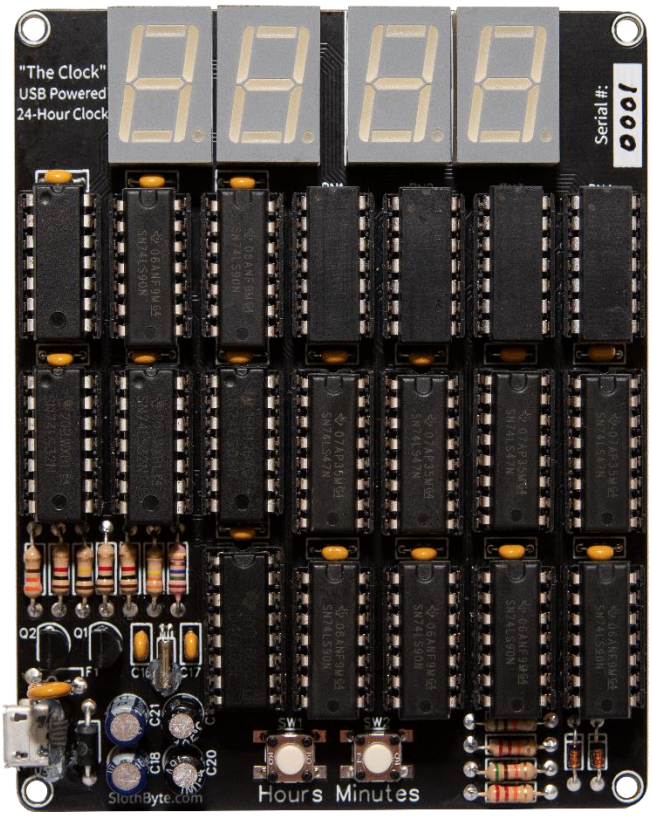
Sloth Byte Limited

“The Clock” Kit



Assembly & User Manual

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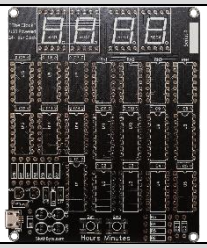
Disclaimer: This kit contains small parts which present a choking hazard to small children. Please keep this kit out of reach of small children. Children old enough to assemble the kit should be supervised, during assembly and during use of the completed kit. This is an educational hobby kit; it is not for use in life-critical systems or where failure could lead to the risk of injury or death. The technical data contained herein has been provided solely for informational purposes and is not legally binding. This manual is subject to change, technical or otherwise.

Attention: This kit is designed to work with a USB power supply (5Vdc 500mA).

Kit Contents

Before you begin, take some time to check that you have received all the components. If you ordered the PCB only and not the kit, the following list can be used as a shopping guide. The pictures are meant as a guide as the actual component design may differ slightly, for example in size or colour.

We have tried our best to ensure that your kit has everything included, if however, something is missing, please contact us at info@slothbyte.com.

Picture	Value	Reference number	Description	QTY
	PCB	-	Circuit Board **Note:** The micro-USB connector is pre-soldered to the PCB	1
	1N5919BRLG	D1	Zener diode (5.6V, 3W)	1
	1N4148	D2, D3	Small signal diode	2
	330 Ω	R10	Resistor Orange-Orange-Brown	1
	1 kΩ	R8, R9, R11	Resistor Brown-Black-Red	3
	22 kΩ	R4, R6	Resistor Red-Red-Orange	2
	51 kΩ	R3, R5	Resistor Green-Brown-Orange	2
	100 kΩ	R7	Resistor Brown-Black-Yellow	1
	330 kΩ	R1	Resistor Orange-Orange-Yellow	1
	15 MΩ	R2	Resistor Brown-Green-Blue-Gold-Yellow	1
	0.1µF	C1-C15	Capacitor	15
	33 pF	C16, C17	Capacitor	2
	1 µF	C19, C20	Capacitor	2
	100 µF	C18, C21	Electrolytic Capacitor	2
	32.768 kHz	X1	Crystal	1
	2N3904	Q1, Q2,	Transistor – NPN	2
	MF-R030	F1	Resettable Fuse 600mA	1
	-	SW1, SW2	Tactile Push Button	2

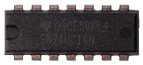
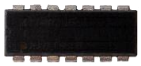
	-	Seg1 – 4	Seven Segment Display	4
	CD4060BE	U1	14-stage binary ripple counter with oscillator	1
	SN74LS90N	U2,3,4,5,6,7	Decade counter	6
	SN74LS47N	U8,9,10,11	BCD to seven segment display decoder	4
	SN74LS32N	U12,13	OR gates	2
	SN74LS08N	U14	AND gates	1
	SN74HC14N	U15	NOT gates (Schmitt-Trigger)	1
	4114R-1-331LF	RN1-4	DIP14 330Ω Resistor network	4

Figure 1 - Parts List

Introduction

For millennia people have used devices to measure the passing of time. These devices include but are not limited to; water clocks, hour glasses, sun dials, mechanical clocks, quartz crystal oscillator mechanical and digital clocks, atomic clocks, radio controlled clocks and more recently, internet connected clocks that are automatically set to the correct time using SNTP or NTP (Simple Network Time Protocol or Network Time Protocol).

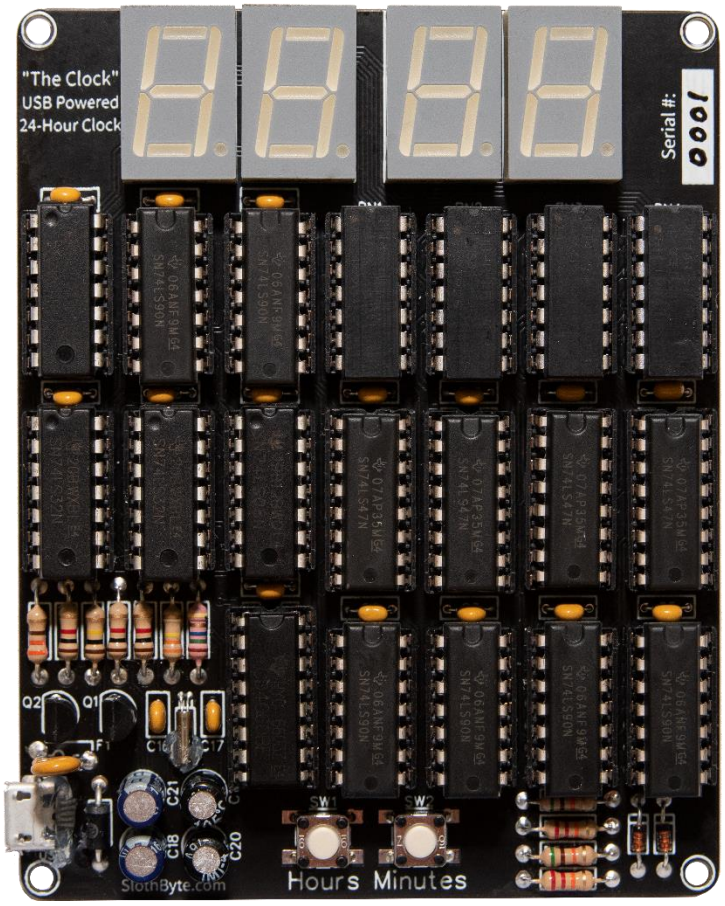


Figure 2 - Completed "The Clock" Kit

"The Clock" kit is a USB powered, quartz crystal oscillator 24-hour digital clock. It is designed around "old school" chips without the need for a microcontroller or CPU. As you progress through this manual and the build the kit, we will cover how the clock keeps track of time.

Components Overview

Resistors

As their name suggests, resistors resist the flow of electrical current. They have two legs and can be inserted into the circuit board in either direction. However, for aesthetics, they do look better when all inserted the same way around, i.e. tolerance band to the right.

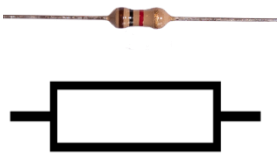
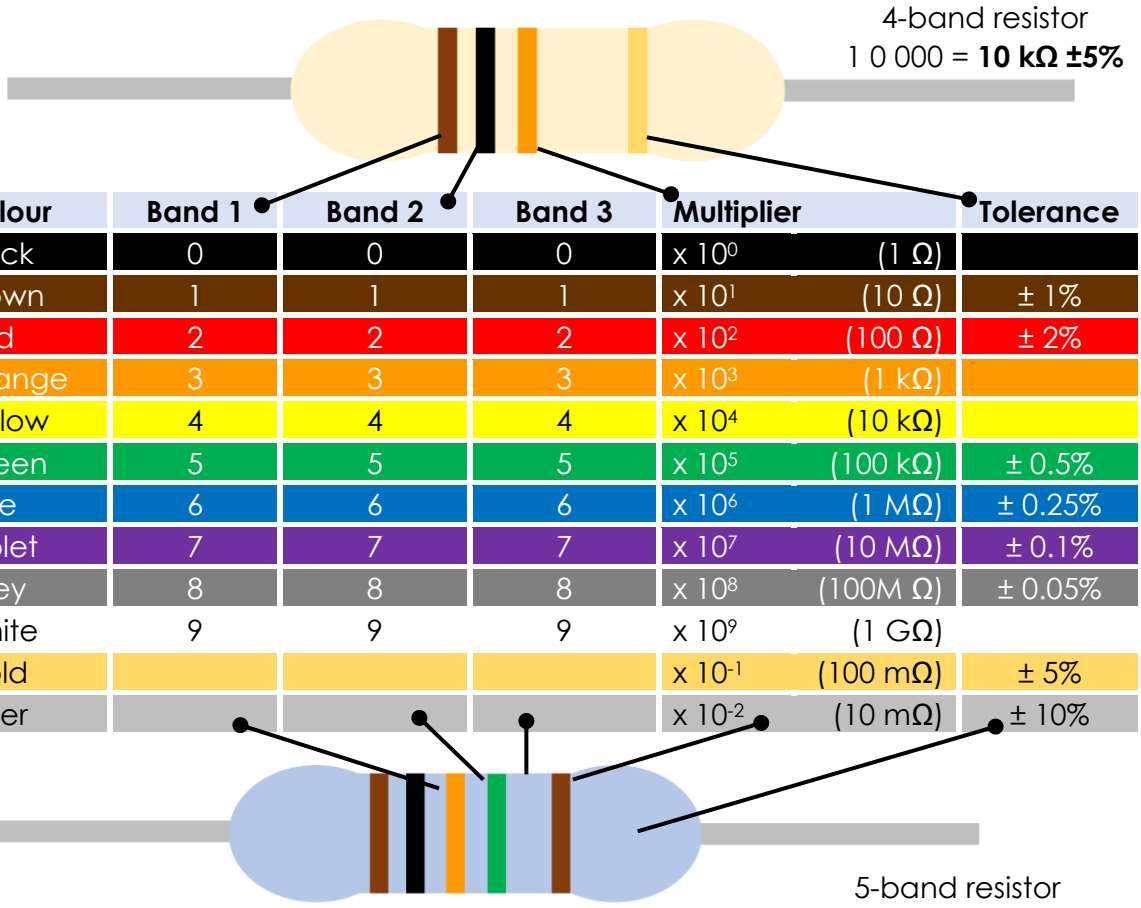


