locktronics

LK75A and LK75B

Electronic Systems 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/0206

TQ Education and Training Ltd

Contents

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locktronics

LK75A and LK75B

Assignments Book

Introduction

Figure 1 The LK75 A+B Component Kits.

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

The assignments in this book cover both the LK75A (Starter) and LK75B (add-on) Kits. The assignments increase in difficulty. You must use some of the components from both kits to complete these assignments.

LK75A and LK75B Components

The LK75A and LK75B 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.

Baseboard LK750 (Available Separately)

A Baseboard with 7 rows and 5 columns of pillars.

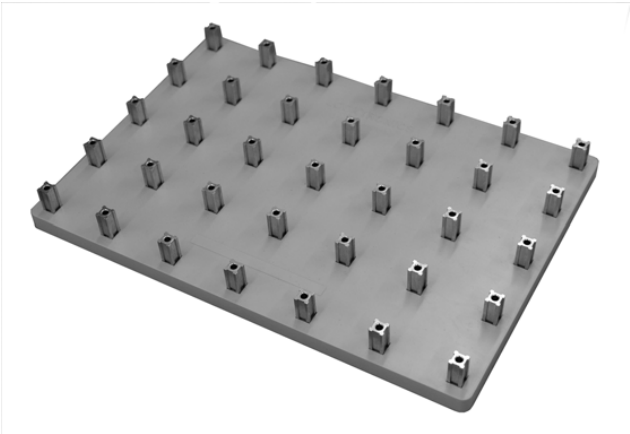


Figure 2 The LK750 Baseboard.

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)

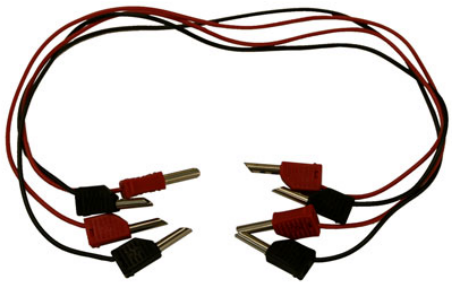


Figure 5 The LKLS Lead Set.

Current Probe LKCP (Available Separately)

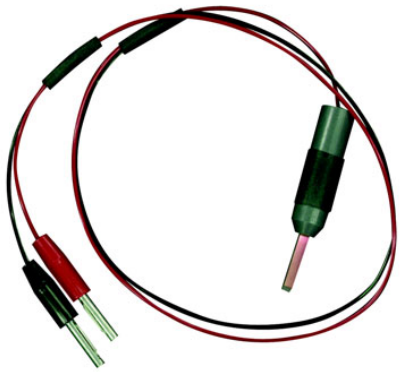


Figure 6 The LKCP Current Probe.

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.

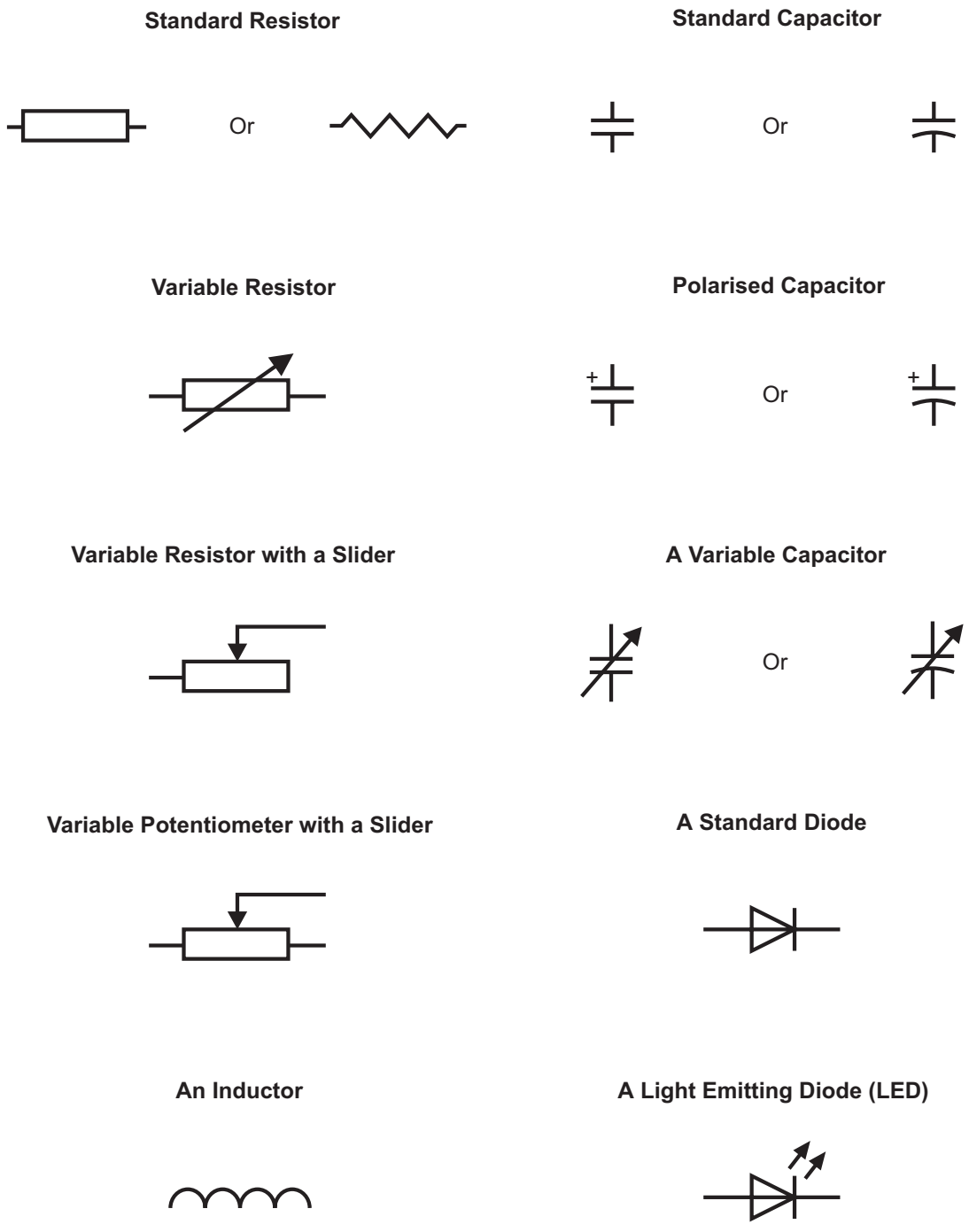


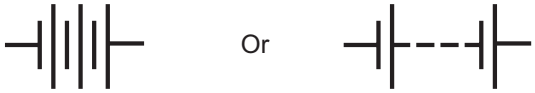
Figure 7 Common component symbols.

A Lamp

A Single Cell

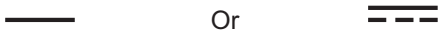
A Voltmeter

A Battery or Group of Cells

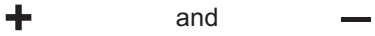


An Alternating Current

Direct Current



Positive and Negative Polarity



A Junction of two wires

A PNP Transistor

An NPN Transistor

Figure 8 Common component symbols.

Systems and the Locktronics Modules

Definitions of a System

- a complex whole
- a set of connected things or parts
- an organized body of material or immaterial things.

An electronic system is made of a selection of electronic ***modules*** that are arranged to do a certain job.

There are three main types of electronic modules:

1. ***Input Transducers*** - Devices that receive energy from outside the system and convert it into electrical energy in the form of a signal voltage for input to the system.

2. ***Signal Processors*** - Devices that modify or control the signal as they pass though the system.

3. ***Output Transducers*** - Devices that convert the final electrical output signal (or signals) into other forms of energy (for example - linear or rotational movement, light sound, magnetism etc).

Figure 9 shows a simple system that uses just one of each of the three modules. Other systems may have more than one of each of the three different types of device.

