By Geoff Graham

Micromite Plus & the Explore 64

This module really packs a punch. Based on our new Micromite Plus, it's more than twice as powerful as the original Micromite, with much faster performance, substantially more RAM, greater program space (flash memory), more I/O pins, support for a wide range of touchscreen displays (up to 8-inch!) and additional functions including support for USB, SD cards and a PS/2 keyboard. It can act as a sophisticated controller or as a completely self-contained computer.

THE MICROMITE PLUS is based on a PIC32 chip and is a revised version of the 28-pin and 44-pin Micromites described in SILICON CHIP over the past couple of years (see Table 1). While the standard Micromite was intended for ordinary controller jobs, the Micromite Plus is much more advanced and can handle more demanding applications (such as machine controllers).

To quantify some of the improvements, the Micromite Mk2 (described in January this year) runs at 48MHz and has 52KB RAM and of 58KB program space, with between 19 and 33 I/O pins available depending on the version (28-pin or 44-pin). By comparison, the Micromite Plus runs at 120MHz, boasts 100KB RAM, 100KB of program space and in the version described here, has a massive 47 I/O pins available, many of them analog-capable.

The Micromite Plus can run very large programs very fast; 2.5 times as fast as the previous Micromite, in fact. It can also drive LCD touchscreens with a diagonal size of between 1.44 and 8 inches (~37-163mm), with a sophisticated graphics library. That library allows you to create animated radio buttons, numeric keypads, push-buttons and many more GUI elements using just one line of BASIC code.

In addition, the Micromite Plus has an SD card driver and a USB 2.0 interface, giving it the capability to work as a self-contained computer.

This article touches on some of the new Micromite Plus software features and also describes the Explore 64 module, designed for breadboarding. In addition to hosting the PIC32 chip running the Micromite Plus software and breaking out the I/Os, serial console and power pins, it carries an onboard USB socket, a microSD card socket, a 3.3V regulator, a reset button and an optional supply supervisor.

In coming months, we will also

Key Improvements From Micromite Mk2

- 2.5 times the speed
- 92% more RAM
- 72% more program space
- More I/O pins
- Integrated USB
- Supports 10 different touchscreen displays
- Comprehensive GUI library code
- Native SD card support
- MicroSD card socket
- Cheaper to build than 44-pin Micromite

The Micromite Plus is just a standard 64 or 100-pin Microchip PIC32MX470 microcontroller programmed with the MMBasic firmware. It is this firmware that transforms the micro into an easy to use programmable controller that can interface with multiple devices, ranging from LCD panels to SD cards and PS/2 keyboards. Photo courtesy Microchip.

describe the Explore 100, a full Micromite Plus-based computer with display, keyboard support and SD card storage, with even more I/O pins thrown into the bargain.

Touch-sensitive LCDs

The Micromite Plus includes support for 10 different types of LCD panel and as previously stated, these range from a 1.44-inch module to an 8-inch panel. Note that imperial units are commonly used for LCD panels and the specified size is the diagonal measurement of the active screen area. For example, a 5-inch panel is typically around 11 x 7cm while an 8-inch panel would be about 17 x 10.5cm.

The Micromite Plus supports displays that use both serial and parallel interfaces. There are six supported display sizes that use serial (SPI) interfaces, between 1.4 and 2.8 inches diagonal, using ILI9341, ST7735 or ILI9163 controller chips. The ILI9341 is the same chip that was used in the Micromite LCD BackPack (introduced in February) but support for the ST7735 and ILI9163 controllers is new in the Micromite Plus.

Four different displays with parallel interfaces are also supported. These range from 4.3 to 8 inches and it is with these displays that the Micromite Plus really stands out. They can display text and graphics in true 24-bit colour with a resolution of up to 800 x 480 pixels. As a result, you can display vivid photo-quality images with 16 million colours.

The parallel interface between the Micromite Plus and the display controller on the LCD panel means that your BASIC program can update the display very quickly, even though it is addressing almost half a million pixels in full 24-bit colour. This sort of performance is important when you are displaying intricate graphic objects such as radio buttons, check boxes and virtual keypads.

GUI commands

The Micromite Plus has all the BASIC graphics commands supported by the standard Micromite (**PIXEL**, **LINE**, **BOX**, **CIRCLE**, etc). But it also has a range of Graphical User Interface (GUI) commands that are both powerful and easy to use.

For example, by using a GUI command, you can define a check-box on the screen. When this is touched, it will be checked with a cross and when touched a second time it will be unchecked. This checking and unchecking is handled in the background (by the MMBasic interpreter) without involving the main BASIC program.

Another example is the text box. This is an on-screen box which, when touched, will display a full alphanumeric keyboard, allowing text to be entered and edited via the touch-sensitive screen.

These are just two examples of the controls built into MMBasic and the range is extensive. Included are radio buttons, switches, pushbuttons, multi-colour LEDs, numeric keypads and spin boxes.

