Z80 Motherboard For RC2014

Assembly Guide

For PCB: SC114 version 1.0

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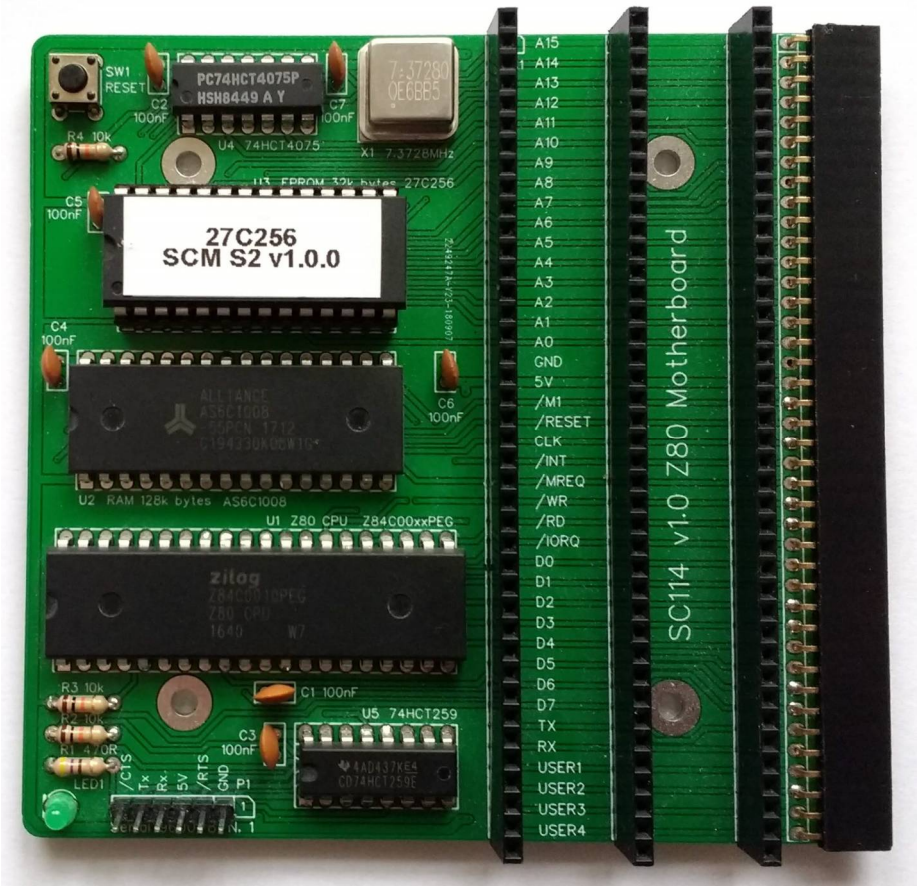
Edition 1.0.0

CONTENTS

Overview

The Z80 Motherboard is designed to be low cost and easy to assemble, with the ultimate aim of making it a more reliable build.



It has few components and thus less soldering, and can even be assembled without the expansion sockets to further reduce the amount of soldering. Jumper options have been avoided to reduce complexity and confusion.

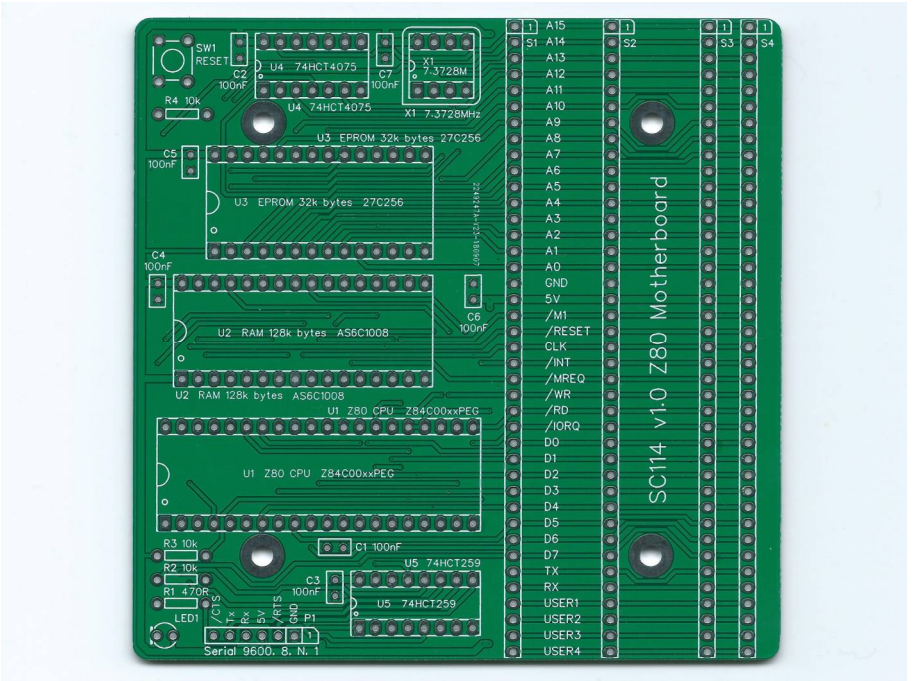
Here's the specs:

