is the caption for the second button, etc. At least one button must be specified and four is the maximum. Any buttons not included in the argument list will not be displayed.

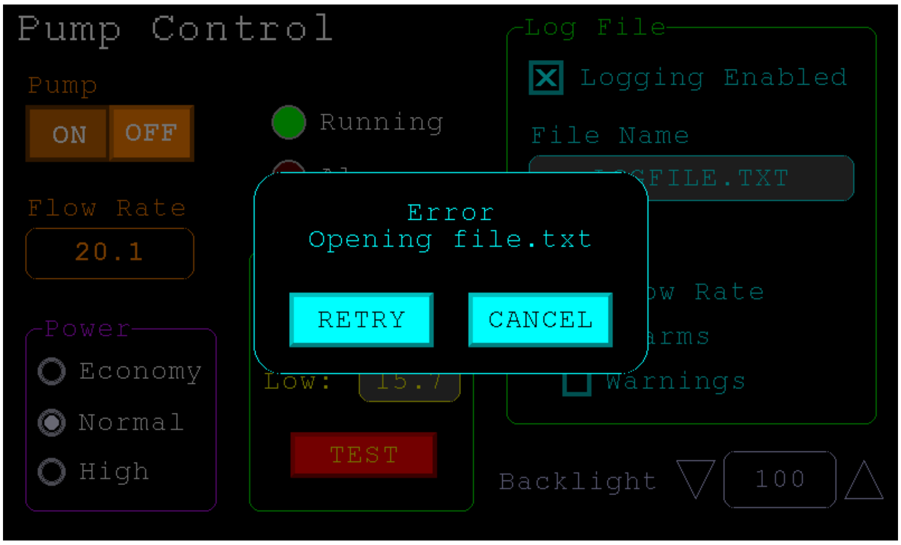
The font used will be the default font set using the FONT command and the colours used will be the defaults set by the COLOUR command. The box will be automatically sized taking into account the dimensions of the default font, the number of lines to display and the number of buttons specified.

When the user touches a button the message box will erase itself, restore the display (eg, re enable all controls) and return the number of the button that was touched (the first button will return 1, the second 2, etc). Note that, unlike all other GUI controls the BASIC program will stop running while the message box is displayed, interrupts however will be honoured and acted upon.

To illustrate the usage of a message box will the following program fragment will attempt to open a file and if an error occurs the program will display an error message using the MsgBox() function. The message has two lines and the box has two buttons for retry and cancel.

```
Do
  On Error Skip
  Open "file.txt" For Input As #1
  If MM.ErrNo <> 0 Then
    if MsgBox("Error~Opening file.txt","RETRY","CANCEL") = 2 Then Exit Sub
  EndIf
Loop While MM.ErrNo <> 0
```

This would be the result if the file "file.txt" did not exist:



Error
Opening file.txt

Advanced Graphics Programming Techniques

When programming using the advanced GUI commands implemented on the Micromite Plus there are a number of hints and techniques to consider that will make it easier to develop and maintain your program.

The User Should Be In Control

Traditional character based programs are normally in control of the interaction with the user. For example, the program may display a menu and prompt the user to select an action. If the user selects an invalid option the program would display an error message and display the menu options again.

However graphical based programs such as that created using the advanced GUI commands are different. Usually the program just starts running doing what it normally does (eg, control temperature, speed, etc) and it is the user's job to select and change parameters without being prompted. This is a different way of programming and is often hard for the traditional programmer to get used to this different technique.

As an example, consider a program that is to control a cutting device. The traditional program would prompt the user for the speed and cutting time. When both have been entered the program would prompt to start the cutting cycle. However, a graphical based program would display two number boxes where the user could enter the speed and time along with a run button. The number boxes could be filled with default values and the run button would be disabled if the user entered an invalid speed or time. When the run button is touched the cutting cycle would start.

A good example of this type of graphical interface is the dialogue box used on a Windows/IOS/Android computer to set the time and date. It displays a number of boxes where the user can enter the date/time along with an OK button that tells the program to accept the data entered. At no time is the user forced to make a selection from a menu. Also, the current time/date is already displayed in the entry boxes so the user can accept them as the default if they wanted to do so.

If you need some inspiration as to how your graphical program should look and feel check your nearest GUI based operating system to see how they operate.

Program Structure

Typically a program would start by defining the controls (which MMBasic will draw on the screen), then it would set the defaults and finally it would drop into a continuous loop where it would do whatever job it was design to do. For example, take the case of a simple controller for a motor where the user could select the speed and cause the motor to run by pressing an on screen button.

To implement this function the program would look something like this:

```
GUI CAPTION #1, "Speed (rpm)", 200, 50       ' label the number box
GUI NUMBERBOX #2, 200, 100, 150, 40          ' define and draw the number box
CtrlVal(#2) = 100                            ' default value for the speed
GUI BUTTON #3, "RUN", 200, 350, 0, RGB(red)  ' define and draw the RUN button

DO                                           ' this runs in a loop forever
  IF CtrlVal(#3)<10 OR CtrlVal(#3)>200 THEN  ' check the speed setting
    GUI DISABLE #3                           ' disable RUN if it is invalid
  ELSE                                       ' otherwise
    GUI ENABLE #3                            ' enable the RUN button
  ENDIF

  IF CtrlVal(#3) = 1 THEN                    ' if the button is pressed
    SetMotorSpeed CtrlVal(#2)                ' make the motor run
  ELSE                                       ' otherwise the button is up
    SetMotorSpeed 0                          ' therefore set motor speed to zero
  ENDIF
LOOP
```

Note that the user is not prompted to do anything; the program just sits in a loop reacting to the changes that the user has made to the controls (ie, the user is in control).

Disable Invalid Controls

As in the above example, disabling a control will prevent a user from using it and MMBasic will redraw it in a dull colour to indicate that it is not available. This is the equivalent of an error message in a traditional text based program and is more user friendly than popping up a message box which must be dismissed before anything else can be done.

There are many times that a control could be invalid, for example when an input is not ready or simply when an option or action does not apply. Later, when the control becomes valid you can use the GUI ENABLE command to return it to use. Another example is when a GUI NUMBERBOX keypad is displayed MMBasic will automatically disable all other controls on the screen so that it is obvious to the user where their input is required.

Disabling a control still leaves it on the screen, so that the user knows that it is there but it will be dimmed and will not respond to touch. Not responding to touch also means that the user cannot change it and an interrupt will not be generated when it is touched. This is handy for you the programmer because you do not have to check if the control is valid before acting on it.

Use Constants for Control Reference Numbers

The advanced controls use a reference number to identify the control. To make it easy to read and maintain your program you should define these numbers as constants with easy to recognise names.

For example, in the following program fragment `MAIN_SWITCH` is defined as a constant and this constant is used wherever the reference number for that control is required:

```
CONST MAIN_SWITCH = 5
CONST ALARM_LED = 6
'…
GUI SWITCH MAIN_SWITCH, "ON|OFF", 330, 50, 140, 50,  RGB(white), RGB(blue)
GUI LED ALARM_LED, 215, 220,30, RGB(red)
'…
IF CtrlVal(MAIN_SWITCH) = 0 THEN …   ' for example turn the pump off
IF ALARM THEN CtrlVal(ALARM_LED) = 1
```

It is much easier to remember what `MAIN_SWITCH` does than remembering what control the number 5 refers to. Also, when you have a lot of controls it is much easier to renumber the controls when all their numbers are defined at the one place at the start of the program.

By default the reference number must be a number between 1 and 100 however the upper limit can be changed with the OPTION CONTROL command. Increasing the number will consume more RAM and decreasing it will recover some RAM.

The Main Program Is Still Running

It is important to realise that your main BASIC program is still running while the user is interacting with the GUI controls. For example, it will continue running even while a user holds down an on screen switch and it will keep running while the virtual keyboard is displayed as a result of touching a TEXTBOX control.

For this reason your main program should not arbitrarily update touch sensitive screen controls, because they might change the on screen image while the user is using them (with undefined results). Normally when a BASIC program using GUI controls starts it will initialise controls such as a SPINBOX, NUMBERBOX and TEXTBOX to some initial value but from then on the main program should just read the value of these controls – it is the responsibility of the user to change these, not your program.

However, if you do want to change the value of such an on-screen control you need some mechanism to prevent both the program and the user making a change at the same time. One method is to set a flag within the key down interrupt to indicate that the control should not be updated during this time. This flag can then be cleared in the key up interrupt to allow the main program to resume updating the control.

Note that this discussion only applies to controls that respond to touch. Controls such as CAPTION can be changed at any time by the main program and often are.

Use Interrupts and SELECT CASE Statements

Everything that happens on a screen using the advanced controls will be signalled by an interrupt, either touch down or touch up. So, if you want to do something immediately when a control is changed, you should do it in an interrupt. Mostly you will be interested in when the touch (or pen) is down but in some cases you might also want to know when it is released.

Because the interrupt is triggered when the pen touches any control or part of the screen you need to discover what control was being touched. This is best performed using the TOUCH(REF) function and the SELECT CASE statement.

For example, in the following fragment the subroutine PenDown will be called when there is a touch and the function TOUCH(REF) will return the reference number of the control being touched. Using the SELECT CASE the alarm LED will be turned on or off depending on which button is touched. The action could be any number of things like raising an I/O pin to turn on a physical siren or printing a message on the console.

```
CONST ALARM_ON = 15
CONST ALARM_OFF = 16
CONST ALARM_LED = 33
GUI INTERRUPT PenDown
'…
GUI BUTTON ALARM_ON, "ALARM ON ", 330, 50, 140, 50, RGB(white), RGB(blue)
GUI BUTTON ALARM_OFF, "ALARM OFF ", 330, 150, 140, 50, RGB(white), RGB(blue)
GUI LED ALARM_LED, 215, 220, 30, RGB(red)
'…
DO : LOOP    ' the main program is doing something

' this sub is called when touch is detected
SUB PenDown
  SELECT CASE TOUCH(REF)
    CASE ALARM_ON
      CtrlVal(ALARM_LED) = 1
    CASE ALARM_OFF
      CtrlVal(ALARM_LED) = 0
  END SELECT
END SUB
```

The SELECT CASE can also test for other controls and perform whatever actions are required for them in their own section of the CASE statement.

The important point is that the maintenance of the controls (eg, responding to the buttons and turning the alarm LED off or on) is done automatically without the main program being involved – it can continue doing something useful like calculating some control response, etc.

Touch Up Interrupt

In most cases you can process all user input in the touch down interrupt. But there are exceptions and a typical example is when you need to change the characteristics of the control that is being touched. For example, if you wanted to change the foreground colour of a button from white to red when it is down. When it is returned to the up state the colour should revert to white.

