#1: The Multimeter

Multimeter is a crucial tool for measuring electrical parameters such as voltage, current, and resistance.
Ohm's Law establishes the relationships among voltage, current, and resistance.
Multimeter has different modes to measure them.
To measure Resistance we must use red probe in voltage socket and then measure by changing modes. Same for the voltage. For voltage the probes must be parallel configuration. But for current measurement we must connect the probes series configuration and change the red probe to current socket.

#2 Dimming all kinds of LEDs!

using a potentiometer for dimming high-power LEDs is not ideal due to two main issues:

1. **Energy waste through heat dissipation, as the potentiometer converts excess energy into heat, making the system inefficient.**
2. **Expensive, heavy-duty potentiometers are needed for high-current applications, adding cost and bulk.**

PWM: PWM stands for Pulse Width Modulation. It's a technique used to control the amount of power delivered to an electrical device by varying the width of the pulses in a signal, rather than adjusting the voltage directly.

Working Principle: PWM rapidly switches the LED on and off, and the duty cycle (on-time percentage) determines the average current and thus the brightness. PWM signals can be generated by microcontrollers (like Arduino's analogWrite()), the 555 timer IC, or other circuits. MOSFETs can be used to switch higher-power LEDs with a PWM signal.

#3: Programming an Attiny+Homemade Arduino Shield

LED setup using a WS 2801 LED strip, controlled by a small, inexpensive microcontroller, the ATtiny 85. The aim is to create multiple animations that can be changed with a push button, eliminating the need for the more expensive ATmega 328 used in the Arduino Uno. This requires different library file and Arduino UNO to programme the ATtiny 85 .

#4: Arduino+Bluetooth+Android=Awesome:

Demonstrates interfacing Arduino with Bluetooth to control devices with Android . Working Principle: An HC-05 Bluetooth module is connected to an Arduino . A voltage divider is used on the Arduino's TX pin for safe communication . An Android app (like S2 Terminal) sends commands over Bluetooth, which the Arduino receives and uses to control connected devices (like an RGB LED) .

#5: How to Multiplex:

Key Point: Explains multiplexing for controlling many LEDs with few pins .
Working Principle: By rapidly activating one row (or column) of LEDs at a time and controlling the other dimension, the persistence of vision creates the illusion of a static image on an LED matrix . P-channel MOSFETs can switch power to rows, and LED driver ICs (like TLC5940) can control column currents .

#6: Standalone Arduino Circuit: ◦

Key Point: Discusses building a standalone Arduino circuit on a PCB.

Working Principle: Components are soldered to a PCB with an ATmega microcontroller (like the one on an Arduino Uno) and necessary support components (crystal, capacitors, etc.) to function without a full Arduino board. Code can be uploaded via in-circuit serial programming (ICSP).

#7: 7 Segment Display: **7-segment displays have individual LEDs for each segment (A-G) and a decimal point (DP), in either common anode or common cathode configuration. They can be driven directly with a microcontroller or using a BCD to 7-segment driver IC (like SN74LS247). For multiple digits, multiplexing or dedicated driver ICs like the SAA1064 (using I2C) are used.**

#8: Everything about LEDs and current limiting resistors:

Resistors are crucial to limit current through LEDs to prevent burnout, calculated using Ohm's Law and considering the LED's forward voltage. Discusses power rating of resistors. Explains connecting LEDs in series (more efficient) and parallel (can cause uneven current). Briefly mentions constant current sources as the best way to drive LEDs (e.g., using LM317 or TLC5940).