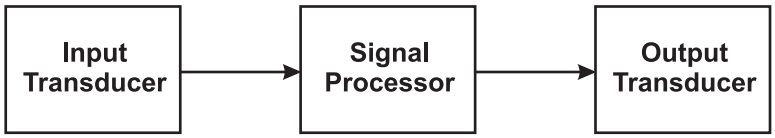


Figure 9 A Simple System

Input Transducer Modules in the LK75 kits

LK75A	LK75B
Light Sensor	Magnetic Sensor (Reed Switch)
Temperature/Rain Sensor	Sound Sensor (Microphone)
Press Switches	
Input Control/Voltage Input Device	
Dual Lead	

Signal Processor Modules in the LK75 Kits

LK75A	LK75B
Transistor Switch	OR Gate
Transducer Driver	NOR Gate/Inverter
Latch	NAND Gate/Inverter
AND Gate	Counter/Display
Non-Inverting Amplifier	Pulse Generator
	Comparator

Output Transducer Modules in the LK75 Kits

LK75A	LK75B
Lamp	Solenoid
Buzzer	Relay Switch
Electric Motor	Earphone/Microphone
LED Indicator	

Suitable Locktronics Module Combinations

Signal Processor	Output accepted by
Transistor Switch	Transistor Switch
	Transducer Driver
	Logic Gates
	Latch
	Buzzer
	Counter/Display
	LED
Transducer Driver	Any Output Transducer
Latch *The latch uses one of two press-switches for reset. Fit the switch to the right of the module.	Transistor Switch
	Transducer Driver
	Logic Gates
AND Gate OR Gate NOR Gate/Inverter NAND Gate/Inverter * Both NOR and NAND gates can be used as inverters (not gates) by connecting the two inputs together with a connecting link inserted in the left-hand cut-out	Any other Logic Gate
	Transistor Switch
	Transducer Driver
	Comparator
	Counter/Display
	LED
Counter/Display	Another Counter/Display
	Any Logic Gate
	Latch
	Transistor Switch
	Transducer Driver
Pulse Generator * The Pulse Generator uses an external capacitor that must be fitted in the lower cut-out of the module for low frequency operation	Transistor Switch
	Transducer Driver
	Any Logic Gate
	Latch
	Buzzer
	Counter/Display
	LED
	Earphone/Microphone

The Locktronics Modules

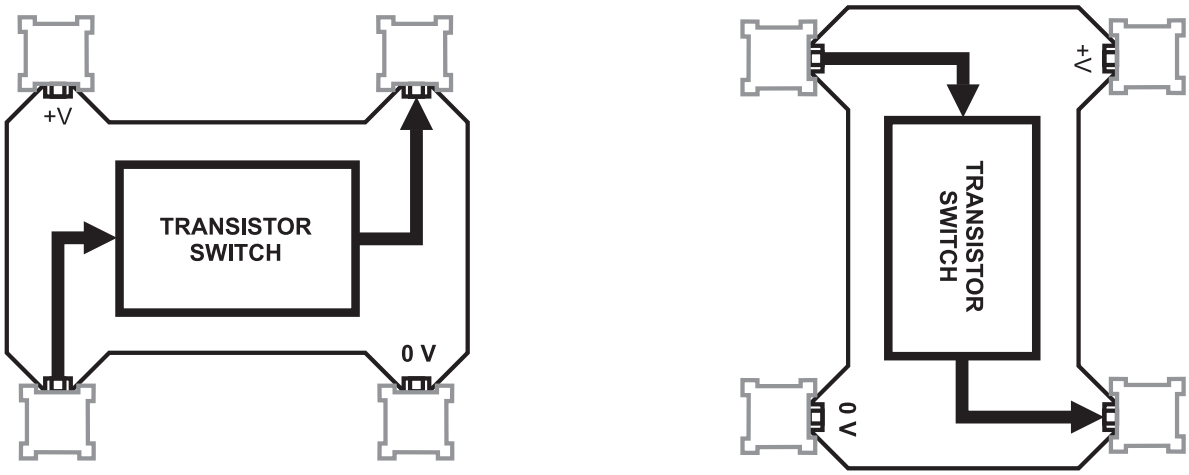


Figure 10 Transistor Switch Module

Most of the Locktronics modules carry their name in a simple rectangle printed on their surface. Their inputs and outputs are clearly indicated by arrows.

The modules will operate in any position (see Figure 10), provided that the connections to them are correct.

NOTE  *Some modules include fixed flying leads for one or both power connections.*

The modules can be nested to save space and to give a neat circuit layout (see Figure 11).

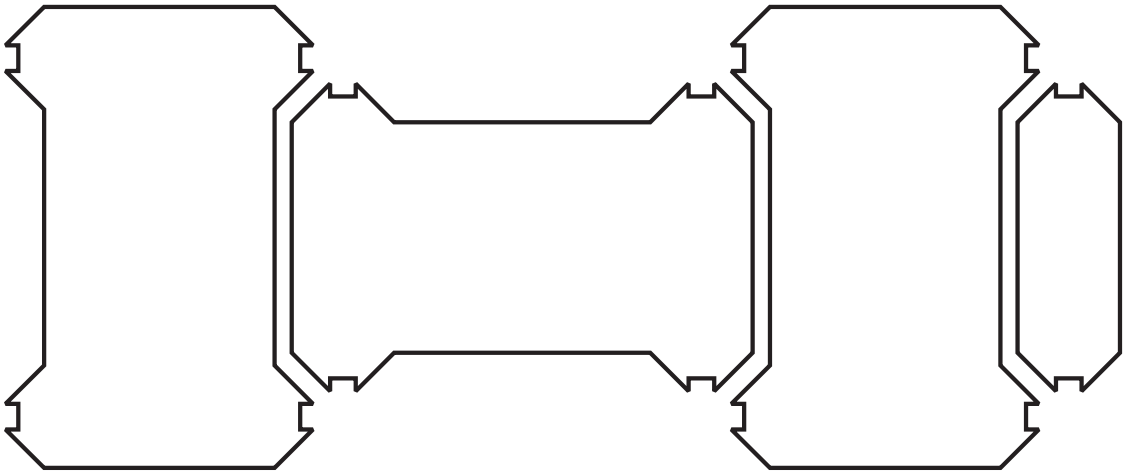


Figure 11 Nested Modules

Supplied with the kits are some connecting links and a capacitor (see Figure 12).

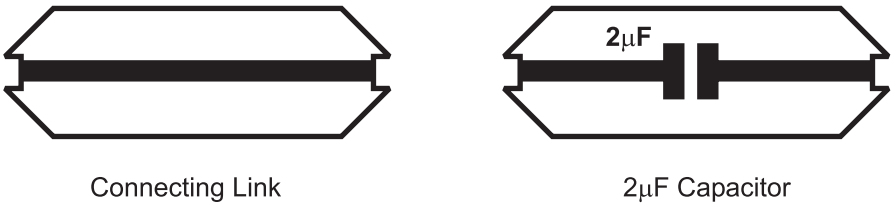


Figure 12 Connecting Links and Capacitor

How to Build Systems with the Locktronics Modules

Figure 13 shows an example of how to build a system correctly.

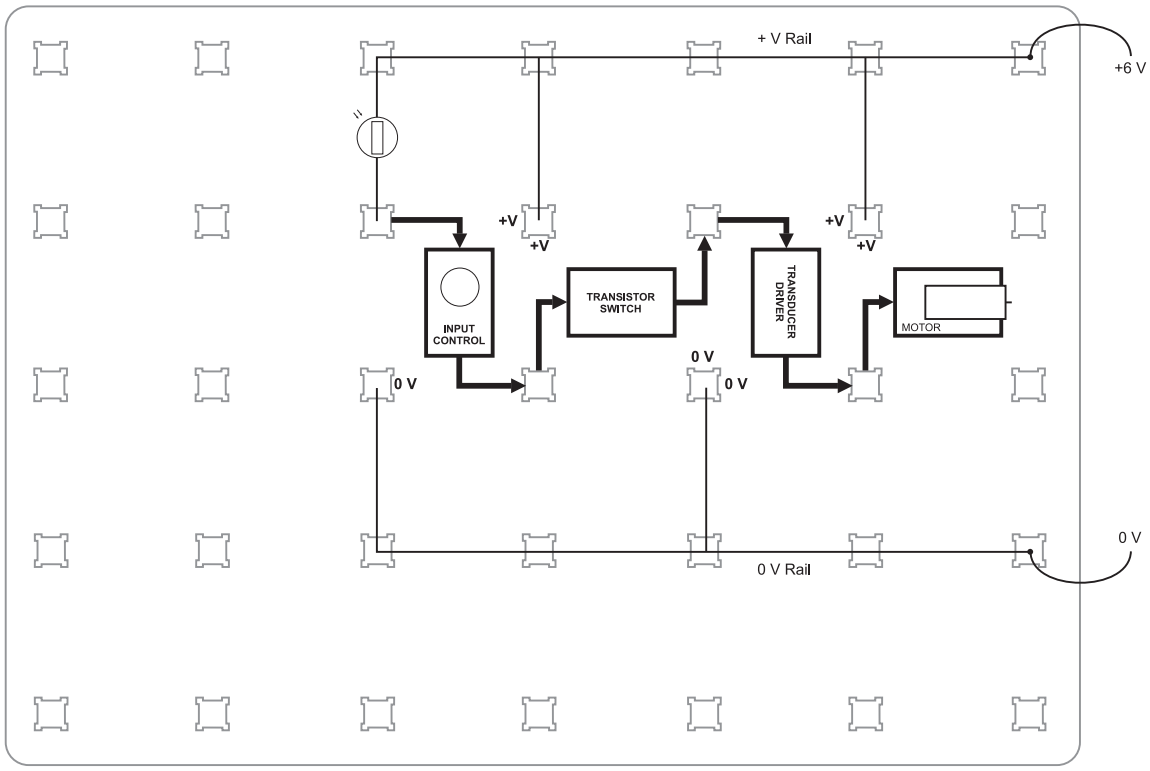


Figure 13 Example System Made of Locktronics Modules

1. Assemble conecting links along the top row of pillars on the board to form a POSITIVE (+V) rail and form a ZERO VOLTS (0 V) rail along the second row of pillars from the bottom.

2. Start with the output module on the right, and place other modules onto the board as in the system diagrams shown in this book. Work towards the left. Take care to ensure the correct ‘flow’ of the input and output arrows from module to module.

3. Fit connecting links to the +V and 0V rails from each module. Note that in many cases, one link will connect two modules. If a module has a flying lead, insert the flat blade of the lead down the side of a pillar, between the pillar and a connecting link.

