

PicoMite Multi

PCB version 1.0 Document version 0.1

By Mixtel90

This system is very flexible and can replace several others. It can be built as a combined unit from scratch or it can be built as a test rig to trial various options. If you use sockets for the processor you can initially build it as RP2040 Pico with LCD touch screen, upgrading it later to RP2350 Pico 2 W with HDMI display, USB keyboard and mouse and a choice of audio modules. You can get five boards from JLCPCB and build each one as an entirely different system. :)

Although the PCB has locations for SMD components (HDMI and SDcard) it is possible to build a complete system without any surface mount soldering whatsoever.

The GPIO header H1 has been positioned such that a horizontal box header can be used, allowing connection of a ribbon cable. Please note the limitations of this port though, as all of the signals may be used elsewhere depending on the system configuration. Unless you do something unusual, 3V3, GND, SCL and SDA are always available and can be used for system I/O expansion.

The PCB pack consists of two boards, both of which are within the "special offer" 100mm x 100mm size limit at JLCPCB. The main PCB is designed to fit the Hammond low cost RM2015 enclosures. The second PCB holds the set of audio and display modules together with some special ones for experimental purposes (not all are detailed here or shown on the circuit diagram). It is possible to just build the main PCB, but that restricts the flexibility of the system drastically. NOTE: You will need a way to cut the second PCB into its various sections.

This system is designed to run MMBasic by Geoff Graham and Peter Mather.

The basic assembly includes a Reset button, real-time clock and full or micro size SD card socket.

To set up the RTC use:

```
OPTION SYSTEM I2C GP20, GP21  
OPTION RTC AUTO ENABLE
```

To set up the SD card use:

```
OPTION SDCARD GP1, GP2, GP3, GP0  
SK2C (the micro SD card module) does not require any surface mount soldering but the two full size sockets are not difficult to solder anyway.
```

The front panel LED is intended to operate as follows:

The Red section is in parallel with the on-board green LED connected to GP25, so will flash instead of that. The Green section is controlled by GP22. If the Heartbeat is enabled and GP22 is off then you will see flashing red, if GP22 is on then you will see alternate green and yellow. You can disable Heartbeat then control each of the red and green sections independently.

GP22 can be re-allocated and used as an input from a IR receiver on the front panel (as described in the PicoMite manual). This option is selectable via a link. (See PCB Configuration section)

If you aren't using the VS1053 and you have a favourite PS2 keyboard that you'd like to use then you can even do that. To set it up enter the following at the console prompt:

```
OPTION KEYBOARD DISABLE  
OPTION KEYBOARD PINS GP4, GP5  
OPTION KEYBOARD n (See PicoMite manual for options).
```

The original GPIO pins are no longer available as they are now used for the console when using the USB firmware.

Build it by numbers!

1. Choose your processor

You can use either a Raspberry Pi Pico or a Pico 2. The PCB is designed for these only and is unlikely to work with any module that is not 100% compatible both electrically and mechanically.

- The Pico uses the RP2040. This is the original module. It will not work with the HDMI display under MMBasic.
- The Pico 2 uses the RP2350A. This will work with all the display modules.

The board is not specifically designed to accommodate the Pico W or Pico 2W, however it will mostly work. On these processors the green Heartbeat LED is not under control of the Pico so the red section of the front panel LED cannot be used in the usual fashion. If, instead of connecting it you close switch S1/3 (labeled PON) the Red LED will indicate Power On. This also applies if you use any plug-in processor without connecting GP25. I wouldn't recommend surface mounting either of the W versions as the antenna is too close to PCB traces and the backplane to be effective.

The system **might** also work with the YD-RP2040 (the "black Chinese clone"), but this will not work with a DVI/HDMI display and will need a mini-USB-C plug to connect the USB signals. Link pins 39 and 40 if you wish to use the PROGRAM USB socket. GP23 and GP29 are not connected, GP25 is unavailable. This module is not suitable for surface mounting.

2. Surface mount or plug-in Pico?

If surface mounting you will need the vertical USB-C programming connector.

There are no jump wires needed for the Pico.

You have the advantage of the shortest HDMI connections and most rugged construction.

The disadvantage is that it is very difficult to remove the Pico.

If making it plug-in you will need to provide the headers and sockets for the Pico.

You will need the "mini" micro-USB plug to connect the USB signals to the USB-C programming connector position (which is not fitted).

If you want the red heartbeat signal on the front panel you will need a jumper wire connected to the pad beneath the Pico.

