locktronics

LK70A and LK70B

Basic and Extended Logic Kits

ASSIGNMENTS BOOK

All due care has been taken to ensure that the contents of this manual are accurate and up to date. However, if any errors are discovered, please inform TQ so the problem may be rectified.

A Packing Contents List is supplied with the equipment. Carefully check the contents of the package(s) against the list. If any items are missing or damaged, contact your local TQ Agent or TQ immediately.

LK/DB/0706

TQ Education and Training Ltd

Contents

TQ Education and Training Ltd

locktronics

LK70A and LK70B

ASSIGNMENTS BOOK

Introduction

Figure 1 The LK70A (SB) and LK70B (SB) Component Kits (AN kits are similar).

Locktronics kits:

- make learning easier and safer for the pupil
- make teaching easier for the teacher

Most Locktronics kits are intended for teaching electronics but they also offer many advantages in the study of basic electricity.

Circuit changes are quick and simple to perform, so more practical work or detailed investigations can be done in the time given to these subjects. In addition the pupil is working solely with theory diagrams and quickly learns to think in these terms.

The apparatus is extremely robust and if used properly will give many years of useful service.

This Book and its Assignments

The assignments in this book continue from the assignments in the LK70 Student Group Kit book. As these kits are add-ons to the LK70, you must use some of the components from both kits to complete these assignments.

The LK70A is the basic logic kit. When used with the LK70 kit you have enough parts to do some but not all of these assignments.

The LK70B is the extended logic kit. When used with the LK70 kit you have enough parts to do all of these assignments, except for the last two (exclusive OR gate) assignments.

LK70A and LK70B Components

The LK70A and LK70B Kits (shown in Figure 1) are component kits. TQ recommends that the dedicated LK750 Baseboard, power supplies and leads (available separately) are used with the kits.

The SB and AN versions of the kits are physically identical. The only difference is that the logic gates are labelled to the ANSI (AN) or the systems block (SB) design.

Baseboard LK750 (Available Separately)

A Baseboard with 7 rows and 5 columns of pillars.

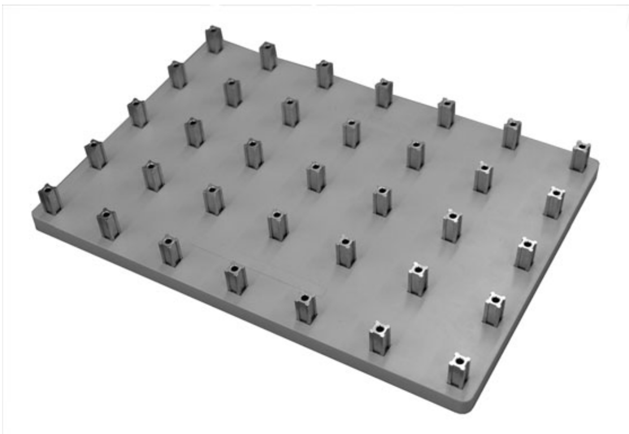

Figure 2 The LK750 Baseboard.

D.C Power Supply CU600T (Available Separately)

A direct current power supply with a key switch at the back to select either a fixed 5 volt supply or a variable 2 to 15 volt dual supply. Maximum 1 ampere rating.

Figure 3 The CU600T Power Supply.

A.C Power Supply CU600AC (Available Separately)

An alternating current source power supply with a fixed 15 V A.C Output. Maximum 500 mA rating.

Figure 4 The CU600AC Power Supply.

Lead Set LKLS (Available Separately)

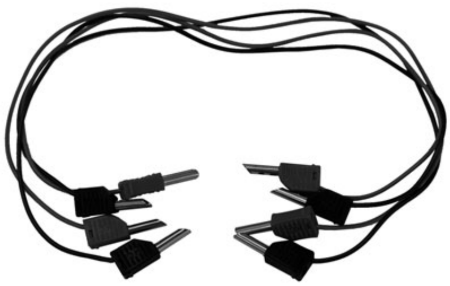

Figure 5 The LKLS Lead Set.

Current Probe LKCP (Available Separately)

Figure 6 The LKCP Current Probe.

Notes to the Supervisor or Teacher

Power Supplies

The CU600 power supply units contain short circuit protection. The CU600T gives an audible warning of a short circuit. This reduces the possibility of circuits being left in a short circuit condition.

Use the recommended power supplies for these assignments or suitably fused and protected low voltage power supplies or batteries of the correct voltage.

General Care and Maintenance

During regular use the kits may become dirty.

Clean the polystyrene component carriers with a damp cloth and a little liquid detergent. Never use spirit solvent. Make sure the carriers are dry before use.

The phosphor bronze contacts are self-cleaning and will retain their proper shapes in normal use. If for any reason they are bent out of shape, use a pair of long-nosed pliers to correct the shape.

CAUTION

Contact with resin bonded material such as chipboard, plywood, etc. can damage the plating on the carrier contact springs thus impairing their efficiency. Do not store the components in such material.

Notes to the Student

As you work through these assignments:

- Copy each individual circuit used into your notebook, together with its title.
- In your diagrams, always use the correct symbol for the components.
- Make a note of any important facts or information which you have learned and may need to recall for your examinations. Brief notes are usually enough.
- Disconnect the power supply leads before making any circuit changes. This will prevent accidental damage to components, particularly in assignments using transistors and other semi-conductor devices.
- Note that some components are different, even though they look the same they may not perform in the same way. There are two different types of bulbs, and several different resistors.

Depending upon the particular subject and examination board setting your exam, you may not need to cover all the assignments given. However, check with your teacher to find out about this.

We hope you find the assignments interesting and stimulating enough to make you want to find out more about the exciting subjects of electronics and electricity which are changing the world in which we live.

TQ Education and Training Ltd.

British Standard Symbols

Symbols are used in diagrams and on the component carriers of the Locktronics range. These symbols are based on a set of symbols approved by the British Standards Institute (BSI). The most common symbols are shown in Figures 7 and 8.

