

Z80 Processor Module For RC2014 User Guide

For module: SC108 version 1.0

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Overview

The Z80 processor module (SC108) contains a Z80 CPU, 128k bytes of RAM, 32k bytes of ROM, clock and reset.



This space saving module is designed to run the Small Computer Monitor, configuration R3, which contains a Machine Code Monitor, BASIC and a CP/M loader.

A minimal system, using this module, is:

- Backplane (2 slots or more)
- This module (processor, RAM, ROM, clock, reset)
- Serial module (68B50 or Z80 SIO, official or third party)

To run CP/M a Compact Flash module is also required, together with a Compact Flash card containing CP/M.

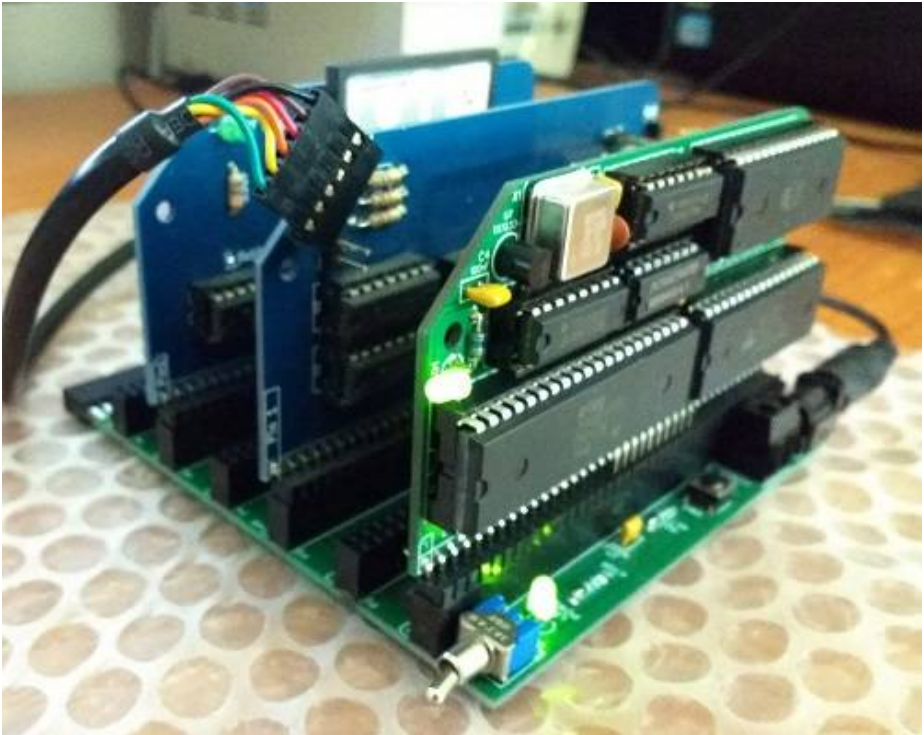
This module is compatible with existing software written for official RC2014 modules, except there are no jumpers to select different RAM, ROM and clock options. It is essentially equivalent to the following set of modules with fixed jumper positions:

- RC2014 CPU module
- RC2014 Dual clock module (clock 1 set to 7.3728 MHz, clock 2 not connected)
- RC2014 Pageable ROM module (32k page size, page selection zero)
- RC2014 64k RAM module (set to paged mode to allow 64k of RAM for CP/M)

The on-board clock oscillator does not have to be 7.3728 MHz if the serial module has its own clock source, such as SC104 Z80 SIO/2. Alternatively, this module does not require a clock oscillator if another module can provide the bus clock signal.

One I/O port address (0x38) is used for memory paging. Tight address decoding is used for this output port so only writes to this single address are detected. Bit zero of this port is set to page the ROM out and the RAM in. Bit 7 is used to select the upper 64k bytes of RAM. Both bits are cleared in hardware at reset.

Below is a 3 module CP/M system based on the SC108 Processor module.



