RPZ Compute System Manual

Manual version 0.1
Note that minor changes in the modules may not be reflected in this manual.

References to the Pico are to be taken to refer to the Raspberry Pi Pico module

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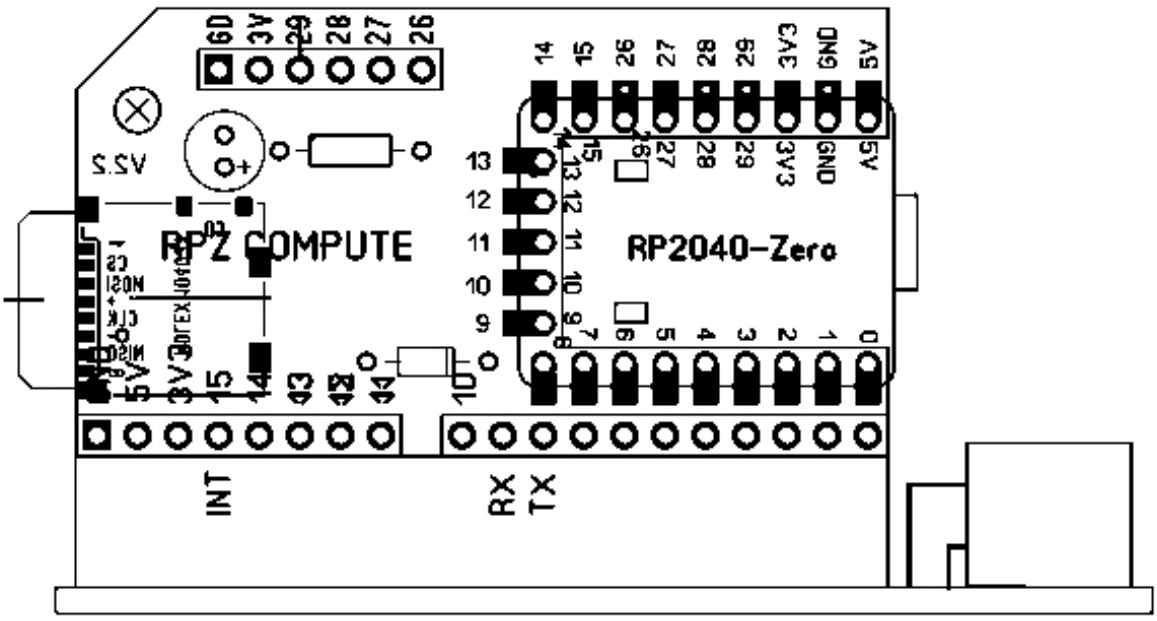
The concept and design of this RPZ Compute System is the Copyright of Mick Ames (MIXTEL 90)

Support is available via thebackshedforum.com

This system is not suitable for critical systems or for installations where failure or incorrect operation could result in injury or death and must not be used in or connected to such systems.

No guarantee of performance is given, not even that it will work at all.
There is no intentional compliance with any standards whatsoever.
The system is totally dependent on third party modular components which may become unavailable or unsuitable. In this instance no support will be available.



Inspiration

The RPZ compute system was initially inspired by the Raspberry Pi Compute module, where the essentials of a Raspberry Pi are on a single plug-in module. This can then be used as the "brain" in an embedded application. I considered doing this with a RP2040 but it's not a computer, it's an embedded controller in its own right so the concept is rather different.

What I ended up with is a series of "intelligent" modules that communicate with each other over either multi-drop RS-232 or a I2C interface. Each module is based on a RP2040-Zero, a "cut down" version of the standard Raspberry Pi Pico coupled with some sort of IO. The modules can be used stand-alone, but there is also an expandable 3-socket motherboard. The use of a 2-wire interface keeps the number of reserved pins to a minimum - the RP2040-Zero doesn't have a lot to start with.

As each module runs independently of each other there is no interraction between them. In fact, you could assemble something with only VGA display modules on a I2C bus, one controlling the content display of the others as well as it's own display.

RPZ System description

Everything has been geared to the hobbyist and has been optimised as far as possible to be low cost.The RP2040-Zero used is the cheapest version available on AliExpress, there is no need for the flat back version for these modules. Although surface mounting is used the components used are large enough for it to be easy. The most difficult component is the micro SD card holder, and that is optional.

The RP2040-Zero has its own Reset button and a user-controlled WS2812B LED on GP16. You can get a nice purple colour from it in MMBasic using BITBANG WS2812 B, GP16, 1, &h0C0210 (you can use DEVICE instead of BITBANG in later releases).

Mechanically the modules are all similar. They are approximately 51mm x 28mm. There is a large notch cut out of the PCB to allow the RP2040-Zero to be surface mounted (there are components on both sides of it). This has the advantages that the module is more robust and also has a narrower profile so they can be mounted closer together. Each module has a 3mm diameter hole. This can be used to lock the modules into the motherboard by threading a bar through it, supported by a bracket at each end.

Electronically, each module has a rp2040-Zero (which is not breadboard friendly) converted to a single-in-line pin connector, ready for a breadboard. Pins 1-8 are spaced apart from pins 10-20 by an empty pin 9 position. The module then plugs into an ordinary 20-pin SIP socket with pin 9 blanked off.Some pins are reserved:
Pin 1 - GND
Pin 2 - 5V supply (bus connection - GP15 as standard)
Pin 3 - 3V3 supply to local IO only
Pin 4 - INT (bus connection)
Pin 9 - Omitted
Pin 11 - RX (bus connection) serial data from the master - GP9 / COM2_RX
Pin 12 - TX (bus connection) serial data to the master - GP8 / COM2_TX

The modules are normally linked by a multi-drop COM (multi-drop RS-232) system with one master and multiple slaves. This is a buffered configuration when used with MMBasic so is easier to use as no messages are missed.
Pin 12 has a diode (D1) with its cathode to GP8 (COM2 TX) . The diode has a solder blob link across it so that it can be taken out of circuit if required. Pin 11 is connected directly to GP9 (COM2 RX).