4. Re-check your circuit against the diagram shown in this book.

5. Check your d.c supply - Set it at 6 V.

6. When you are sure that all things are correct, switch on the supply.

The system shown in Figure 13 is a ‘dark’ activated system. Build it and make sure that light falls on the LDR (light dependant resistor). If the motor is turning, adjust the input control until it stops. Cover the LDR. What happens?

When you understand how the system works, find out what happens if a latch is placed between the Transistor Switch and the Transducer Driver. Insert a press-switch in the right hand cut-out of the Latch in order to give a reset facility.

You will need to rearrange the system with extra connecting links and turn two of the modules by 90°.

If you have both kits, you could use the Counter/Display to count the number of times a system is activated, but remember that if the system includes a Latch, it must be reset after each display change.

Try using different sensors instead of the light sensor. Do not use the microphone - this is dealt with in a later assignment.

Familiarization Assignments

These assignments help you to study the action of each of the modules in turn.

1. The Transistor Switch and Transducer Driver

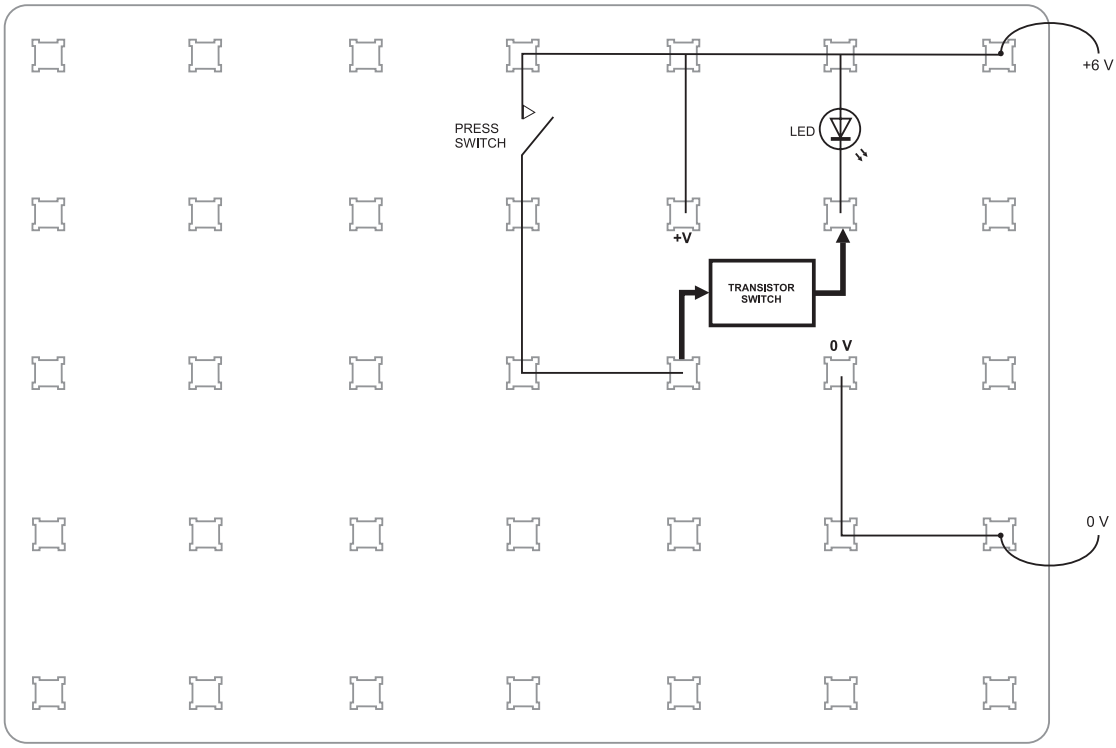


Figure 14 Circuit for ***The Transistor Switch and Transducer Driver***

Assemble the Transistor Switch circuit on the board as shown with a LED connected to the output and a press-switch between the positive voltage rail and the Transistor Switch input. The LED is a polarised device and must be connected exactly as shown.

Note the two connecting links needed to connect the positive and zero volt rails to the Transistor Switch module.

Connect your d.c power supply with the voltage set at 6 V then switch on.

Press the press-switch several times and observe the Transistor Switch action as indicated by the LED. Note that the Transistor Switch is acting as an inverter. the ‘high’ input signal from the press-switch is changed to a ‘low’ output signal that causes the LED to light.

Replace the Transistor Switch module with the Transducer Driver module.

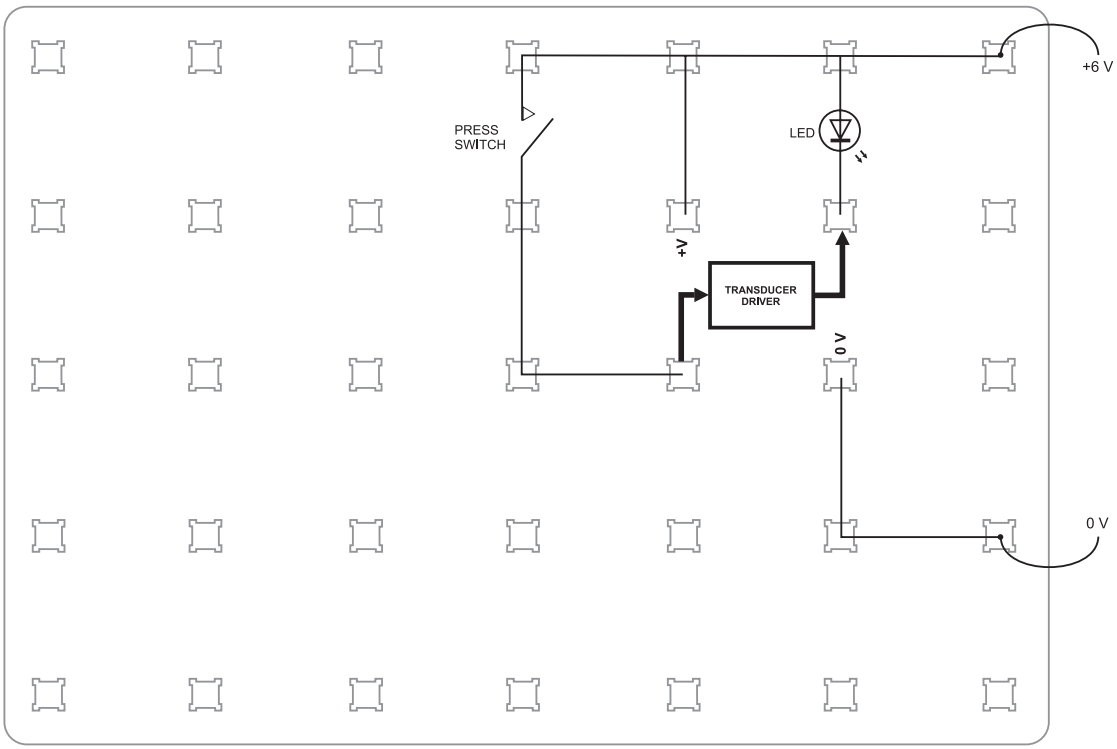


Figure 15 Circuit, Showing the Transistor Switch Replaced by the Transducer Driver

Use the press-switch several times and monitor the action of the Transducer Driver, shown by the LED. Once again, like the Transitor Switch, a ‘high’ input is changed into a ‘low’ output.

The purpose of the Transducer Driver is to provide enough output current to operate an Output Transducer safely, without damaging any signal processor. It is therefore good practice to include a Transducer Driver as the last signal processor in any system that operates an Output Transducer.

2. The Latch

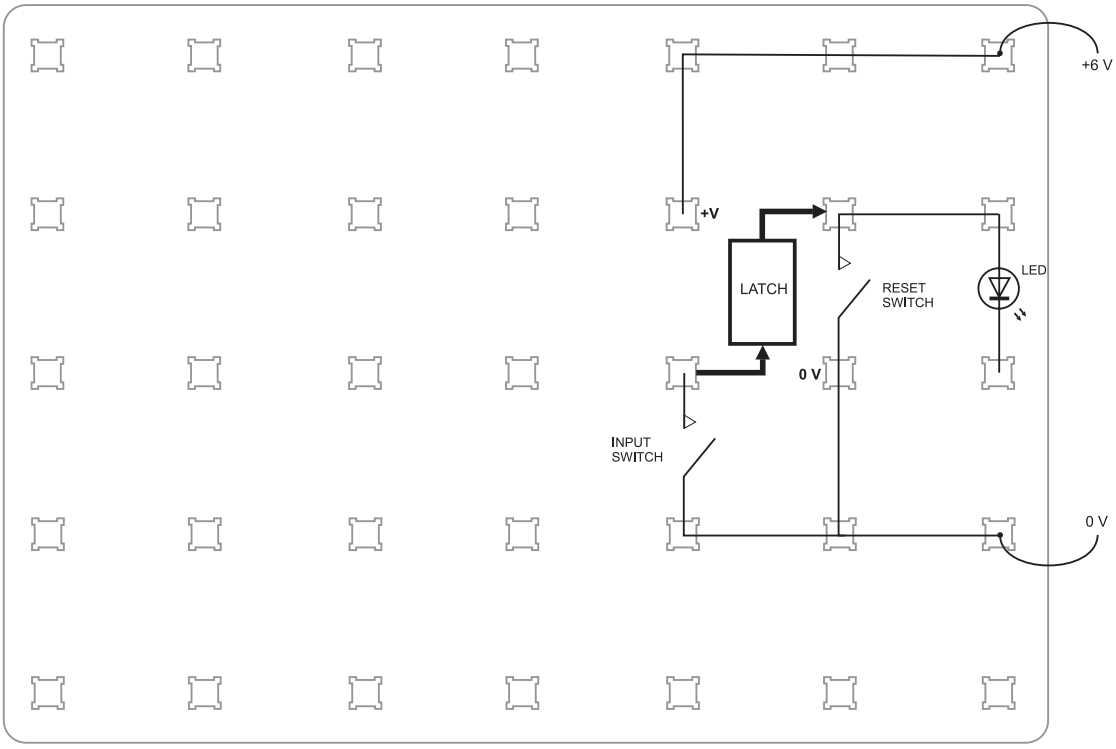


*Figure 16 Circuit for **The Latch***

This is special electronic switch with a sticking action. once switched on, it stays on until it is ‘reset’ ready for use once again.

