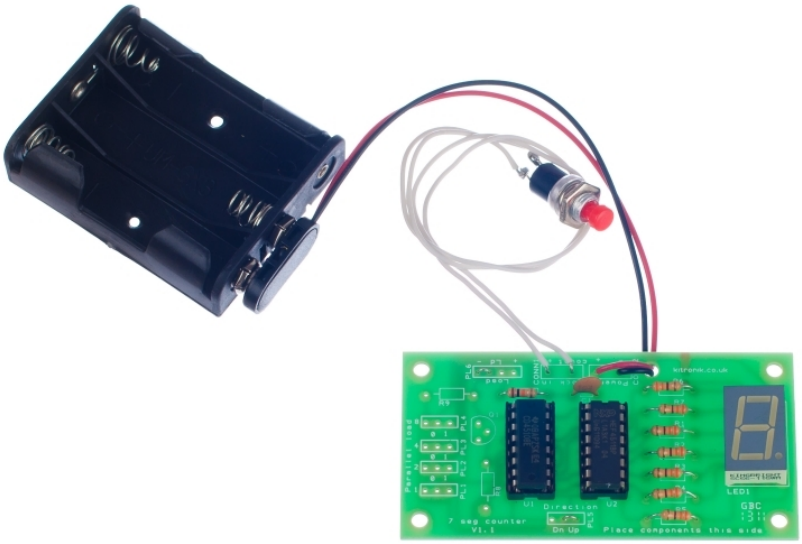
Kitronik

TEACHING RESOURCES

SCHEMES OF WORK
DEVELOPING A SPECIFICATION
COMPONENT FACTSHEETS
HOW TO SOLDER GUIDE

CREATE YOUR OWN SCORE BOARD WITH THIS

7 SEGMENT LED DISPLAY KIT



Version 2.0

Index of Sheets

TEACHING RESOURCES
- Index of Sheets
- Introduction
- Schemes of Work
- Answers
- The Design Process
- The Design Brief
- Investigation / Research
- Developing a Specification
- Design
- Design Review (group task)
- Soldering in Ten Steps
- Resistor Values
- LEDs & Current Limit Resistors
- LEDs Continued
- Capacitor Basics
- Evaluation
- Packaging Design

ESSENTIAL INFORMATION
- Which pages of build instructions do I need?
- Build Instructions
- Build Instructions – Standard Configuration
- Build Instructions – Options
- Checking Your PCB
- Adding an On / Off Switch
- Fault finding flowchart
- Switch Debounce
- Designing the Enclosure
- How the Seven Segment Display Counter Works
- Online Information

Introduction

About the project kit

Both the project kit and the supporting material have been carefully designed for use in KS3 Design and Technology lessons. The project kit has been designed so that even teachers with a limited knowledge of electronics should have no trouble using it as a basis from which they can form a scheme of work.

The project kits can be used in two ways:

1. As part of a larger project involving all aspects of a product design, such as designing an enclosure for the electronics to fit into.
2. On their own as a way of introducing electronics and electronic construction to students over a number of lessons.

This booklet contains a wealth of material to aid the teacher in either case.

Using the booklet

The first few pages of this booklet contains information to aid the teacher in planning their lessons and also covers worksheet answers. The rest of the booklet is designed to be printed out as classroom handouts. In most cases all of the sheets will not be needed, hence there being no page numbers, teachers can pick and choose as they see fit.

Please feel free to print any pages of this booklet to use as student handouts in conjunction with Kitronik project kits.

Support and resources

You can also find additional resources at www.kitronik.co.uk. There are component fact sheets, information on calculating resistor and capacitor values, puzzles and much more.

Kitronik provide a next day response technical assistance service via e-mail. If you have any questions regarding this kit or even suggestions for improvements, please e-mail us at:

support@kitronik.co.uk

Alternatively, phone us on 0845 8380781.

Schemes of Work

Two schemes of work are included in this pack; the first is a complete project including the design & manufacture of an enclosure for the kit (below). The second is a much shorter focused practical task covering just the assembly of the kit (next page). Equally, feel free to use the material as you see fit to develop your own schemes.

Before starting we would advise that you to build a kit yourself. This will allow you to become familiar with the project and will provide a unit to demonstrate.

Complete product design project including electronics and enclosure

Hour 1	Introduce the task using 'The Design Brief' sheet. Demonstrate a built unit. Take students through the design process using 'The Design Process' sheet. Homework: Collect examples of score board products and/or some electronic display products. List the common features of these products on the 'Investigation / Research' sheet.
Hour 2	Develop a specification for the project using the 'Developing a Specification' sheet. Resource: Sample of products. Homework: Using the internet or other search method, find out what is meant by 'design for manufacture'. List five reasons why design for manufacture should be considered on any design project.
Hour 3	Read 'Designing the Enclosure' sheet. Develop a product design using the 'Design' sheet. Homework: Complete design.
Hour 4	Using cardboard, get the students to model their enclosure design. Allow them to make alterations to their design if the model shows any areas that need changing.
Hour 5	Split the students into groups and get them to perform a group design review using the 'Design Review' sheet.
Hour 6	Using the 'Soldering in Ten Steps' sheet, demonstrate and get students to practice soldering. Start the 'Resistor Value' and 'LEDs & Current Limit Resistors' worksheets. Homework: Complete any of the remaining resistor tasks.
Hour 7	Build the electronic kit using the 'Build Instructions'.
Hour 8	Complete the build of the electronic kit. Check the completed PCB and fault find if required using the 'Checking Your PCB' section and the fault finding flow chart. Homework: Read 'How the 7 Segment LED Display Works' sheet.
Hour 9	Build the enclosure.
Hour 10	Build the enclosure.
Hour 11	Build the enclosure.
Hour 12	Using the 'Evaluation' and 'Improvement' sheet, get the students to evaluate their final product and state where improvements can be made.

Additional Work

Package design for those who complete ahead of others.

Electronics only

Hour 1	Introduction to the kit demonstrating a built unit. Using the 'Soldering in Ten Steps' sheet, practice soldering.
Hour 2	Build the kit using the 'Build Instructions'.
Hour 3	Check the completed PCB and fault find if required using 'Checking Your PCB' and fault finding flow chart.

