Z80 PIO Module For RC2014

User Guide

For module: SC103 version 1.0

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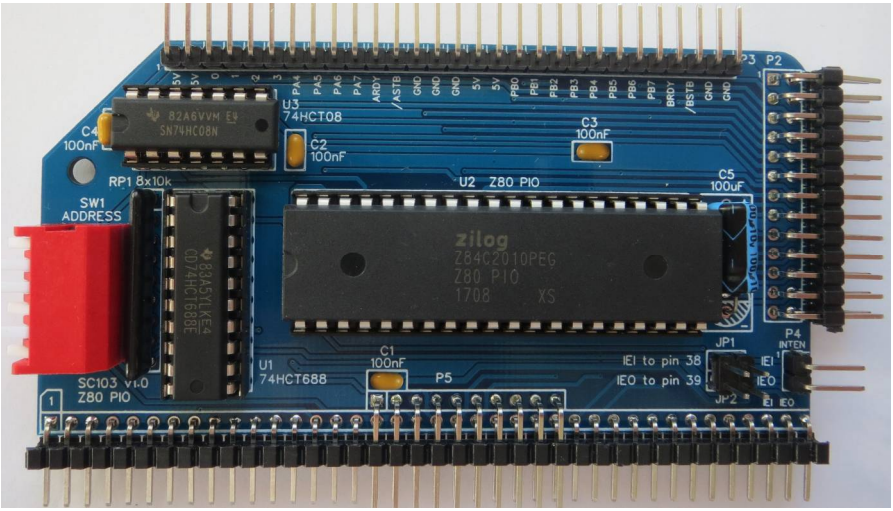
Edition 1.0.1

CONTENTS

Overview

The Z80 PIO module (SC103) provides two 8-bit parallel ports with handshaking and flexible input and output connectivity, as well as support for Z80 mode 2 interrupt daisy chaining.



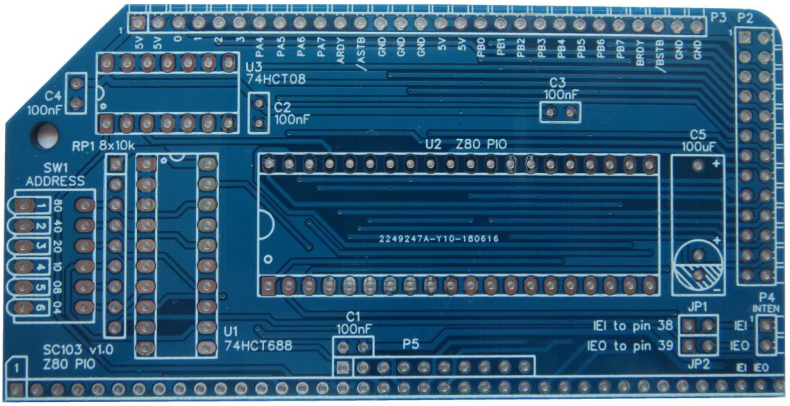
Each port has eight bidirectional data lines and two handshaking lines. The PIO has flexible interrupt generation and fully supports Z80 mode 2 interrupts.

For full details of the Z80 PIO see the Zilog data sheet.

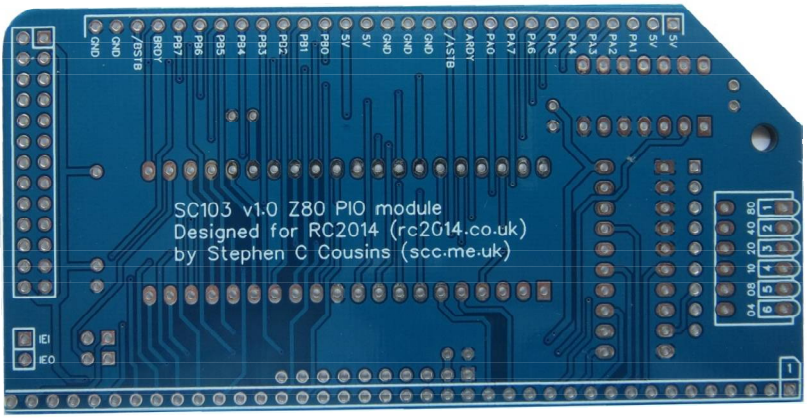
Printed Circuit Board

The printed circuit board is a standard footprint RC2014 board.

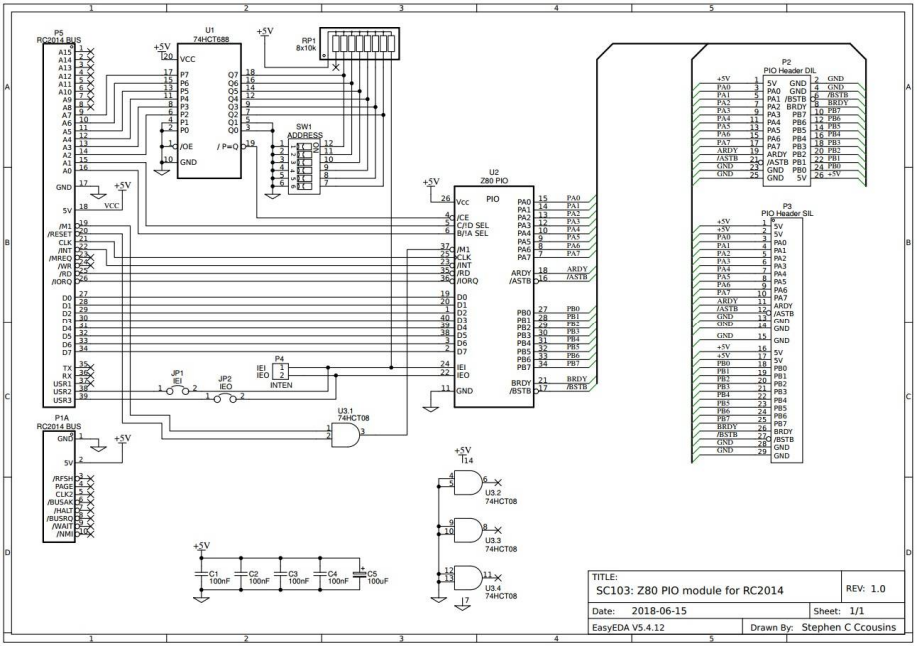
Printed circuit board, top/component side:



Printed circuit board, bottom/solder side:



Schematic



Errata

Version 1.0 of the PCB has the RC2014 IEI (pin 38) and IEO (pin 39) incorrectly labelled. The labels are incorrectly shown next to pins 37 and 38, not 38 and 39. Also port A I/O lines are not correctly labelled on the back of the board. The labels on the front of the board are correct though.