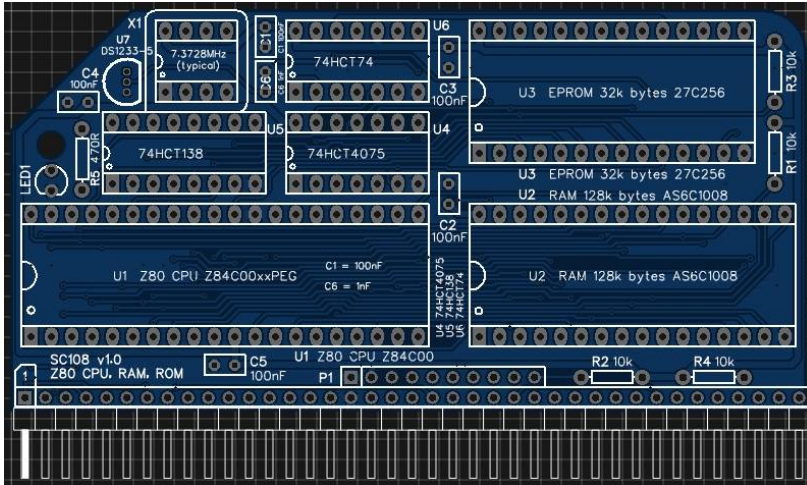
The above image contains:

- SC108 processor module (Z80 CPU, 128k RAM, 32k ROM, Clock and Reset)
- Standard RC2014 dual serial module (Z80 SIO/2)
- Standard RC2014 compact flash module
- SC105 six slot backplane

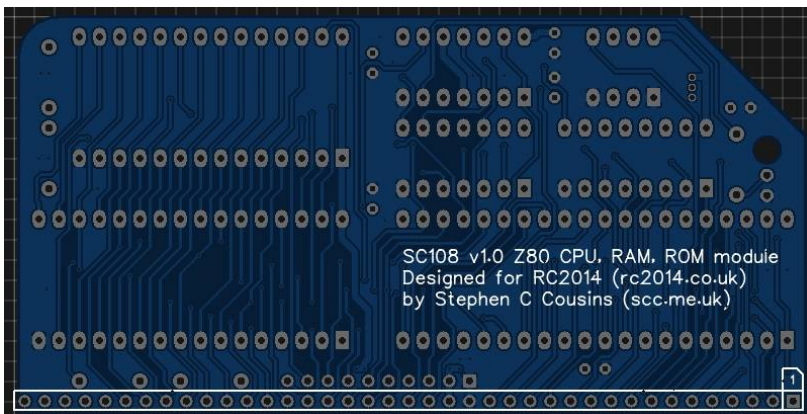
Printed Circuit Board

The printed circuit board is a standard footprint RC2014 board.

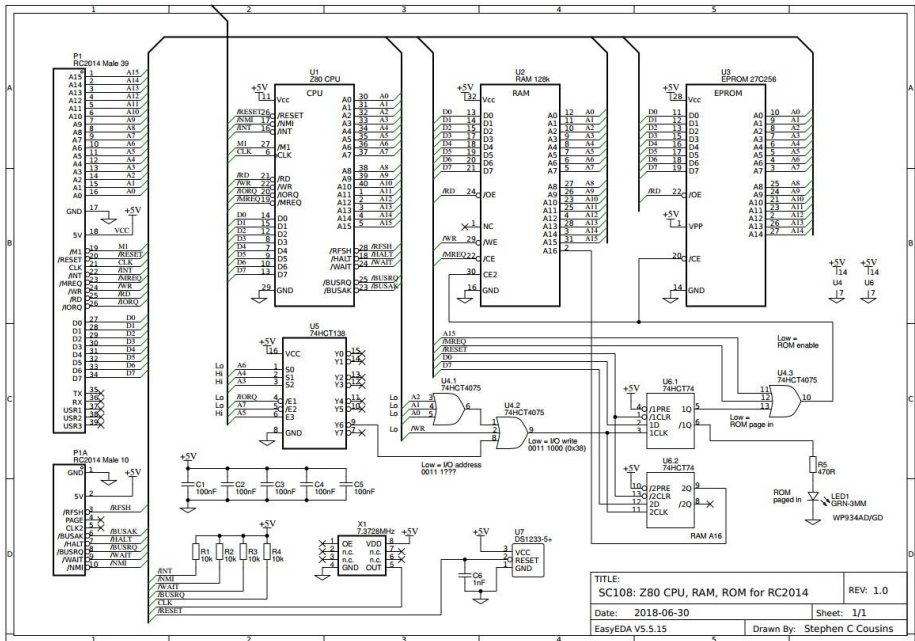
Printed circuit board, top/component side:



Printed circuit board, bottom/solder side:



Schematic



Errata

None yet.

What You Need

The Z80 processor module (SC108) is a multi-function device, allowing some parts to be left off if only a subset of its features are required.

The following components are required to assemble the module with its full functionality. Header pins P1 may need to be cut from a longer strip.