Answers

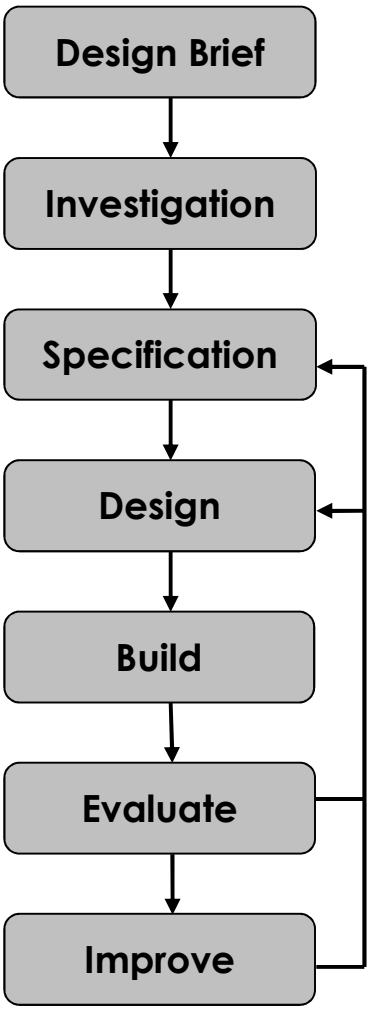
Resistor questions

1st Band	2nd Band	Multiplier x	Value
Brown	Black	Yellow	*100,000 Ω*
Green	Blue	Brown	*560 Ω*
Brown	Grey	Yellow	*180,000Ω*
Orange	White	Black	*39Ω*

Value	1st Band	2nd Band	Multiplier x
180 Ω	Brown	Grey	*Brown*
3,900 Ω	Orange	White	*Red*
47,000 (47K) Ω	Yellow	Violet	*Orange*
1,000,000 (1M) Ω	Brown	Black	*Green*

The Design Process

The design process can be short or long, but will always consist of a number of steps that are the same on every project. By splitting a project into these clearly defined steps, it becomes more structured and manageable. The steps allow clear focus on a specific task before moving to the next phase of the project. A typical design process is shown on the right.



Design brief

What is the purpose or aim of the project? Why is it required and who is it for?

Investigation

Research the background of the project. What might the requirements be? Are there competitors and what are they doing? The more information found out about the problem at this stage, the better, as it may make a big difference later in the project.

Specification

This is a complete list of all the requirements that the project must fulfil - no matter how small. This will allow you to focus on specifics at the design stage and to evaluate your design. Missing a key point from a specification can result in a product that does not fulfil its required task.

Design

Develop your ideas and produce a design that meets the requirements listed in the specification. At this stage it is often normal to prototype some of your ideas to see which work and which do not.

Build

Build your design based upon the design that you have developed.

Evaluate

Does the product meet all points listed in the specification? If not, return to the design stage and make the required changes. Does it then meet all of the requirements of the design brief? If not, return to the specification stage and make improvements to the specification that will allow the product to meet these requirements and repeat from this point. It is normal to have such iterations in design projects, though you normally aim to keep these to a minimum.

Improve

Do you feel the product could be improved in any way? These improvements can be added to the design.

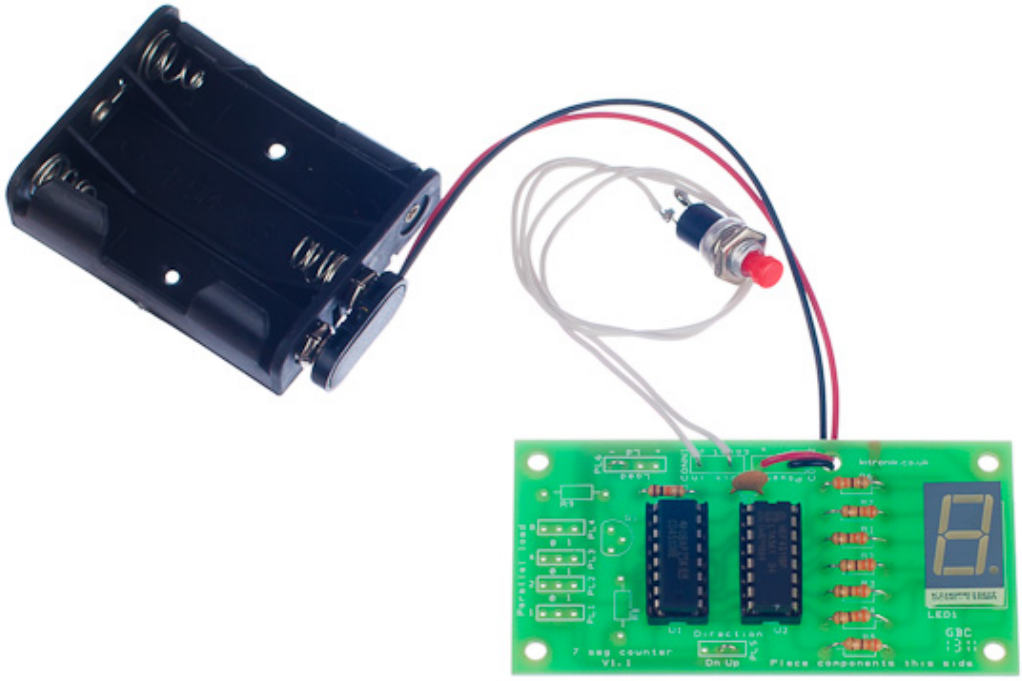
The Design Brief

A game manufacturer has developed a score counter for use with some of its products. The counter can count up or down between zero and nine. The circuit has been developed to the point where they have a working Printed Circuit Board (PCB).

The manufacturer would like ideas for an enclosure for the PCB and has asked you to do this for them. You need to identify the type of game that it will be used with (quiz, table football etc.) and it is important that you make sure that the final design meets all of the requirements that you identify for such a product.

Complete circuit

A fully built circuit is shown below.



Investigation / Research

Using a number of different search methods, find examples of similar products that are already on the market. Use additional pages if required.

Name…… Class……

Developing a Specification

Using your research into the target market for the product, identify the key requirements for the product and explain why each of these is important.

Name…… Class……

Requirement	Reason
Example: The enclosure should have a hole for the seven segment display.	Example: So that the display can be easily seen.