The plug-in assembly is less rugged and you will have to remove it from the case to update MMBasic (you have to unplug the "mini" connector and plug in the PC lead but there is likely to be insufficient clearance for this).

You do have the advantage of an easily upgradable system though.

3. Choose a Display option

If you want to use a Pico 2 and are happy soldering surface mount components then you can install a DVI output directly onto the PCB. If you don't want to do this, simply don't like SMD soldering or want to use an ordinary Pico then it doesn't matter. You don't lose out. :)

There are three alternative systems, each requires its own variation of MMBasic:

DVI - This can use either the onboard components or the Adafruit DVI breakout module, which includes the necessary series resistors.. DVI is not supported on the original RP2040 Pico under MMBasic as it uses the HSTX peripheral of the RP2350 processor. **If you wish to use the Adafruit module then I recommend that you obtain it prior to ordering anything else as there may be a problem with availability.**

Settings:

OPTION HDMI PINS 13, 14, 16, 19

The other display modules plug into the same headers that the Adafruit HDMI breakout board uses. The rear end is supported on two insulating pillars.

VGA - The standard MMBasic VGA display system.

Settings:

OPTION VGA PINS GP12, GP16

LCD - this is for connecting a SPI display with or without touch support. It uses the SPI (SPI0) port.

The connector is a polarised 10-pin box header, suitable for connecting a ribbon cable via a IDC plug.

| | |
|--------------|-----------|
| 1 - GND | 2 - MISO |
| 3 - DC | 4 - CLK |
| 5 - RESET | 6 - MOSI |
| 7 - CS | 8 - T_IRQ |
| 9 - VCC (5V) | 10 - T_CS |

Settings:

OPTION SYSTEM SPI, GP18, GP19, GP16

OPTION LCDPANEL ILI9341, L, GP17, GP14, GP15

OPTION TOUCH GP13, GP12

Unfortunately there are insufficient signals available to give backlight control on a separate pin. This could be hacked, but the choice was made to simply ignore the problem for the moment. :) There is insufficient space for a 12-pin box header so it would be necessary to use a non-box version. GP11 has been made available for those who wish to try this.

4 - Choose an Audio system

Note that if you are going to want to play mp3 files then you will need either a Pico 2 or, if using an ordinary Pico, a VS1053 audio module. The Pico has insufficient memory to decode these.

There are four alternative options here:

PWM - This uses the filter designed by Volhout. It is intended to be a line output, feeding an external amplifier and speakers. If you increase C97 and C98 to 47uF and reduce R93 and R94 to about 1K it will usually give acceptable results with high impedance (over 32R) headphones. Note that there may be some noise on this type of output.

Settings:

OPTION AUDIO GP10, GP11

SPI DAC - Using the MCP48x2 chip to give 8-bit, 10-bit or 12-bit resolution. It is SPI driven, using SPI2 (SPI1). There is sufficient output to drive high impedance headphones.

Settings:

OPTION AUDIO SPI GP7, GP10, GP11

VS1053 - This is also a SPI driven hardware CODEC module which also supports MIDI playback. This uses all the spare GPIO pins, using SPI2 (SPI1). If using this module you will need to solder wires to the rear of the SPK socket and connect them to the 3-pin header next to the front panel jack socket. As it stands you shouldn't attempt to use the SPK output as a line output signal, it is only intended for headphones.

Settings:

OPTION AUDIO VS1053, GP26, GP27, GP28, GP7, GP5, GP4, GP6

I2S DAC - Using a PCM5102 module. This module includes a separate supply regulator for the DAC to minimise noise on the output. Note that if this is used on a RP2040 W or with a VGA display on a RP2040 then there is no spare PIO available to the user.

Settings:

OPTION AUDIO I2S GP10, GP7

Bill of Materials

Recommended enclosures:

Hammond RM2015S if only using the on-board DVI display.

Hammond RM2015M if using display modules

These are available from many sources, including just about all of the major electronic component suppliers.

