Video-1

Objective:
Measure various electrical properties such as voltage, current, and resistance within circuits using a single handheld instrument.

Uses:
• Verifying battery voltage
• Measuring resistance of electronic components

Functions:
• **DC Voltage:** Measures voltage from direct current sources
• **AC Voltage:** Measures voltage from alternating current sources
• **Current:** Measures the flow of current; requires connection in series
• **Resistance:** Determines resistance in components like resistors and wires

Types of Multimeters:
• **Analog Multimeter:** Features a needle gauge; less commonly used today
• **Digital Multimeter (DMM):** Displays readings on an LCD; more accurate and widely used

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Video-2:
Objective:
Regulate LED brightness through Pulse Width Modulation (PWM), demonstrated using a green LED.

Setup:
• Green LED utilized
• Brightness controlled via PWM signal
• Duty cycle adjusted to vary intensity

Why PWM Dimming:
• Offers efficient control of brightness
• Preserves the LED's color quality
• Produces less heat compared to resistive dimming

Video-3:

Objective:

Program an ATtiny microcontroller using an Arduino as an ISP programmer with a custom-built shield.

Components Used:

• ATtiny85 microcontroller
• Arduino Uno (functioning as programmer)
• Homemade shield (ZIF socket or direct pin connection)
• 10µF capacitor between RESET and GND on Arduino

Process:

• Install ATtiny board support
• Select ATtiny85 with 8 MHz clock
• Upload “ArduinoISP” sketch to Uno
• Insert ATtiny into custom shield
• Use “Burn Bootloader” once
• Upload code using “Upload Using Programmer” option

Video-4:

Objective:

Use text commands sent from an Android phone via Bluetooth to control LED colors.

Components Used:

• Arduino Uno
• Android phone (with Bluetooth terminal application)
• RGB LED or separate colored LEDs
• Resistors

Working Principle:

• User types a color name (e.g., “blue”) into the phone app
• Text is transmitted to Arduino via Bluetooth
• Arduino interprets the command and activates the corresponding LED

Commands:

• "blue" → Activates blue LED

• "green" → Activates green LED
• "off" → Turns off all LEDs

Video-5:
Objective:
Control a large quantity of LEDs arranged in a matrix using minimal Arduino pins.

Concept Used:
• Multiplexing
• Shift Registers
• LED Drivers

Working Principle:
• LEDs are structured in rows and columns (or 3D layers like in a cube)
• Arduino activates one row/layer at a time at high speed
• Shared connections reduce the number of pins required
• Example: 8×8 matrix = 64 LEDs
• Using shift registers, all LEDs can be controlled with just 3 Arduino pins

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Video-6:
Objective:
Operate Arduino-based projects without the full Arduino board—using only the microcontroller and essential components.

Components:
• ATmega microcontroller (from Arduino Uno)
• Power supply (battery or regulated 5V)
• 16 MHz crystal oscillator
• 22 picofarad capacitors
• 1k ohm resistor

Working Principle:
• After uploading the program to the ATmega chip, remove it from the Arduino board

• Place the chip onto a breadboard
• It runs independently, saving both space and cost

Video-7:
Objective:
Display numerical values using 7-segment displays with the aid of driver ICs.

Types of 7-Segment Displays:
• **Common Cathode (CC):** All cathodes (grounds) connected together
• **Common Anode (CA):** All anodes (Vcc) connected together

BCD to 7-Segment Driver:
• Converts 4-bit Binary Coded Decimal (BCD) input into segment control signals
• Automatically illuminates segments to display digits 0–9
• Specifically designed for common cathode displays
• Minimizes Arduino pin usage (only 4 input pins required)

SAA1064:
• Utilizes I2C protocol for communication (only 2 wires: SDA and SCL)
• Supports common cathode displays
• Offers adjustable brightness settings
• Ideal for compact, multi-digit numeric displays

Video-8:
Objective:
Ensure safe LED usage by calculating and applying current-limiting resistors.

Why Resistors are Needed:
• LEDs possess minimal internal resistance
• Without a resistor, excessive current may damage or destroy the LED
• Resistors regulate current flow to safe levels

Kirchhoff's Laws:
• **Kirchhoff's Current Law (KCL):** The sum of currents entering a junction equals the sum of currents leaving it—reflecting charge conservation

• **Kirchhoff's Voltage Law (KVL):** The total of voltage drops around any closed circuit loop equals zero—indicating energy conservation

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Video-9:
Objective:
Explore the operation of general-purpose diodes and their applications in both DC and AC circuits, especially power supplies.

Key Facts:
• Diodes allow current flow in one direction only (when forward-biased)
• Block current in the reverse direction (when reverse-biased)

In AC Circuits:
• Used for rectification—converting AC to DC
• Single diode = half-wave rectifier

Video-10:
Objective:
Convert binary digital signals into analog voltage outputs.