Image	Qty	Reference	Description
	1	PCB	Printed circuit board SC108 Processor
	5	C1, 2, 3, 4, 5	Capacitor 100nF, ceramic, lead spacing = 2.54mm
	1	C6	Capacitor 1nF, ceramic, lead spacing = 2.54mm
	1	LED1	LED, 3mm, green, right angled
	1	P1	Pin header, male, 2 rows x 39 pins, angled (2nd row optional)
	4	R1 to R4	Resistor 10k, axial, 5%, carbon film, 0.25W
	1	R5	Resistor 470R, axial, 5%, carbon film, 0.25W
	1	U1	Z80 CPU, 8MHz, Z84C0008PEG (or Z80 CPU, 10MHz, Z84C0010PEG), PDIP 40
	1	U1 socket	40 pin PDIP IC socket 0.6" wide
	1	U2	RAM 128k bytes, AS6C1008-55PCN, PDIP 32
	1	U2 socket	32 pin PDIP IC socket 0.6" wide
	1	U3	EPROM 32k bytes, AT27C256R-45PU (or 64k bytes, AT27C512R-45PU, top half used), PDIP 28

	1	U3 socket	28 pin PDIP IC socket 0.6" wide
	1	U4	74HCT4075, triple 3-input OR gate
	1	U4 socket	14 pin PDIP IC socket 0.3" wide
	1	U5	74HCT138, 3-to-8 line decoder
	1	U5 socket	16 pin PDIP IC socket 0.3" wide
	1	U6	74HCT74, Dual D-type flip-flop
	1	U6 socket	14 pin PDIP IC socket 0.3" wide
	1	U7	DS1233-5+, 5V EconoReset, TO-92 package
	1	X1	Oscillator module 7.3728MHz, 8 pin PDIP size
	1	X1 socket	8 pin PDIP IC socket 0.3" wide (optional)


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 SC108 Processor
		Supplier	Part number
		EasyEDA	Search EasyEDA.com for RC2014 Processor


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, 5

Image	Qty	Reference	Description
	5	C1, 2, 3, 4, 5	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.


C6

Image	Qty	Reference	Description
	1	C6	Capacitor 1nF, ceramic, lead spacing = 2.54mm
		Supplier	Part number
		Farnell	2332953
		Mouser	594-K102K15X7RH53L2
		RS	852-3227

This capacitor forms part of the reset circuit, together with U7 (DS1233-5).

If an on-board reset is not required, this capacitor and U7 can be left off.


LED1

Image	Qty	Reference	Description
	1	LED1	LED, 3mm, green, right angled
		Supplier	Part number
		Farnell	1003385
		Mouser	604-WP934ADGD
		RS	616-4475

When this LED is ON, the ROM chip is paged in to memory. The memory map then has ROM in the lower 32k bytes and RAM in the upper 32k bytes. This is the condition immediately following reset.

When the LED is OFF, the ROM is paged out of memory, leaving a full 64k bytes of RAM. This is the configuration selected by CP/M as it loads.


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, but the full functionality of this module requires the enhanced RC2014 bus and thus a double row header.


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

R1, 2, 3, 4

Image	Qty	Reference	Description
	4	R1, 2, 3, 4	Resistor 10k, axial, 5%, carbon film, 0.25W
		Supplier	Part number
		Farnell	9339060
		Mouser	603-CFR-25JR-5210K
		RS	707-7745


These resistors are pull up resistors for the Z80 CPU inputs: /INT, /NMI, /WAIT and /BUSRQ.

R5

Image	Qty	Reference	Description
	1	R5	Resistor 470R, axial, 5%, carbon film, 0.25W
		Supplier	Part number
		Farnell	9339531
		Mouser	603-CFR-25JR-52470R
		RS	707-7647

This resistor sets the LED current. You may change this value from about 330R to 1K depending on the type of LED you fit and your preference for brightness. A value of 470R will work fine with just about any LED, so if in doubt use this value.


U1

Image	Qty	Reference	Description
	1	U1	Z80 CPU, 8MHz, Z84C0008PEG (or Z80 CPU, 10MHz, Z84C0010PEG), PDIP 40
		Supplier	Part number
		Farnell	1081891 (10 MHz)
		Mouser	692-Z84C0010PEG (10 MHz)
		RS	625-9078 (10 MHz)


This integrated circuit is the Z80 Central Processing Unit (CPU). A minimum of an 8 MHz rated part is required, but a faster part can also be used.