Design

Develop your ideas to produce a design that meets the requirements listed in the specification.

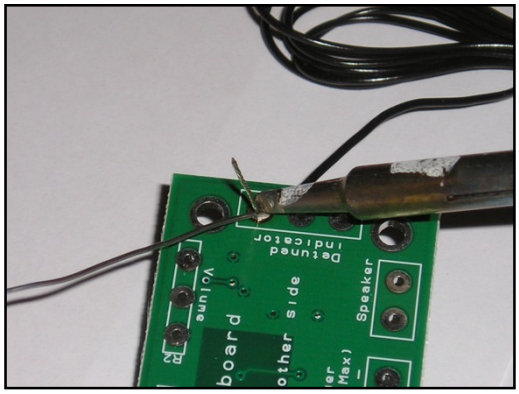
Name…… Class……

Design Review (group task)

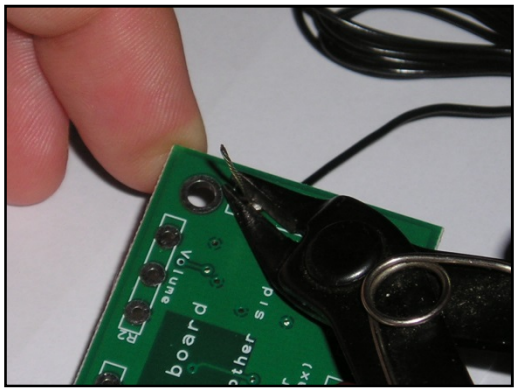
Split into groups of three or four. Take it in turns to review each person's design against the requirements of their specification. Also look to see if you can spot any additional aspects of each design that may cause problems with the final product. This will allow you to ensure that you have a good design and catch any faults early in the design process. Note each point that is made and the reason behind it. Decide if you are going to accept or reject the comment made. Use these points to make improvements to your initial design.

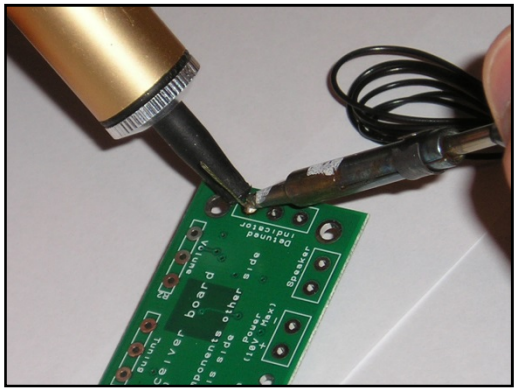
Comment	Reason for comment	Accept or Reject

Soldering in Ten Steps

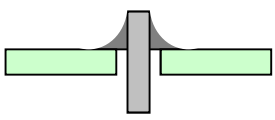
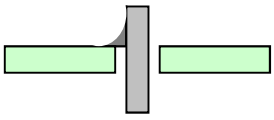
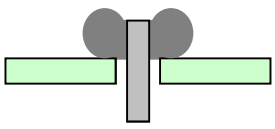


1. Start with the smallest components working up to the taller components, soldering any interconnecting wires last.
2. Place the component into the board, making sure that it goes in the right way around and the part sits flush against the board.
3. Bend the leads slightly to secure the part.
4. Make sure that the soldering iron has warmed up and if necessary, use the damp sponge to clean the tip.
5. Place the soldering iron on the pad.
6. Using your free hand, feed the end of the solder onto the pad (top picture).
7. Remove the solder, then the soldering iron.
8. Leave the joint to cool for a few seconds.
9. Using a pair of cutters, trim the excess component lead (middle picture).
10. If you make a mistake heat up the joint with the soldering iron, whilst the solder is molten, place the tip of your solder extractor by the solder and push the button (bottom picture).





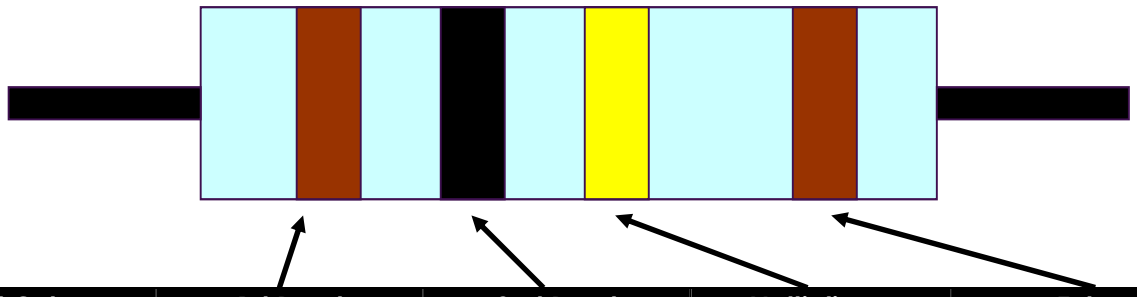
Solder joints

		
Good solder joint	Too little solder	Too much solder

Resistor Values

A resistor is a device that opposes the flow of electrical current. The bigger the value of a resistor, the more it opposes the current flow. The value of a resistor is given in Ω (ohms) and is often referred to as its 'resistance'.

Identifying resistor values



Band Colour	1st Band	2nd Band	Multiplier x	Tolerance
Silver			÷ 100	10%
Gold			÷ 10	5%
Black	0	0	1	
Brown	1	1	10	1%
Red	2	2	100	2%
Orange	3	3	1000	
Yellow	4	4	10,000	
Green	5	5	100,000	
Blue	6	6	1,000,000	
Violet	7	7		
Grey	8	8		
White	9	9		

Example: Band 1 = Red, Band 2 = Violet, Band 3 = Orange, Band 4 = Gold

The value of this resistor would be:
2 (Red) **7** (Violet) x **1,000** (Orange) = 27 x 1,000
= **27,000** with a 5% tolerance (gold)
= **27KΩ**

Too many zeros?

Kilo ohms and mega ohms can be used:

1,000Ω = 1K

1,000K = 1M

Resistor identification task

Calculate the resistor values given by the bands shown below. The tolerance band has been ignored.

1st Band	2nd Band	Multiplier x	Value
Brown	Black	Yellow	
Green	Blue	Brown	
Brown	Grey	Yellow	
Orange	White	Black	

Calculating resistor markings

Calculate what the colour bands would be for the following resistor values.