Main PCB

| | | |
|------|------------------|---|
| B1 | Battery | CR1220 & holder. (optional) |
| C1 | 10uF | tantalum capacitor |
| C2 | 100n | Ceramic cap |
| C3 | 10uF | Tantalum capacitor |
| C4 | 10uF | Tantalum capacitor |
| C5 | 10uF | electrolytic capacitor |
| C6 | 100n | Ceramic cap |
| D1 | 1N5818 | or similar 1A Schottky diode |
| D2 | 3.5mm LED | red/green or red/blue common cathode |
| H1 | 2x5 way | 0.1in male pin header |
| H2 | 2off 20-way | 0.1in female SIP socket (optional) |
| H3 | 11-way | 0.1in female SIP socket |
| H4 | 10-way | 0.1in female SIP socket |
| H5 | 3-way | 0.1in female SIP socket |
| H6 | 3-way | 0.1in male pin header |
| H7 | 11-way | 0.1in female SIP socket |
| H8 | 3-way | 0.1in female SIP socket |
| H9 | 5-way | 0.1in male pin header |
| H10A | 1x4 | 2mm header |
| H10B | 1x4 | 2mm header |
| H10C | 1x4 | 2mm header |
| H10D | 1x4 | 2mm header |
| H10E | 1x4 | 2mm header |
| IR1 | | TSOP4838, ZD1952, ZI611A or sim 38kHz receiver (optional) |
| R1 | 4K7 | resistor |
| R2 | 4K7 | resistor |
| R3 | 1K2 | resistor |
| R4 | 1K2 | resistor |
| R5 | 2R2 | resistor |
| S1 | 3-way | DIP switch |
| S2 | B3F-315n | Horizontal 6x6 tactile switch |
| SK1 | USB-A | Double USB-A socket |
| SK3 | | 3.5mm jack socket (square pattern) |
| SK4 | PS2 skt | |
| SK5 | USB-A skt | FCI 73725-0110BLF (RS 771-0048) |
| SK6 | USB-A skt | FCI 73725-0110BLF (RS 771-0048) |
| SK7 | USB-C header | USB-C skt to 0,1 male pin header converter |
| SK2A | DM1AA-SF-PEJ(72) | Push-push SD card connector |
| SK2B | XF-40T | Push-pull SD card connector |
| SK2C | | micro USB socket module |

* SK2A,B and C are alternatives. Use only one. *

| | | |
|-----|----------|--|
| SP1 | 11mm | M3 plastic support pillar and hardware |
| SP2 | 11mm | M2.5 plastic support pillar and hardware |
| SP3 | 11mm | M2.5 plastic support pillar and hardware |
| U1 | CP2102 | USB-C converter - 3V3 data |
| U2 | PicoMite | Pico or Pico 2 |
| U3 | mini RTC | RTC module for Raspberry Pi |
| U4 | FE11SX4 | 4-port USB hub module |

On-board HDMI display components

| | | |
|-----|------|-------------------|
| R10 | 10K | 0805 SMD resistor |
| R11 | 220R | 0805 SMD resistor |
| R12 | 220R | 0805 SMD resistor |
| R13 | 220R | 0805 SMD resistor |
| R14 | 220R | 0805 SMD resistor |
| R15 | 220R | 0805 SMD resistor |
| R16 | 220R | 0805 SMD resistor |
| R17 | 220R | 0805 SMD resistor |
| R18 | 220R | 0805 SMD resistor |

| | | |
|------|--|-------------|
| SK10 | | HDMI socket |
|------|--|-------------|

DISPLAY MODULES

HDMI Display Module

Adafruit DVI breakout module

VGA Display Module

| | | |
|-----|--------|-----------------------|
| H71 | 11-way | 0.1in male pin header |
| H72 | 2-way | 0.1in male pin header |
| R71 | 220R | resistor |
| R72 | 820R | resistor |
| R73 | 390R | resistor |
| R74 | 220R | resistor |

| | | |
|------|------------------|-----------------|
| SK71 | 3-row VGA socket | compact pattern |
|------|------------------|-----------------|

LCD Display Module

| | | |
|------|--------|-----------------------------------|
| H61 | 11-way | 0.1in male pin header |
| H62 | 3-way | 0.1in male pin header |
| SK61 | 2x5 | 0.1in right angle male box header |

AUDIO MODULES

SPI DAC Audio module

| | | |
|-----|---------|-------------------------|
| C81 | 100n | Ceramic cap |
| C82 | 100n | Ceramic cap |
| C83 | 10uF | Electrolytic capacitor |
| C84 | 100n | Ceramic cap |
| C85 | 100n | Ceramic cap |
| C86 | 47uF | Electrolytic capacitor |
| C87 | 47uF | Electrolytic capacitor |
| | | |
| H81 | 11-way | 0.1in male pin header |
| H82 | 3-way | 0.1in male pin header |
| | | |
| R81 | 120R | Resistor |
| R82 | 120R | Resistor |
| R83 | 1K | Resistor |
| R84 | 1K | Resistor |
| R85 | 10K | Resistor |
| R86 | 10K | Resistor |
| | | |
| U81 | LM33CZ | 3V3 100mA LDO regulator |
| U82 | MCP48x2 | DAC |

For U82 order as below:

MCP4802 - 8-bit resolution

MCP4812 - 10-bit resolution

MCP4822 - 12-bit resolution

There are no program changes needed in MMBasic.