The INT signal is actually not allocated. It is usually "open drain" with a pullup resistor (R1) on the motherboard. As "open drain" isn't available on the RP2040, this should be configured as an input when not being used and as a low output to trigger an interrupt.It could also be used as a common reset signal, depending on your project..

If a RPZ module is being used in a stand-alone system then pins GP15, GP8 and GP9 can be used as conventional IO.

When used as a bused system each module has to be programmed with its own address. I would suggest that this should be defined as a CONST at the beginning of the program and recorded somewhere, allowing it

to be found and changed easily should a module need to be replaced at a later date. Having the modules addressed rather than the sockets can lead to some confusion as the module will operate according to it's address, not its physical location.

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Things you must be careful of:

Note that if you connect one nodule on the bus to a PC then all the modules will be powered via the 5V rail. This may be too much for some USB ports if you have more than one motherboard linked. There is no USB negotiation so the higher supply currents may not be available.

You must not connect a module or a bus of modules to a PC if the external 5V supply is connected. The RP2040-Zero does not have the protection diode that's present in the Pico so there will be a back-feed into the USB port under certain circumstances..

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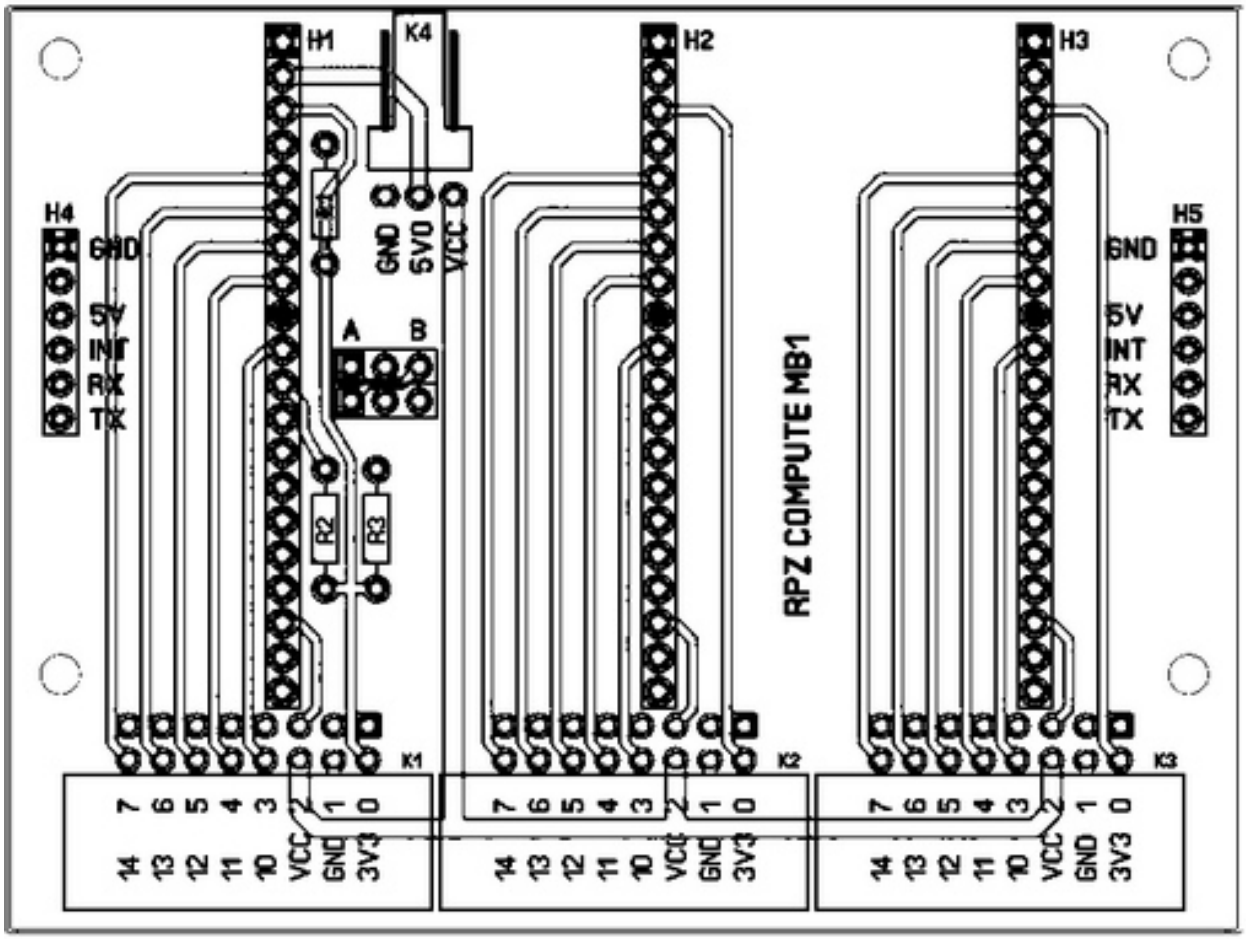
Ordering PCBs

The MB1 motherboard and one RPZ Compute module will fit onto a single 100mm x 100mm PCB.
You can get a further four RPZ Compute modules onto a second 100mm x 100mm PCB.
If you order from JLCPCB then this size of PCB is available at a special offer price on a single order four five pieces, so if you place an order for each board you can get five motherboards and 25 RPZ Compute modules for a very low cost. Unfortunately you won't be able to get the sixth available module in this way. You will also need the means to cut up the boards yourself as it gets expensive otherwise.