Setting the colour on the touch down is easy. Just define a touch down interrupt and change the colour in the interrupt when that control is touched. However, to return the colour to white you need to detect when the touch has been removed from the control (ie, touch up). This can be done with a touch up interrupt.

To specify a touch up interrupt you add the name of the subroutine for this interrupt to the end of the GUI INTERRUPT command. For example:

```
GUI INTERRUPT IntTouchDown, IntTouchUp
```

Within the touch up subroutine you can use the same structure as in the touch down sub but you need to find the reference number of the last control that was touched. This is because the touch has already left the screen and no control is currently being touched. To get the number of the last control touched you need to use the function TOUCH(LASTREF)

The following example shows how you could meet the above requirement and implement both a touch down and a touch up interrupt:

```
SUB IntTouchDown
  SELECT CASE TOUCH(REF)
    CASE ButtonRef
      GUI FCOLOUR RGB(RED), ButtonRef
  END SELECT
END SUB

SUB IntTouchUp
  SELECT CASE TOUCH(LASTREF)
    CASE ButtonRef
      GUI FCOLOUR RGB(WHITE), ButtonRef
  END SELECT
END SUB
```

Keep Interrupts Very Short

Because a touch interrupt indicates a request by the user it is tempting to do some extensive programming within an interrupt. For example, if the touch indicates that the user wants to send a message to another controller it sounds logical to put all that code within the interrupt. But this is not a good idea because the Micromite Plus cannot do anything else while your program is processing the interrupt and sending a message could take many milliseconds.

Instead your program should update a global variable to indicate what is requested and leave the actual execution to the main program. For example, if the user did touch the "send a message" button your program could simply set a global variable to true. Then the main program can monitor this variable and if it changes perform the logic and communications required to satisfy the request.

Remember the commandment "Thou shalt not hang around in an interrupt”.

Multiple Screens

Your program might need a number of screens with differing controls on each screen. This could be implemented by deleting the old controls and creating new ones when the screen is switched. But another way to do this is to use the GUI SETUP and PAGE commands. These allow you to organise the controls onto pages and with one simple command you can switch pages. All controls on the old page will be automatically hidden and controls on the new page will be automatically shown.

To allocate controls to a page you use the GUI SETUP nn command where nn refers to the page in the range of 1 to 32. When you have used this command any newly created controls will be assigned to that page. You can use GUI SETUP as many times that you want. For example, in the program fragment below the first two controls will be assigned to page 1, the second to page 2, etc.

```
GUI SETUP 1
GUI Caption #1, "Flow Rate", 20, 170,, RGB(brown),0
GUI Displaybox #2, 20, 200, 150, 45

GUI SETUP 2
GUI Caption #3, "High:", 232, 260, LT, RGB(yellow)
GUI Numberbox #4, 318, 6,90, 12, RGB(yellow), RGB(64,64,64)

GUI SETUP 3
GUI Checkbox #5, "Alarms", 500, 285, 25
GUI Checkbox #6, "Warnings", 500, 325, 25
```

By default only the controls setup as page 1 will be displayed and the others will be hidden.

To switch the screen to page 3 all you need do is use the command `PAGE 3`. This will cause controls #1 and #2 to be automatically hidden and controls #5 and #6 to be displayed. Similarly `PAGE 2` will hide all except #3 and #4 which will be displayed.

You can specify multiple pages to display at the one time, for example, `PAGE 1,3` will display both pages 1 and 3 while hiding page 2. This can be useful if you have a set of controls that must be visible all the time. For example, `PAGE 1,2` and `PAGE 1,3` will leave the controls on page 1 visible while the others are switched on and off.

It is perfectly legal for a program to modify controls on other pages even though they are not displayed at the time. This includes changing the value and colours as well as disabling or hiding them. When the display is switched to their page the controls will be displayed with their new attributes.

It is possible to place the PAGE commands in the touch down interrupt so that pressing a certain control or part of the screen will switch to another page.

Note that when ALL is used for the list of controls in commands such as GUI ENABLE ALL this only refers to the controls on the pages that are currently selected for display. Controls on other pages will be unaffected.

All programs start with the equivalent of the commands GUI SETUP 1 and PAGE 1 in force. This means that if the GUI SETUP and PAGE commands are not used the program will run as you would expect with all controls displayed.

A typical usage of the PAGE command is shown below. Two buttons (which are always displayed) allow the user to select between the first page and the second page. The switch is done in the touch down interrupt.

```
GUI SETUP 1
GUI Button #10, "SELECT PAGE ONE", 50, 100, 150, 30, RGB(yellow), RGB(blue)
GUI Button #11, "SELECT PAGE TWO", 50, 140, 150, 30, RGB(yellow), RGB(blue)

GUI SETUP 2
GUI Caption #1, "Displaying First Page", 20, 20

GUI SETUP 3
GUI Caption #2, "Displaying Second Page", 20, 50

Page 1, 2
GUI INTERRUPT TouchDown
Do
   ' the main program loop
Loop

Sub TouchDown
  If Touch(REF) = 10 Then Page 1, 2
  If Touch(REF) = 11 Then Page 1, 3
End Sub
```

Multiple Interrupts

With many screen pages the interrupt subroutine could get long and complicated. To work around that it is possible to have multiple interrupt subroutines and switch dynamically between them as you wish (normally after switching pages). This is done by redefining the current interrupt routines using the GUI INTERRUPT command.

For example, this program fragment uses different interrupt routines for pages 4 and 5 and they are specified immediately after switching the pages.

```
PAGE 4
GUI INTERRUPT P4keydown, P4keyup
...
PAGE 5
GUI INTERRUPT P5keydown, P5keyup
...
```

Using Basic Drawing Commands

There are two types of objects that can be on the screen. These are the GUI controls and the basic drawing objects (PIXEL, LINE, TEXT, etc). Mixing the two on the screen is not a good idea because MMBasic does not track the position of the basic drawing objects and they can clash with the GUI controls.

As a result, unless you are prepared to do some extra programming, you should use either the GUI controls or the basic drawing objects – but you should not use both. So, for example, do not use TEXT but use GUI CAPTION instead. If you only use GUI controls MMBasic will manage the screen for you including erasing and redrawing it as required, for example when a virtual keyboard is displayed.

Note that the CLS command (used to clear the screen) will automatically set any GUI controls on the screen to hidden (ie, it does a GUI HIDE ALL before clearing the screen).

The main problem with mixing basic graphics and GUI controls occurs with the Text Box, Formatted Box and Number Box controls which display a virtual keyboard. This can erase any basic graphics and MMBasic will not know to restore them when the keyboard is removed. If you want to mix basic graphics with GUI controls you should:

- Intercept the touch down interrupt for the Text Box, Formatted Box and Number Box controls as that indicates that a virtual keyboard is about to be displayed and that will give you the opportunity to redraw your non GUI basic graphics in anticipation of this event (for example, draw them in a dimmed state to appear as if they are disabled).
- Intercept the touch up interrupt for the same controls as that indicates that the virtual keyboard has been removed and you could then redraw any non GUI graphics in their original state.

The following example demonstrates this technique. On a 5" or 7" display it initially draws a box filled with bright blue using the basic drawing commands. Then, when the number pad is about to pop up it will redraw the box in a dull colour. Finally, when the keypad is removed from the screen the pen up interrupt will redraw the box in its original colours.

```
GUI INTERRUPT TouchDownInterrupt, TouchUpInterrupt
BOX 400, 250, 300, 200,  , RGB(WHITE), RGB(BLUE)
GUI NUMBERBOX 1, 318,100,90,40,RGB(YELLOW),RGB(64,64,64)
DO : LOOP

SUB TouchDownInterrupt
  IF TOUCH(REF) = 1 THEN BOX 400, 250, 300, 200,  , RGB(128,128,128), RGB(0,0,128)
END SUB

SUB TouchUpInterrupt
  IF TOUCH(LASTREF) = 1 THEN BOX 400, 250, 300, 200,  , RGB(WHITE), RGB(BLUE)
END SUB
```

Overlapping Controls

Controls can be defined to overlap on the display, this mostly occurs with GUI AREA which, as an example, you might want to capture a touch that was intended for (say) a GUI BUTTON. This will allow you to create your own animation for the button rather than that provided by MMBasic. In this case the control that you wish to respond to the touch (ie, GUI AREA) should have a lower reference number (ie, `#ref`) than the control that it is covering (ie, the GUI BUTTON). This is because when the screen is touched MMBasic will check the current list of active controls starting with control number 1 and working upwards. When a match is made MMBasic will take the appropriate action and terminate the search. This results in the lower numbered control effectively masking out a higher numbered control covering the same screen area as the touched location.

Console Input/Output

In the Micromite all programming is done through the console. At the console you can enter commands, edit programs, run programs and observe the output of your program – including error messages!

The Micromite Plus has three console input/outputs. These are the serial console, serial emulation over USB and an optional PS2 keyboard and LCD display. All of these operate in parallel, anything received from any of the inputs is placed in the input queue for the interpreter or your program to read and anything outputted by your program or the interpreter will be sent to all three devices (if they are connected).

Serial Console

This is the traditional method of communicating with a Micromite and it is turned on by default when the Micromite firmware is programmed into the chip.

The default baud rate is 38400 and the performance of the editor and the speed of displaying text can be improved considerably by selecting a higher baud rate (see the OPTION BAUDRATE command in the in the *Micromite User Manual*).

If the serial console is not required it can be disabled. This allows the two I/O pins previously used by the console to be used as general I/O pins or as a fourth serial port (COM4:). The command to disable the serial console is:

```
   OPTION CONSOLE OFF
```

Note that this command must be issued at the command prompt (not within a program) and when used it will cause the Micromite Plus to restart. As a side effect this will cause any USB connection to be reset.

This option will be remembered even if the power is cycled. The serial console can be restored with the command `OPTION CONSOLE ON`.

USB Console

See the heading "Typical Circuit" towards the start of this manual for details of the USB connections.

There is nothing that you need to do on the Micromite Plus to use the USB console. Just plug the USB cable from the Micromite Plus into your host computer and MMBasic will automatically create a virtual serial port over USB so that you can communicate with it from a Windows, Linux or Macintosh computer using nothing more than the USB port. Note that the CPU speed must be 20MHz or more.

The communications protocol used is the CDC (Communication Device Class) protocol and there is native support for this in Windows 10, Linux (the cdc-acm driver) and Apple OS/X. Macintosh users can refer to the document "Using Serial Over USB on the Macintosh" on http://geoffg.net/maximite.html.

