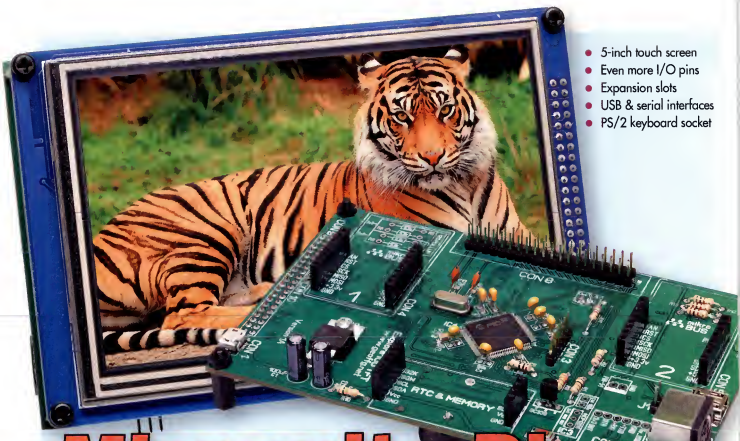



# Micromite Plus Explore 100

**Pt.1: By Geoff Graham**

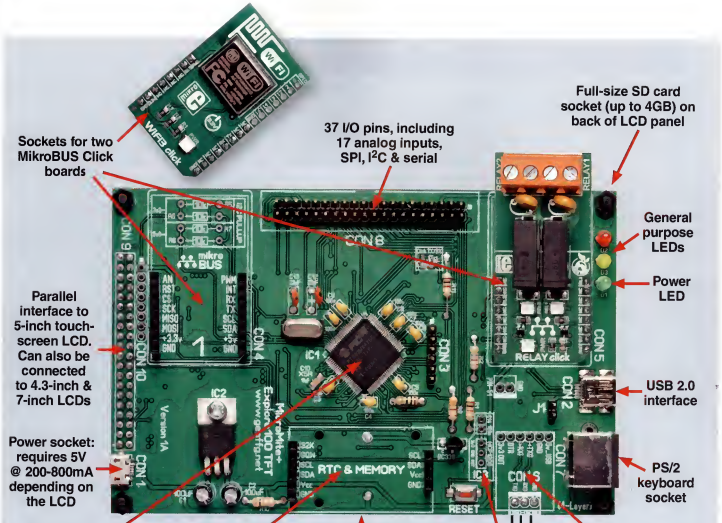
**The Explore 100 expands on the Micromite Plus Explore 64 described last month, adding more I/O pins, two slots for mikroBUS Click expansion boards, provision for a Real Time Clock (RTC), USB-to-serial adaptors and a PS/2 keyboard socket. Perhaps most importantly, it connects directly to (and mounts on) a 5-inch touchscreen for stunning graphics. It can be used as a fully integrated computer or as an advanced embedded controller.**

THE EXPLORE 100 combines a high-performance microcontroller, programmed with the Micromite Plus firmware, with a large and colourful display panel that can draw graphics and sophisticated on-screen controls such as radio buttons, check boxes, spin boxes and more.

The Explore 100 PCB is designed to match the dimensions of a standard 5-inch touch-sensitive LCD panel so that when the two are mated, they make a slim "sandwich". This neat display/controller package can be treated as a single intelligent device and mounted in a control panel or on the front of an enclosure where it could display data and accept control input via the touch-sensitive screen.

At the core of the Explore series is the Micromite Plus, a fast microcontroller with a built-in BASIC interpreter and drivers for touch-sensitive LCD displays, PS/2 keyboards, SD/microSD cards and a host of special devices such as infrared remote controls and temperature sensors.

This project has a dual personality. Firstly, it makes an ideal controller/interface for anything that needs an in-




**This photo summarises the features and capabilities of the Explore 100. These features include the 32-bit microcontroller with its in-built BASIC interpreter, 37 input/output pins for controlling external devices, two sockets for MikroElektronika click boards, a USB 2.0 interface, a connector for a PS/2 keyboard and on-board sockets for a super-accurate real time clock (RTC) module and a USB-to-serial converter.**

put system and control display panel. Examples include a sophisticated irrigation controller, an easy-to-use security system, a computer-controlled lathe and a general industrial controller.