The Latch is reset by means of a press-switch in the right-hand cut-out of the Latch. Assemble the Latch circuit as shown in Figure 16. Note the TWO press-switches, one for the input, the other for reset.

Connect the power supply and switch on.

Press the input signal press-switch once and monitor the sticking action of the Latch, indicated by the LED coming on and STAYING on. The signal is latched.

Press the reset switch.

Repeat both these actions several times until you are familiar with the latching process.

Note that with the Latch, the input signal needed is a ‘low’ one and that the output signal is a ‘high’ one. It also gives an inverting action.

3. Input Transducers and Input Control

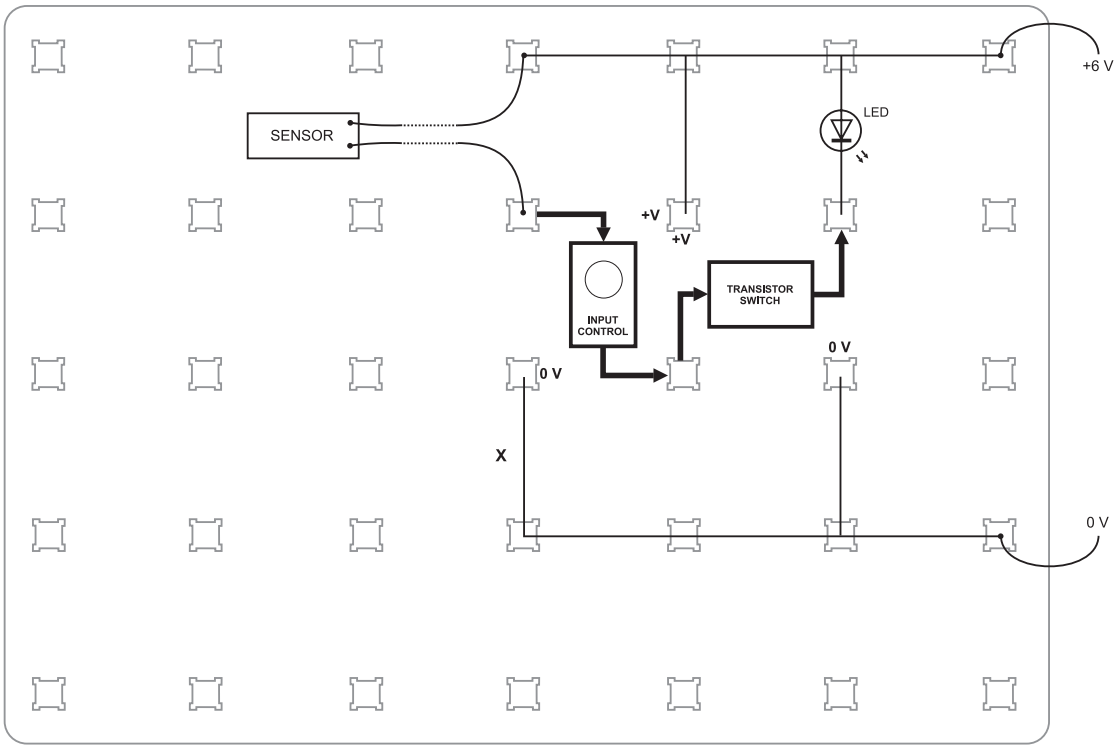


Figure 17 Circuit for ***Input Transducers and Input Control***

Input sensors are normally connected between the positive rail and the input of the Input Control module. Figure 17 shows the dual lead used for remote operation. Assume the Input Control and Sensor are one unit.

Assemble the circuit and use the light sensor (LDR). Connect the power supply and switch on. Expose the light sensor to activate the system (you may need to adjust the input control).

Exchange the positions of the light sensor and the 0 V link, marked X. Activate the sensor - the system should now work in reverse (the 'light' activated system will now be a 'dark' activated system).

Repeat this assignment several times with different sensors and activate them by applying the energy needed (for example - heat, magnetism etc).

If you have both kits do not use the sound sensor, this is dealt with in a later assignment.

4. Logic Gates

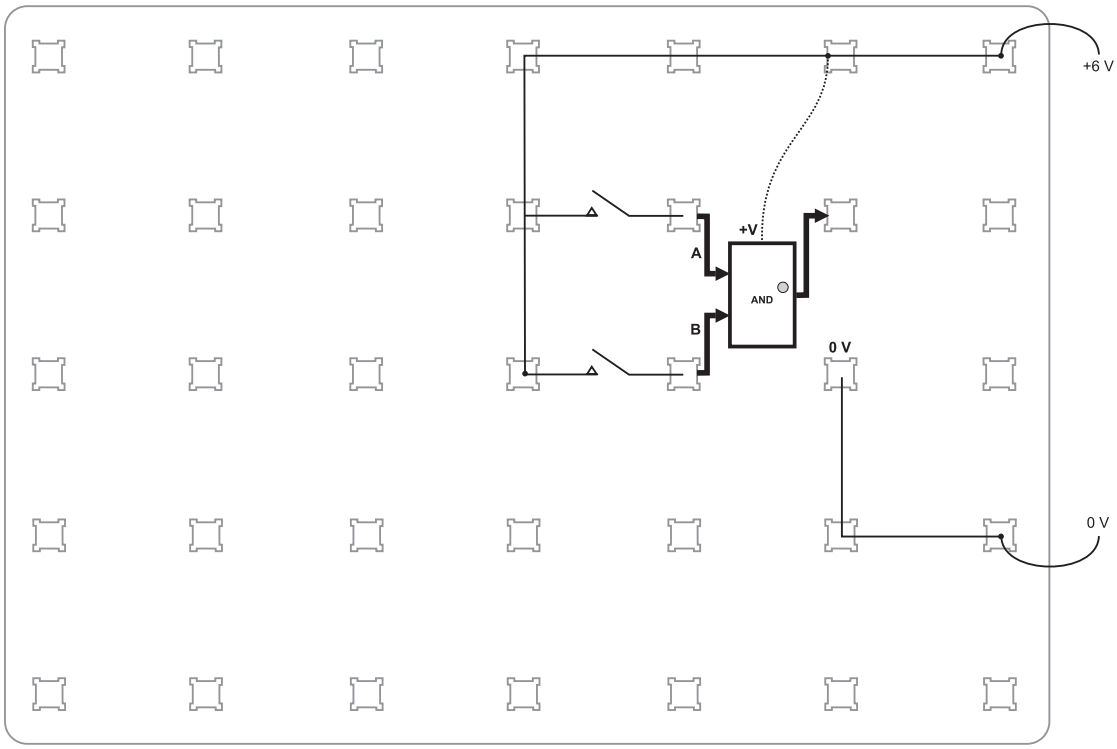


Figure 18 Circuit for Logic Gates

All the logic gates provided in the kit are 2-input devices. They all act like electronic switches because they are all 2 -state devices (either on or off), but each type of gate needs a different set of input conditions to switch it.

Each gate is fitted with its own LED to indicate the state of the output. When the LED is on, the output is ‘high’ (gate ‘on’). When the LED is off, the output is ‘low’ (gate ‘off’).

Note that all the Logic Gates have a fixed flying lead for the +V connection.

5. Truth Tables (Needs LK75B Kit)

The behaviour of the Logic Gates is usually described by a Truth Table.

Here is the Truth Table for the AND gate. Note that a '1' indicates a 'high' voltage and a '0' indicates a 'low' voltage.

The two inputs are indicated by A and B.

AND		
A	**B**	**Output**
0	0	0
1	0	0
0	1	0
1	1	1

Table 1 Truth Table for a Two Input AND Gate

If you have an the LK75B Add-on kit, make Truth Tables for the three other Logic Gates.

By joining the two inputs of the NAND (or NOR) gate together, by means of a connecting link placed in the left hand cut-out of the module, the device acts as a inverter (NOT gate) requiring only one input. Complete the Truth Table for the Inverter.

TECHNICAL NOTE:

The logic gates are fitted with 'pull-down' resistors on the inputs. This means that when not connected to an input signal source they are at 0 V level.