Value	1st Band	2nd Band	Multiplier x
180 Ω			
3,900 Ω			
47,000 (47K) Ω			
1,000,000 (1M) Ω			

What does tolerance mean?

Resistors always have a tolerance but what does this mean? It refers to the accuracy to which it has been manufactured. For example if you were to measure the resistance of a gold tolerance resistor you can guarantee that the value measured will be within 5% of its stated value. Tolerances are important if the accuracy of a resistors value is critical to a design's performance.

Preferred values

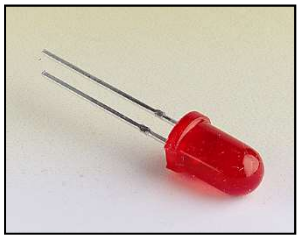
There are a number of different ranges of values for resistors. Two of the most popular are the E12 and E24. They take into account the manufacturing tolerance and are chosen such that there is a minimum overlap between the upper possible value of the first value in the series and the lowest possible value of the next. Hence there are fewer values in the 10% tolerance range.

E-12 resistance tolerance (± 10%)											
10	12	15	18	22	27	33	39	47	56	68	82

E-24 resistance tolerance (± 5 %)											
10	11	12	13	15	16	18	20	22	24	27	30
33	36	39	43	47	51	56	62	68	75	82	91

LEDs & Current Limit Resistors

Before we look at LEDs, we first need to start with diodes. Diodes are used to control the direction of flow of electricity. In one direction they allow the current to flow through the diode, in the other direction the current is blocked.



An LED is a special diode. LED stands for Light Emitting Diode. LEDs are like normal diodes, in that they only allow current to flow in one direction, however when the current is flowing the LED lights.

The symbol for an LED is the same as the diode but with the addition of two arrows to show that there is light coming from the diode. As the LED only allows current to flow in one direction, it's important that we can work out which way the electricity will flow. This is indicated by a flat edge on the LED.

For an LED to light properly, the amount of current that flows through it needs to be controlled. To do this we use a current limit resistor. If we didn't use a current limit resistor the LED would be very bright for a short amount of time, before being permanently destroyed.

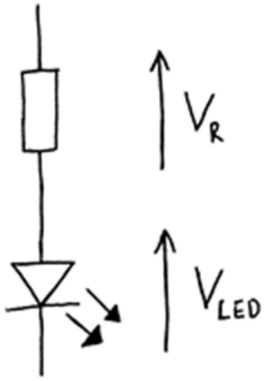
To work out the best resistor value we need to use Ohms Law. This connects the voltage across a device and the current flowing through it to its resistance.

Ohms Law tells us that the flow of current (I) in a circuit is given by the voltage (V) across the circuit divided by the resistance (R) of the circuit.

$$I = \frac{V}{R}$$

Like diodes, LEDs drop some voltage across them: typically 1.8 volts for a standard LED. However the high brightness LED used in the 'white light' version of the lamp drops 3.5 volts.

The USB lamp runs off the 5V supply provided by the USB connection so there must be a total of 5 volts dropped across the LED (V_{LED}) and the resistor (V_R). As the LED manufacturer's datasheet tells us that there is 3.5 volts dropped across the LED, there must be 1.5 volts dropped across the resistor. ($V_{LED} + V_R = 3.5 + 1.5 = 5V$).



LEDs normally need about 10mA to operate at a good brightness. Since we know that the voltage across the current limit resistor is 1.5 volts and we know that the current flowing through it is 0.01 Amps, the resistor can be calculated.

Using Ohms Law in a slightly rearranged format:

$$R = \frac{V}{I} = \frac{1.5}{0.01} = 150\Omega$$

Hence we need a 150Ω current limit resistor.

LEDs Continued

The Colour Changing LEDs used in the 'colour' version of the lamp has the current limit resistor built into the LED itself. Therefore no current limit resistor is required. Because of this, a 'zero Ω' resistor is used to connect the voltage supply of 5V directly to the Colour Changing LED.

Packages

LEDs are available in many shapes and sizes. The 5mm round LED is the most common. The colour of the plastic lens is often the same as the actual colour of light emitted – but not always with high brightness LEDs.

Advantages of using LEDs over bulbs

Some of the advantages of using an LED over a traditional bulb are:

Power efficiency	LEDs use less power to produce the same amount of light, which means that they are more efficient. This makes them ideal for battery power applications.
Long life	LEDs have a very long life when compared to normal light bulbs. They also fail by gradually dimming over time instead of a sharp burn out.
Low temperature	Due to the higher efficiency of LEDs, they can run much cooler than a bulb.
Hard to break	LEDs are much more resistant to mechanical shock, making them more difficult to break than a bulb.
Small	LEDs can be made very small. This allows them to be used in many applications, which would not be possible with a bulb.
Fast turn on	LEDs can light up faster than normal light bulbs, making them ideal for use in car break lights.

Disadvantages of using LEDs

Some of the disadvantages of using an LED over a traditional bulb are:

Cost	LEDs currently cost more for the same light output than traditional bulbs. However, this needs to be balanced against the lower running cost of LEDs due to their greater efficiency.
Drive circuit	To work in the desired manner, an LED must be supplied with the correct current. This could take the form of a series resistor or a regulated power supply.
Directional	LEDs normally produce a light that is focused in one direction, which is not ideal for some applications.

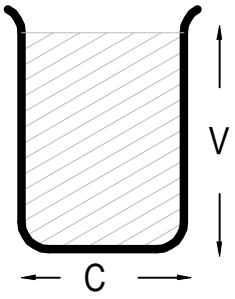
Typical LED applications

Some applications that use LEDs are:

- Bicycle lights
- Car lights (break and headlights)
- Traffic lights
- Indicator lights on consumer electronics
- Torches
- Backlights on flat screen TVs and displays
- Road signs
- Information displays
- Household lights
- Clocks

Capacitor Basics

What is a capacitor?

