CREATE YOUR OWN SCORE BOARD WITH THIS

7 SEGMENT LED DISPLAY KIT
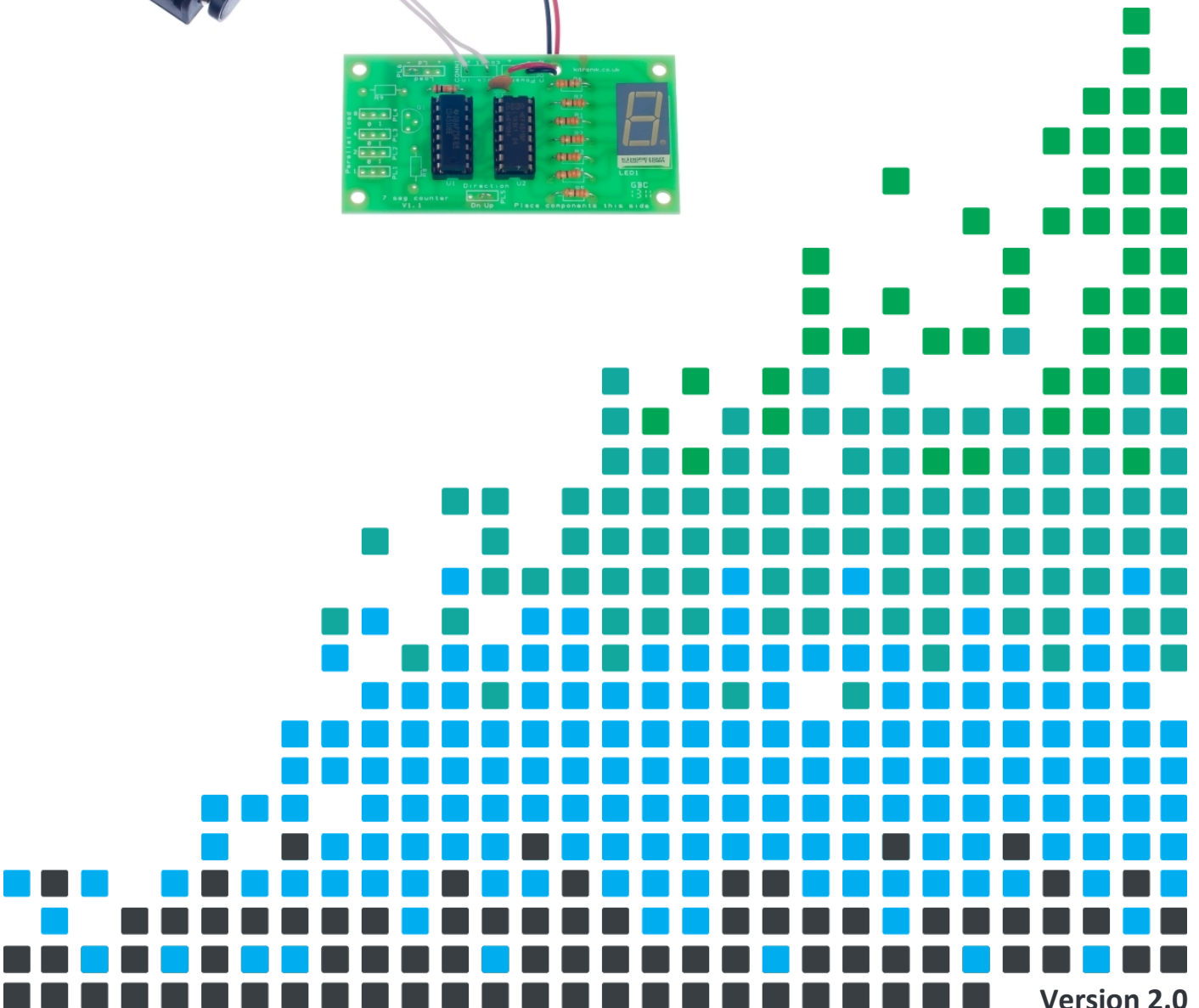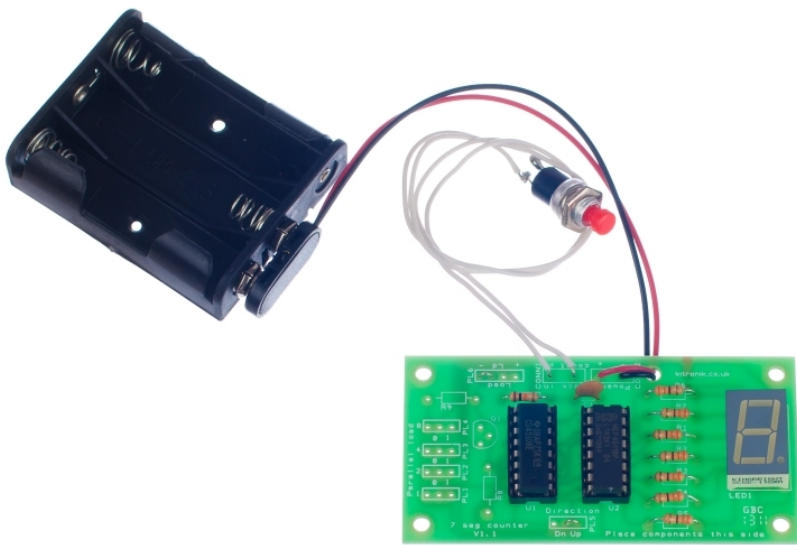
Version 2.0

Which pages of build instructions do I need?

The seven segment counter has been designed to be flexible in the way that it is built. Unfortunately this configuration makes the standard case of just wanting the board to count more complicated.

The build instructions are, therefore, written in two parts. You should always start with the first page of build instructions, which are titled 'Build Instructions'.

If you are building the standard configuration, which will either count up or down when the button is pressed, follow the first page of the instructions with 'Build Instructions – Standard Configuration'.

If you would like to use a switch to set the count direction, load a predetermined value on demand or use a separate circuit to do the counting then you should follow the first page of instructions with the two pages titled 'Build Instructions – Options'.

It is possible to make a 7 segment dice using this kit with a tone generator kit. Full details of this can be found in an application note on the Resources section of the Kitronik website.

7 Segment LED Display Essentials

Build Instructions

Before you start, take a look at the Printed Circuit Board (PCB). The components go in the side with the writing on and the solder goes on the side with the tracks and silver pads.

1   PLACE RESISTORS

Start with the seven 330Ω resistors. The text on the PCB shows where R1, R2 etc go.

Place the 330Ω resistors (with orange, orange, brown coloured bands) in R1 to R7. Ensure that you put the resistors in the right place.

You don't need to worry about the three 10K resistors at the moment.
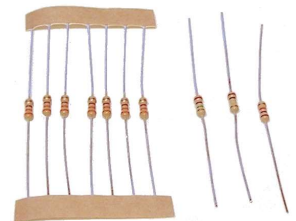
2   SOLDER THE IC HOLDERS