- Z80 running at 7.3728 MHz
- 128k bytes RAM (second 64k not easy to use, so best consider it to be 64k usable)
- 32k bytes ROM, which can be paged out with the usual write to port 0x38
- Simple bit-bang serial port to get you started
- Four RC2014 standard bus sockets
- Simple reset button (no power on reset or reset debounce)
- LED for power and status indication
- Runs the Small Computer Monitor, with ROM BASIC and the CP/M loader included

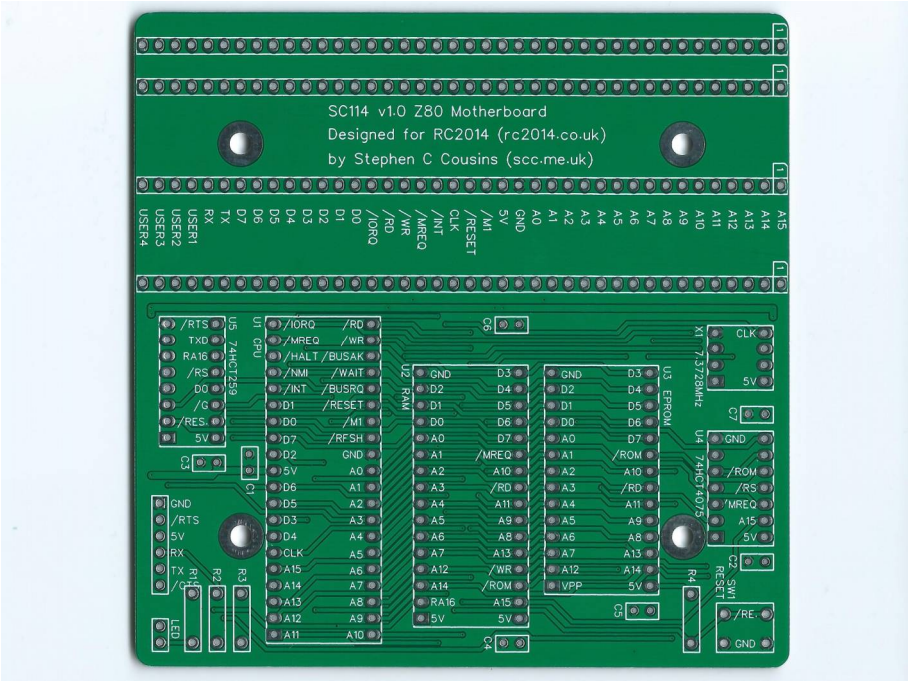
Printed Circuit Board

The circuit board measures 101.6mm by 101.6mm.

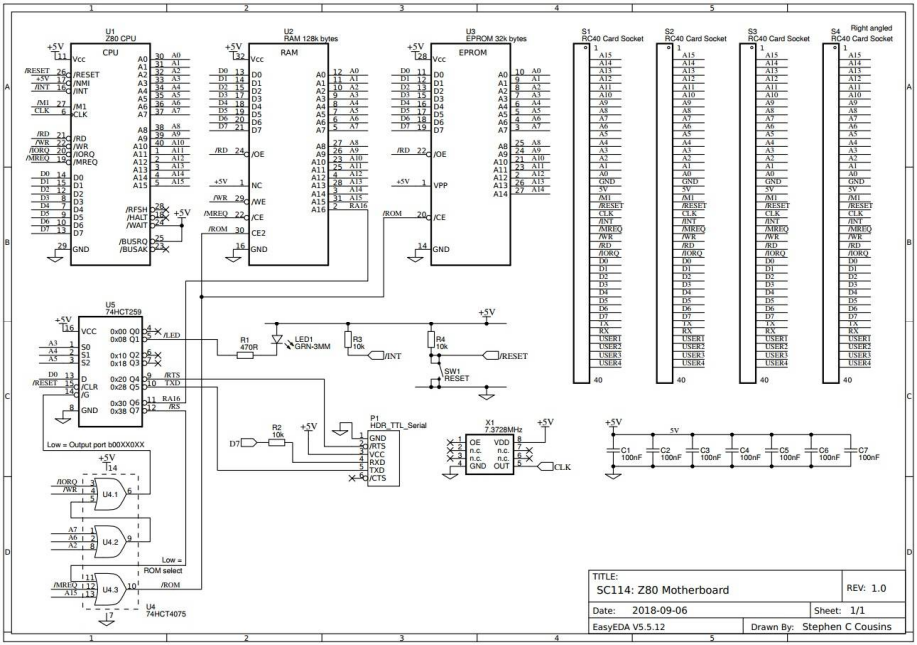
Printed circuit board, top/component side:



Printed circuit board, bottom/solder side:



Schematic



Errata

None yet.