MMBasic handles all the drawing, animation and interface requirements for GUI elements. All that the BASIC program needs to do is define the on-screen control (with a single command) and from then on, MMBasic

Explore 64: Main Features

- A 32-bit CPU running at 120MHz with 512K of flash memory and 128K RAM.
- Built in BASIC interpreter is Microsoft compatible with 64-bit integer, floating point and string variables, arrays and user defined subroutines and functions.
- 47 input/output (I/O) pins which can be independently configured as digital inputs or outputs. 27 of these can be used as analog inputs.
- The Explore 64 can be plugged into a standard solderless breadboard, or into a protoboard or a custom PCB via standard female headers.
- Supports touch-sensitive LCD panels ranging from 1.44 inches to 8 inches diagonal. Supports LCDs with up to 16 million colours. Built-in graphics commands include pixel, line, circle and box.
- Six built-in fonts plus many more fonts that can be embedded in a program.
- Advanced graphics commands include on-screen keyboards, buttons, switches, checkboxes and radio buttons.
- USB 2.0 interface which creates a serial-over-USB communications channel for program editing and upload/download from a larger computer.
- SD card interface supports SD cards with up to 64GB capacity. Up to five files can be opened simultaneously for read, write and random access.
- Provision for a PS/2 keyboard so that the Explore 64 can act as a fully self-contained computer and development system.
- All the standard features of the Micromite range, including a comprehensive range of communications protocols, inbuilt commands to directly interface with devices such as an IR remote control and temperature sensors, PWM or SERVO outputs and special embedded controller features such as variable CPU speed, sleep, watchdog timer and automatic start and run.
- Power supply: 5V @ 80mA (not including LCD current drain, etc).

Table 1: Micromite Articles In Silicon Chip

Title	Publication Date
The Micromite	May & June 2014
ASCII Video Terminal	July 2014
The 44-pin Micromite	August 2014
The Micromite Mk2	January 2015
Micromite LCD BackPack	February 2016

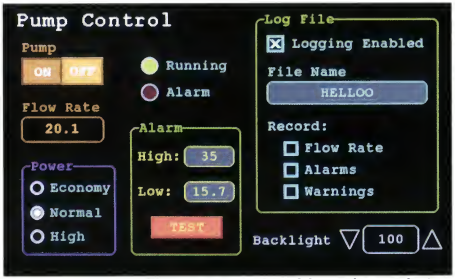


Fig1: this is an example of an on-screen control panel that can be created using the Explore 64 and an LCD panel. Most objects on the screen are touch-sensitive and will react when touched. Each is created with a single BASIC command and from then on MMBasic will manage the display, including animating the objects when a user touches them. We will describe these GUI controls in detail in a later article.

does the rest. The BASIC program flow is unaffected by this activity and can later inspect the state of the control using a single function.

Fig.1 shows an example of a complex pump control panel that is constructed from GUI commands. Each object on the screen required just one line of BASIC code to create it. The GUI controls will be described in detail in article in this series.

SD card & keyboard

The Micromite Plus includes support for SD cards with capacities up to 64GB, formatted as either FAT16 or FAT32. Programs can be loaded and saved to the SD card and up to five data files can be open at the same time from within a BASIC program. These files can be opened for reading, writing or random access. The latter provides quick access to any part of a file and is useful for storing and recalling large amounts of data.

Images held on the SD card can be loaded under program control and displayed on the attached LCD to add screen logos or background images. The files created on the SD card are compatible with Windows, Linux or Macintosh systems, so data can be easily transferred from the Micromite Plus to a desktop computer for analysis.

Another important feature of the Micromite Plus is the ability to attach a PS/2 keyboard. This allows the Micromite Plus to be the heart of a fully self-contained computer, with programs composed and edited on the LCD and saved to an SD card. This is reminiscent of the TRS-80 and Commodore 64 computers of the 1970s and the Maximite series of computers featured in SILICON CHIP in recent years.

MMBasic includes its own colour-coded program editor, so an external computer is not required for the user to compose, edit and run their own programs on the Micromite Plus. If you wish, you can also compose and edit programs on a larger desktop or laptop computer and transfer them to the Micromite Plus using the USB interface or the serial console.

PIC32 microcontroller

The Micromite Plus firmware will run on a number of Microchip PIC32 microcontrollers with either 64 or 100 pins (see Suitable Microcontrollers panel). All come in surface-mount TQFP packages but their pin pitch is a relatively forgiving 0.5mm, so they can be hand-soldered to a carrier board. SILICON CHIP sells suitable carrier boards, ie, www.siliconchip.com.au/Shop/18/3227 and www.siliconchip.com.au/Shop/18/3218

Note, however, that this type of adaptor normally has pins along all four edges and so it is not suitable for plugging into a breadboard, while the Explore 64 is.

The PIC32 microcontrollers listed in the panel each have an optimised MIPS 32-bit processor core which can run at up to 120MHz and supports 512KB of flash memory and 128KB of RAM. This might sound complex and daunting but they are not expensive and the complexity is hidden by the MMBasic interpreter.

This month, we are presenting the Explore 64 which uses the 64-pin version of the chip, while a future instalment will introduce the Explore 100 which uses the 100-pin chip and is designed to mount on the back of a 5-inch LCD panel (although it can be used stand-alone or with a different display).

Explore 64

The Explore 64 is a small PCB designed by SILICON CHIP reader Graeme Rixon of Dunedin, NZ. It can be plugged into a solderless breadboard for prototyping and for exploring the capabilities of the Micromite Plus but could also be used as a replaceable module that's plugged into a larger system.

The PCB includes a 64-pin PIC32 (the Micromite Plus), a mini USB connector, a microSD card socket and the power supply parts. There are 47 I/O pins. Of these, 17 are 5V tolerant, while 27 can be used as analog inputs. So there's plenty of capability to develop a complex project that requires lots of I/O ports.

In order to make it small enough to fit onto a breadboard, the PCB was designed using surface-mount components. Despite this, it's not difficult to build. IC1 (the microcontroller) uses a 0.5mm spacing between its pins and can be hand-soldered using a normal temperature-controlled soldering iron. In addition, the solder pads for the passive components will accept either 1206, 0805 or 0603-size components, so you can use whatever size suits your soldering skills.

