Practical Skills and Techniques

Described Skills.

- Soldering.
- Drilling.
- General Construction
- Board Connections.
- General Multi-meter use.
- First Aid
- Health and Safety
- ESD
- Electrical Safety/Wiring.
- Build a Net List.
- Flow Charts.
- State Machines.
- The Log Book.
- Electrical Installation.

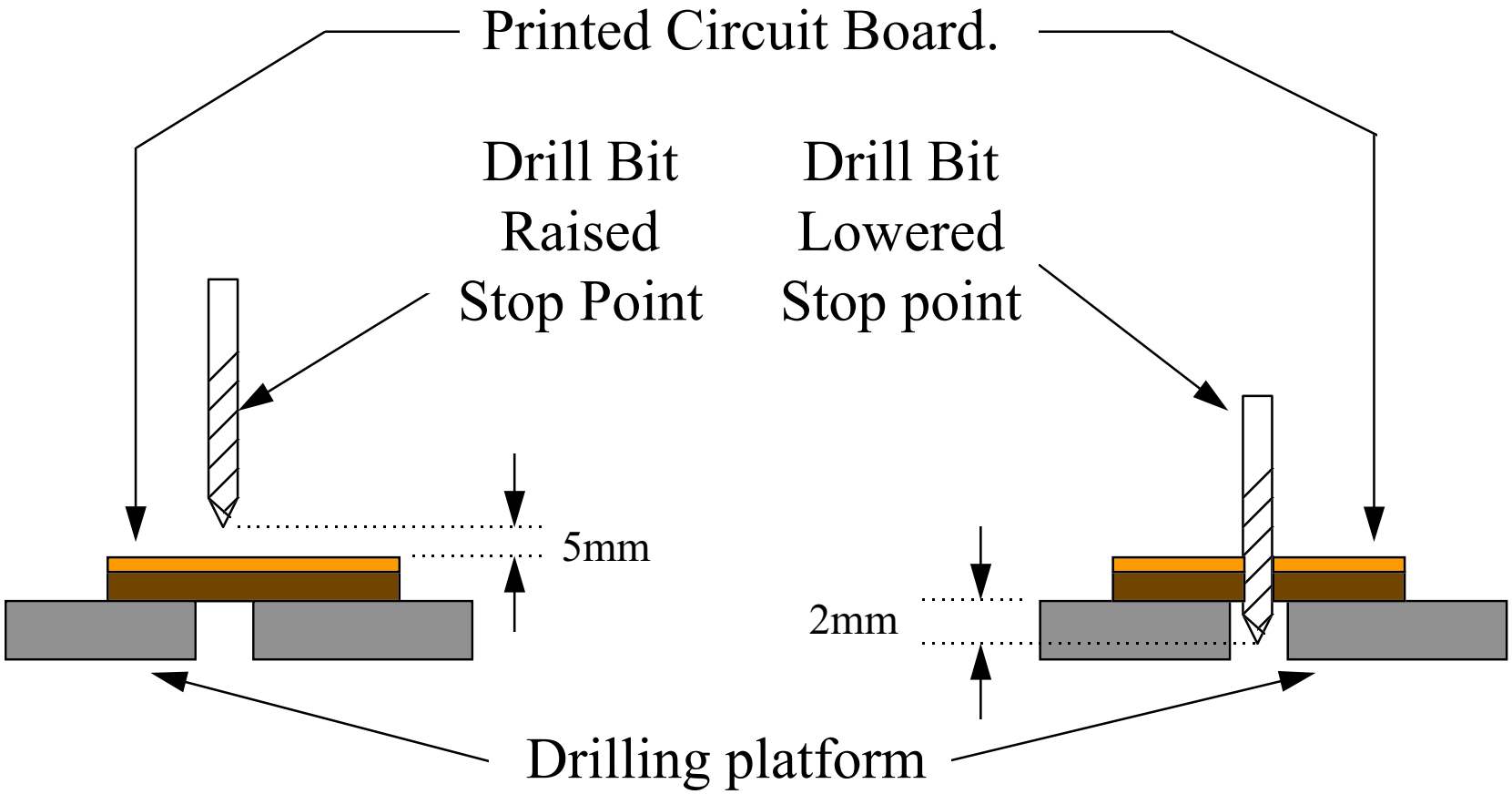
Soldering.

Soldering.

- A good soldered joint will be
  - Shiny.
  - Concave.
  - No Lumps, Bumps or holes.
- Tinning wire (Wire preparation)
  - Strip insulation from wire.
  - Twist the strands together.
  - Apply thin coat of solder from insulation end.
  - Cut tinned end to size.

Drilling.

Drilling.



Adjust Drill settings as shown above before cutting the first hole.
Keep PCB fully secured when drilling to avoid breaking drill.

General Construction Concepts

General Construction Concepts.

- Connection from a Positive Power source should use **RED** wires. Last resort **Yellow**.
- Connection from a Negative Power source should use **BLACK** or **BLUE** wires.
- Connection from a Common Point should use **Green** wires.
- Use any other colours for signal and data lines eg. Pink, White, Orange etc

General Construction Concepts.

- When Using Breadboards:-
  - Use the Bus (Long Tracks) to transfer power around the board.
    - Remember to link across the breaks.
  - Chip and other devices
    - Check when fitting / positioning that the pins across the devices are **not** accidentally connected.
  - Avoid wires that cross over the top of a chip.
    - Route all your wires around the Devices/Chips.
  - Avoid locking wires on to breadboard.
    - enable all wires to be removed easily if required.

General Construction Concepts.

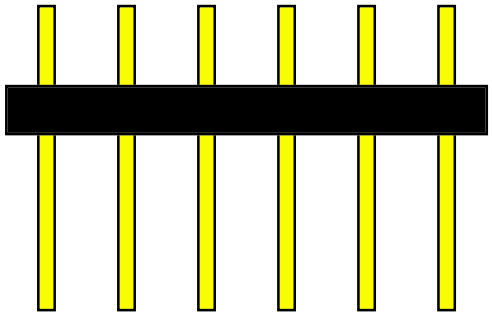
- When Using Breadboards:-
  - To remove insulation from 1/0.6/2 wire
    - use the back of the wire cutters to push the insulation off the wire. Only gentle pressure on the cutters is required to separate insulation sections.
  - Keep stripped insertion section of the wire to a length of about 5mm
    - The longer the stripped section is, the harder it is to remove from the breadboard when dis-assembling.

Board Connections.

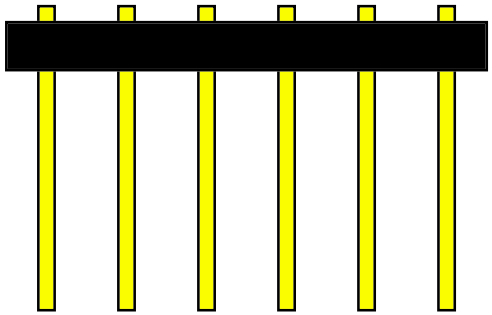
Board Connections.

Push Pins through Holder
as shown below.

Before

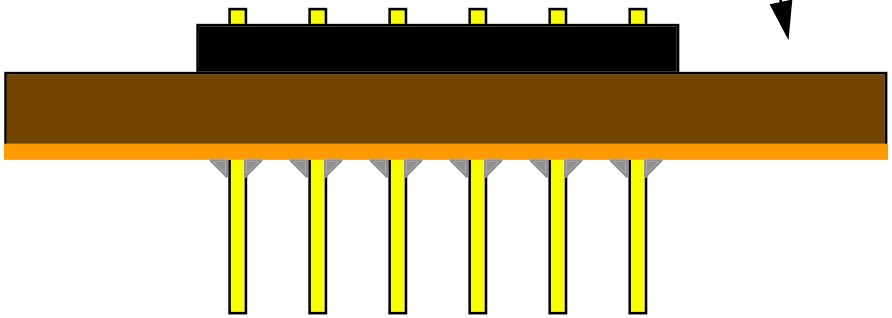


After



Component side of board

Inserted in PCB



On Copper side of board use just
a touch of solder to secure Pins.

Using Test Equipment.

Using Test Equipment.

Display Screen

Off Position

Range Selection Switch

Positive Terminal

The Basic Controls

Negative or **Common** Terminal

Using Test Equipment.

DC Voltage measurement Range area

AC Voltage measurement Range area

DC Current measurement Range area

Resistance Range area

DO NOT use.

The Switch Controls

Using Test Equipment.

- Ensure that you know what it is that you are trying to measure. (Amps , Volts , Ohms)
- Check that your meter can measure your required value.
- Set meter to highest value in range.
- Reduce range until you get an appropriate reading on you meter.
- Record reading you have taken and the meter settings for that reading.

Using Test Equipment.

Simple Circuit Testing

- Checking/Looking for Short circuits S/C.
  - Set meter to 200Ω range
  - Expect readings of less than 10Ω to indicate a Short Circuit.
- Checking/Looking for Open circuits O/C.
  - Set meter to 200KΩ range
  - Expect readings of Greater than 100KΩ to indicate an Open Circuit.
  - Note: If screen just presents a “1” on the left hand side this means the measured value is too big to display.

First Aid

Electrical Safety.

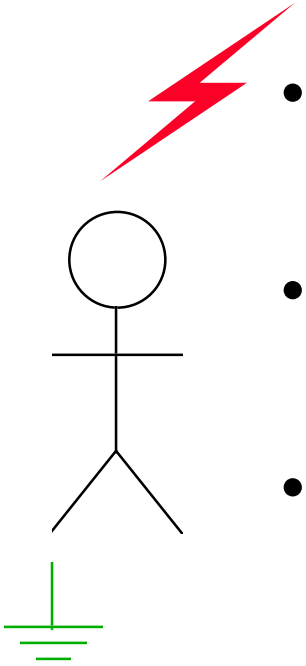
Electric Shock: First Aid and Safety.

- Raise Alarm (Call for medical/First Aid support)
- Remove the power from the electric source or remove the individual from the power ensuring that you use a non-conducting medium to separate patient from the power source.
- Ensure patient is breathing. [Resuscitation may be required CPR (Cardiac Pulmonary Resuscitation)].
- If patient breathing, place them in Recovery position.
- Treat electrical burns wounds (Entry and Exit).

Health & Safety

Health & Safety.

Electrical Safety

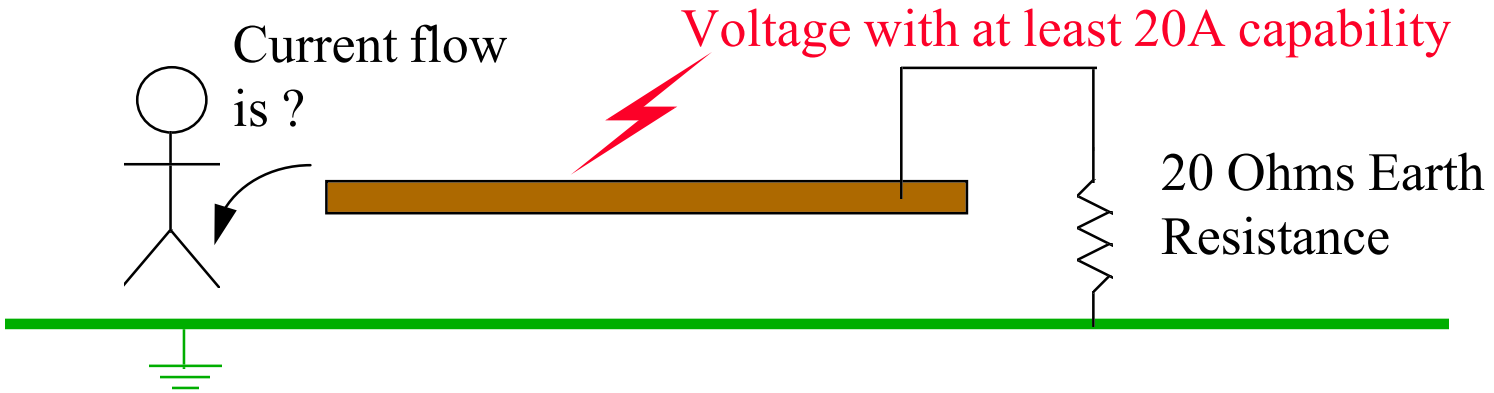


- All **Voltages** above 50 Volts potentially can produce a current that can kill.
- All electrical shocks have an entry and an exit point/wound. (First Aid Treatment)
- Always avoid any possibility of current to flow through the Heart.
- It is the **Current** that kills NOT the **Voltage** (Typically 1 - 2mA) through the heart.
- RF Shocks/burn are extremely slow to heal (if at all).

