Video-1:

Device: Multimeter

Objective:
Measure electrical properties like voltage, current, and resistance in circuits using a single handheld device.

Uses:

- Checking battery voltage
- Measuring resistance of components

Functions:

- **DC Voltage :** Measures direct current voltage.
- **AC Voltage :** Measures alternating current voltage.
- **Current :** Measures current flow; requires series connection.
- **Resistance :** Measures resistance of resistors, wires, etc..

Types of Multimeters:

- **Analog Multimeter:** Uses needle gauge; less common now.
- **Digital Multimeter (DMM):** Shows values on an LCD; more accurate and popular.

Video-2:

Objective:
Control LED brightness using PWM, tested with green LED.

Setup:

- Used a green LED
- Controlled via PWM signal
- Adjusted duty cycle to vary brightness

Why PWM Dimming:

- Efficient brightness control

- Maintains LED color integrity
- Less heat compared to resistive dimming

Video-3:

Objective:
Program an ATtiny microcontroller using an Arduino as ISP with a custom shield.

Components Used:

- ATtiny85
- Arduino Uno (as programmer)
- Homemade shield (ZIF socket or direct pins)
- Capacitor (10µF) between RESET & GND on Arduino

Process:

- Installed ATtiny board
- Selected ATtiny85, 8 MH
- Uploaded “ArduinoISP” sketch to Uno
- Placed ATtiny on custom shield
- Used “Burn Bootloader” once
- Uploaded code via “Upload Using Programmer”

Video-4:

Objective:
Control LED color by sending text commands from an Android phone via Bluetooth.

Components Used:

- Arduino Uno
- Android phone (with Bluetooth terminal app)
- RGB or individual LEDs
- Resistors

Working Principle:

- User types color name (e.g., “blue”) in phone app
- Bluetooth sends the text to Arduino
- Arduino checks the message and lights up matching LED

Commands:

- **"blue"** → Blue LED turns on
- **"green"** → Green LED turns on
- **"off"** → All LEDs turn off

Video-5:

Objective:
Control a large number of LEDs in a matrix using limited Arduino pins.

Concept Used:

- Multiplexing
- Shift Registers
- LED Drivers

Working Principle:

- LEDs are arranged in rows & columns (or layers in a cube)
- Arduino controls one row/layer at a time very quickly
- Fewer pins needed due to shared connections
- 8×8 Matrix = 64 LEDs
- Using shift registers, can control all with just **3 Arduino pins**

Video-6:

Objective:
Run Arduino-based projects without using the full Arduino board — just the microcontroller and minimal components.

Components:

- ATmega (from Arduino Uno)
- Power supply (battery or regulated 5V)
- One 16 mega hz clock crystal
- 222 picofarad capacitors
- 1k ohm resistor

Working Principle:

- After uploading code to ATmega, it can be removed from Arduino board
- Placed on breadboard
- Runs independently, saving space and cost

Video-7:

Objective:
Display numbers using 7-segment displays with the help of driver ICs.

Types of 7-Segment Displays:

- **Common Cathode (CC):** All grounds connected together
- **Common Anode (CA):** All Vcc pins connected together

BCD to 7-Segment Driver):

- Takes Binary Coded Decimal (BCD) input (4 bits)
- Automatically lights up segments to show numbers (0–9)
- Designed for **common cathode** displays
- Reduces Arduino pin usage (4 input pins only)

SAA1064

- Communicates using **I2C protocol** (only 2 pins: SDA & SCL)
- Works with **common cathode** displays
- Supports adjustable brightness
- Useful for compact multi-digit numerical displays

##For extra details about I^2C and IC : [Tutorial: Arduino and the NXP SAA1064 4-digit LED display driver – tronixstuff.com]

Video-8:

Objective:
safely use LEDs by calculating and applying current limiting resistors.

Why Resistors are Needed:

- LEDs have very low internal resistance
- Without a resistor, too much current flows → LED burns out
- Resistor limits current to a safe value

Kirchhoff's Laws are fundamental principles in electrical circuit analysis that describe how current and voltage behave in circuits:

- **Kirchhoff's Current Law (KCL)** states that the total current entering a junction must equal the total current leaving that junction, reflecting the conservation of charge.