The Explore 100 can be mounted in a control panel where it can display graphs and numbers while accepting input commands on its touch-sensitive screen. It has 37 spare input/output lines which can be used for monitoring voltages, currents, switch closures, etc and can control external devices by closing relays, illuminating LEDs etc.

Secondly, the Explore 100 can act as a completely self-contained computer, similar to the Tandy TRS-80, Commodore 64 or Apple II of yesteryear. It's a bit like the popular Maximite featured in Silicon Chip in the March-May 2011 and September & October 2012 issues – but much more powerful! With its colourful LCD screen and PS/2 keyboard interface, you can learn to program it in the easy-to-use BASIC language and make use of the SD card facility to save and load programs and data.

Using BASIC, you can draw graphic objects on the LCD panel, including lines, circles and boxes, as well as turn individual pixels on (or off) in any one of 16 million colours. You can use it for educating your children, tracking astronomical objects, writing games or just exploring a fun, easy-to-use computer system.

## LCD touch-screen panel

The Explore 100 can use all the different LCD panels that were described in the Explore 64 article last month, ranging from a tiny 1.44-inch display up to a monster 8-inch touchscreen with a resolution of 800x480 pixels. But it's specifically designed to work with panels that use the SSD1963 display controller, ranging from 4.3 inches (diagonal) to 8 inches. The SSD1963 has a parallel interface, allowing the Micromite Plus to transfer data at high speed, so these screens are ideal for displaying complex graphics.

Compatible displays can be found on eBay for US$25 to US$60. In addition to the display itself, they feature a touch-sensitive screen surface and a full-size SD card socket, both of which are fully supported by the Micromite Plus.

## Explore 100: Features & Specifications

- Mates with a 5-inch SSD1963-based tauch-sensitive LCD with 800 x 480 pixels @ 16 million colours (4.3, 7 & 8-inch panels are also suitable)
- 32-bit CPU running at 120MHz with 512KB of flash memory (58KB available far programs) and 128KB RAM (52KB available).
- In-built Microsaft-campatible BASIC interpreter with 64-bit integer, floating point and string variables, arrays and user-defined subroutines and functions
- 37 I/O pins independently configurable as digital inputs or autputs; 17 can be used as analog inputs
- Twa MikraElektranika Click board sockets. Almost 200 Click boards are available including Ethernet, WiFi, Bluetooth, relay outputs, current measuring and mare
- USB 2.0 serial interface far program editing and upload/dawnlaad fram a PC
- Supports micraSD and SD cards up to 64GB
- On-board sackets for accurate real-time clack and USB-to-serial canverter
- PS/2 keyboard cannectar allaws the Explare 100 ta can act as a fully self-cantained camputer and develapment system
- In-built graphics cammands, including pixel, line, circle and box
- Six in-built fants plus many more fonts that can be embedded in a program
- Advanced graphics commands include an-screen keybaards, buttans, switches, check baxes and radia buttons
- Standard Micramite features, including many communicatians pratocals with SPI, I²C and 1-Wire plus in-built cammands ta directly interface with IR remate cantrols, temperature sensors and ather devices
- PWM ar SERVO autputs and special embedded cantraller features such as variable CPU speed, sleep, watchdag timer and autamatic start and run
- Runs from 5V DC at up ta 750mA (depending an LCD panel and brightness)

The mounting holes and physical dimensions of the Explore 100's PCB are designed to match the 5-inch display version. The Explore 100 is secured to the back of the display using four spacers, one at each corner, to create a single rigid assembly.

### Input/output pins

The Explore 100 has a 40-pin general purpose input/output (GPIO) connector. Various pins on this connector can be configured as analog or digital inputs, digital outputs, frequency inputs, PWM outputs and much more. Also available on this connector are three high-speed serial ports (RS-232 TTL), an I²C interface and an SPI interface.

In total, this connector has 37 I/O pins plus three pins for supplying power (ground, +3.3V and +5V). All of the I/O pins can act as either digital inputs or outputs, while 17 of them can also be used for measuring analog voltages. The GPIO connector can be linked to another PCB via a 40-way ribbon cable or connected directly to another PCB which can piggyback onto the Explore 100, making a 3-board sandwich.