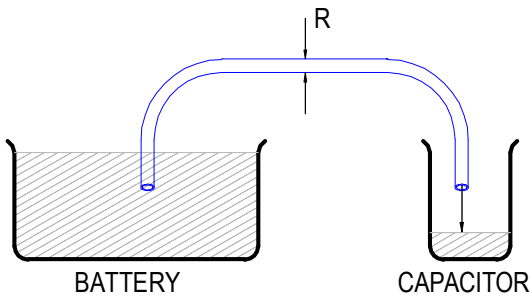


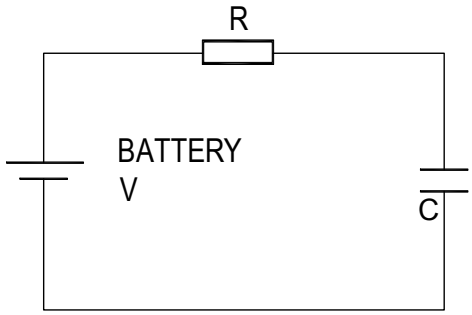
A capacitor is a component that can store electrical charge (electricity). In many ways, it is like a rechargeable battery.

A good way to imagine a capacitor is as a bucket, where the size of the base of the bucket is equivalent to the capacitance (C) of the capacitor and the height of the bucket is equal to its voltage rating (V).

The amount that the bucket can hold is equal to the size of its base multiplied by its height, as shown by the shaded area.

Filling a capacitor with charge

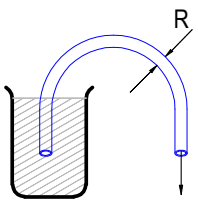




When a capacitor is connected to an item such as a battery, charge will flow from the battery into it. Therefore the capacitor will begin to fill up. The flow of water in the picture above left is the equivalent of how the electrical charge will flow in the circuit shown on the right.

The speed at which any given capacitor will fill depends on the resistance (R) through which the charge will have to flow to get to the capacitor. You can imagine this resistance as the size of the pipe through which the charge has to flow. The larger the resistance, the smaller the pipe and the longer it will take for the capacitor to fill.

Emptying (discharging) a capacitor

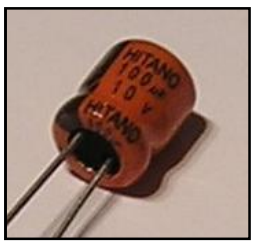


Once a capacitor has been filled with an amount of charge, it will retain this charge until it is connected to something into which this charge can flow.

The speed at which any given capacitor will lose its charge will, like when charging, depend on the resistance (R) of the item to which it is connected. The larger the resistance, the smaller the pipe and the longer it will take for the capacitor to empty.

Maximum working voltage

Capacitors also have a maximum working voltage that should not be exceeded. This will be printed on the capacitor or can be found in the catalogue the part came from. You can see that the capacitor on the right is printed with a 10V maximum working voltage.



Evaluation

It is always important to evaluate your design once it is complete. This will ensure that it has met all of the requirements defined in the specification. In turn, this should ensure that the design fulfils the design brief.

Check that your design meets all of the points listed in your specification.

Show your product to another person (in real life this person should be the kind of person at which the product is aimed). Get them to identify aspects of the design, which parts they like and aspects that they feel could be improved.

Good aspects of the design	Areas that could be improved

Improvements

Every product on the market is constantly subject to redesign and improvement. What aspects of your design do you feel you could improve? List the aspects that could be improved and where possible, draw a sketch showing the changes that you would make.

Packaging Design

If your product was to be sold in a high street electrical retailer, what requirements would the packaging have? List these giving the reason for the requirement.

Requirement	Reason

Develop a packaging design for your product that meets these requirements. Use additional pages if required.

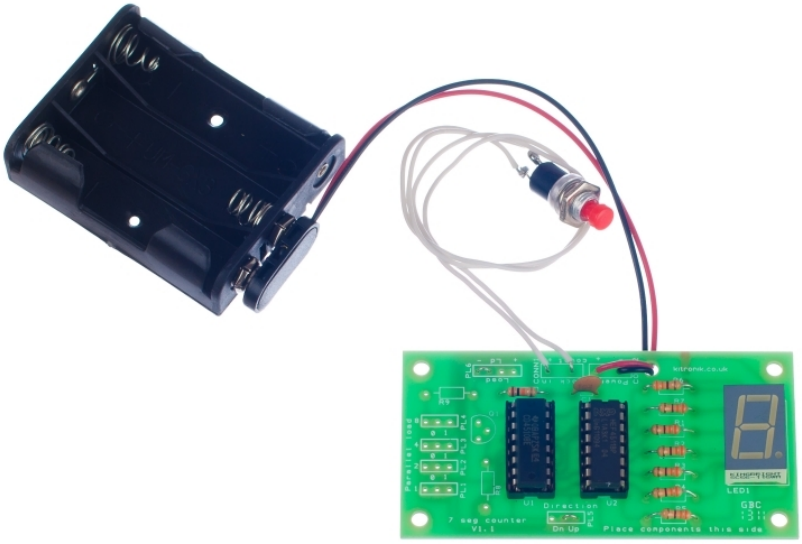
Kitronik

ESSENTIAL INFORMATION

BUILD INSTRUCTIONS
CHECKING YOUR PCB & FAULT-FINDING
MECHANICAL DETAILS
HOW THE KIT WORKS

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

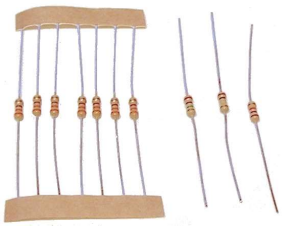
www.kitronik.co.uk/2118

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.

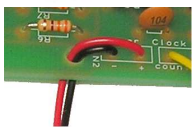
3 INSERT THE 7 SEGMENT DISLPAY

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

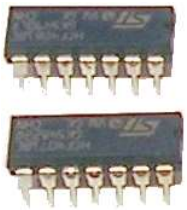
Now you must attach the battery clip. Start by feeding the leads through the strain relief hole near R6. The wire should be fed in from the rear of the board (see right, below).

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.

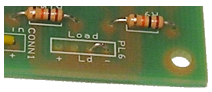


Build Instructions – Standard Configuration

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.