Figure 3 - Resistor and Symbol

The amount of resistance offered by the resistor is expressed in the unit ohms. The symbol used for ohms is the uppercase Greek letter Omega (Ω).

Resistors have their value printed on them using a colour code. The table below shows how to read 4-band and 5-band resistors.



Colour	Band 1	Band 2	Band 3	Multiplier		Tolerance
Black	0	0	0	x 10^0	(1 Ω)	
Brown	1	1	1	x 10^1	(10 Ω)	± 1%
Red	2	2	2	x 10^2	(100 Ω)	± 2%
Orange	3	3	3	x 10^3	(1 kΩ)	
Yellow	4	4	4	x 10^4	(10 kΩ)	
Green	5	5	5	x 10^5	(100 kΩ)	± 0.5%
Blue	6	6	6	x 10^6	(1 MΩ)	± 0.25%
Violet	7	7	7	x 10^7	(10 MΩ)	± 0.1%
Grey	8	8	8	x 10^8	(100M Ω)	± 0.05%
White	9	9	9	x 10^9	(1 GΩ)	
Gold				x 10^{-1}	(100 mΩ)	± 5%
Silver				x 10^{-2}	(10 mΩ)	± 10%

Figure 4 - Resistor Colour Code

The first resistor in the example is a 4-band resistor; it has four coloured bands representing its value. The tolerance band is spaced further away from the other bands and is always placed on the right-hand side when reading the value of the resistor.

Let's look at the value; the bands are brown, black, orange and gold. From the chart, we can see that these are equal to 1, 0, x 10^3 and ±5% respectively. This gives a value of 10000 Ω with a tolerance of ±5%, although you usually see such a large number formatted as 10 kΩ, where k is short for kilo (1000).

With a tolerance of ±5% we'd expect this resistor to measure anywhere in the region of 9.5 kΩ to 10.5 kΩ.

As a final note on resistors, when I was at college, my lecturer taught the class a way to remember the colour code with the phrase "*Betty Brown Runs Over Your Garden But Violet Grey Walks*".

Resistor Network

The resistor networks used in this kit look like chips. They are packaged in DIP14 (Dual Inline Package with 14 legs), and each device contains seven 330 Ω resistors. Instead of colour codes, resistor networks have the value printed on them. If you look closely at one of the resistor networks, you'll see the value "331".

So why does 331 mean 330 Ω? The numerical digits refer to the values in the resistor colour code chart, so if this were a three-band resistor, then we would have 3, 3, and the multiplier would be $x10^1$. This becomes 33 $x10^1$ which is 330 Ω.



Figure 5 - Resistor Network

Resistor networks must be inserted the correct way around, they have a small notch on them that matches the image on the PCB.

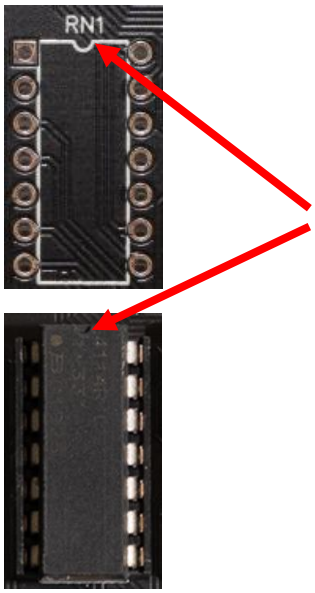


Figure 6 - Resistor Network Orientation

The symbol for a resistor network seems to vary depending on the CAD package used. The symbol used in this kit is shown below. Looking at the symbol, you can see how each of the seven resistors are connected between opposite pins on the DIP.

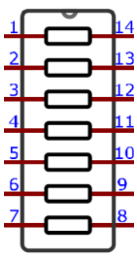


Figure 7 - Resistor Network Symbol (DIP14)

Diodes

Diodes only allow current to flow in one direction, so must be fitted to the circuit board the correct way around. They have two legs; one is called the Anode (+), and the other is the Cathode (-). In the symbols below, the Anode is the left side, and the Cathode is the right side.

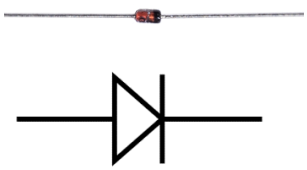


Figure 8 - Diode and Symbol

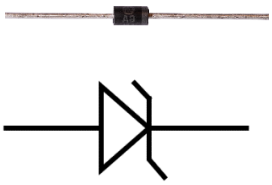


Figure 9- Zener Diode and Symbol

Regular diodes (symbol on the left), have a line printed on their Cathode side which corresponds to the line in the symbol (vertical line to the right of the triangle). There is also a line printed on the circuit board to help orientate the diode the correct way around when installing it.

A Zener diode can be used in reverse bias to stabilise the supply voltage. This kit uses a 5.6 volt Zener diode to protect the clock should the USB power supply give too much voltage.

Tip: Diodes must be inserted the correct way around and this is indicated on the circuit board by a line. The line on the diode must match the line on the circuit board.

Capacitors

Capacitors store energy in an electric field. A capacitor has two connections, and depending on its type may need to be installed the correct way around.

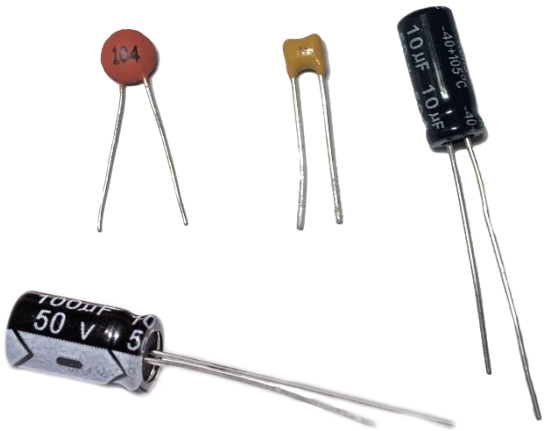


Figure 10 - Selection of Capacitors

The symbol below on the left is for a capacitor; these can be installed in any direction. However, the symbol on the right is for an electrolytic capacitor; these must be installed the correct way around to avoid destruction and the release of magic smoke. Electrolytic capacitors usually have the negative leg clearly marked.



Figure 11 - Left: Capacitor Symbol Right: Electrolytic Capacitor Symbol

Capacitors are made of two conductors separated by a dielectric (non-conductive material). If you look at the symbol for a capacitor, you can see this notion is graphically represented by two parallel lines separated by a gap.

Capacitance is measured using the unit farad (F). 1F is actually a pretty large value; you'll most likely come across values in the pF (x 10^{-12}), nF (x 10^{-9}) and µF (x 10^{-6}) range. For example, 100 µF expressed as farads is 0.0001 F.

Tip: Electrolytic capacitors must be inserted the correct way around; their negative leg is usually marked with a stripe containing the minus symbol (-) down one side of the capacitor as per the image at the top of the page.

Transistors

Transistors are small electronic switches that have three connections; Base Emitter and Collector (B, E and C respectively). Transistors must be installed the correct way around; incorrect orientation can cause them to fail. The correct orientation is marked on the circuit board of this kit, the shape printed on the board matches that of the component. This kit uses only NPN transistors.

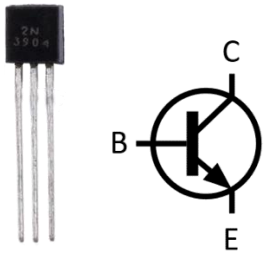


Figure 12 -NPN Transistor and Symbol

When the base-emitter voltage of an NPN transistor is around +0.7V (voltage at the base is 0.7 volts higher than at the emitter), current flow from the collector to the emitter is switched on; hence they act like tiny electronic switches.

Tip: Transistors must be inserted the correct way around. The two types of transistor in this kit look the same, always check the number printed on the front of them.

Tactile Switch (Push Button)

A small momentary open-going-closed switch. When pressed the switch's state is changed to on. The switch will momentarily remain in this state until the push button is released. The switch will only physically fit into the PCB one of two ways round, either way is ok.

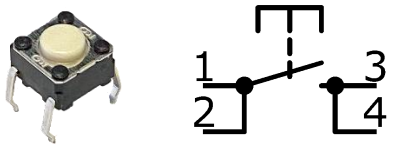


Figure 13 - Tactile Switch and Symbol

Seven-Segment Display

A seven-segment display consists of seven separate LED "segments" and an LED decimal point. LED is short for Light Emitting Diode; these are diodes that emits light when current flows through them.