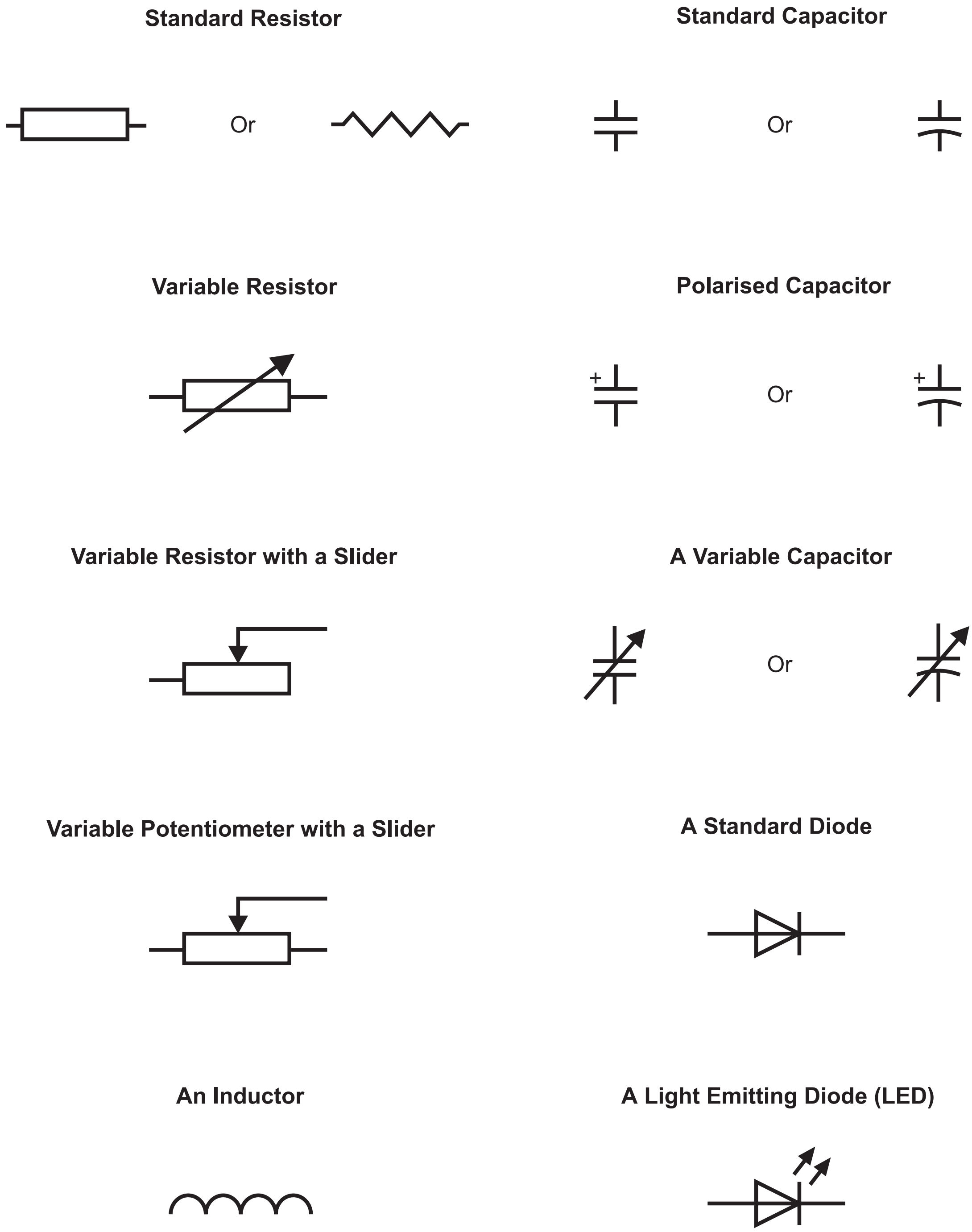

Figure 7 Common component symbols.

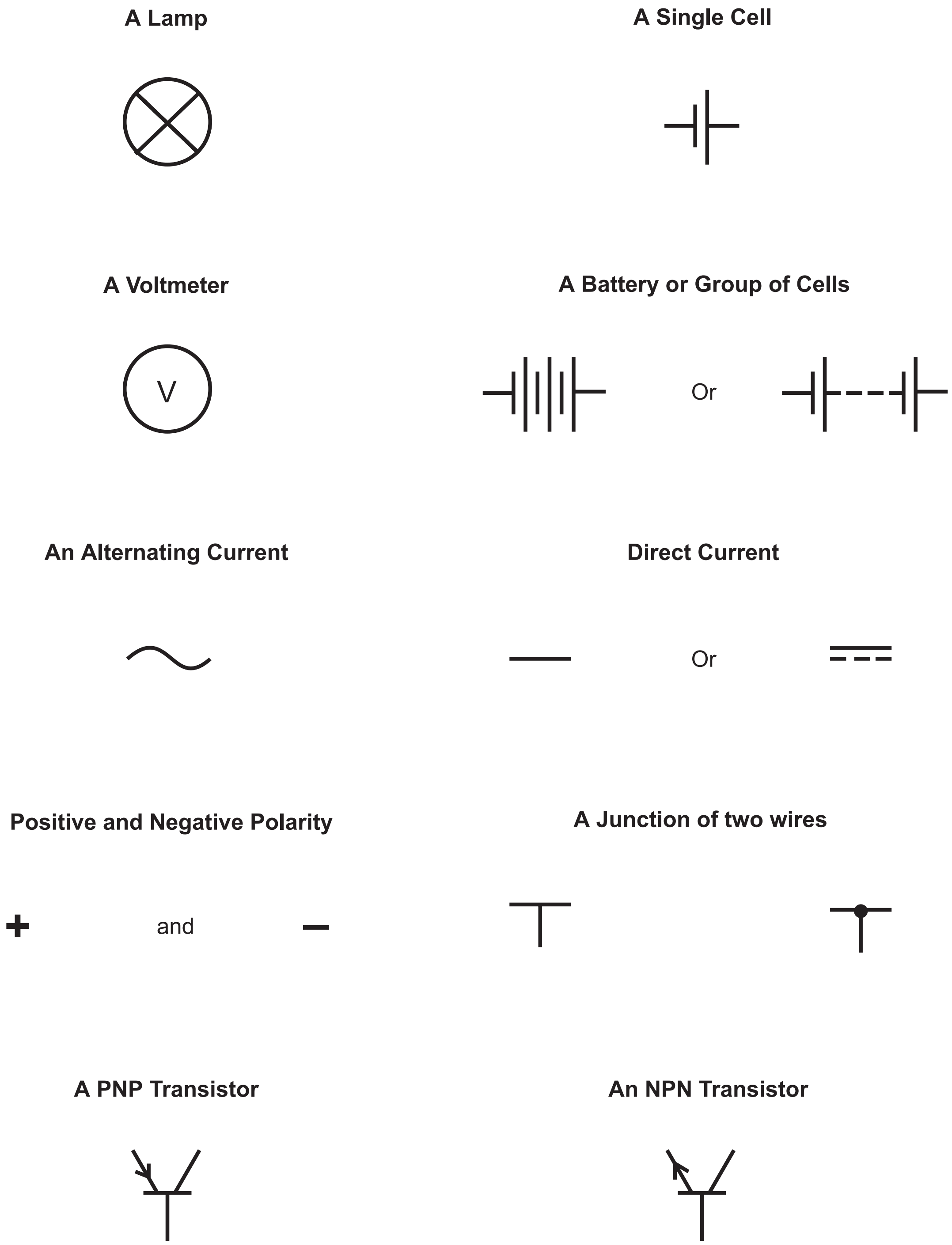

Figure 8 Common component symbols.

Standard Assignments

1. Introduction To Logic

As you probably know, in a digital computer the numerical data and the instructions which tell the computer what to do are all in binary form. This means they can easily be represented by electronic switches like the transistor which can be either on or off to represent a 1 or 0. Because there are no moving parts the condition of the switches can be reversed at extremely high speed.

In addition to computers the same system is used in modern control circuits of many different kinds in industrial and even domestic equipment. Did you know that a modern washing machine uses the same kind of electronic circuits as those used in a computer?

We call these special circuits **LOGIC** circuits or **LOGIC GATES**.

If you wish to understand the use of logic gates the first thing is to understand the idea of opposite pairs.

For example: Black is NOT white
False is NOT true
Up is NOT down

Think of as many opposite pairs as you can, then copy Table 1 into your notebook and complete it as you do so.

High	
Male	
Tall	
Strong	
Binary 1	

Table 1 Opposite Pairs

From our point of view the most important opposite pair is of course the last in the table as voltage levels representing these are used as logic signals in logic circuits.

The voltage levels used in this kit are +6 V to represent logic 1 and 0 V to represent logic 0.

There are five logic gates to learn about. These are the **OR** gate, the **AND** gate, the **NOT** gate, the **NOR** gate and the **NAND** gate.

2. The 'OR' Gate

Each type of logic gate has its own special symbol. The OR gate has two or more inputs and a single output. It is represented in circuits by the symbol shown in Figure 9. Refer to the **Logic Symbols** on page 45 for more details.