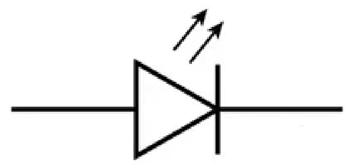
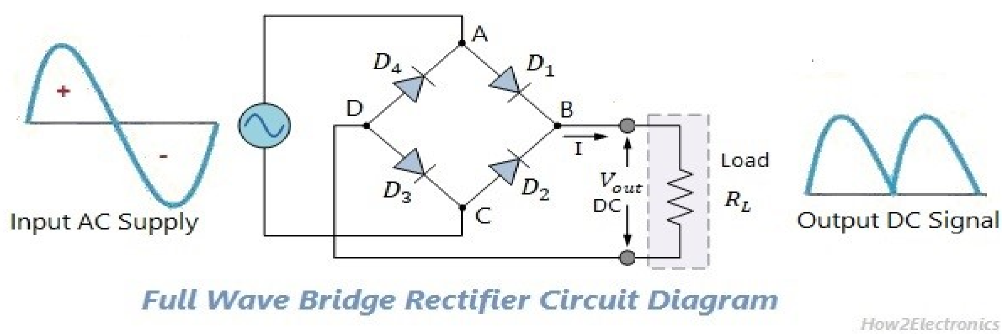


fig:LED circuit diagram

#9: Diodes & Bridge Rectifiers:

Diode: A semiconductor device that allows current to flow in one direction only, acting as a one-way switch.

Bridge Rectifier: A circuit that uses four diodes in a bridge configuration to convert alternating current (AC) to direct current (DC).



Working Principle: Diodes allow current to flow only from anode to cathode.In forward bias diode acts as shorted path and reverse bias it works as open path. A bridge rectifier uses four diodes to convert AC input to DC output by ensuring current flows in one direction through the load regardless of input polarity.

#10: Digital to Analog Converter (DAC):

Key Point: Introduces the Digital to Analog Converter (DAC) and its function of converting digital signals (on/off, high/low, 0/1) into analog signals (sine, triangle, ramp).
Working Principle: Explains the R-resistor ladder method as one conversion technique. Digital input values control switches that connect different resistors in a network, resulting in different analog voltage outputs. A voltage follower (op-amp) is used to stabilize the output

when a load is connected. Examples: Demonstrates generating a ramp function by incrementally increasing a digital value and a triangle function by increasing and then decreasing it. Briefly mentions generating a sine wave and using the I2C protocol with PCF 8591 (8-bit DAC) and MCP 4725 (12-bit DAC).

#11: Sending SMS with Arduino || TC 35 GSM Module:

Key Point: Explains how to use a TC35 GSM module with an Arduino UNO to send SMS messages.

Working Principle: The module is powered and communicates via a serial connection using AT commands. Initiating a login to the mobile network is mentioned. The Arduino sends specific AT commands to the GSM module to send an SMS message, including the recipient's number and the message content.

#12-13: Coils / Inductors :

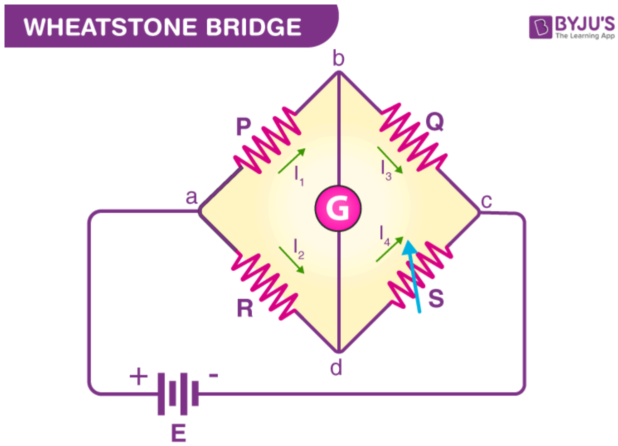
Inductor: inductors (coils) is a fundamental passive components.

Current flowing through a wire creates a magnetic field around it. In a DC circuit, the current does not follow voltage instantly due to the inductor's opposition to changes in current. Inductors store energy in a magnetic field. They can be used in step-down converters or switching power supplies as energy storage to maintain a constant output voltage. Inductors oppose the flow of alternating current, and this opposition is called inductive reactance. Unlike resistance, reactance doesn't dissipate power as heat but stores it in a magnetic field. Inductive reactance increases with frequency, given by the formula $X_L=2\pi fL$. This frequency dependence allows inductors to be used in filters. There is a phase shift between voltage and current in inductive circuits where voltage leads the current.