If you want to develop additional circuitry on a breadboard, you can purchase adapter boards that take a 40-way cable and spread the signal lines out to 0.1-inch pins that can plug into a standard solderless breadboard. They are intended for use with the Raspberry Pi but they work well with the Explore 100 (all except a few I/O pins are available).


**The Explore 100 uses a 100-pin Microchip PIC-32MX470 micro-controller pro-grammed with the MMBasic firmware. The pins on this surface-mount package have a 0.5mm spacing which can be soldered with a standard temperature-controlled soldering iron. Photo courtesy Microchip.**

### mikroBUS Click boards

The Explore 100 has two sockets for mikroBUS Click boards, which is a standard developed by the European company MikroElektronika. At last count, there were almost 200 of these little boards providing just about any function that you can think of, including an Ethernet interface, Bluetooth, WiFi and GPS (plus many more). They are ideal for adding a specific function to the Explore 100 without the hassle of building it yourself.

For example, by plugging in the TextToSpeech Click board, you can make voice announcements from your BASIC program and by using one of the WiFi boards, your program can generate a web page for access via the internet. Another example is the RF Meter click board which can be used to measure RF power over a frequency range of 1MHz to 8GHz with a 60dB dynamic range.

The MikroElektronika catalog also includes an adaptor Click board which allows you to use the range of 10-pin Olimex UEXT Modules and these add a further 100 or so modules to the available selection. You can find compatible Click boards by searching the internet for "click board" and UEXT modules by searching for "UEXT".

### A self-contained computer

Perhaps the most exciting feature of the Explore 100 is that it makes an excellent self-contained computer. It starts up instantly, contains its own programming language and it's just a matter of plugging in a keyboard to start experimenting.

If this sounds familiar, it might be because you've read the articles on (or perhaps even built) the Maximite and the Colour Maximite, featured in SILICON CHIP in March-May 2011 and September-October 2012. The Explore 100 acts very much the same as these; the difference is that it uses a full colour LCD panel (rather than eight colours on a bulky VGA monitor) and runs twice as fast with four times the memory.

The keyboard interface will work with a standard PS/2 keyboard and has support for the number pad, function and editing keys. The keyboard is essential if you are using the Explore 100 as a general-purpose, self-contained computer and is also useful when the Explore 100 is mounted in a control panel. In that case, you can plug in a keyboard and make changes to the program without pulling out your laptop.

An important part of a self-contained computer is the program editor. The full-screen editor used in the Micromite Plus is quite advanced and allows you to scroll through your program, search for text and cut or copy text to the clipboard and paste it somewhere else. It also displays your program on the LCD panel with colour coding, so that keywords are in one colour, comments in another and so on.

The best part of the editor is that the run/edit/run cycle is very fast. When you have edited your program, you only need to press the F2 key on the keyboard to automatically save and run it. If your program contains an error, the BASIC interpreter will stop and display an error message.

You can then press the F4 key to take you back into the editor, with the cursor positioned at the line which halted the program. After you have corrected the fault, pressing F2 will save and run the program again. It doesn't get much easier than this.

You can save programs on an SD (or microSD) card for safekeeping, although this is not strictly necessary as the program in the Micromite Plus is held in non-volatile flash memory, which means that it will not be lost when the power is turned off. However, using an SD card allows you to have multiple programs which you can load, edit and save at will.

As a self-contained computer, the Explore 100 still has access to all the features of the Micromite Plus, including a USB (serial) interface, multiple fonts, an extensive suite of graphics commands and powerful input/output facilities. In addition, the two Click board sockets allow you to quickly add extra functions to expand the computer's capability. For example, you could plug in an RS-232 Click board and use the Explore 100 to control an item of test equipment.

## Display size

When you are using the Explore 100 as a self-contained computer, the larger the screen size the better. We recommend the 5-inch display as it works well and matches the size of the Explore 100 board. However, if you opt for a larger screen, the characters are correspondingly larger and easier to read.