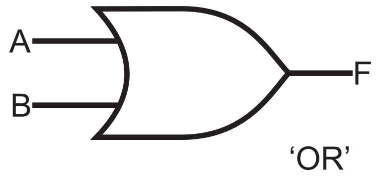

Figure 9 The OR Gate Symbol

The two inputs are labelled A and B and the output is labelled F. F was chosen for the output symbol because the output is a function of (depends upon) the logical operation on the inputs.

Assemble the circuit shown in Figure 10, connect your 6 V supply and switch on.

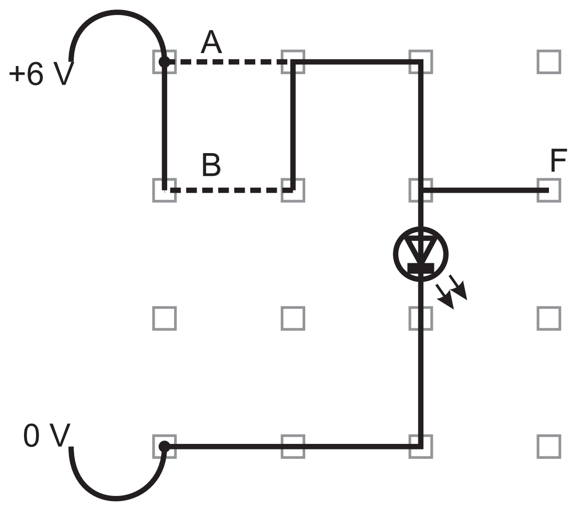

Figure 10 The OR Gate

If you insert a link at input A indicated by the dotted line you will see that the output LED lights to indicate a logic 1 at the output F. (LED lit = logic 1, LED out = logic 0). Remove the link and observe a logic 0 at the output F.

Now insert a link at input B. What happens? The output F once again indicates a logic 1.

You are using the links as simple switches.

Link in means an input of logic 1, link out means an input of logic 0.

This time input two logic 1's simultaneously by the insertion of both links at the same time. What happens? Once again a logic 1 output at F.

This simple parallel switch circuit is the simplest way of showing the action of the **OR** operation. If we use three parallel arms it will show the action of a three input **OR** GATE. We can sum up this action thus:

An **OR** gate gives an output of logic 1 if:
either Input A
OR Input B
OR ***both*** are at logic 1.

Obviously this simple circuit is of no use in computers or control. You will learn about real electronic gates later on.

3. Truth Tables

Probably the simplest way of expressing the function of a particular logic gate is to draw up a table giving all the possible input combinations for that particular gate together with their corresponding outputs. Such a table is called a TRUTH TABLE.

Copy Table 2 into your notebook, then repeat the **The 'OR' Gate** and complete the third column (F) indicating the output of an OR gate for all four pairs of possible input conditions. Check it against the 'OR' Truth Table shown in the .

When completed this is the Truth Table for a two input OR gate.

OR		
A	**B**	**F**
0	0	
0	1	
1	0	
1	1	

Table 2 Truth Table for a Two Input OR Gate

4. The 'AND' Gate

The AND gate also has two or more inputs and only one output. Its symbol is shown in Figure 11. Refer to the **Logic Symbols** on page 45 for more details.

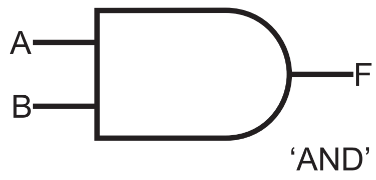

Figure 11 The Symbol for an AND Gate

Note that this time we have a simple SERIES circuit instead of a PARALLEL one.

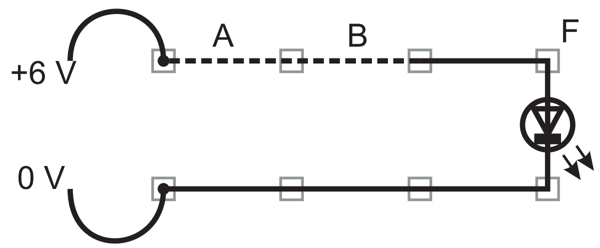

Figure 12 The AND Gate

Connect the power supply and switch on as usual then first input a logic 1 at input A by inserting a link. What output is indicated? A logic 0 of course. Now input a logic 1 at input B by inserting a second link. Now what happens? The output F immediately indicates a logic 1. This simple series switching circuit illustrates the action of an AND gate.

> An **AND** gate only gives an output of logic 1, if ***both*** Input A **AND** Input B are at logic 1

Make a Truth Table for the AND gate in your notebook. Work through this assignment to complete the column for output F then check your Truth Table with the AND table shown in the **Appendix**.

5. The IC 'NOT' Gate

This is the simplest gate. It is often called an Inverter or Negator. It has only one input and one output. It is important to realise at this point that the inputs and outputs of all logic gates can only be either ON (high voltage level = logic 1) or OFF (low voltage level = logic 0). For this reason logic gates are often described as two state devices.

The standard symbols used for the gate are shown in **Logic Symbols** on page 45. The systems symbol for a NOT gate is shown in Figure 13.

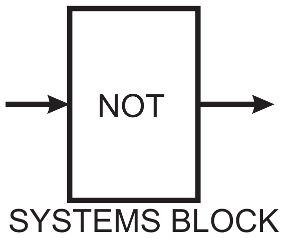

Figure 13 Systems Symbol for a NOT Gate

Copy the particular symbol used by your examining board into your notebook.

Assemble the circuit shown in Figure 14, then connect your power supply.

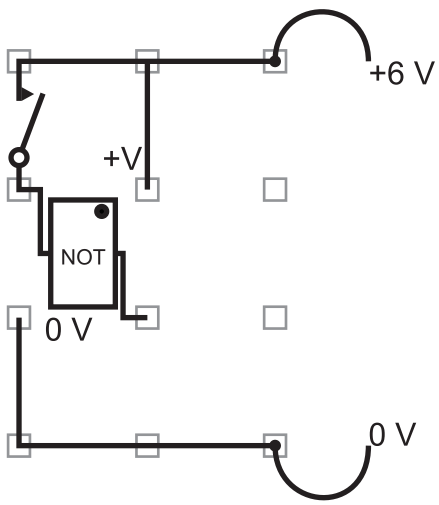

Figure 14 Circuit For the IC NOT Gate

Use the press switch to input a logic 1 (+6 V). If the switch is not pressed, the input will be a logic 0 because of the pull-down resistor. Observe the LED indicator connected to the output. If it lights the output is at logic 1. If not the output is at logic 0.

Press the switch a number of times and observe the LED. It should be fairly obvious why the gate is called an Inverter. A logic 0 input produces a logic 1 output and vice versa.

The behaviour of the gate can be described by a Table similar to Table 3, called a Truth Table.

NOT	
A	**F**
0	
1	

Table 3 Truth Table for a NOT Gate

Use the press switch a number of times then copy the truth table into your notebook and complete it by filling in the output column. Label it 'TRUTH TABLE - NOT GATE'. It is shown in the **Appendix** on page 45.