Health & Safety.

Earthing Connections.

- Voltage across resistance is I*R = 20 * 20 = 400V
- Human resistance typically 5K ohms.
- Current flow = V/R = 400 / 5000 = 80mA **(Sufficient to Kill)**
- Therefore Earth bonding resistance's should be as low as possible Ideally less than 0.1 Ohms tested at 20 Amps.



ESD

Electro-Static Discharge

Electro-Static Discharge.

- The Basic Situation :-
- Most Digital Electronic components are designed to work at low VOLTAGE.
- Many Components have Very High Impedance (Very High Resistance) inputs.
- Static charges on individuals due to synthetic fibers are often in range +20KV.
- "Result" discharge through components to earth destroys or stresses the device.

Electro-Static Discharge.

- How do we Protect :-
- Keep components in their ESD protection packaging until they need to be used.
- Ensure YOU , YOUR WORKSPACE and THE COMPONENTS are at Earth potential.
- Ensure before inserting components that power is not applied to the circuit board.
- Remember Components can be destroyed in Micro seconds due to bad handling.

Electro-Static Discharge.

- Observations:-
- Bad handling of components may not be immediately obvious.
- Stressed components will fail long before their normal life expectancy.
- In the WORK PLACE a breach of Company ESD regulations will often result in immediate dismissal from that employment. (ie. sacked on the spot)

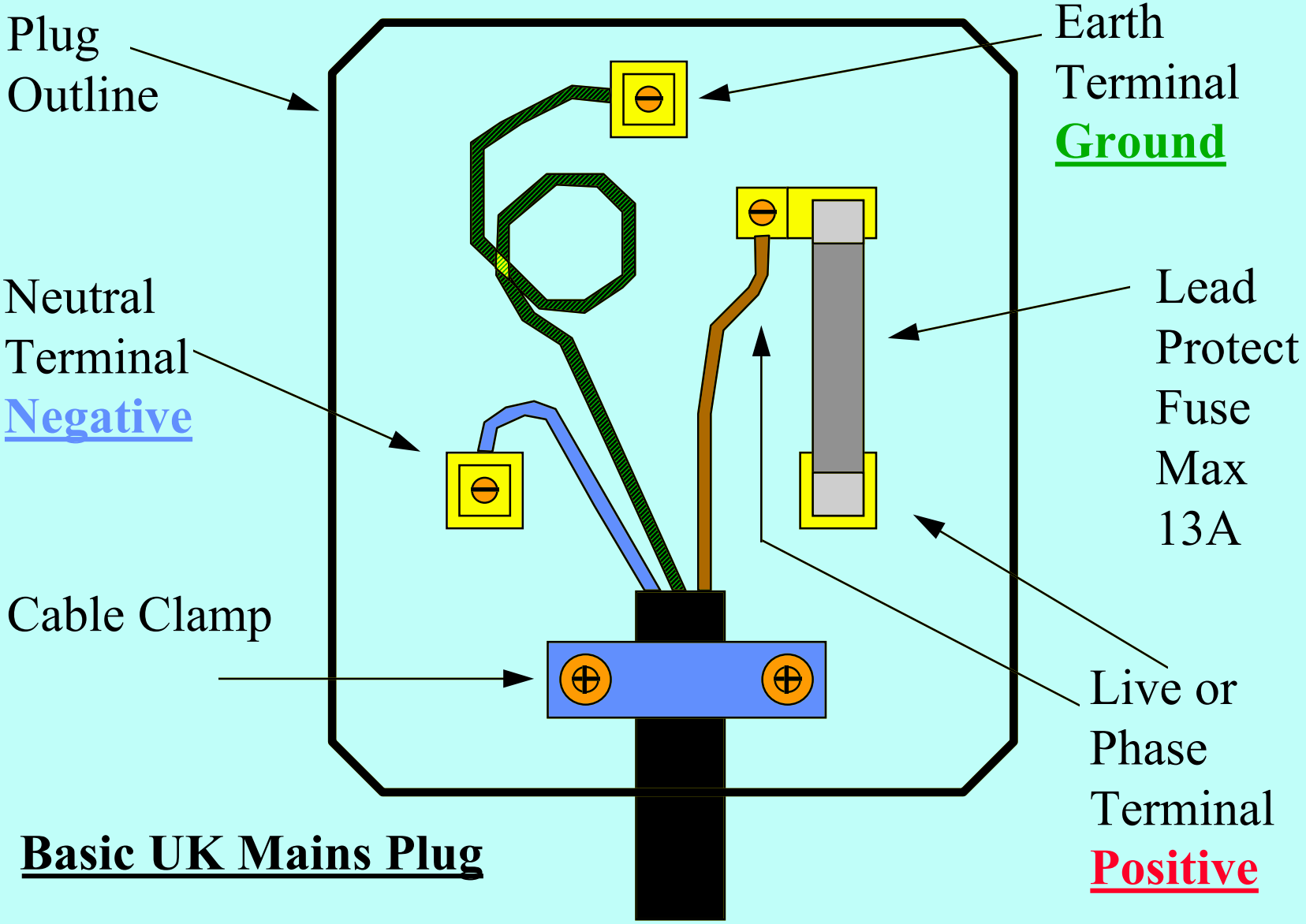
Electrical Safety.

Electrical Safety.

Fitting a Plug.

- Remember Mains = 240V a.c **can kill**.
- Trim Outer Cable Insulation to size.
- Cut Wire Lengths to size (Live, Neutral, and Earth Remember you need extra wire for the Loop)
- Strip wire insulation (ensure no strands are broken)
- Attach correct wires securely to the Plug Pins.
- Ensure Cable clamp grips the Cable Insulation.
- Fit Plug cover

Electrical Safety.



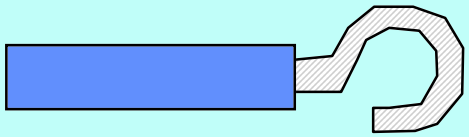
Basic UK Mains Plug

Electrical Safety.

Twist and Trim

or for Screw Terminals

Twist, Trim and Fold



Twist, Trim and Shape

for Screw Clamps

Finally:

Ensure you make a good tight electrical connection.

How to Build a NET List.

Building a Net List

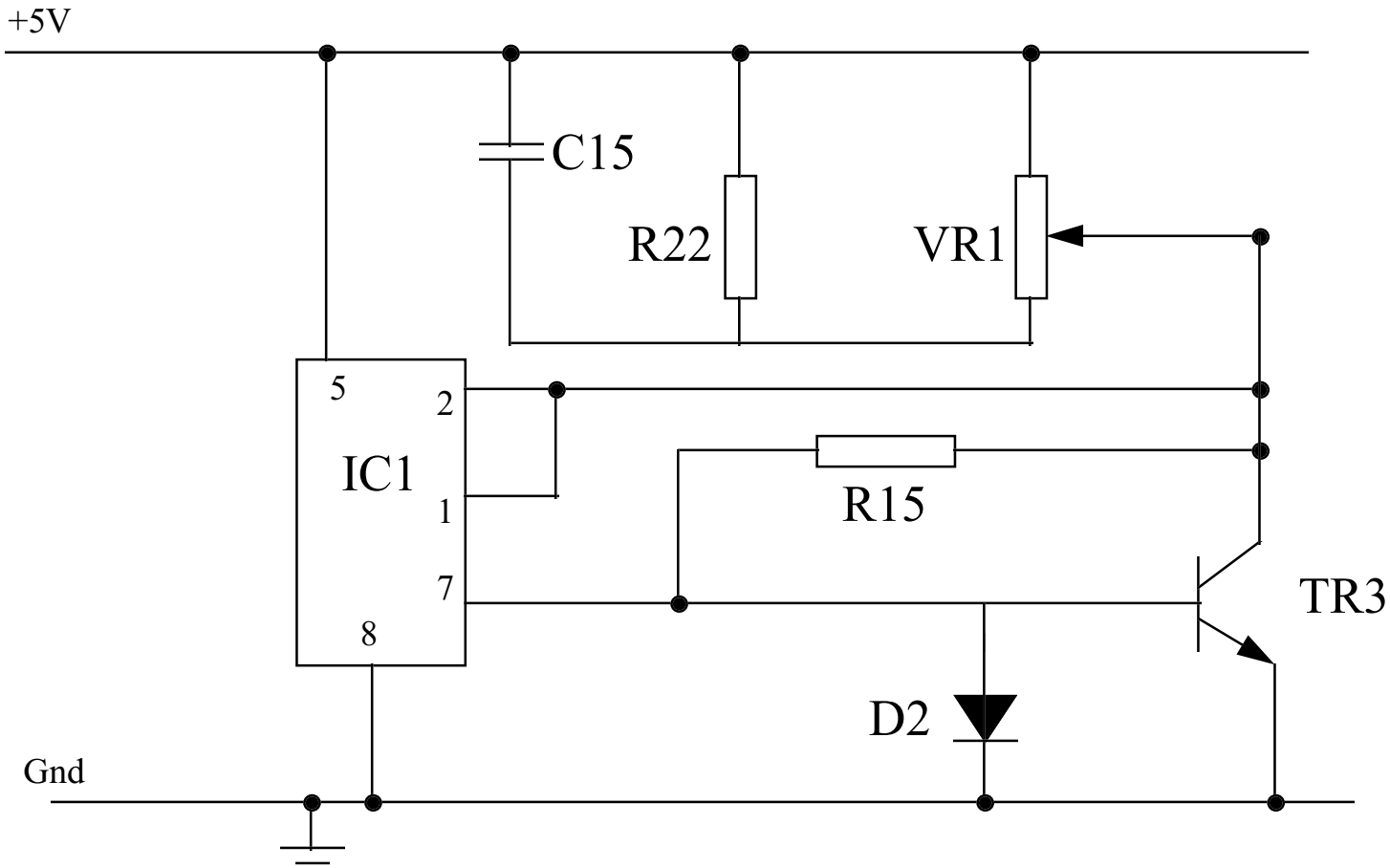
- This is a relatively simple process that will allow you to be able to test or verify that you have identified all connections in an electronic circuit.
- The process also allows you to be able to prepare for circuit or bread boards layouts.

The Process

Building a Net List

- Stage 1: Identify all components that you are using from the circuit diagram.
- Stage 2: Identify , allocate a pin code to every electrically connected component.
- Stage 3: Identify connections or nets and as each pin code is added to a net remove it from the resource list. You may optionally assign a name to the Net to aid identification.

The Demo Circuit.



Example Demo Circuit (Basic Circuit Diagram).