7 Segment LED Display Essentials

www.kitronik.co.uk/2118

Build Instructions – Options

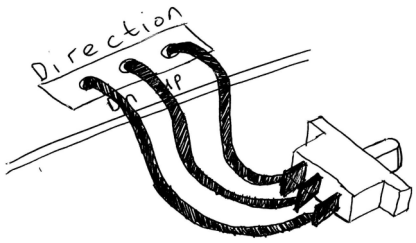
Count direction

Up or down

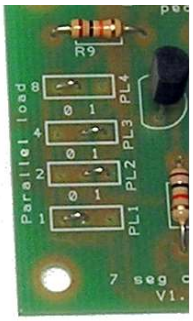
Setting the direction in which the counter will count (either up or down) is done by adding a wire link on the PCB. Find the terminals labeled 'Direction' (shown below). You need to link the terminals above the text of the desired direction. In the picture below, the terminals above the text 'up' have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



Example of loading 6

With parallel load

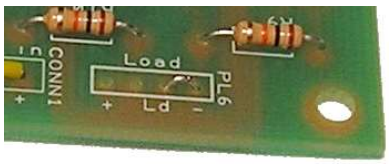
A predetermined value can be loaded on demand. To do this the number that is going to be loaded needs to be set using the 'Parallel load' terminals and a means of triggering the load will need to be added. The number that will be loaded is selected by placing four wire links into the 'parallel load'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

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

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

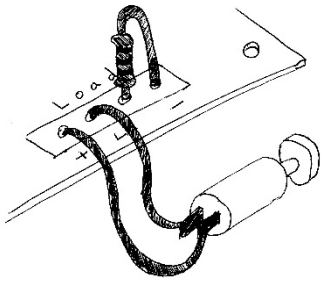
7 Segment LED Display Essentials

www.kitronik.co.uk/2118

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.

7 Segment LED Display Essentials

www.kitronik.co.uk/2118

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:

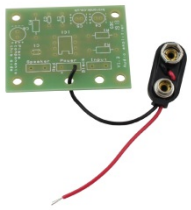
- The shape of the ICs and IC holders match the outline on the PCB.
- The dot on the 7 segment display is on the bottom right and NOT the top left.
- The coloured bands on R1 – R7 are orange, orange, brown.
- The battery clip red wire connects to '+' and the black wires to '-'.

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.