If you are using Windows you will need to install the Windows Serial Port Driver (available from http://geoffg.net/maximite.html#Downloads). Full instructions are included in the download and when you have finished you should see the connection in Device Manager as a numbered communications port.

You can then use a terminal emulator such as Tera Term to connect to this communications port and it will work the same as if you were using a hardwired serial console. In Tera Term you do not have to specify a baud rate because the USB connection will run as fast as it can.

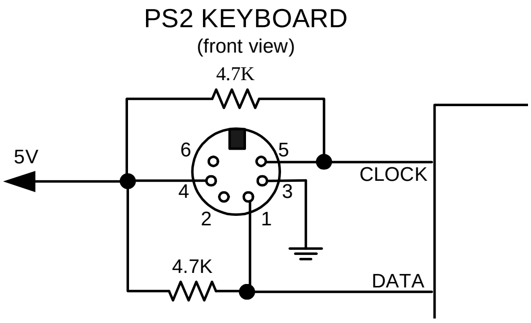
Be aware however that the USB connection will be reset if the Micromite Plus is reset and there are many things that can do this including the watchdog timer, the command CPU RESET and so on. For this reason the USB console is recommended only for situations where a stable program is running and a reset is not expected. For other situations it is recommended that the console be accessed via a USB to serial bridge connected to the serial console pins.

Another aspect to be aware of is that you should not use the CPU SLEEP command while a USB session is active. The results will be undefined but could possibly cause the Micromite Plus to crash and reboot.

PS2 Keyboard

On the Micromite Plus you can attach a PS2 keyboard and, if you are using a SSD1963 based LCD panel, display the output of the interpreter on the LCD. This turns the Micromite Plus into a completely self contained computer with its own keyboard and display. Using the built in colour coded editor programs can be entered, edited and run without requiring another computer.

The connection diagram for the keyboard is shown on the right. The Micromite Plus enables weak pullups on the clock and data lines so the 4.7K resistors shown in the diagram are optional and for most keyboards there will be no ill effects if they are omitted. Refer to the pinout diagrams in section "Micromite Plus Connections" of this manual for the I/O pin numbers to use with the keyboard.



Before the keyboard can be used it must first be enabled by specifying the language of the keyboard:

```
   OPTION KEYBOARD language
```

Where ‘language’ is a two character code such as US for the standard keyboard used in the USA, Australia and New Zealand. Other keyboard layouts that can be specified are United Kingdom (UK), French (FR), German (GR), Belgium (BE), Italian (IT) or Spanish (ES). Note that the non US layouts map some of the special keys present on these keyboards but the corresponding special character will not display as they are not part the standard Micromite fonts (another character will be used instead).

This command configures the I/O pins dedicated to the keyboard and initialises it for use. As with the similar commands for TOUCH, etc this option will be saved in flash memory and automatically applied on power up. If you want to remove the keyboard you can do this with the OPTION KEYBOARD DISABLE command.

LCD Display as the Console Output

The keyboard can be used on its own as an alternative input method but it works particularly well when the LCD display panel is used as the console output. The LCD must be one of the SSD1963 versions in the landscape or reverse landscape orientation and it must be first configured using OPTION LCDPANEL.

To enable the output to the LCD panel you should use the following command:

```
   OPTION LCDPANEL CONSOLE [font [, fc [, bc [, blight]]]
```

'font' is the default font, 'fc' is the default foreground colour, 'bc' is the default background colour and 'blight' is the default backlight brightness (2 to 100). These settings are saved in flash and are used to configure MMBasic at power up. They are all optional and default to font 2, white, black and 100%.

Colour coding in the editor (see below) is also turned on by this command (OPTION COLOURCODE OFF will turn it off again). To disable using the LCD panel as the console the command is OPTION LCDPANEL NOCONSOLE.

Used with a PS2 keyboard this option turns the Micromite Plus into a self contained computer with its own keyboard and display. Rather like a modern version of the Maximite (see http://geoffg.net/maximite.html).

Miscellaneous Features

Real Time Clock

The I/O pins used for the Real Time Clock (RTC) can be set with the OPTION RTC command. This will define a private I^{2}C interface to the RTC and free up the main I2C interface for other uses.

This command also causes MMBasic to automatically retrieve the time and date from the RTC on power up and set its internal clock accordingly. This can be useful when the Micromite Plus is being used as a general purpose computer with a keyboard and a SSD1963 display as the console.

If the I/O pins specified are the same as the normal I^{2}C interface pins (ie, 43 and 44 on the 64-pin chip) the normal I^{2}C interface will be used to get the time and the time will also be automatically retrieved on startup.

Serial Interface

The Micromite Plus has built in support for up to four serial interfaces. COM1, COM2 and COM3 are available as standard. When the serial console is disabled (OPTION CONSOLE OFF) the I/O pins freed by this command can be opened as a fourth serial port (COM4:).

Note that using OPTION CONSOLE OFF will cause a restart of MMBasic so it can only be used at the console prompt. Also, the interrupt feature (number of characters in the buffer or special received character) cannot be used on COM4: .

All serial ports on the Micromite Plus can operate at high speed (up to 1M baud) at any CPU speed and support the INV, OC and S2 options. In addition COM1 supports the DE and 9BIT options (for RS485) as described in the Micromite User Manual.

SPI Interface

The Micromite Plus has built in support for two SPI interfaces. The commands to control these interfaces use the identifier SPI for the first SPI port and SPI2 for the second port. All commands and functions that can be used on the first port (SPI) as described in the Micromite User Manual can be used on the second by using the identifier SPI2. These are:

- SPI2 OPEN
- SPI2 WRITE
- SPI2 READ
- = SPI2(args, …)
- SPI2 CLOSE

SPI based displays, the touch controller and the SD Card interface (if implemented) will all use the second SPI interface (SPI2). If any of these features are enabled SPI2 will be unavailable to BASIC programs (which should use the first SPI channel instead).

Upgrading Your BASIC Program in the Field

Often it is desirable to send an upgraded version of your BASIC program to a user and let them load it under control of the program already running on the Micromite Plus. This can be easily accomplished with the command:

```
   LOAD "filename.bas", R
```

Where *filename.bas* is the name of the upgraded BASIC file on the SD card. This will load the BASIC program into the Micromite's program memory and immediately restart the CPU and run the new program.

Your program could execute this command when the user touched a screen button –or- it could check once every minute for that file name and, if found, load and run it. Then, all you have to do is send the updated program (on an SD card) to your user to initiate an upgrade. Easy.

Examples

Basic Explore 64 Configuration

To use the USB feature of the Explore 64 board you should check the requirements of your operating system (see the section *USB Console* above). Then it should be simply a case of plugging the Explorer 64 USB into your host computer, starting Tera Term or a similar terminal emulator and connecting to the virtual serial port created by the Micromite Plus on your computer.

To use the SD Card on the Explore 64 board you should run the following command at the command prompt:

```
OPTION SDCARD 12, 14
```

To test the SD command you can run the command FILES which should list the files on your SD card.

SSD1963 Based Display Connection

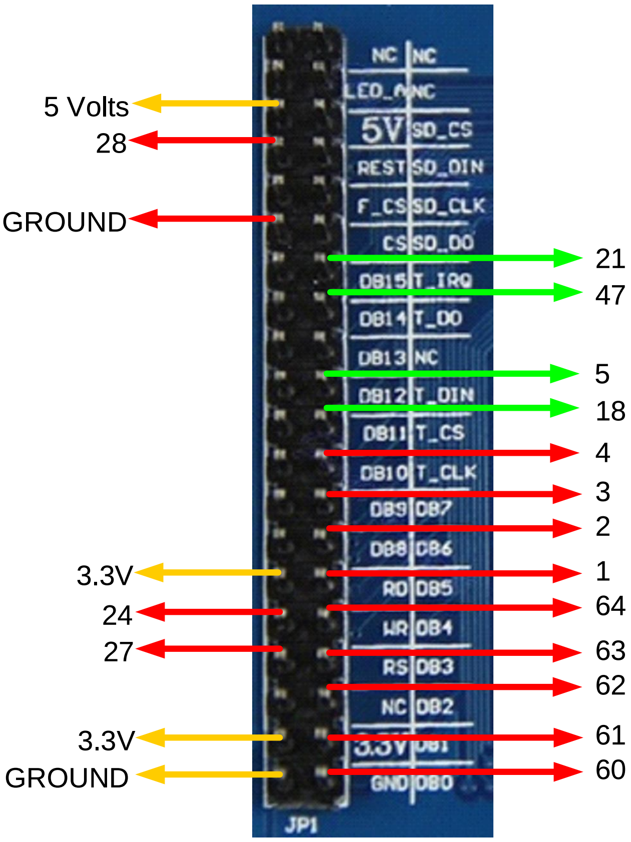
First, ensure that the jumper on the SSD1963 controller board is moved from the pair of solder pads marked LED-A to the pair marked 1963-PWM. This will place the backlight brightness under the control of SSD1963 chip (see "Connecting an SSD1963 Based LCD Panel" earlier in this manual).

If the board does not have these jumpers you will have to control the brightness via the LED-A pin as described in the above referenced section.

Next, connect the Explore 64 I/O pins to the SSD1963 display connector as shown in the diagram to the right. The power supply connections are shown in yellow, the SSD1963 controller connections are in red and the touch controller in green. Note that the touch Chip Select signal (pin 14) must be configured in MMBasic when using the SD card on the Explore 64 board. Without this the pin will float causing the touch controller to mistakenly respond to commands intended for the SD card.

You need to configure MMBasic for the display. An example is:

```
OPTION LCDPANEL SSD1963_7, L
```



This will configure the display as a 7" LCD panel in the landscape orientation. If your display is not the 7" version you should change the display type to SSD1963_4 or SSD1963_5 to suit your display.

To check that the LCD display panel is working correctly you can test it with the command:

```
GUI TEST LCDPANEL
```

You should see a rapid sequence of circles being drawn. Press the space bar to terminate the test.

Next, connect a pizeo buzzer from pin 50 of the Micromite Plus to ground (pin 50 has a 30mA drive capability and this should be enough to operate most pizeo buzzers). This will be used be used to generate a click sound when controls are touched, it is optional but the audible feedback makes using the advanced controls more intuitive.

The touch controller must be made known to MMBasic and the following gives an example:

```
OPTION TOUCH 18, 21, 50
```

This specifies that the touch controller's chip select is on pin 18, IRQ is on pin 21, and pin 50 is the click output.

To verify the configuration you can use the command OPTION LIST to list all options that have been set including the configuration of the LCD panel and touch input.