Clearly, the 7-inch display will be easier to read than the 5-inch display and the 8-inch display easier again (available from EastRising at www.buydisplay.com). **Note though that the EastRising panel uses non-standard interface connector pin-outs so you must use point-to-point wiring between the Explore 100 PCB and the LCD panel.**


**The Explore 100 has two sockets for mikroBUS-compatible Click boards. This is a standard developed by the European company MikroElektronika and covers a wide range of plug-in modules, including Ethernet, Bluetooth, WiFi and GPS modules – perfect for adding extra functions to the Explore 100. A WiFi board and a relay board are shown connected here**

Incidentally, the LCD panels do not cost a huge amount so you could always purchase both a 5-inch and a 7-inch panel and see which one better suits your requirements. That will also give you a back-up panel which could come in handy during testing.

## Console connections

On the lower righthand corner of the Explore 100's PCB are the serial console and USB console connectors. The console is an important part of the Micromite Plus as this is how you configure and program it using a larger computer, running a terminal emulator. The serial console and USB console work the same, so you can use either as the console or even both at the same time.

In the Explore 64 article last month, we discussed when and why a serial console is handy (rather than just using the USB console). Basically it's because the serial interface will remain working whenever the Micromite Plus is restarted, unlike the USB interface which will lose its connection on every restart.

Depending on what type of development work you are doing, you may need to reset the Micromite Plus regularly and this is where the serial console is handy. If you are using the Explore 100 as a self-contained computer, this is less of an issue and generally the in-built USB interface will be fine.

## Serial port driver

If you are using a version of Windows earlier than Windows 10, you must install the Silicon Chip USB Serial Port Driver on your PC (available for download from the Silicon Chip website) before you can use the USB console. The full instructions are in-

cluded with this driver. The Micromite Plus uses the standard CDC protocol and drivers are built into the Mac and Linux operating systems (and also into Windows 10).

The PCB also features a footprint to suit a CP2102-based USB-to-serial converter which gives the Explore 100 a USB console that will not reset when the Micromite is reset. These converters are available from the SILICON CHIP Online Shop – see **www.siliconchip.com.au/Shop/7/3543**.

The CP2102-based USB-to-serial converter needs a 6-pin header soldered to the appropriate pins and then it can be simply plugged into its position on the PCB. There are no special configuration commands that need to be run, as MMBasic defaults to using a serial console unless told otherwise.

## Other features

The Explore 100 is designed to use the full-sized SD card socket which is mounted on all compatible LCD display panels. However, if you are mounting the Explore 100 on the back of the 5-inch display as intended, the SD card will stick out the top.

This could be a bit awkward in some situations so the SILICON CHIP version of the Explore 100 PCB also has an on-board microSD card socket (the original version has an SD card header only – see panel). You can use either, or both. The two sockets share the same SPI serial interface but have separate CS (card select) and CD (card detect) lines.

Currently, the Micromite Plus has to be rebooted to change the SD card pins so you can't switch between the sockets at will, although this might change in future versions

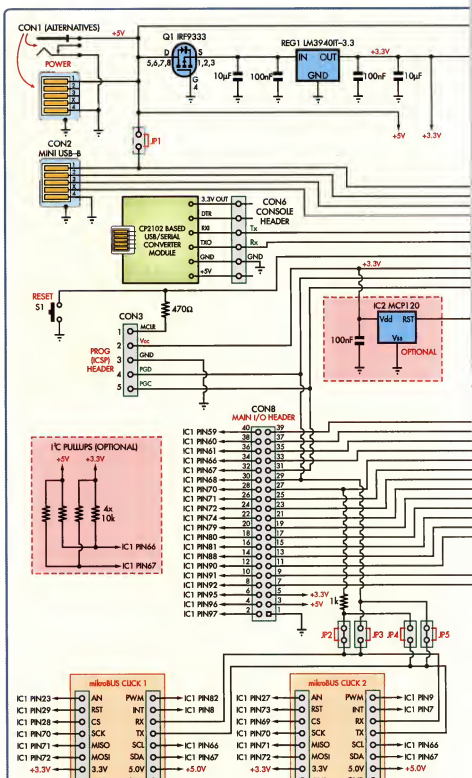
You can open files on either card to read or write data from within the BASIC program. All files created are compatible with standard desktop computers so you can use the SD card to log data for later analysis.