#14: Capacitors: **Capacitors consist of metal films with a dielectric material. They have a voltage limit and polarity considerations for electrolytic types. In DC circuits, voltage across a capacitor cannot change instantly, while current changes immediately. Capacitors store energy in an electric field and are used to stabilize voltages, decouple ICs, and create signals in RC circuits. In AC circuits, they cause a phase shift and contribute to reactive power.**

#15: Temperature Measurement || NTC, PT100, Wheatstone Bridge:

Key Point: Discusses methods for temperature measurement, focusing on NTC thermistors. Working Principle: NTC thermistors are resistors with a negative temperature coefficient (resistance decreases with temperature). They can be used in voltage dividers with a microcontroller to measure temperature. The video also mentions ICs like LM35 and DS18B20 which provide linear voltage or digital outputs for temperature. A limitation of resistance-based methods is their slow response time.



#16: Resistors:

Resistors limit current according to Ohm's Law (V=IR). They also have a power rating indicating how much power they can dissipate as heat. Resistors can be used to divide voltage, level shift signals, act as pull-up/pull-down resistors, in potentiometers (variable resistors), for current sensing (by measuring voltage drop), and as fuses. Mentions PT100 sensors for temperature measurement and parasitic inductance/capacitance in AC circuits. •

#17: Oscillators || RC, LC, Crystal:

Oscillators used for generating periodic AC signals.
Working Principle: RC oscillators use a resistor and capacitor to control charging and discharging times, often with a comparator or the 555 timer IC to create oscillations. LC resonators (LC tank circuits) use the exchange of energy between a capacitor and an inductor to create high-frequency oscillations, but parasitic resistance causes them to decay. Crystal oscillators are mentioned as precise frequency sources.

#18: DC & Brushless DC Motor + ESC:

Key Point: Explains DC motors and brushless DC motors (BLDC) with Electronic Speed Controllers (ESCs).
Working Principle: Brushed DC motors use permanent magnets (stator), coils (rotor), a commutator, and carbon brushes to create rotation by reversing the magnetic field through mechanical switching. Brushless DC motors have permanent magnets on the rotor and coils on the stator. Rotation is achieved electronically by the ESC energizing coil pairs in a specific sequence. The ESC controls speed by adjusting the frequency of voltage bursts. Discusses KV rating and motor types (OutRunner, InRunner).

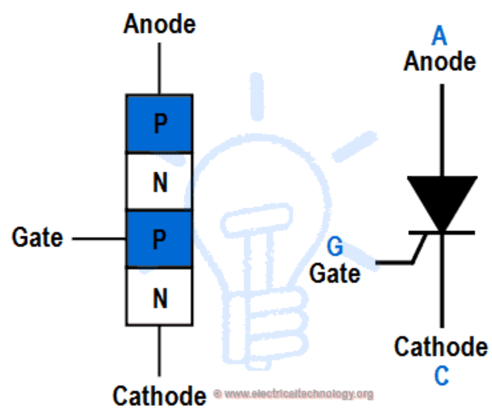
#19: I2C and how to use it:

Key Point: Explains the I2C (Inter-Integrated Circuit) communication protocol.

Working Principle: I2C is a synchronous serial bus using two wires: SDA (serial data) and SCL (serial clock). One or more master devices can communicate with up to 112 slave devices. Communication involves a start condition, 7-bit slave address, read/write bit, acknowledge bit, data bytes, and a stop bit. Pull-up resistors are needed on SDA and SCL. The Arduino's Wire library simplifies I2C communication. Datasheets are crucial for understanding device-specific communication requirements.

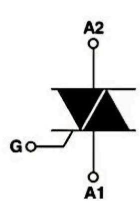
#20: Thyristor, Triac || Phase Angle Control:

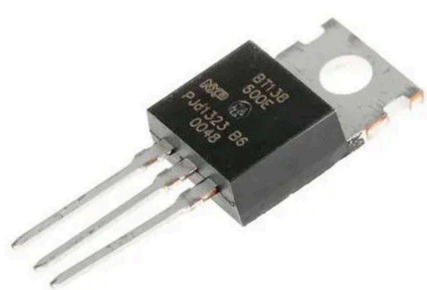
Thyristor: A thyristor is a type of semiconductor device that acts as a switch, which can be turned on or off to control the flow of current in a circuit. It is a four-layer, three-junction device typically made of silicon, and it is often used in power control applications. The key characteristic of a thyristor is that once it is triggered on, it remains on until the current drops below a certain threshold, making it useful for controlling high-voltage or high-current loads.