The touch controller then needs to be calibrated. To do this, enter this command and follow the on screen prompts which will request a touch on all four corners of the display:

```
   GUI CALIBRATE
```

Finally, you can test the touch feature with the command:

```
   GUI TEST TOUCH
```

When you touch the screen a white mark should appear exactly under the location touched. You can even draw on the screen to test your artistic skills !!

Keyboard and LCD Console

If you want to use the Micromite Plus and the SSD1963 display panel as a stand alone computer you can connect a keyboard and send the console output to the LCD panel.

To connect the keyboard follow the connections listed in the section "Console Input/Output". The PS2 clock signal (pin 5 on the DIN connector) should connect to pin 54 on the Micromite Explore 64 and the data signal (pin 1 on the DIN connector) should connect to pin 55. The keyboard should also be connected to +5V and ground.

Use the following command to configure the standard US layout and enable the keyboard:

```
   OPTION KEYBOARD US
```

You can also direct the console output to the LCD panel with the command:

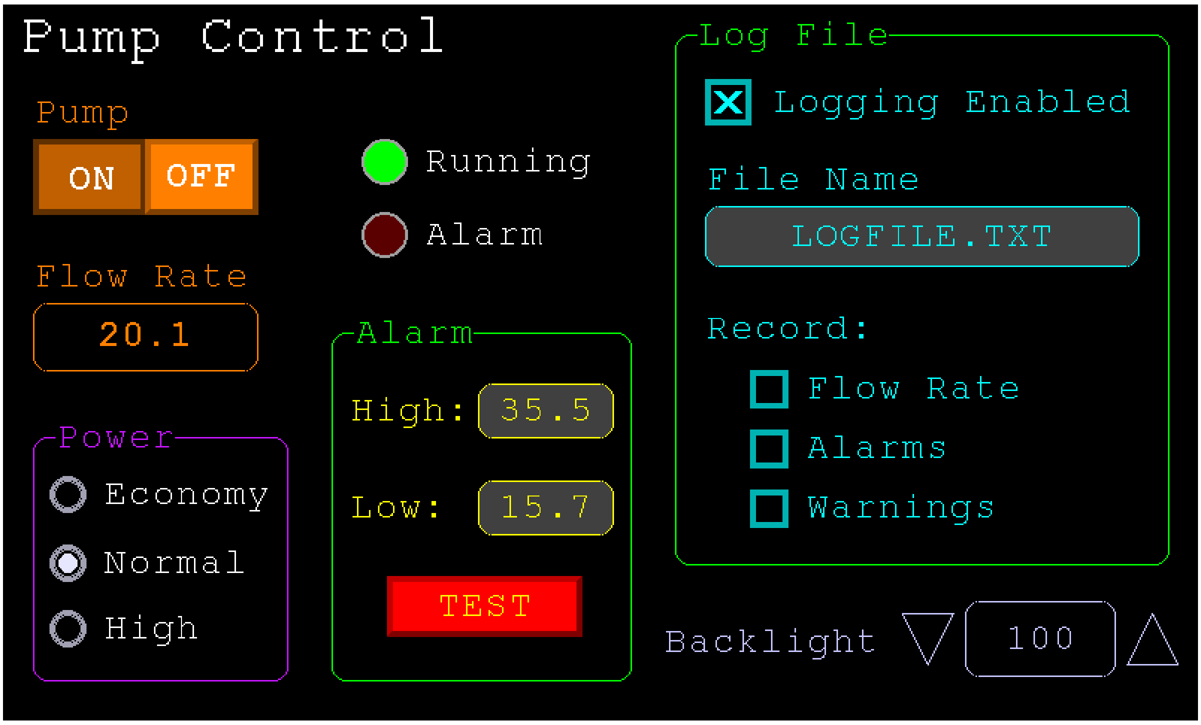
```
   OPTION LCDPANEL CONSOLE
```

These options will be retained even when the power is removed so you can disconnect the serial or USB console and use the keyboard and LCD panel as a self contained computer programmed in the BASIC language (rather like the TRS-80 or Apple II of yesterday).

Example Program

As a test you can enter the following "Pump Control" demonstration program as shown in this YouTube video: https://youtu.be/j12LidkzG2A. It will draw a selection of advanced controls as shown below.

These controls are active so that you can test how they work.



Pump Control

Flow Rate 20.1

Power: ○ Economy ● Normal ○ High

● Running ● Alarm

Alarm High: 35.5 Low: 15.7

Log File ☒ Logging Enabled

File Name LOGFILE.TXT

Record: □ Flow Rate □ Alarms □ Warnings

Backlight 100

Note that this demonstration expects a 800 x 480 pixel LCD panel in landscape orientation with touch (ie, a 5”, 7" or 8" SSD1963 based panel).

```
'''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''
' Demonstration program for the Micromite+
' It does not do anything useful except demo the various controls
'
' Geoff Graham, October 2015
'''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''''

Option Explicit
Dim ledsY
Colour RGB(white), RGB(black)

' reference numbers for the controls are defined as constants
Const c_head = 1, c_pmp = 2, sw_pmp = 3, c_flow = 4, tb_flow = 5
Const led_run = 6, led_alarm = 7
Const frm_alarm = 20, nbr_hi = 21, nbr_lo = 22, pb_test =23
Const c_hi = 24, c_lo = 25
Const frm_pump = 30, r_econ = 31, r_norm = 32, r_hi = 33
Const frm_log = 40, cb_enabled = 41, c_fname = 42, tb_fname = 43
Const c_log = 44, cb_flow = 45, cb_pwr = 46, cb_warn = 47
Const cb_alarm = 48, c_bright = 49, sb_bright = 50

' now draw the "Pump Control" display
CLS
GUI Interrupt TouchDown, TouchUp

' display the heading
Font 2,2 : GUI Caption c_head, "Pump Control", 10, 0
Font 3 : GUI Caption c_pmp, "Pump", 20, 60, , RGB(brown)

' now, define and display the controls
' first display the switch
Font 4
GUI Switch sw_pmp, "ON|OFF", 20, 90, 150, 50, RGB(white),RGB(brown)
CtrlVal(sw_pmp) = 1

' the flow rate display box
Font 3 : GUI Caption c_flow, "Flow Rate", 20, 170,, RGB(brown),0
Font 4 : GUI Displaybox tb_flow, 20, 200, 150, 45
CtrlVal(tb_flow) = "20.1"

' the radio buttons and their frame
Font 3 : GUI Frame frm_pump, "Power", 20, 290, 170, 163, RGB(200,20,255)
GUI Radio r_econ, "Economy", 43, 328, 12, RGB(230, 230, 255)
GUI Radio r_norm, "Normal", 43, 374
GUI Radio r_hi, "High", 43, 418
CtrlVal(r_norm) = 1     ' start with the "normal" button selected

' the alarm frame with two number boxes and a push button switch
Font 3 : GUI Frame frm_alarm, "Alarm", 220, 220, 200, 233,RGB(green)
GUI Caption c_hi, "High:", 232, 260, "LT", RGB(yellow)
GUI Numberbox nbr_hi, 318,MM.VPos-6,90,MM.FontHeight+12,RGB(yellow),RGB(64,64,64)
GUI Caption c_lo, "Low:", 232, 325, LT, RGB(yellow),0
GUI Numberbox nbr_lo, 318,MM.VPos-6,90,MM.FontHeight+12,RGB(yellow),RGB(64,64,64)
GUI Button pb_test, "TEST", 257, 383, 130, 40,RGB(yellow), RGB(red)
CtrlVal(nbr_lo) = 15.7 : CtrlVal(nbr_hi) = 35.5

' draw the two LEDs
Const ledsX = 255, coff = 50    ' define their position
ledsY = 105 : GUI LED led_run, "Running", ledsX, ledsY, 15, RGB(green)
ledsY = ledsY+49 : GUI LED led_alarm, "Alarm", ledsX, ledsY, 15, RGB(red)
CtrlVal(led_run) = 1   ' the switch defaults to on so set the LED on

' the logging frame with check boxes and a text box
Colour RGB(cyan), 0
GUI Frame frm_log, "Log File", 450, 20, 330, 355, RGB(green)
GUI Checkbox cb_enabled, "Logging Enabled", 470, 50, 30, RGB(cyan)
GUI Caption c_fname, "File Name", 470, 105
GUI Textbox tb_fname, 470, 135, 290, 40, RGB(cyan), RGB(64,64,64)
GUI Caption c_log, "Record:", 470, 205, , RGB(cyan), 0
GUI Checkbox cb_flow, "Flow Rate", 500, 245, 25
GUI Checkbox cb_alarm, "Alarms", 500, 285, 25
GUI Checkbox cb_warn, "Warnings", 500, 325, 25
CtrlVal(cb_enabled) = 1
CtrlVal(tb_fname) = "LOGFILE.TXT"

' define and display the spinbox for controlling the backlight
GUI Caption c_bright, "Backlight", 442, 415, ,RGB(200,200,255),0
GUI Spinbox sb_bright, MM.HPos + 8, 400, 200, 50,,,10, 10, 100
CtrlVal(sb_bright) = 100

' All the controls have been defined and displayed. At this point
' the program could do some real work but because this is just a
' demo there is nothing to do.  So it just sits in a loop.
Do : Loop


' the interrupt routine for touch down
' using a select case command it has a different process for each control
Sub TouchDown
  Select Case Touch(REF)      ' find out the control touched
    Case cb_enabled           ' the enable check box
      If CtrlVal(cb_enabled) Then
        GUI ENABLE c_fname, tb_fname, c_log, cb_flow, cb_alarm, cb_warn
      Else
        GUI Disable c_fname, tb_fname, c_log, cb_flow, cb_alarm, cb_warn
      EndIf
    Case sb_bright            ' the brightness spin box
      BackLight CtrlVal(sb_bright)
    Case sw_pmp               ' the pump on/off switch
      CtrlVal(led_run) = CtrlVal(sw_pmp)
      CtrlVal(tb_flow) = Str$(CtrlVal(sw_pmp) * 20.1)
      CtrlVal(r_norm) = 1
    Case pb_test              ' the alarm test button
      CtrlVal(led_alarm) = 1
      GUI beep 250
    Case r_econ               ' the economy radio button
      CtrlVal(tb_flow) = Str$(CtrlVal(sw_pmp) * 18.3)
    Case r_norm               ' the normal radio button
      CtrlVal(tb_flow) = Str$(CtrlVal(sw_pmp) * 20.1)
    Case r_hi                ' the high radio button
      CtrlVal(tb_flow) = Str$(CtrlVal(sw_pmp) * 23.7)
  End Select
End Sub

' interrupt routine when the touch is removed
Sub TouchUp
  Select Case Touch(LASTREF)   ' use the last reference
    Case pb_test               ' was it the test button
      CtrlVal(led_alarm) = 0   ' turn off the LED
  End Select
End Sub
```

Read Only Variables (extra for the Micromite Plus Only)

MM.HPOS MM.VPOS	The current horizontal and vertical position (in pixels) following the last graphics or print command.
MM.ERRNO	Is set to the error number if a statement involving the SD card fails or zero if the operation succeeds. This is dependent on the setting of OPTION ERROR. The possible values for MM.ERRNO are: 0 = No error 1 = No SD card found 2 = SD card is write protected 3 = Not enough space 6 = Cannot find file 7 = Cannot find file or directory 8 = Cannot create directory 12 = Hardware error 13 = File system error 14 = Directory not empty 16 = Syntax or general programming error Note that these error numbers and messages have changed with the introduction of the advanced file access introduced in V5.4 however, for backwards compatibility, the important error numbers (errors 1 and 6) have not changed.