The Modules

RPZ COMPUTE MB1

This is a "3-slot" extendable motherboard. The overall size is approximately 92mm x 69mm. It has four fixing holes and three 16-pin horizontal connectors along the front edge, suitable for keyed IDC ribbon connectors. This arrangement allows full access to the RP2040-Zero USB connectors with all the IO connectors in place. Additional 6-pin SIP sockets at each end of the board allow for expansion on either side using a simple connector made from two strips of male header pins and a small piece of stripboard.



The leftmost slot is configured for the master module when used with the multi-drop COM system or it can be set up like the others if I2C is used.. There are positions for pull-up resistors for INT and I2C signals. A 3-pin polarised horizontal JYK connector (rated at 3A max) at the rear provides connections for GND, 5V and a VCC supply that is only linked to the IO connectors for that particular motherboard. Thus you could bring in an additional supply if you create devices to plug into the IO system. When the micro SD card connector is used on the RPZ COMPUTE module it also projects from the rear of the motherboard.

The MB1 has to be configured in one of two ways depending on the bus signals used before it can be used. This is done by changing the positions of two jumpers.

Position A - Multidrop COM
This system uses the normal COM port handling in MMBasic. The master device has an input connected to the TX bus, with a pull-up resistor (R2). Slave devices have a diode (D1) connected from this line to an output pin. With the output idle it will be high so the diode isolates it from the bus, allowing the TX line to be operated by any single slave. The master device has an output pin connected to the RX bus. The slave devices connect that bus to an input pin so they are always listening.

The master module must have D1 replaced by a wire link or disabled by using the solder blob link on the underside of the board beneath it. All other modules require D1.Omit both R3 and H4.

Position B - I2C
This uses the I2C commands in MMBasic and may be a little more inconvenient in some ways as I2C is not buffered. However, the system can be multi-master and a master can occupy any MB1 position. Expansion is possible at both ends of the MB1. GP8 becomes I2C_SDA and GP9 becomes I2C_SCL.

The D1 diodes are not required on any modules must either be replaced by wire links or the solder blob link beneath them should be closed.

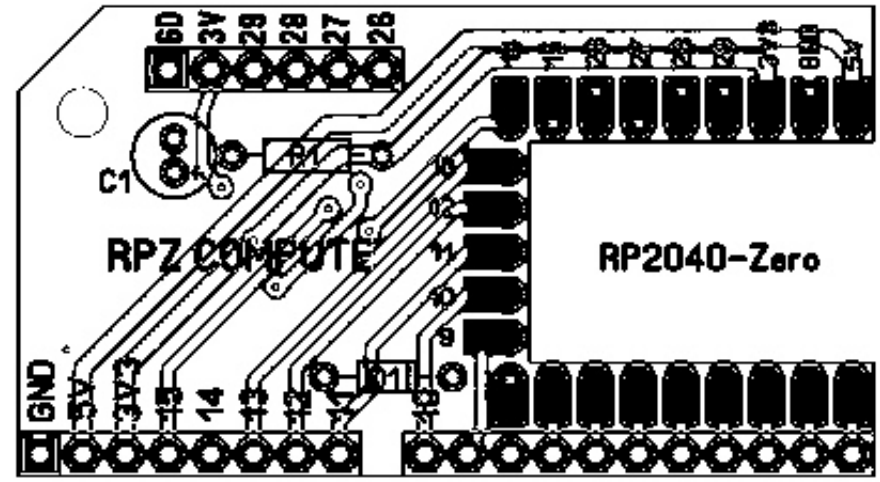
Bill Of Materials

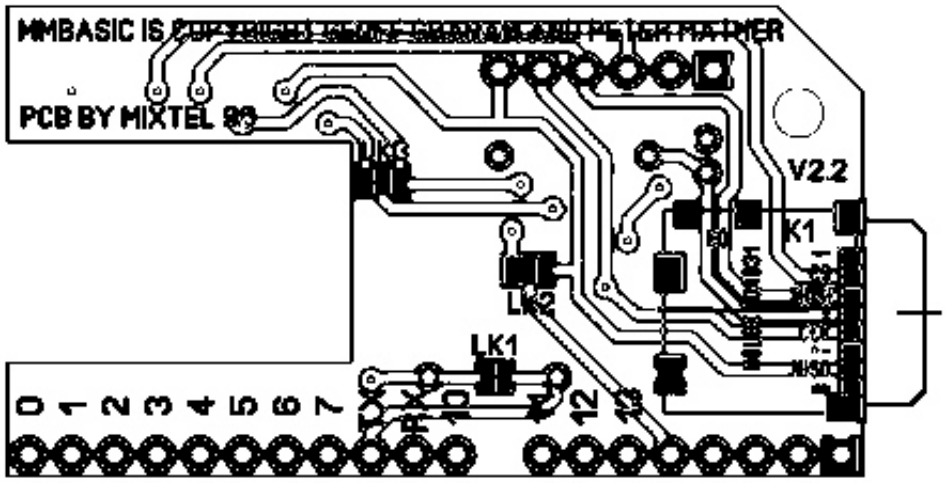
Name	Value	Comment
	PCB	Custom
H1	20-pin	2.54mm female SIP socket
H2	20-pin	2.54mm female SIP socket
H3	20-pin	2.54mm female SIP socket
H4	6-pin	2.54mm female SIP socket
H5	6-pin	2,54mm female SIP socket
JP1	3-pin	2.54mm male pin header with link
JP2	3-pin	2.54mm male pin header with link
K1	8+8	2.54mm 90 degree keyed boxed header
K2	8+8	2.54mm 90 degree keyed boxed header
K3	8+8	2.54mm 90 degree keyed boxed header
K4	3-pin	2.54mm horiz. male JYK connector
R1	4K7	resistor
R2	4K7	resistor
R3	4K7	resistor

It is possible to fit the MB1 into a low cost Hammond box type 1591XXTS. You will need to make cutouts for cable entries etc. and use 4.5mm or 5mm spacers to mount the board. This is a simple "box with lid", not an instrument enclosure.