Circuit details

Fig.2 shows the circuit details of the Explore 64. It's designed to run from a 5V supply and this can be fed in via USB socket CON1, if jumper JP1 is fitted. Alternatively, if JP1 is removed, the 5V supply can be fed in via the 5V IN and GND pins on the board's edge.

The 5V supply is reduced to 3.3V by low-dropout linear regulator REG1, an MCP1703A. The resulting +3.3V rail is then used to power microcontroller IC1 and is also made available on an

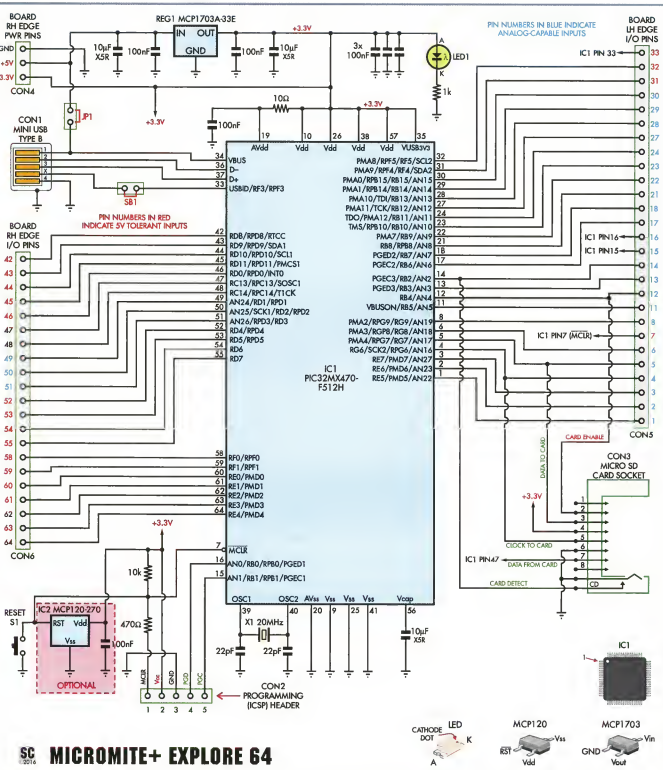


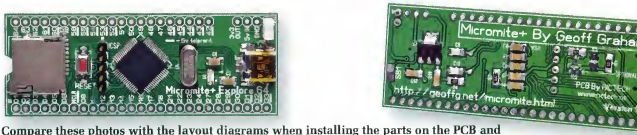
Fig.2: the Explore 64 is mostly a carrier for the 64-pin Micromite Plus (IC1), so its circuit is relatively simple. Most I/O pins from the microcontroller are made available on the board's edge where they can be plugged into a solderless breadboard or into header sockets on a larger board. Voltage regulator REG1 provides 3.3V for the microcontroller and the reset supervisor (IC2) ensures that the microcontroller is held in reset if the 3.3V supply drops below a critical level.

I/O pin on the board's edge for powering external circuitry.

The capacitors across the supply lines before and after the regulator ensure regulator stability and reduce variations in supply voltage with changing current demands. Note the capacitor connected between pin 56 of IC1 and ground. This stabilises IC1's internal 1.8V core regulator and must be a multilayer ceramic type, preferably with an X5R or X7R dielectric.

Ideally, all capacitors should be X5R or X7R ceramic types except for the 22pF crystal load capacitors which

Fig.3: follow these top and bottom PCB parts layout diagrams to build the Explore 64. The top of the PCB (left) carries most of the parts including the microcontroller, SD card socket and USB connector, while most of the power supply components and I/O pin headers are on the bottom side.



Compare these photos with the layout diagrams when installing the parts on the PCB and check that all polarised parts are correctly orientated. CON1-CON3, IC2 and S1 can be left off if they are not required but most constructors will want to fit them.

should be C0G/NP0 ceramic. As a bonus, these capacitors tend to have a very long life (practically indefinite).

I/O pins

Most of IC1's I/O pins are connected to pads along the sides of the PCB, as depicted on either side of the circuit diagram and in Table 2, along with pads for the +5V and +3.3V supply rails and ground. CON3 is the microSD card connector. The I/O pins used for this connector are also brought out to the sides of the PCB so that they can be used as general purpose I/O pins if the microSD connector isn't used.

IC2 (bottom left of Fig.2) is an optional "supervisor" chip. This holds the Micromite Plus in reset until the 3.3V power supply reaches a set level (2.7V in this case). It will also monitor the 3.3V line and reset the microcontroller if there is a glitch or if the supply drops to a low value (a brown-out condition). IC1 has an internal brown-out detector but its threshold is much lower and external circuitry could stop working well before this trips.

The supervisor chip will be important if the Micromite Plus is used in an industrial situation where power fluctuations and electrical noise are common. In other situations, the supervisor chip is not critical and so IC2 and its associated 100nF capacitor can be left out with no ill-effects. We'll be supplying the MCP120-270 in our kits, so you might as well fit it anyway; it certainly won't hurt.

CON2 is an in-circuit serial programming (ICSP) header and this allows the Micromite Plus firmware to be loaded into a blank microcontroller. It suits a Microchip PICkit 3 programmer or similar.

The only other items of note are the USB socket, which connects directly to IC1, and a 20MHz crystal which is used as the clock source for IC1. SB1 is a solder bridge which should be left open; it's included to give the option of supporting a USB device (such as a USB keyboard) in a future firmware upgrade.