- **Kirchhoff's Voltage Law (KVL)** states that the sum of the electrical potential differences (voltage) around any closed circuit loop must equal zero, indicating the conservation of energy.

Video-9:

Objective:
Understand how general-purpose diodes work and their role in both DC and AC circuits — especially in building power supplies.

Key Facts:

- Allow current to flow in **one direction only** (forward-biased)
- Block current in the **reverse direction** (reverse-biased)

In AC Circuits:

- Used in **rectification** — converting AC to DC
- One diode = **half-wave rectifier**

Video-10:

Objective:
Convert digital binary values into analog voltage signals.

8-bit R-2R Ladder DAC

- A simple and popular DAC circuit
- Made using only **2 resistor values**: R and 2R
- Binary inputs (8 bits) control how much voltage is contributed at each stage

Voltage Follower (Op-Amp Buffer)

- R-2R DAC output has **high output impedance**
- Adding a **voltage follower** (op-amp in unity gain mode) provides:
    - **Low output impedance**
    - **Stable voltage**
    - No loading effect

Video-11:

Objective:
Send SMS messages from an Arduino using the **TC35 GSM module**.

TC35 GSM Module

- A GSM communication module by Siemens
- Supports SMS, voice, and GPRS (2G network)
- Communicates via **serial (TX/RX)**

Operating Voltage:

- Needs **external 5V regulated power**
- Requires **at least 2A current** during transmission

Connections

TC35 TX to Arduino RX is safe (3.3V logic)

Video-12:

Objective:
Understand how inductors (coils) behave in DC circuits and why they are essential in various electronic applications.

Magnetic Field (MF):

- When current flows through a coil, it creates a **magnetic field**
- The field stores **energy** and resists sudden changes in current

Electromagnetic Induction:

- Changing magnetic field induces voltage in the coil itself or nearby coils
- This is the basic principle of energy conversion in inductors

Inductance (L):

- Measured in **Henrys (H)**
- Describes how strongly an inductor resists change in current

###

- Inductors **resist changes in current**, not voltage
- Always consider inductance value, core material, and current rating
- Can **store energy**, **filter signals**, or **protect components**

Video-13:

Objective:
Understand what **reactance** means in AC circuits, especially for inductors, and how it affects power and phase.

Reactance:

Reactance is the opposition that **inductors (or capacitors)** offer to **AC current**.

Unit: Ohms (Ω)

Inductive Reactance

Formula:

$XL=2\pi fL$

Where:

- f= frequency (Hz)
- L = inductance (Henrys, H)

Reactive Power (Q):

- Power stored and released by inductors or capacitors
- Measured in **VARs (Volt-Ampere Reactive)**

Phase Shift (Inductive Circuits):

- In an inductor, **current lags voltage**

- Voltage leads by **90° in pure inductance**

Video-14:

Objective:

capacitors function, what their ratings mean, and how they behave in different types of circuits.

How Capacitors Work:

A capacitor **stores electrical energy** in the form of an **electric field** between two conductive plates separated by an insulator (dielectric).

Electrolytic Capacitor Ratings

1. **Capacitance Value (µF):**
   - How much charge it can store
2. **Voltage Rating (V):**
   - Max voltage it can handle before breaking
3. **Polarity Marking:**
   - Electrolytic capacitors are **polarized** (must be connected correctly)
   - Stripe marks the **negative** pin (–)

Behavior in AC Circuit

- Current flows as voltage **changes direction**
- Capacitor passes AC signals (especially higher frequencies)

Capacitive Reactance (XC):

- Opposition to AC, depends on frequency:

  XC=1\2πfC

  - Higher frequency = **less reactance**
  - Larger capacitance = **less opposition**

Video-15:

Objective

the resistance of materials changes with temperature

Resistance:

- Many materials change resistance with temperature
- This change can be **measured and converted** into a temperature value
- Used in industrial, medical, and hobby electronics