Solder the two Integrated Circuit (IC) holders into U1 and U2. When putting them into the board, be sure to get them the right way around. The notch on the IC holders should line up with the notch on the lines marked on the PCB.

3   INSERT THE 7 SEGMENT DISLPAY

Insert the Seven Segment Display where it is labelled LED1. It is important that the dot on the display matches the position of the dot on the outline. This will be at the bottom right as you look at the PCB.

### 4   ATTACH THE BATTERY CLIP

 Now you must attach the battery clip. Start by feeding the leads through the strain relief hole near R6. The wire should be fed in from the rear of the board (see right, below).

The leads should be connected to the 'power' terminals. The red lead should be soldered to the '+' terminal and the black lead should be soldered to the '-' terminal.

5   INSERT THE ICs

The ICs can now be put into the holders, ensuring the notch on the chip lines up with the notch on the holder. IC 4510B should go into U1 and IC 4511B should go into U2.
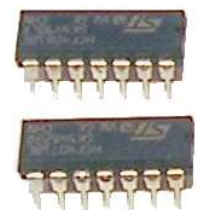
# Build Instructions – Standard Configuration

6 CONNECT THE WIRES

Setting the direction in which the counter will count (either up or down) is done by soldering a wire link into the PCB. Find the terminals labelled 'Direction'. You need to link the terminals above the text of the desired direction. In the picture to the right, the terminals above the text 'up' have been linked, therefore, it will count up.

7 CONNECT THE WIRES

The parallel load option is not needed so must be disabled. This is done by soldering a wire link between the right most two connections on the load terminal ('Ld' and '-'), see right.
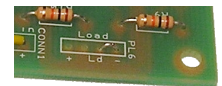
8 PLACE RESISTOR

Solder a 10K resistor (with brown, black, orange coloured bands) into the board where it is labelled R10.

9 PLACE CAPACITOR

Solder the 10nF capacitor into the board where it is labelled C1. It does not matter which way around the device is fitted.