What You Need

The following components are required to assemble the module. Header pins JP1 and JP2, and P1 to P4 may need to be cut from longer strips.

Image	Qty	Reference	Description
	1	PCB	Printed circuit board SC103 Z80 PIO
	4	C1, 2, 3, 4	Capacitor 100nF, ceramic, lead spacing = 2.54mm
	1	C5	Capacitor 100uF, electrolytic, lead spacing = 2.54mm (radial) or 14mm (axial)
	1	JP1 and JP2	Pin header, male, 2 rows x 2 pins, straight
	2	JP1 and JP2	Jumper shunt for pin spacing = 2.54mm
	1	P1	Pin header, male, 2 rows x 39 pins, angled (2nd row optional)
	1	P2	Pin header, male, 2 rows x 13 pins, angled
	1	P3	Pin header, male, 1 row x 29 pins, angled
	1	P4	Pin header, male, 1 row x 2 pins, angled
	1	RP1	Resistor pack 8x10k, SIL, 9-pin
	1	SW1	DIP switch, 6 way, piano style
	1	U1	74HCT688, 8-bit identity comparator, PDIP 20
	1	U1 socket	20 pin PDIP IC socket 0.3" wide

	1	U2	Z80 PIO, 8MHz, Z84C2008PEG (or Z80 PIO, 10MHz, Z84C2010PEG), PDIP 40
	1	U2 socket	40 pin PDIP IC socket 0.6" wide
	1	U3	74HCT08, quad 2-input AND gate
	1	U3 socket	14 pin PDIP IC socket 0.3" wide

Also required to assemble the module from the above components:

- Long nose pliers
- Side cutters
- Soldering iron
- Solder
- PCB cleaning materials

Components: What They Do & Where To Get Them

Each component is described below. I have listed multiple sources for most components, but have not actually tried all of them, so best treat the specified part numbers as guidance only. Where eBay is listed as a supplier, the part is likely to be cheaper there than the other sources, sometimes considerably cheaper. Further savings are usually possible by ordering parts direct from countries like China.

PCB

Image	Qty	Reference	Description
	1	PCB	Printed circuit board SC103 Z80 PIO
		Supplier	Part number
		EasyEDA	Search EasyEDA.com for SC103
		Tindie	Search Tindie.com for SC103

The PCB is currently only available to be ordered from EasyEDA.com, although you can download the Gerber and send it to your preferred manufacturer.

C1, 2, 3, 4

Image	Qty	Reference	Description
	4	C1, 2, 3, 4	Capacitor 100nF, ceramic, lead spacing = 2.54mm
		Supplier	Part number
		Farnell	1100533
		Mouser	75-1C10Z5U104M050R
		RS	699-5027

These capacitors provide power supply decoupling (or bypass). The fast switching in digital circuits creates spikes on the power supply lines which are suppressed with decoupling capacitors placed at key points on the circuit board.

C5

Image	Qty	Reference	Description
	1	C5	Capacitor 100uF, electrolytic, lead spacing = 2.54mm (radial) or 14mm (axial)
		Supplier	Part number
		Farnell	9452478 (100uF, 16V, radial)
		Mouser	140-REA101M1CBK0611P (100uF, 16V, radial)
		RS	711-0933 (100uF, 16V, radial)

This capacitor provides suppression of transients on the power supply. The PIO module may well be used to power and control external electronics, in which case there could be significant transients generated on the supply lines. Where possible supply transients should be suppressed at source, so this component *should* not be critical.

The PCB allows for a radial or axial capacitors. In order to build a low profile board, the capacitor should lay on its side. An axial capacitor would be most secure in this configuration, but there is limited length allocated and you probably don't have one!

JP1 and JP2

Image	Qty	Reference	Description
	1	JP1 and JP2	Pin header, male, 2 rows x 2 pins, straight
		Supplier	Part number
		eBay	200906546562 (2x40 pin to be cut to length)
		Farnell	2356151 (2x40 pin to be cut to length)
		Mouser	710-61308021121 (2x40 pin to be cut to length)
		RS	155-721 (2x40 pin to be cut to length)

This pair of jumpers allow the interrupt daisy chain signals to be connected to the RC2014 bus signal USER 2 (pin 38) and USER 3 (pin 39). To make use of this feature you must use a backplane that is specifically designed to provide the necessary daisy chain, such as Backplane SC107. The current official RC2014 backplanes do not support this feature.

Alternatively the signals IEI and IEO can be found on connector P2 on the back edge of the board. Dupont wires can be used to daisy chain these signals to other modules.

JP1 and J2

Image	Qty	Reference	Description
	2	JP1 and JP2	Jumper shunt for pin spacing = 2.54mm
		Supplier	Part number
		eBay	201261690156
		Farnell	2396303
		Mouser	649-68786-102LF
		RS	674-2397

These shunts (small sockets) connect the required pins on JP1 and J2.