RPZ COMPUTE Module

This is the fundamental module, used as a general purpose IO device. All the available GP pins on the RP2040-Zero are brought oiut in some way, making it useful for stand-alone use.





Available connections are:

1 - GND	10 - GP10
2 - 5V	11 - GP9 / RX
3 - 3V3	12 - GP8 / TX
4 - GP15 / INT	13 - GP7
5 - GP14	14 - GP6
6 - GP13	15 - GP5
7 - GP12	16 - GP4
8 - GP11	17 - GP3
	18 - GP2
	19 - GP1
	20 - GP0

There is a 6-pin auxiliarey "analogue" connector with the following connections:
1 - GND
2 - 3V3
3 - GP29 - SDCS - SP2_CS - I2C1_SCL - PWM6B - COM1_RX
4 - GP28 - SDMOSI - SP2_RX - I2C1_SDA - PWM6A - COM1_TX
5 - GP27 - SDSCLK - SP2_TX - I2C2_SCL - PWM5B
6 - GP26 - SDMISO - SP2_CLK - I2C2_SDA - PWM5A

GP26 - GP29 are also connected to pads for a micro SD card socket. If this is fitted MMBasic can use it with:
OPTION SDCARD GP29, GP27, GP28, GP26
Obviously you cannot use them as IO pins if the SD card is configured.

Solder blob links on the rear of the PCB allow other variations, particularly if the module is to be used stand-alone.
LK1 - used to short out D1 if it isn't required.
LK2 - changes the GP14 pin from it's default GP14 connection to GP26 / ADC0
LK3 - changes the GP15 pin from it's default GP15 connection to GP27 / ADC1

Reconfiguring the GP15 (INT) pin should only be done if the module is being used stand-alone.

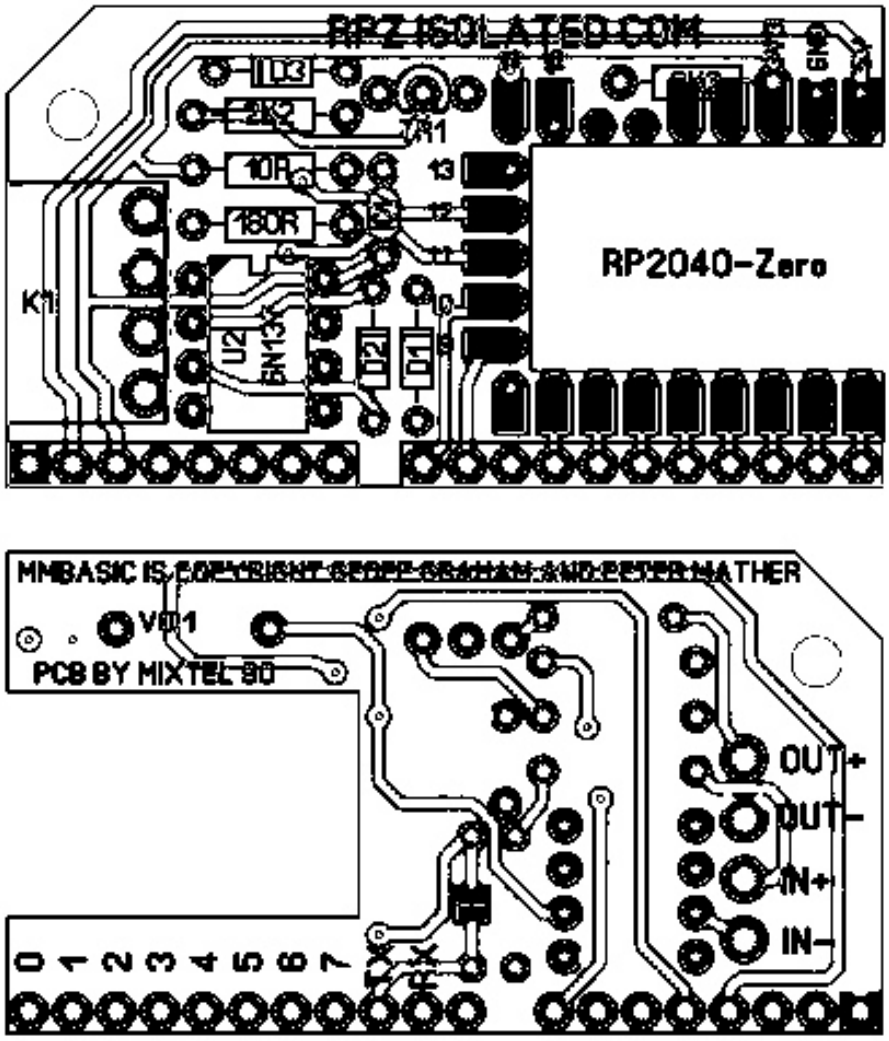
If the micro SD card socket isn't installed then omit R1 and C1.
If the micro SD card socket is installed then omit the analogue signals connector (H3).

Bill Of Materials

Name	Value	Comment
	PCB	Custom
C1	2.2uF	electrolytic capacitor
D1	BAT41	or similar small Schotky diode
H1	1x8 pin	2.54mm right-angle male header
H2	1x11 pin	2.54mm right-angle male header
H3	6-pin	2.54mm right-angle male header (analogue)
K1	Molex 104031	SMD push-pull micro SD socket
R1	2R2	resistor
U1	RP2040-Zero	

RPZ ISOLATED COM Module

This provides a full duplex optically isolated link based on a MIDI connection. The module has a protected current output which drives an opto-coupler at the remote end. The maximum current output is over 100mA and is short-circuit protected. The input is protected against incorrect polarity connection.