10 SOLDER THE SWITCH

Cut and strip two pieces of wire to the required length for connecting the switch. Solder one end of each wire to each of the terminals on the switch and the other end to the terminals labelled 'CONN1 - Clock In'. It does not matter which wire goes to which terminal.

Build Instructions – Options

Count direction

Up or down

Setting the direction in which the counter will count (either up or down) is done by adding a wire link on the PCB. Find the terminals labeled 'Direction' (shown below). You need to link the terminals above the text of the desired direction. In the picture below, the terminals above the text 'up' have been linked, therefore, it will count up.
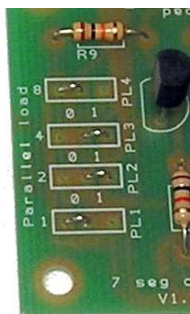
Selectable by the user

To allow the direction to be changed whilst the counter is in use you will need a SPDT switch, which should be connected as shown below:
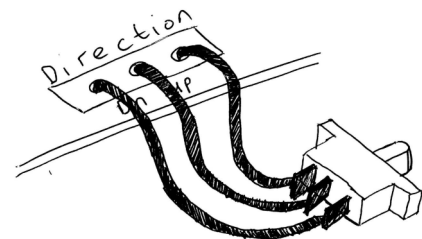
Loading a pre-set value on demand (Parallel Load)

With parallel load

A predetermined value can be loaded on demand. To do this the number that is going to be loaded needs to be set using the 'Parallel load' terminals and a means of triggering the load will need to be added. The number that will be loaded is selected by placing four wire links into the 'parallel load' terminals. The table below shows how PL1 to PL4 need to be linked (either as a 1 or 0) for different parallel load numbers.

Example of loading 6

Without parallel load

If you do not wish to use the parallel load function, you should insert a wire link across the negative (-) labelled 'Load' terminals. This is shown in the picture shown below:
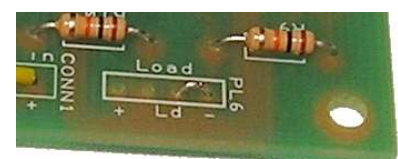
Now go to count input on the next page

Parallel Load Selector

PL4 (8)	PL3 (4)	PL2 (2)	PL1 (1)	= Number
0	0	0	0	0
0	0	0	1	1
0	0	1	0	2
0	0	1	1	3
0	1	0	0	4
0	1	0	1	5
0	1	1	0	6
0	1	1	1	7
1	0	0	0	8
1	0	0	1	9

Triggering a parallel load to take place

Using a load switch

With a load switch, when the switch is pressed the number set by the parallel load terminals will be loaded. To connect a load switch you should use one of the 10K resistors (brown, black, orange) and solder this into the right two terminals on the load connection. A push to make switch can then be connected to the other two connections, as shown below:

Loading upon count value

The board has been set up so that when counting down, as zero is reached a parallel load can happen. In this case zero is not displayed but changed for the value as given by the parallel load setting.

To do this R8 & R9 need to have a 10K resistor (brown, black orange) soldered in place.

Q1 should be fitted with the transistor.

The load terminal should not have any connections.

Count input

Count upon button press

To count when a button is pressed you will need to connect a push button to the clock in connection and also add a resistor and capacitor.
Solder a 10K resistor (brown, black orange) into R10.
Solder the 10nF capacitor into C1.

Fitting the switch

Cut and strip two pieces of wire to the required length for connecting to the switch. Solder one end of each wire to each of the terminals on the switch and the other end to the terminals labelled 'CONN1 - Clock In'. It does not matter which wire goes to which terminal.

Count upon logic input

When a logic input is used to connect a count from a separate circuit the switch de-bounce components (R10 & C1) are not required.

The clock out of your circuit should be connected to the 'clock in' terminal, only the 'count' connection needs to be used. But be sure that the 0v of both circuits are connected together.

Checking Your PCB

Check the following before you insert the batteries:

Check the bottom of the board to ensure that:
- All the leads are soldered.
- Pins next to each other are not soldered together.

Check the top of the board to ensure that:
- The shape of the ICs and IC holders match the outline on the PCB.
- The dot on the 7 segment display is on the bottom right and NOT the top left.
- The coloured bands on R1 – R7 are orange, orange, brown.
- The battery clip red wire connects to '+' and the black wires to '-'.