P1

Image	Qty	Reference	Description
	1	P1	Pin header, male, angled, 2-row x 39-pin, 2 row (1 row optional)
		Supplier	Part number
		eBay	200906546562 (2x40 pin to be cut to length)
		Farnell	2032912 (2x40 pin to be cut to length)
		Mouser	571-9-103795-0 (2x40 pin to be cut to length)
		RS	155-743 (2x40 pin to be cut to length)

This connector mates with the RC2014 bus backplane. You can fit a single or a double row header. The only reasons for the second row is to provide additional power supply pins, make the module the same height as the others and to increase stability of the module.

Some pins need to be removed, using a pair of pliers, before fitting.

P2

Image	Qty	Reference	Description
	1	P2	Pin header, male, 2 rows x 13 pins, angled
		Supplier	Part number
		eBay	200906546562 (2x40 pin to be cut to length)
		Farnell	2032912 (2x40 pin to be cut to length)
		Mouser	571-9-103795-0 (2x40 pin to be cut to length)
		RS	155-743 (2x40 pin to be cut to length)

This connector provides access to all the PIO I/O signals in a format suitable to connect to external devices via a ribbon cable. See schematic for pin-out.

P3

Image	Qty	Reference	Description
	1	P3	Pin header, male, 1 rows x 29 pins, angled
		Supplier	Part number
		eBay	200906546562 (1x40 pin to be cut to length)
		Farnell	2356192 (1x40 pin to be cut to length)
		Mouser	710-61304011021 (1x40 pin to be cut to length)
		RS	156-077 (1x40 pin to be cut to length)

This connector provides access to all the PIO I/O signals in a format suitable to connect to breadboards and other prototyping projects via Dupont wires.

This connector is optional, so if you want to put the RC2014 in a case or just don't like the look of it, you can leave this connector off. Alternatively you might prefer a different connector, such as a female header socket.

Pin 15 is a ground terminal between the two port I/O connections. You may wish to remove this pin before assembly, so that it is easier to visually identify required connections. See schematic for pin-out.

P4

Image	Qty	Reference	Description
	1	P4	Pin header, male, angled, 1-row x 2-pin
		Supplier	Part number
		eBay	200906546562 (1x40 pin to be cut to length)
		Farnell	2356192 (1x40 pin to be cut to length)
		Mouser	710-61304011021 (1x40 pin to be cut to length)
		RS	156-077 (1x40 pin to be cut to length)

As the official RC2014 backplanes do not provide a Z80 mode 2 interrupt daisy chain (IEI and IEO signals), these have been brought to the back of the board where they can be easily linked to other modules with Dupont wires.

RP1

Image	Qty	Reference	Description
	1	RP1	Resistor pack 8x10k, SIL, 9-pin
		Supplier	Part number
		Farnell	9356819
		Mouser	652-4609X-1LF-10K
		RS	333-864

This is a network of 8 resistors with one end of each resistor common to pin 1. The resistors are used to pull up the address select switch (SW1) outputs and also to pull up the interrupt enable input signal (IEI).

SW1

Image	Qty	Reference	Description
	1	SW1	DIP switch, 6 way, piano style
		Supplier	Part number
		eBay	262361463572
		Farnell	2452331
		Mouser	653-A6FR-6104 (black)
		RS	877-2359

This switch is used to set the I/O address for the module. It sets the required state of address lines A2 to A7, thus allowing the module to occupy a 4 address block on any 4-byte boundary.

In order to provide some certainty for software it is strongly recommended you set the base address of your first PIO module to 0x68, so that the module occupies I/O addresses 0x68 to 0x6B. This is done by setting switches 1 to 6, to On, Off, Off, On, Off, On where On is the switch closed. In the case of the piano style DIP switch, the On position is the switch lever pushed down towards the circuit board.

Switches in the On position pull down the input of the address comparator U1. Switches in the Off position allow the input of the address comparator to be pulled up by RP1.

U1

Image	Qty	Reference	Description
	1	U1	74HCT688, 8-bit identity comparator, PDIP 20
		Supplier	Part number
		Farnell	2407104
		Mouser	595-CD74HCT688E
		RS	663-0650

This integrated circuit provides the address decoding, by comparing the current address from the CPU with the address set with the DIP switch SW1.

U1 socket

Image	Qty	Reference	Description
	1	U1 socket	20 pin PDIP IC socket 0.3"
		Supplier	Part number
		Farnell	4285608
		Mouser	571-1-2199298-6
		RS	674-2444

U2

Image	Qty	Reference	Description
	1	U2	Z80 PIO, 8MHz, Z84C2008PEG (or Z80 PIO, 10MHz, Z84C2010PEG), PDIP 40
		Supplier	Part number
		Farnell	6MHz version only
		Mouser	692-Z84C2008PEG (8 MHz version) 692-Z84C2010PEG (10 MHz version)
		RS	625-8952 (8 MHz version)

The Z80 PIO provides provides two 8-bit parallel ports with handshaking and flexible interrupt functions. It has mode 2 interrupt support, making it a usual general purpose I/O chip for use in an expanded Z80 system.

For further details see the Zilog PIO data sheet.

U2 socket

Image	Qty	Reference	Description
	1	U2 socket	40 pin PDIP IC socket 0.6"
		Supplier	Part number
		Farnell	4285669
		Mouser	571-1-2199299-5 or 649-DILB40P223TLF
		RS	674-2466

U3

Image	Qty	Reference	Description
	1	U3	74HCT08, quad 2-input AND gate
		Supplier	Part number
		Farnell	9591796
		Mouser	595-CD74HCT08N
		RS	527-514

This integrated circuit provides a special reset signal to the PIO. There is no separate reset pin on the PIO, so instead the M1 pin has an extra function. When M1 is low and both RD and IORQ are high, the PIO enters a reset state.