An Example

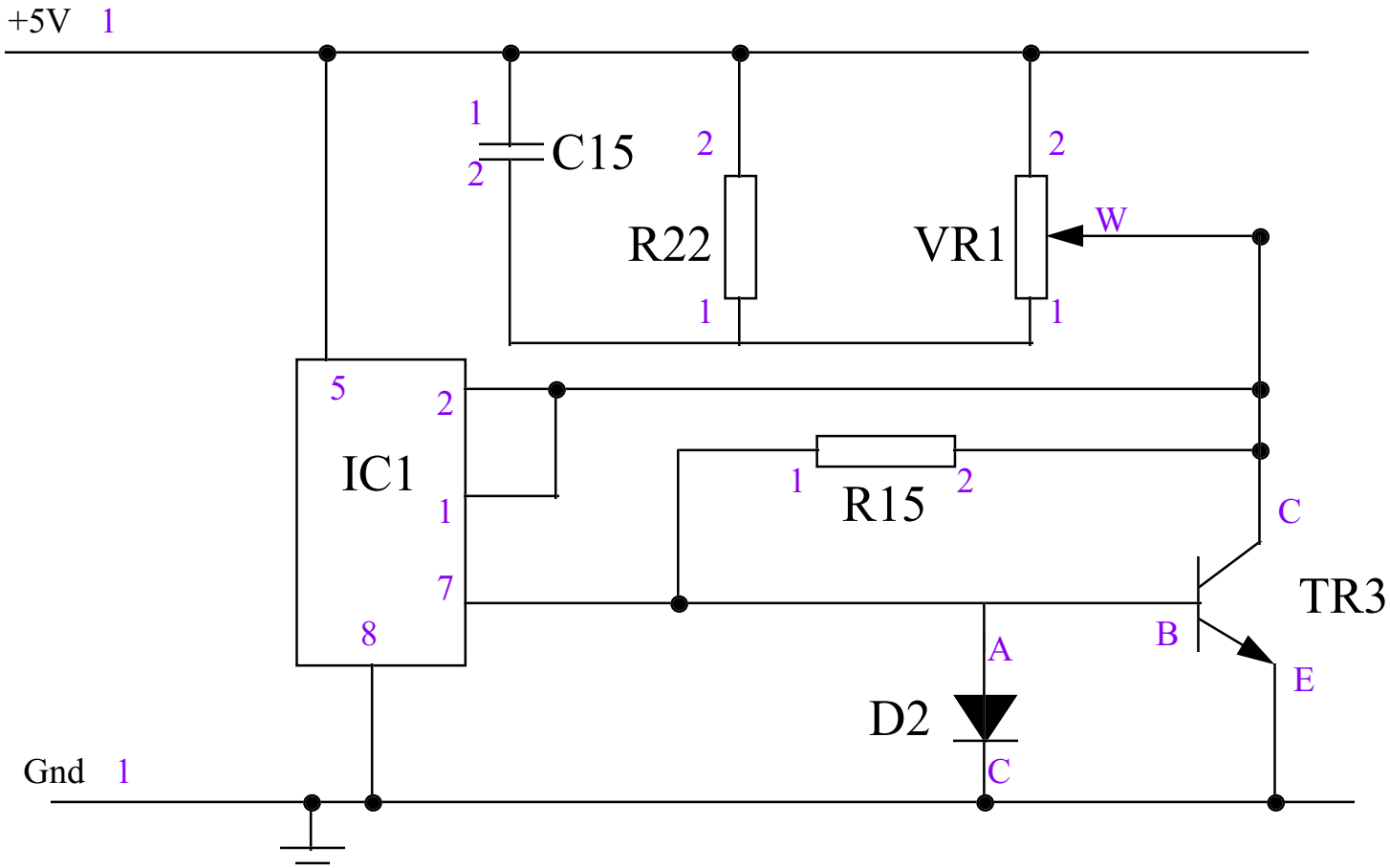
Building a Net List

- The Resource List Basic Components
- IC1
- R22
- R15
- VR1
- C15
- TR3
- D2
- +5V
- Gnd

Next

Identify from the circuit diagram all the Pins or points of connection then allocate each item into the Resource List.

The Demo Circuit.



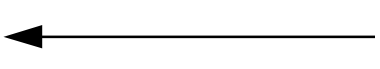
Example Demo Circuit (With Pin Allocations).

An Example

Building a Net List

- The Resource List

IC1	1	2	5	7	8
R22	1	2			
R15	1	2			
VR1	1	W	2		
C15	1	2			
TR3	C	B	E		
D2	A	C			
+5V	1				
Gnd	1				



Next

Select an initial Pin from the Resource List and identify every other pin that is attached to it.

An Example

Building a Net List

- The Resource List

IC1	1	2	5	7	8
R22	1	2			
R15	1	2			
VR1	1	W	2		
C15	1	2			
TR3	C	B	E		
D2	A	C			
+5V	1				
Gnd	1				

- The Net List
- +5V,1

Next

Build a list and cross off or circle each pin as it is transferred to the Net list table.

Usual format is:-

Node,Pin code

An Example

Building a Net List

- The Resource List
- IC1 1 2 5 7 8
- R22 1 2
- R15 1 2
- VR1 1 W 2
- C15 1 2
- TR3 C B E
- D2 A C
- +5V 1
- Gnd 1
- The Net List
- +5V,1 → IC1,5

Next

Build a list and cross off or circle all other pin/s that are directly attached to each other and transfer them to the Net list table.

The symbol " → " separating each <Node,Pin code> item indicates Connected together.

An Example

Building a Net List

- The Resource List
- IC1 1 2 5 7 8
- R22 1 2
- R15 1 2
- VR1 1 W 2
- C15 1 2
- TR3 C B E
- D2 A C
- +5V 1
- Gnd 1

Next

When all Nodes of a Net have been identified start on next Net.

i.e. in this case Gnd

- The Net List
- +5V,1 → IC1,5 → R22,2 → VR1,2 → C15,1

An Example

Building a Net List

- The Resource List
- IC1 1 2 5 7 8
- R22 1 2
- R15 1 2
- VR1 1 W 2
- C15 1 2
- TR3 C B E
- D2 A C
- +5V 1
- Gnd 1

Next

Repeat process till all pins have been allocated to a Net

- The Net List
- +5V,1 → IC1,5 → R22,2 → VR1,2 → C15,1
- Gnd,1 → D2,C → TR3,E → IC1,8

An Example

Building a Net List

- The Resource List

• IC1	1	2	5	7	8
• R22	1	2			
• R15	1	2			
• VR1	1	W	2		
• C15	1	2			
• TR3	C	B	E		
• D2	A	C			
• +5V	1				
• Gnd	1				

And Finally

The Process competed all nodes used.

- The Net List

• +5V,1	→	IC1,5	→	R22,2	→	VR1,2	→	C15,1
• Gnd,1	→	D2,C	→	TR3,E	→	IC1,8		
• IC1,1	→	IC1,2	→	R15,2	→	VR1,W	→	TR3,C
• D2,A	→	TR3,B	→	R15,1	→	IC1,7		
• R22,1	→	VR1,1	→	C15,2				

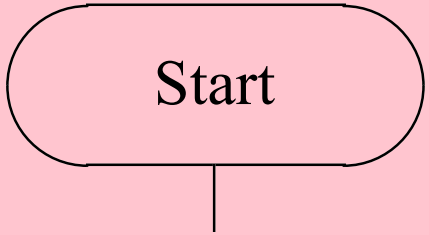
Flow Charts

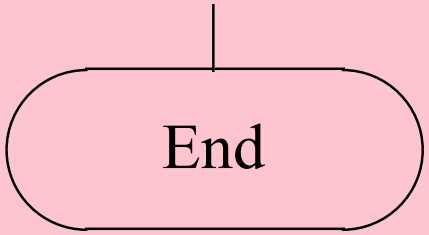
Flow Charts.

- Flow charts are used to give a pictorial representation of how a system operates.
- The flow charts use a limited number of symbols that are fairly intuitive in their use.
- The Main symbols are :-
  - The Start and End Symbols.
  - The Process block symbol.
  - The Decision block symbol.
- Additional or Optional symbols :-
  - Input / Output block symbol.
  - On and Off Page Connectors.
  - Repeat or Iterative Block Symbols.

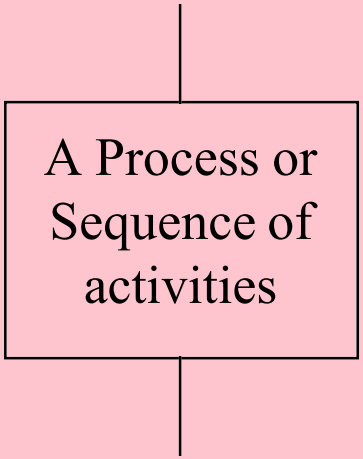
Flow Charts.

Start , End Symbols

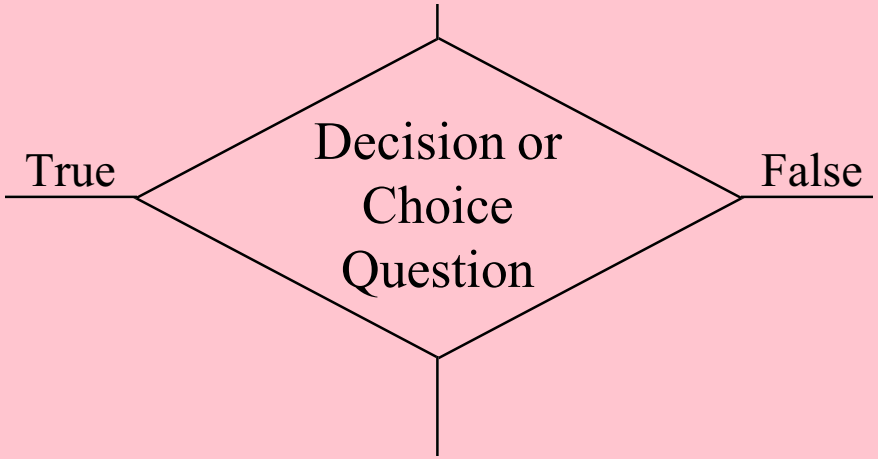




The Process Symbol



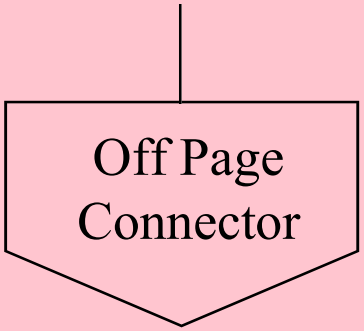
The Decision Symbol



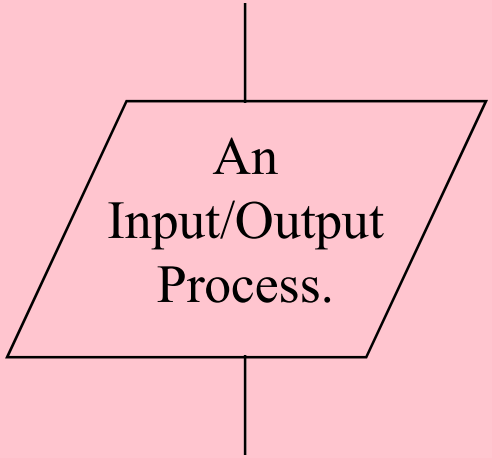
Other 2 Decision answers could also be YES/NO , Success/Error etc.
The 3 Decision answers are usually Higher , Same , Lower (FORTRAN)

Flow Charts.