6. Pulse Generator (Needs LK75B Kit)

The behaviour of this module is fairly obvious from its name.

Assemble the circuit as shown in Figure 19.

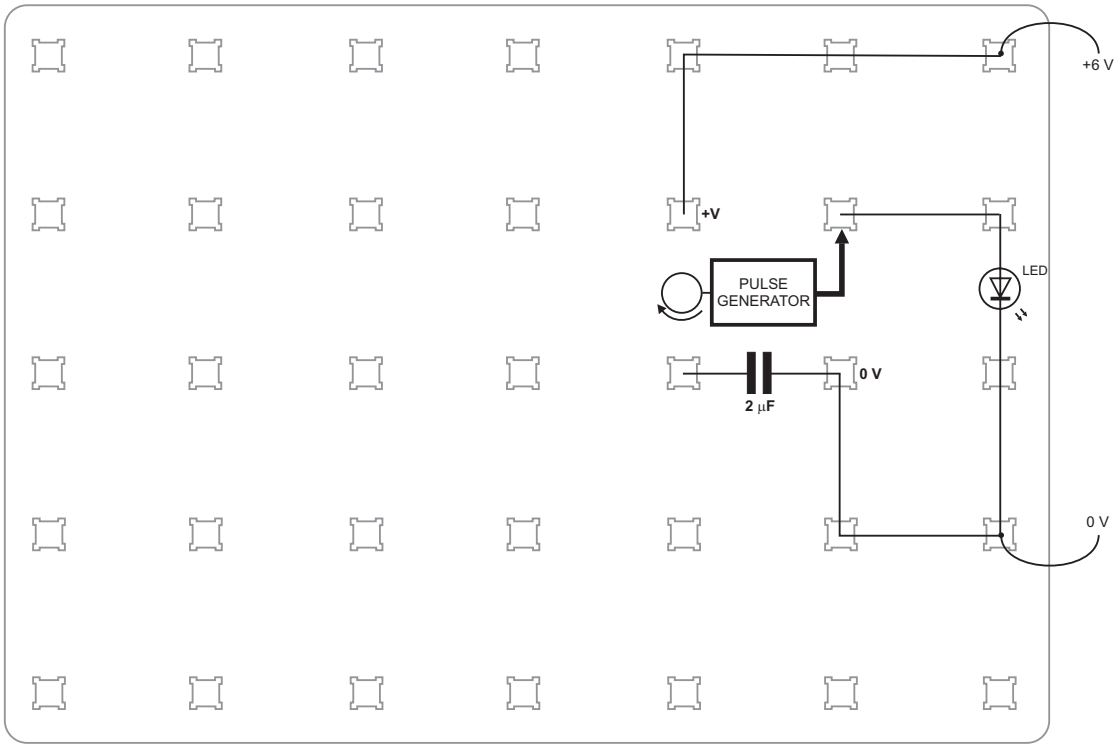


Figure 19 Circuit for Pulse Generator

Note that a 2µF Capacitor is placed in the lower cut-out of the module. Once again an LED is used to show the output.

Once the power supply is connected the pulse generator should start working.

Rotate the frequency control knob on the carrier and observe its action.

Important Note:
If the 2µF capacitor is not fitted, the pulse generator will still work but its frequency is too high to be detected by the eye and the LED will appear to be permanently on.

Remove the capacitor and turn the control.

The full range of the pulse generator is:

With the 2µF capacitor - 0.5 Hz to 15 Hz
Without the 2µF capacitor - 30 Hz to 1 kHz

Remove the LED carrier and replace it with the Earphone. Turn the control once again.

7. Counter/Display Module (Needs LK75B Kit)

Once again, the behaviour of this module is easily seen. It will count up or down, can be re-set to indicate zero and will 'carry' out to the next counter module if needed. This module has 2 flying leads for connection to the +V and 0 V rails.

The circuit shows the Counter/Display being operated by the pulse generator.

It can also be operated by the sensors, the electronic switches and the Logic gates.

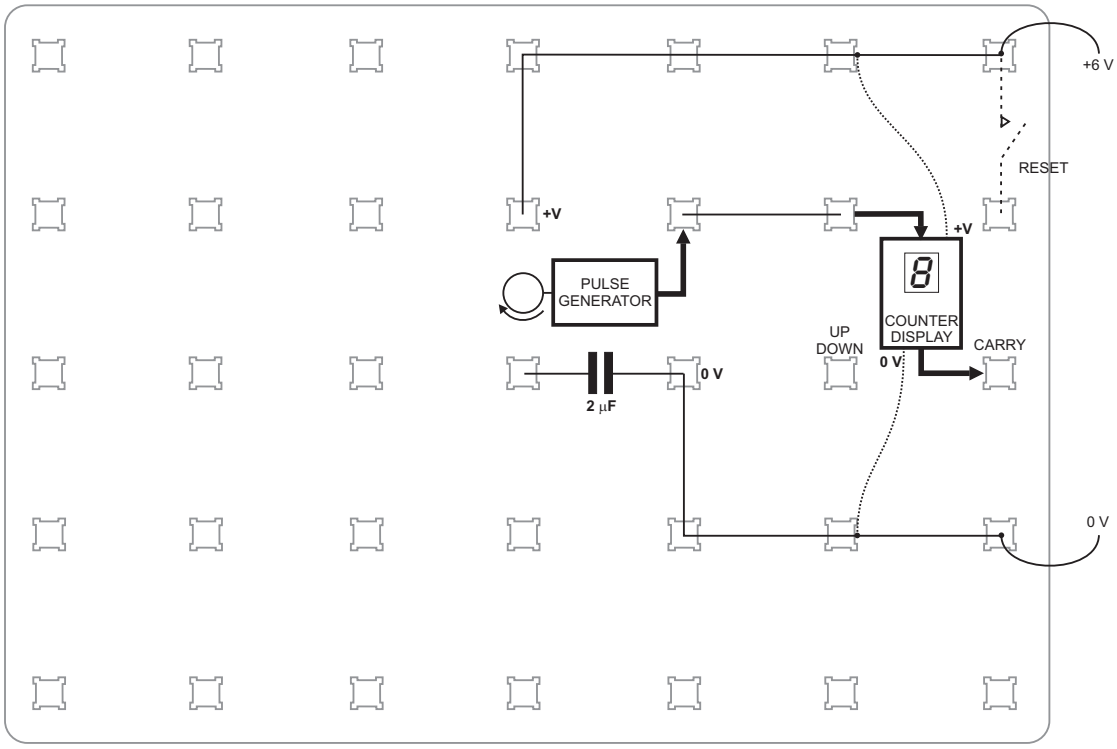


Figure 20 Circuit for Counter Display Module

Assemble the circuit, connect the power and switch on. The Counter/Display will display a count. As shown it will count up. To make it count down, connect a single link between the up/down input and the 0 V rail. To reset, place a press-switch in the position indicated by the dotted line and press to reset.

8. Output Transducers

All the Output Transducers supplied are activated in the same way.

Each one needs a connection to the +V rail and a second connection to the Transducer Driver output. When the output of the Transducer Driver goes low (i.e. the Transducer input) the Transducer will operate.

On the large carriers the +V connection is indicated on the upper surface and the transducer input will be shown by an arrow in the usual way.

Test each Transducer in turn using the circuit shown in Figure 21. The press-switch simulates the action of the Transducer Driver.

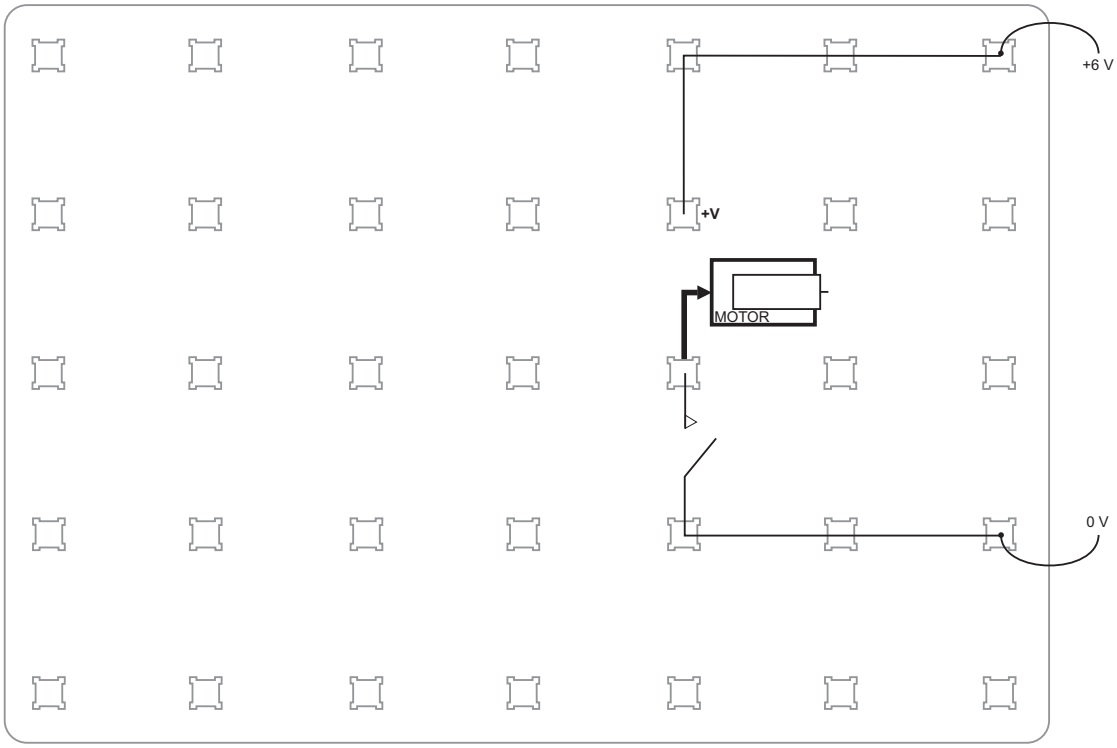


Figure 21 Circuit for Output Transducers

Operational Amplifier Assignments

The next few assignments use the operational amplifier (Op-amp). It is a very high gain amplifier that was designed for use in early computers.