1. NTC Thermistors (Negative Temperature Coefficient)

- Resistance **decreases** as temperature **increases**
- Common, cheap, good for 0–100°C range

2. PT100 (Platinum Resistance Temperature Detector)

- Platinum sensor with **100Ω at 0°C**
- Resistance **increases** linearly with temperature
- Very **accurate and stable**

3. Wheatstone Bridge

- Measures **small changes in resistance**
- Ideal for sensors like **PT100**

4. LM35 (Analog Temperature Sensor)

- Gives analog voltage: **10mV/°C**
- Easy to use with Arduino's analog pins

Video-16:

Objective:
Understand how resistors are used in real-world schematics for controlling voltage, current, and more.

1. Current Limiting Resistors

Protect LEDs, transistors, ICs by **limiting current**.

In an LED circuit:

```
text
Copy code
+5V ──[ 330Ω ]──▶|── GND
                LED
```

2. Voltage Dividers

Divide a voltage into smaller parts.

Voltage Divider circuits are used to produce different voltage levels from a common voltage source but the current is the same for all components in a series cicruit

3. Current Shunt Resistors

Measure current flow by observing voltage drop.

Ohm's Law:

V=IR

4. Pull-Up and Pull-Down Resistors

Set a default HIGH or LOW state on digital inputs.

5. Biasing Resistors

Set operating point of transistors in amplifier circuits.

Video-17:

Objective:
oscillators are essential and how three key types generate periodic signals.

1. RC Relaxation Oscillators

Use a **resistor-capacitor (RC)** network to charge/discharge a capacitor, creating a repeating signal.

- Capacitor charges slowly through resistor

2. LC Tank Oscillators

Use **inductor (L)** and **capacitor (C)** to form a resonant circuit.

4. **Crystal Oscillators**
   Use a **quartz crystal's mechanical resonance** to generate a stable frequency.

Video-18:

Objective:
a **brushless motor** spins using an **Electronic Speed Controller (ESC)**,.

1. DC Motor

- **Stator**: permanent magnet
- **Rotor (armature)**: coil with brushes
- **Brushes + commutator** switch current direction mechanically

2. Brushless Motor (BLDC)

- **Stator**: coils (stationary)
- **Rotor**: permanent magnets (rotating part)

3 ESC (Electronic Speed Controller)

- Uses **PWM (Pulse Width Modulation)** to control speed
- Sends **precisely timed current pulses** to the motor coils

Video-19:

Objective:
I2C (Inter-Integrated Circuit) allows multiple devices to communicate using only **2 wires** use it with Arduino.

1. I2C

- **Master** (usually Arduino) controls communication
- Each **slave** has a **unique 7-bit address**

2. I2C

- Fewer pins
- Easy to connect many devices
- Perfect for sensors, displays, RTCs

Video-20:

Objective:
a **thyristor** and how a **TRIAC** can be used to control **AC voltage** in a practical circuit.

1. a Thyristor

A controllable diode

- Has **3 terminals**: Anode, Cathode, and Gate

2. a TRIAC

A bidirectional thyristor

- Controls **both halves** of AC waveform
- Often used for **AC dimming**, **motor speed control**, or **heater regulation**

3. TRIAC AC Control Circuit

Components:

- TRIAC
- Resistors, capacitor
- Load (lamp or fan)
- AC supply

Video 21

Objective:

- OpAmps working and apply 3 key rules to build:

Working:

An OpAmp amplifies the voltage difference between its inputs:

$$V_{out}=A(V_+-V_-)$$

Rules:

1. **No Input Current:**
   - $I_+=I_-=0$
2. **Equal Input Voltage (with feedback):**
   - $V_+ = V_-$
3. **High Gain (A → ∞):**
   - Ensures Rule 2 holds in feedback systems

Video 22

Objective:

NPN and **PNP** transistors as **electronic switches** to control high-current loads with low-power signals

NPN as Low-Side Switch:

- Load connected between **Vcc** and **Collector**

- When base is HIGH → transistor **conducts**, load turns ON
- When base is LOW → **OFF**