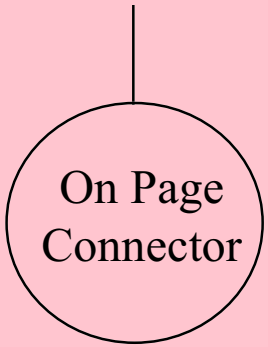
Off-Page Connector Symbols

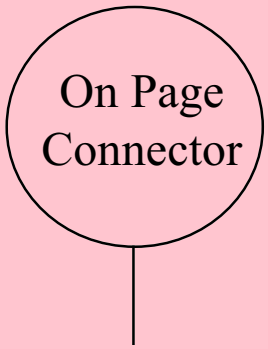


The Input/Output Process Symbol

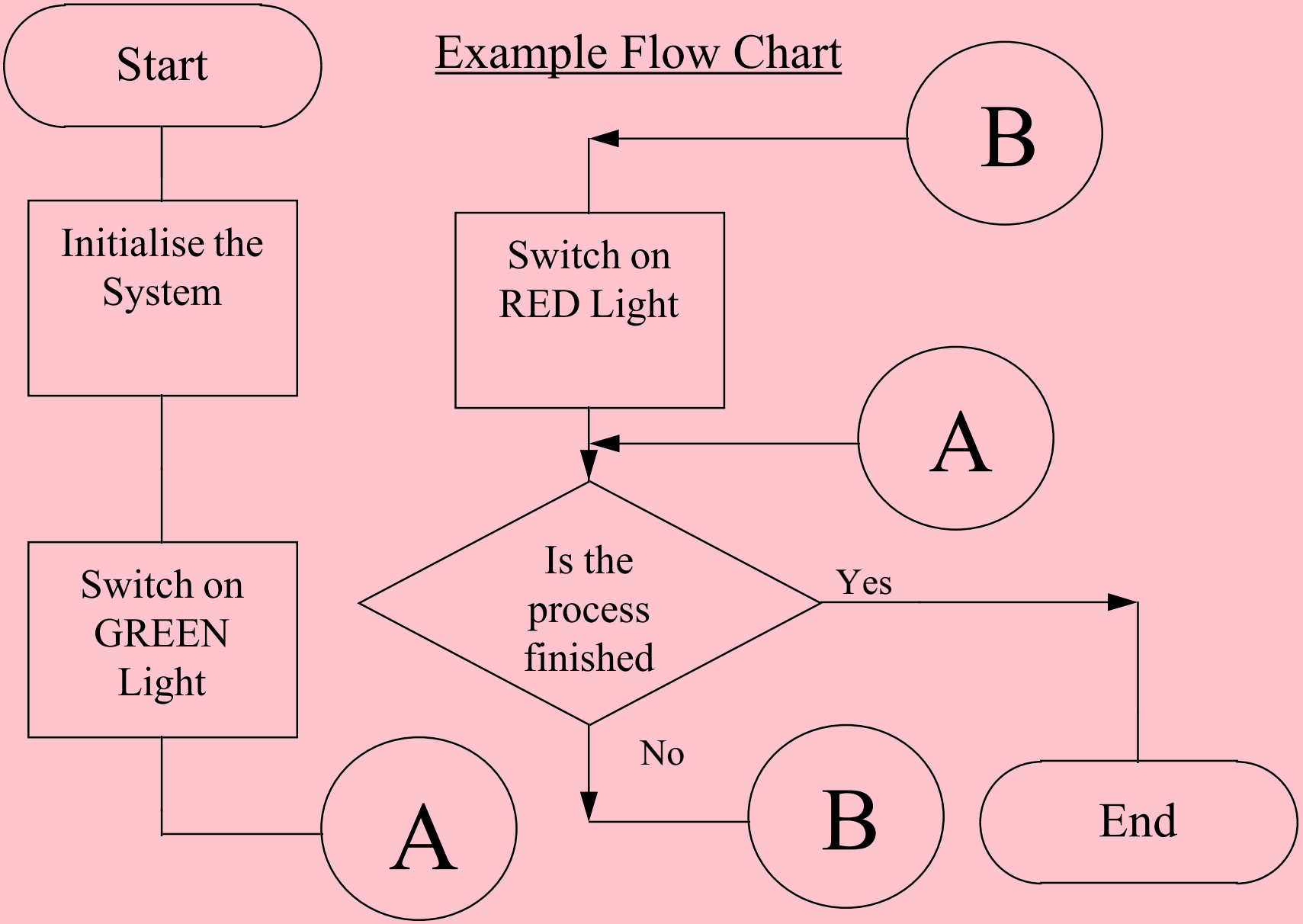


On-Page Connector Symbols





Flow Charts.

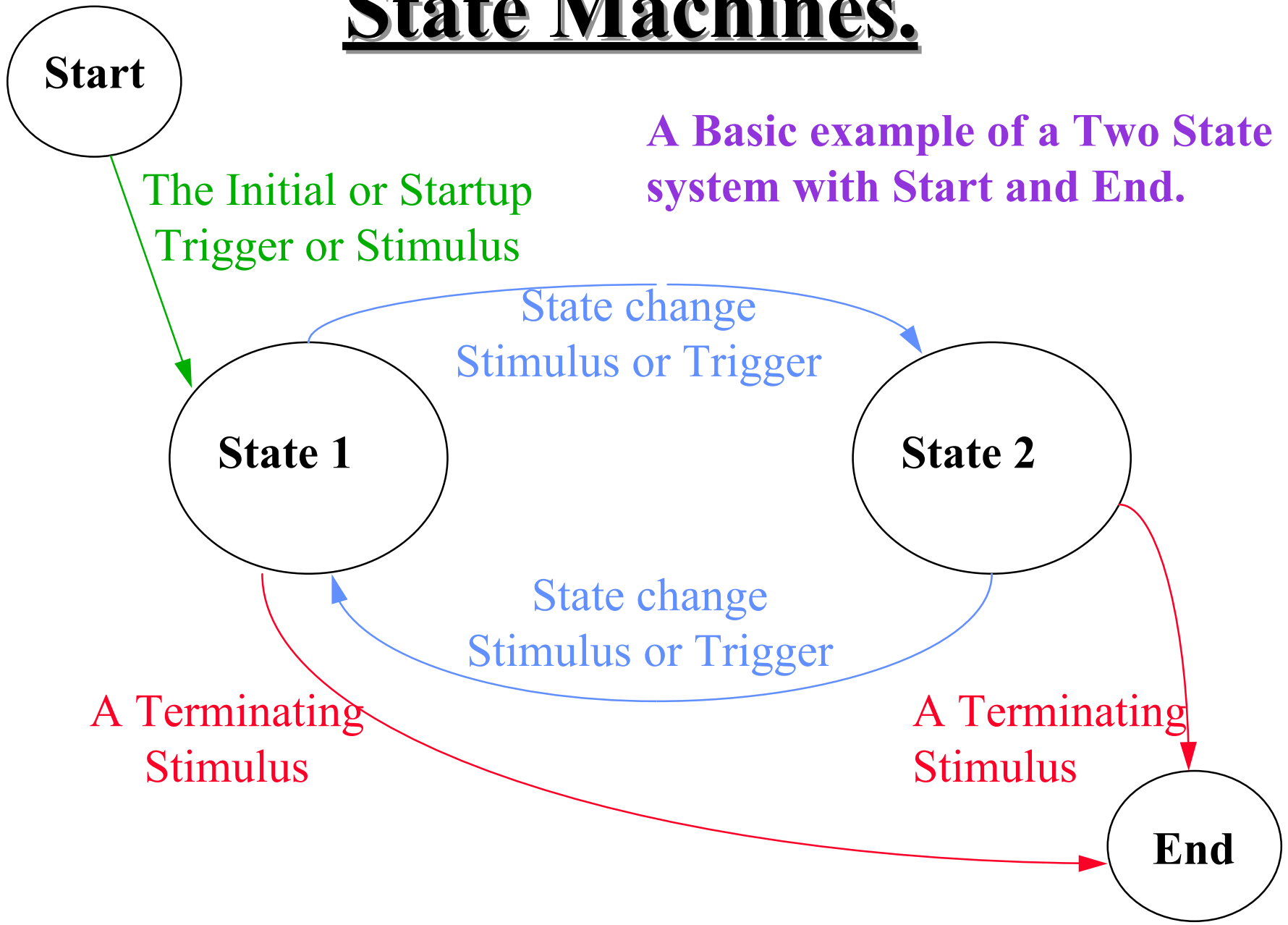

Example Flow Chart
Start
Initialise the System
Switch on GREEN Light
A
Switch on RED Light
B
A
Is the process finished
Yes
No
B
End

State Machines or Diagrams.

State Machines.

- What is a State Machine ?
- ***It is a system that moves from one stable condition to another dependent on an external stimulus.***
- Many systems or problems can be subdivided into a sets of stable conditions (or states) that respond to some trigger stimulus.
- We can produce diagrams that both define a problem or can be used to produce an analytical solution to the problem.
- States are represented by **Circles or Boxes** with text inserts.
- Trigger, Stimulus are **Lines** drawn between the states.

State Machines.



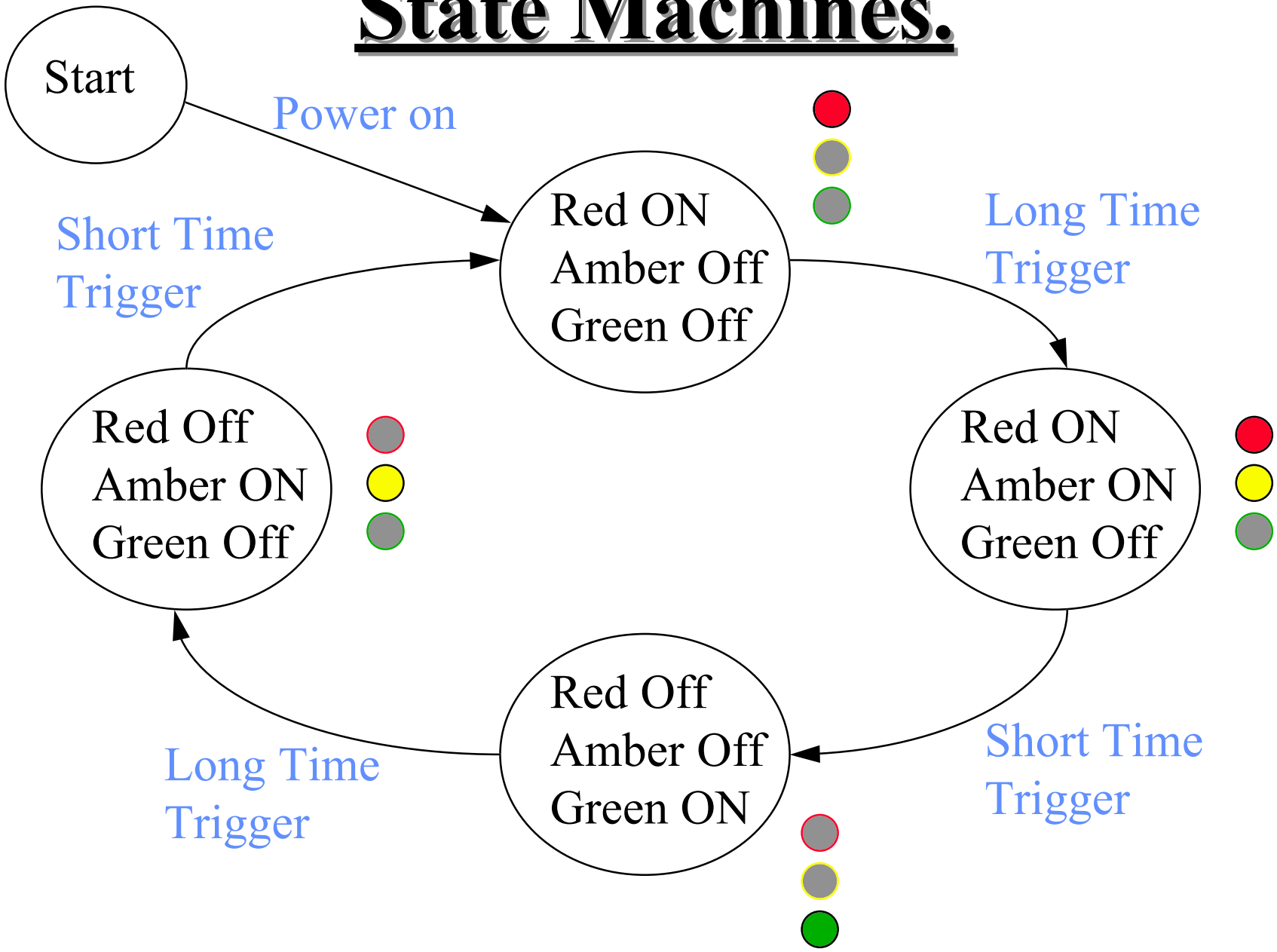
State Machines.

- How may we represent a set of traffic lights ?
- What states can the lights be in ?
- RED, RED + AMBER , GREEN , AMBER, and then back to RED (4 States).
- What sort of transitions signals do we have ?
- We have :-
- A Power on Transition (When they start)
- A Short Display transition that moves

  (RED → RED+AMBER) and (GREEN → AMBER)
- A Long Display transition that moves

  (RED+AMBER → GREEN) and (AMBER→ RED)

State Machines.