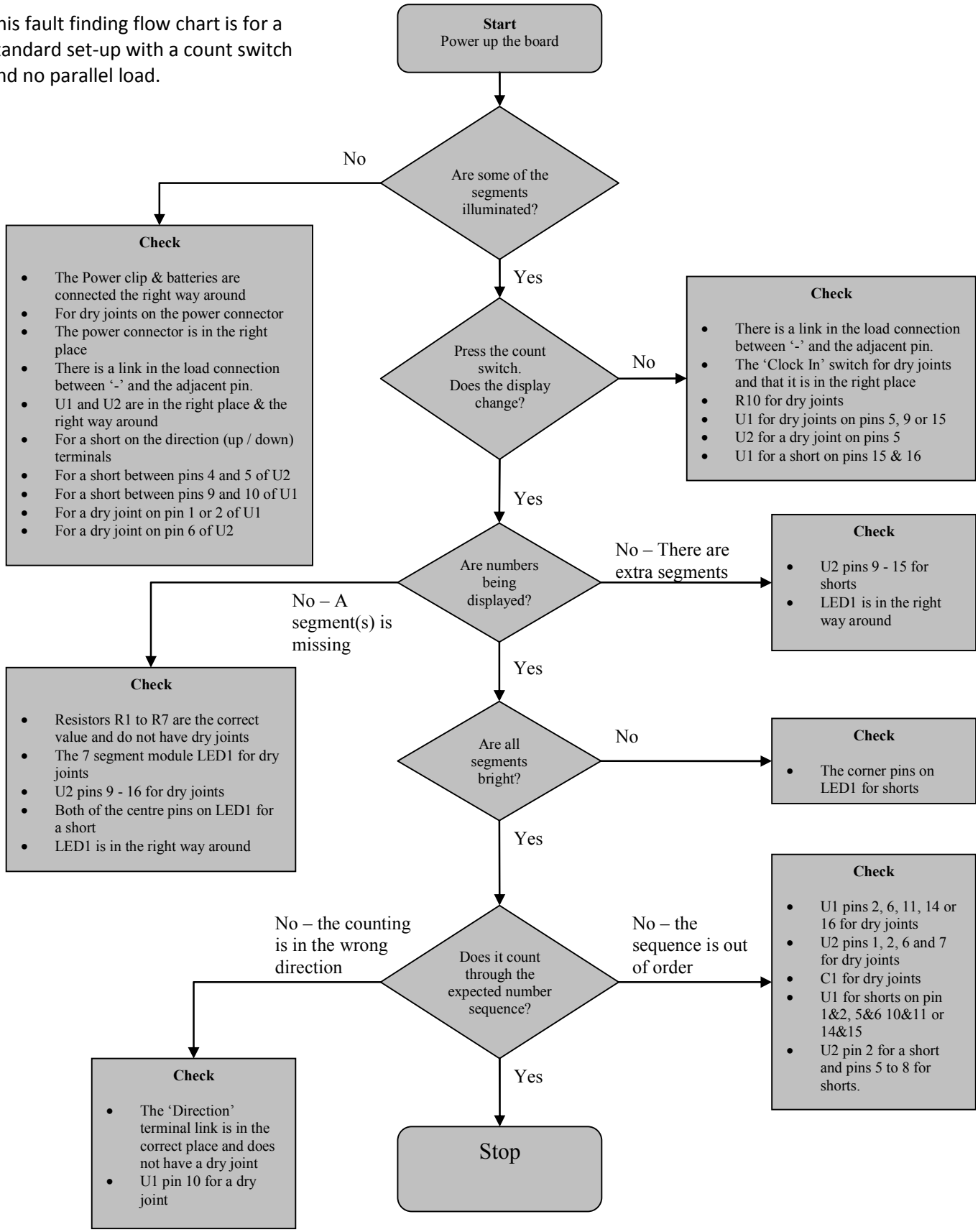
3

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

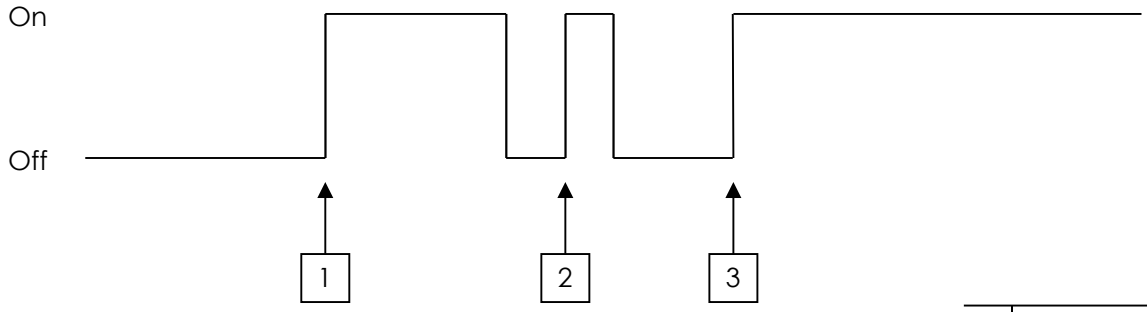
This fault finding flow chart is for a standard set-up with a count switch and no parallel load.



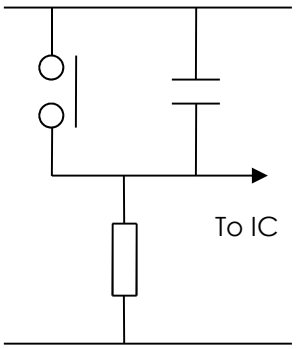
Switch Debounce

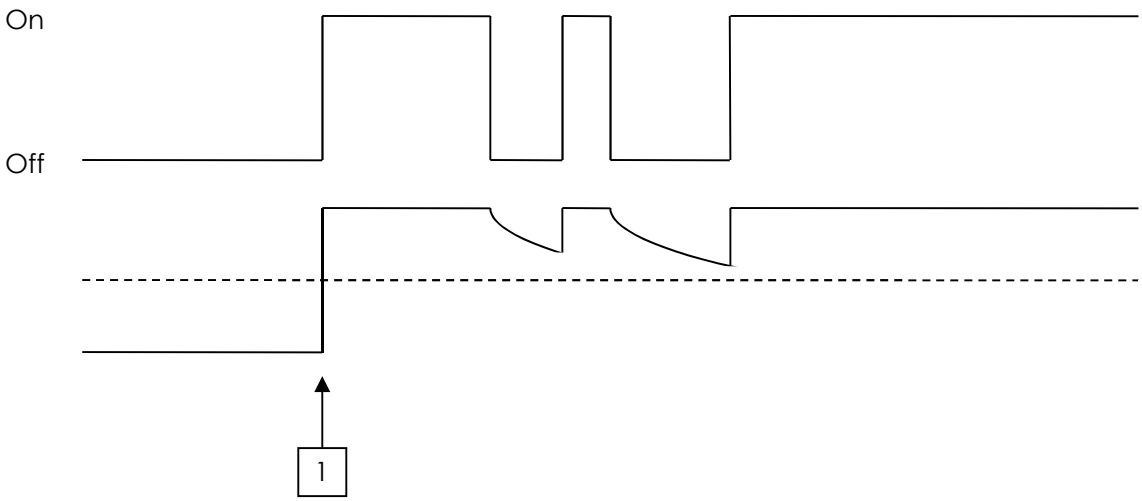
If a switch is used to complete a circuit with a lamp, it will appear that when the switch is pressed the lamp goes straight from off to on. However as the switch is pressed it will probably make contact several times during the transition from off to on. With a simple circuit such as a switch being 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:



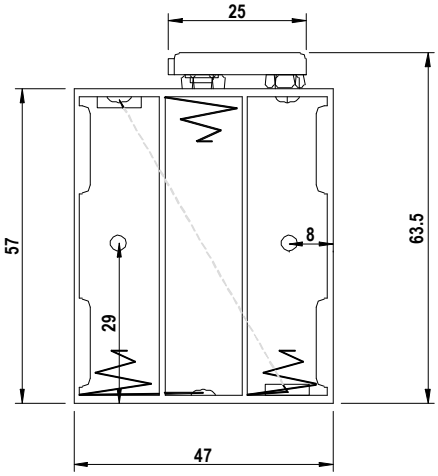


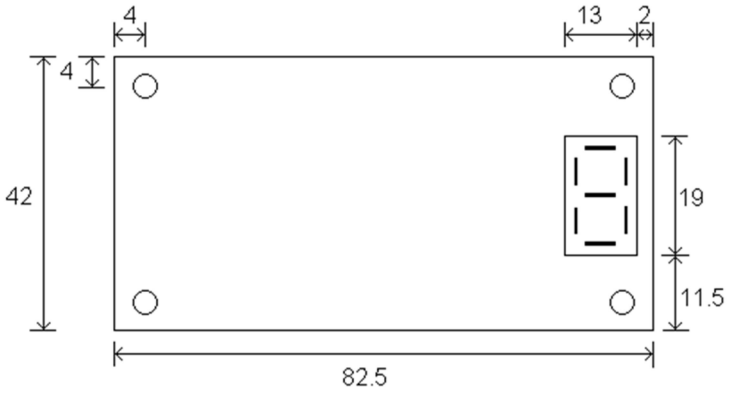
Designing the Enclosure

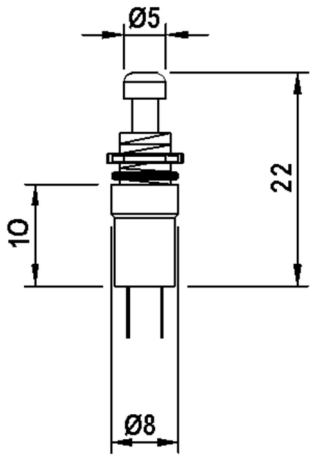
When you design the enclosure, you will need to consider:

- 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).

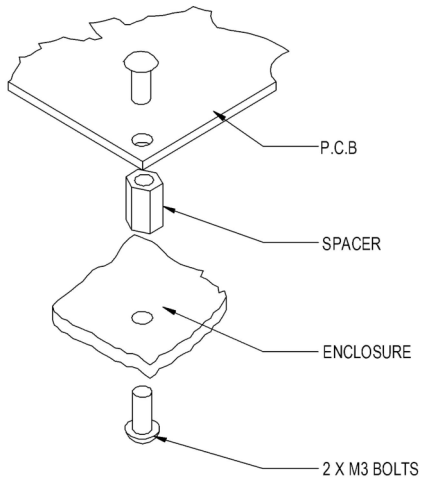
These technical drawings of the parts should help you to design your enclosure.