What You Need

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 SC114
	7	C1 to C7	Capacitor 100nF, ceramic, lead spacing = 2.54mm
	3	S1 to S3	Pin header socket, female, 1 rows x 40 pins, straight, pitch 2.54mm
	1	S4	Pin header socket, female, 1 rows x 40 pins, angled, pitch 2.54mm
	1	P1	Pin header, male, 1 rows x 6 pins, straight
	1	R1	Resistor 470R, axial, 5%, carbon film, 0.25W
	3	R2 to R4	Resistor 10k, axial, 5%, carbon film, 0.25W
	1	SW1	Switch, tactile button
	1	LED1	LED, 3mm, green
	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	74HCT259, 8-bit addressable latch
	1	U5 socket	16 pin PDIP IC socket 0.3" wide
	1	X1	Oscillator module 7.3728MHz, 8 pin PDIP size

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 SC114
		Supplier	Part number
		EasyEDA	Search EasyEDA.com for SC114
		Tindie	Search Tindie for SC114

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

C1 to C7

Image	Qty	Reference	Description
	7	C1 to C7	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.

S1 to S3

Image	Qty	Reference	Description
	3	S1 to S3	Pin header socket, female, 1 rows x 40 pins, straight, pitch 2.54mm
		Supplier	Part number
		eBay	200906546562 or 232346774001
		Farnell	1667503 (very expensive)
		Mouser	200-BCS140LSTE (very expensive)
		RS	766-6593 (very expensive)

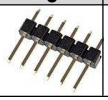
This set of connectors are standard 40 pin RC2014 bus module sockets, allowing a range of RC2014 compatible modules to be connected. These include simple digital input and outputs, as well as more sophisticated sound and video modules. The first module to add is probably going to be a serial port, as the one on the motherboard is very limited. The next might well be the Compact Flash module to allow CP/M to be run.

S4

Image	Qty	Reference	Description
	1	S4	Pin header socket, female, 1 rows x 40 pins, angled, pitch 2.54mm
		Supplier	Part number
		eBay	200906546562
		Farnell	Could not find exact match
		Mouser	Could not find exact match
		RS	Could not find exact match

This connector is similar to S1 to S3, but is mounted at right angles. This allows an RC2014 module to be connected horizontally which is sometimes very useful. It also provides a means of adding a modular backplane board, such as SC113, to further extend the system.

P1

Image	Qty	Reference	Description
	1	P1	Pin header, male, 1 rows x 6 pins, straight
		Supplier	Part number
		eBay	200906546562 (1x40 pin to be cut to length)
		Farnell	2356175 (1x40 pin to be cut to length)
		Mouser	855-M20-9774046 (1x40 pin to be cut to length)
		RS	156-049 (1x40 pin to be cut to length)

This header provides access to the built in 5 volt (or TTL) serial interface. The pin-out is compatible with the official RC2014 serial port and also many third party serial devices. These includes FTDI style USB to serial adapters, which are used to connect the Z80 system to a modern computer running terminal emulation software.

This port is very basic, providing only a software generated 9600 baud, 8 data bit, 1 stop bit, no parity serial interface. It is designed to provide a very low cost 'starter' port to get the system up and running as easily and cheaply as possible. It is suitable for simple applications, but a more capable serial module should be added for sophisticated applications such as running CP/M.

R1

Image	Qty	Reference	Description
	1	R1	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.

R2 to R4

Image	Qty	Reference	Description
	3	R2 to R4	Resistor 10k, axial, 5%, carbon film, 0.25W
		Supplier	Part number
		Farnell	9339060
		Mouser	603-CFR-25JR-5210K
		RS	707-7745

These resistors provide pull-up and current limiting functions.

- R2 limits the current from the serial port receive pin, allowing it to pull the Z80 data bus signal D7 up or down when no other devices is active on the bus.
- R3 pulls up the Z80 interrupt input (/INT). When a device needs to interrupt the Z80 processor it pulls this line low.
- R4 pulls up the Z80 reset input (/RESET). The reset line is pulled low to reset the system.

SW1

Image	Qty	Reference	Description
	1	SW1	Switch, tactile button
		Supplier	Part number
		Farnell	2468761 (red button)
		Mouser	506-FSM4JH (red button)
		RS	479-1413 (black button)

This is the reset switch, which pulls down the backplane's reset signal (/RESET) and thus resets the system.

This simple motherboard does not have a power on reset, so it will usually be necessary to press this button after the system is turned on.

LED1

Image	Qty	Reference	Description
	1	LED1	LED, 3mm, green
		Supplier	Part number
		Farnell	1581114
		Mouser	859-LTL-4231N
		RS	180-8502

This LED is a simple status indicator. It is normally on when the power is connected, but it can be controlled by software if required.

At reset is will turn on, even if the processor is not running. It will then turn off and on again, indicating the processor is running.

If a suitable serial port module is not found in any of the RC2014 sockets, the LED will turn off and on again to indicate the built in serial port is being used.