U3 socket

Image	Qty	Reference	Description
	1	U3 socket	14 pin PDIP IC socket 0.3"
		Supplier	Part number
		Farnell	2445621
		Mouser	571-1-2199298-3
		RS	674-2438

Assembly Guide

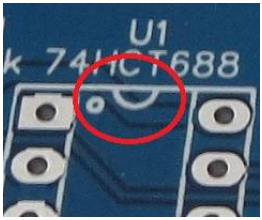
This guide assumes you are familiar with assembling circuit boards, soldering and cleaning. If not, it is recommended you read some of the guides on the internet before continuing.

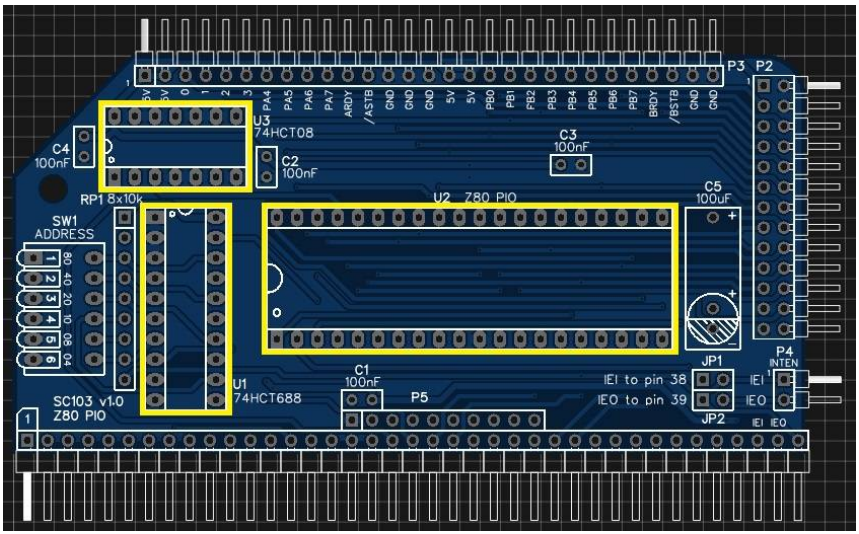
First check you have all the required components, as listed in the section “What You Need”. Header pins JP1 and JP2, and P1 to P4 may need to be cut from longer strips.

Step 1

Fit and solder IC sockets for U1, U2 and U3.

Be sure to fit them with the notch matching the legend on the circuit board, so you do not end up fitting the IC the wrong way round too.

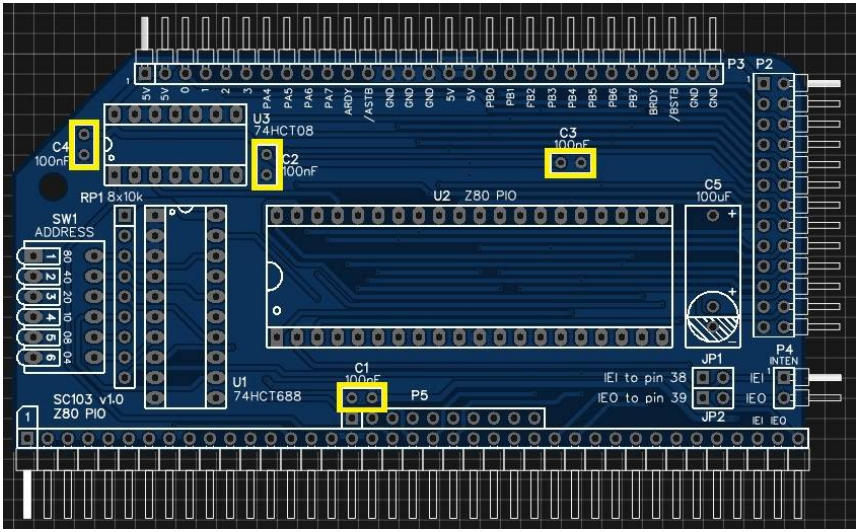




Step 2

Fit and solder capacitors C1, C2, C3 and C4.

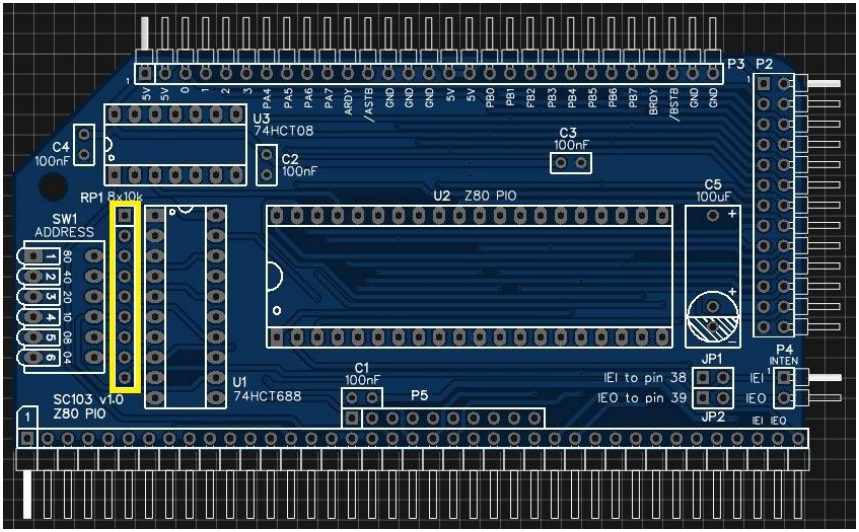
These can be fitted either way round, as they are not polarity dependent.



Step 3

Fit and solder resistor pack RP1.

This must be fitted the correct way round. The component should have pin 1 marked with a dot, as illustrated right.