One of the first and still the most common type of Op-amp is the 741, developed during the 1960's and 1970's. Modern Op-amps have improved features, but the basic design is still identical.

The Op-amp supplied in the LK75 A and B is fitted in two modules:

The Non-inverting Amplifier

The Comparator

The Op-amp used in the kits is a dual version (two Op-amps in one package) of the 741 and is connected so that it can operate from a single supply. Each module uses the Op-amp in a slightly different way. For more information on Op-amps, try the Locktronics LK80 Operational Amplifier Kit.

9. Non-inverting Amplifier

Assemble the simple system shown in Figure 22.

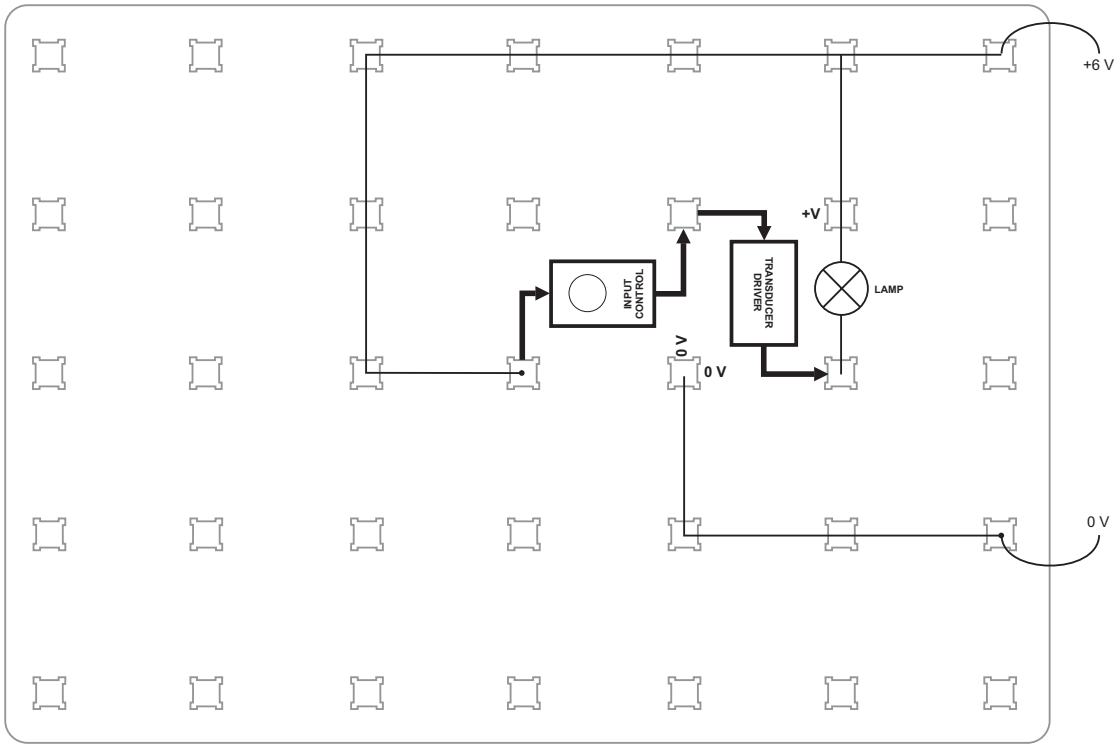


Figure 22 Circuit for Non-inverting Amplifier - Part A

Note that the Input Control module is used as a Voltage Input module.

Rotate the control slowly until the lamp indicating the output just FAILS to light.

Measure the voltage at the input of the Transducer Driver. Record this voltage.

Without altering the control knob setting on the Voltage Input module, rebuild the system as shown in Figure 23. It includes the Non-Inverting Amplifier.

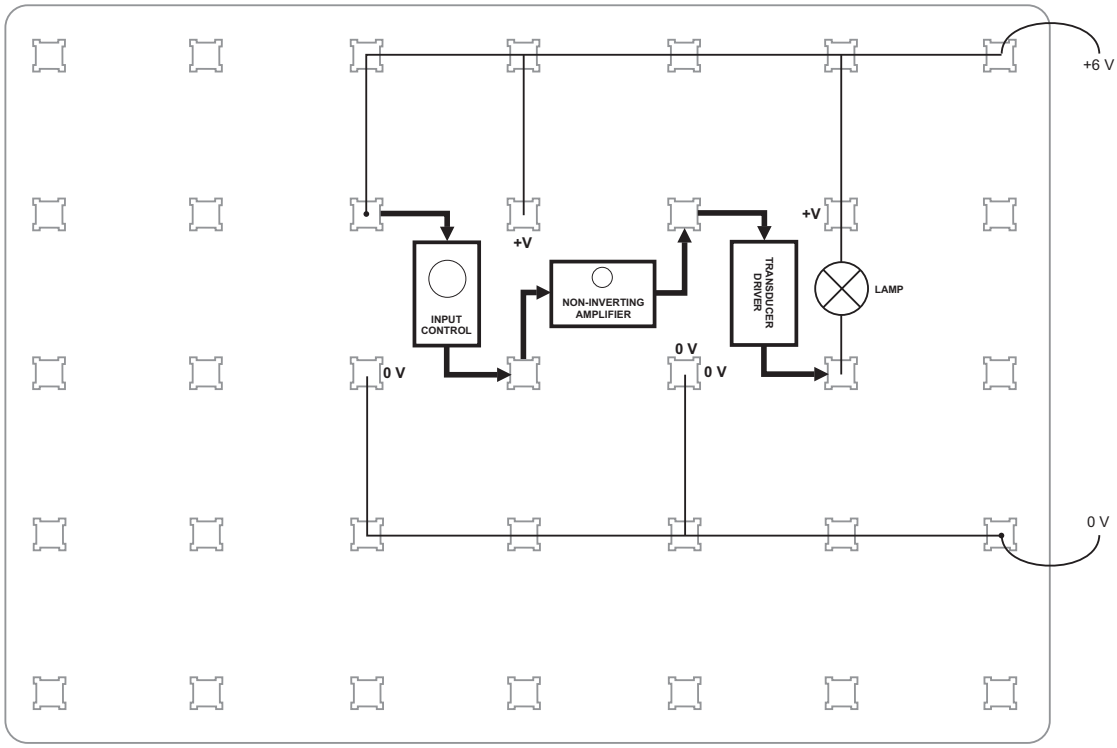


Figure 23 Circuit for Non-inverting Amplifier - Part B

Set the amplifier gain to maximum by rotating the gain control knob fully clockwise.

If you have not touched the voltage input the lamp should now be lit. Once again rotate the control knob on the Voltage Input Module until the lamp just fails to light.

Measure the voltage at the input of the Transducer Driver. Is it the same as before?

Now measure the voltage at the input to the Non-inverting Amplifier, compare the two voltages and complete the following sentence:

The Non-inverting Amplifier is used to ……. the signal voltages from any ….. ……----….. before being passed on to a signal processor.

Repeat the assignment with the amplifier gain set at different levels. What do you find from the results?

10. The Comparator (Needs LK75B Kit)

This device can 'compare' two voltages, one of which, the reference voltage, can be varied by the control on the module.

Assemble the circuit shown in Figure 24.