A log-on message is then sent to the terminal via the serial port indicated.

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.

The CPU is the brains of the board. It is able to execute instructions stored in the read only memory (ROM) chip U3 or programs downloaded or written to the random access memory (RAM) chip U2.

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 device specified above 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 motherboard has been designed to have the Small Computer Monitor installed in the ROM chip, although any compatible code can be used instead. Currently the recommended version of the Small Computer Monitor for this board is v1.0 configuration S2. This is available as both source code and HEX file from www.scc.me.uk as part of the Small Computer Workshop download. The hex file is in the folder: SCWorkshop\SCMonitor\Builds

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.

The integrated circuit contains three 3-input OR gates. Two of them are combined to partially decode the output port addresses used by the motherboard. The third decodes an active low ROM select signal.

The partially decoded output port address is 00XXX0XX, expressed in binary with 'X' indicating a bit which can be in either state. This signal is further refined by integrated circuit U5.

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	74HCT259, 8-bit addressable latch
		Supplier	Part number
		Farnell	1214402
		Mouser	595-CD74HCT259E
		RS	121-9247

This integrated circuit is an 8-bit addressable latch. It has eight outputs which can be individually turned on and off.

The partially decoded port address signal from U4 is used to enable latching of data to this chip. The required output is determined by the address lines A3, A4 and A5, and the signal latched to that output is determined by data line D0.

The output port addresses, expressed in binary, are thus:

Bits: 7654 3210

00XX X0XX	Partially decoded address enabled U5	
0000 00XX	0x00 to 0x03	Not used
0000 10XX	0x08 to 0x0B	Status LED (low = on)
0001 00XX	0x10 to 0x13	Not used
0001 10XX	0x18 to 0x1B	Not used
0010 00XX	0x20 to 0x23	Serial port, request to send (RTS)
0010 10XX	0x28 to 0x2B	Serial port, transmit data (TXD)
0011 00XX	0x30 to 0x33	RAM bottom 64k selected (active low)
0011 10XX	0x38 to 0x3B	ROM selected (active low)

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

X1

Image	Qty	Reference	Description
	1	X1	Oscillator module 7.3728MHz, 8 pin PDIP size
		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 provides the main processor bus clock.

A socket is not recommended for this device, but you can fit one if you wish.

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 from a longer strip.

Before assembling it is worth visually inspecting the circuit board for anything that looks out of place, such as mechanical damage or apparent manufacturing defects.

If you have a multimeter that measures resistance or has a continuity test function, check there is not a short on the power supply tracks. Connect the probes to each terminal of one of the capacitors, such as C1. This should be an open circuit, not a short.

Step 1

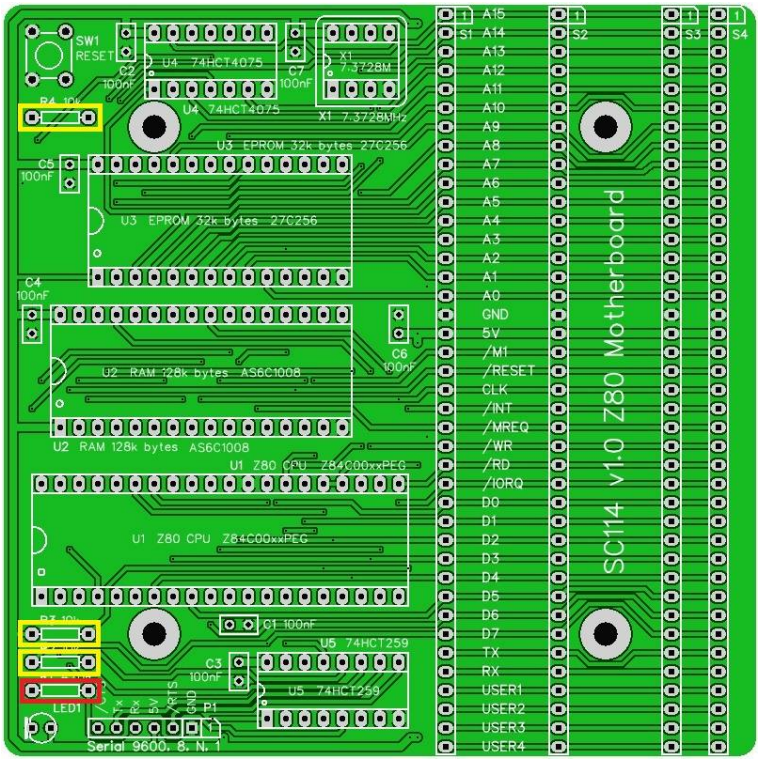
Fit and solder the 470R resistor R1 (shown in RED below).

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

Fit and solder the three 10k resistors R2 to R4 (shown in yellow below).

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

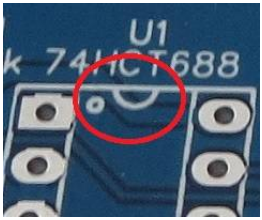
Resistors can be fitted either way round, as they are not polarity dependent.