PNP as High-Side Switch:

- Load connected between **Emitter** and **Vcc**
- When base is HIGH → transistor **OFF**

Video 23

Objective:

MOSFETs as **efficient electronic switches** to control high-current loads using low-power control signals

N-Channel MOSFET – Low-Side Switch:

- **Load between Vcc and Drain**
- Source to **GND**
- Gate LOW → **Turns OFF**

P-Channel MOSFET – High-Side Switch:

- **Load between Source and GND**
- Source to **Vcc**
- close to Vcc → **Turns OFF**

Video 24

Objective:

hybrid stepper motors works, and how to control them **with or without a microcontroller (µC)**.

How It Works:

- **Hybrid stepper** = mix of **variable reluctance** & **permanent magnet** types
- Rotor has **teeth + permanent magnet** → aligns precisely with stator field
- Moves in **discrete steps** (e.g. 1.8° per step)

How to Control:

Without Microcontroller:

- Use **stepper motor driver (e.g. ULN2003, A4988)**
- Send step signals manually via **555 timer**, switches, or logic gates

With Microcontroller (Arduino etc.):

- Use **driver modules**

Video-25:

Objective

a **standard servo** for precise angle movement in projects, with or without a microcontroller.

How It Works:

- Contains DC motor, gears, potentiometer, and control circuit.
- Controlled by **PWM**:

- **1 ms = 0°**, **2 ms = 180°**
- Signal repeated every 20 ms

Control Methods:

Without μC:

- Use **555 timer** to generate PWM
- Adjust pulse width to set angle

Video 26

Objective:

555 Timer IC works and use it in **monostable, bistable, and astable** modes for delays, toggles, or PWM generation.

Works:

- Contains **flip-flop, discharge transistor, and voltage divider**
- Key pins:
  - **Trigger (2)**, **Threshold (6)**, **Discharge (7)**, **Output (3)**

Monostable

- Trigger pulse → 555 outputs **HIGH for set time**

Flip-flop:

- One input **sets**, another **resets**
- Used for **switching, memory**

Oscillator:

- Free-running mode → generates square wave

Video 27

Objective:

ADC (Analog-to-Digital Converter) specs, how **Successive Approximation Register (SAR)** ADCs work

- **Resolution** (bits): number of output levels
- **Sampling Rate**: how fast analog values are converted
- **Accuracy**: how close output is to true value

SAR ADC:

1. Sample analog input
2. Comparator checks against internal DAC
3. Bit-by-bit, SAR logic adjusts guess

Video 28

Objective:

an **IGBT** (Insulated Gate Bipolar Transistor) to switch loads, and when it's better than a MOSFET.

- IGBT = **MOSFET gate** + **BJT output**

- Gate controlled like a MOSFET (voltage-driven)

How to Use It:

- Gate drive similar to MOSFET
- Use **gate resistor** and possibly gate driver IC

Video 29

Objective:

wire solar panels, use **diodes**, and **maximize power** with MPPT/PWM charge controllers for battery charging.

Solar Panels:

- **Series** = higher voltage
- **Parallel** = higher current

Bypass Diodes:

- Protect against **shading** → prevent power loss & hot spots
- Let current flow **around shaded cells**

Blocking Diodes:

- Stop **reverse current** from battery to panel at night

Getting the Most Power:

- Keep panels **clean, well-angled, and unshaded**
- Use **Maximum Power Point Tracking (MPPT)**:
    - Adjusts voltage to find **max power point**

PWM Controller:

- Connects panel directly to battery
- Simple, cheaper, but less efficient

MPPT Controller:

- Converts excess voltage into extra current
- Up to **30% more efficient** in real conditions

Video-30:

Objective:

precise timing events and create a **PWM signal**

1. Timer1 or Timer2:

- ATmega has **Timer0, Timer1, and Timer2**.
- **Timer1** is 16-bit.

At 8 MHz PWM, only **TOP = 1 → 2 clock cycles per cycle**.

- **Duty cycle options are limited** (0%, 50%, 100%).
- For more resolution, reduce frequency or use external timer/FPGA.