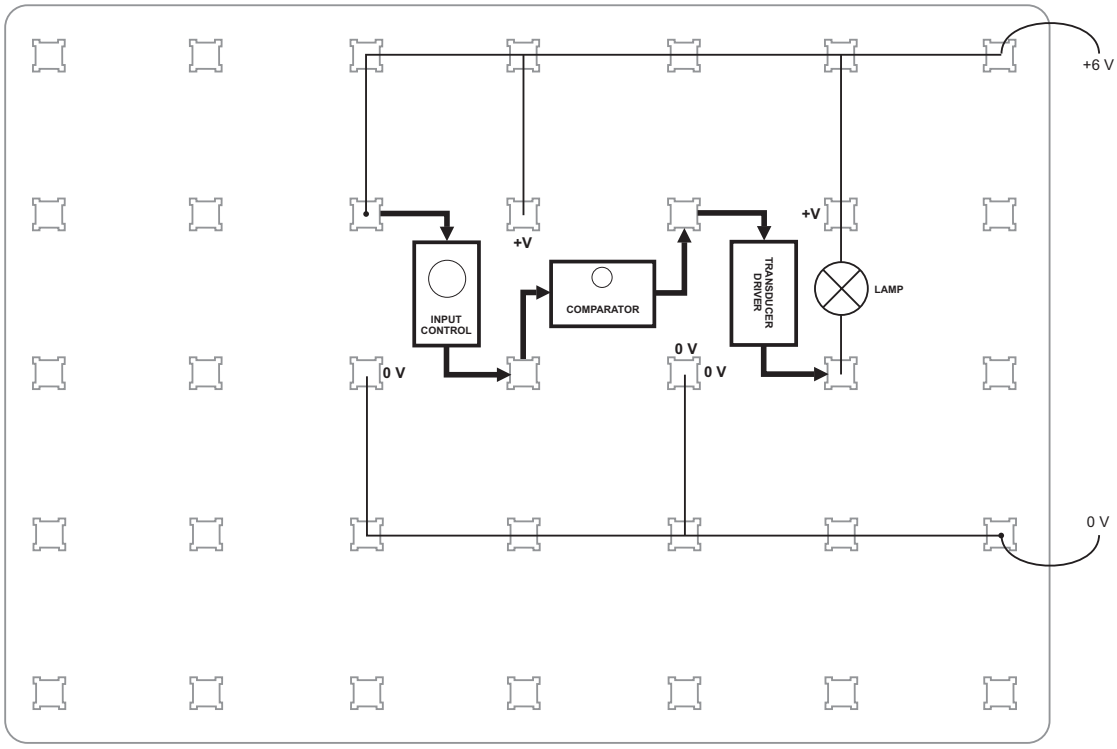


Figure 24 Circuit for The Comparator

First rotate the comparator reference voltage (‘ref volts’) control fully clockwise. The reference voltage is now set at its highest level.

Rotate the input control fully anti-clockwise. The input to the comparator is now set at zero volt (0 V).

Connect your power supply and switch on. Rotate the input control knob slowly clockwise until the output lamp lights then back again fully anti-clockwise. Repeat this slowly once again but this time measure the voltage at the input to the comparator as you do so. Record the voltage at which the lamp comes on. Set the reference voltage (‘ref volts’) control to about its midway position and repeat once more. Again record the voltage at which the lamp comes on.

Set the reference voltage to zero (fully anti-clockwise) and repeat once more. Complete this sentence:

The comparator is an electronic switch that operates only when its …..... voltage becomes the same as, or exceeds, its reference …….....

11. The Sound Sensor (Microphone) (Needs LK75B Kit)

Assemble the system shown in Figure 25.

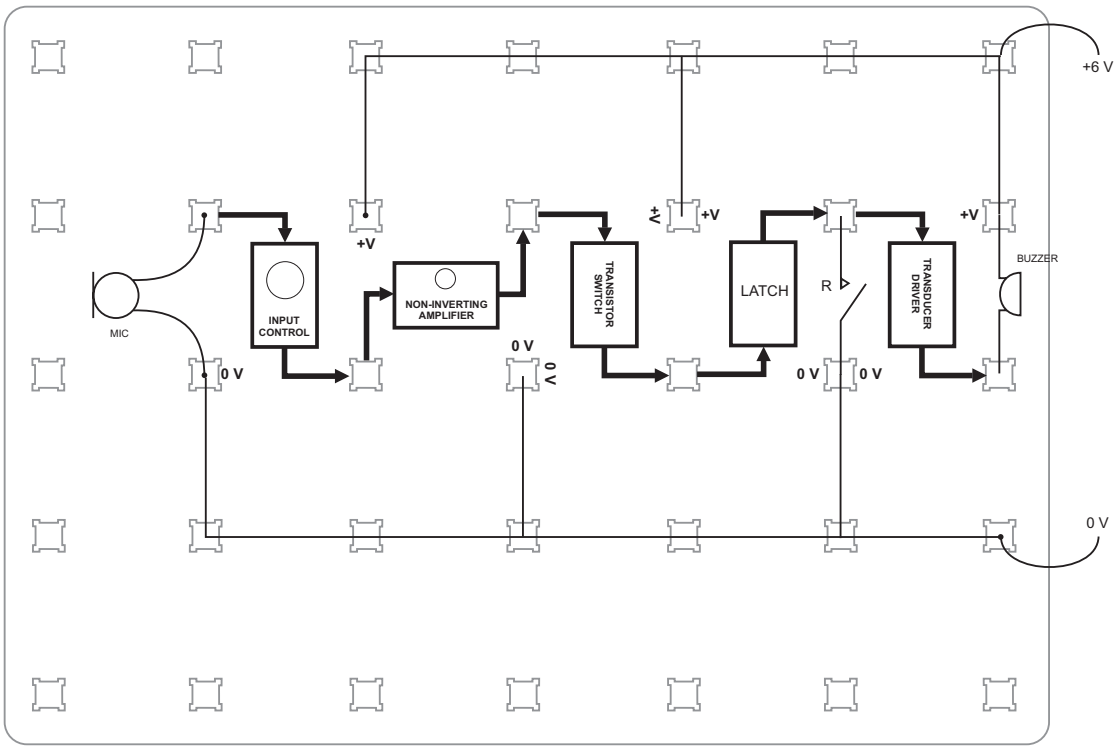


Figure 25 Circuit for The Sound Sensor

Note that the microphone, unlike all the other input transducers (Assignment 3), is connected to the 0 V rail instead of the +V rail. This is because it generates a potential difference across its connections in proportion to the amplitude of sound it receives. The other input transducers change their resistance (or simply switch on and off) , so they need a current to pass through them in order to create a change in voltage across them.

The system shown is a sound operated alarm. The sound level which will operate the alarm can be adjusted by using the input control in the usual way.

When you have tested the system, use the comparator instead of the non-inverting amplifier.

Problem Solving (Needs LK75B Kit)

Your experience with the modules should now allow you to look at problems and create one or more solutions.

The normally accepted technique for solving problems using Electronic Systems modules is to use these simple rules:

1. Decide what the OUTPUT(S) of the system is (are) going to be.
2. Decide what the INPUT(S) is (are) going to be.
3. Decide which SIGNAL PROCESSOR(S) is (are) needed to produce the output you need.
4. Produce a design on paper using systems 'blocks'.
5. Assemble the prototype system.
6. Test the system to see if it fulfils ALL the desired functions.
7. Produce the second, modified design, on paper.
8. Assemble and test the modified system.

LOCKTRONICS SYSTEMS MODULES are particularly suited for problem solving exercises because of the speed at which modifications to a system may be made.

12. Problem Solving Example

A photographer wishes to design a cupboard which can only be opened when the dark room light is off AND a switch is made.

Outputs, Inputs and Signal Processors

Output	Inputs	Signal Processors
Operation of a solenoid to enable the door to be opened.	Light sensor to detect absence of light (NOT light)	INVERTER to follow the light sensor/Input Control.
	Press switch to be used by the photographer	AND gate

System Diagram:

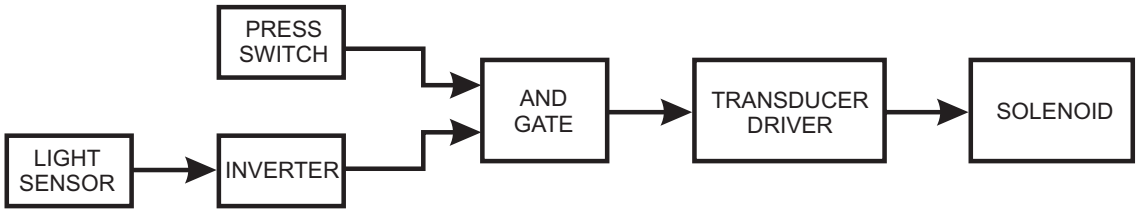


Figure 26 System Diagram

Prototype Design

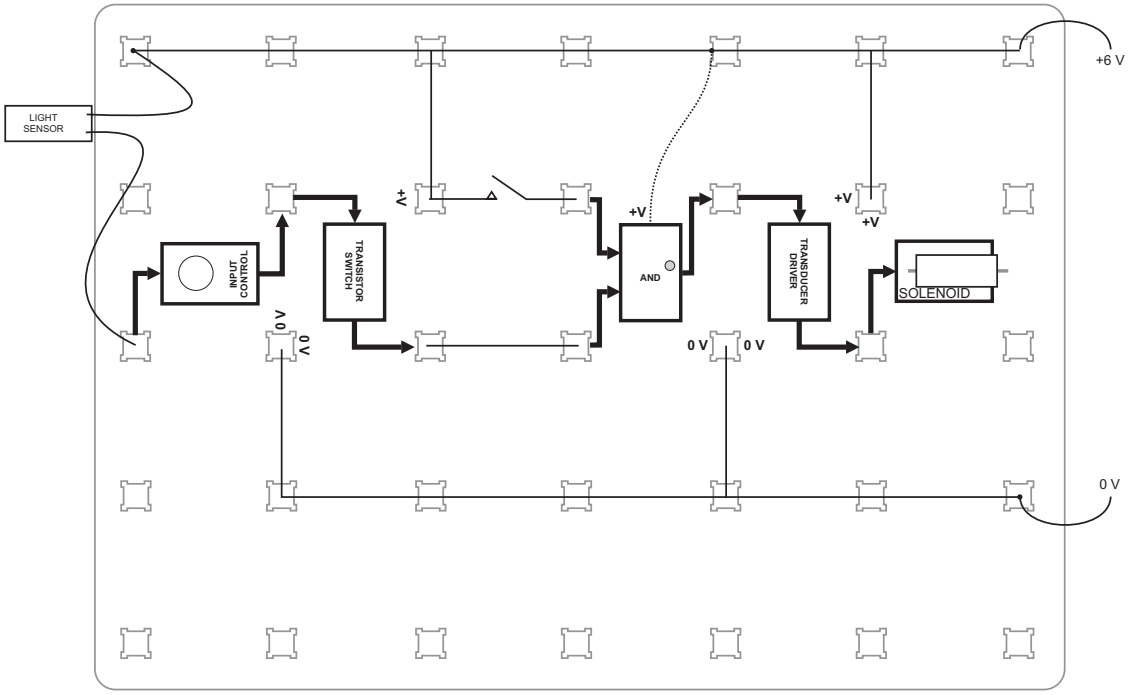


Figure 27 Prototype System Circuit for the Photographers Cupboard

A test of the circuit shown in Figure 27 should prove it works quite well, but the inclusion of a Latch between the switch and the AND gate would enable the photographer to have both hands free after pressing the switch momentarily.