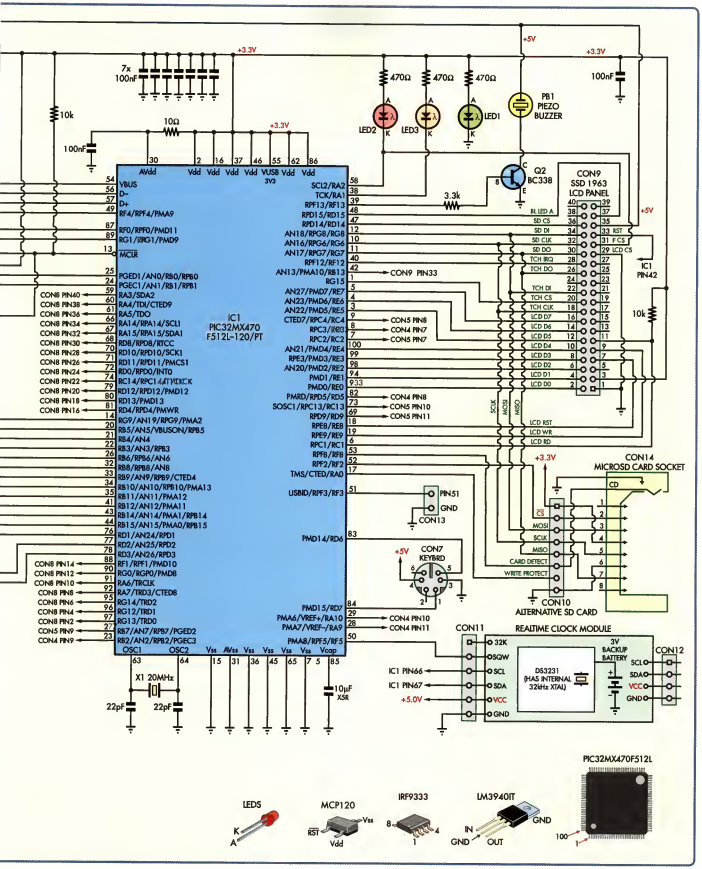
You could also mount a second SD card socket somewhere else using the alternate SD card connector (CON10), which is wired in parallel with the on-board microSD card socket.

## MCP120 reset supervisor

The PCB also has provision for installing a Microchip MCP120 supervisor device. This is optional and if installed, will monitor the main 3.3V power rail and reset the Micromite Plus if the voltage drops below a critical level (around 2.7V for the specified part).

Basically, the MCP120 is designed to provide an extra level of protection in an industrial environment where power brownouts and electrical noise could cause a microcontroller like the






Micromite Plus to run amok.

Yet another feature is a piezo buzzer. This is mounted underneath the board and produces a "click" sound for au-

**Fig.1: the complete circuit of the Explore 100 module. It's based on a 100-pin PIC32MX470F512L microcontroller IC1, running the Micromite Plus firmware. Many of the pins on IC1 are routed to various connectors for GPIO, the LCD panel, Click boards and other modules. The remaining circuitry consists of a power supply (based on REG1) and an optional supply supervisor (IC2).**

## Explore 100 Parts List

1 4-layer PCB, code 07109161, 135mm x 85mm
1 5-inch LCD panel with SSD1963 controller, touch interface and SD card socket ***OR***
1 4.3-inch, 7-inch or 8-inch LCD panel with SSD1963 controller
1 5V DC 1A+ regulated DC power supply with 2.1/2.5mm inner diameter DC connector (centre pin positive) or micro-USB plug
1 PCB-mount DC socket, 2.1/2.5mm inner diameter, to suit power supply (CON1a; eg, Altronics P0620) ***OR***
1 SMD micro-USB Type B socket (CON1b)
1 SMD mini USB Type B socket (CON2; Altronics P1308 or similar)
4 8-pin, two 6-pin and one 4-pin female header sockets (CON4-CON6,CON11a,CON11b) ***OR***
2 40-pin or 1 50-pin female header socket cut into sections (as above)
1 40-pin or 50-pin male header, 2.54mm pitch, snapped into two 2-pin, one 6-pin & one 8-pin sections (JP1, JP2, CON3, CON10)
1 3-pin right-angle header, 2.54mm pitch (CON6)
1 6-pin PCB-mount mini DIN socket (CON7; Altronics P1106 or similar)
1 dual-row 40-pin header, 2.54mm pitch (CON8)
1 dual-row 40-pin female header, 2.54mm pitch, or dual-row 40-pin male header and matching IDC cable (CON9; see text)
1 microSD card socket (CON12, optional; Altronics P5717 or similar)
2 shorting blocks (JP1,JP2)
1 20MHz crystal, low profile (X1)
1 23mm buzzer (Altronics S6108) or 14mm buzzer (Altronics S6104 or S6105) (PB1; see text)
1 tactile pushbutton switch, four pin, through hole (S1)
4 M3 x 12mm tapped spacers & 8 M3 x 6mm machine screws ***OR***
4 M3 x 12mm untapped spacers & 4 x M3 x 16mm machine screws plus 4 x M3 nuts (LCD mounting)
1 M3 x 6mm machine screw with matching nut (for REG1)