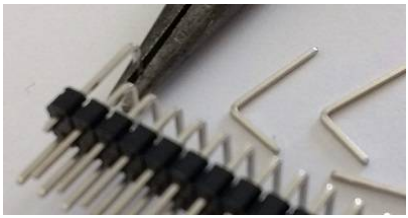


Step 4

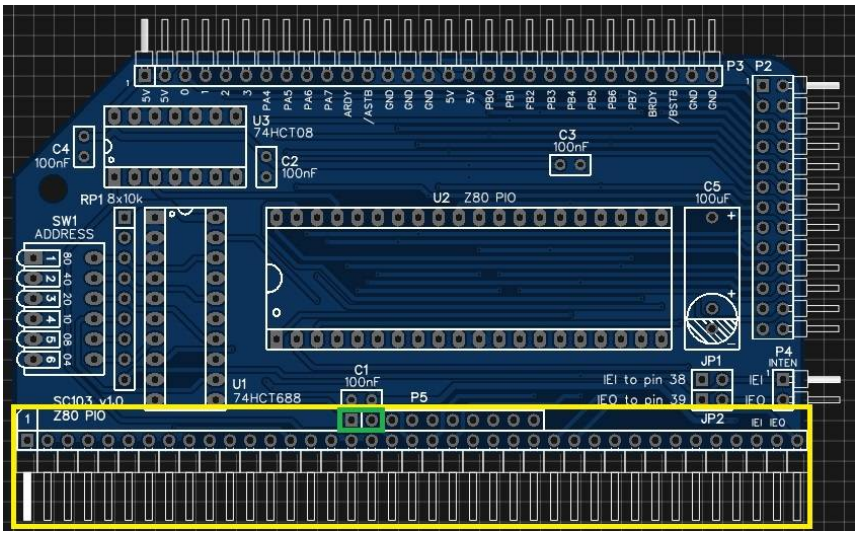
Fit and solder connector P1.

You can fit just a single row header as used by the RC2014 standard bus. The only reasons for the second row is to provide additional power supply pins, make the module the same height as the others and to increase stability of the module.

To prepare the header, it should first be cut to length (if starting with a strip more than 39 pins long) and then unwanted pins must be removed. If you want to make the board as easy to insert and remove as possible, you can remove all the pins in the second row except those shown on the schematic as used and indicated below in green.



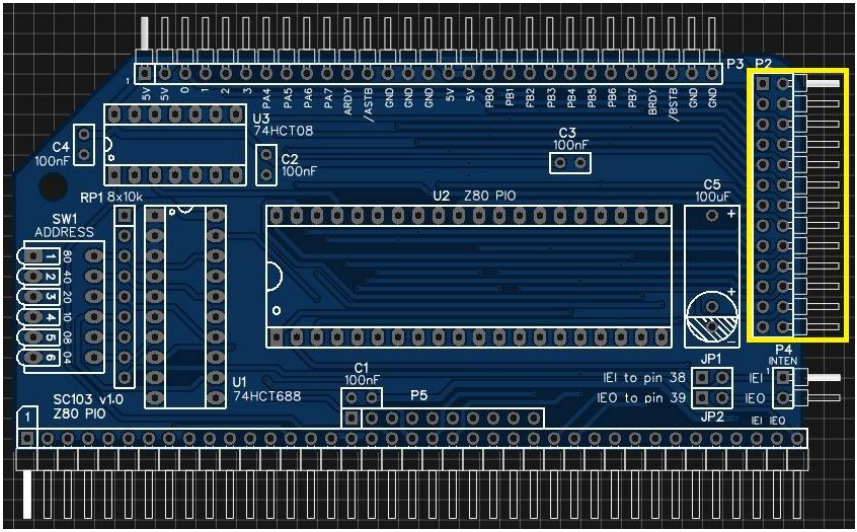
Take care to ensure the pins are parallel to the circuit board so that the board will be vertical when plugged into a backplane.



Step 5

Fit and solder connector P2.

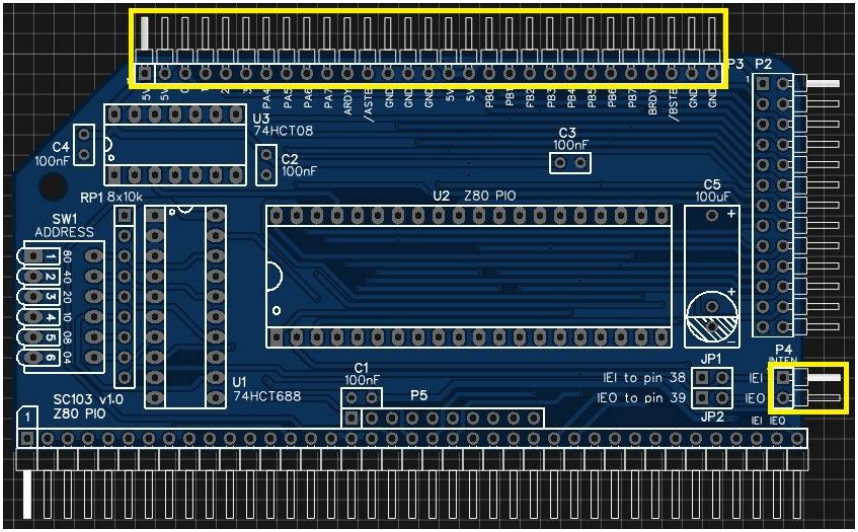
Take care to ensure the pins are parallel to the circuit board.



Step 6

Fit and solder connector P3 and P4.

Take care to ensure the pins are parallel to the circuit board.