Available connections are:

1 - GND	10 - GP10
2 - 5V	11 - GP9 / RX
3 - 3V3	12 - GP8 / TX
4 - GP15 / INT	13 - GP7
5 - GP14	14 - GP6
6 - nc	15 - GP5
7 - nc	16 - GP4
8 - GP11	17 - GP3
	18 - GP2
	19 - GP1
	20 - GP0

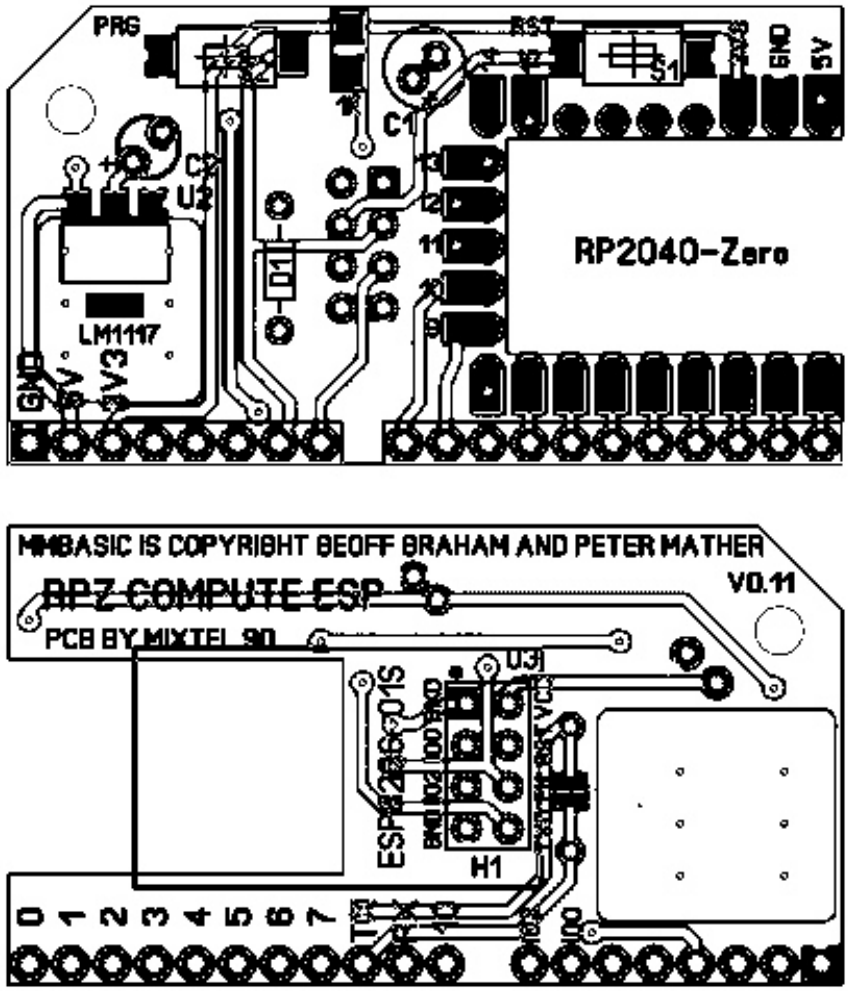
The optical connection uses GP12 / COM1_TX and GP13 / COM1_RX

Bill Of Materials

Name	Value	Comment
	PCB	Custom
C1	100n	Ceramic cap
D1	BAT41	or similar small Schottky diode
D2	1N4148	or similar small silicon diode (can be BAT41)
D3	BAT41	or similar small Schottky diode
H1	1x8 pin	2.54mm right-angle male header
H2	1x11 pin	2.54mm right-angle male header
K1	4-way	3.5mm horiz. pluggable terminal socket
R1	180R	resistor
R2	2K2	resistor
R3	10R	resistor
R4	2K2	resistor
TR1	BC327	or similar PNP transistor
U1	RP2040-Zero	
U2	6N137	high speed opto coupler

RPZ COMPUTE ESP

This adapts a ESP8266-01 wireless modem module to work with the RPZ Compute system. The module provides a separate 3V3 regulator to power it and two control buttons. Additionally IO0 and IO2 are connected to pins of the RP2040-Zero.



Available connections are:

1 - GND	10 - GP10
2 - 5V	11 - GP9 / RX
3 - 3V3	12 - GP8 / TX
4 - GP15 / INT	13 - GP7
5 - nc	14 - GP6
6 - nc	15 - GP5
7 - IO0	16 - GP4
8 - IO2	17 - GP3
	18 - GP2
	19 - GP1
	20 - GP0

The ESP8266-01S control connections are:
RST has a button to GND
EN - GP11
TXD - GP13 / COM1_RX
RXD - GP12 / COM1_TX
IO0 also has a button to GND