**Semiconductors**

1 PIC32MX470F512L-120/PF (120MHz) ***OR*** PIC32MX470F512L-I/PF (100MHz) in 100-pin TQFP package, programmed with Micromite Plus firmware (IC1)
1 MCP120-270GI/TO reset supervisor, TO-92 package (IC2, optional – see text)
1 LM3940IT-3.3 regulator, TO-220 package (REG1)
1 IRF9333PbF Mosfet (Q1, optional – see text)
1 BC338 transistor, TO-92 (Q2)
1 green 3mm LED (LED1)
1 red 3mm LED (LED2)
1 yellow 3mm LED (LED3)

**Capacitors**

2 100µF 16V electrolytic
1 10µF SMD ceramic, 3216/1206 package, X5R or X7R dielectric
11 100nF ceramic disc or multi-layer ceramic
2 22pF NP0 ceramic disc

**Resistors (0.25W, 5%)**

2 10kΩ
1 3.3kΩ
1 1kΩ
4 470Ω
1 10Ω

### Where To Buy Parts

A PCB and a short form kit with the four surface-mount components already soldered in place is available from Graeme Rixon – see **www.rictech.nz/micromite-products**

Silicon Chip can also supply the PCB, programmed microcontroller, RTC module and USB-to-serial adaptor as separate items, as well as a complete kit without the LCD – see our Online Shop for details.

## Two PCB Versions

As noted in the text, the Explore 100 PCB was designed by Graeme Rixon of Dunedin, NZ – see **www.rictech.nz/micromite-products**

The PCB sold by Silicon Chip is virtually identical to this board, the main difference being that we've added an on-board micro-SD card socket (CON14). It's linked directly to the original SD card header on the PCB (CON10).

The Silicon Chip PCB can also accept either a DC power socket or a micro-USB socket for CON1, whereas the alternative PCB now has provision for a DC socket only (in place of the original micro-USB socket).

Finally, note that the PCB shown in the photos is a prototype and the final version differs in a few respects. In particular, the earlier version did not include Mosfet Q1 in the supply line to provide protection against reversed supply polarity.

dible feedback when a GUI element on the screen is activated.

The PCB also has three indicator LEDs. The green LED is the power indicator, while the red and yellow LEDs are general-purpose indicators which can be controlled by the BASIC program to signify some status.

## Circuit details

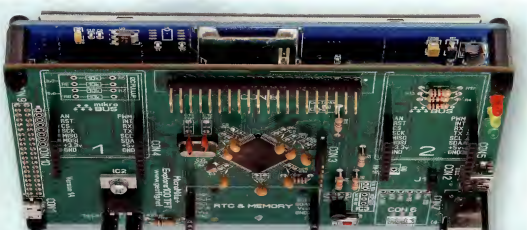
Referring to Fig.1, you can see that the Explore 100 is mostly a carrier for the 100-pin PIC32 chip (programmed with the Micromite Plus firmware) and the various connectors. Other than the voltage regulator and two transistors, there are no other active devices.

The power input is protected from reverse polarity by Q1 which is a P-channel Mosfet. This is optional and the board is designed so that you can run a blob of solder over two pads and dispense with the Mosfet. Having said that, it doesn't cost much and has little effect on the circuit other than to protect it against damage, so we'd recommend you fit it.