6. The Electronic 'OR' Gate (DRL)

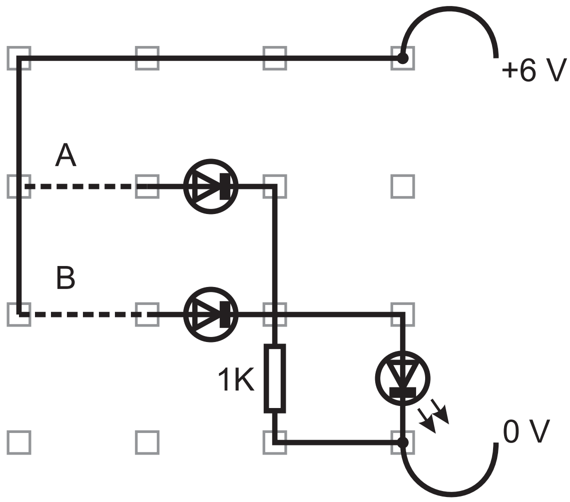

Figure 15 The Electronic OR Gate

Why is this kind of 'REAL' electronic logic gate called DRL? Try to work it out from the components used.

Apply the four possible pairs of input conditions by inserting links at inputs A and B. Observe the output shown by the LED in each case and compare with the OR Truth Table in the **Appendix** to confirm that you have made an 'OR' gate.

7. The Electronic 'AND' Gate

This is another DRL circuit.

Assemble the circuit but do not connect the supply yet.

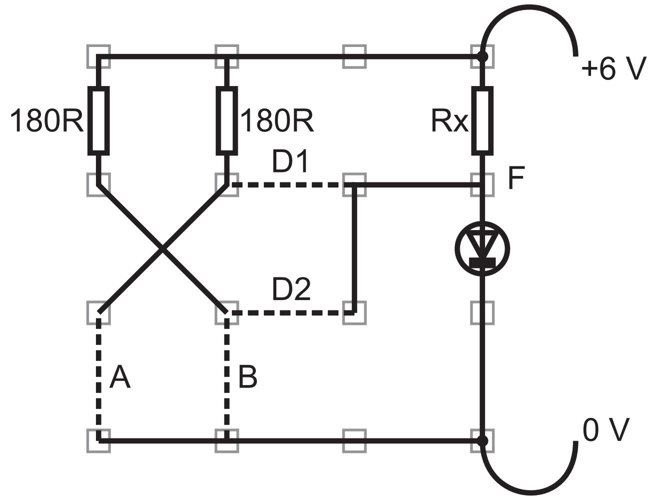

Figure 16 The Electronic AND Gate

Add two diodes to the inputs in the positions shown by the dotted lines D1 and D2. Which way round should you fit them? Think about the action of the 'AND' gate first. Fit the diodes, connect the supply and switch on.

Check your gate by trying the four lines of the Truth Table for 'AND' by inserting links at A and B to input logic 0's. If the links are not in place the inputs will automatically act as if they are at logic 1.

The correct AND circuit is shown in Figure 17.

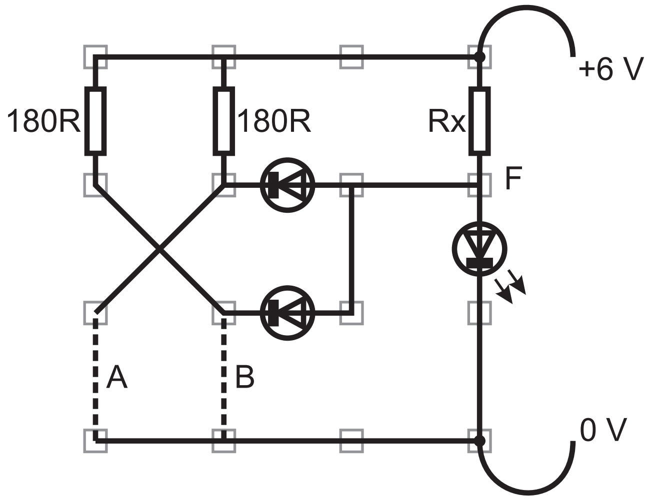

Figure 17 The Correct Circuit for the Electronic AND Gate

With the circuit shown and no inputs the gate shows a logic 1 output, ie the LED is lit. With an 'AND' gate of course this means the gate is acting as if it has two logic 1 inputs. For a logic 0 output, ie the LED out, one or both of the inputs must be connected to the 0 V rail. The diode(s) will then become forward biased and current will flow through resistor Rx (120 R). The voltage drop across the resistor will cause the output voltage at F to fall to almost 0 V.

If you connected the diodes the wrong way round the gate will not work. Reverse them and check the action of the correct circuit.

8. The 'NOT' Gate

This gate, which is often called an inverter, simply inverts its input. Remember opposite pairs. Logic 1 is NOT logic 0 and vice versa.

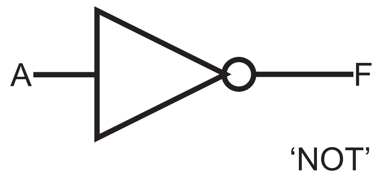

Figure 18 The NOT Gate Symbol

A NOT gate has only one input.

You should be able to answer this question: If a Transistor switch has a low input voltage what will its output voltage be? A high voltage of course. The Transistor switch acts as an inverter of logic signals.

Earlier you were told that +6 V is a logic 1 and 0 V is a logic 0 but in the most common 5 V supplied TTL (Transistor to Transistor Logic) circuits, any signal voltage between 2 V and 5 V is treated as a logic 1 and any signal voltage which between 0 V and 0.8 V is treated as a logic 0 by the logic gates.

Assemble the transistor switch circuit, connect your power supply then switch on.

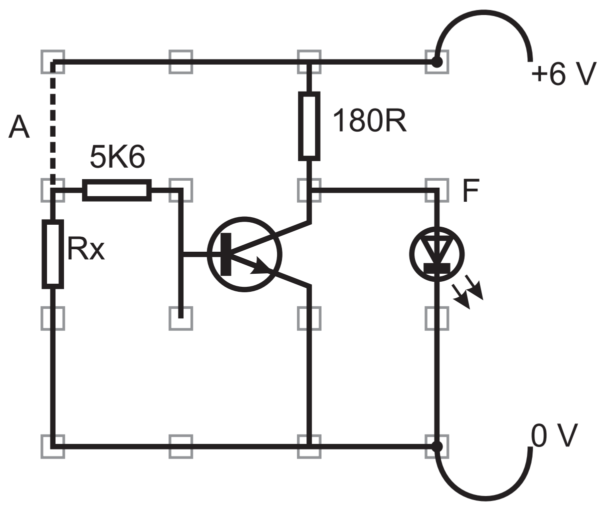

Figure 19 The NOT Gate

Note that in this circuit we are using an LED to indicate whether the output F is a logic 1 or a logic 0. There is no lamp in the collector circuit. It has been replaced by a 180 R resistor. The LED should be lit.

Input a logic 1 at A by inserting a link to connect the input to the positive rail (+6 V). What happens?

The LED goes out to indicate a logic 0 at the output F. Remove the link at A to input a logic 0. The LED immediately lights to indicate a logic 1 at the output. The Transistor switch is acting as a NOT gate. (Inverter).

Even a NOT gate has a Truth Table. It obviously has only two possible inputs and two possible outputs. What are they?

Enter the NOT gate Truth Table in your notebook. Check your results with the 'NOT' Truth Table in the **Appendix**.

This Transistor circuit is a 'REAL' NOT gate and could be used in a computer or a control circuit.

IC Logic Gate Assignments

The next group of assignments includes the use of the Integrated Circuit (IC) Logic Gates.

Logic 'Gates'

An essential part of every digital computer or microprocessor is the Arithmetic and Logic Unit (A.L.U.) which performs the basic mathematical operations and takes the necessary logical decisions needed in program handling.