For further details see the Zilog CPU data sheet.

U1 socket


Image	Qty	Reference	Description
	1	U1 socket	40 pin PDIP IC socket 0.6"
		Supplier	Part number
		Farnell	4285669
		Mouser	571-1-2199299-5 or 649-DILB40P223TLF
		RS	674-2466

U2


Image	Qty	Reference	Description
	1	U2	RAM 128k bytes, AS6C1008-55PCN, PDIP 32
		Supplier	Part number
		Farnell	1562896
		Mouser	913-AS6C1008-55PCN
		RS	744-4542

This is the module's Random Access Memory (RAM). Although this is a 128k byte RAM chip, the Z80 CPU can only 'see' 64k bytes at any given time. The second 64k bytes can be selected in software, but it is quite difficult to use. In practice it is likely that only 64k will ever be used.

U2 socket

Image	Qty	Reference	Description
	1	U2 socket	32 pin PDIP IC socket 0.6" wide
		Supplier	Part number
		Farnell	2678542
		Mouser	649-DILB32P223TLF
		RS	674-2463

U3


Image	Qty	Reference	Description
	1	U3	EPROM 32k bytes, AT27C256R-45PU (or 64k bytes, AT27C512R-45PU, top half used), PDIP 28
		Supplier	Part number
		Farnell	2345637 (32k bytes)
		Mouser	556-AT27C256R-45PU (32k bytes)
		RS	127-6557 (32k bytes)

This is the module's Read Only Memory (ROM). The specific type listed is an Electrically Programmable Read Only Memory (EPROM), meaning it can have its contents programmed in with an EPROM programmer. The contents then remain fixed. The specified device can not be erased and re-programmed.


In order for a computer to do anything useful, it needs some program code to execute. Even reading a program from a disk drive requires program code to perform that read. Thus a computer needs some program code permanently available to execute when it is first switched on. This is the function of the ROM chip.

This module has been designed to have the Small Computer Monitor installed in the ROM chip, although any compatible code can be used instead.

U3 socket


Image	Qty	Reference	Description
	1	U3 socket	28 pin PDIP IC socket 0.6" wide
		Supplier	Part number
		Farnell	2453476
		Mouser	571-1-2199299-2
		RS	674-2454

U4


Image	Qty	Reference	Description
	1	U4	74HCT4075, triple 3-input OR gate
		Supplier	Part number
		Farnell	1749887
		Mouser	595-CD74HCT4075E
		RS	807-2482

This forms part of the address decoding and RAM/ROM paging circuit.

U4 socket


Image	Qty	Reference	Description
	1	U4 socket	14 pin PDIP IC socket 0.3" wide
		Supplier	Part number
		Farnell	2445621
		Mouser	571-1-2199298-3
		RS	674-2438

U5


Image	Qty	Reference	Description
	1	U5	74HCT138, 3-to-8 line decoder
		Supplier	Part number
		Farnell	1470803
		Mouser	595-SN74HCT138N
		RS	144-9994

This forms part of the address decoding circuit.

U5 socket


Image	Qty	Reference	Description
	1	U5 socket	16 pin PDIP IC socket 0.3" wide
		Supplier	Part number
		Farnell	2445622
		Mouser	571-1-2199298-4
		RS	674-2432

U6


Image	Qty	Reference	Description
	1	U6	74HCT74, Dual D-type flip-flop
		Supplier	Part number
		Farnell	1470823
		Mouser	595-SN74HCT74N
		RS	633-981

This forms part of the RAM/ROM paging circuit, providing latches for the RAM/ROM select bit and the RAM upper/lower bank select. Both bits are cleared in hardware at reset.

U6 socket

Image	Qty	Reference	Description
	1	U6 socket	14 pin PDIP IC socket 0.3" wide
		Supplier	Part number
		Farnell	2445621
		Mouser	571-1-2199298-3
		RS	674-2438


U7

Image	Qty	Reference	Description
	1	U7	DS1233-5+, 5V EconoReset, TO-92 package
		Supplier	Part number
		Farnell	2519488
		Mouser	700-DS1233-5
		RS	732-7282

This device provides a clean reset pulse when the power is applied, when the supply voltage recovers from being out of tolerance or when the reset button is pressed.

As it monitors the supply voltage, it can hold the system in reset if the voltage is below 4.75 volts. So if the system does not start, check the supply voltage.