Adding an On / Off Switch

If you wish to add a power switch, don't solder both ends of the battery clip directly into the board, instead:
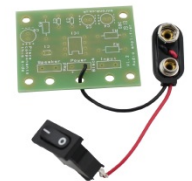
1

Solder one end of the battery clip to the PCB, either black to '-' or red to '+'.
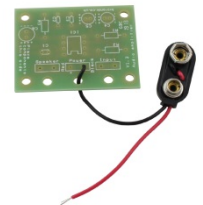
2

Solder the other end of the battery clip to the on / off switch.

3

Using a piece of wire, solder the remaining terminal on the on / off switch to the remaining power connection on the PCB.
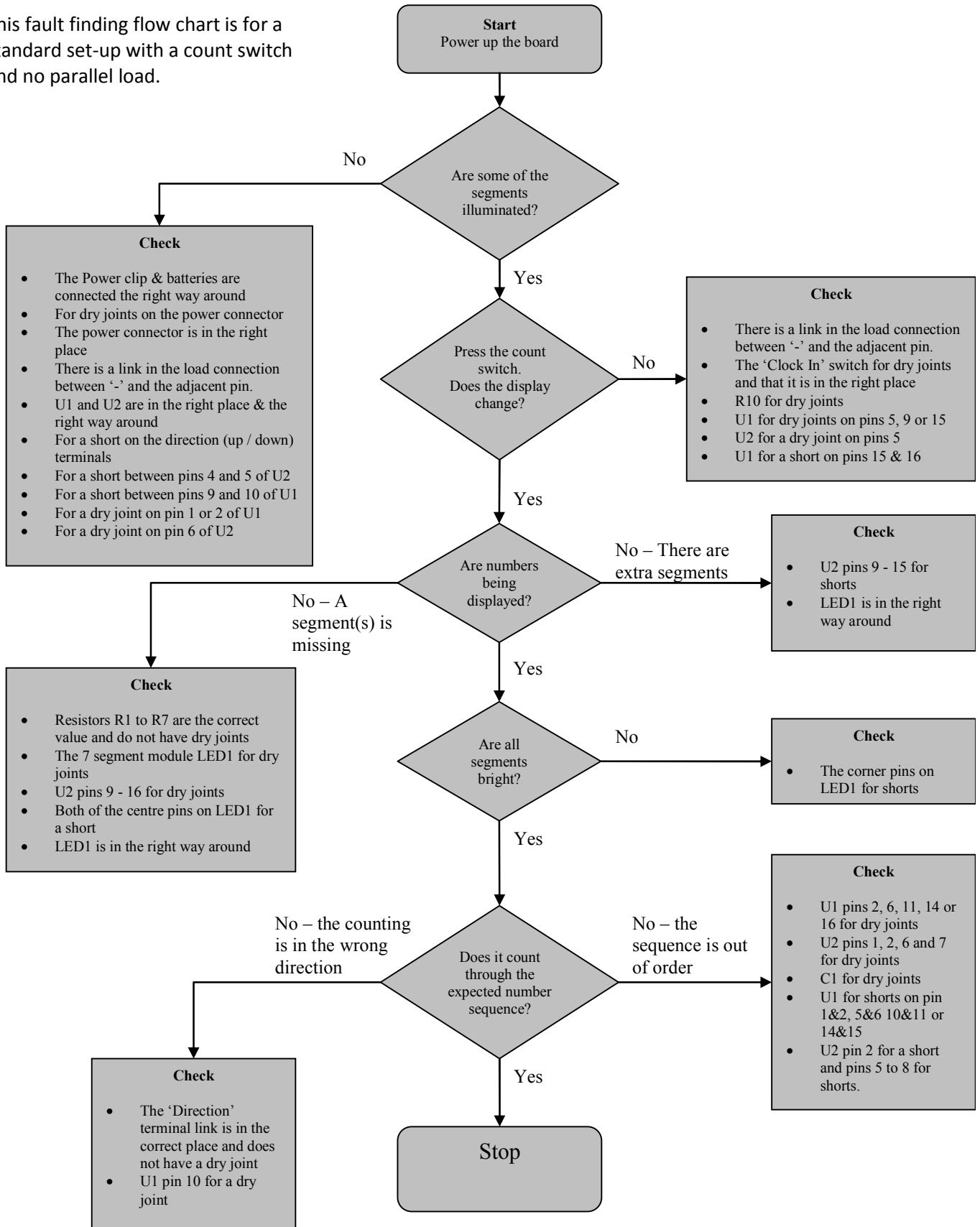
7 Segment LED Display Essentials

www.kitronik.co.uk/2118

This fault finding flow chart is for a standard set-up with a count switch and no parallel load.