The input 5V is routed to a number of locations, including the Click board sockets, the real-time clock module (RTC), keyboard and I/O connector (CON8). It is also routed to the LCD connector (CON9) as some displays, particularly the 7-inch versions, use this for powering the backlight.

REG1 is a low-dropout linear regulator which provides 3.3V to the PIC32 (Micromite Plus), the Click boards, I/O connector and the LCD panel. It is mounted on a large area of copper on the PCB which acts as a heatsink. As a result, it only gets slightly warm, even at full load.

As with most designs involving a microcontroller, there are 100nF capac-



**The Explore 100 is designed to work with LCD panels that use the SSD1963 display controller which range in size from 4.3 inches (diagonal) to 8 inches. The mounting holes and physical dimensions of the PCB are designed to match the 5-inch version of this display. The PCB mounts onto the back of the display with four spacers, one at each corner, which creates a single rigid assembly.**

itors across all supply lines to reduce voltage variations when pulses of current are drawn. These are through-hole components; the only surface-mount passive component is the 10µF multilayer ceramic capacitor for the PIC32's internal 1.8V core regulator (connected to pin 65). The part used should have an X5R or X7R dielectric.

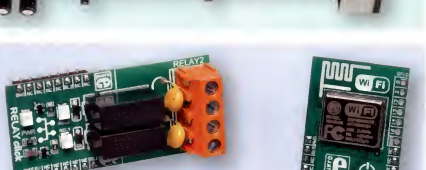
The circuit shows pin 51 from IC1 connected to a 2-pin header. This I/O pin was spare and rather than ignore it, we routed it to a header so that it can be used for something if needed. The circuit also shows four 10kΩ resistors marked "$I^2C$ pull-ups". These provide the option of pulling up the $I^2C$ signal lines to either 3.3V or 5V. Normally they are not required as most modules using $I^2C$ already have these resistors onboard.

**Jumper JP1 allows 5V from USB connector CON2 to supply power to the Explore 100. For normal use, a jumper should not be fitted as it could cause the 5V supply from CON1 to back-feed the USB host (a no-no!). However, if you want the USB connector to power the board, you can short JP1 but then you must not use CON1.**

## Power supply

The photos show an early version of the prototype which used a micro-USB connector for the power input. The final PCB has the option of using either a micro-USB or a standard DC power connector. It also has provision for the previously-described optional Mosfet to protect against accidental power polarity reversal.

The most convenient power source for the Explore 100 is a 5V regulated plugpack. **Make sure that you do not use one of the older transformer-style plugpacks which can easily deliver 8V or more when unloaded, even though they are labelled as 5V. An over-voltage of that magnitude will destroy IC2, the keyboard and any attached Click boards.**




**The Explore 100 has two sockets for mikroBUS Click boards, allowing a range of functions to be easily added to the Explore 100. A twin-relay board and a WiFi module are pictured here but there are lots more.**

The current drawn by the Explore 100 depends on the LCD panel used. With a standard 5-inch panel it will be about 500mA, not including the power drawn by the Click boards or I/O pins. With a 7-inch LCD, it will be about 750mA with the same provisos.

## PCB design

The Explore 100 is built on a four-layer PCB which, like the Explore 64 described last month, was designed by Silicon Chip reader Graeme Rixon of Dunedin, New Zealand. Normally you would expect something of this complexity to fit on a double-sided board but because the 100-pin Micromite Plus in the centre connects to almost every other place on the board, a 4-layer design was required.

A 4-layer PCB essentially consists of two thin double-sided PCBs glued in a sandwich, with a dielectric (insulator) in between. The layers are connected by drilled and plated vias which pass through all four layers.

Note that some 4-layer boards have vias which don't go all the way through. In fact, in some cases, they only pass through internal layers ("blind vias"), so they are not visible from the outside of the board. Our design doesn't use any such vias, though.

We're using the outer (top and bottom) layers for signal and power routing and ground planes, with the two internal layers for additional signal routing only. Typically, for a four or 6-layer PCB, the internal layers are used for power and ground planes and the outer layers for signal routing but this is a signal-heavy board so a different scheme was used.

## Next month

That's all we have space for this month. Next month, we'll give the full assembly details for the Explore 100, describe the display mounting and describe the setting-up, testing and fault-finding procedures. **SC**