PWM Filter audio module

| | | |
|-----|------|------------------------|
| C91 | 33nF | Capacitor |
| C92 | 33nF | Capacitor |
| C93 | 2n7 | Capacitor |
| C94 | 2n7 | Capacitor |
| C95 | 68nF | Capacitor |
| C96 | 68nF | Capacitor |
| C97 | 1uF | Capacitor |
| C98 | 1uF | Electrolytic capacitor |
| | | |
| L91 | | Epcos B78108S +value |
| L92 | | Epcos B78108S +value |
| | | |
| R91 | 220R | Resistor |
| R92 | 220R | Resistor |
| R93 | 4K7 | Resistor |
| R94 | 4K7 | Resistor |
| R95 | 4K7 | Resistor |
| R96 | 4K7 | Resistor |

VS1053 audio CODEC module Obtained from AliExpress. See photograph.

PCM5102 I2S DAC audio module Obtained from AliExpress. See photograph.

SK2C



SK7



SK4



SK3



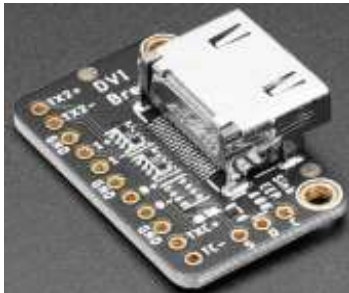
U3



U4



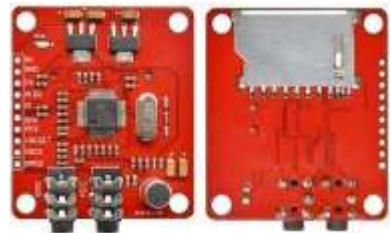
ADFRUIT DVI BREAKOUT



PCM5102 MODULE



VS1053 MODULE



SK71



U1



SK10 - HDMI



Assembly notes

As usual, assemble the board from the lowest components upwards. Also take special note of areas like the one around the audio jack, where it would be very awkward to fit SK2A after the jack socket!

When preparing the VS1053 module fit the male pin header from the component side of the module. It is plugged into the main board with its copper side to the top.

Note that the 4-pin headers and sockets for the USB hub are 2mm pitch and not 2.54mm (0.1in).

It is recommended that you don't fit a header for SK7, solder its pins directly to the PCB. This is for three reasons, it's much stronger mechanically, gives a much more reliable connection and makes it impossible to plug SK7 in the wrong way round.

If you surface mount the Pico then you must fit SK7 as the on-board USB socket is obstructed.

If you wish, a short connecting lead linking GND, DP and DM can be used with plug-in PicoMite modules. This is terminated in a micro USB plug at the Pico end and connects to the three holes under the Pico. If SK7 is then fitted, it allows programming without removing the PCB from the enclosure to get sufficient clearance for a plug.

The RTC module has an on-board lithium cell, which is not charged from the power rail. Eventually these die (and you have no idea how long the module has been in storage when you get it). By removing the cell and putting a wire link from the pad closest to the connector round to the normally unused pin you can connect it to the CR1220 cell. These don't have a great lifetime, but at least they are replaceable.

The PCB is marked to position the Reset button at the back of the board. However, it can also be mounted at the front instead of the infra-red receiver. Operationally it makes no difference. If you have a love of big red buttons the front position will accept a button cap, which will project from the front panel by less than 0.5mm. You can even fit both if you like. :)

PCB Configuration

There are two "solder blob" links on the bottom of the PCB and one on the top. Normally these will not need changing. Note that the Adafruit DVI module connects H8 directly to pins on the HDMI connector. **Do not close either LK1 or LK2 if there is even a chance that this module might be used!**

LK1 - Connects the centre pin of H8 to 3V3 - normally open. This is purely experimental and is intended to provide a supply to an emitter follower to drive VGA display in sixteen shades of grey.

LK2 - Connects the rear pin of H8 to GP11 - normally open. This would normally be used to provide a backlight control signal to a LCD display. This signal is not available on the box header.

LK3 - (On top) Changes GP22 from controlling the Green LED to IR receiver input.

Installing MMBasic

Simply follow the instructions in the MMBasic manual, but first turn switches S1/1 and S1/2 (labeled DM and DP respectively) to the OFF position. If you fail to do this then Windows will not recognize the Pico as a folder. Remember to restore these switches to the ON position afterward or the USB hub will not be recognized.