Start
Power up the board

Are some of the segments illuminated?

No →

Check

- The Power clip & batteries are connected the right way around
- For dry joints on the power connector
- The power connector is in the right place
- There is a link in the load connection between '-' and the adjacent pin.
- U1 and U2 are in the right place & the right way around
- For a short on the direction (up / down) terminals
- For a short between pins 4 and 5 of U2
- For a short between pins 9 and 10 of U1
- For a dry joint on pin 1 or 2 of U1
- For a dry joint on pin 6 of U2

Yes

Press the count switch. Does the display change?

No →

Check

- There is a link in the load connection between '-' and the adjacent pin.
- The 'Clock In' switch for dry joints and that it is in the right place
- R10 for dry joints
- U1 for dry joints on pins 5, 9 or 15
- U2 for a dry joint on pins 5
- U1 for a short on pins 15 & 16

Yes

Are numbers being displayed?

No – A segment(s) is missing

No – There are extra segments →

Check

- U2 pins 9 - 15 for shorts
- LED1 is in the right way around

Check

- Resistors R1 to R7 are the correct value and do not have dry joints
- The 7 segment module LED1 for dry joints
- U2 pins 9 - 16 for dry joints
- Both of the centre pins on LED1 for a short
- LED1 is in the right way around

Yes

Are all segments bright?

No →

Check

- The corner pins on LED1 for shorts

Yes

Does it count through the expected number sequence?

No – the counting is in the wrong direction

No – the sequence is out of order →

Check

- U1 pins 2, 6, 11, 14 or 16 for dry joints
- U2 pins 1, 2, 6 and 7 for dry joints
- C1 for dry joints
- U1 for shorts on pin 1&2, 5&6 10&11 or 14&15
- U2 pin 2 for a short and pins 5 to 8 for shorts.

Check

- The 'Direction' terminal link is in the correct place and does not have a dry joint
- U1 pin 10 for a dry joint

Yes

Stop

Switch Debounce

If a switch is used to complete a circuit with a lamp, it will appear that when the switch is pressed the lamp goes straight from off to on. However as the switch is pressed it will probably make contact several times during the transition from off to on. With a simple circuit such as a switch being used to control a lamp this will not be a problem, however if the switch is used to control logic such as a counter then it will cause what looks like incorrect behaviour.