Commands (extra for the Micromite Plus Only)

ARC x, y, r1, [r2], a1, a2 [, c]	Draws an arc of a circle with a given colour and width between two radials (defined in degrees). Parameters for the ARC command are: x: X coordinate of centre of arc y: Y coordinate of centre of arc r1: inner radius of arc r2: outer radius of arc - can be omitted if 1 pixel wide a1: start angle of arc in degrees a2: end angle of arc in degrees c: Colour of arc (if omitted it will default to the foreground colour) Zero degrees is at the 9 o'clock position.
BACKLIGHT percent	Controls the brightness of the LCD panel's backlight (SSD1963 based display panels only). 'percent' is the degree of brightness ranging from 0 (fully off) to 100 (full brightness).
BLIT READ [#]b, x, y, w, h BLIT WRITE [#]b, x, y, w, h BLIT CLOSE [#]b	Copy one section of the display screen to or from a memory buffer. BLIT READ will copy a portion of the display to the memory buffer '#b'. The source coordinate is 'x' and 'y' and the width of the display area to copy is 'w' and the height is 'h'. When this command is used the memory buffer is automatically created and sufficient memory allocated. This buffer can be freed and the memory recovered with the BLIT CLOSE command. BLIT WRITE will copy the memory buffer '#b' to the display. The destination coordinate is 'x' and 'y' and the width/height of the buffer to copy is 'w' and 'h'. BLIT CLOSE will close the memory buffer '#b' to allow it to be used for another BLIT READ operation and recover the memory used. Notes: • Eight buffers are available ranging from #1 to #8. • When specifying the buffer number the # symbol is optional. • All other arguments are in pixels. • The display must use the ILI9341 controller or the SSD1963 controller with the RD (read) pin connected (or VGA on the Micromite eXtreme).
BLIT x1, y1, x2, y2, w, h	Copy one section of the display screen to another part of the display. The source coordinate is 'x1' and 'y1'. The destination coordinate is 'x2' and 'y2'. The width of the screen area to copy is 'w' and the height is 'h'. All arguments are in pixels. The source and destination can overlap. The display must use the ILI9341 controller or the SSD1963 controller with the RD (read) pin connected.
CHDIR dir$	Change the current working directory on the SD card to 'dir$' The special entry ".." represents the parent of the current directory and "." represents the current directory.
CLOSE [#]fnbr [,[#]fnbr] …	Close the file(s) previously opened with the file number '#fnbr'. The # is optional. Also see the OPEN command.
COPY fname1$ TO fname2$	Copy a file from 'fname1$' to 'fname2$'. Both are strings. A directory path can be used in both 'fname$' and 'fname$'. If the paths differ the file specified in 'fname$' will be copied to the path specified in 'fname2$' with the file name as specified.

CTRLVAL(#ref) =	This command will set the value of an advanced control. '#ref' is the control's reference number. For off/on controls like check boxes it will override any touch input and can be used to depress/release switches, tick/untick check boxes, etc. A value of zero is off or unchecked and non zero will turn the control on. For a LED it will cause the LED to be illuminated or turned off. It can also be used to set the initial value of spin boxes, text boxes, etc. For example: `CTRLVAL(#10) = 12.4` All controls expect to be assigned a number (float or integer) except Frame, Caption, Display Box, Text Box and Format Box which expect a string.
FILES [fspec$]	Lists files in the current directory on the SD card. 'fspec$' (if specified) can contain search wildcards. Question marks (?) will match any character and an asterisk (*) will match any number of characters. If omitted, all files will be listed. For example: *.* Find all entries *.TXT Find all entries with an extension of TXT E*.* Find all entries starting with E X?X.* Find all three letter file names starting and ending with X
GUI AREA #ref, startX, startY, width, height	This will define an invisible area of the screen that is sensitive to touch and will generate touch down and touch up interrupts. It can be used as the basis for creating custom controls which are defined and managed by the program. '#ref' is the control's reference number. 'startX' and 'startY' are the top left coordinates while 'width' and 'height' set the dimensions.
GUI BCOLOUR colour, #ref1 [, #ref2, #ref3, etc]	This will change the background colour of the specified controls to 'colour' which is an RGB value for the drawing colour. '#ref' is the control's reference number.
GUI BEEP msec	This will sound the pizeo buzzer if configured with the OPTION TOUCH command. 'msec' is the number of milliseconds that the buzzer should be driven. A time of 3ms produces a click while 100ms produces a short beep.
GUI BARGAUGE #ref, StartX, StartY, width, height, FColour, BColour, min, max, c1, ta, c2, tb, c3, tc, c4	Define either a horizontal or vertical analogue bar gauge. '#ref' is the control's reference number. 'StartX' and 'StartY' are the top left coordinates of the bar while 'width' is the horizontal width and 'height' the vertical height. If the width is less that the height the bar gauge will be drawn vertically with the graph growing from the bottom towards the top. Otherwise it will be drawn horizontally with the graph growing from the left towards the right. 'Fcolour' is the colour used for the gauge while 'Bcolour' is the background colour. 'min' is the minimum value of the gauge and 'max' is the maximum value (both floating point). A multi colour gauge can be created using 'c1' to 'c4' for the colours and 'ta' to 'tc' for the thresholds used to determine when the colour will change. 'width', 'height', 'FColour', 'BColour', 'min' and 'max' are optional and will default to the values used in the previous definition of a GUI BARGAUGE. 'c1', 'ta', 'c2', 'tb', 'c3', 'tc' and 'c4' are optional and if not specified the gauge will use less colours. If all are omitted the gauge will be drawn using 'Fcolour'. The section *Advanced Graphics* has a more detailed description.

GUI BUTTON #ref, caption$, startX, startY, width, height [, FColour] [,BColour]	This will draw a momentary button which is a square switch with the caption on its face. When touched the visual image of the button will appear to be depressed and the control's value will be 1. When the touch is removed the value will revert to zero. #ref' is the control's reference (a number from 1 to 100). 'caption$' is the string to display on the face of the button. It can be a single string with two captions separated by a | character (eg, "UP|DOWN"). When the button is up the first string will be used and when pressed the second will be used. 'startX' and 'startY' are the top left coordinates while 'width' and 'height' set the dimensions. ' FColour and 'BColour' are RGB values for the foreground and background colours. 'width', 'height', FColour and 'BColour' are optional and default to that used in previous controls or set with the COLOUR command.
GUI CAPTION #ref, text$, startX, startY [,align$] [, FColour] [, BColour]	This will draw a text string on the screen. '#ref' is the control's reference number. 'text$' is the string to display. 'startX' and 'startY' are the top left coordinates. 'align$' is zero to three characters (a string expression or variable is also allowed) where the first letter is the horizontal alignment around X and can be L, C or R for LEFT, CENTER, RIGHT and the second letter is the vertical alignment around Y and can be T, M or B for TOP, MIDDLE, BOTTOM. A third character can be used in the string to indicate the rotation of the text. This can be 'N' for normal orientation, 'V' for vertical text with each character under the previous running from top to bottom, 'I' the text will be inverted (ie, upside down), 'U' the text will be rotated counter clockwise by 90º and 'D' the text will be rotated clockwise by 90º. The default alignment is left/top with no rotation. 'FColour and 'BColour' are RGB values for the foreground and background colours. On a display that supports transparent text BColour can be -1 which means that the background will show through the gaps in the characters. FColour and 'BColour' are optional and default to the colours set by the COLOUR command.
GUI CHECKBOX #ref, caption$, startX, startY [, size] [, colour]	This will draw a check box which is a small box with a caption. When touched an X will be drawn inside the box to indicate that this option has been selected and the control's value will be set to 1. When touched a second time the check mark will be removed and the control's value will be zero. '#ref' is the control's reference number. The string 'caption$' will be drawn to the right of the control using the colours set by the COLOUR command. 'startX' and 'startY' are the top left coordinates while 'size' set the height and width (the bix is square). 'colour' is an RGB value for the drawing colour. 'size' and 'colour' are optional and default to that used in previous controls.
GUI DELETE #ref1 [,#ref2, #ref3, etc] or GUI DELETE ALL	This will delete the controls in the list. This includes removing the image of the control from the screen using the current background colour and freeing the memory used by the control. '#ref' is the control's reference number. The keyword ALL can be used as the argument and that will disable all controls.