Construction

Building the Explore 64 is reasonably easy despite the fact that it uses SMD components. Soldering SMD devices is not that much harder than soldering through-hole components; it just requires a different technique and is easy when you have mastered it.

The essential tools are a good magnifier, plenty of flux and a steady hand. The magnifier needs to be at least x3 power and preferably x10. A jeweller's loupe can be used but the best option is a stereo microscope and SILICON CHIP reviewed some good candidates in the July 2014 and November 2015 issues.

The flux should be a good quality flux paste/gel such as Cat. H1650A from Altronics or Cat. NS3036 from Jaycar.

Fig.3 shows the parts layout on the Explore 64 PCB. The first step is to install microcontroller IC1. Apply flux to all of its pads, then position the chip so that its pin 1 (marked with a dimple)

Suitable Microcontrollers

The Micromite Plus uses Microchip's MX470 series chips. These are part of Microchip's PIC32 (32-bit processor) range and are available in 64-pin and 100-pin packages with top speeds of 100MHz or 120MHz.

The Micromite's firmware starts up at 100MHz so you can use chips with either speed. However, a 120MHz version gives you option of stepping up to 120MHz in your program.

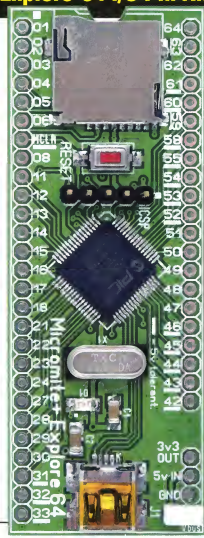
The recommended chips for the Micromite Plus are:

- **PIC32MX470F512H-I/PT: 64-pin, 100MHz**
- **PIC32MX470F512H-120/PT: 64-pin, 120MHz**
- **PIC32MX470F512L-I/PF: 100-pin, 100MHz**
- **PIC32MX470F512L-120/PF: 100-pin, 120MHz**

SILICON CHIP will supply the 120MHz version in all cases, ie, for individually purchased programmed PICs as well as in kits.

Table 2: Explore-64 I/O Pin Allocations

SSD1963 D5 - ANA	1	64	ANA - SSD1963 D4
SSD1963 D6 - ANA	2	63	5V - SSD1963 D3 - PWM1C
SSD1963 D7 - ANA	3	62	ANA - SSD1963 D2
SPI2 CLOCK - ANA	4	61	5V – SSD1963 D1
SPI2 OUT - ANA	5	60	5V – SSD1963 D0
CONSOLE Rx	6	59	5V – COM1 Rx
CPU Reset when Low		58	CONSOLE Tx
SPI1 OUT - ANA	8	55	5V - KEYBOARD DATA
COM2 Tx - ANA	11	54	5V - KEYBOARD CLOCK
ANA	12	53	5V - PWM 2A
COM2 Rx - ANA	13	52	5V - COUNT
ANA	14	51	ANA - COUNT - WU - IR
COM1 Tx - ANA	15	50	ANA - SPI1 CLOCK
COM3 Tx - ANA	16	49	ANA - COUNT
COM3 Rx - ANA	17	48	PWM 1A
ANA	18	47	SPI2 IN - PWM 2B
ANA	21	46	5V
ANA	22	45	5V - SPI1 IN
COUNT - ANA	23	44	5V - I²C CLOCK
SSD1963 WR - ANA	24	43	5V - I²C DATA
SSD1963 RS - ANA	27	42	5V - PWM 1B
SSD1963 Reset - ANA	28		
COM1 Enable - ANA	29		
ANA	30		3.3V OUTPUT (100mA MAX)
5V	31		5V OUTPUT OR INPUT
5V	32		GROUND
DIGITAL INPUT ONLY	33		



(1) Pin Nbr refers to the number used in MMBasic to identify an I/O pin; (2) All pins (except 33) are capable of digital input/output and can be used as an interrupt pin; (3) ANA means that the pin can be used as an analog input; (4) 5V means that the pin is 5V tolerant; (5) COUNT means that the pin can be used for counting or frequency/period measurement; (6) SSD1963 refers to pins that are used to interface to LCD panels using the SSD1963 controller; (7) If the serial console is disabled the CONSOLE pins can be used for COM4

Note: the Explore 64 is shown here scaled up by a factor of almost 2.

is lined up with the pin 1 marking on the PCB (at left). That done, hold it in position using a toothpick or tweezers and solder one corner pin.

Now check that the IC is correctly aligned; if not, re-melt the solder while gently nudging it into position. Once it's in position, apply more flux to all the pins and solder each one in turn, then recheck the first pin and add fresh solder if necessary.

The technique here is simple; put a very small amount of solder on your iron's tip, touch the tip to the solder pad and slide it forwards to gently touch the first pin. The solder should flow around the pin and the pad. You should then be able to solder at least 15 more pins (one side of the IC) before you need to add more solder to the iron.

The secret is to be generous with the flux, as this will allow the solder to flow freely onto the pads and their corresponding pins. Alternatively, if you have a mini-wave tip or a very steady hand, with sufficient flux in place, you can drag solder across one side (16 pins) in a single movement.

Often you will find that you are actually soldering two or more pins simultaneously but the solder will not usually bridge the pins. If it does, this is an indication that you have too much solder on your iron. If any pins are bridged, come back later with solder wick (and more flux) and remove the excess.

The SD card connector is next on the list. It's located on the PCB by two small plastic pins that match two holes on the board. Solder its four mounting lugs first, followed by the signal pins. These pins are soldered using the same technique as for IC1.