Consider what happens as a switch is pressed to step a counter up from zero to one. As far as the viewer is concerned, the count jumps from zero to, say, three. In actual fact the count goes from zero, to one, to two and then on to three, however this all happens so fast that anyone viewing the count will see it jump straight to three. The diagram below shows what's happening as time passes from left to right; the whole event will be over in just a few hundredths of a second.
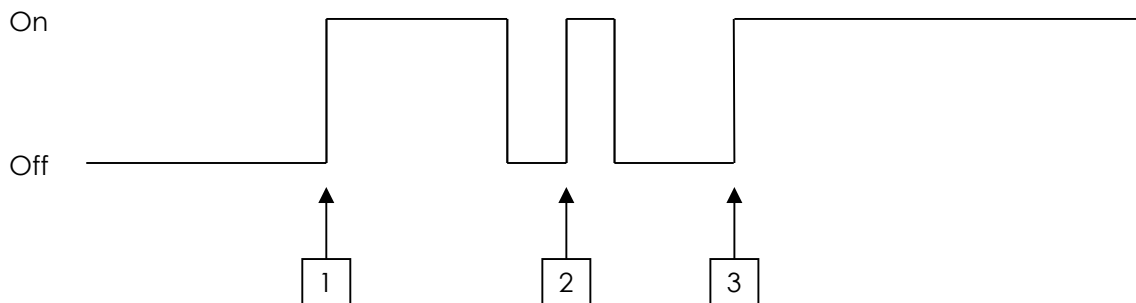
Fortunately it is fairly easy to remove these unwanted changes as the switch is pressed. This technique is called 'switch debounce'. Although a logic input such as a count input is thought of as a digital input that can either be in a logic high or a logic low state, the actual voltage present on the pin doesn't need to be. Inside the chip the signal must be either high or low and to make sure that this is the case there will be a threshold at which the chip decides either a high or low condition is present. For the purpose of this explanation, assume this is half the supply voltage. A pull up / down resistor will already be present but a capacitor can be added to the input (as shown right). Now the input to the chip will change much slower as the resistor controls how fast the capacitor can charge. This will result in a correct count as shown below:
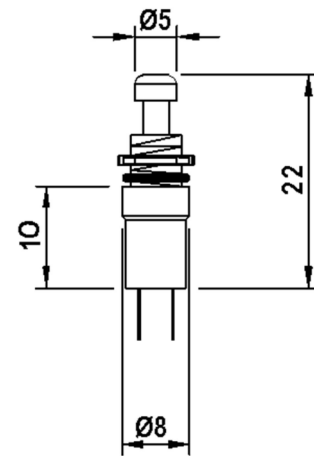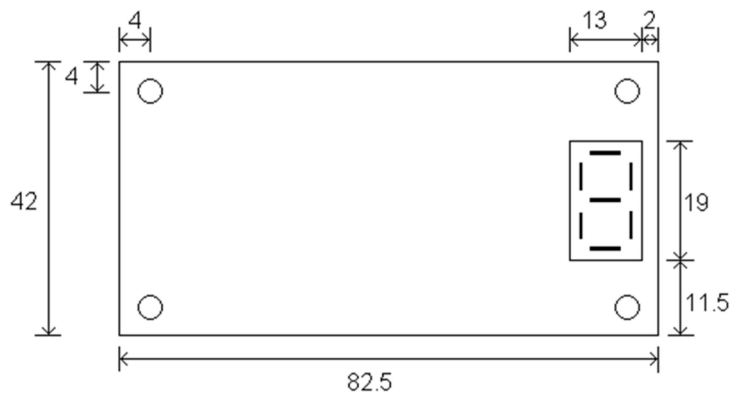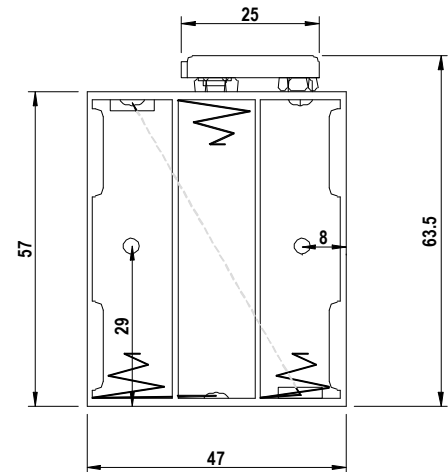

To IC
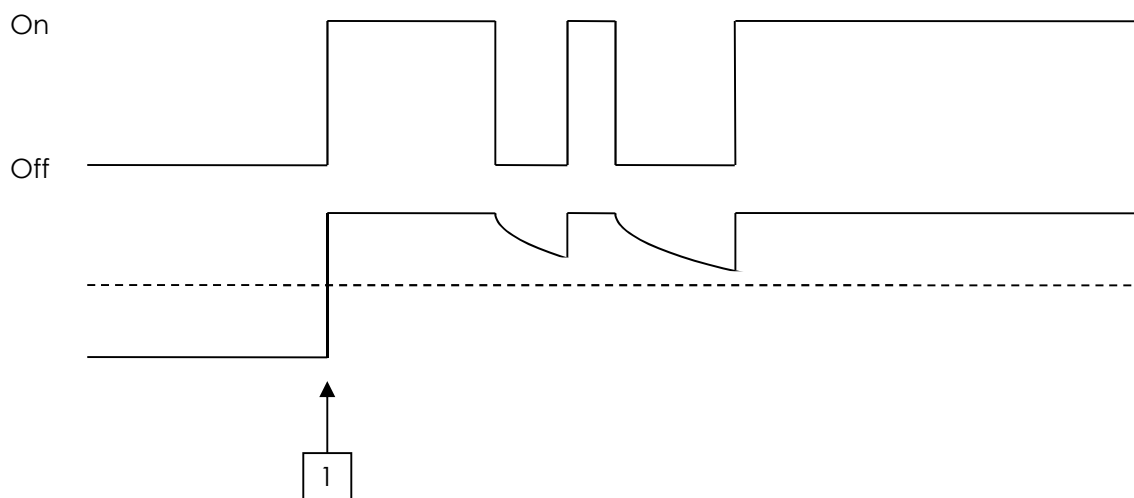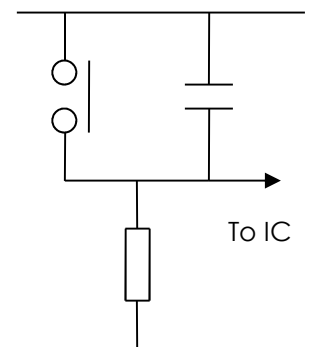
Designing the Enclosure

When you design the enclosure, you will need to consider:

- The size of the PCB (see below).
- Where the seven segment LED display is mounted.
- Where the batteries will be housed (right), height 16mm.
- Where the switch will be mounted (below right).