The LOG Book

The LOG Book.

- Used to record Laboratory and experimental session work.
- Each session starts with :-
  - The Activity **Title** and **Date**.
  - The Activity **Objective**.
  - The **Equipment used** (Serial Numbers etc.)
  - Identification of **Other resources**.

The LOG Book.

- Each session write up will contain :-
  - The **Method** or Methods used
  - Appropriate diagrams or sketches.
  - The **Results** or recordings
    - in Tabular or Graphical form
    - Equipment Settings or Configuration
    - Programme Settings or Configuration
    - Observations (of what happened)
  - and most importantly ...

The LOG Book.

- Each session write up will contain :-
  - Your **Conclusion**
  - (This is the most important section of all)
    - Explain What happened?
    - Were the results correct?
    - If errors occurred Why?
    - What improvements could be made if any?

The LOG Book.

- Additional Notes.
- The **Blue** keywords are an important guide to your section headers.
- If you make a mistake cross out do not erase explain what happened.
- Annotate graph with the correct scales and points of interest. Use the correct units.
- Colour may help to enhance sketches and diagrams but do not over do it.

The LOG Book.

- And finally be :-
- Clear
- Concise (to the point)
- Accurate
- and most of all . . .
- Answer the question you have been asked and **NOT** the question you think you would like to answer.

Domestic Wiring

Domestic Wiring.

- In the UK you are likely to come across a number of different wiring standards and regulations.
- The standards are usually set by an organisation call The “Institute of Electrical Engineers” more often known as the IEE.
- The wiring will normally conform to one of the standards ie. IEE 17th regulations.

Domestic Wiring.

- Whenever you are involved in any electrical wiring activity you should always use the latest practice, standards and regulations.
- Ensure whenever possible all circuits are dead before proceeding with any work.
- Experience shows that about 90% of all faults with electrical and electronic circuits are as a result of bad connections, therefore one should try to make all wiring connections as accessible as possible.

Domestic Wiring.

- The first major difference you would notice is that cable wiring colours have changed.

	Old Standard	New Standard
Live Wire	Red 	Brown 
Neutral Wire	Black 	Blue 
Earth Wire	Bare or Green 	Green + Yellow Stripe 

Domestic Wiring.

- All wiring will normally start from the consumer unit (a distribution box) which is connected to the mains source.
- The consumer unit allows you to have access to a number of fuse or trip protected outlets for distribution.
- Older systems used fuses to protect from excess current demand but modern units use mechanical trips and usually have some form of earth leakage protection as well.

Domestic Wiring.

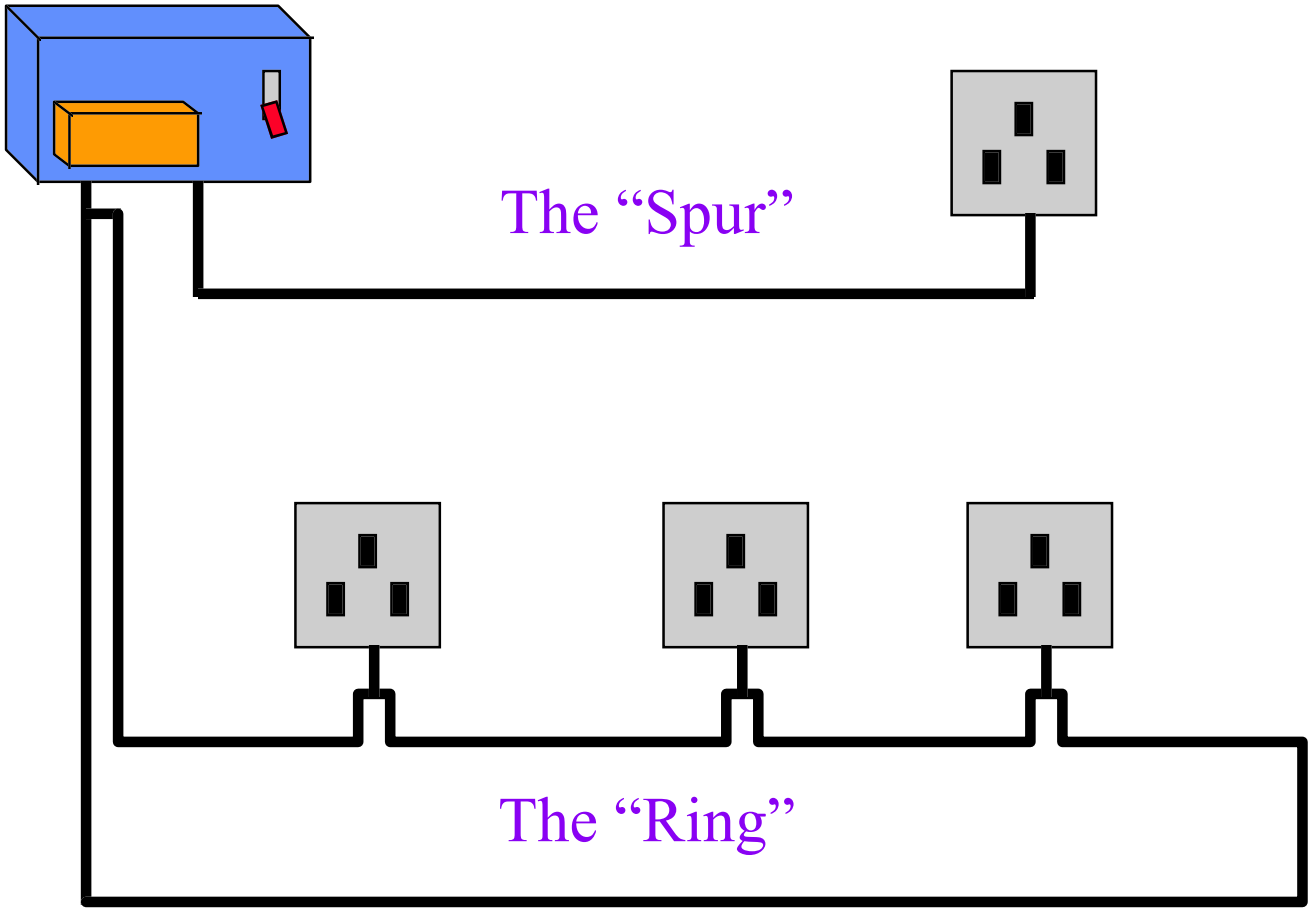
- There are two distinct methods of connecting circuits to the consumer unit.
- The “Spur” is a single cable from the consumer unit to a specific service eg. A power shower or cooker.
- The “Ring Main” is the most popular method used in the UK where a number of services are connected in a serial manner. This is possible in the UK as all plugs contain a fuse to protect the appliance cable.

Domestic Wiring.

Advantages of the Ring Main:-

- Voltage drop to a service is less than if a Spur had been used.
- The Ring can easily be extended if more services need to be added.
- Areas can easily be partitioned to a single fuse or trip ie. Upper Lights, Lower Lights etc.
- A Spur can be run off a Ring provided only one service is connected to the Spur.

Domestic Wiring.



Domestic Wiring.

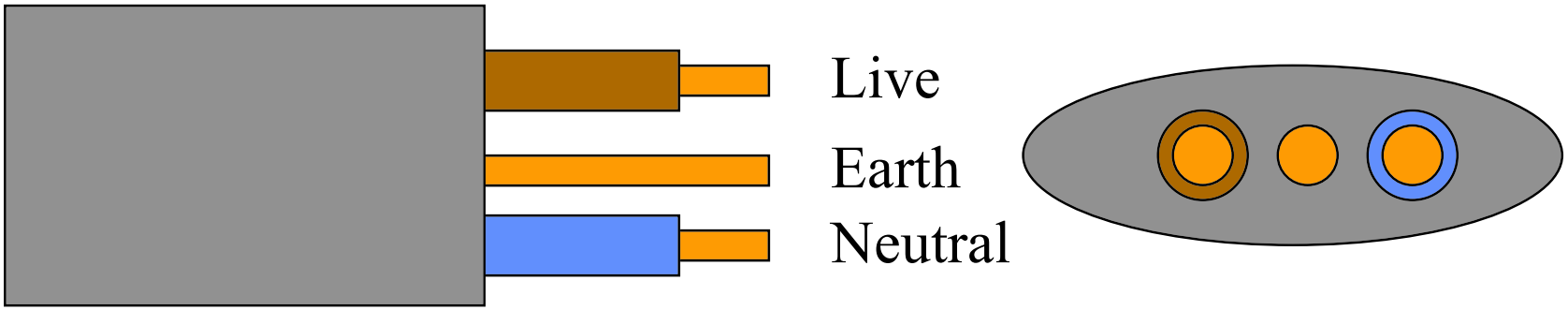
Cables.

- In the UK you will usually only encounter the cable type known as Twin and Earth; however; in some installations single wires enclosed in conduits may be used.
- Twin and Earth cable consists of three conductors. A Brown wire for Live, a Blue wire for neutral and a bare wire for Earth with the whole cable enclosed in an outer insulation.

Domestic Wiring.

Cables.

- An example of what a Twin and Earth cable looks like.



Viewed from above

End on View

The Earth wire is for protection and should be always connected whenever an Earth termination exists and especially when fittings are made of or have accessible metal parts which could make contact with a power connection.

Domestic Wiring.

Cables.

The four most common sizes are :-

- 1.5mm for use in lighting circuits with a maximum current capability of 16.5Amps.
- 2.5mm for use in power circuits with a maximum current capability of 23Amps.
- 6mm for use with small appliances with a maximum current capability of 38Amps.
- 10mm for use with power showers and cookers with a maximum current capability of 52 Amps.
- All cable ratings are based on a 240V supply.

Domestic Wiring.

Fuses and Circuit Breakers.

- Typical consumer unit protection devices.

	Old Standard	New Standard
Lighting Circuits	5 Amps Using Fuse wire	6 Amps Using a Trip breaker
Power Ring Circuits	20 Amps Using Fuse Wire	32 Amps Using a Trip breaker
Other Circuits	15 or 30 Amps Using Fuse Wire	16 or 40 Amps Using a Trip breaker

Domestic Wiring.

Switches.

- Normal convention is that when a switch is **Down** the power is connected and when a switch is **Up** the power is disabled.
- Exceptions :-
- Trips in consumer units and power breakers
  Up = On and **Down** = Off
- Changeover switches eg. Stair Lights
  these may be either way, up or down
  when power is connected.

Domestic Wiring.

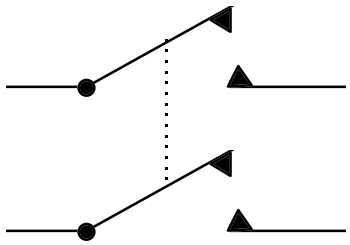
Switches.

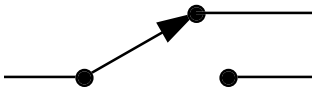
- There are three different switch configurations that you are most likely to encounter.
- SPST: Single Pole Single Throw
  used for Simple On/Off switches
- DPST: Double Pole Double Throw
  used for Power Isolation Circuits
- SPDT: Single Pole Double Throw
  used for Changeover switch applications

Domestic Wiring.

Switches.