Note that the SD card connector's pins are fragile and the plastic they are embedded in will melt if too much heat is applied so only touch the soldering iron to the pins for a very short time. As before, apply plenty of flux before soldering.

The mini-USB connector can now go in. It also has locating pins to posi-

A Microchip PICkit 3 can be used to load the firmware into the PIC32 micro. Alternatively, you can buy a pre-programmed PIC32 chip from the SILICON CHIP Online Shop.

tion it correctly and you should push it down firmly so that it sits flush against the board. Once again, solder the mounting lugs first and then the signal pins. These are a bit of a challenge as they are partially under the connector's body and you will need a fine-tipped soldering bit to reach them; we have extended the pads outside the body to make this easier.

Passive SMD components

Soldering the passive SMD components requires a different technique compared to that used the microcontroller. Start by applying flux to one solder pad and then tin it by applying a thin layer of solder to it. That done, you have two choices.

First, you can place the component in position and hold it still with a toothpick or tweezers while you apply the iron's tip to the end sitting on the tinned pad, so that the component's lead sinks into the solder underneath. Alternatively, you can slide the component into place while heating the solder on the pad. The second technique will probably require more practice but it will be quicker once you get used to it.

Either way, once the component is secure, apply more flux and solder the other end before returning to the first to make sure that the joint is good. Once again, the secret is to use plenty of flux and don't forget that it may have boiled off one of the pads while you were soldering the other end of the component, so keep reapplying it.

LED1 (the power indicator LED) is polarised and should be marked with a bar or dot on the cathode end. Some LEDs might be different so it's good practice to use a multimeter's diode test facility to check the polarity. Be sure to solder it in with its cathode towards the bottom of the board, as shown in Fig.3.

You can use a similar technique as used for the passives to solder regulator REG1 and IC2 (if this is to be fitted). The only trick is that with REG1, you first apply flux to all four pads and then start by soldering one of the smaller leads. That done, check its alignment before soldering the other smaller leads and finally the large tab. It may take a few seconds to heat the part and PCB up enough to get a good solder joint on that tab.

Crystal X1 is a through-hole part and can be soldered using the usual method. PCBs supplied by SILICON CHIP will have solder mask over the top side of the mounting pads so it should be possible to push the crystal can right down onto the PCB surface before soldering it.

That just leaves tactile pushbutton S1 (which can be fitted either way around) and the various pin headers, which are made by snapping longer pin headers to length and then soldering them in the usual manner. Normally, JP1 and CON2 should be fitted on the top of the board, with the other pin headers on the bottom (see Fig.3). CON2 does not need to be fitted if you have a pre-programmed PIC chip.

Loading firmware into the PIC32

Pre-programmed PIC32s are available from the SILICON CHIP Online Shop. If using a blank PIC32 chip, you will need to program it yourself. In this case, you will need a suitable programmer such as a PICkit 3 from Microchip.

The Explore 64 has a set of header pins on the top surface labelled ICSP and the PICkit 3 plugs directly onto them (see photo at left).

The first step is to download the firmware from the SILICON CHIP website and extract the Micromite Plus HEX file (0710816A.hex). It's then just a matter of using your computer and the MPLAB software supplied with the PICkit 3 (or downloaded from Microchip) to program the HEX file into the microcontroller (see page 26 of the February 2016 issue for further details).

During this procedure, the PICkit3 will verify the programming operation by reading back the data on the chip. If it reports a fault, you will need to fix that before progressing. Usually though, the programming operation

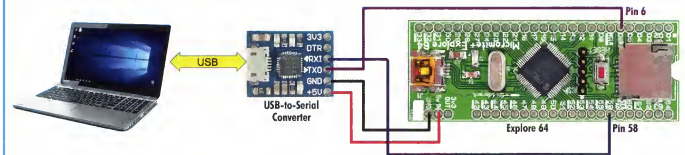
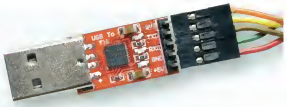


Fig.4: here's how to connect a USB-to-serial converter between your PC and the Explore 64. Note that the converter can supply the 5V power required by the Explore 64 but you also need to fit jumper JP1 (see text).

USB-to-Serial Converter



A USB-to-serial converter such as this CP2102-based unit from the SILICON CHIP Online Shop is necessary in order to use the serial console when developing or editing programs. This unit is supplied complete with a short DuPont cable and plugs directly into your PC's USB port (which also supplies the power). The DuPont cable then connects between the converter and the Explore 64 as shown in Fig.4.

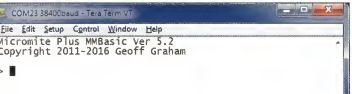


Fig.5: this is what you should see in your terminal emulator when you press the reset button on the Explore 64. If you don't see this, the probable reason is that the USB-serial converter is not connected correctly.

will be verified as OK, indicating that the PIC32 has been correctly programmed.

Serial console

To set up and use the Explore 64, you must connect a terminal emulator to its console. The console is a serial interface over which you can issue commands to MMBasic to configure the chip and edit or run programs. MMBasic also uses the console to display error messages.

The Explore 64 actually has two consoles, one serial and one USB. The USB console is useful for making quick changes to a running program or for developing a program where the Explore 64 is being used as a general-purpose computer. However, if you are using the Explore 64 as a controller, it's best to use the hard-wired serial console via a USB-to-serial converter.