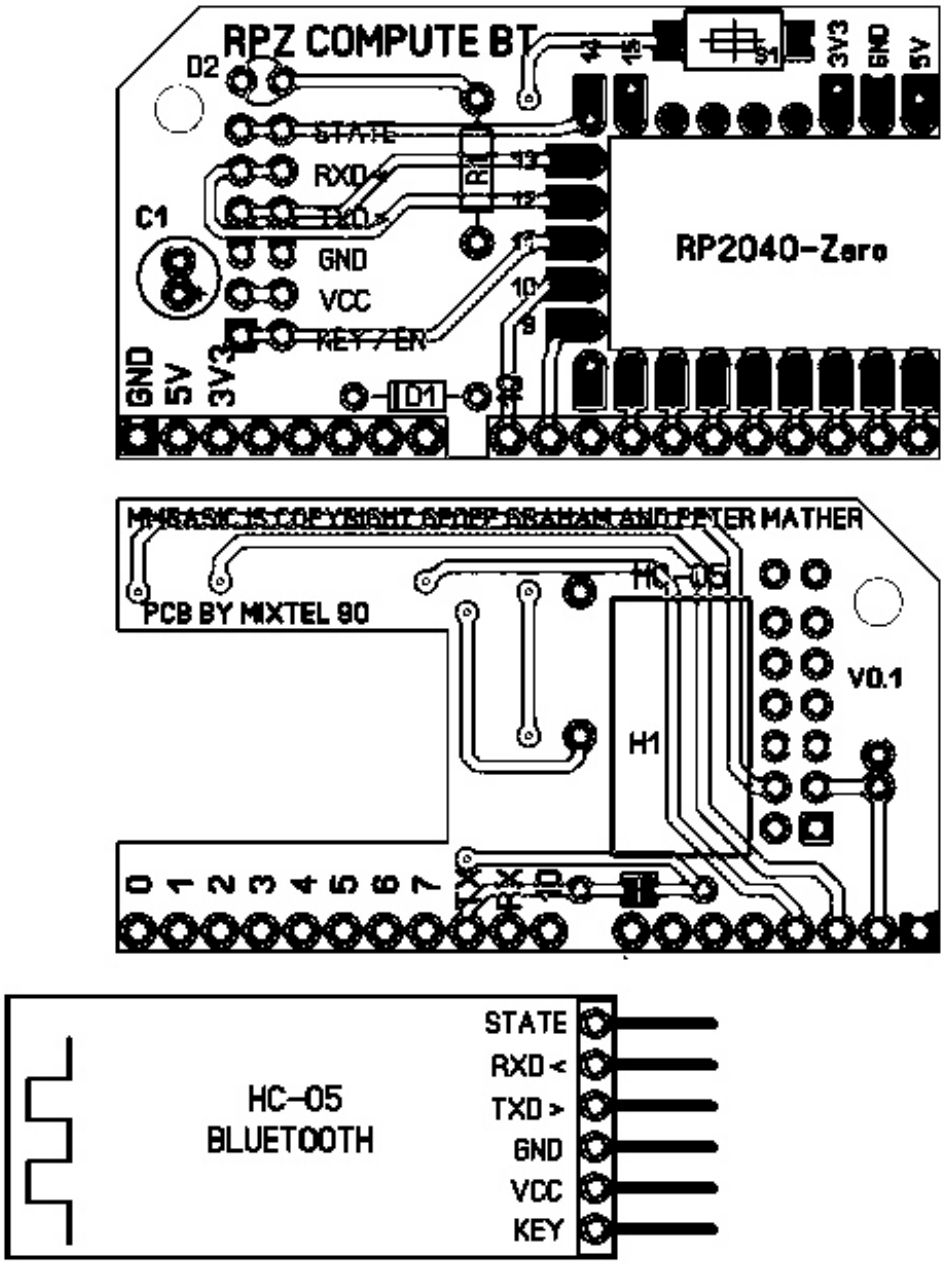
Bill Of Materials

Name	Value	Comment
	PCB	Custom
C1	47uF	electrolytic capacitor
C2	22uF	electrolytic capacitor
D1	BAT41	or similar small Schottky diode
H1	2x4	2.54mm female socket
H2	1x11	2.54mm 90 degree male pin header
H2	1x8	2.54mm 90 degree male pin header
S1	3x6	SMD tactile switch
S2	3x6	SMD tactile switch
U1	RO2040-Zero	
U2	LM1117	SOT223 type
U3	ESP8266-01S	wireless modem module

Note:
This module requires a "real" ESP8266-01S, not a ESP8266-01 or one with pull-up resistors missing on GPIO0, GPIO2, RST and EN or a pull-down resistor missing on GPIO15 of the chip. Nost of them seem to be OK now.

RPZ COMPUTE BT

This adapts a HC-05 Bluetooth module to the RPX Compute system.A button is provided for the Key/EN input to the module. A LED is connected to the STATE output to indicate a connection.



Available connectiions are:

1 - GND	10 - GP10
2 - 5V	11 - GP9 / RX
3 - 3V3	12 - GP8 / TX
4 - GP15 / INT	13 - GP7
5 - nc	14 - GP6
6 - nc	15 - GP5
7 - nc	16 - GP4
8 - nc	17 - GP3
	18 - GP2
	19 - GP1
	20 - GP0

The HC-05 connections are:
STATE - GP14
RXD - GP12 / COM1_RX
TXD - GP13 / COM1_TX
KEY / EN - GP11 and a button to GND