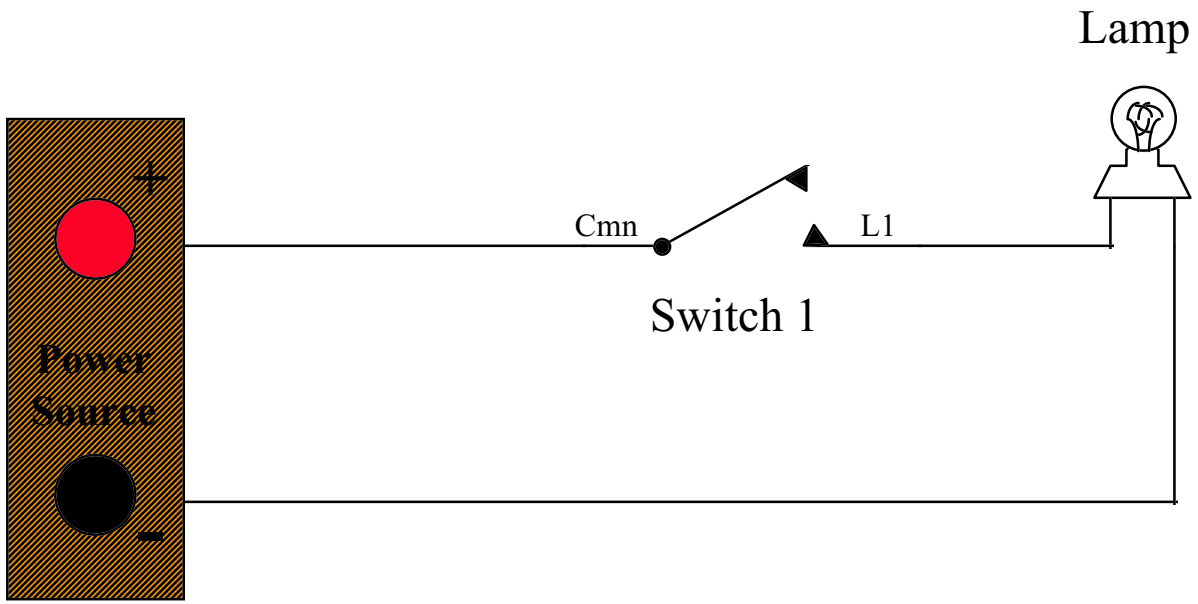
- A Switch can also come in different variants.
- Single Pole Single Throw (SPST).
- ie one set of connections.
- Double Pole Single Throw (DPST).
- Two circuits mechanically connected
- Single Pole Double Throw (SPDT).
- ie one connection set with two routing options.





Domestic Wiring.

Switch Circuits.

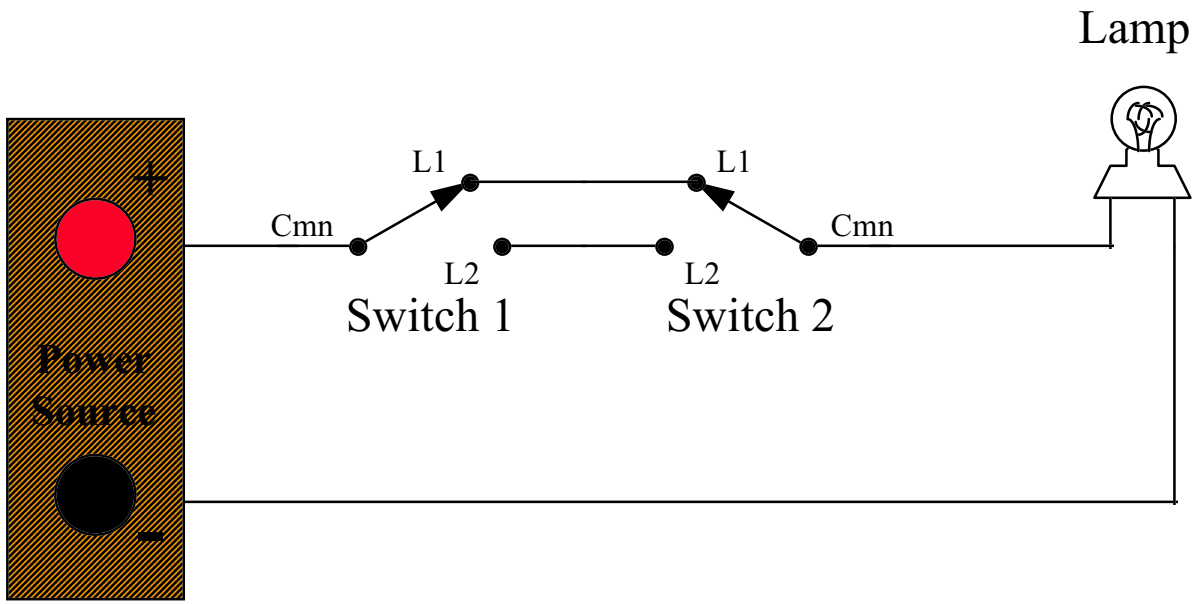


Simple Spur Lamp Circuit

Note: The switch will turn the lamp On or Off.

Domestic Wiring.

Switch Circuits.

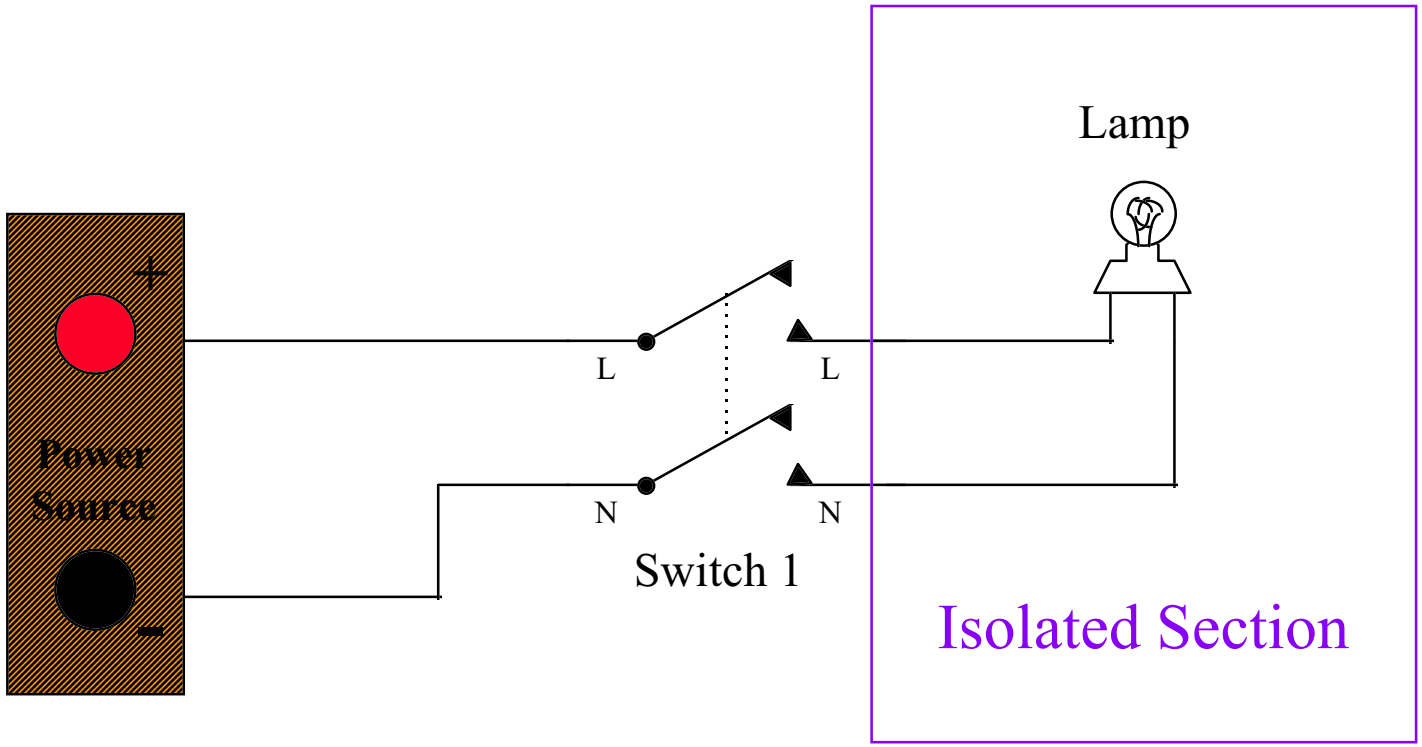


Basic Changeover Lamp Circuit

Note: Either switch can make the lamp go On or Off.

Domestic Wiring.

Switch Circuits.

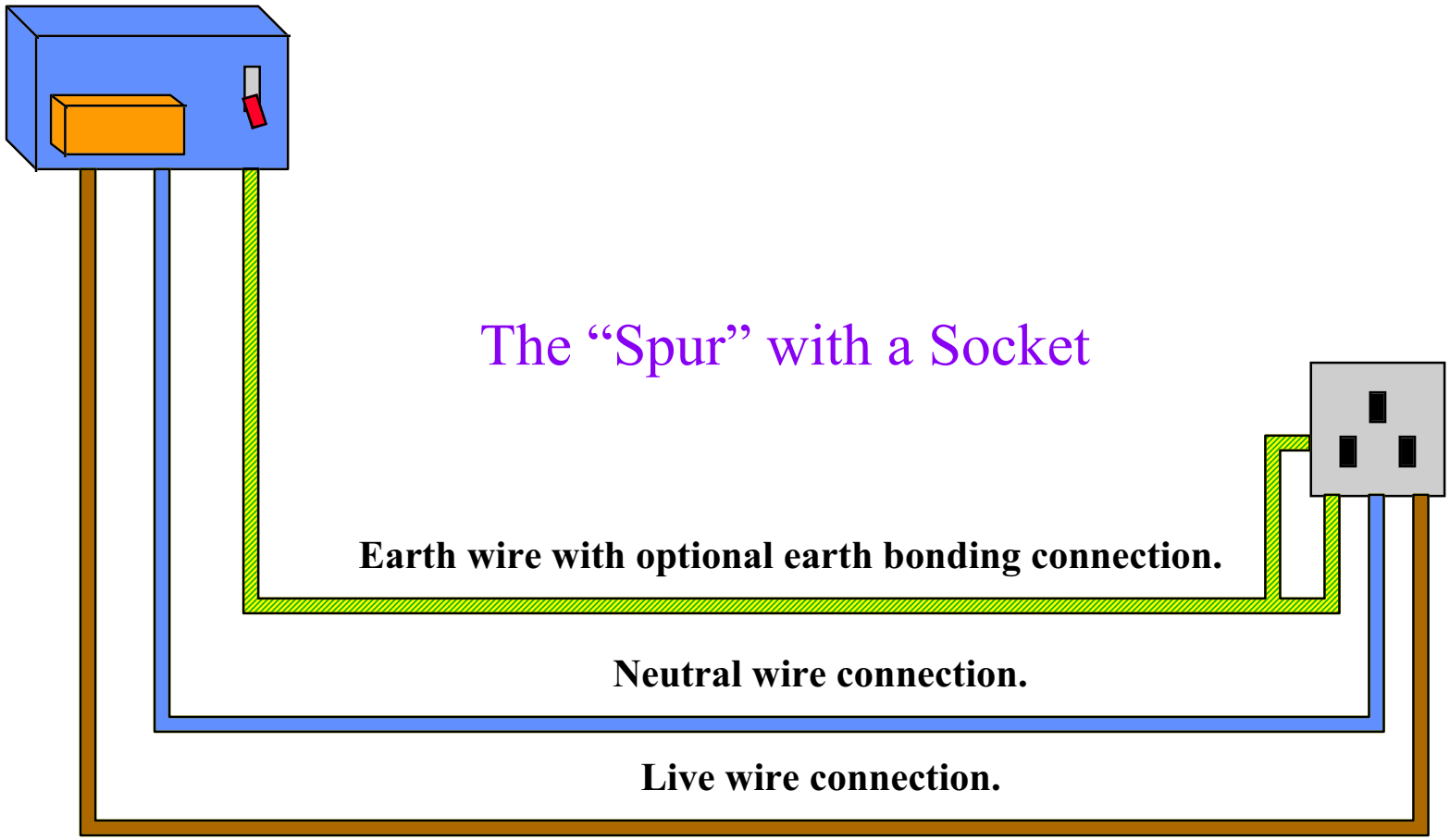


Situation where a Circuit can be totally isolated

Note: The Switch will either Light the Lamp or leave it totally isolated from the power source.

Domestic Wiring.