Thyristor (SCR) Structure & Symbol

Triac: A Triac (Triode for Alternating Current) is a type of semiconductor device that is similar to a thyristor but with the key difference that it can conduct current in both directions, making it particularly useful for AC (alternating current) applications. It is widely used for controlling power in AC circuits, such as in light dimmers, motor speed controls, and other electrical appliances.





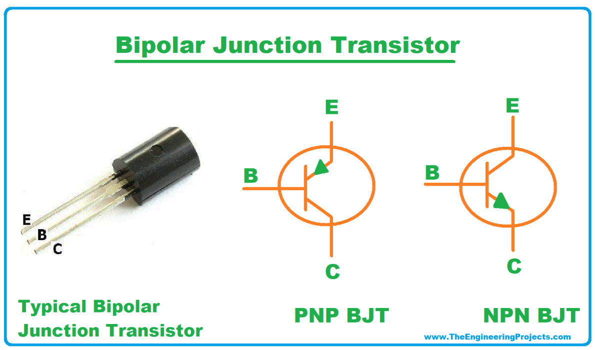
Working Principle: A thyristor is a controllable diode that turns on when a gate current is applied and stays on until the current drops below the holding current. A Triac is similar but can conduct in both directions and is used for AC control. The video demonstrates phase angle control using a Triac and Arduino to regulate power to an AC appliance by delaying the point in the AC cycle when the Triac is turned on. This method can decrease the power factor.

#21: OpAmp (Operational Amplifier):

Key Point: Introduces operational amplifiers (op-amps) and their basic configurations. ◦ Working Principle: Op-amps amplify the voltage difference between their inputs. The first golden rule states the output attempts to keep the input voltage difference at zero. The video explains non-inverting and inverting amplifier configurations and their gain formulas. Discusses applications like amplifying sensor signals and the limitations of real op-amps (input/output impedance, voltage swing). Also introduces the op-amp as a comparator.

#22: Transistor (BJT) as a Switch:

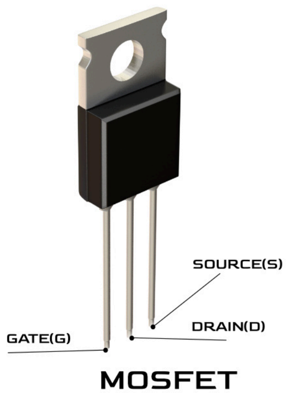
A BJT (Bipolar Junction Transistor) is a type of transistor, which is a semiconductor device used to amplify or switch electronic signals. The term transistor refers to a broad category of semiconductor devices, and a BJT is one specific type of transistor.

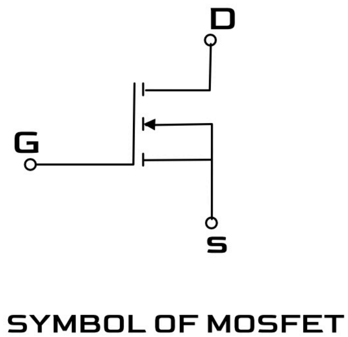


Working Principle: BJTs (NPN and PNP types) have three terminals: emitter, collector, and base. A small base current controls a larger collector current. A current-limiting resistor is needed on the base. The video shows circuits for switching an LED and larger loads, discussing power loss and heat generation. Darlington transistors are introduced for switching high currents with small base currents due to their high current gain

#23: Transistor (MOSFET) as a Switch:

A MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor) is a type of Field-Effect Transistor (FET) that is widely used for switching and amplifying electronic signals in a variety of applications. Unlike BJTs (Bipolar Junction Transistors), which rely on both electron and hole charge carriers, MOSFETs are unipolar devices, meaning they use only one type of charge carrier (either electrons or holes).