The reason for this is that when the Micromite Plus PIC32 is reset, it will also reset its USB interface. This generally means that you must close the terminal emulator then restart it to restore the connection. When you are developing a program for controlling other equipment, you often need to reset the Micromite Plus and repeatedly closing and re-opening the terminal emulator can get tedious.

A USB-to-serial converter is required in order to use the hard-wired serial console. One end of this converter plugs into a USB port on your computer, while the other end connects to the Explore 64's serial console (Fig.4). To your computer it will look like a serial port (via USB), while the connection to the Explore 64 is a standard serial interface with TTL (0-3.3V) signals levels.

We recommend converters based on the CP2102 chip. These are available from the SILICON CHIP online shop at www.siliconchip.com.au/Shop/7/3437 It is supplied with a short DuPont female/female cable which plugs straight into the Explore 64 board. We also have USB/serial converters based on other chipsets (see our website for the full listing).

Fig.4 shows how a CP2102-based converter is connected to the Explore 64 (other types should be similar). Note that the converter feeds through the 5V supply rail derived from the PC's USB port to power the Explore 64.

When the converter is plugged into your computer and the correct driver is installed, it will appear as a serial port (eg, COM3 in Windows). You then need to start a terminal emulator on your computer.

For Windows we recommend **Tera Term V4.88** which can be downloaded for free from http://tera-term.en.lo4d.com You will need to set its interface speed to 38,400 baud and connect it to the serial port created by the USB-to-serial converter.

Explore 64 Parts List

1 double-sided PCB, code 07108161, 72 x 27mm
1 tactile switch, 2-pin, surface-mount (S1)
1 20MHz crystal, low profile HC-49 (X1)
1 Mini USB type B socket (CON1) (Altronics P1308 or similar)
1 microSD card socket (CON3) (Altronics P5717 or similar)
2 40-pin or 50-pin male headers, 2.54mm pitch (JP1, CON2, CON4-6)
1 shorting block (JP1)

Semiconductors

1 PIC32MX470F512H-120/PT (120MHz) or PIC32MX470-F512H-I/PT (100MHz) 32-bit microcontroller programmed with 0710816A.hex (IC1)
1 MCP1703A(T)-3302E/DB low-dropout 3.3V regulator, SOT-223 (REG1)
1 MCP120(T)-270I/TT 2.7V supply supervisor, SOT-23 (IC2; optional – see text)
1 green SMD LED* (LED1)

Capacitors*

3 10µF 6.3V ceramic, X5R or X7R
7 100nF 50V ceramic, X5R or X7R
2 22pF ceramic, C0G/NP0

Resistors, 1% or 5%*

1 10kΩ 1 470Ω
1 1kΩ 1 10Ω

* Use SMD 3216 (1206 imperial) size; 2012/0805 or 1608/0603 sizes are also suitable but not recommended for beginners.

Where To Buy Parts

A kit for the Explore 64 is available from the SILICON CHIP Online Shop. This includes the PCB, a programmed PIC32 microcontroller and all other parts as listed above.

The PCB & programmed Micromite Plus microcontrollers are also each available separately.

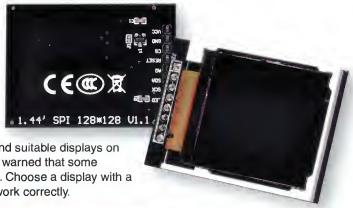
Also available are CP2102 USB-to-serial converters and 2.8-inch ILI9341 touchscreen displays (as used in the LCD Backpack).

PCBs, complete kits and fully assembled and tested Explore 64s are also available from Graeme Rixon (the designer of the PCB) – see www.rictech.nz/micromite-products

Supported LCD Panels

The Micromite Plus has built-in support for 10 different LCD panels, as follows:

1.44-inch ILI9163-Based Displays

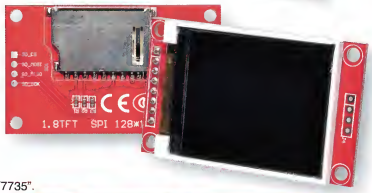


ILI9163-based displays use an SPI interface and have the following basic specifications:

- A 1.44-inch LCD.
- 128 x 128 pixels resolution.
- 25.5 x 26.5mm viewing area.
- Do not come with a touch controller.
- Do not have an SD card socket.

A typical ILI9163 based display is shown at right. You can find suitable displays on eBay by searching for the controller name, ie, "ILI9163". Be warned that some displays with a red PCB won't work with the Micromite Plus. Choose a display with a black PCB (as illustrated), as these have been tested and work correctly.

1.8-inch ST7735-Based Displays

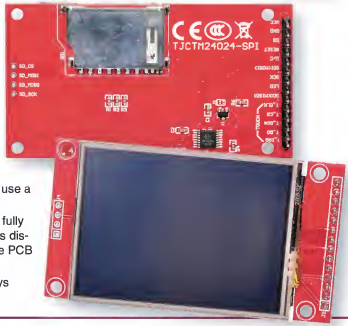


The ST7735-based displays also use a SPI interface and have the following basic specifications:

- A 1.8-inch LCD.
- 160 x 128 pixel resolution and a colour depth of 262K/65K.
- 38 x 35mm viewing area.
- Do not come with a touch controller.
- Have a full-size SD card socket.

You can find suitable displays on eBay by searching for "ST7735".

2.2 to 2.8-inch ILI9341-Based Displays



ILI9341-based displays use an SPI interface and have the following basic specifications:

- A 2.2, 2.4, 2.6 or 2.8-inch LCD.
- 320 x 240 pixel resolution and a colour depth of 262K/65K
- 43.5 x 35mm to 57.5 x 43mm viewing area.
- May have a touch controller (SPI interface).
- Have a full-size SD card socket.