GUI DISABLE #ref1 [,#ref2, #ref3, etc] or GUI DISABLE ALL	This will disable the controls in the list. Disabled controls do not respond to touch and will be displayed dimmed. '#ref' is the control's reference number. The keyword ALL can be used as the argument and that will disable all controls. GUI ENABLE can be used to restore the controls.
GUI DISPLAYBOX #ref, startX, startY, width, height, FColour, BColour	This will draw a box with rounded corners that can be used to display a string '#ref' is the control's reference number. 'startX' and 'startY' are the top left coordinates while 'width' and 'height' set the dimensions. ' FColour and 'BColour' are RGB values for the foreground and background colours. 'width', 'height', FColour and 'BColour' are optional and default to that used in previous controls. Any text can be displayed in the box by using the CtrlVal(r) = command. This is useful for displaying text, numbers and messages. This control does not respond to touch.
GUI ENABLE #ref1 [,#ref2, #ref3, etc] or GUI ENABLE ALL	This will undo the effects of GUI DISABLE and restore the control(s) to normal operation. '#ref' is the control's reference number. The keyword ALL can be used as the argument and that will disable all controls.
GUI FCOLOUR colour, #ref1 [, #ref2, #ref3, etc]	This will change the foreground colour of the specified controls to 'colour' which is an RGB value for the drawing colour. '#ref' is the control's reference number.
GUI FRAME #ref, caption$, startX, startY, width, height, colour	This will draw a frame which is a box with round corners and a caption. '#ref' is the control's reference number. 'caption$' is a string to display as the caption. 'startX' and 'startY' are the top left coordinates while 'width' and 'height' set the dimensions. 'colour' is an RGB value for the drawing colour. 'width', 'height' and 'colour' are optional and default to that used in previous controls. A frame is useful when a group of controls need to be visually brought together. It is also used to surround a group of radio buttons and MMBasic will arrange for the radio buttons surrounded by the frame to be exclusive. ie, when one radio button is selected any other button that was selected and within the frame will be automatically deselected. A frame does not respond to touch.
GUI FORMATBOX #ref, Format, startX, startY, width, height, FColour, BColour	This will draw a box with rounded corners that can be used to create a virtual keypad for entry of data using a specific format. '#ref' is the control's reference number. 'startX' and 'startY' are the top left coordinates while 'width' and 'height' set the dimensions. ' FColour and 'BColour' are RGB values for the foreground and background colours. 'width', 'height', FColour and 'BColour' are optional and default to that used in previous controls. The 'Format' argument specifies the format of the entry as follows: DATE1 Date in UK/Aust/NZ format (dd/mm/yy) DATE2 Date in USA format (mm/dd/yy) DATE3 Date in international format (yyyy/mm/dd) TIME1 Time in 24 hour notation (hh:mm) TIME2 Time in 24 hour notation with seconds (hh:mm:ss) TIME3 Time in 12 hour notation (hh:mm AM/PM)

	TIME4 Time in 12 hour notation with seconds (hh:mm:ss AM/PM) DATETIME1 Date (UK fmt) and time (12 hour) (dd/mm/yy hh:mm AM/PM) DATETIME2 Date (UK fmt) and time (24 hour) (dd/mm/yy hh:mm) DATETIME3 Date (USA fmt) and time (12 hour) (mm/dd/yy hh:mm AM/PM) DATETIME4 Date (USA fmt) and time (24 hour) (mm/dd/yy hh:mm) LAT1 Latitude in degrees, minutes and seconds (dd° mm' ss" N/S) LAT2 Latitude with seconds to one decimal place (dd° mm' ss.s" N/S) LONG1 Longitude in degrees, minutes and seconds (ddd° mm' ss" E/W) LONG2 Longitude seconds to one decimal place (ddd° mm' ss.s" E/W) ANGLE1 Angle in degrees and minutes (ddd° mm') For example, this command: `GUI FORMATBOX #1, LAT1, 50, 50, 300, 50` would create a format box which would accept the entry of latitude in the format of dd° mm' ss" N/S. The value of CtrlVal(#1) would be a string which includes the numbers and separating characters. For example an entry of 17 degrees, 32 minutes and 1 second south would result in the string 17° 32' 01" S MMBasic will try to position the virtual keypad on the screen so as to not obscure the format box that caused it to appear. A pen down interrupt will be generated just before the keypad is deployed and a key up interrupt will be generated when the entry is complete and the keypad is hidden.
GUI GAUGE #ref, StartX, StartY, Radius, FColour, BColour, min, max, nbrdec, units$, c1, ta, c2, tb, c3, tc, c4	Define a graphical circular analogue gauge with a digital display in the centre. '#ref' is the control's reference number. 'StartX' and 'StartY' are the coordinates of the centre of the gauge, 'Radius' is the distance from the centre to the outer edge. 'min' is the minimum value of the gauge and 'max' is the maximum value (both floating point). 'nbrdec' specifies the number of decimal places to be used when drawing the digital value in the centre of the gauge. Under this 'units$' will be displayed. 'Fcolour' is the colour used for the gauge while 'Bcolour' is the background colour. A multi colour gauge can be created using 'c1' to 'c4' for the colours and 'ta' to 'tc' for the thresholds used to determine when the colour will change. When colours and thresholds are specified the background of the gauge will be drawn with a dull version of the colour at that level. Also the digital value will change to the colour specified by the current value. 'Radius', 'FColour', 'BColour', 'min', 'max', 'nbrdec' and 'units$' are optional and will default to the values used in the previous definition of a GUI GAUGE. 'c1', 'ta', 'c2', 'tb', 'c3', 'tc' and 'c4' are optional and if not specified the gauge will use less colours. If all are omitted the gauge will be drawn using 'Fcolour'. The section *Advanced Graphics* has a more detailed description.
GUI HIDE #ref1 [,#ref2, #ref3, etc] or GUI HIDE ALL	This will hide the controls in the list. Hidden controls do not respond to touch and will not be visible. '#ref' is the control's reference number. The keyword ALL can be used as the argument and that will hide all controls. GUI SHOW can be used to restore the controls.

GUI INTERRUPT down [, up]	This command will setup an interrupt that will be triggered on a touch on the LCD panel and optionally if the touch is released. 'down' is the subroutine to call when a touch down has been detected. 'up' is the subroutine to call when the touch has been lifted from the screen ('up' and 'down' can point to the same subroutine if required). Specifying the number zero (single digit) as the argument will cancel both of these interrupts. ie: `GUI INTERRUPT 0`
GUI LED #ref, caption$, centerX, centerY, radius, colour	This will draw an indicator light which looks like a panel mounted LED. A LED does not respond to touch. '#ref' is the control's reference number. The string 'caption$' will be drawn to the right of the control using the colours set by the COLOUR command. 'centerX' and 'centerY' are the coordinates of the centre of the LED and 'radius' is the radius of the LED. 'colour' is an RGB value for the drawing colour. 'radius' and 'colour' are optional and default to that used in previous controls. When a LED's value is set to a value of one it will be illuminated and when it is set to zero it will be off (a dull version of its colour attribute). The LED can be made to flash on then off by setting the value of the LED to a number greater than one which is the time in milliseconds that it should remain on. The colour can be changed with the GUI FCOLOUR command.
GUI NUMBERBOX #ref, startX, startY, width, height, FColour, BColour	This will draw a box with rounded corners that can be used to create a virtual numeric keypad for data entry. '#ref' is the control's reference number. 'startX' and 'startY' are the top left coordinates while 'width' and 'height' set the dimensions. ' FColour and 'BColour' are RGB values for the foreground and background colours. 'width', 'height', FColour and 'BColour' are optional and default to that used in previous controls. When the box is touched a numeric keypad will appear on the screen. Using this virtual keypad any number can be entered into the box including a floating point number in exponential format. The new number will replace the number previously in the box. The value of the control can set to a literal string (not an expression) starting with two hash characters. For example: `CtrlVal(nnn) = "##Enter Number"` and in that case the string (without the leading two hash characters) will be displayed in the box with reduced brightness. This can be used to give the user a hint as to what should be entered (called "ghost text"). Reading the value of the control displaying ghost text will return zero. When the control is used normally the ghost text will vanish. MMBasic will try to position the virtual keypad on the screen so as to not obscure the number box that caused it to appear. A pen down interrupt will be generated just before the keypad is deployed and a key up interrupt will be generated when the Enter key is touched and the keypad is hidden. Also, when the Enter key is touched the entered number will be evaluated as a number and the NUMBERBOX control redrawn to display this number.

GUI RADIO #ref, caption$, centerX, centerY, radius, colour	This will draw a radio button with a caption. '#ref' is the control's reference number. The string 'caption$' will be drawn to the right of the control using the colours set by the COLOUR command. 'centerX' and 'centerY' are the coordinates of the centre of the button and 'radius' is the radius of the button. 'colour' is an RGB value for the drawing colour. 'radius' and 'colour' are optional and default to that used in previous controls. When touched the centre of the button will be illuminated to indicate that this option has been selected and the control's value will be 1. When another radio button is selected the mark on this button will be removed and its value will be zero. Radio buttons are grouped together when surrounded by a frame and when one button in the group is selected all others in the group will be deselected. If a frame is not used all buttons on the screen will be grouped together.
GUI REDRAW #ref1 [,#ref2, #ref3, etc] or GUI REDRAW ALL	This will redraw the controls on the screen. It is useful if the screen image has somehow been corrupted. '#ref' is the control's reference number. The keyword ALL can be used as the argument and that will first clear the screen then redraw all controls. This is useful if the whole screen needs to be refreshed.
GUI SETUP #n	This will allocate any new controls created to the page '#n'. This command can be used as many times as needed while GUI controls are being defined. The default when a program starts running is GUI SETUP 1. See also the GUI PAGE command.
GUI SHOW #ref1 [,#ref2, #ref3, etc] or GUI SHOW ALL	This will undo the effects of GUI HIDE and restore the control(s) to being visible and capable of normal operation. '#ref' is the control's reference number. The keyword ALL can be used as the argument and that will disable all controls.
GUI SPINBOX #ref, startX, startY, width, height, FColour, BColour, Step, Minimum, Maximum	This will draw a box with up/down icons on either end. When these icons are touched the number in the box will be incremented or decremented. Holding down the up/down icons will repeat the step at a fast rate. '#ref' is the control's reference number. 'startX' and 'startY' are the top left coordinates while 'width' and 'height' set the dimensions. ' FColour and 'BColour' are RGB values for the foreground and background colours. 'width', 'height', FColour and 'BColour' are optional and default to that used in previous controls. 'Step' sets the amount to increment/decrement the number with each touch. 'Minimum' and 'Maximum' set limits on the number that can be entered. All three parameters can be floating point numbers and are optional. The default for 'Step' is 1 and 'Minimum' and 'Maximum' if omitted will default to no limit.
GUI SWITCH #ref, caption$, startX, startY, width, height, FColour, BColour	This will draw a latching switch which is a square switch that latches when touched. '#ref' is the control's reference number. 'caption$' is a string to display as the caption on the face of the switch. 'startX' and 'startY' are the top left coordinates while 'width' and 'height' set the dimensions. ' FColour and 'BColour' are RGB values for the foreground and background colours. 'width', 'height', FColour and 'BColour' are optional and