X1

Image	Qty	Reference	Description
	1	X1	Oscillator module 7.3728MHz, either 8 pin or 14 pin
		Supplier	Part number
		Farnell	2508742 (7.328MHz 8-pin QX8T50B)
		Mouser	774-MXO45HS-3C-7.3 (7.3728MHz 8-pin MXO45HS)
		RS	796-0574 (7.328MHz 8-pin QX8T50B)

This oscillator is optional. If fitted it provides the main processor bus clock.

This oscillator does not have to be 7.3728 MHz if the serial module has its own clock source, such as SC104 Z80 SIO/2. Alternatively this module does not require a clock oscillator if another module can provide the system bus clock signal.

X1 socket

Image	Qty	Reference	Description
	1	X1 socket	14 pin PDIP IC socket 0.3"
		Supplier	Part number
		Farnell	2445621
		Mouser	571-1-2199298-3
		RS	674-2438

Oscillator module (X1) is quite large, so if you want to make a low profile board it is best to solder the oscillator directly onto the circuit board rather than fit this socket.

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 P1 may need to be cut to length from a longer strip.

Step 1



Fit and solder the four 10k resistors R1 to R4 (shown in red below).

Colour code for 10k resistor: Brown, Black, Orange

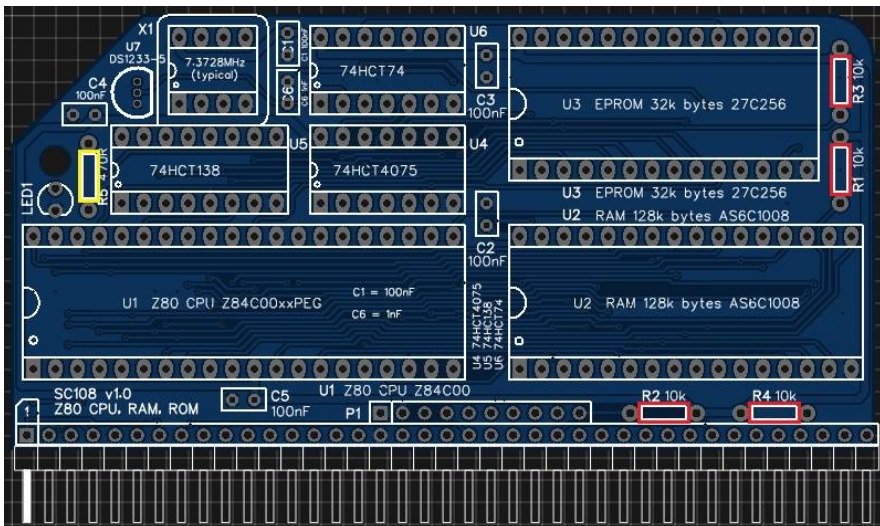


Fit and solder the four 470R resistor R5 (shown in yellow below).

Colour code for 470R resistor: Yellow, Violet, Brown



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



Step 2

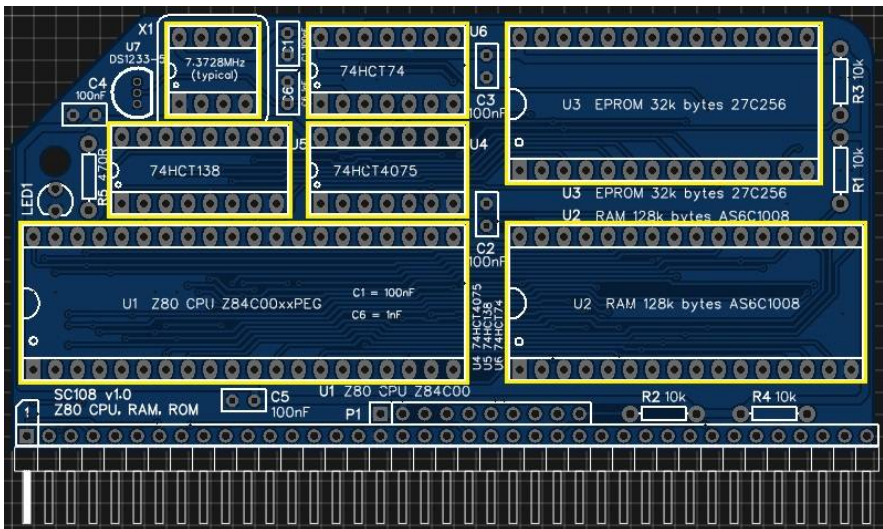


Fit and solder IC sockets for U1, U2, U3, U4, U5, U6 and optionally X1.