LEDs typically require a low voltage (around 1.8 V), a resistor is used in series with them to drop the supply voltage to a suitable level. The seven-segment display used in this kit has a common anode (+ volts side) and each LED segment requires its own current limiting resistor which this kit achieves with resistor networks.

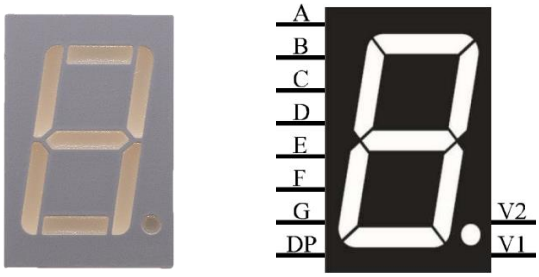


Figure 14 - Seven-Segment Display and Symbol

Tip: The seven-segment display must be inserted the correct way around, use the image on the PCB as a guide. Note that the decimal point is positioned on the lower right corner.

Quartz Crystal

Quartz crystals are used to provide a stable clock frequency, it's worth noting that temperature can affect the stability of the frequency. The crystal used in this kit has a frequency of 32.768 kHz (32,768 pulses per second) which is divided down using a binary counter until it reaches 1 Hz.

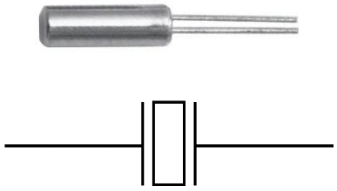


Figure 15 – Quartz Crystal and Symbol

Tip: The quartz crystal can be inserted either way around. It is one of the most challenging components in this kit to solder as the PCB pads are so small and close together. After soldering it in place, check that there is no short between the pads, if there is, heat the joints and use a solder sucker or solder wick to remove the excess solder.

Integrated Circuits

Several integrated circuits (ICs) or chips as they are often referred to are used in this kit. Chips contain a collection of components; transistors, resistors, capacitors etc. on a wafer of silicon. Chips come in all sorts of sizes with all sorts of functions. Early chips contained only a handful of components; however modern computer CPUs contain billions of transistors.

Chips must be inserted the correct way; The chips used in this kit are all DIP (Dual Inline Package – they have two rows on pins) and have a small notch at one end that aligns with the image on the PCB.

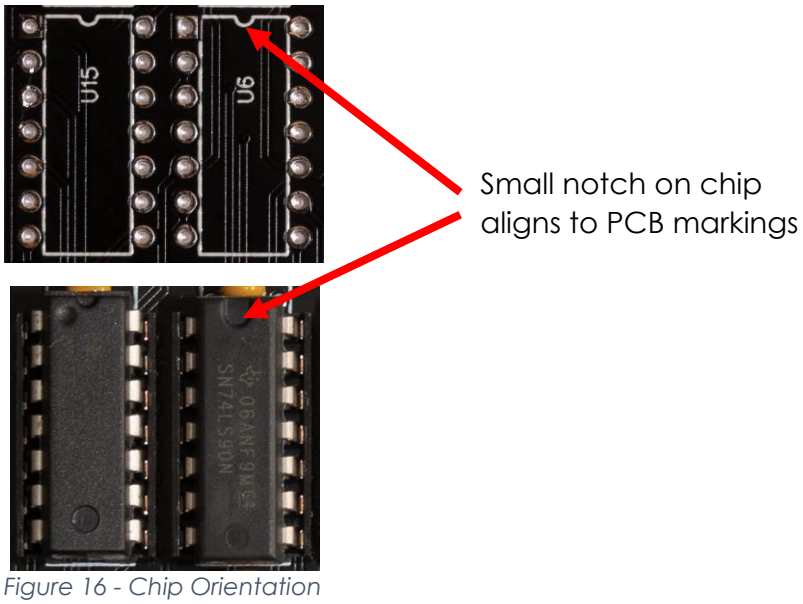


Figure 16 - Chip Orientation

Ther are six different types of chips used in this kit. Although they look the same each type of chip does a different task and must be inserted in the correct location.

Chips have their part number written on them, depending on the manufacturer and exact specification of a chip, the part number may vary slightly. Don't be supprised if you you see different letters or no letters on the chips in this kit. For example, SN74LS08N may just be written as 7408 on some chips or have different letters.

Chip part number	IC Reference number	Function
CD4060BE	U1	14-stage binary ripple counter with oscillator
SN74LS90N	U2,3,4,5,6,7	Decade counter
SN74LS47N	U8,9,10,11	BCD to seven segment display decoder
SN74LS32N	U12,13	OR gates
SN74LS08N	U14	AND gates
SN74HC14N	U15	NOT gates (Schmitt-Trigger)

Figure 17 - Chips included with this kit

If your kit contains the optional chip holders, these should be soldered into place before inserting the chips and resistor networks. There are two chip holder sizes used, DIP14 and DIP16. The number refers to the number of pins that the chip holder has.

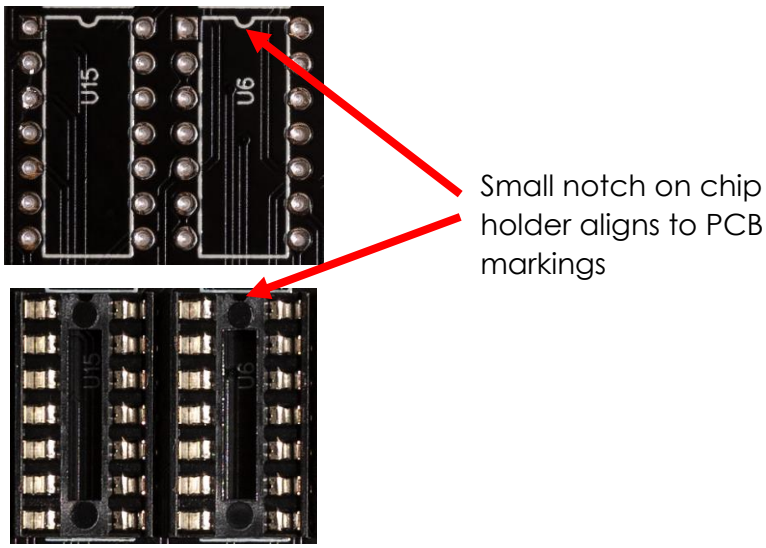


Figure 18 - Chip Holder Orientation

Fuse

A fuse protects a circuit from too much current. The fuse used in this kit is a resettable fuse that resets once it has cooled down enough. The fuse is not polarity conscious and can be inserted either way around.

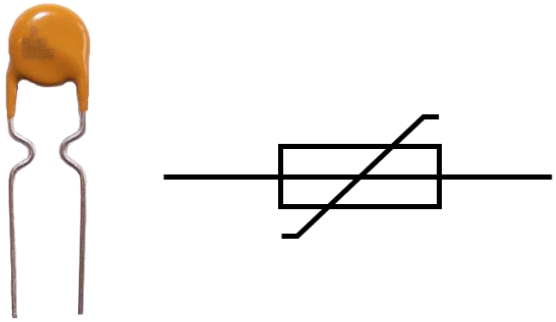


Figure 19 - Fuse and Symbol

Attention! If there is a short on the PCB and the circuit tries to draw too much current, the fuse will become hot!

Tools



Required Tools

You will need some basic tools to complete this kit.

- Soldering Iron & solder
- Small wire cutters
- Multimeter

Optional tools

- Small needle-nose pliers
- Magnifying glass for checking solder joints if fault-finding
- Solder sucker/wick
- Soldering matt to protect your desk

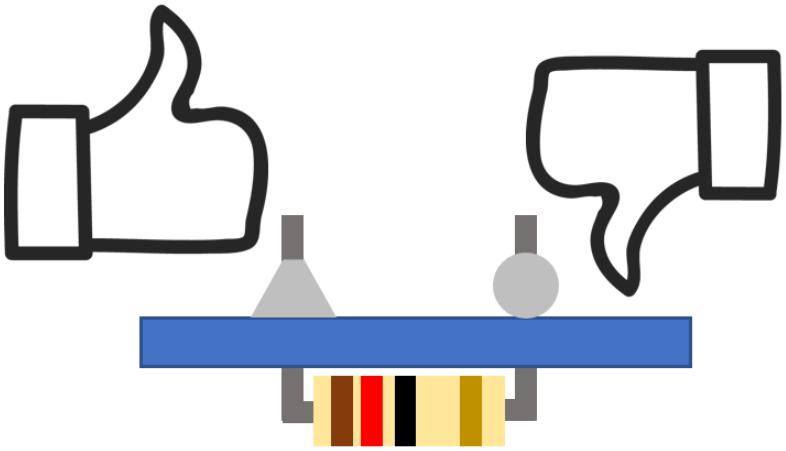
Soldering

As with all things, the more you practice, the better your soldering will become.

The order to construct this kit is covered in the next section, but before you read that, here is a little overview of soldering.

When the soldering iron is hot, start by applying a small amount of solder to the tip. Then hold the tip of the iron to the leg and pad of the joint to be soldered, heat them both up. Finally, apply some solder to the joint. Remove the iron, and that's your first joint done.

The image below shows what a good joint should look like, along with a bad joint.



Tip: Different types of solder have different melting temperatures, and some are easier to work with. The wattage of your soldering iron and size of tip affect the ease of soldering.

Important: Ensure that you solder in a well-ventilated area and avoid breathing the fumes. Always wash your hands after handling solder.

Assembly

Micro USB Connector

The micro USB connector has been pre-soldered to the PCB, so there you can move on to the next step.