The instructions and data in a program are received by the A.L.U. in groups or 'words' of binary digits (***bits***) which arrive on separate parallel conductors. Often a 'word' will have eight bits, although other larger 'words' are now in common use. A group of parallel conductors which carries these 'words' is called a ***bus***. A data bus carries data and instructions to and from the A.L.U. and a similar bus, called the address bus, connects the A.L.U. to the memory stores. A group of bits treated as one, is called a ***byte***.

The special electronic circuits that make up the A.L.U are called LOGIC circuits or LOGIC GATES. They are called gates because they are either open or closed.

There are five different IC logic gates in your kit. These are the NOT gate, the OR gate, the AND gate, the NOR gate and the NAND gate.

Symbols

Each type of logic gate has its own symbol. There are three different systems of symbols in common use today. The first is the American (ANSI) system and the second is the British Standards (B.S.) system. Logic gates are also often represented by a system block diagram with the name of the gate printed inside the rectangular block.

Different Examination Boards use the different systems so it is important that you make sure you are familiar with the diagrams required by your particular Board.

All the LOCKTRONICS logic gates in this kit will use a systems block diagram with the name printed inside the rectangle. Inputs and outputs are indicated by the direction of the arrows in the diagrams.

I.C. Gates

Originally logic gates were built from discrete components such as resistors, diodes and transistors but those circuits have now given way to Integrated Circuits (IC's) or 'chips' as they are often called.

The two most widely used families of IC Logic gates are CMOS 4000 Series (Complementary Metal Oxide Silicon) and TTL (Transistor Transistor Logic) 7400

Series. CMOS chips will operate on any supply voltage between +3 V and +15 V, but TTL chips have a FIXED operating voltage of +5 V which must not be exceeded. CMOS chips also have the advantage of extremely low power consumption. All the IC's used in this kit are CMOS.

Examine the Logic gate carriers in your kit.

You will find the CMOS IC's situated in their holders on the underside of the carriers mounted on a printed circuit board (pcb.). Note that they are ***DIL*** (dual in-line) packages which simply means that the IC connector pins are arranged in two straight lines. The actual silicon chip on which the circuits are etched is inside the package and is much smaller.

Note that the carriers have LEDs fitted to indicate whether the output of the gate is high (logic 1) or low (logic 0). LED lit = logic 1.

Note that the pcb also has a transistor mounted on it and a number of resistors and diodes. The transistor is used to provide the drive current for the LED. One resistor is used to limit the current through the LED and the others are 'pull down' resistors fitted to the inputs of the gates. The purpose of the 'pull down' resistor is to ensure that in the absence of an input signal voltage the gate assumes a logic 0 input.

The purpose of the diodes is to prevent accidental damage to the chip from unwanted voltages or by accidental reversal of the supply polarity.

Note that with the exception of the NOT gate carrier a special flying lead is provided to connect the +V supply. This lead terminates in a blade connector which is inserted between the metal pillar and the spring beneath the small cut-out at the end of any single link forming the +V rail.

9. The IC 'OR' Gate

Unlike the NOT gate, the OR gate has two (or more) inputs, usually labelled A and B (C, D etc.) and a single output usually labelled F. We choose F because the output is a function of (depends upon) the state of the inputs, although quite often the output is labelled Q or Z.

The standard symbols used for the gate are shown in the **Appendix**. The systems symbol used for the OR gate is shown in Figure 20.

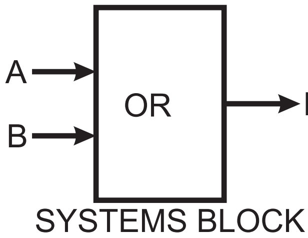

Figure 20 Systems Symbol for the OR Gate

Copy the particular symbol used by your examining board into your notebook.

Assemble the circuit shown in Figure 21 and connect the power supply.

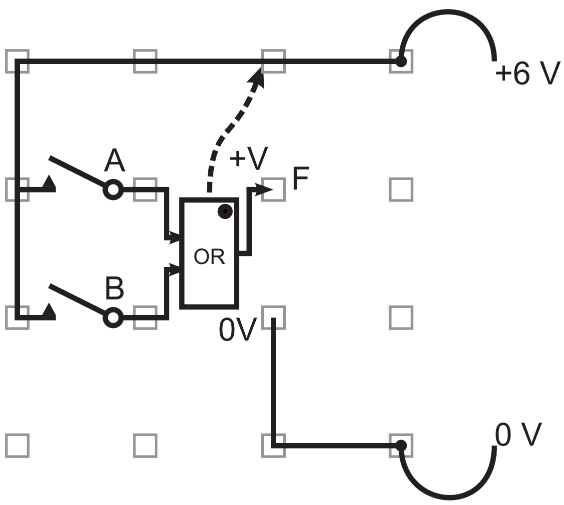

Figure 21 Circuit for the IC OR Gate

Do not forget to connect +V to the carrier by using the special lead.

Use the press switches to input the four possible pairs of 0's and 1's observing the output LED as you do so, then copy the Truth Table below into your notebook. Use the switches once again and complete the Truth Table as you do so by filling in the output column.

OR		
A	**B**	**F**
0	0	
0	1	
1	0	
1	1	

Table 4 Truth Table - OR gate

Copy the following sentence into your notebook:

An OR gate gives an output of logic 1 for an input of logic 1 at ***either*** Input A ***OR*** Input B ***OR both*** together.

The completed table is shown in the **Appendix**.

10. The IC ‘AND’ Gate

Just like the OR gate this gate has two or more inputs and a single output.

The system symbol used for the AND gate is shown in Figure 22.

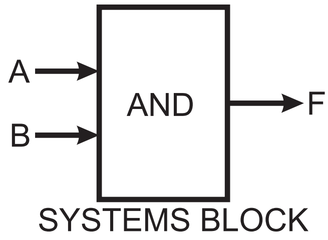

Figure 22 Systems Symbol for the AND Gate

Copy the particular symbol used by your examining board into your notebook.

Assemble the circuit shown in Figure 23 and connect your power supply. Remember your special carrier lead.

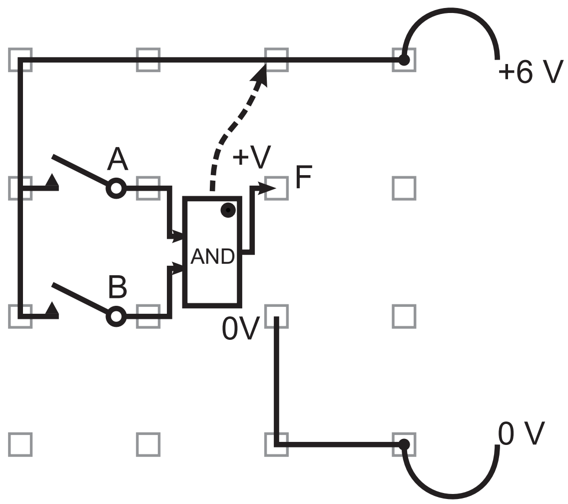

Figure 23 Circuit Disgram for the AND Gate

Use your press switches as in the last assignment and make a truth table for AND in your notebook. Complete the output column as before.

You can compare your truth table with the one shown in the **Appendix**.

Copy this sentence into your notebook:

An AND gate gives an output of logic 1 when ***all*** inputs are at logic 1.

11. The IC 'NOT' Gate

This is the simplest gate. It is often called an Inverter or Negator. It has only one input and one output. It is important to realise at this point that the inputs and outputs of all logic gates can only be either ON (high voltage level = logic 1) or OFF (low voltage level = logic 0). For this reason logic gates are often described as two state devices.

The standard symbols used for the gate are shown in the **Appendix**. The systems symbol for a NOT gate is shown in Figure 13.