The display that you purchase should look like the display shown at right, as there are other ILI9341-based displays which use a different interface and will not work with the Micromite.

In most cases, this display has a touch-sensitive facility which is fully supported by MMBasic. However, there are some versions of this display without the touch controller (the 16-pin IC on the back of the PCB at bottom right).

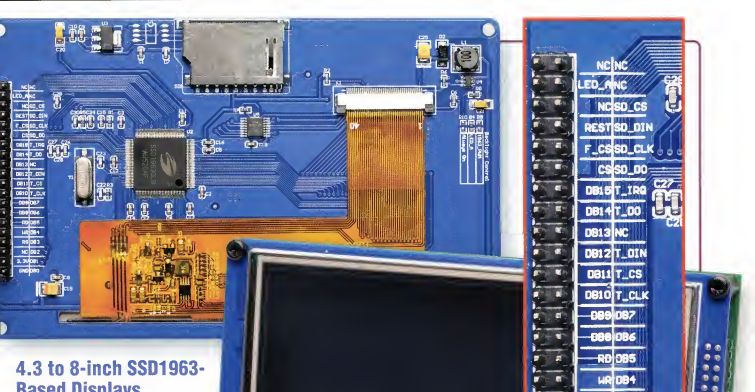
The standard Micromite also supports the ILI9341-based displays (both 28-pin and 44-pin versions).

Once that's been done, hit the Enter key in the terminal emulator and you should see the Micromite's command prompt (>). You can then enter, edit and run programs from this command prompt using nothing more than the PC's terminal emulator and the USB cable.

Testing

If you don't see the Micromite's prompt, something is definitely wrong and you will need to go through the following troubleshooting procedure.

The first step is to measure the current drawn by the Explore 64 from the 5V power supply. With nothing attached to its I/O pins, this should be



4.3 to 8-inch SSD1963-Based Displays

Displays based on the SSD1963 controller use a parallel interface, are available in sizes from 4.3 to 8 inches and have much better specifications than the smaller SPI-based displays. The characteristics of supported SSD1963-based displays are:

- A 4.3, 5, 7 or 8-inch LCD.
- 480 x 272 pixels resolution for the 4.3-inch version; 800 x 480 pixel resolution for 5, 7 and 8-inch versions.
- 95 x 54mm to 176.5 x 99mm viewing area.
- SSD1963 display controller with a parallel interface (8080 format).
- Have a touch controller (SPI interface).
- Have 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 in the photo at top right.** It is strongly recommended that any display purchased has this type of connector so that you can be reasonably confident that the manufacturer has followed the standard that the Micromite Plus is designed to use.

The 8-inch display supplied by the Chinese company EastRising uses a different connector layout to that shown, However, it has been tested with the Micromite Plus and works perfectly.

60-80mA. If it's substantially more or less than this, it indicates that something is wrong with either the soldering, the microcontroller or its power supply.

If this is the case, check that +3.3V is present on pins 10, 26, 38, 57 & 35 of IC1 and on various other components – see Fig.1. If this checks out, check that the capacitor connected to pin 56 (Vcap) of IC1 is correctly soldered and is the correct type; it must be a 10µF multi-layer ceramic type. A faulty capacitor will prevent the internal CPU from running and the current drain will be quite low (less than 10mA).

A disconnected pin can also prevent the micro from running so check the soldering on IC1's pins. It's easy to miss a pin and leave it floating just above its solder pad and without a decent magnifier and bright light, this may not be obvious.

Another cause of low current drain is either not programming the Micromite Plus firmware into the PIC32 chip or ignoring an error during this operation. Check that the micro has been correctly programmed.

If the current drain is about right, the next step is to attach the Explore 64's console to your computer or terminal emulator as shown in Fig.4. You could also try using the USB connector as the console but this is best left until last as it can involve some work

Fig.6: this is the display that you will see on the LCD when the command GUI TEST LCDPANEL is used. The display is animated with the circles being rapidly drawn on top of each other.

in installing the correct device driver and that would just confuse the testing process.

With the console connected, press the Reset button on the Explore 64 and you should see the start-up banner as shown in Fig.5. Note that you will not see this banner if you are using the USB console because resetting the Micromite Plus will also reset the USB interface.

If you don't see the start-up banner you should check the console Tx pin for some activity when the Reset button is pressed (this indicates that MMBasic is outputting its start-up banner). This can be done using a logic probe, oscilloscope or, at a pinch, a moving coil multimeter. If you do see some activity, the fault is probably either an incorrect console connection or is in the USB-to-serial converter.

User manuals

The Micromite Plus is quite an advanced device. After all, it is a full computer with a multitude of facilities. As a result, it has two user manuals which together add up to almost 150 pages.

The first manual is called the "Micromite User Manual" and it describes the features that are standard across the whole Micromite range, from the original 28-pin version to the 100-pin Micromite Plus (to be described in this magazine in the near future). The extra features of the Micromite Plus are described in the "Micromite Plus Addendum" which covers subjects such as the GUI functions, the SD card interface and other features that are only found in the Micromite Plus.

Both manuals are in PDF format and available for free download from the Silicon Chip website. Before you build and test the Explore 64, it would be worthwhile downloading and looking through them as they provide a lot more information than we can fit into these pages.

Configuring an SD card

Once your Explore 64 is up and running, you can configure it to use an SD card. This occupies I/O pins 4, 5, 12, 14 & 47, ie, they can no longer be used as general purpose I/Os (GPIOs).