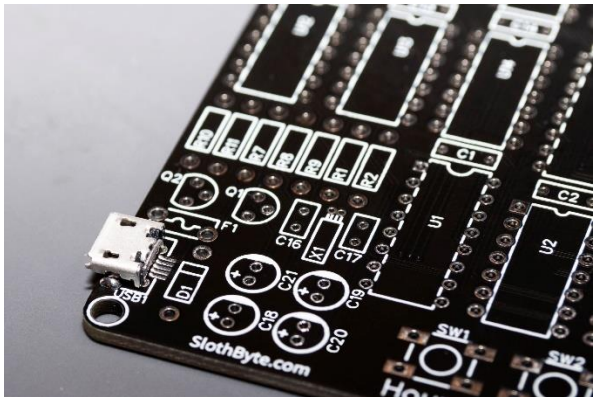


Figure 20 - Pre-soldered Micro USB Connector

Diodes

There are three diodes to solder. D1 is a Zener diode and must not be mixed up with D2 and D3. The Zener diode is used as a voltage stabiliser, meaning that if the incoming USB voltage raises too high, the Zener diode will clamp it down to a maximum of 5.6 volts to protect the circuit.

When inserting the diodes, pay attention to the line printed on the diode, it must match the position of the line printed on the circuit board.

When bending the legs of D2 and D3, take care not to bend it too close to the glass tube as this may cause the glass to break.

After soldering each diode into place, check that they are seated correctly and then cut the excess legs off. If not seated correctly, heat the joint and reposition the diode.

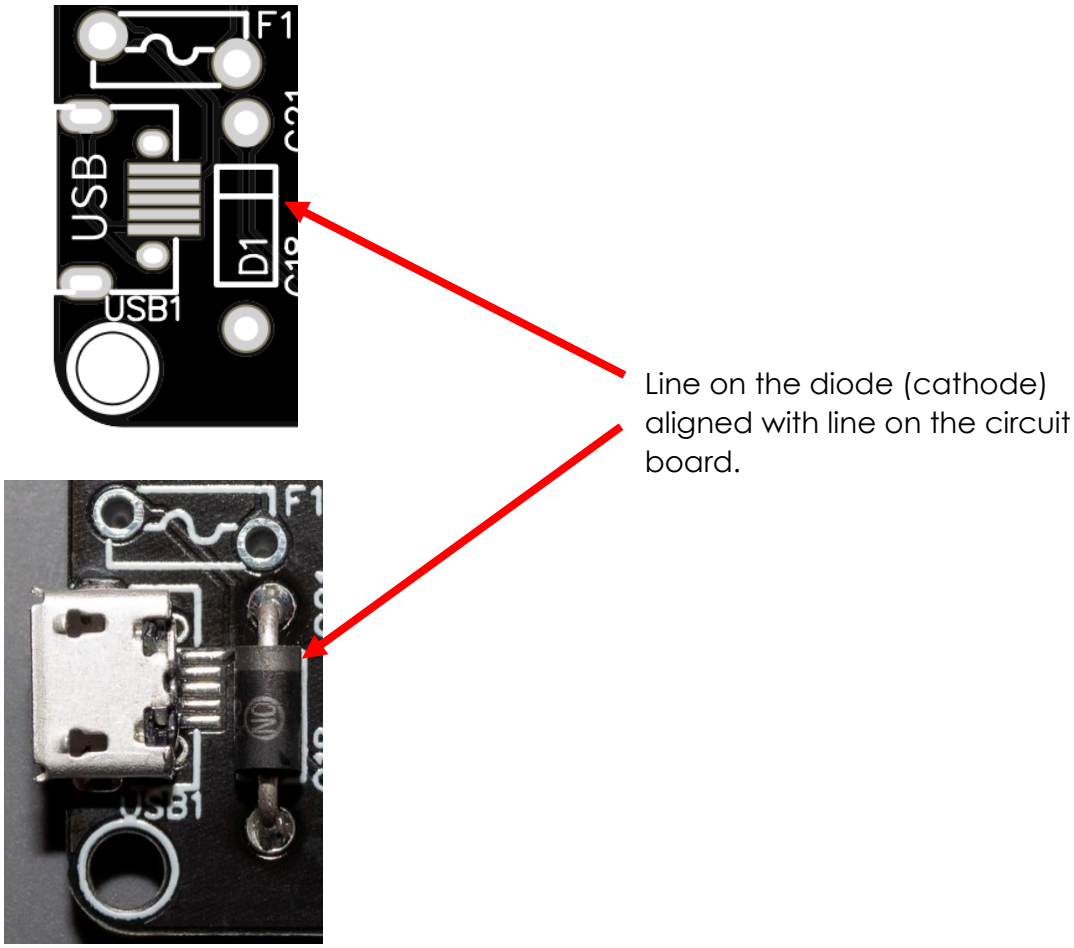


Figure 21 - Diode Orientation

Resistors

There are seven different resistor values used in this kit. It is essential that the correct value is inserted into the correct position or the kit will not work as intended. The resistors were labelled when the kit was packed. If however, they have since been mixed up, the easiest way to identify them is by checking their colour code against the table below. You could also use a multimeter set to the ohms range to identify them. Or if you want to practice the colour code, then you can refer to the **Resistors** section and the colour code table contained within.

Work in whatever order you prefer, e.g. R1, R2, R3, R4 etc. or by resistor value, e.g. all of the 1 KΩ resistors and then the next value and so on. Just be sure to take your time and not mix up the values.

Resistors can be installed either way around. However, the finished kit will look nicer if they are all inserted the same way, i.e. the tolerance band on the same side of each resistor.

Reference Number	Value	Colours
R10	330 Ω	Orange-Orange-Brown
R8, R9, R11	1 kΩ	Brown-Black-Red
R4, R6	22 kΩ	Red-Red-Orange
R3, R5	51 kΩ	Green-Brown-Orange
R7	100 kΩ	Brown-Black-Yellow
R1	330 kΩ	Orange-Orange-Yellow
R2	15 MΩ	Brown-Green-Blue-Gold-Yellow

Table 1 - Resistor Values and Colours

Figure 22 below shows the resistors soldered to the PCB.

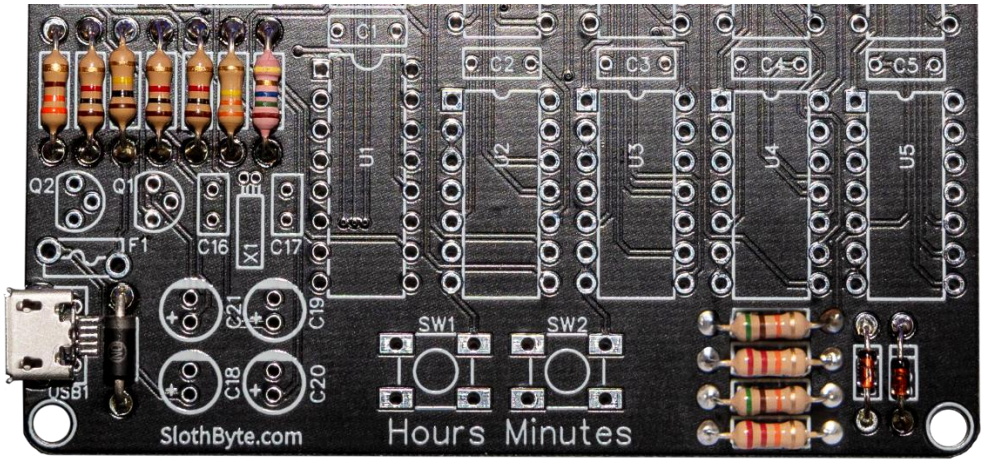


Figure 22 - Resistors

Crystal

This circuit board is designed so that the crystal lays flat once soldered in place.

The manufacturer of the crystal recommends rubber adhesive to hold the cylinder of the crystal in place after the legs have been soldered. If you don't have any, then a glue like UHU® will do the job. As a temporary solution you could always use some sticky tack to hold the crystal in place. See the image below as to where to glue.

When applying the glue, take care not to cover the spaces for nearby components.

What happens if you don't glue it in place? Since applying a voltage to the crystal causes it to physically vibrate, you may hear a high-pitched sound if it isn't glued in place.

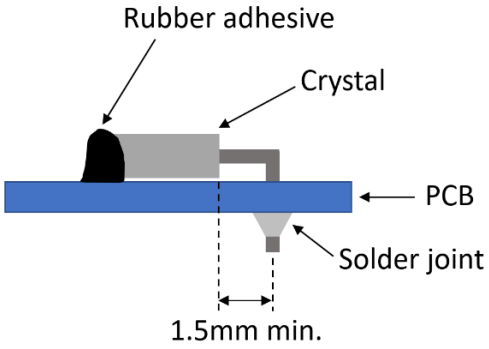


Figure 23 - Gluing the Crystal

The image below shows the crystal glued to the PCB using UHU® glue.

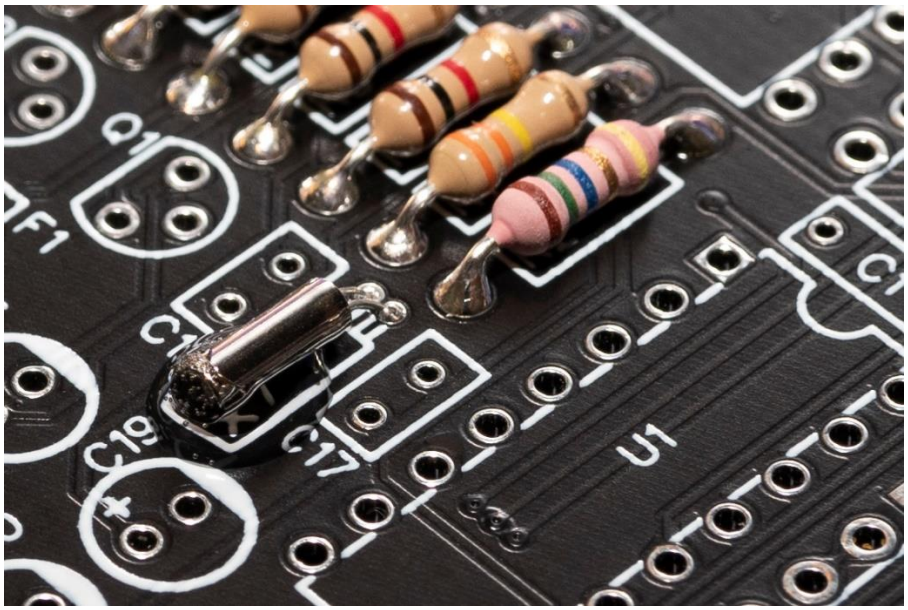


Figure 24 - Glued Crystal

Capacitors (C1 to C17)

Solder capacitors C1 to C17 in place and trim their legs once soldered. These capacitors can be inserted either way around. Note that the values for C1 – C15 are the same (0.1 µF) and that the values for C16 and C17 (33 pF) are the same. It is important not to mix the values.