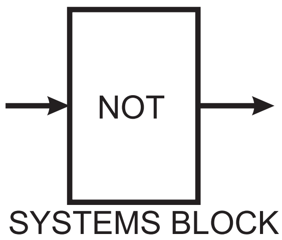

Figure 24 Systems Symbol for a NOT Gate

Copy the particular symbol used by your examining board into your notebook.

Assemble the circuit shown in Figure 14, then connect your power supply.

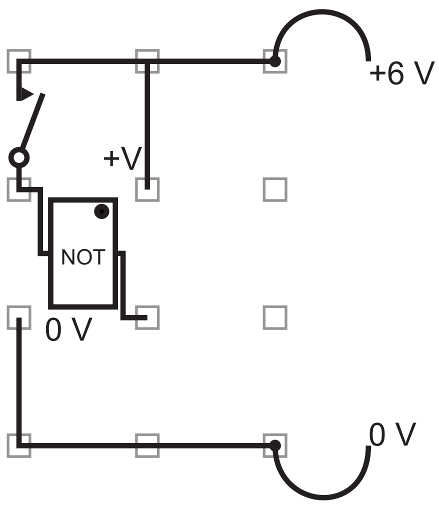

Figure 25 Circuit For the IC NOT Gate

Use the press switch to input a logic 1 (+6 V). If the switch is not pressed, the input will be a logic 0 because of the pull-down resistor. Observe the LED indicator connected to the output. If it lights the output is at logic 1. If not the output is at logic 0.

Press the switch a number of times and observe the LED. It should be fairly obvious why the gate is called an Inverter. A logic 0 input produces a logic 1 output and vice versa.

The behaviour of the gate can be described by a Table similar to Table 3, called a Truth Table.

NOT	
A	**F**
0	
1	

Table 5 Truth Table for a NOT Gate

Use the press switch a number of times then copy the truth table into your notebook and complete it by filling in the output column. Label it ‘TRUTH TABLE - NOT GATE’. It is shown in the **Appendix**.

12. Combining I.C Logic Gates - The ‘NAND’ and ‘NOR’ Gates

In Logic Circuits, gates are often joined together, the output of one gate being used as the input of another. By doing this other gates can be made. These two new gates are very important and you must try to understand them. The three basic gates are AND, OR and NOT, but if we follow the output of an OR gate by a NOT gate the combined action of the two gates fulfils the "NOT-OR' function which is abbreviated to 'NOR'. In the same way an AND gate followed by NOT becomes a 'NAND' (NOT-AND) gate. Their symbols are:

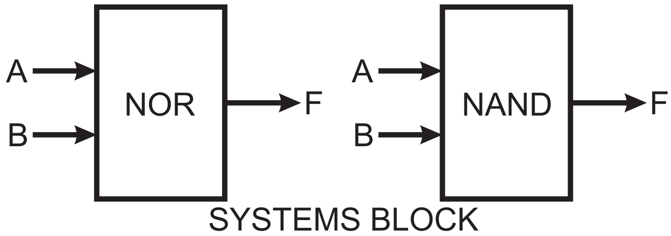

Figure 26 Systems Symbols for NOR and NAND Gates

Copy the particular symbols used by your Examination Board into your notebook.

The ANSI and BS symbols are the same as those for OR and AND but with an extra circle. The circle indicates inversion.

The circuit shown in Figure 27 shows an OR followed by a NOT gate to produce the NOR function.

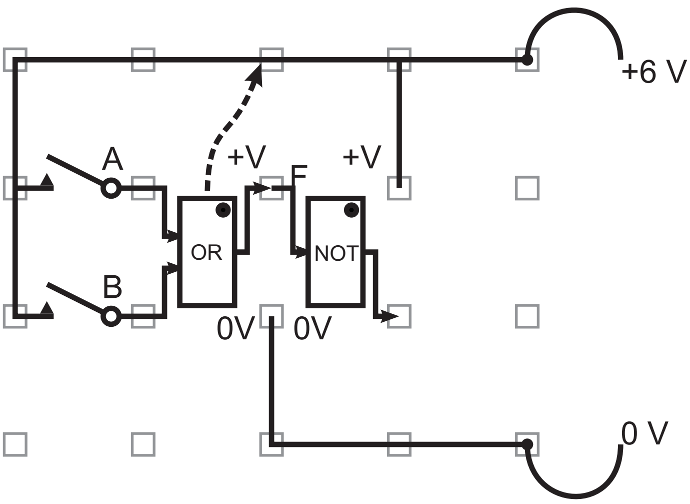

Figure 27 Circuit for NOR Gate (OR and NOT)

Assemble this circuit and produce a truth table for NOR in the usual way. Replace the OR with the AND to produce a NAND and create a new truth table.

IC NOR and NAND

Your kit includes an IC NOR gate and an IC NAND gate. Build your circuit as in **The IC 'OR' Gate** or **The IC 'AND' Gate**, but use the NOR and NAND gates.

Create Truth Tables for each and copy them into your notebook. Compare them with the ones shown in the **Appendix**.

13. Combinational Logic

If you combine two or more logic gates together to perform a special function, the circuit is called a ***Combinational Logic*** circuit.

A four-input AND gate can be made by the combination shown in Figure 28.

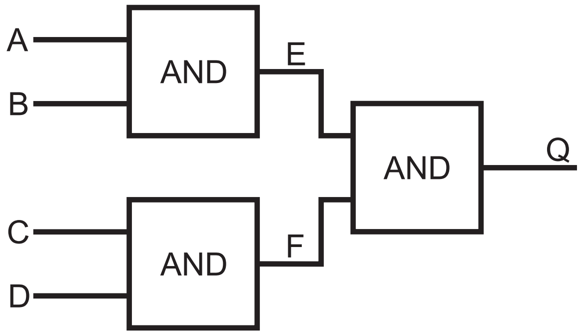

Figure 28 System Diagram of a Four Input AND Gate

The Truth Table for this combination is shown in Table 10, partly completed. You should be able to complete it. Can you think of a use for such a gate?

4-Input AND						
A	**B**	**C**	**D**	**E**	**F**	**Q**
0	0	0	0	0	0	
0	0	0	1	0	0	
0	0	1	0	0	0	
0	0	1	1	0	1	
0	1	0	0	0	0	
0	1	0	1	0	0	
0	1	1	0	0	0	
0	1	1	1	0	1	

Table 6 Incomplete Truth Table for a 4-Input AND Gate

14. Combinational Logic Exercise

A submarine has an automatic dive control system fitted. It will automatically dive if:

An unidentified aircraft approaches within 50 miles
OR
An unidentified ship approaches within 20 miles
AND
The conning tower hatch is shut

Design a combinational logic circuit for this system and test it. The system design is shown in Figure 29. Use switches or links to simulate the inputs and an LED to show the dive condition.

Draw a Truth Table for your circuit.

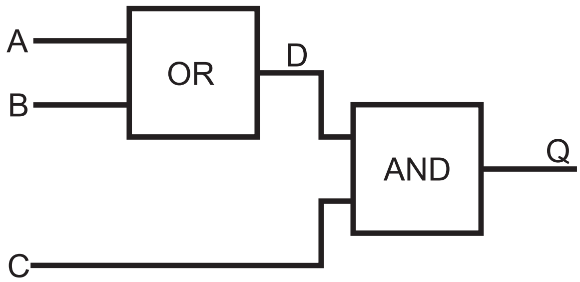

Figure 29 Combinational Logic System Design

15. Schmitt Trigger

Some of you may already be familiar with the transistor version or the Op-amp version of the Schmitt trigger. In the diagram below the top line shows an input voltage varying over time. If it is applied to a normal logic gate, the output of that gate will switch several times when the input voltage is close to the switching voltage. The second line shows this. If the same input is applied to a Schmitt Trigger Logic gate then the output changes once as the input rises and once as the input falls. This is shown by the third line.