To set up the SD card, you need to use the **OPTION SDCARD** command. Note that this must be entered at the command prompt and can not be used in a program. The syntax is:

```
OPTION SDCARD CS-pin, CD-pin
```

where "CS-pin" is the I/O pin number that is used as chip select and "CD-pin" is the I/O pin number used for the card detect pin on the SD card connector.

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.

On the Explore 64, 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 you should enter the following command:

```
OPTION SDCARD 12, 14
```

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. As another test, you can pop an SD card into the slot and run the command **FILES**. This will list all the files and directories on the SD card.

Note that some SD cards can be temperamental and may not work so if you encounter a problem here, try a few SD cards before deciding that you have a fault. For example, some cards (especially high capacity, fast types) may demand more current than the power supply on the Explore 64 can provide.

USB interface

The USB interface on the Explore 64 doesn't need configuring. MMBasic monitors the interface and if it detects a host computer, it automatically configures it for serial emulation over USB.

A Windows-based host computer (versions before Windows 10) will require the installation of the "Silicon Chip Serial Port Driver", which can be downloaded from the Silicon Chip website. Macintosh and Linux based computers do not need a device driver, as support is built into the operating system.

Similarly, Windows 10 should not require any drivers to be installed.

Once configured, the USB interface works just like a serial port that's connected to the console. You can start up a terminal emulator such as "Tera Term for Windows" and tell it to connect to the virtual serial port created by the Micromite Plus.

Anything outputted by the Micromite Plus will be sent out on both the USB interface and the serial console. Similarly, anything received on either of these interfaces will be sent to MMBasic.

One benefit of using the USB interface as the console is that you can disable the serial console. This allows you to use the I/O pins allocated to the serial console for other duties, including use as a fourth serial I/O port. This is described further in the "Micromite Plus Addendum".

Configuring a display

As stated, MMBasic for the Micromite Plus has inbuilt support for 10 different LCD panels (1.44 to 8 inches). The smaller displays employ an SPI interface which uses only five I/O pins, so they are a good choice when you need a small display and want to keep as many I/O pins free as possible.

By contrast, the larger displays (4.3-8 inches) use an 8-bit parallel interface to transfer data. This requires 11 I/O pins but this is a small sacrifice considering the speed that it brings.

The full selection of supported displays is listed in an accompanying panel. Note that you do not have to use a display with the Explore 64; it is entirely optional and MMBasic will work perfectly well without one.

Having said that, using an LCD touchscreen is so simple and it adds such a professional air to a project that it is hard to think why you would not want to use one.

To configure the Micromite Plus for a particular LCD panel, use the **OPTION LCDPANEL** command. This comes in two forms. Displays with an SPI interface use this form:

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

While displays that have a parallel interface use this form:

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

The "controller" parameter defines what type of display controller chip is used on the display. This can be one of:

- **ILI9163:** a 1.44-inch display with an ILI9163 controller.
- **ST7735:** a 1.8-inch display with an ST7735 controller.
- **ILI9341:** A 2.2, 2.4, 2.6 or 2.8-inch 240 x 320 pixel display with an ILI-9341 controller.
- **SSD1963_4:** a 4.3-inch display with an SSD1963 controller.
- **SSD1963_5:** a 5-inch display with an SSD1963 controller.
- **SSD1963_5A:** an alternative version of the 5-inch display if SSD1963_5 doesn't work.
- **SSD1963_7:** a 7-inch display with an SSD1963 controller.
- **SSD1963_7A:** an alternative version of the 7-inch display if SSD1963_7 doesn't work.
- **SSD1963_8:** an 8-inch display supplied by the Chinese company East-Rising (www.buydisplay.com).

The "orientation" parameter specifies the normal position of the display which might be mounted in a portrait orientation or even upside-down. Your choices for this parameter are **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.

The remaining parameters in the command specify some of the I/O pins used for the display. There are other pins that are dedicated when you specify a type of display as listed the "Micromite Plus Addendum". This specifies exactly how to connect a display and what I/O pins to use.

To test the display, enter the command:

GUI TEST LCDPANEL

You should immediately see an animated display of colour circles being rapidly drawn on top of each other (Fig.6). Pressing the space bar on the console's keyboard stops the test.

When using an LCD panel that has an SSD1963 controller, the Micromite Plus can display 800x480 pixels in true (24 bit) colour. This image of a tiger demonstrates the resolution and colour range.

Configuring touch

Most displays are supplied with a resistive touch-sensitive panel and its associated controller chip. To use the touch feature in MMBasic, the touch controller must first be connected to the Micromite Plus and then configured. The connections for the touch controller are different on each LCD panel, so refer to the "Micromite Plus Addendum" for the details.

MMBasic is configured for touch using the **OPTION TOUCH** command at the command prompt (not in a program). This should be done after the LCD panel has been configured. The syntax is:

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).

The "click_pin" parameter is optional 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, thereby providing an audible feedback whenever a GUI element on the screen is activated. We will cover this subject in detail in a future article, where we describe the on-screen graphic (GUI) controls.

As with other options, this command only needs to be run once and 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.

Before the touch facility can be used, it must be calibrated using the **GUI CALIBRATE** command. The calibration processes starts with MMBasic displaying

Firmware Updates

For firmware updates and other information relating to the Micromite Plus, check the author's website at geoffg.net/micromite.html

Firmware updates will also be made available for download from the SILICON CHIP website as soon as we have been notified.