Capacitors C1 – C15 are used as decoupling capacitors. Each one is placed next to an IC on the circuit board and each is electrically connected across the supply voltage (+5 volt and 0V). The purpose of a decoupling capacitor is to smooth the supply voltage to the ICs. As various parts of a circuit turn on or off, it can cause the supply voltage to dip or rise. The capacitor will help smooth this out and absorb (charge) any rises and discharge on any dips, keeping the supply voltage as stable as possible.

Capacitors C16 and C17 form part of the oscillator circuit which is responsible for keeping the clock on time. The oscillator circuit pulses on and off 32,768 times per second!

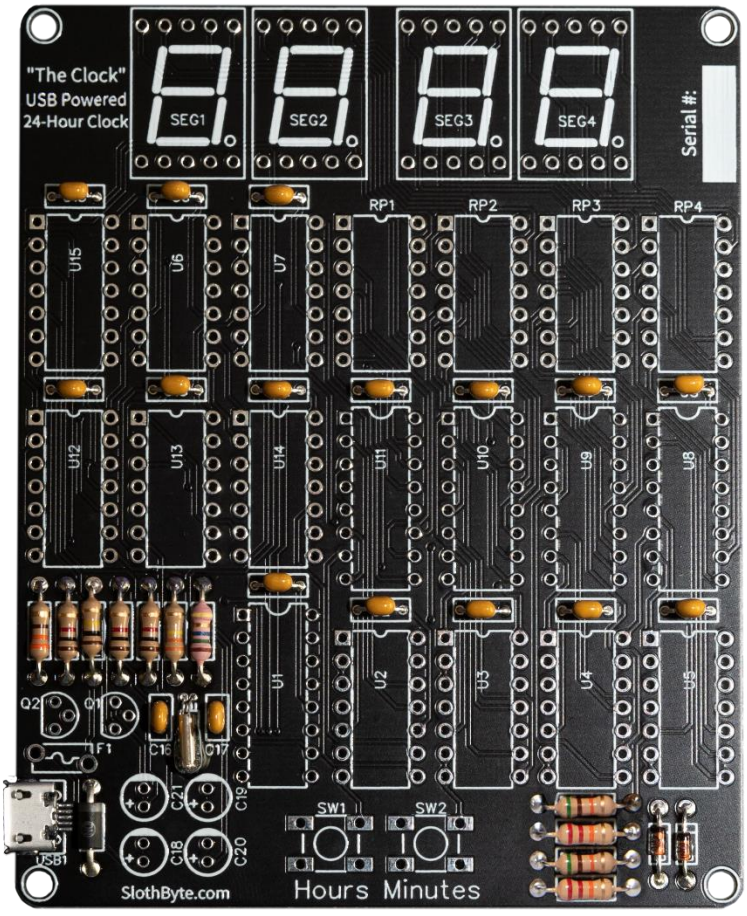


Figure 25 - Capacitor s added to the PCB

Tactile Switches (Push Button)

Solder the two tactile push buttons into place. These are used to set the time, SW1 sets the hours and SW2 sets the minutes.



Figure 26 - Tactile Switches

Chip Holders

If you purchased the optional chip holders, then they should be soldered into place now. Although the chip holders will electrically function either way around, it is good practice to insert them the correct way, matching the image on the PCB. This will help avoid confusion when inserting the chips in a later step. The chip holders have a small notch at one end that should be aligned with the image on the PCB.

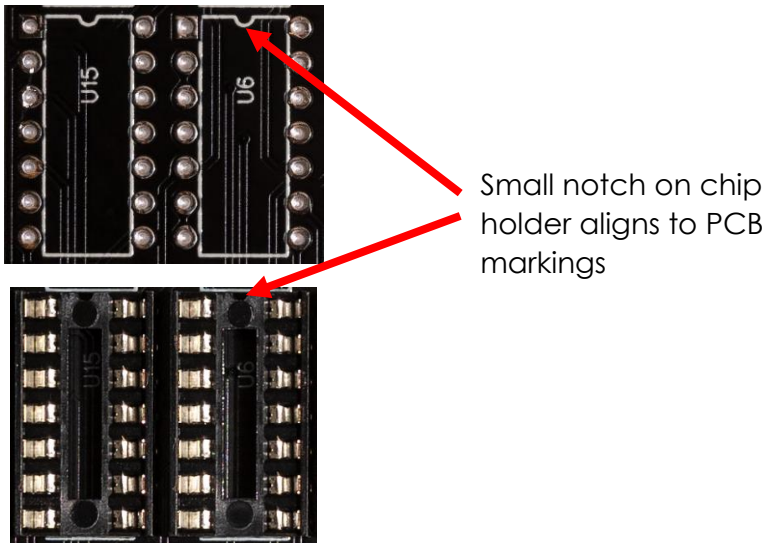


Figure 27 - Chip Holder Orientation

Chip holders are also included for the resistor networks, RN1 to RN4.

There are two sizes of chip/resistor network used in this kit, DIP14 and DIP16. The following shows which chip requires which size chip holder.

DIP14 (14 pins)

- RN1 – 4
- U2 – 7
- U12 – U15

DIP16 (16 pin)

- U1
- U8 - 11

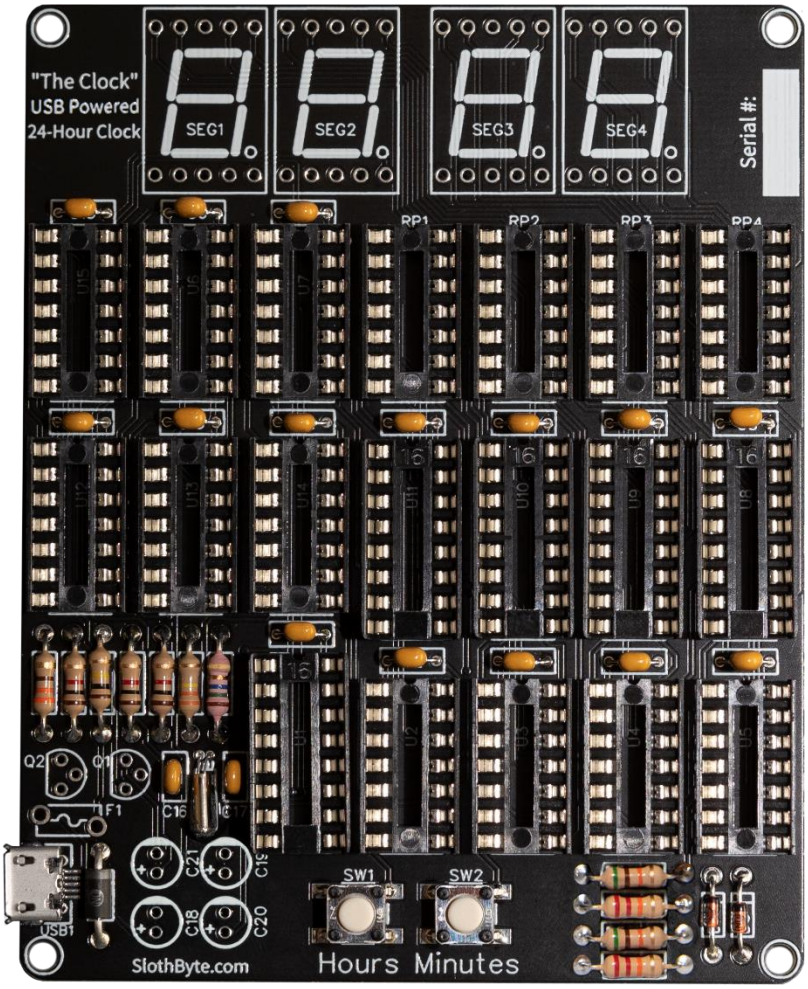


Figure 28 - Chip holders fitted to the PCB

Tip: Solder just two pins (opposite diagonal corners) of the chip holder, then flip the board over and check if the holder is nice and level. If it isn't, heat up the joints and push flush to the board. Once level, solder the remaining legs.

Transistors

There are two transistors used in this kit, Q1 and Q2. Both transistors are 2N3904 NPN transistors.

Insert the transistors orientated the same way as the image printed on the PCB. When pushed down, they will naturally sit around 3 to 4 mm off the PCB.