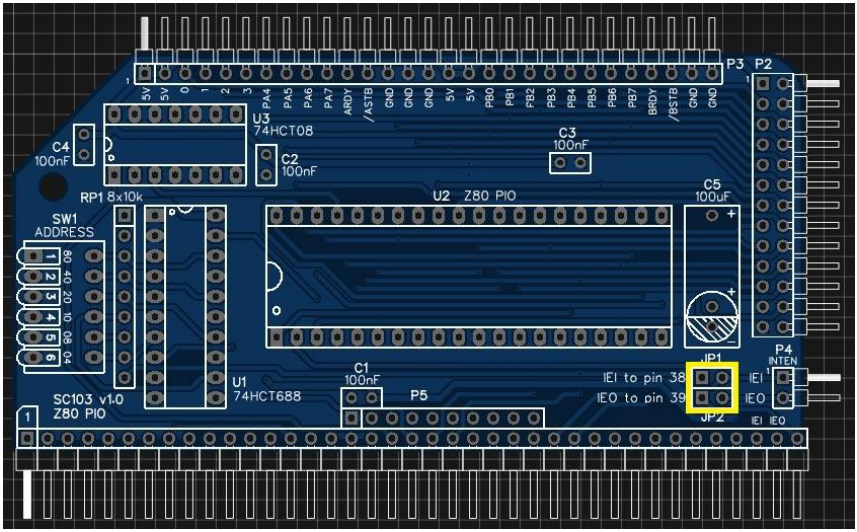
Connector P3 is optional, so if you want to put the RC2014 in a case or just don't like the look of it, you can leave this connector off. Alternatively you might prefer a different connector, such as a female header socket.

Connector P3 pin 15 is a ground terminal between the two port I/O connections. You may wish to remove this pin before assembly, so that it is easier to visually identify required connections. Alternatively you may feel an extra ground pin in more useful. See schematic for pin-out.

Step 7

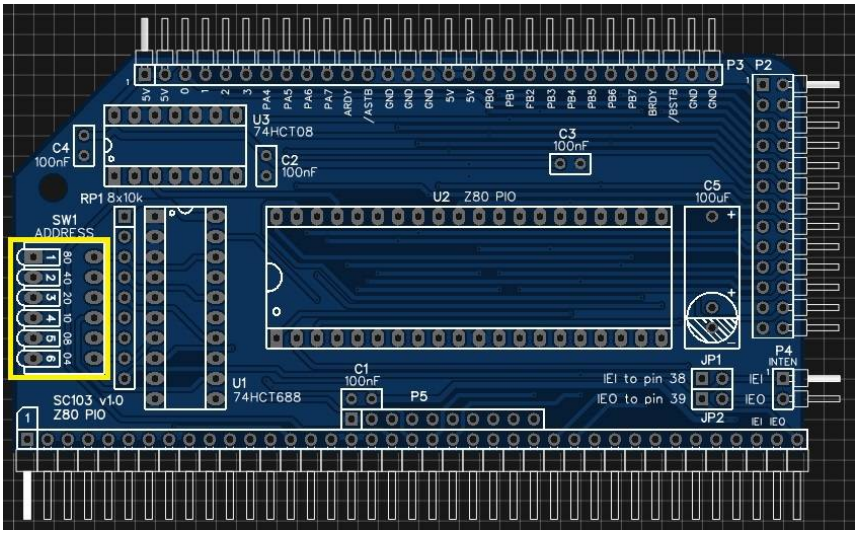
Fit and solder header pins JP1 and JP2.

JP1 and JP2 are made up of a single header 2 pins by 2 pins as illustrated right.

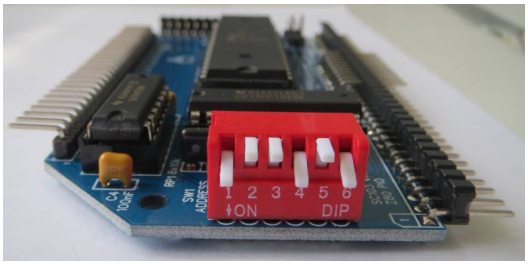


Step 8

Fit and solder the DIP switch SW1.



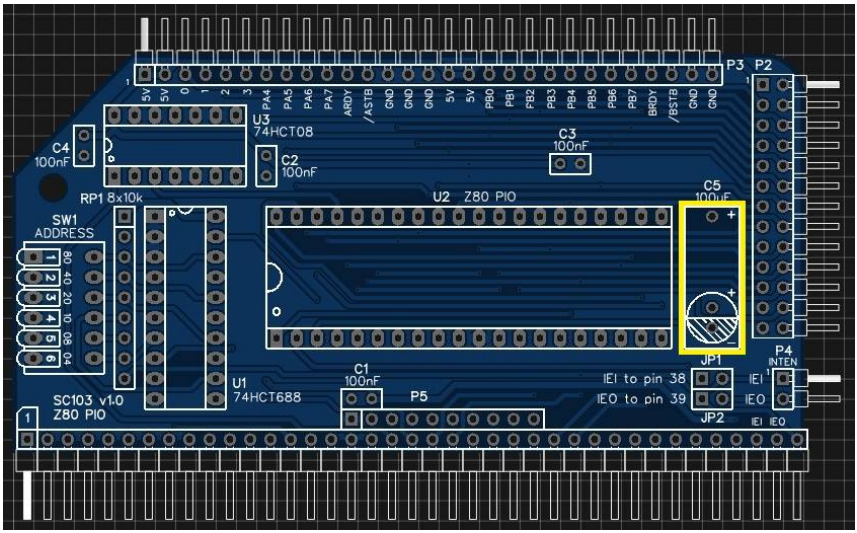
In order to provide some certainty for software it is strongly recommended you set the base address of your first PIO module to 0x68. The module then occupies I/O addresses 0x68 to 0x6B. This is done by setting the switches as illustrated below.



If you have a second PIO module the recommended base address is 0x6C.

Step 8

Fit and solder capacitor C5.



The PCB allows for a radial or axial capacitor. In order to build a low profile board, the capacitor should lay on its side. An axial capacitor would be most secure in this configuration, but there is limited length allocated and you probably don't have one!

You can fit a radial capacitor on its side, but it is not as secure as an axial package as both leads come out of the same end.