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



Mounting the PCB to the enclosure

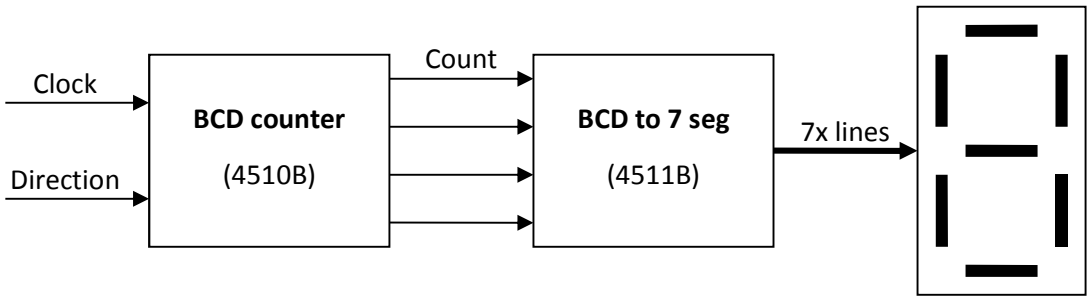
The drawing to the left shows how a hex spacer can be used with two bolts to fix the PCB to the enclosure.

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

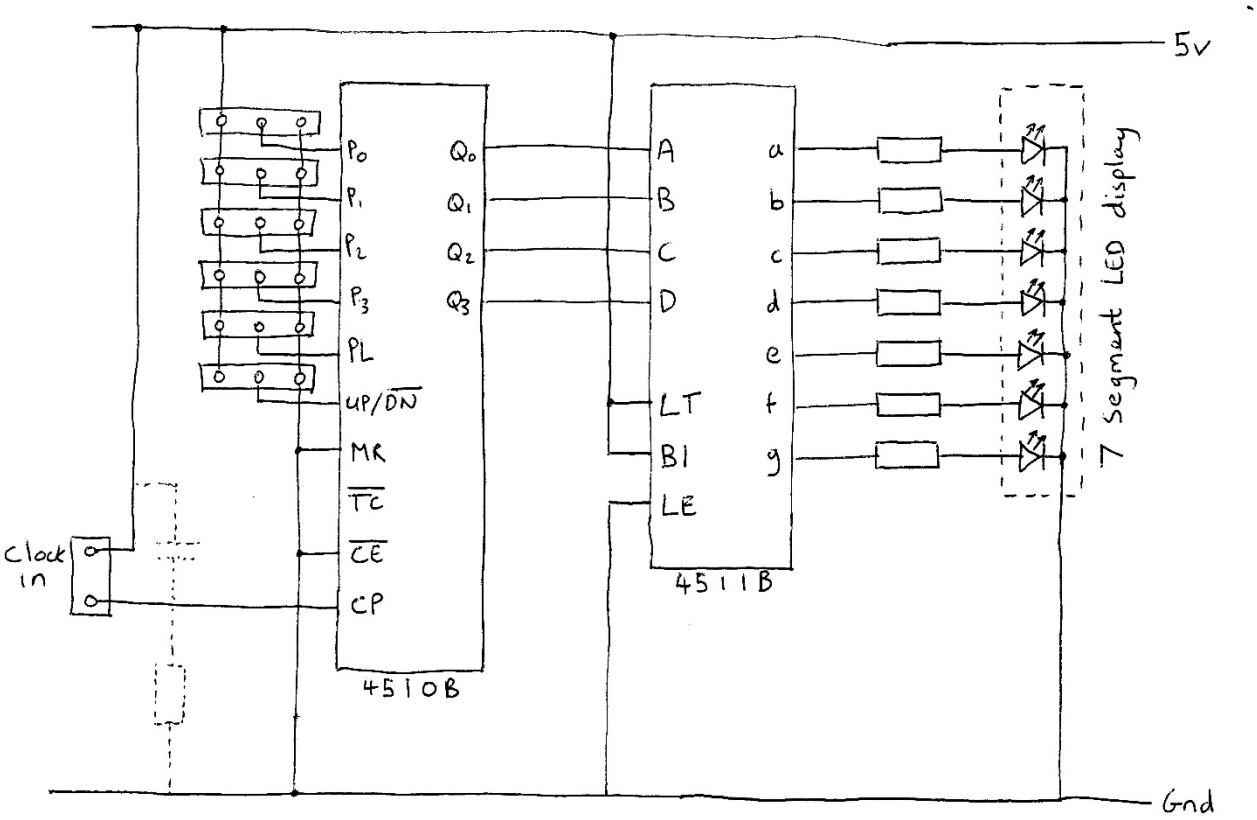
How the Seven Segment Display Counter Works

Introduction

The basic block diagram for the system is shown below:

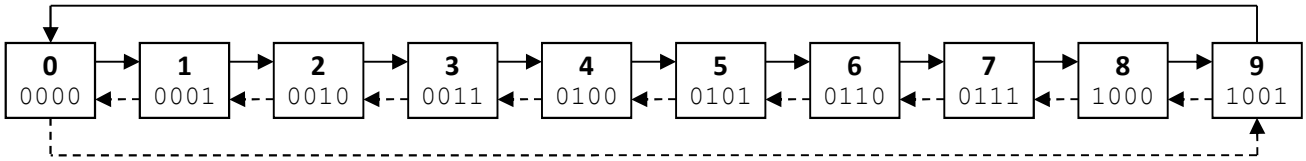


On the left of the diagram is a clock source. When this signal changes it clocks (steps) the binary coded decimal (BCD) counter. Each time the counter is clocked, it moves on to the next number in the sequence. The next stage in the process is to convert the binary number from the counter into an output,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



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

Every effort has been made to ensure that these notes are correct, however Kitronik accept no responsibility for issues arising from errors / omissions in the notes.

© Kitronik Ltd - Any unauthorised copying / duplication of this booklet or part thereof for purposes except for use with Kitronik project kits is not allowed without Kitronik's prior consent.