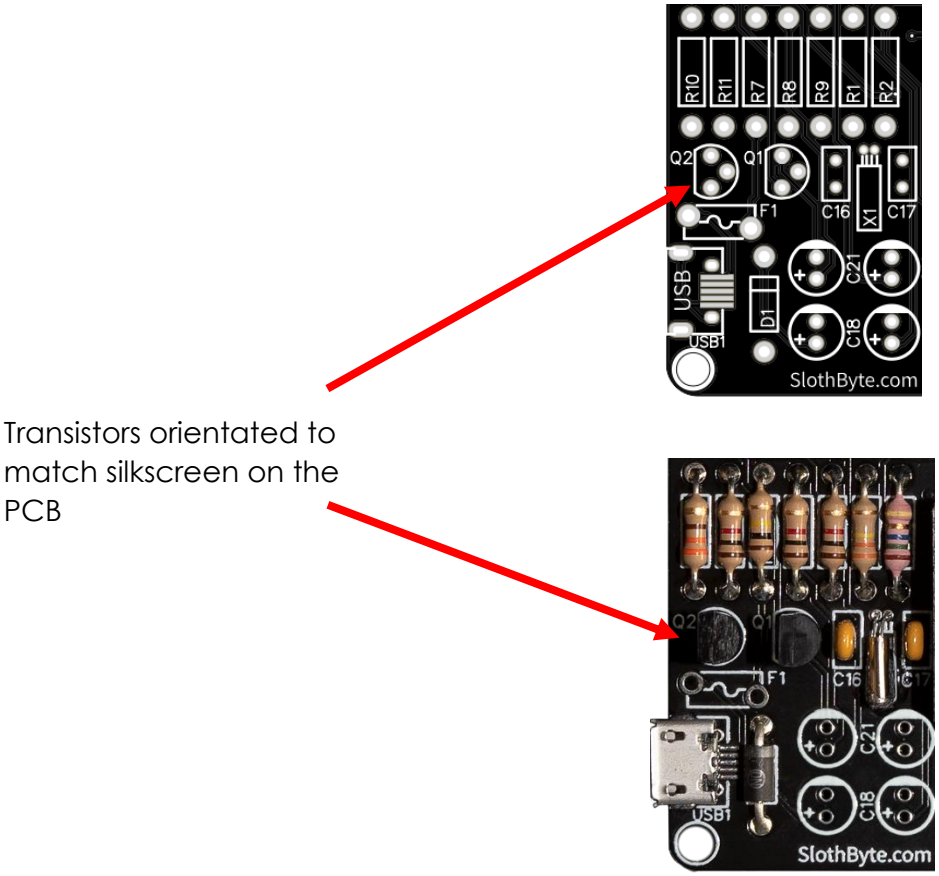


Figure 29 - Transistor orientation

Tip: The pads for the transistors are small and close together making them quite challenging to solder into place. If you find that the solder keeps bridging the pads, try trimming the legs down a bit and with the soldering iron heat the joint, and suck the excess solder away using a solder sucker. Some people get on better with solder wick, so you could also give that a go.

Use a magnifying glass and/or multimeter to check for shorts. If there are any shorts between the transistor pads, then the kit will not work.

Seven-Segment LED Display

The seven-segment displays must be inserted the correct way around to work. To help with this, match the orientation to the image shown on the PCB.

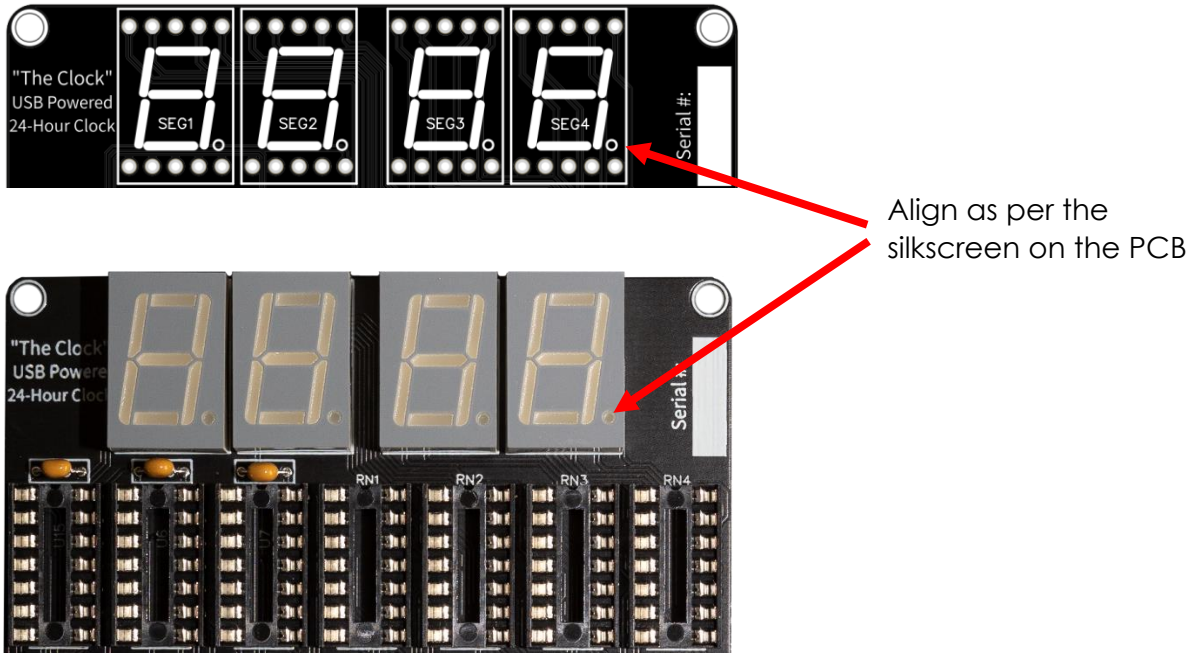


Figure 30 - Seven-Segment Displays fitted to PCB

Tip: As with the chip holders, just solder two opposite corner legs of the seven-segment display and check if it is still flush to the board and sitting nice and square with the one next to it. If not, heat the joints and push flush. When you are happy with the position, solder the other legs.

Fuse

Solder the resettable fuse (F1) into place and trim the excess legs. The fuse can be inserted either way around.



Figure 31 - Fuse fitted to the PCB

Capacitors (C18 – C21)

C18 and C21 (100 µF) are electrolytic capacitors and must be inserted the correct way around. The negative side of the capacitor is marked by a white line containing minus symbols, and the positive side has the longest leg. Pay attention to this and the PCB markings when inserting the capacitor.

C19 and C20 (1 µF) are not electrolytic capacitors and can therefore be inserted either way around.



Figure 32 - Capacitors fitted to the PCB

Tip: Pay attention to the orientation of C18 and C21. When inserting the capacitors, push all the way down so that it sits flush on the PCB and solder into place. It is best to solder just one leg, then check if the capacitor is still standing straight. If not, heat the solder joint and adjust the position of the capacitor, then solder the other leg and trim the excess legs.

Chips and Resistor Networks

It's now time to insert the chips and resistor packs into the chip holders. Refer to the table below as to which chip goes where. The silkscreen on the PCB has been designed so that the IC reference numbers can be read even when the chip holders have been soldered into place.

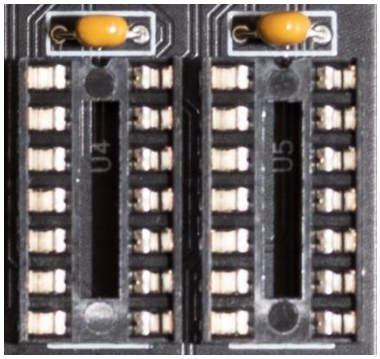


Figure 33 - IC Reference Numbers

Chip	IC Reference number	Function
CD4060BE	U1	14-stage binary ripple counter with oscillator
SN74LS90N	U2,3,4,5,6,7	Decade counter
SN74LS47N	U8,9,10,11	BCD to seven segment display decoder
SN74LS32N	U12,13	OR gates
SN74LS08N	U14	AND gates
SN74HC14N	U15	NOT gates (Schmitt-Trigger)

Table 2 - ICs

The resistor networks look like chips, and each one contains seven 330 Ω resistors. The resistor networks are used in this kit as current limiting resistors for the seven-segment displays. An advantage of using a resistor network over individual resistors, is that less space is required on the PCB.

Just like chips, resistor packs have a small notch at one end that must be aligned to the notch on the chip holder and PCB.

Note that the legs on some new chips are slightly angled out, to fit them in the chip holder, it is necessary to first straighten them. An easy way to do this is to place the legs on a flat service and gently press down.

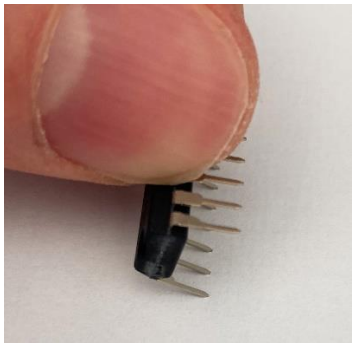


Figure 34 - Bending the Chip Legs

Tip: If any of the decoupling capacitors are not sitting straight, they may get in the way of a chip being fully inserted into the chip holder. If this is the case, don't worry, they can be carefully bent over to make room for the chip.

Congratulations your clock is now complete!

Before connecting the clock to a USB power supply, there are a few checks that should first be made, these are covered in the next section.