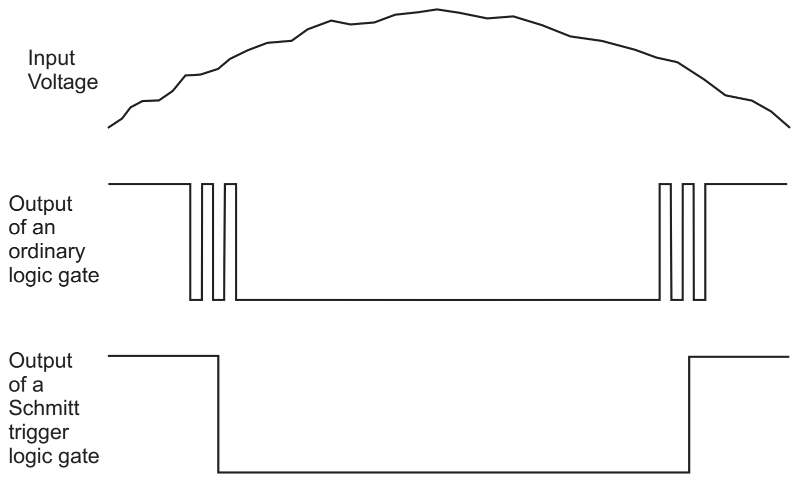

Figure 30 Comparison of an Ordinary Logic Gate and a Schmitt Trigger

The NOT gate in the kit is a Schmitt Trigger Inverter, so you can use it to find out how a Schmitt Trigger works.

Assemble the circuit shown in Figure 31.

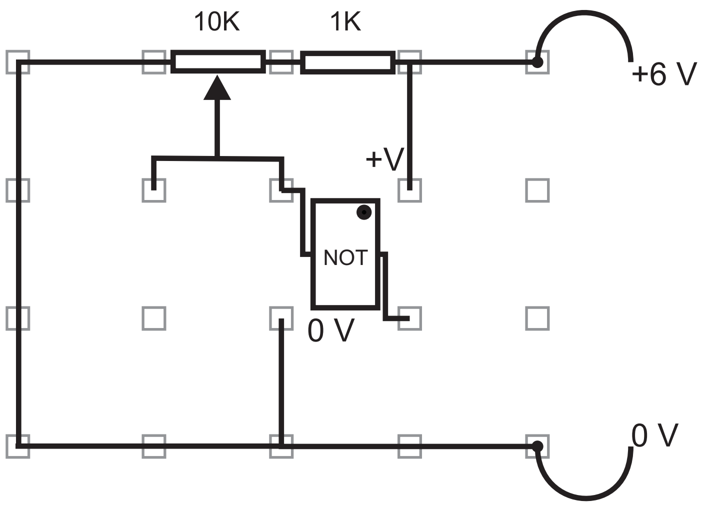

Figure 31 Circuit to Test the Schmitt Trigger Inverter

Rotate the control knob and notice where the LED switches on and off. The difference between the points where the LED switches on and where is switches off should be noticeable. This action of the Schmitt Trigger gate is known as hysteresis or backlash. Use a voltmeter to measure the input voltage when the LED switches on and when it switches off. Measure these switching voltages several times and use your results to calculate average values. Now you can use these results to show how the output voltage would change for the input voltage shown in Figure 32.

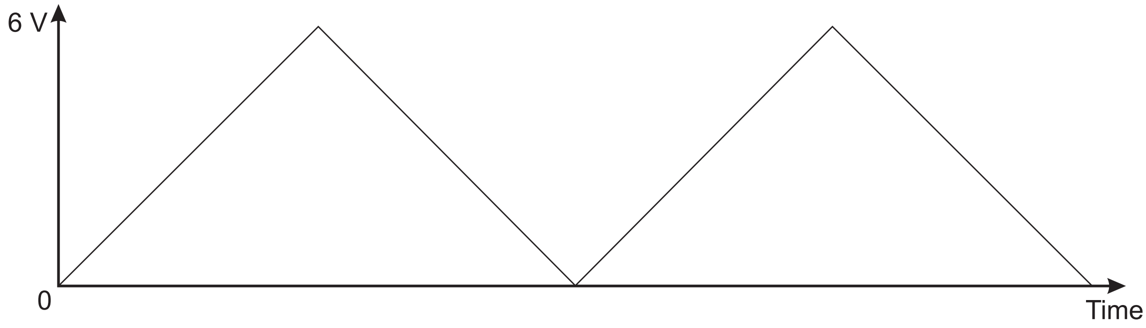

Figure 32 Input Voltages

Remember that LED on means 6 V and LED off means 0 V.

16. The Exclusive-OR Gate (Optional Extra)

There is another type of gate as well as the ones we have seen so far. This gate is called the Exclusive-OR. This is sometimes known as the XOR or EXOR gate.

This gate is available as an optional extra to the LK70A and LK70B kits.

The symbols for the XOR gate are shown in Figure 33.

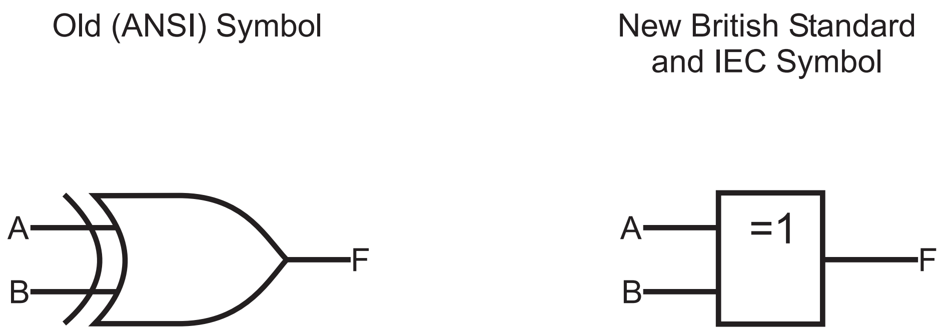

Figure 33 XOR Gate Symbols

Assemble the circuit shown in Figure 34.

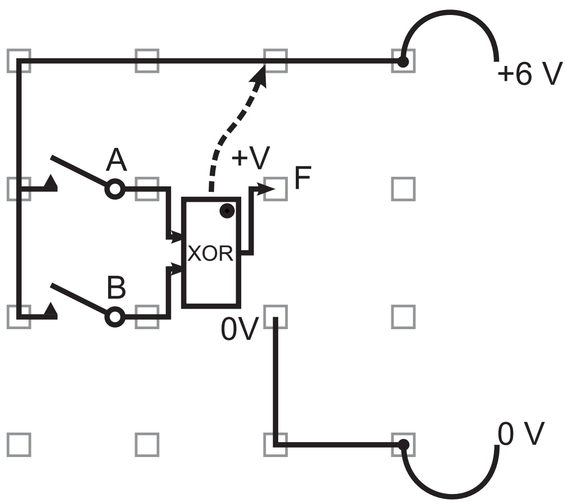

Figure 34 Circuit for the Exclusive OR

Now use the circuit to complete the truth table.

A	B	F
0	0	
0	1	
1	0	
1	1	

You should notice that the output F is 1 when A or B is 1. But the output excludes the case where both A and B are 1.