	default to that used in previous controls. When touched the visual image of the button will appear to be depressed and the control's value will be 1. When touched a second time the switch will be released and the value will revert to zero. Caption can consist of two captions separated by a | character (eg, "ON|OFF"). When this is used the switch will appear to be a toggle switch with each half of the caption used to label each half of the toggle switch.
GUI TEXTBOX #ref, startX, startY, width, height, FColour, BColour	This will draw a box with rounded corners that can be used to create a virtual keyboard for data entry '#ref' is the control's reference number. 'startX' and 'startY' are the top left coordinates while 'width' and 'height' set the dimensions. ' FColour and 'BColour' are RGB values for the foreground and background colours. 'width', 'height', FColour and 'BColour' are optional and default to that used in previous controls. On a display that supports transparent text BColour can be -1 which means that the background will show through the gaps in the characters. When the box is touched a QWERTY keyboard will appear on the screen. Using this virtual keyboard any text can be entered into the box including upper/lower case letters, numbers and any other characters in the ASCII character set. The new text will replace any text previously in the box. The value of the control can set to a string starting with two hash characters. For example: `CtrlVal(nnn) = "##Enter Filename"` and in that case the string (without the leading two hash characters) will be displayed in the box with reduced brightness. This can be used to give the user a hint as to what should be entered (called "ghost text"). Reading the value of the control displaying ghost text will return an empty string. When the control is used normally the ghost text will vanish. MMBasic will try to position the virtual keyboard on the screen so as to not obscure the text box that caused it to appear. A pen down interrupt will be generated just before the keyboard is deployed and a key up interrupt will be generated when the Enter key is touched and the keyboard is hidden.
GUI TEXTBOX ACTIVATE #ref	This will cause the virtual keyboard for the control '#ref' to be displayed under program control without the control being touched. It is the same as if the user touched the control except that the touch down interrupt is not generated.
GUI TEXTBOX CANCEL	This will dismiss a virtual keyboard if it is displayed on the screen. It is the same as if the user touched the cancel key except that the touch up interrupt is not generated. If a keyboard is not displayed this command will do nothing.
INPUT #fnbr, list of variables	Same as the normal INPUT command except that the input is read from a file previously opened for INPUT as '#fnbr'. See the OPEN command.
KILL file$	Deletes the file specified by 'file$'. If there is an extension it must be specified.
LINE INPUT #fnbr, string-variable$	Same as the LINE INPUT command except that the input is read from a file previously opened for INPUT as '#fnbr'. See the OPEN command.
LOAD file$ [,R]	Loads a program called 'file$' from the SD card into program memory. If the optional suffix ,R is added the program will be immediately run without prompting (in this case file$ must be a string constant). If an extension is not specified ".BAS" will be added to the file name.

LOAD IMAGE file$ [, x, y]	Load a bitmapped image from the SD card and display it on the LCD panel. "file$' is the name of the file and 'x' and 'y' are the screen coordinates for the top left hand corner of the image. If the coordinates are not specified the image will be drawn at the top left hand position on the screen. If an extension is not specified ".BMP" will be added to the file name. All types of the BMP format are supported including black and white and true colour 24-bit images.
MKDIR dir$	Make, or create, the directory 'dir$' on the SD card.
NAME old$ AS new$	Rename a file or a directory from 'old$' to 'new$'. Both are strings. A directory path can be used in both 'old$' and 'new$'. If the paths differ the file specified in 'old$' will be moved to the path specified in 'new$' with the file name as specified.
OPEN fname$ FOR mode AS [#]fnbr	Opens a file for reading or writing. 'fname' is the filename with an optional extension separated by a dot (.). Long file names with upper and lower case characters are supported. A directory path can be specified with the backslash as directory separators. The parent of the current directory can be specified by using a directory name of .. (two dots) and the current directory with . (a single dot). For example OPEN "..\dir1\dir2\filename.txt" FOR INPUT AS #1 'mode' is INPUT, OUTPUT, APPEND or RANDOM. INPUT will open the file for reading and throw an error if the file does not exist. OUTPUT will open the file for writing and will automatically overwrite any existing file with the same name. APPEND will also open the file for writing but it will not overwrite an existing file; instead any writes will be appended to the end of the file. If there is no existing file the APPEND mode will act the same as the OUTPUT mode (i.e. the file is created then opened for writing). RANDOM will open the file for both read and write and will allow random access using the SEEK command. When opened the read/write pointer is positioned at the end of the file. 'fnbr' is the file number (1 to 10). The # is optional. Up to 10 files can be open simultaneously. The INPUT, LINE INPUT, PRINT, WRITE and CLOSE commands as well as the EOF() and INPUT$() functions all use 'fnbr' to identify the file being operated on. See also OPTION ERROR and MM.ERRNO for error handling.
OPTION CONSOLE OFF or OPTION CONSOLE ON	Disable or enable the serial console. When the console is disabled the serial port can be opened as COM4:. This command can only be run from the command line and will cause a restart so if the command was issued via the USB console the connection will be lost and will need to be re-established. The new value will remembered, even when the power is cycled or a new program loaded. Note that the other OPTION CONSOLE commands supported by the standard Micromite (OPTION CONSOLE INVERT, etc) are also recognised.
OPTION CONTROLS nn	Set the maximum number of controls that can be created by a program to 'nn'. This can be any number from 1 to 1000. The default is 100. A larger number will use more RAM (each control entry uses about 50 bytes of RAM). This command can only be run from the command line and the new value will remembered, even when the power is cycled or a new program loaded.

OPTION KEYBOARD nn	Enable an attached PS2 keyboard and set its language type. ‘nn is a two character code defining the keyboard layout. The choices are US for the standard keyboard layout in the USA, Australia and New Zealand , UK (United Kingdom), FR (French), GR (German), BE (Belgium), IT (Italian) or ES (Spanish). OPTION KEYBOARD DISABLE will disable the keyboard and return the I/O pins to normal use. See the section "*PS2 Keyboard*" for details of connecting the keyboard. This command can only be run from the command line and the new value will remembered, even when the power is cycled or a new program loaded.
OPTION LCDPANEL controller, orientation, D/C pin, reset pin [,CS pin] or OPTION LCDPANEL controller, orientation [,LCD-A pin] or OPTION LCDPANEL DISABLE	Configures the Micromite Plus to work with an attached LCD panel. 'controller' can be: • ILI9163 SPI based 1.44" panels using the ILI9163 controller • ST7735 SPI based 1.8" panels using the ST7735 controller • ILI9341 SPI based 2.2", 2.4" and 2.8" panels using the ILI9341 controller • SSD1963_4 4.3" panels using the SSD1963controller • SSD1963_5 5" panels using the SSD1963controller • SSD1963_5A alternative version of the 5" panel • SSD1963_7 7" panels using the SSD1963controller • SSD1963_7A alternative version of the 7" panel • SSD1963_8 8" panels using the SSD1963controller 'orientation' can be LANDSCAPE, PORTRAIT, RLANDSCAPE or RPORTRAIT. These can be abbreviated to L, P, RL or RP. The R prefix indicates the reverse or "upside down" orientation. **ILI9341, ST7735 and ILI9163 based panels:** 'C/D pin' and 'reset pin' are the Micromite I/O pins to be used for these functions. Any free pin can be used. 'CS pin' can also be any I/O pin but is optional. If a touch controller is not used this parameter can be left off the command and the CS pin on the LCD display wired permanently to ground. If the touch controller is used this pin must then be specified and connected to a Micromite I/O pin. NOTE: The CPU speed must be 20MHz or greater. **For SSD1963 based panels:** 'LCD-A pin' can also be any I/O pin but is optional. This can be used to control the brightness of the backlight if the internal SSD1963 controller is not used. This command only needs to be run once as the parameters are stored in non volatile memory. When the Micromite is restarted the display will be automatically initialise ready for use. If the LCD panel is no longer required the command OPTION LCDPANEL DISABLE can be used to disable the LCD panel feature and return the I/O pins for general use.
OPTION LCDPANEL CONSOLE [font [, fc [,bc blight]]] or OPTION LCDPANEL NOCONSOLE	Configures the LCD display panel for use as the console output. The LCD must be one of the SSD1963 versions in the landscape or reverse landscape orientation and it must be first configured using OPTION LCDPANEL SSD1963_x (above). 'font' is the default font, 'fc' is the default foreground colour, 'bc' is the default background colour and 'blight' is the default backlight brightness (2 to 100). These parameters are optional and default to font 2, white, black and 100%. These settings are applied at power up. Colour coding in the editor is also turned on by this command (OPTION COLOURCODE OFF will turn it off again). This setting is saved in flash and will be automatically applied on startup. To disable it use the OPTION LCDPANEL NOCONSOLE command.

OPTION RTC Data-pin, Clock-pin or OPTION RTC DISABLE	Configures the Micromite Plus for access to a Real Time Clock (RTC). 'Data-pin' is the I/O pin number used for the I^2C data line and Clock-pin is the same for the I^2C clock. If they are the same as the standard I^2C interface then that interface will be used. If they are different a private I^2C interface will be created to communicate with the RTC (this frees up the main I^2C interface for other tasks). When this command is used the settings will be saved in non volatile memory and automatically applied at startup or reset. Also on startup MMBasic will automatically query the RTC for the current time and date and set the internal clock (similar to the RTC GETTIME command). The general commands for accessing the RTC (RTC SETTIME, RTC GETREG, etc) can still be used and will access the RTC connected to the I/O pins specified in this command. The command OPTION RTC DISABLE can be used to disable this feature and return the I/O pins for general use.
OPTION SDCARD CS-pin [, CD-pin [,WP pin]] or OPTION SDCARD DISABLE	Configures the Micromite Plus to access an attached SD card. 'CS-pin' is the I/O pin number that will be used as chip select (pin 1 on the SD card connector). 'CD-pin' is optional and is the I/O pin number that will be used to connect to the card detect pin on the SD card connector. The Micromite will provide a weak pullup on this pin which is switched to ground when a card is inserted. If this signal is not provided the Micromite Plus will need to be restarted if the SD card was changed. 'WP-pin' is optional and is the I/O pin number that will be used to connect to the write protect pin on the SD card connector. The Micromite will provide a weak pullup on this pin which is switched to ground when a write protected card is inserted. Some SD card connectors reverse the polarity of the 'CD-pin' or 'WP-pin' signal - ie, they are open (and therefore the signal is high) when the card is inserted or write protected. In this case the pin numbers used for 'CD-pin' and 'WP-pin' can be a negative number. This will tell MMBasic to invert the polarity of these signals. This command only needs to be run once. When the Micromite is restarted MMBasic will automatically initialise the SD card interface. If the SD card is no longer required the command OPTION SDCARD DISABLE can be used which will disable the SD card and return the I/O pins for general use.
OPTION TOUCH T_CS pin, T_IRQ pin [, click pin] or OPTION TOUCH DISABLE	Configures the Micromite Plus to suit the touch sensitive feature of an attached LCD panel. 'T_CS pin' and 'T_IRQ pin' are the Micromite I/O pins to be used for chip select and touch interrupt respectively (any free pins can be used). 'click pin' specifies an optional I/O pin that will be driven briefly high when a screen control is touched. This can be used to drive a small Piezo buzzer. This command only needs to be run once as the parameters are stored in non volatile memory. Every time the Micromite is restarted MMBasic will automatically initialise the touch controller. If the touch facility is no longer required the command OPTION TOUCH DISABLE can be used to disable the touch feature and return the I/O pins for general use.
PAGE #n [,#n2, #n3, etc]	This will switch the display to show controls that have been assigned (via the GUI SETUP command) to the page numbers specified on the command line (#n, #n2, etc). Any controls that were displayed but are not on the current list of pages will be automatically hidden. Any controls on a page that was displayed on the old screen and is also specified in the new PAGE command will remain unaffected. The default when a program starts running is PAGE 1 and GUI SETUP 1. This means that if these commands are not used the program will run as normal