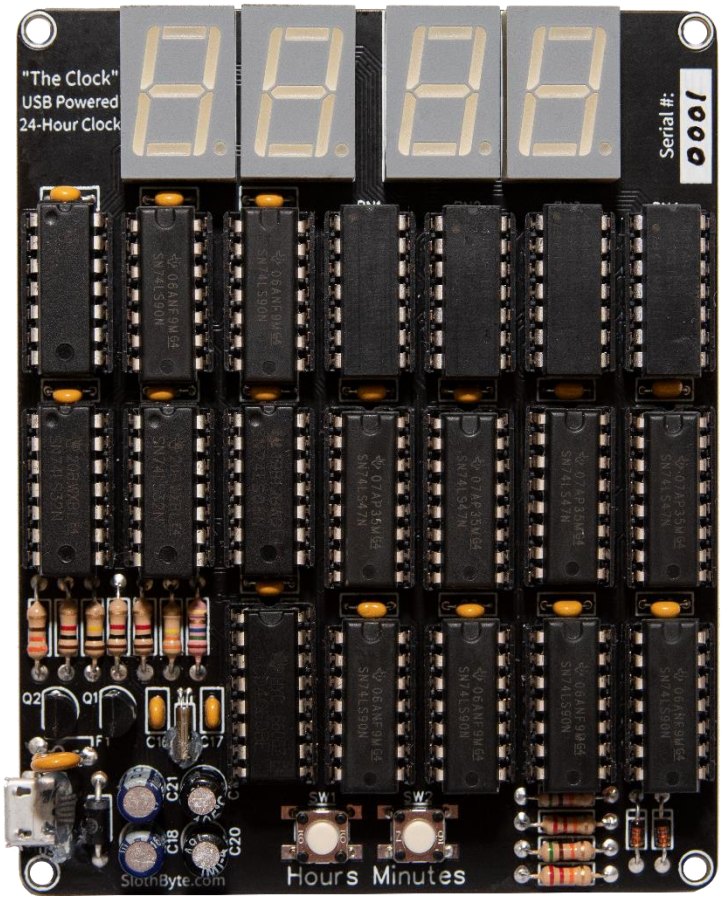


Figure 35 - Completed "The Clock" Kit

Inspecting and Testing

Inspecting

Before connecting the clock to a USB power supply, it is first necessary to inspect it for any shorts and to ensure that the component values are in the correct place.

Tip: Print this page and the kit contents, then mark off each component after checking its value and that there are no shorts.

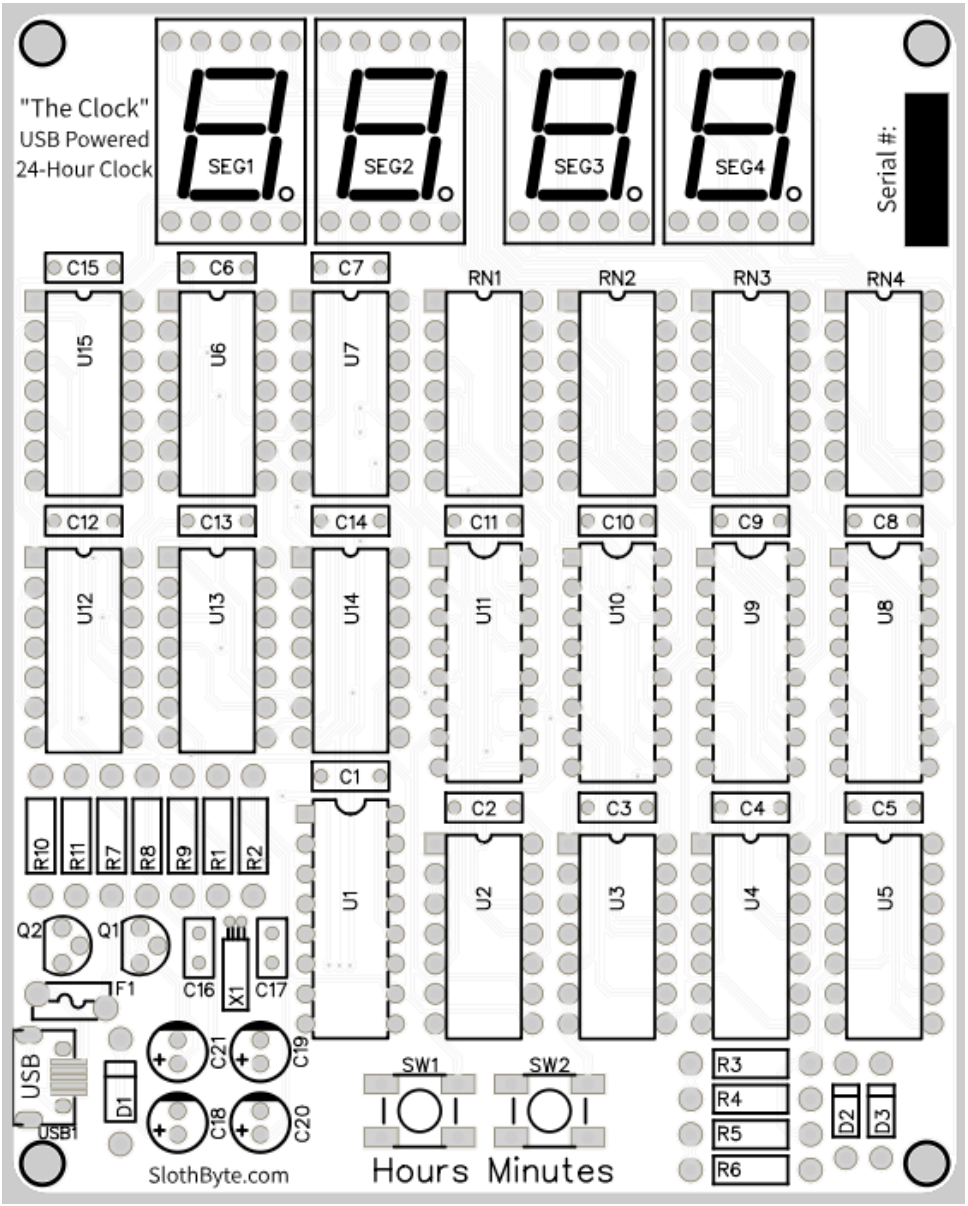


Figure 36 - PCB Layout

When you are happy that all component values are fitted to the correct locations and that visually there appears to be no shorts, there is one test to do before powering on the clock.

Using a multimeter set to ohms, and looking at the PCB from the component side, measure between the left leg of the fuse (F1) and the bottom leg of the Zener diode (D1). You should get a reading of around 100 kΩ that slowly begins to increase.

If, however, you read a short (0 Ω) or very low resistance, do not connect the clock to a USB power supply as there is a short circuit across its input. Instead you'll need to carefully inspect the PCB again looking for a short between solder joints. A magnifying glass is your friend with this task.

Testing

Connect the micro-USB connector to a USB power supply capable of suppling up to 500 mA and then turn on the USB power supply (micro-USB lead and USB power supply not included in the extent of supply).

The clock incorporates a power on reset that resets the time to 00.00 upon power on. The seconds LED will start flashing after approximately one or two seconds of the clock being powered on. The power on reset circuit is necessary, as without it, the counter chips (SN74LS90N) will assume random outputs when they are first powered on.

To set the time, press the minutes and hours buttons accordingly. Note that when pressing the minutes button, if the minutes wrap around from 59 minutes to 00, then the hours will also increment by one. Also note that when the minutes button is pressed, the seconds counter is reset to 00.

Now all that's left is to site back, relax and use your clock.

Reading Circuit Diagrams

Circuit diagrams are a way of representing a circuit in pictorial form using pre-agreed upon symbols, some of which we've already covered. Circuit diagrams are usually laid out in such a way as to minimise the clutter of lines. This means that components that are often next to each other on the diagram may not actually be physically located next to each other on the circuit board.

Connections

Where there is an electrical connection between two components, this is represented in the diagram by a line connecting the two components.

Where multiple lines are connected, they are shown with a small dot at the point of the connection.

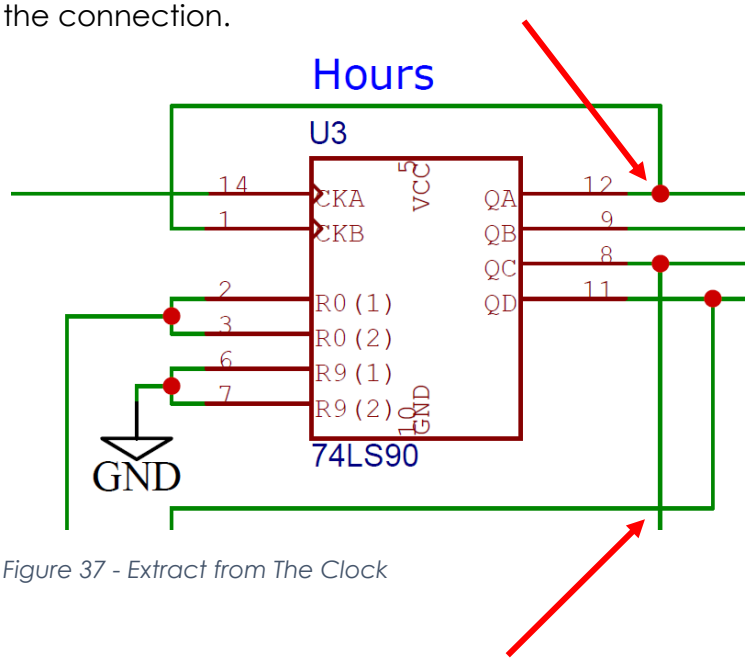


Figure 37 - Extract from The Clock

Large circuit diagrams can get quite busy with lines crossing over each other. If there is no dot where they cross, then there is no electrical connection between the two lines. They merely cross over like this as there is no other practical route to draw the line.

Components

Each component in the circuit diagram has a unique reference number, typically a letter followed by a number, for example, R1. But the drawing may not always follow this convention.

The following letters are typically used to identify components, although not everyone follows this.

- C = Capacitor
- D = Diode
- Q = Transistor
- R = Resistor
- S = Switch
- U = Integrated Circuit (IC/Chip)
- X = Crystal

Shortcuts When Drawing Lines

Often on large circuit diagrams, you'll find lines that terminate at a label. You'll find a label with the same name elsewhere on the circuit diagram. Labels sharing the same name are electrically connected. Drawing the lines like this is a way to cut down on the need to cover the page in long lines and help make the diagram easier to read.