It is important to fit this capacitor the right way round. The PCB's legend shows a plus and minus sign next to the round outline of a radial packaged capacitor (bottom of image to left). It also shows the alternative plus position for an axial capacitor (top of image to left). In both cases the negative terminal is at the bottom. The image to the right shows the typical marking of the negative terminal of the capacitor.

Step 10

Remove any solder 'splats' with a brush, such as an old toothbrush.

Visually inspect the soldering for dry joints and shorts.

Clean the flux off with suitable cleaning materials.

Visually inspect again.

Before fitting the ICs or jumper shunts, plug the board into an RC2014 backplane with no other boards fitted. Power the backplane and perform the following checks with a volt meter:

- Check the supply voltage on the PIO module, between, say, U1 pin 10 and U1 pin 20. This should be 4.5 to 5.5 volts, preferably 4.75 to 5.25 volts.
- Check the interrupt enable input (IEI) on connector P4 is being pulled up to at least 4.5 volts.
- Check each address switch input (Q2 to Q7) on U1 is being pulled up to at least 4.5 volts when the appropriate switch (SW1) is Off (open) and drops to less than 0.4 volts when the appropriate switch (SW1) is On (closed).

If all is well, power down and remove the PIO module.

Step 11

Insert the ICs into their sockets, taking care to insert them the right way round, as illustrated below. Be careful not to bend any legs over.

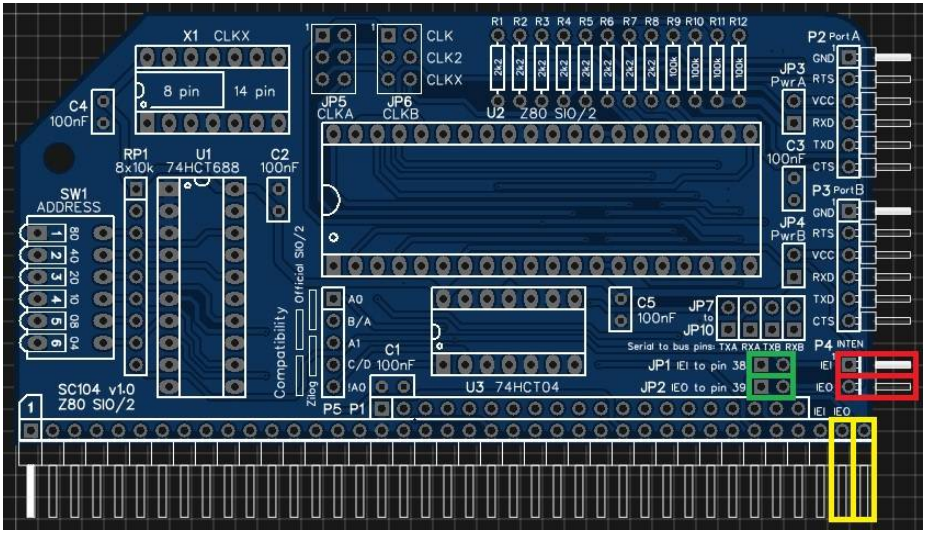
Now plug the PIO module into the RC2014 backplane together with your normal working set of modules. Power up and check the system is working as usual.

Configuring the PIO Module

The only jumpers on the PIO board are for interrupt daisy chain signals IEI and IEO. If your system has more than one device using interrupt mode 2, it will be necessary to set up an interrupt daisy chain.

This is fully described in the Z80 peripherals data sheet, but essentially it requires linking the output (IEO) of one interrupt generating device to the input (IEI) of the next, and so on. The position in the chain determines the device's interrupt priority.

The illustration shows the connections required when using external Dupont wires on P4 (shown in red) and the RC2014 bus USER pins (shown in yellow). To connect the IEI and IEO signals to the RC2014 bus fit shunts to jumpers J1 and J2 (shown in green).



Note that v1.0 of the PCB has the IEI and IEO bus pins incorrectly labelled. It indicates the use of pins 37 and 38, not 38 and 39.

Setting up a mode 2 interrupt system is not trivial so requires study of the data sheets rather than following any simple example I could write here.

Address Selection

The module's address can be set to any address that is a multiple of 4, such as address 0, 4, 8, 12, 16, ... , 252. This address is known as the base address, with the module occupying this address plus the next three addresses. Thus if the base address is 0, then the module occupies the address range 0 to 3.

The address is set with the 6 way DIP switch SW1.

The six address switches, 1 to 6, represent addresses 128, 64, 32, 16, 8 and 4 respectively. The base address is the sum of all the switches in the Off position. For a piano style DIP switch, as illustrated below, Up is Off and Down is On.

In the illustration below the switches are:

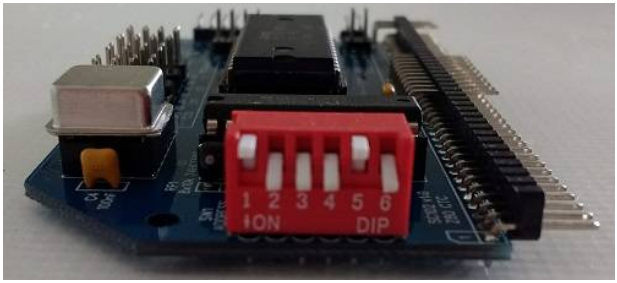
Up Down Down Down Up Down

This represents the address:

128 + 0 + 0 + 0 + 8 + 0

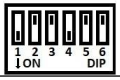
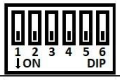
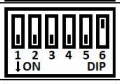
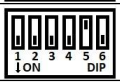
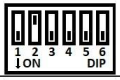
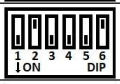
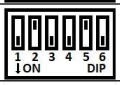
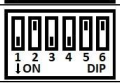
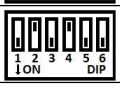
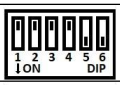
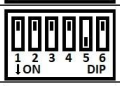
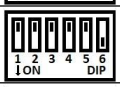
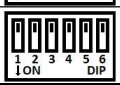
= 128 + 8

= 136 (or 0x88 in hexadecimal).