Bill Of Materials

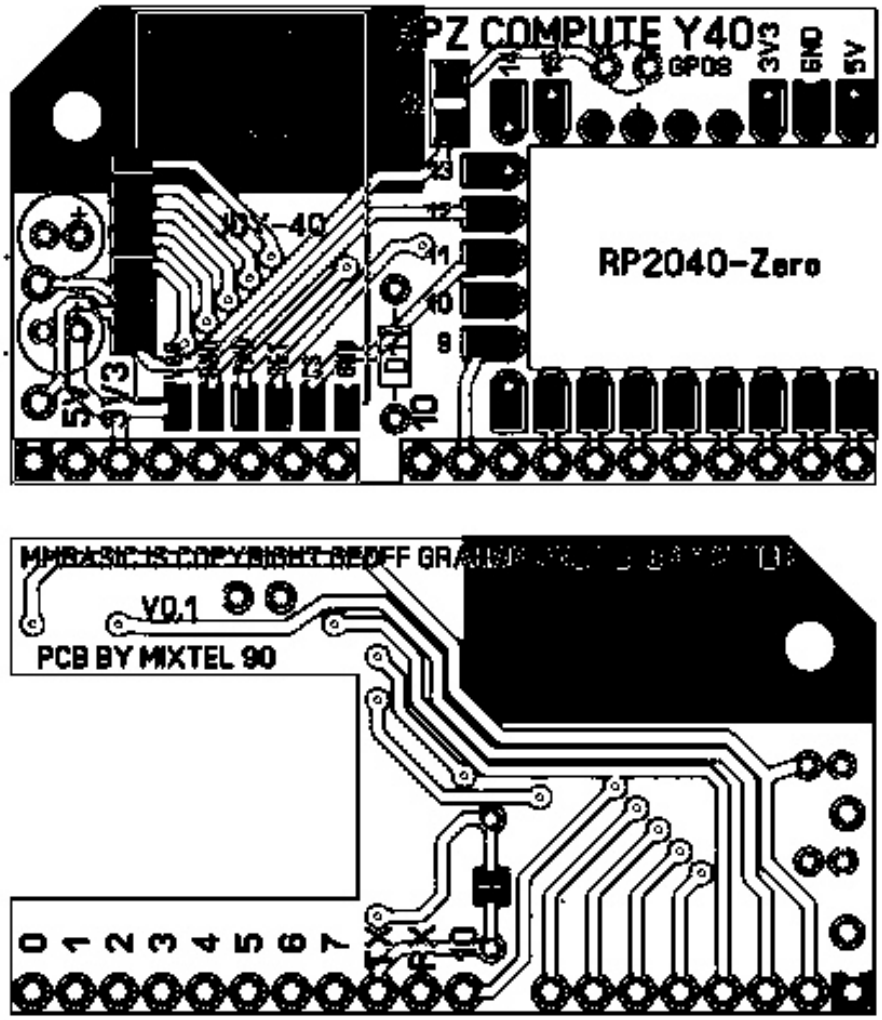
Name	Value	Comment
	PCB	Custom
C1	47uF	electrolytic capacitor
D1	BAT41	or similar small Schottky diode
D2	Red LED	high efficiency type
H1	6+6	2.54mm 90 degree female socket
H2	1x11	2.54mm 90 degree male pin header
H3	1x8	2.54mm 90 degree male pin header
R1	1K	resistor
S1	3x6	SMD tactile switch
U1	HC-05	Bluetooth module
U2	RP2040-Zero	

RPZ COMPUTE Y40

This uses the JDY-40 2.4GHz wireless modem / remote control module. Some of its GPIO pins are available as well as the RP24-0 pins.

There are several configuration options for this module. Its GPIO pins can be configured as digital inputs or as digital outputs, with pulse and latching options (although they all have to have the same configuration). By default it is a simplex wireless modem. It is a relatively short range device but takes very little power to operate when in digital mode.

If you use this as a digital transmitter it will transmit only when an input changes state. It does this independently of the RP2040-Zero. Likewise, if it receives a change in its GPIO pins then they will change state without intervention by the RP2040-Zero.



Available connections are:

1 - GND	10 - GP01*
2 - 5V	11 - GP9 / RX
3 - 3V3	12 - GP8 / TX
4 - GP15 / INT	13 - GP7
5 - GP05*	14 - GP6
6 - GP04*	15 - GP5
7 - GP03*	16 - GP4
8 - GP02*	17 - GP3
	18 - GP2
	19 - GP1
	20 - GP0

* GPIO pins on the JDY-40

Additionally, GP08 of the JDY-40 is brought out to a LED. This can be used to indicate transmission when the device is being used as a "button" remote control transmitter. GP06 and GP07 are made available as PCB pads only.

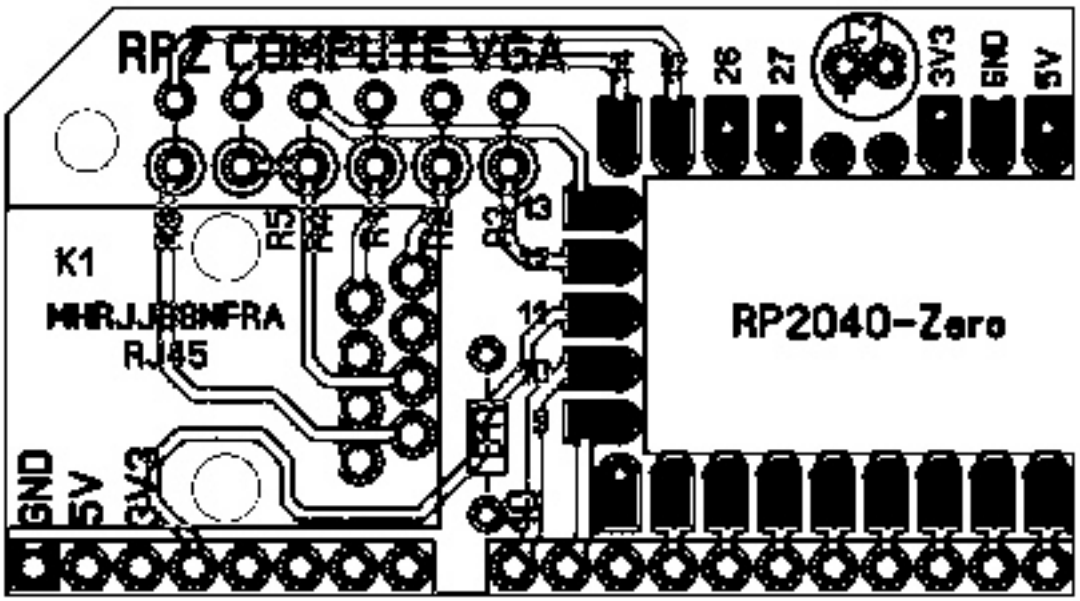
The JDY-40 connections are:
RXD - GP12 / COM1_TX
TXD - GP13 / COM1_RX
SET - GP14
CS - GP11