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.



You may wish to solder the oscillator X1 directly to the board, in which case fit the oscillator now instead of the socket.



Step 3



Fit and solder capacitors C1, C2, C3, C4 and C5 (shown in red below).

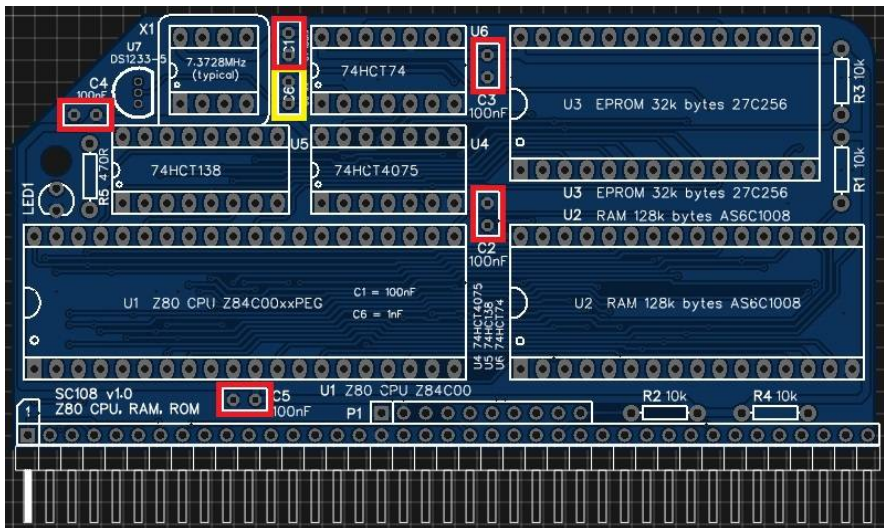
The capacitor value is 100nF and should be marked "104"



Fit and solder capacitor C6 (shown in yellow below).

The value capacitor is 10nF and should be marked "102"

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



Step 4



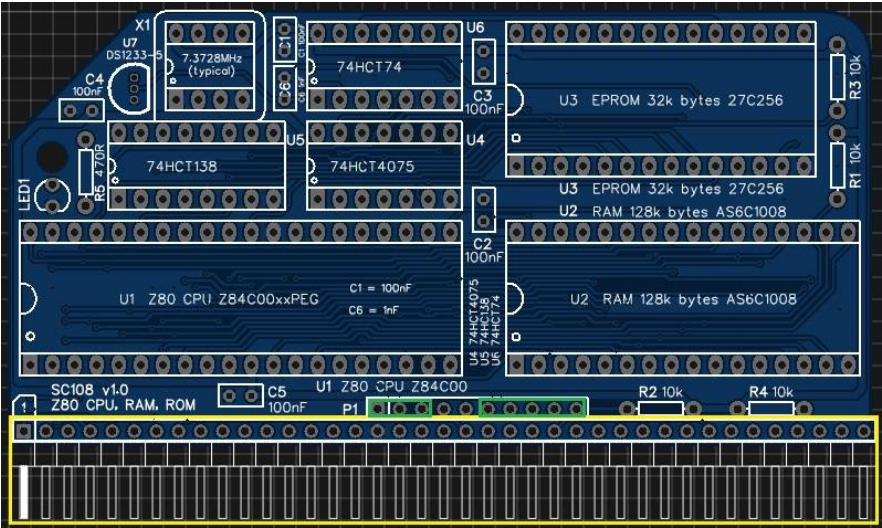
Fit and solder connector P1.

You can fit just a single row header as used by the RC2014 standard bus, but doing so means not all the features of this module can be used. It is best to fit a double row even if the module is initially only used with a standard bus backplane.

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.