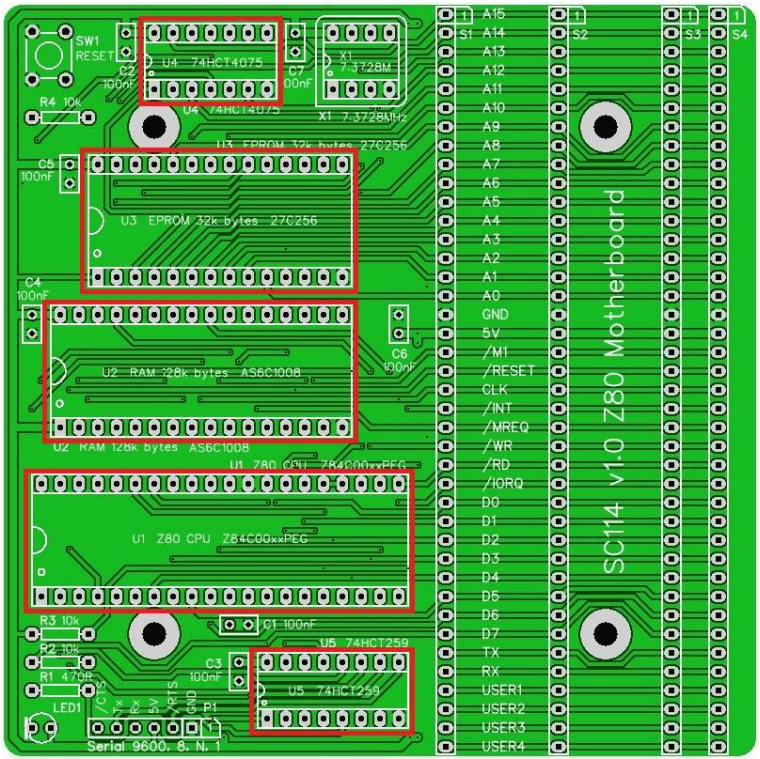
Step 2

Fit and solder IC sockets for U1 and U5.

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.



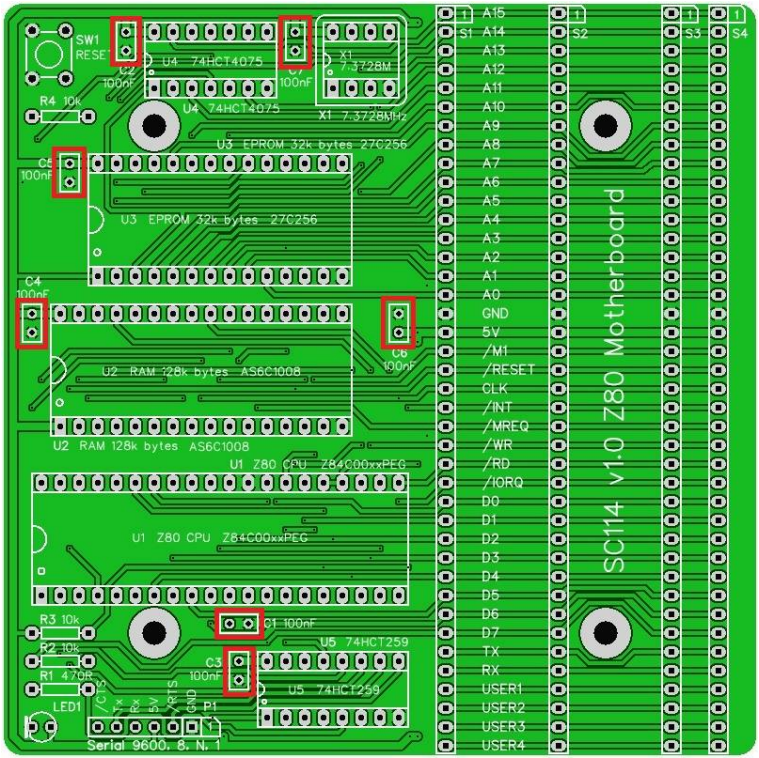
The sockets should be fitted in the positions shown below.



Step 3

Fit and solder capacitors C1 to C7.