Modified Design

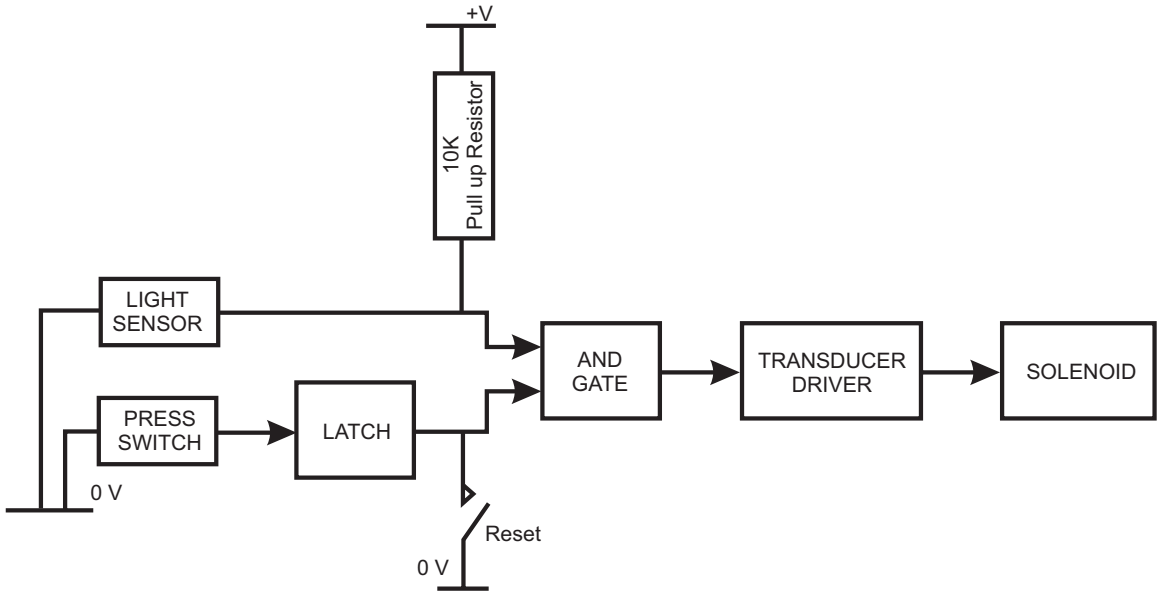


Figure 28 Modified Design

Note: This modified design illustrates one of the major advantages of LOCKTRONICS, i.e. its ability to use a standard component as a systems device. In this case the 10K (10 Kilohm) 'pull-up' resistor holds the upper input of the AND gate high in the absence of light but if light falls on the sensor the input immediately goes low and keeps the output of the gate low even if the switch is pressed. This means the inverter and the input control are no longer needed; The switch will be connected to 0 V rail in this case to provide a low input for the Latch.

Final assembly and testing of the modified system should prove its success.

13. More Problem Solving Exercises to Try

1. Automatic Watering System for a greenhouse
2. A Burglar Alarm that takes a photograph of the burglar
3. A Counter for people entering a room
4. A Fire Alarm with sprinkler
5. A Level Detector for a bottle filling conveyor with 'knock off' device if the level is too low
6. A Denary Dice
7. An Adjustable Egg-Timer
8. A Light Meter
9. A Sound Operated Camera
10. Baby Awake Alarm

If you are lucky enough to have other Locktronics Kits, some of them include useful signal processor and transducer modules that you can use for other systems exercises. These modules include:

Signal Processors	Input Transducers	Output Transducers
R.S Latch	Slotted Opto Switch	Relay C/O Switch
Bar Driver	Strain Gauge	Slotted Opto switch (Isolator)
Schmitt Trigger NAND	Tilt Switch	
Pulse Delay Module		
4 Input AND Gate		
4 Input OR Gate		
Difference Amplifier		

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 29 shows the comparison.

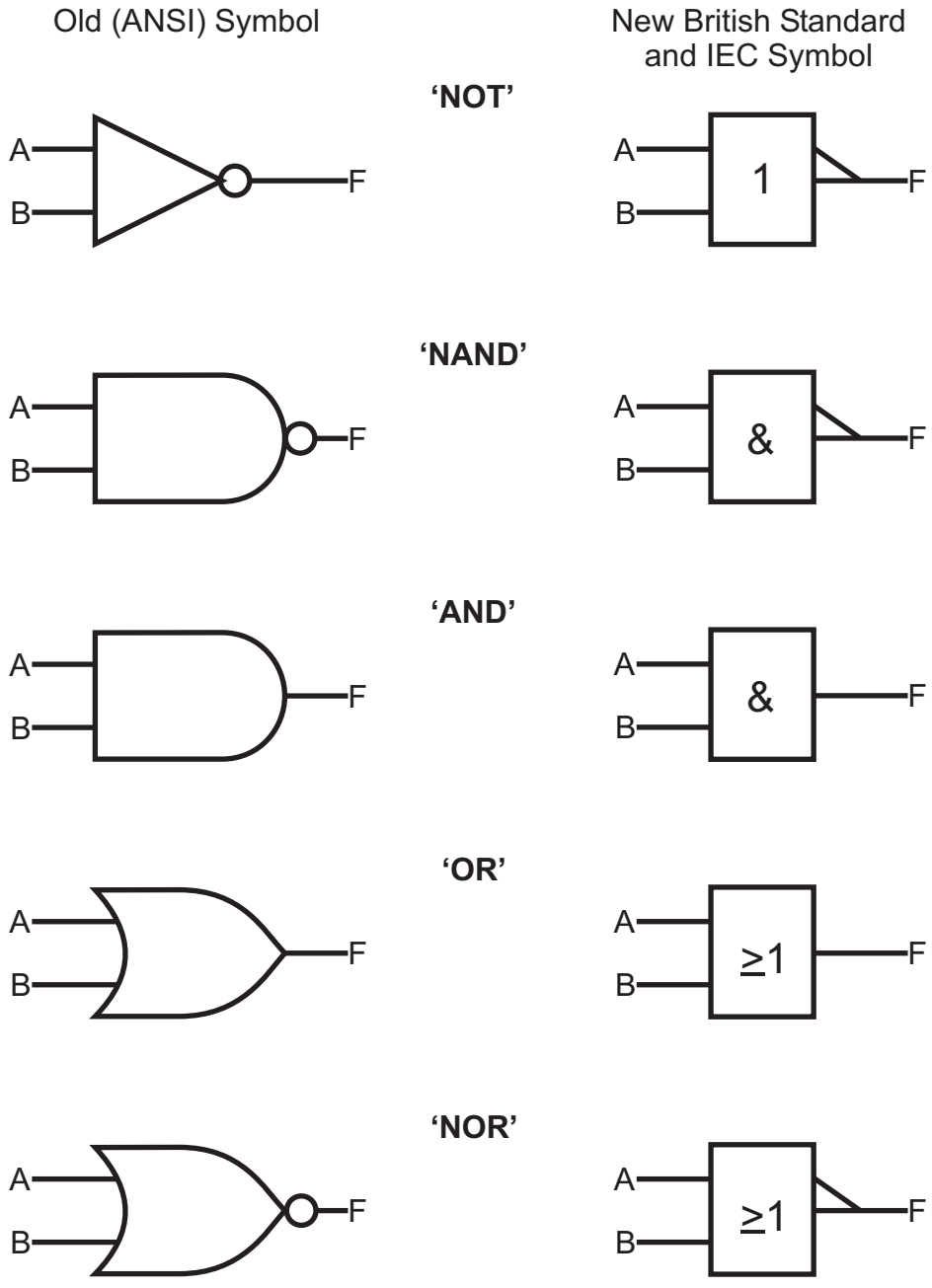


Figure 29 Older American and Newer BS/IEC Symbols

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 2 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 3 NOR and NAND Truth Tables

NOT	
A	**F**
0	1
1	0

Table 4 NOT Table