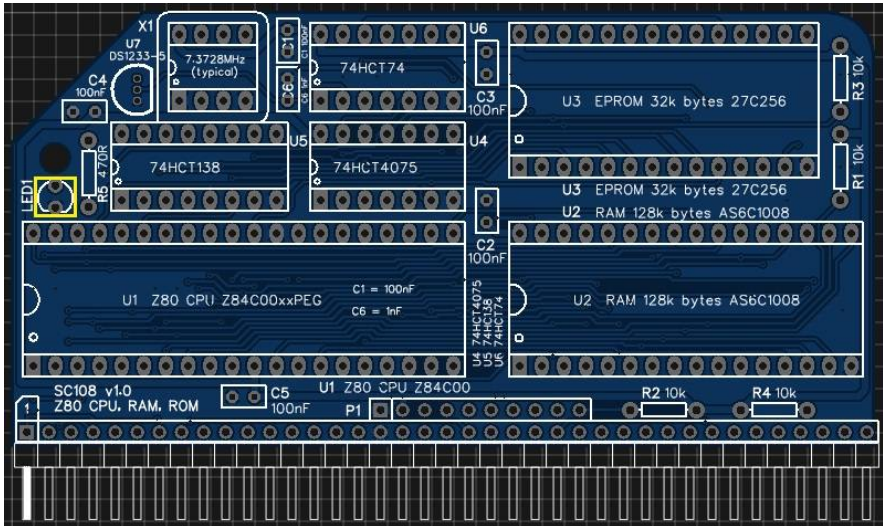
Take care to ensure the pins are parallel to the circuit board so that the board will be vertical when plugged into a backplane.



Step 5



Fit and solder LED1



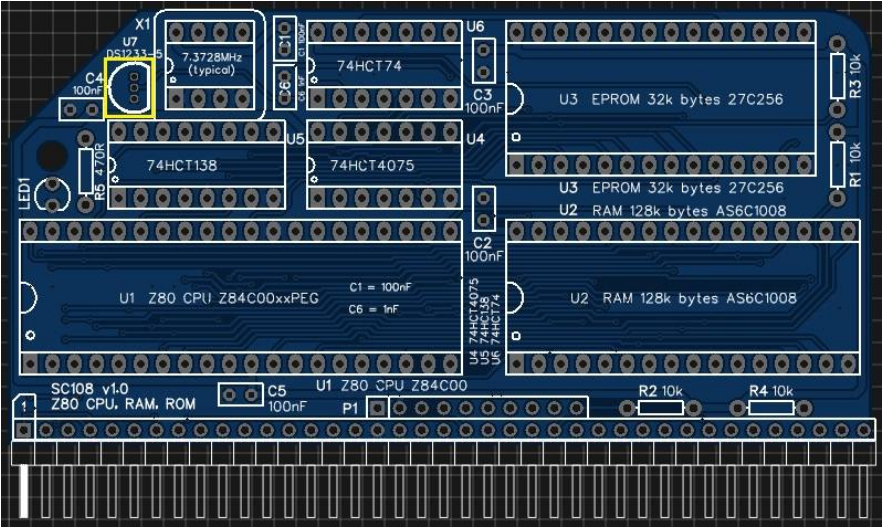
While the LED illustrated above looks very nice, you can fit an ordinary LED. Bending the legs so the LED faces to the left (as illustrated above) makes it easier to see when the module is fitted to a backplane along with other modules.

It is important to fit this component the correct way round. LEDs usually have a small flat side to indicate the cathode (the negative end). This should be positioned to match the flat side shown on the circuit board. Also the cathode pin on the LED is usually shorter than the other pin (the Anode).

Step 6



Fit and solder U7



It is important to fit this component the correct way round. It should match the outline shown on the circuit board.

Step 7

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.

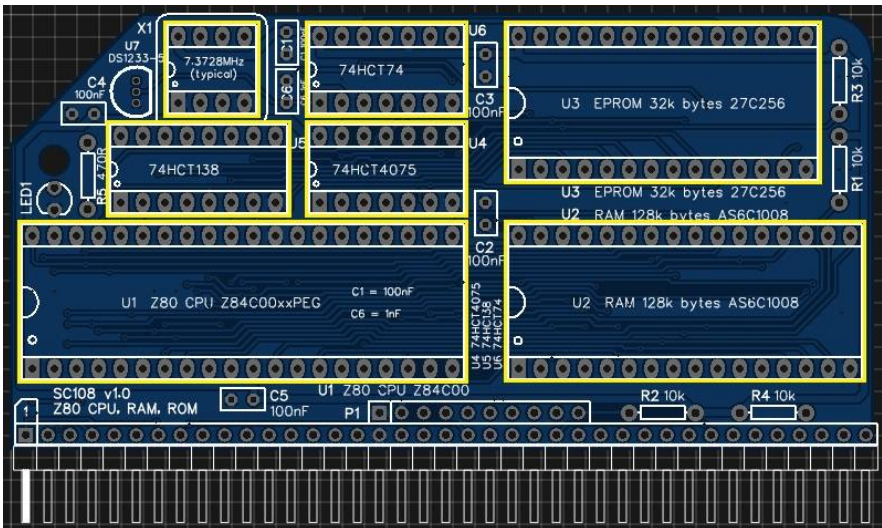
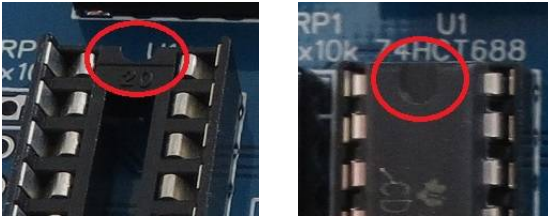
Before fitting the ICs, plug the board into an RC2014 backplane with no other boards fitted. Power the backplane and perform the following checks with a volt meter:

- Check the supply voltage on the Processor module, between, say, U5 pin 8 and U5 pin 16. This should be 4.75 to 5.25 volts.
- Check the four signals with pull-up resistors on connector P1 are being pulled up to at least 4.75 volts. Signals: /INT, /NMI, /WAIT and /BUSRQ.
- If you fitted the reset chip U7, check the voltage on the reset signal as U1 pin 26 is being pulled up to at least 4.0 volts.
- If you fitted the oscillator X1 and have oscilloscope or logic probe, check the clock signal at U1 pin 6.

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

Step 8

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 Processor module into the RC2014 backplane together with a normal working serial module. Power up and check the system is working as usual.

Configuring the Processor Module

There is nothing to configure on the Processor module, other than perhaps deciding which oscillator to plug in to socket X1, and then only if you fitted a socket. However, there may be things to do on other modules.

If you have fitted the on-board oscillator X1:

- You must ensure no other module is trying to output a clock signal to the RC2014 CLK pin (#21). In the case of the SC104 SIO/2 module, you must not fit a jumper shunt on both CLK and CLKX. Similarly for the SC103 CTC module.
- If using the RC2014 dual clock module, do not fit a jumper shunt on the Clock 1 jumper.
- If using the RC2014 SIO/2 module you may need to fit a jumper shunt on the Port B Clock jumper. This will be needed if you don't have a dual clock module with a jumper shunt fitted to the Clock 2 jumper, or supplying SIO/2 port B with a clock from any other source.

If you have fitted the on-board reset chip U7:

- Ensure your system does not have another active reset circuit. It can have multiple reset switches, such as those often included on backplanes, but another active circuit might cause problems.
- Ensure the power supply you are using provides between 4.75 and 5.25 volts as measured on one of the modules. With this reset chip fitted the system will not start if the voltage is too low. It will simply stay in reset and do nothing.

You should not have another RAM or ROM module in the system unless this Processor module has its RAM or ROM chip removed.

Purchasing the Printed Circuit Board

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

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 Z80 Processor" or "sccousins"

Select, from the list shown, the project "SC108 v1.0 Z80 Processor for RC2014"

The project's details should now be displayed.

From here you can select "Download Gerber" or "Order at JLCPCB". You also have the option to "Open in Editor" a private copy of the schematic or PCB.

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 is 1 legitimate warning that may be reported due to the position of the last hole on the RC2014 bus connector being too close to the edge of the board when using the standard RC2014 board outline. This warning can be safely ignored, but any others may be a cause for concern.

Fault Finding

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.

If you have the Small Computer Monitor ROM fitted and an RC2014 digital I/O module, with LEDs on output port address 0x00, the LEDs may give a clue. Check the Small Computer Monitor User Guide to find out what the LEDs indicate following reset and self test.

Plug the Processor module 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 Processor module, between, say, U5 pin 8 and U5 pin 16. This should be 4.75 to 5.25 volts.
- Check the four signals with pull-up resistors on connector P1 are being pulled up to at least 4.75 volts. Signals: /INT, /NMI, /WAIT and /BUSRQ.
- If you fitted the reset chip U7, check the voltage on the reset signal as U1 pin 26 is being pulled up to at least 4.0 volts.
- If you fitted the oscillator X1 and have oscilloscope or logic probe, check the clock signal at U1 pin 6.

If all looks good, then add a serial module to the system. With the Small Computer Monitor ROM fitted, at power up you should get a sign on message. After this there should be nearly constant activity on the serial interface IC's chip select pin.

If there is no activity at all check the supply voltage again and the reset signal.

History

2018-07-09	v1.0	First circuit boards
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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/?ref=offsite_badges&utm_source=sellers_Semachthemonkey&utm_medium=badges&utm_campaign=badge_medium

Credits

Thanks to all those who provided encouragement, feedback and contributed ideas to the design of my modules to date.