	showing all GUI controls that have been defined. See also the GUI SETUP command.
PLAY TONE left [, right [, dur]]	Generates two separate sine waves on the sound output left and right channels. The sound output is stereo with the pin allocated to PWM 2A as the left channel and PWM 2B as the right channel. The output is a pulse width modulated signal so a low pass filter is required to remove the carrier frequency. See the section *Sound Output* in this manual for the details. 'left' and 'right' are the frequencies in Hz to use for the left and right channels. The tone plays in the background (the program will continue running after this command) and 'dur' specifies the number of milliseconds that the tone will sound for. If the duration is not specified the tone will continue until explicitly stopped or the program terminates. The frequency can be from 1Hz to 20KHz and is very accurate (it is based on the PIC32 crystal oscillator). The frequency can be changed at any time by issuing a new PLAY TONE command.
PLAY WAV file$ [, interrupt]	Will play a WAV file on the sound output. The sound output is stereo with the pin allocated to PWM 2A as the left channel and PWM 2B as the right channel. The output is a pulse width modulated signal so a low pass filter is required to remove the carrier frequency. See the section *Sound Output* in this manual for the details. 'file$' is the WAV file to play (the extension of .wav will be appended if missing). The WAV file must be PCM encoded in stereo with 8-bit sampling. The sample rate can be 8KHz or 16kHz. The WAV file is played in the background. 'interrupt' is optional and is the name of a subroutine which will be called when the file has finished playing.
PLAY PAUSE PLAY RESUME PLAY STOP	PLAY PAUSE will temporarily halt the currently playing file or tone. PLAY RESUME will resume playing a sound that was paused. PLAY STOP will terminate the playing of the file or tone. When the program terminates for whatever reason the sound output will also be automatically stopped.
PLAY VOLUME left, right	Will adjust the volume of the audio output. 'left' and 'right' are the levels to use for the left and right channels and can be between 0 and 100 with 100 being the maximum volume. There is a linear relationship between the specified level and the output. The volume defaults to maximum when a program is run.
PRINT #fnbr, expression [[,;]expression] … etc	Same as the normal PRINT command except that the output is directed to a file previously opened for OUTPUT or APPEND as ‘#fnbr’. See the OPEN command.
RMDIR dir$	Remove, or delete, the directory ‘dir$’ on the SD card.
SAVE [file$]	Saves the program in the current working directory of the SD card as ‘file$’. Example: SAVE “TEST.BAS” If an extension is not specified “.BAS” will be added to the file name.
RUN file$	Loads the program called ‘file$’ from the SD card into program memory and immediately runs it (file$ must be a string constant). If an extension is not specified “.BAS” will be added to the file name.
SAVE IMAGE file$	Save the current image on the LCD panel as a BMP file. 'file$' is the name of the file. If an extension is not specified “.BMP” will be added to the file name. The panel must support transparent text (see page 17). The image is saved as a true colour 24-bit image.

SEEK [#]fnbr, pos	Will position the read/write pointer in a file that has been opened on the SD card for RANDOM access to the 'pos' byte. The first byte in a file is numbered one so `SEEK #5,1 w`ill position the read/write pointer to the start of the file.
TRIANGLE X1, Y1, X2, Y2, X3, Y3 [, C [, FILL]]	Draws a triangle on the LCD display panel with the corners at X1, Y1 and X2, Y2 and X3, Y3. 'C' is the colour of the triangle and defaults to the current foreground colour. 'FILL' is the fill colour and defaults to no fill (it can also be set to -1 for no fill).

Functions (extra for the Micromite Plus Only)

BIN2STR$(type, value [,BIG])

Returns a string containing the binary representation of 'value'.

'type' can be:

INT64	signed 64-bit integer converted to an 8 byte string
UINT64	unsigned 64-bit integer converted to an 8 byte string
INT32	signed 32-bit integer converted to a 4 byte string
UINT32	unsigned 32-bit integer converted to a 4 byte string
INT16	signed 16-bit integer converted to a 2 byte string
UINT16	unsigned 16-bit integer converted to a 2 byte string
INT8	signed 8-bit integer converted to a 1 byte string
UINT8	unsigned 8-bit integer converted to a 1 byte string
SINGLE	single precision floating point number converted to a 4 byte string
DOUBLE	double precision floating point number converted to a 8 byte string

By default the string contains the number in little-endian format (ie, the least significant byte is the first one in the string). Setting the third parameter to ‘BIG’ will return the string in big-endian format (ie, the most significant byte is the first one in the string)

In the case of the integer conversions, an error will be generated if the ‘value’ cannot fit into the ‘type’ (eg, an attempt to store the value 400 in a INT8).

This function makes it easy to prepare data for efficient binary file I/O or for preparing numbers for output to sensors and saving to flash memory.

See also the function STR2BIN

CTRLVAL(#ref)

Returns the current value of an advanced control.

'#ref' is the control's reference. For controls like check boxes or switches it will be the number one (true) indicating that the control has been selected by the user or zero (false) if not. For controls that hold a number (eg, a SPINBOX) the value will be the number (normally a floating point number). For controls that hold a string (eg, TEXTBOX) the value will be a string.

CWD$

The current working directory on the SD card. Invalid for exFAT format.

The format is: `A:/dir1/dir2`.

DIR$(fspec, type)
or
DIR$(fspec)
or
DIR$( )

Will search an SD card for files and return the names of entries found.

'fspec' is a file specification using wildcards the same as used by the FILES command. Eg, "*.*" will return all entries, "*.TXT" will return text files.

Note that the wildcard *.* does not find files or folders without an extension.

'type' is the type of entry to return and can be one of:

VOL	Search for the volume label only
DIR	Search for directories only
FILE	Search for files only (the default if 'type' is not specified)

The function will return the first entry found. To retrieve subsequent entries use the function with no arguments. ie, DIR$( ). The return of an empty string indicates that there are no more entries to retrieve.

This example will print all the files in a directory:

```
f$ = DIR$("*.*", FILE)
DO WHILE f$ <> ""
  PRINT f$
  f$ = DIR$()
LOOP
```

You must change to the required directory before invoking this command.

EOF([#]fnbr)	Will return true if the file previously opened on the SD card for INPUT with the file number ‘#fnbr’ is positioned at the end of the file. The # is optional. Also see the OPEN, INPUT and LINE INPUT commands and the INPUT$ function.
EVAL(string$)	Will evaluate 'string$' as if it is a BASIC expression and return the result. 'string$' can be a constant, a variable or a string expression. The expression can use any operators, functions, variables, subroutines, etc that are known at the time of execution. The returned value will be an integer, float or string depending on the result of the evaluation. For example: S$ = `"COS(RAD(30)) * 100" : PRINT EVAL(S$)` Will display: `86.6025`
INPUT$(nbr, [#]fnbr)	Will return a string composed of ‘nbr’ characters read from a file on the SD card previously opened for INPUT with the file number ‘#fnbr’. This function will read all characters including carriage return and new line without translation. The # is optional. Also see the OPEN command.
LOC([#]fnbr)	For a file on the SD card opened as RANDOM this will return the current position of the read/write pointer in the file. Note that the first byte in a file is numbered 1. The # is optional.
LOF([#]fnbr)	For a file on the SD card this will return the current length of the file in bytes. The # is optional.
MSGBOX (msg$, b1$ [,b2$ … b4$])	This function will display a message box on the screen with one to four touch sensitive buttons. All other controls will be disabled until the user touches one of the buttons. The message box will then be erased, the previous controls will be restored and the function will return the number of the button touched (the first button is number one) 'msg$' is the message to display. This can contain one or more tilde characters (~) which indicate a line break. Up to 10 lines can be displayed inside the box. 'b1$' is the caption for the first button, 'b2$' is the caption for the second button, etc. At least one button must be specified and four is the maximum. Any buttons not included in the argument list will not be displayed.
PIXEL(x, y)	Returns the colour of a pixel on an attached LCD display panel. 'x' is the horizontal coordinate and 'y' is the vertical coordinate of the pixel. See the chapter "Basic Drawing Commands" for a definition of the colours and graphics coordinates. This function is only available on displays that use the ILI9341 controller or an SSD1963 controller. The latter must have the RD pin specified in the OPTION LCDPANEL command. On the Micromite eXtreme the VGA output also supports this function (see the *Micromite eXtreme Manual*).
STR2BIN(type, string$ [,BIG])	Returns a number equal to the binary representation in ‘string$’. ‘type’ can be: INT64 converts 8 byte string representing a signed 64-bit integer to an integer UINT64 converts 8 byte string representing an unsigned 64-bit integer to an integer INT32 converts 4 byte string representing a signed 32-bit integer to an integer UINT32 converts 4 byte string representing an unsigned 32-bit integer to an integer INT16 converts 2 byte string representing a signed 16-bit integer to an integer UINT16 converts 2 byte string representing an unsigned 16-bit integer to an integer

	INT8 converts 1 byte string representing a signed 8-bit integer to an integer UINT8 converts 1 byte string representing an unsigned 8-bit integer to an integer SINGLE converts 4 byte string representing single precision float to a float DOUBLE converts 8 byte string representing single precision float to a float By default the string must contain the number in little-endian format (ie, the least significant byte is the first one in the string). Setting the third parameter to ‘BIG’ will interpret the string in big-endian format (ie, the most significant byte is the first one in the string). This function makes it easy to read data from binary data files, interpret numbers from sensors or efficiently read binary data from flash memory chips. An error will be generated if the string is the incorrect length for the conversion requested See also the function BIN2STR$
TOUCH(DOWN)	Will return true if the screen is currently being touched.
TOUCH(UP)	Will return true if the screen is currently NOT being touched.
TOUCH(LASTX)	Will return the X coordinate of the last location that was touched.
TOUCH(LASTY)	Will return the Y coordinate of the last location that was touched.
TOUCH(REF)	Will return the reference number of the control that is currently being touched or zero if no control is being touched.
TOUCH(LASTREF)	Will return the reference number of the last control that was touched.