Working Principle: MOSFETs (N-channel and P-channel) have gate, drain, and source terminals. They are voltage-controlled; a voltage on the gate controls the current flow between drain and source. MOSFETs generally have lower energy loss as switches compared to BJTs, leading to higher efficiency. MOSFET driver ICs can be used for demanding applications.

#24: Stepper Motors and how to use them:

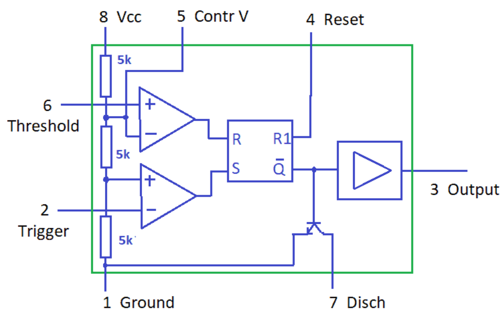
Key Point: Explains stepper motors and their control.
Working Principle: Stepper motors, like hybrid synchronous stepper motors, have a rotor and stator with multiple teeth. They move in discrete steps by sequentially energizing their coils. The step angle determines the resolution. Control typically involves using an H-bridge to energize the motor coils based on a specific stepping sequence, often managed by a microcontroller. Microstepping allows for smoother motion. Dedicated driver ICs like the A4988 are also used.

#25: Servos and how to use them:

Key Point: Explains how servos work for positioning.
Working Principle: Servos integrate a DC motor, control electronics, and a feedback mechanism (potentiometer). They are controlled by a PWM signal with a period of 20ms (50Hz) and a duty cycle between 1ms and 2ms that corresponds to the desired angle. Internal gears reduce speed and increase torque. The feedback potentiometer allows the control electronics to drive the motor via an H-bridge to the commanded position.

26: 555 Timer IC:

Key Point: Introduces the popular 555 timer IC and its functionality.



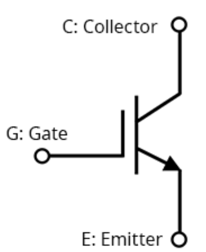
Working Principle: Internally, the 555 timer has comparators, a flip-flop, and a discharge transistor, controlled by three internal 5kΩ resistors creating voltage reference levels. By connecting external resistors and capacitors, it can be configured in astable (oscillator), monostable (one-shot), and bistable (flip-flop) modes for various timing and pulse generation applications.

#27: ADC (Analog to Digital Converter):

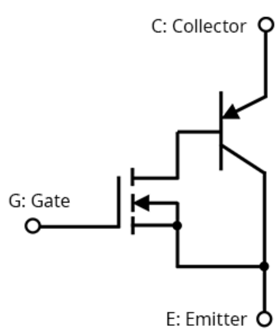
Key Point: Explains Analog to Digital Converters (ADCs) and their specifications.
Working Principle: ADCs convert analog voltages into digital values. Important specifications include sampling rate and resolution (number of bits). The Nyquist-Shannon theorem sets the minimum sampling rate. The video explains the successive approximation ADC method, which uses a sample-and-hold circuit, a comparator, a DAC, and a successive approximation register. Briefly introduces flash ADCs as a fast alternative.

#28: IGBT and when to use them:

An IGBT (Insulated Gate Bipolar Transistor) is a type of transistor used in electronic circuits, particularly in high-power applications. It combines the characteristics of both MOSFETs (Metal-Oxide-Semiconductor Field-Effect Transistors) and BJTs (Bipolar Junction Transistors), allowing it to efficiently handle high voltages and currents while being controlled by a low-power signal.



Circuit diagram symbol of an N-channel IGBT



Equivalent circuit example for an N-channel IGBT

Working Principle: IGBTs combine MOSFET gate characteristics with BJT output characteristics. They are voltage-controlled like MOSFETs but have a BJT-like output voltage drop. IGBT drivers are recommended for higher frequencies. IGBTs are suitable for

medium-fast, high-voltage, high-current switching below 200 kHz, offering a balance between MOSFET and BJT performance.