These technical drawings of the parts should help you to design your enclosure.

All dimensions in mm.
x4 holes 3.3mm diameter.
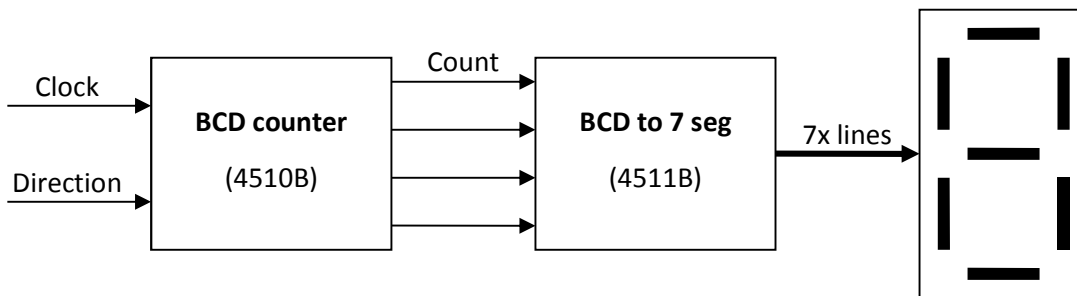7 segment display height is 8mm above board.

Mounting the PCB to the enclosure

The drawing to the left shows how a hex spacer can be used with two bolts to fix the PCB to the enclosure.

*Your PCB has four mounting holes designed to take M3 bolts.*

How the Seven Segment Display Counter Works

Introduction

The basic block diagram for the system is shown below:

On the left of the diagram is a clock source. When this signal changes it clocks (steps) the binary coded decimal (BCD) counter. Each time the counter is clocked, it moves on to the next number in the sequence. The next stage in the process is to convert the binary number from the counter into an output, which can be shown on the 7 segment display.
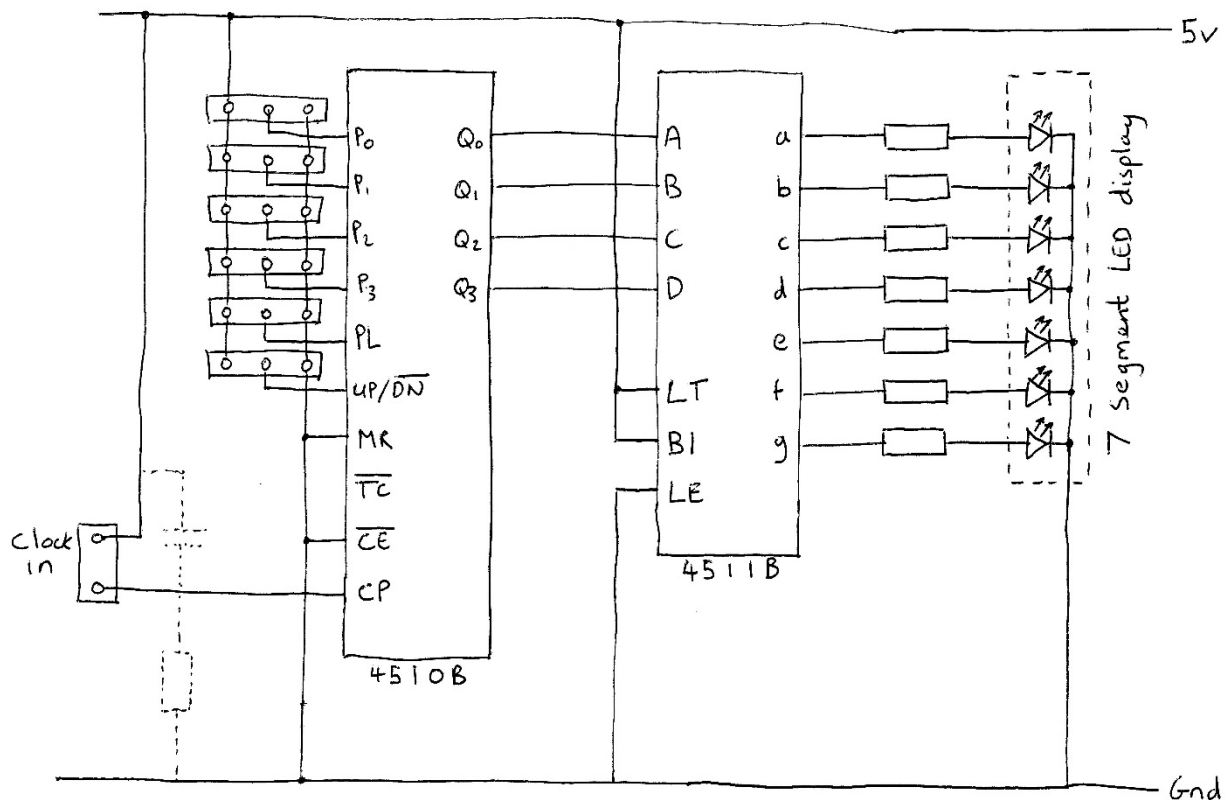
Counter (4510B)