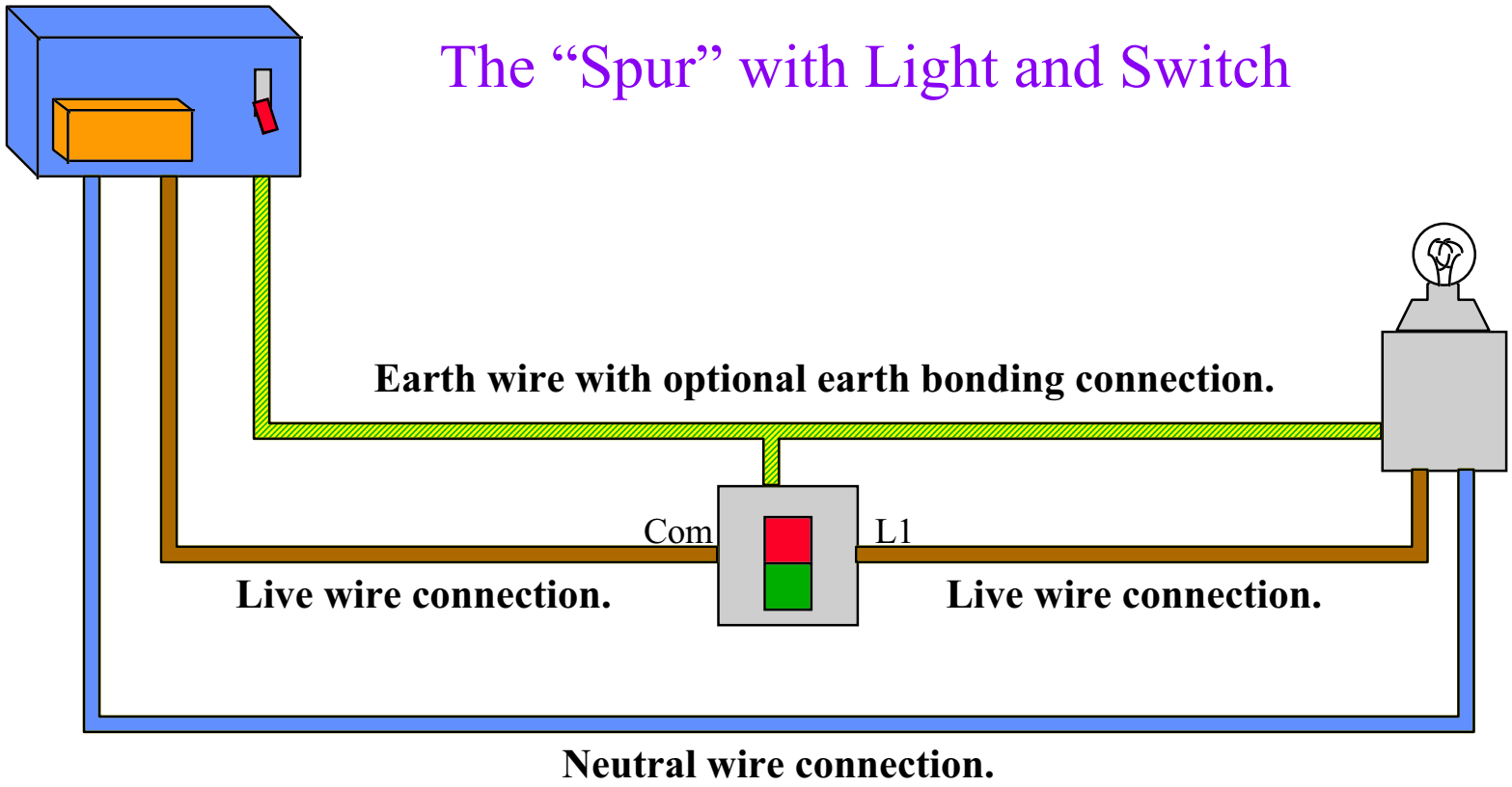
Circuits.



Domestic Wiring.

Circuits.

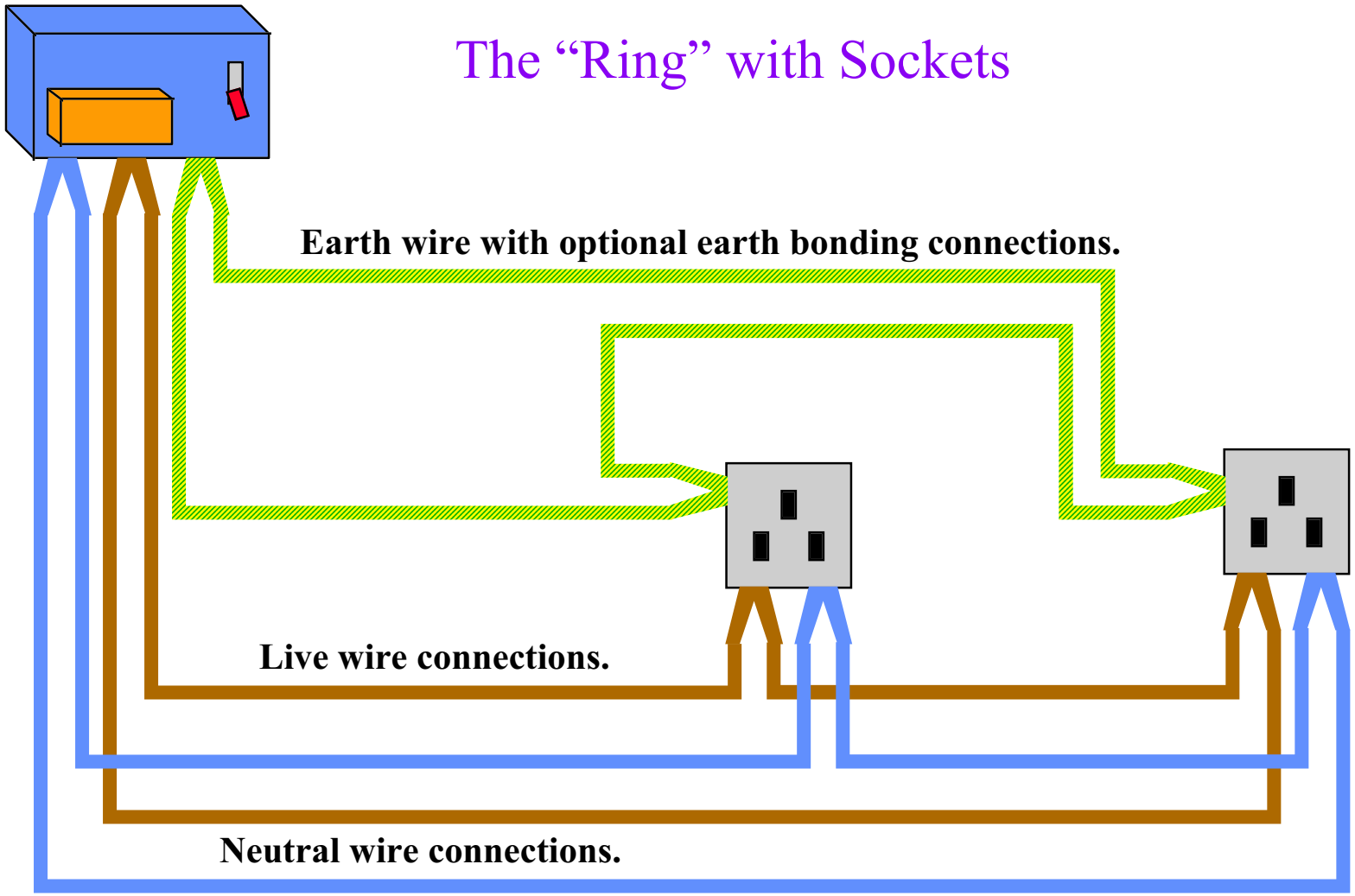
The “Spur” with Light and Switch



Domestic Wiring.

Circuits.

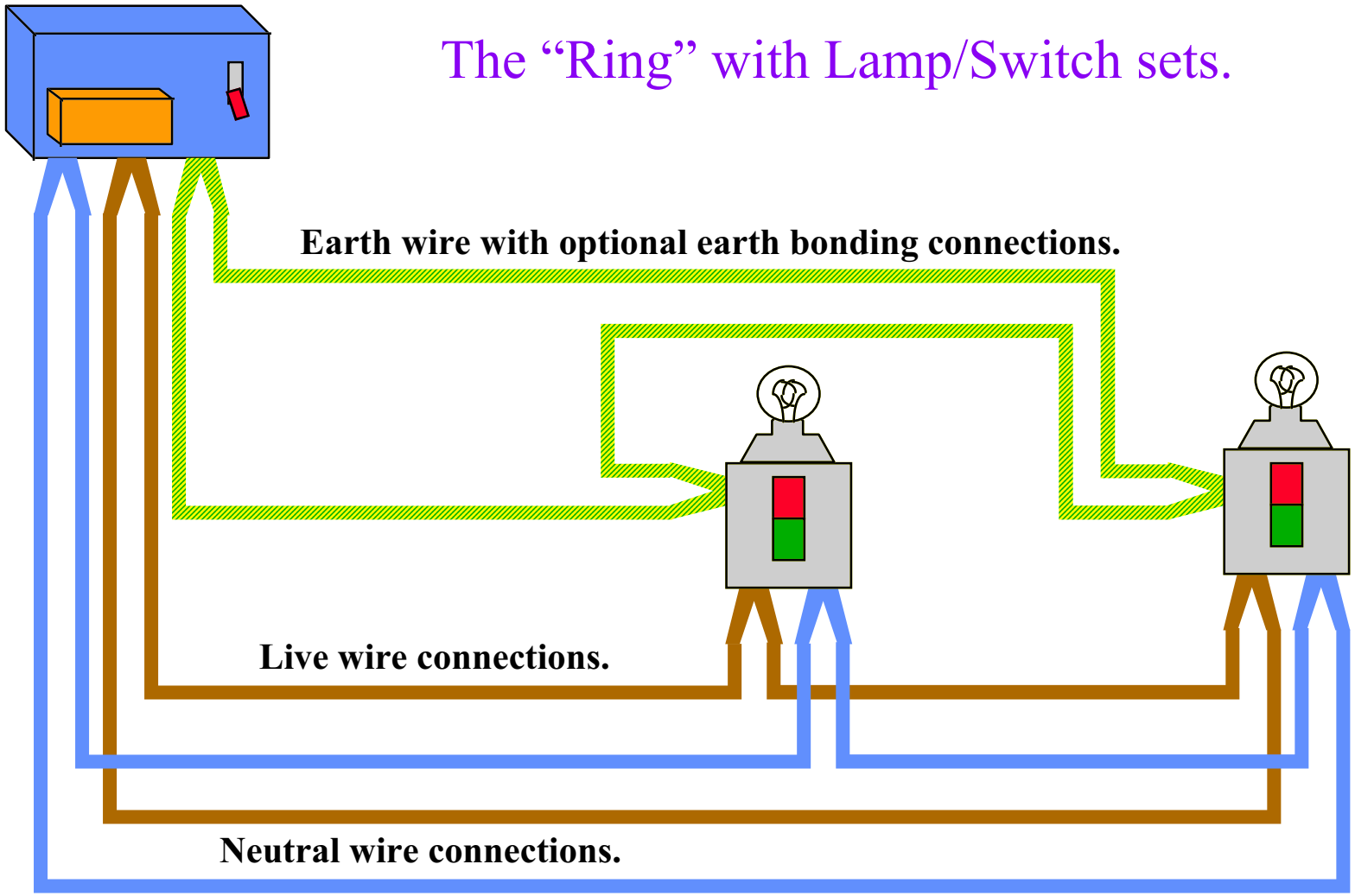
The “Ring” with Sockets



Domestic Wiring.