#29: Solar Panel & Charge Controller:

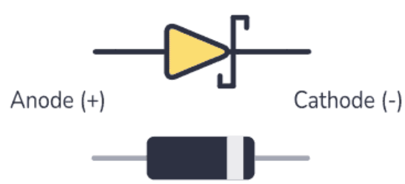
Key Point: Explains solar panels and charge controllers.
Working Principle: Solar panels are made of solar cells connected in series to increase voltage. They have a maximum power point (MPP). Charge controllers are necessary to safely charge batteries from solar panels, with more efficient types using MPPT (Maximum Power Point Tracking) and simpler ones using PWM.

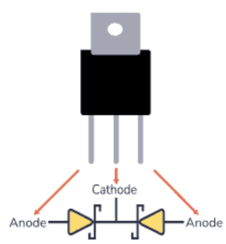
#30: Microcontroller (Arduino) Timers:

Key Point: Explains timers in microcontrollers like Arduino.
Working Principle: Timers are hardware peripherals that can generate precisely timed events and PWM signals. The video focuses on the Arduino's 16-bit Timer 1, explaining how to configure it for normal mode (timed interrupts) and 8-bit fast PWM mode to generate PWM signals with variable duty cycle and frequency.

#31: Schottky Diode & Zener Diode:

Schottky diode: A Schottky diode is a type of diode that uses a metal-semiconductor junction instead of a semiconductor-semiconductor junction (like in a regular diode).





Zener Diode:
A Zener diode is a special type of diode designed to operate in the reverse breakdown region. It allows current to flow in both directions but is specifically designed to have a well-defined breakdown voltage, known as the Zener voltage.
Working Principle: Schottky diodes have a low forward voltage drop and fast switching speeds, making them useful for reverse voltage protection and high-frequency circuits. Zener diodes are designed to conduct in reverse at a specific zener voltage, allowing them to be used as voltage regulators or references.

#32: Relays & Optocouplers:

Key Point: Explains relays and optocouplers.
Working Principle: A relay is an electromechanical switch consisting of a coil and contacts; applying voltage to the coil creates a magnetic field that moves the contacts. An optocoupler uses an LED and a phototransistor to provide electrical isolation between circuits; light from the LED turns on the phototransistor.

#33: Strain Gauge/Load Cell and how to use them to measure weight:

Key Point: Explains using strain gauges and load cells for weight/force measurement. ◦ Working Principle: A strain gauge is a resistor whose resistance changes with strain, typically used in a Wheatstone bridge. A load cell integrates strain gauges in a bridge configuration. Small voltage changes from the bridge are amplified (often using a differential op-amp or a dedicated IC like the HX711) and measured by an ADC to determine weight.

#35: Schmitt Trigger and when to use them:

Key Point: Explains Schmitt triggers and their use in cleaning up noisy signals.

Working Principle: Schmitt triggers are comparators with hysteresis, meaning they have different upper and lower threshold voltages. This prevents oscillations when the input signal slowly crosses the threshold. The video introduces the 74HC14 hex inverting Schmitt trigger IC. •

#36: SPI and how to use it:

Key Point: Explains the SPI (Serial Peripheral Interface) communication protocol. Working Principle: SPI is a synchronous serial protocol using four wires: CLK, MISO, MOSI, and SS (Slave Select). A master device communicates with one or more slave devices. Each slave needs a dedicated SS pin. Communication involves pulling SS low, transferring data, and pulling SS high. Discusses bit order (MSB first) and SPI modes. SPI is generally faster than I2C

#37: What is Impedance? (AC Resistance?):

Key Point: Explains impedance as the extension of resistance to AC circuits.

Working Principle: In AC circuits, inductors and capacitors also oppose current flow in a frequency-dependent way, called reactance. Inductive reactance (XL) increases with frequency ($XL = 2\pi fL$), and voltage leads current by 90 degrees. Impedance (Z) is the total opposition to AC current and includes resistance and reactance, affecting both current magnitude and phase.

#38: True, Reactive, Apparent & Deformed Power:

Key Point: Explains different types of power in AC circuits.

Working Principle: Apparent power (VA) is the product of voltage and current. It consists of true power (W), which does useful work, and reactive power (VAR), which oscillates in reactive components . Deformed power arises from non-sinusoidal waveforms with harmonics . Power factor relates true power to apparent power and indicates efficiency .