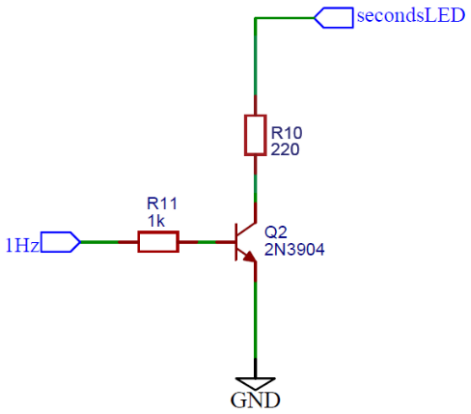


Figure 38 - Extract from The Clock Circuit Diagram Showing Labels

Power

Throughout this kit, all circuit diagrams will refer to the supply + volts dc as "VCC" and the supply 0V as "GND".

Attention: This kit is designed to work with a USB power supply (5Vdc 500mA). Do not connect to other voltage sources.

Technical Drawings

Technical drawings such as circuit diagrams generally have some important information in the lower right-hand corner. Below is an extract from the circuit diagram for this kit. Information that you'll find here can often tell you what the drawing is for, which company drew it along with the revision number, date, and how many pages there are.

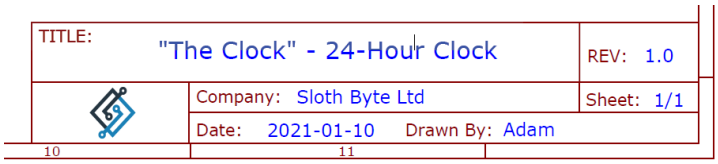


Figure 39 - Extract from The Clock Circuit Diagram

When I was at University, one of my lecturers told us about the importance of this information. He explained how he'd used it at a job interview when presented with a diagram and asked what the circuit's function was.

After graduating from University and attending some job interviews, I found myself in the same situation. A complex circuit diagram was placed in front of me, and I was asked what its function was. Its function was clearly written in the bottom right-hand corner; I got the job.

Appendix

Block Diagram

When dealing with complex circuits, it can be easier to get an overview of what's going on by concentrating on the bigger picture. Instead of worrying about each individual component, the function of several components can be grouped together into a block that describes how that group of components function.

In the case of this kit, the entire circuit can be represented by the block diagram below. The clock keeps track of time by counting vibrations in a quartz crystal, 32,768 times per second! This count is then divided down using a 14-bit ripple counter to 2 Hz, and then fed into divided by 2 counter so that the output is 1 cycle per second, 1Hz (Hertz).

The 1 Hz clock pulse is fed into the seconds counter which is configured to reset at 60 and increment the minutes counter by one. The minutes counter is configured to reset on 60 and increment the hours counter by one. The hours counter is then configured to reset at 24, and the entire process begins again.

Both the minutes and hours counter can be manually increased using the "set minutes" and "set hours" buttons. The output of both the minutes and hours counters are fed into a binary coded decimal (BCD) to seven segment display driver which in turn is connected to the seven segment displays.

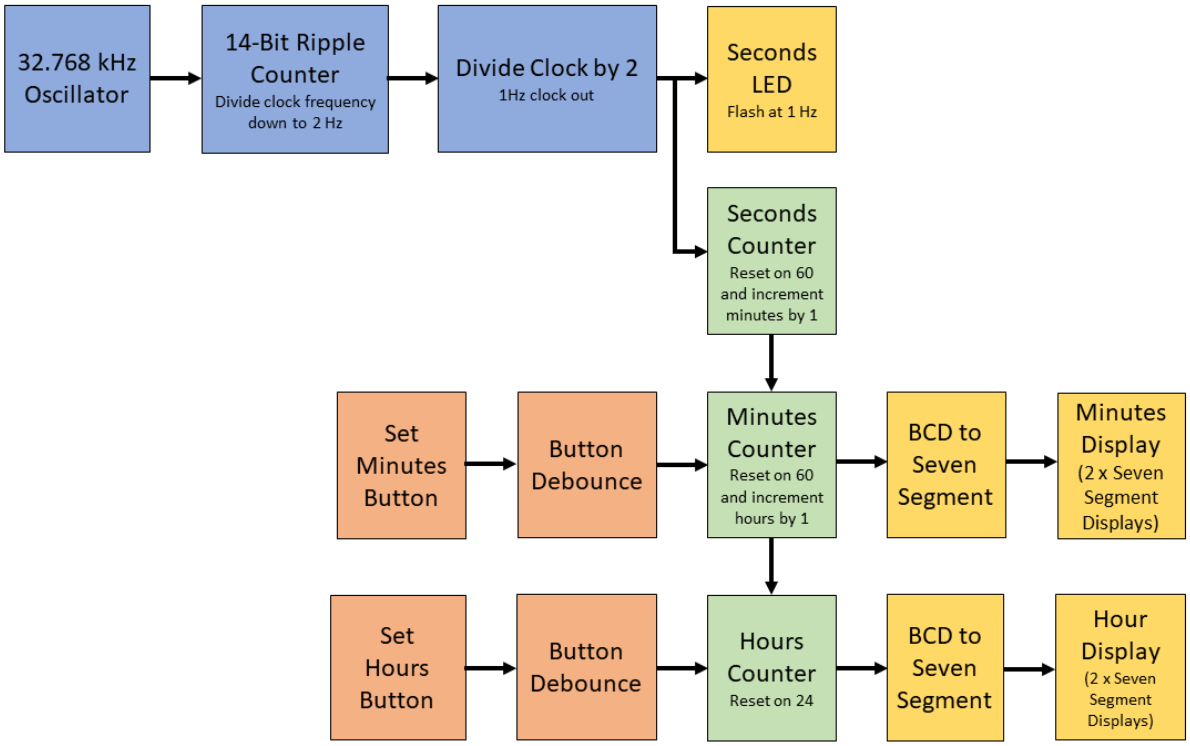
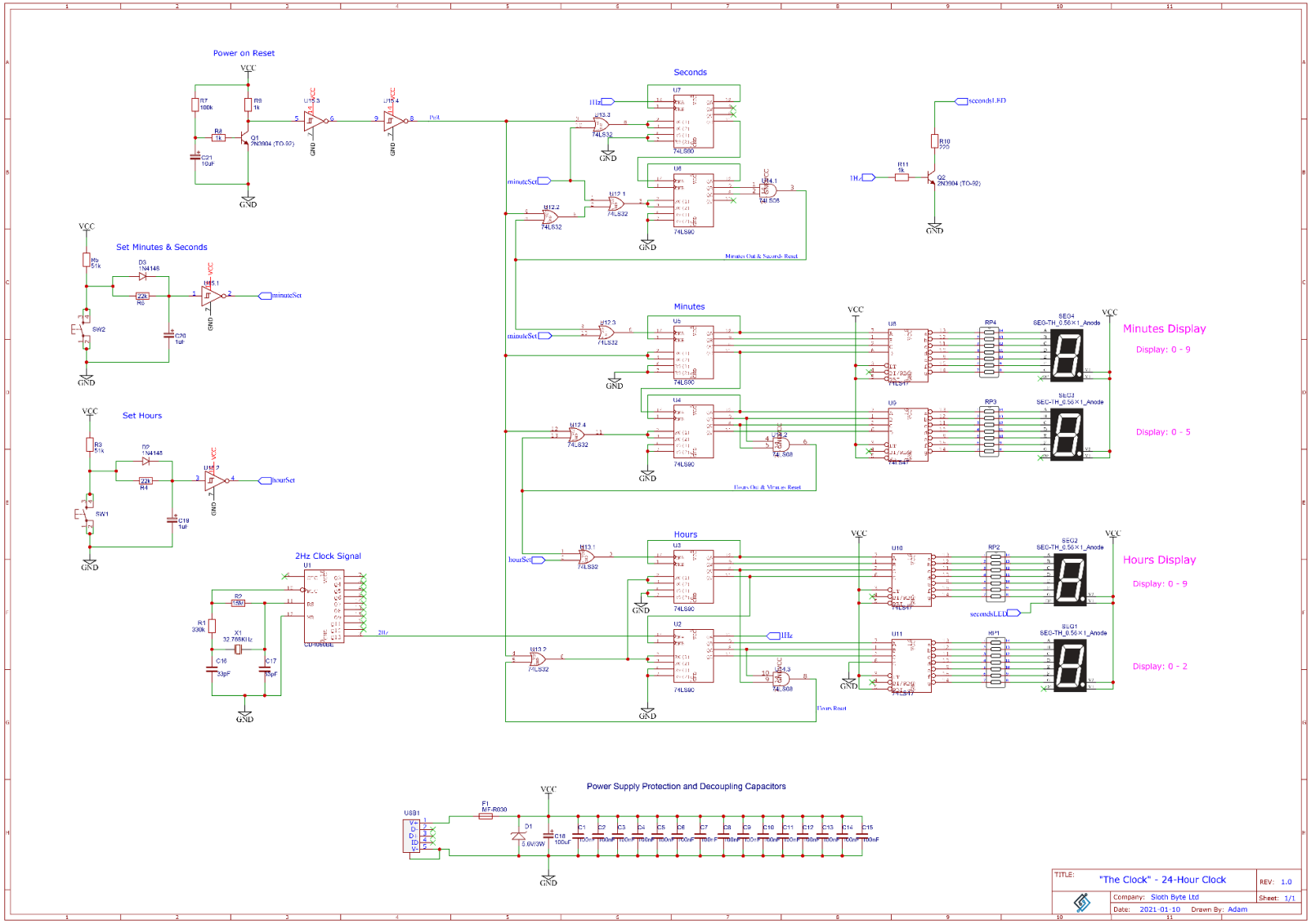


Figure 40 - "The Clock" Block Diagram

Schematic


Power on Reset
Seconds
Set Minutes & Seconds
Minutes
Set Hours
Hours
2Hz Clock Signal
Minutes Display
Display: 0 - 9
Display: 0 - 5
Hours Display
Display: 0 - 9
Display: 0 - 2
Power Supply Protection and Decoupling Capacitors
"The Clock" - 24-Hour Clock
Company: Sloth Byte Ltd
Date: 2021-01-10 Drawn By: Adam