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

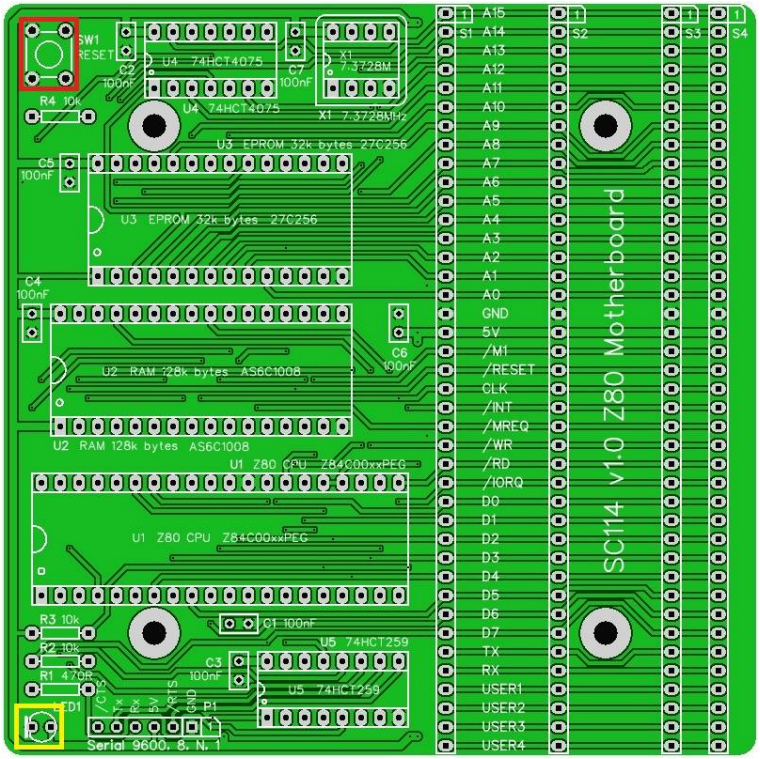


Step 4

Fit and solder the push button switch SW1 (shown in red below).

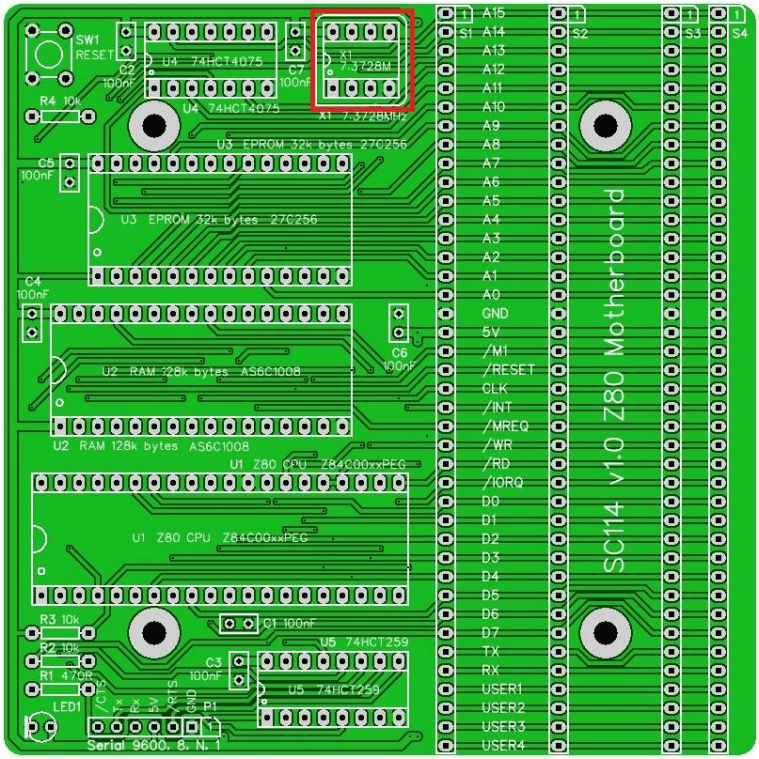
Fit and solder the LED (shown in yellow below).

It is important to fit the LED 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 5

Fit and solder the oscillator X1.

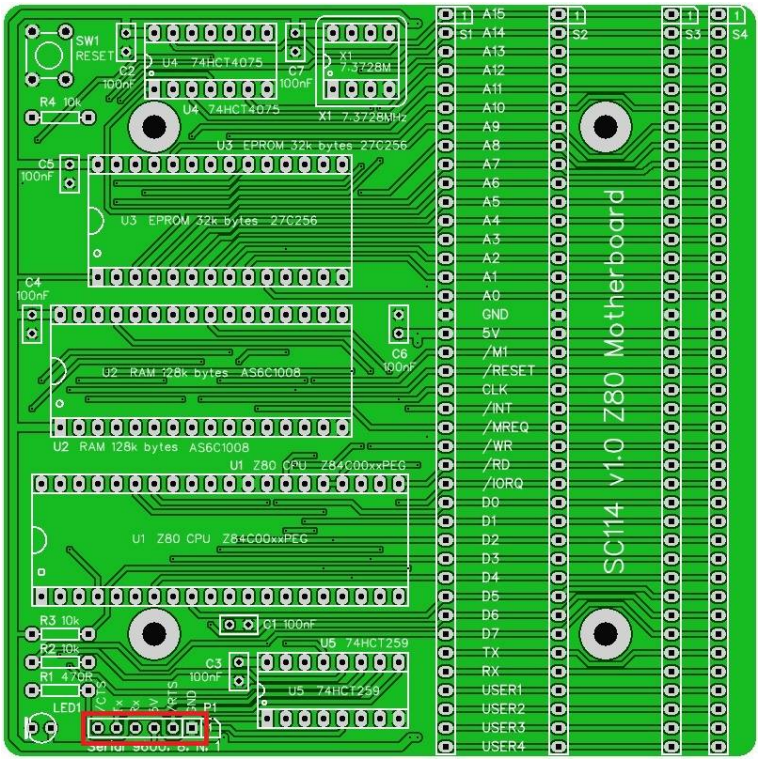


Step 6

Fit and solder connector P1.