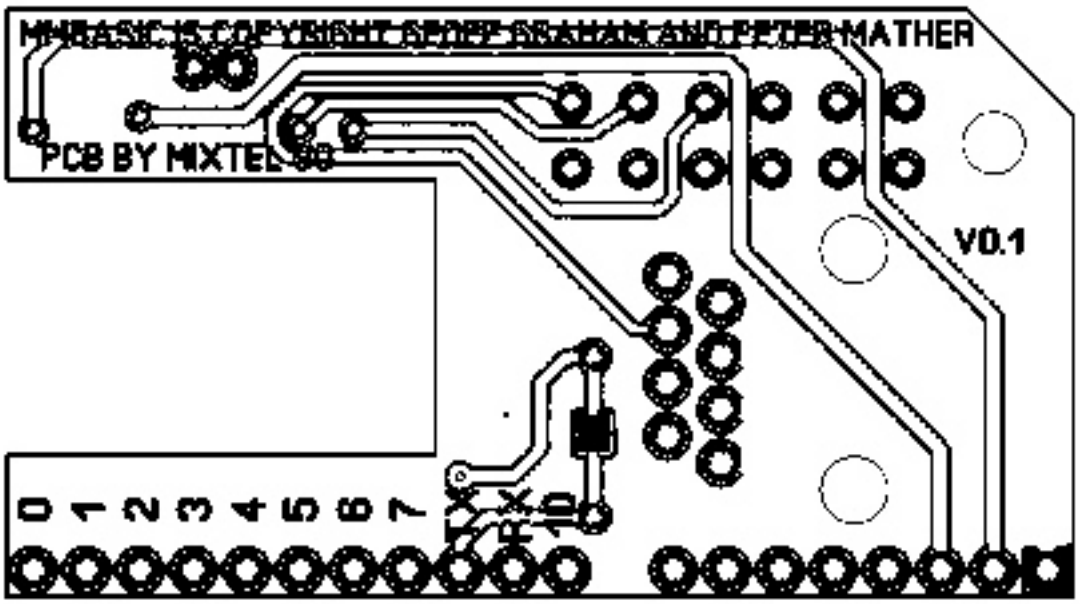
Bill Of Materials

Name	Value	Comment
	PCB	Custom
C1	22uF	electrolytic capacitor
C2	22uF	electrolytic capacitor
D1	BAT41	or similar small Schottky diode
D2	red LED	high efficiency type
H1	1x11	2.54mm 90 degree male pin header
H2	1x8	2.54mm 90 degree male pin header
R1	1K	1206 SMD resistor
U1	JDY-40	wireless serial port module
U2	RP2040-Zero	

RPZ COMPUTE VGA

This provides a VGA display, intended to be used for such things as announcement boards or industrial plant mimic diagrams. Although it will draw to it's display at full speed, if it is dependent on information provided via the serial bus it will be appreciably slower. Thus a simple command system could be used to provide graphic and textual primitive commands. Possibly something based on ANSI controls.





Available connections are:

1 - GND	10 - GP10
2 - 5V	11 - GP9 / RX
3 - 3V3	12 - GP8 / TX
4 - GP11 / INT	13 - GP7
5 - nc	14 - GP6
6 - nc	15 - GP5
7 - nc	16 - GP4
8 - nc	17 - GP3
	18 - GP2
	19 - GP1
	20 - GP0

The VGA connection is via a RJ45 socket. Adapters are commonly available to connect RJ45 to VGA and one of these can be used at the monitor end of the cable. Ordinary CAT5 ethernet leads can be used.

The connections are as follows:

Signal	VGA PIN	RJ45 PIN	Pico GP
VSYNC	14	1	GP27
HSYNC	13	2	GP26
BLUE	3	3	GP12
BLUE GND	7	4	GND
GREEN	2	5	GP13 (DK GN), GP14 (GRN)
GREEN GND	8,5,10	6	GND
RED	1	7	GP15
RED GND	6	8	GND

Used with MMBasic, the pins would be initialised using OPTION VGA PINS GP26, GP12

Bill Of Materials

Name	Value	Comment
	PCB	Custom
C1	47uF	electrolytic capacitor
D1	BAT41	or similar small Schottky diode
H1	1x11	2.54mm 90 degree male pin header
H2	1x8	2.54mm 90 degree male pin header
K1	MHRJJ88NFRA	RJ45 socket
R1	270R	resistor
R2	270R	resistor
R3	270R	resistor
R4	820R	resistor
R5	390R	resistor
R6	270R	resistor
U1	RP2040-Zero	

ADDITIONAL TOOLS

There are two additional tools available for the RPZ Compute system. If the suggested 2-board orders are made then these are included in spare space on the boards so there is no additional PCB cost. They are not considered to be operational modules.

Bus Monitor

This can be plugged into any empty bus socket. It has LEDs to indicate 5V, INT, RX and TX. there are also pads, suitable for pins or small crocodile clips, for GND, INT, RX and TX.

Bill Of Materials

Name	Value	Comment
	PCB	Custom
C1	100n	Ceramic cap
C2	22uF	electrolytic capacitor
D1	red LED	3mm high efficiency type
D2	red LED	3mm high efficiency type
D3	red LED	3mm high efficiency type
D4	red LED	3mm high efficiency type
H1	1x8 pin	2.54mm right-angle male header
H2	1x4 pin	2.54mm right-angle male header
R1	1K	resistor
R2	1K	resistor
R3	1K	resistor
R4	1K	resistor
U1	LF33CZ	3V3 LDO regulator

Isolated Terminal

This can be plugged into the bottom row of IO pins for a RPZ Compute module. It connects COM1 to a USB-C connector via opto-couplers and a USB-TTL converter module. If COM1 is then set to be the console a PC can be used without powering or receiving power from a bus of modules.

Bill Of Materials

Name	Value	Comment
	PCB	Custom
H1	1x8	2.54 right angle female socket
R1	4K7	resistor
R2	4K7	resistor
R3	470R	resistor
R4	470R	resistor
U1	CH340E	module from AE
U2	6N137	high speed opto coupler
U3	6N137	high speed opto coupler