17. The Half-Adder

Suppose we need to add two ***binary digits*** together. There are 4 possible results

A + B = CS
0 + 0 = 00
0 + 1 = 01
1 + 0 = 01
1 + 1 = 10

If we call the two digits we want to add A and B, we call the 1's bit of the result the sum S and the 2's bit of the result the ***carry*** C, then we can write out the two truth tables for C and S.

A	B	CARRY C
0	0	
0	1	
1	0	
1	1	

A	B	SUM S
0	0	
0	1	
1	0	
1	1	

Copy the truth tables and fill in the values for C and S.

Now design a circuit that allows you to input values for A and B and get the correct outputs C and S.

Build the circuit and test it to see if it works in the way you expected.

One solution is given in Figure 35. Note - this solution uses the XOR gate, which is an optional extra to the LK70A and LK70B kits.

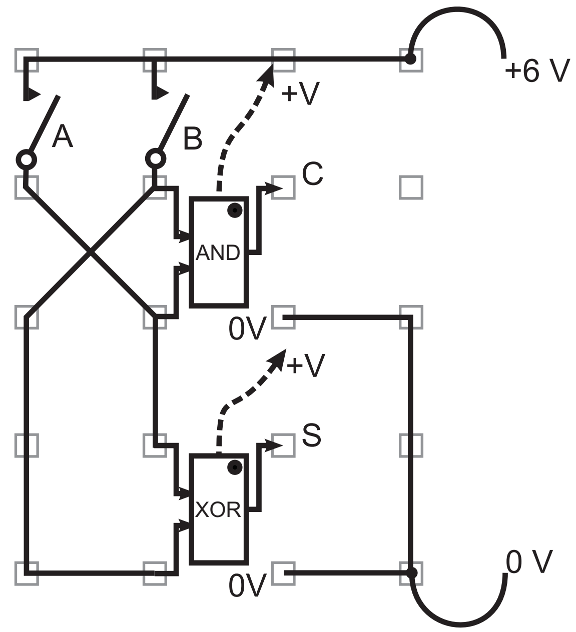

Figure 35 Half Adder Circuit

Appendix

Logic Symbols

The logic symbols used on the Locktronics range are simple block diagrams with the name of the logic symbol. In real circuit diagrams, you will see the older ANSI (American National Standards Institute) style, and the newer IEC and BS (British Standard). Figure 36 shows the comparison.

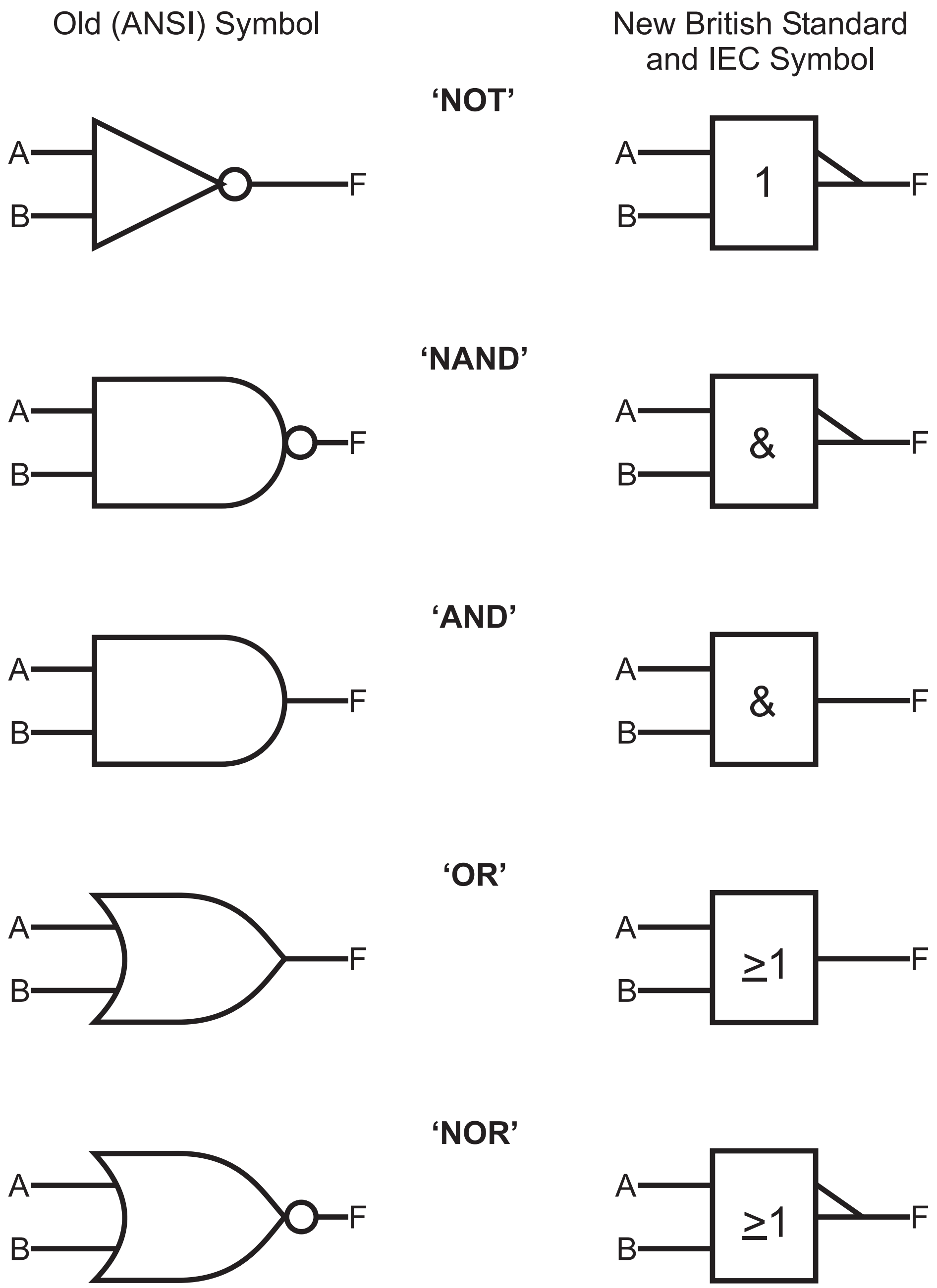

Figure 36 Older American and Newer BS/IEC Symbols

Truth Tables

OR		
A	B	F
0	0	0
0	1	1
1	0	1
1	1	1

AND		
A	B	F
0	0	0
0	1	0
1	0	0
1	1	1

Table 7 OR and AND Truth Tables

NOR		
A	B	F
0	0	1
0	1	0
1	0	0
1	1	0

NAND		
A	B	F
0	0	1
0	1	1
1	0	1
1	1	0

Table 8 NOR and NAND Truth Tables

NOT	
A	F
0	1
1	0

XOR		
A	B	F
0	0	0
0	1	1
1	0	1
1	1	0

Table 9 NOT and XOR Truth Tables

4-Input AND						
A	**B**	**C**	**D**	**E**	**F**	**Q**
0	0	0	0	0	0	0
0	0	0	1	0	0	0
0	0	1	0	0	0	0
0	0	1	1	0	1	0
0	1	0	0	0	0	0
0	1	0	1	0	0	0
0	1	1	0	0	0	0
0	1	1	1	0	1	0
1	0	0	0	0	0	0
1	0	0	1	0	0	0
1	0	1	0	0	0	0
1	0	1	1	0	1	0
1	1	0	0	1	0	0
1	1	0	1	1	0	0
1	1	1	0	1	0	0
1	1	1	1	1	1	1

Table 10 Truth Table for a Four Input AND Gate