This may need to be cut down from a longer strip.

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

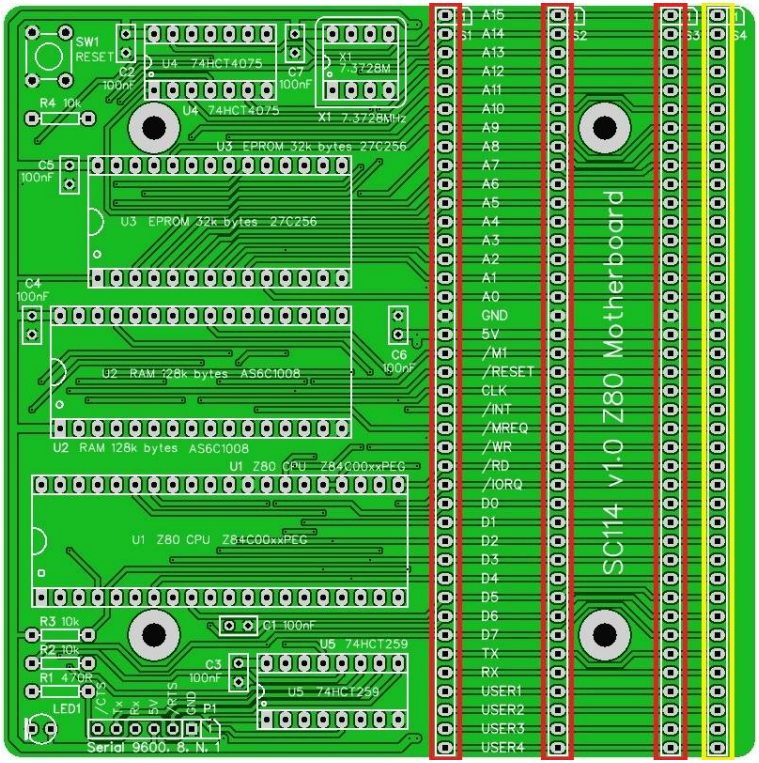


Step 7

This step is not required for the motherboard to operate as a single board computer. You may wish to skip this step for now.

Fit and solder connector S1 to S3 (shown in red below).

Fit and solder connector S4 (shown in yellow below).



Step 8

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

Visually inspect the soldering for dry joints and shorts.

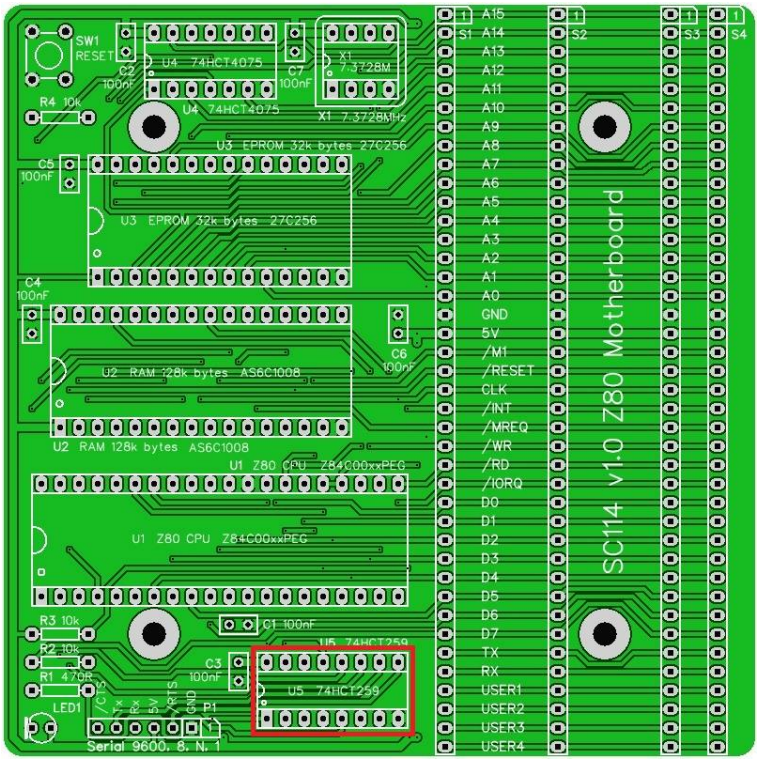
Clean the flux off with suitable cleaning materials.

Visually inspect again.

With a suitable FTDI style TTL level serial to USB adapter connected from P1 to a powered USB socket, check the supply voltage on this circuit board between U4 pin 7 and U4 pin 14. This should be 4.5 to 5.5 volts, preferably 4.75 to 5.25 volts.