The counter is a binary coded decimal four-bit-up-down counter (4510B). This means that it can either count up from 0 to 9 or down from 9 to 0 and that the output of this is indicated in binary.

0	1	2	3	4	5	6	7	8	9
0000	0001	0010	0011	0100	0101	0110	0111	1000	1001
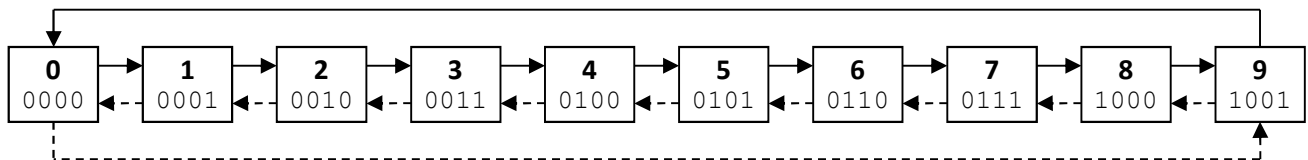
The diagram above shows how the counter operates when clocked, the solid line indicating a clock when set to 'up' and the dotted line shows the step when clocked in the 'down' mode. The second number in each of the boxes is the binary representation of the data that will be present on the counter outputs Q_4 to Q_1. The direction in which the counter counts is determined by the state of the up down pin. When low it counts down, when high it counts up.

Parallel load

The board has the option to allow a number to be loaded via the parallel load pins. When parallel load is not in use, the parallel load pin is held low. When the parallel load pin is taken high, the data on the inputs P_3 to P_0 are loaded into the counter. This functionality can be used to reload the counter with any value between 0 and 9.

Other control pins

A number of the pins on the IC don't change, but need to be connected to allow the counter to work. There is an enable pin (EN) – this is low so that counting is enabled, in a high state counting is disabled. The Master Reset (MR) pin is held low for normal operation, in a high state the device is kept in reset and all inputs and outputs are disabled.

BCD to seven segment display conversion (4511B)

The 4511 IC does the simple job of converting the binary coded decimal output of the 4510 counter IC into the correct format to drive the 7 segment display. Each separate section of the 7 segment display is an individual LED. Each of these segments has a corresponding input line. The circuit uses a common cathode display, which means that all of the cathodes on the 7 LEDs are connected together and in turn to 0V. Therefore to turn a segment on its line is taken high.

There are a few other pins on the BCD to seven segment converter IC that have a fixed setting. Lamp Test (LT) is held high in normal operation, if taken low all the segments light, to test the LEDs. Blanking (BL) is held in a high state for normal operation. The IC could be driven by a square wave should a dimming function be required. Latch Enable (LE) this is kept in a low state, if taken high the last number is latched allowing the binary number on the input to be changed without the output changing.

The resistors R1-R7 are 330Ω. These resistors limit the current that can flow through the LED's. This protects the LEDs and controls their brightness.

Online Information

Two sets of information can be downloaded from the product page where the kit can also be reordered from. The 'Essential Information' contains all of the information that you need to get started with the kit and the 'Teaching Resources' contains more information on soldering, components used in the kit, educational schemes of work and so on and also includes the essentials. Download from:

www.kitronik.co.uk/2118

This kit is designed and manufactured in the UK by Kitronik

Telephone: +44 (0) 845 8380781

Sales email: sales@kitronik.co.uk

Tech support email: support@kitronik.co.uk

Web: www.kitronik.co.uk

www.kitronik.co.uk/twitter

www.kitronik.co.uk/facebook

www.kitronik.co.uk/youtube

www.kitronik.co.uk/google