In order to provide some certainty for software it is strongly recommended you set the base address of your first PIO module to 0x68. If you have a second PIO module the recommended base address is 0x6C. If everybody follows this recommendation then software written for the PIO module will know where to find the hardware.

The following table shows examples of address switch settings.

Switches	Base Address	Address Range	Recommended
	0x68 hexadecimal (104 decimal)	0x68 to 0x6B hexadecimal (104 to 107 decimal)	1st PIO module address
	0x6C hexadecimal (108 decimal)	0x6C to 0x6F hexadecimal (108 to 111 decimal)	2nd PIO module address
	0x00 hexadecimal (0 decimal)	0x00 to 0x03 hexadecimal (0 to 3 decimal)	
	0x04 hexadecimal (4 decimal)	0x04 to 0x07 hexadecimal (4 to 7 decimal)	
	0x08 hexadecimal (8 decimal)	0x08 to 0x0B hexadecimal (8 to 11 decimal)	
	0x40 hexadecimal (64 decimal)	0x40 to 0x43 hexadecimal (64 to 67 decimal)	
	0x44 hexadecimal (68 decimal)	0x44 to 0x47 hexadecimal (68 to 71 decimal)	
	0x48 hexadecimal (72 decimal)	0x48 to 0x4B hexadecimal (72 to 75 decimal)	
	0x4C hexadecimal (76 decimal)	0x4C to 0x4F hexadecimal (76 to 79 decimal)	
	0x50 hexadecimal (80 decimal)	0x50 to 0x53 hexadecimal (80 to 83 decimal)	
	0xF0 hexadecimal (240 decimal)	0xF0 to 0xF3 hexadecimal (240 to 243 decimal)	
	0xF4 hexadecimal (244 decimal)	0xF4 to 0xF7 hexadecimal (244 to 247 decimal)	
	0xF8 hexadecimal (248 decimal)	0xF8 to 0xFB hexadecimal (248 to 251 decimal)	
	0xFC hexadecimal (252 decimal)	0xFC to 0xFF hexadecimal (252 to 255 decimal)	

Purchasing the Printed Circuit Board

Currently the circuit board is available from EasyEDA (in China), or more accurately from their production partner JLCPCB, and from Tindie.

You can download Gerber files from EasyEDA and send them to your preferred manufacturer, but the following describes the ordering process through EasyEDA.

Browse to EasyEDA.com

Select the main menu item "Explore"

In the search box, enter "RC2014 PIO" or "sccousins"

Select, from the list shown, the project "SC103 v1.x Z80 PIO for RC2014"

The project's details should now be displayed.

Select "Open in Editor" (the button next to the circuit board illustration, not the one next to the schematic).

Select "Generate Fabrication File (Gerber)" to get a summary of the board details.

Select "Generate Gerber" to download the Gerber files or "Order at JLCPCB" to order the boards direct from JLCPCB. Selecting "Order at JLCPCB" requires you to log in (or create an account and log in).

Wait for the progress bar to complete.

You should now be presented with the image of each side of the board and the following options:

Layers	2	
Dimensions	50 x 99 mm	
PCB Qty	10	There is no saving selecting less than 10
PCB Thickness	1.6	
PCB Colour	Green	You may want to change this to Blue
Surface Finish	HASL	
Copper Weight	1 oz	
Gold Fingers	No	
Material Details	FR4-Standard Tg 140C	
Panel By JLCPCB	No	
Different Design	1	

Note, the price increases significantly if you select a colour other than green.

Select “Save to Cart”

Select “Checkout securely”

Enter your details and select your shipping options.

And finally complete the order.

Warning

You may get a warning about design rule violations. There are 2 legitimate warnings that may be reported due to the position of the last pair of holes on the RC2014 bus connector being too close to the edge of the board when using the standard RC2014 board outline. These warnings can be safely ignored, but any others may be a cause for concern.

Fault Finding

Check all links and jumpers, check no chips have bent legs and thus not making contact with their socket, carefully inspect all soldering, check all the chips are inserted the right way round, check all the components are in the right place.

With the PIO module plugged in to the RC2014 backplane with no other boards fitted. Power the backplane and perform the following checks with a volt meter:

- Check the supply voltage on the PIO module, between, say, U1 pin 10 and U1 pin 20. This should be 4.5 to 5.5 volts, preferably 4.75 to 5.25 volts.
- Check the interrupt enable input (IEI) on connector P4 is being pulled up to at least 4.5 volts.
- Check each address switch input (Q2 to Q7) on U1 is being pulled up to at least 4.5 volts when the appropriate switch (SW1) is Off (open) and drops to less than 0.4 volts when the appropriate switch (SW1) is On (closed).

History

2018-06-25	v1.0	First circuit boards
2018-06-27	e1.0.0	First release of this user guide
2019-03-06	e1.0.1	Revised this user guide General improvements plus corrected some component part numbers

Contact Information

If you wish to contact me regarding this document, or the hardware and software it relates to, use the contact page at www.scc.me.uk

Stephen C Cousins, Chelmsford, Essex, United Kingdom.

RC2014 information

Information about the RC2014 system can be found at www.rc2014.co.uk

RC2014 support

Issues related to the RC2014 can be posted on the google group "RC2014-Z80".

RC2014 supplies

Parts can be purchased through Tindie at www.tindie.com (search "RC2014")

Official RC2014 parts are at:
https://www.tindie.com/stores/Semachthemonkey/

Credits

Thanks to all those who provided encouragement, feedback and contributed ideas to the design. Specifically: Mark T, Jon L, Jay C, and anyone else I forgot!

See RC2014 google group for full details:
https://groups.google.com/forum/#!topic/rc2014-z80/JJ2JKAIehck