Step 9

Insert the IC U5 (74HCT259) into its socket, taking care to insert it the right way round, as illustrated below. Be careful not to bend any legs over.



Step 10

With a suitable FTDI style TTL level serial to USB adapter connected from P1 to a powered USB socket, check the LED lights. If not then follow these steps.

- Check the supply voltage between U5 pin 8 and U5 pin 16. This should be 4.5 to 5.5 volts, preferably 4.75 to 5.25 volts.

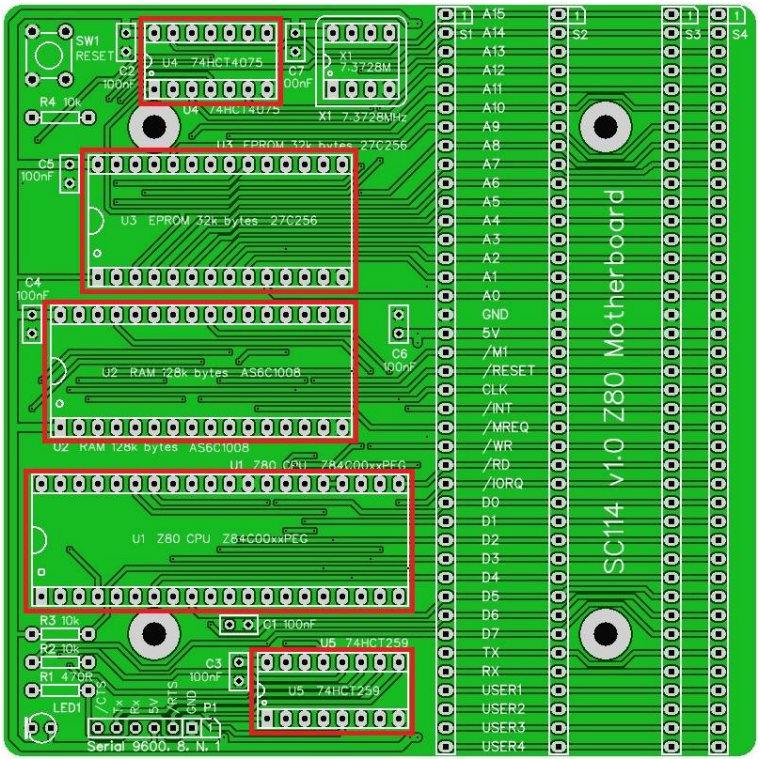
- Check the LED is the correct way round.

- Check the RESET signal is high, but goes low when the reset button is pressed. The LED should light when U5 is powered and working, and the RESET signal on U5 pin 15 is low. With the other ICs not fitted the LED may not stay on after the RESET signal goes high.

Do not continue assembly until the LED is working.

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.



Quick Start Guide

Below is a very brief guide to getting started with the Z80 motherboard (SC114). For further details so the SC114 User Guide.

It is assumed the Z80 motherboard is fully assembled, but no modules are fitted in the RC2014 bus sockets. The ROM should contain the Small Computer Monitor v1.0 configuration S2 (available from www.scc.me.uk).

Connect a suitable FTDI style TTL level serial to USB adapter from P1 to a powered USB socket on a PC (or similar). Press the reset button and check the LED lights. It should flash off and on again either once or twice as previously described.

Start a suitable terminal emulation program, such as Tera Term, on the PC. Configure the PC's serial port for 9600 baud, 8 data bits, 1 stop bit, no parity and hardware flow control (RTS/CTS).

Press the reset button on the Z80 motherboard. You should see the terminal program display something like "Small Computer Monitor - SC114".

You are now ready to play!

Purchasing the Printed Circuit Board

Currently the circuit board is available from Tindie and 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 “SC114” or “sccousins”

Select, from the list shown, the project “SC114 v1.0 Z80 Motherboard 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	101.6 x 101.6 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.

Fault Finding

Check there are no chips with 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 a suitable FTDI style TTL level serial to USB adapter connected from P1 to a powered USB socket, check the supply voltage on this circuit board between, say, U4 pin 7 and U4 pin 14. This should be 4.5 to 5.5 volts, preferably 4.75 to 5.25 volts.

Check the LED is on. If it is not then check the LED is the correct way round. Also check the RESET signal is high, but goes low when the reset button is pressed. The LED should light when U5 is powered and working, and the RESET signal on U5 pin 15 is low.

If the LED is working, check it flashes off then on again, either once or twice after a reset. If it flashes then the motherboard is running code successfully. This would indicate that all the main components are generally working. If the LED flashes off once after reset the system has detected a serial module plugged into one of the RC2014 sockets. If it flashes off twice it has not detected a serial module and is using the on-board serial port (P1). If it keeps flashing the self test has failed, most likely indicating the RAM is not working.

History

2018-10-15	v1.0	First circuit boards
2018-12-31	v1.0	This Assembly Guide (e1.0.0) released

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

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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/