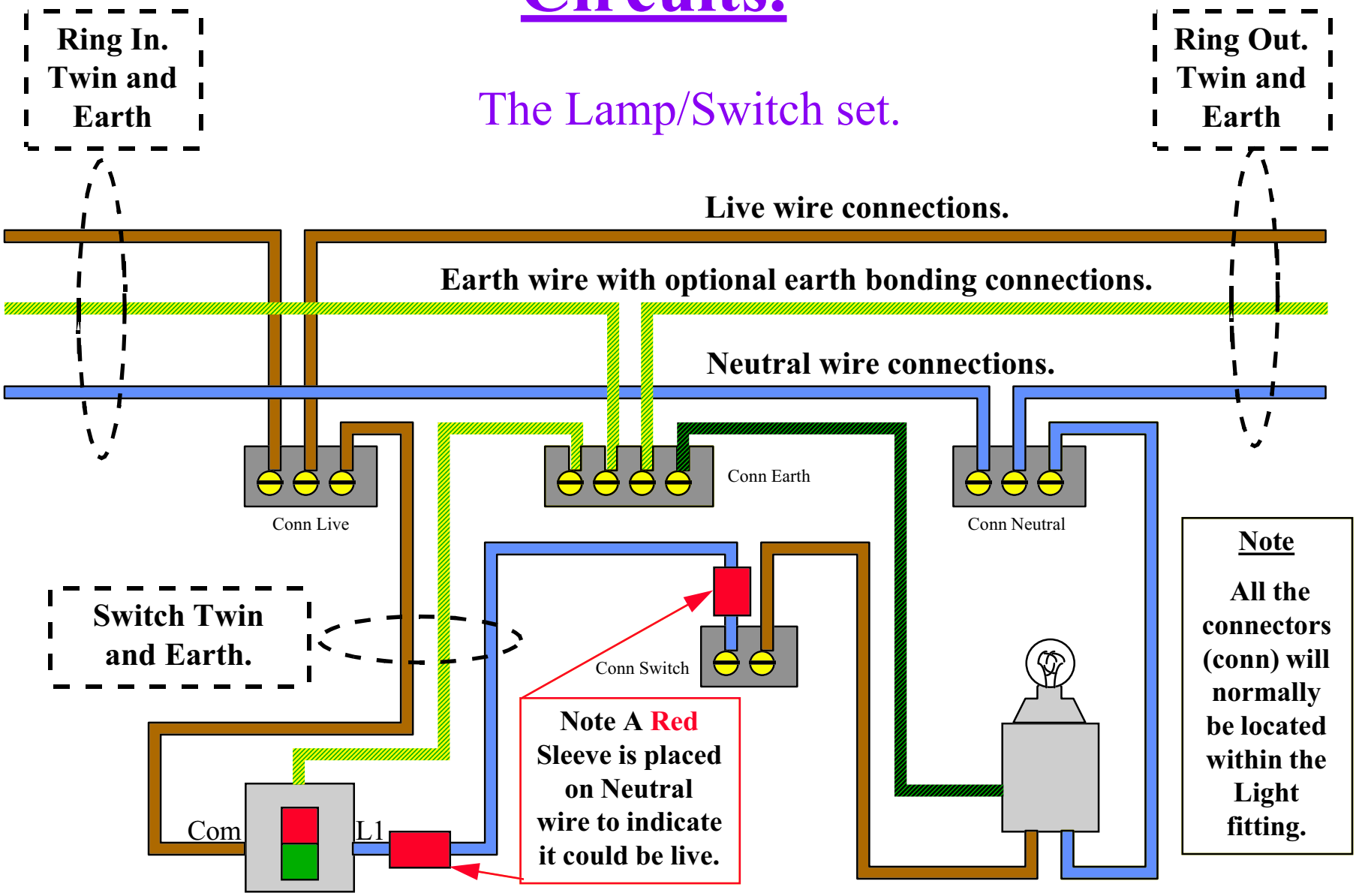
Circuits.

The “Ring” with Lamp/Switch sets.



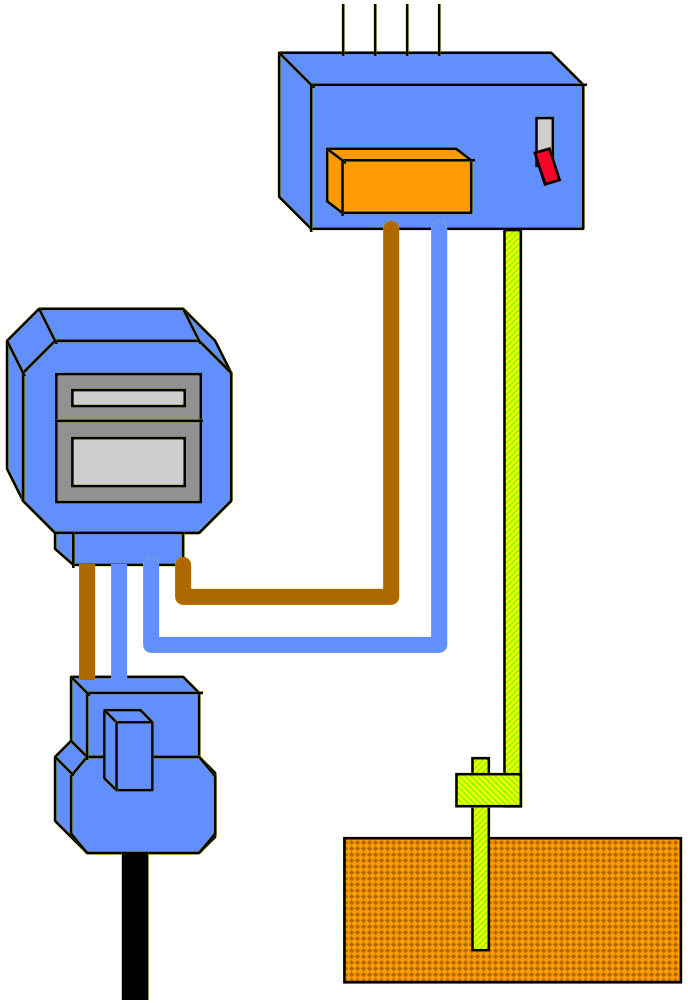
Domestic Wiring.

Circuits.



Electrical Installation.

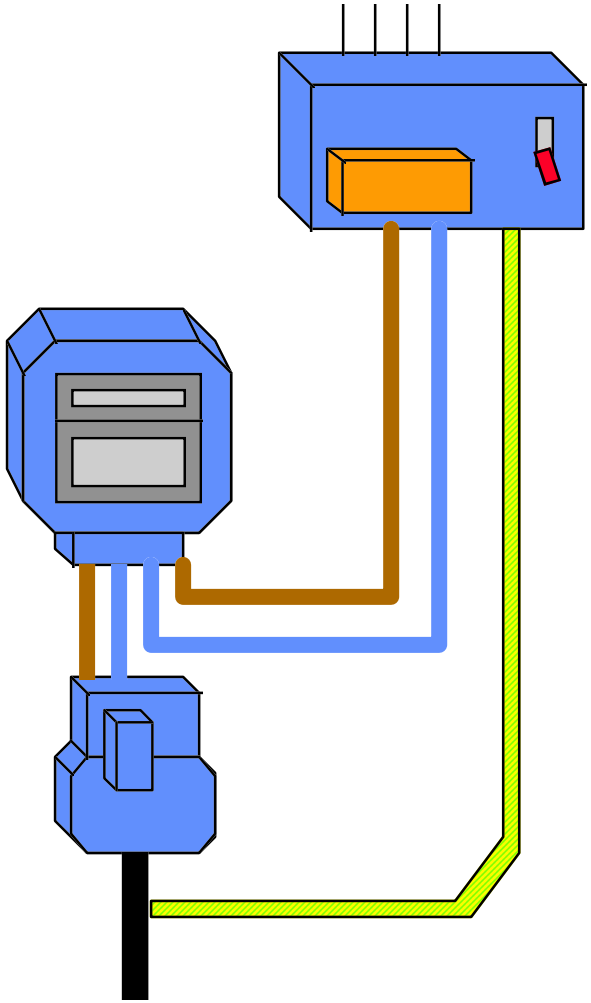
Supply Characteristics.



TT

- Earthing provided by the consumer's own installation earth electrode - no earthing facility is made available to the consumer by the distributor, or if such a facility is made available, it is not used.

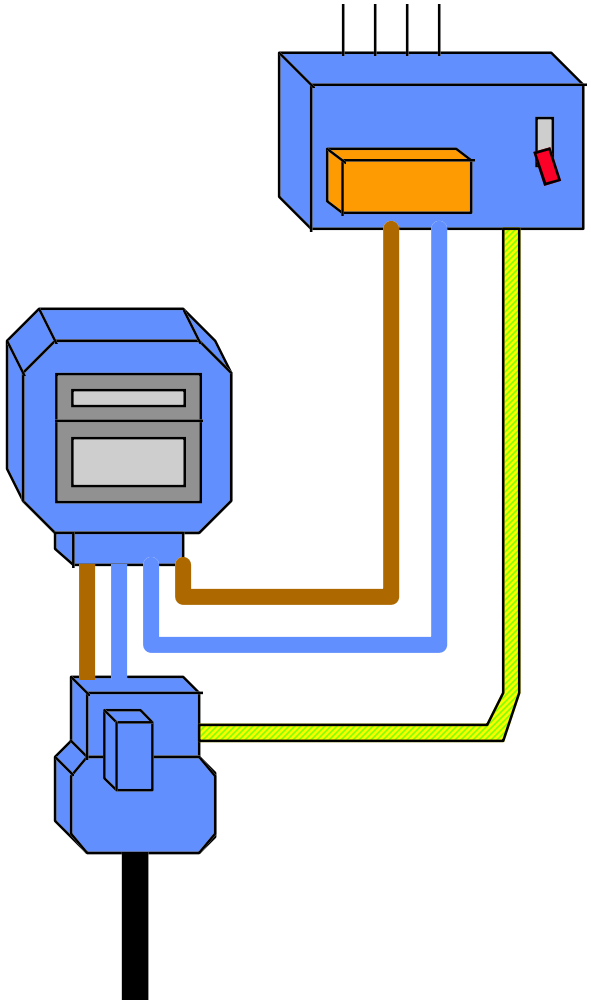
Supply Characteristics.



TT-S

- Earthing facility provided by the distributor for the consumer's use - provision usually by means of a connection to the supply cable sheath or a separate protective conductor in the form of a split-concentric cable or overhead conductor.

Supply Characteristics.



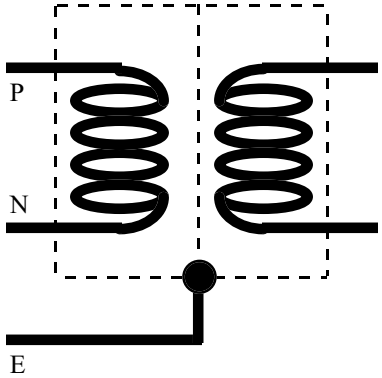
TT-C-S

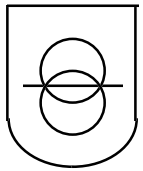
- Earthing facility provided by the distributor, connected to the incoming supply neutral to give a Protective Multiple Earth (PME) supply, where the supply neutral and protective conductors are in the form of a Combined Neutral and Earth (CNE) conductor.

Transformers.

Separated Extra-Low Voltage (SELV)

Circuit Diagram

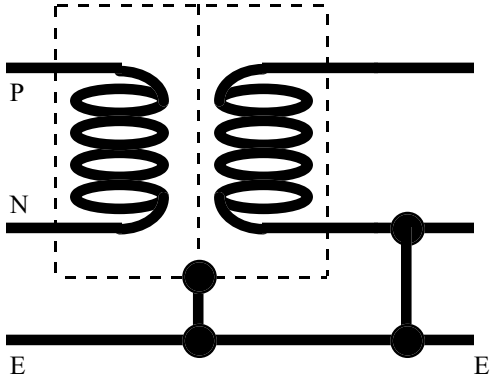


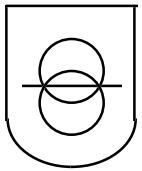


Symbol

Protective Extra-Low Voltage (PELV)

Circuit Diagram





Symbol

End Slide

Revision Page

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