8-bit R-2R Ladder DAC:
• A straightforward and commonly used DAC circuit
• Constructed with just two resistor values: R and 2R
• Each of the 8 binary inputs contributes proportionally to the output voltage

Voltage Follower (Op-Amp Buffer):
• R-2R DAC outputs have high impedance
• Adding an op-amp in unity gain mode provides:
o Low output impedance
o Consistent voltage levels
o Isolation from loading effects

Video-11:

Objective:

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

TC35 GSM Module

- A GSM communication module developed by Siemens
- Supports SMS, voice, and GPRS on 2G networks
- Communicates via serial interface (TX/RX)

Operating Voltage:

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

Connections

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

Video-12:

Objective:

Understand how inductors (coils) behave in DC circuits and why they are vital in many electronic applications.

Magnetic Field (MF):

- When current flows through a coil, a magnetic field is created
- The field stores energy and resists sudden changes in current

Electromagnetic Induction:

- A changing magnetic field induces voltage in the coil or nearby coils
- This is the fundamental principle of energy conversion in inductors

Inductance (L):

- Measured in Henrys (H)
- Indicates how strongly an inductor resists current changes

- Inductors resist changes in current, not voltage
- Always consider inductance, core material, and current rating
- Used for energy storage, signal filtering, or component protection

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Video-13:
Objective:
Understand the concept of reactance in AC circuits, especially for inductors, and its impact on power and phase.

Reactance:
Reactance is the opposition inductors (or capacitors) provide to AC current.
Unit: Ohms (Ω)

Inductive Reactance Formula:
XL = 2πfL
Where:
• f = frequency in Hz
• L = inductance in Henrys (H)

Reactive Power (Q):
• Power temporarily stored and released by inductors or capacitors
• Measured in VARs (Volt-Ampere Reactive)

Phase Shift (Inductive Circuits):
• In inductors, current lags behind voltage
• In pure inductance, voltage leads by 90°

Video-14:
Objective:
Understand how capacitors function, what their ratings signify, and how they behave in different circuit types.

How Capacitors Work:
A capacitor stores electric energy as an electric field between two conductive plates separated by an insulator (dielectric).

Electrolytic Capacitor Ratings:

1. **Capacitance Value (µF):**
   o Indicates the amount of charge the capacitor can store

2. **Voltage Rating (V):**
   o Maximum voltage the capacitor can withstand

3. **Polarity Marking:**
   o Electrolytic capacitors are polarized and must be correctly connected
   o A stripe indicates the negative pin (–)

Behavior in AC Circuits:
• Current flows as voltage alternates direction
• Capacitor allows AC signals to pass, especially at higher frequencies

Capacitive Reactance (XC):
• Opposition to AC current, based on frequency:
XC = 1 / (2πfC)
o Higher frequency = lower reactance
o Larger capacitance = less opposition

Video-15:
Objective:
Explore how material resistance changes with temperature.

Resistance:
• Many materials experience resistance variation with temperature
• This property can be measured and translated into a temperature reading
• Used in industrial, medical, and DIY electronics

1. **NTC Thermistors (Negative Temperature Coefficient):**
   • Resistance drops as temperature rises
   • Common, affordable, ideal for 0–100°C

2. **PT100 (Platinum Resistance Temperature Detector):**
   • Platinum sensor with 100Ω at 0°C
   • Resistance increases linearly with temperature
   • Extremely accurate and reliable

3. **Wheatstone Bridge:**
   • Detects small resistance changes
   • Ideal for precise sensors like PT100

4. **LM35 (Analog Temperature Sensor):**
   • Outputs analog voltage at 10mV per °C
   • Easily read by Arduino's analog pins

Video-16:
Objective:
Understand how resistors are practically used in electronic schematics for voltage, current control, and more.

1. **Current Limiting Resistors**
   Protect LEDs, transistors, and ICs by limiting current.
   Voltage Dividers
   Divide a voltage into smaller values.
   • Useful for generating different voltage levels from one source
   • Current remains the same through series components

2. **Current Shunt Resistors**
   Measure current by monitoring voltage drop.
   Ohm's Law: V = IR

3. **Pull-Up and Pull-Down Resistors**
   Set default HIGH or LOW logic levels on digital inputs.

4. **Biasing Resistors**
   Establish operating points for transistors in amplifier configurations.

Video-17:
Objective:
Understand why oscillators are essential and how three common types produce periodic signals.

1. **RC Relaxation Oscillators**
   Use a resistor-capacitor (RC) network to charge and discharge a capacitor, generating a repeating signal.
   • Capacitor charges slowly through a resistor

2. **LC Tank Oscillators**
   Use an inductor (L) and capacitor (C) to create a resonant circuit.

3. **Crystal Oscillators**
   Use the mechanical resonance of a quartz crystal to produce a stable frequency.

Video-18:
Objective:
Understand how a brushless motor spins using an Electronic Speed Controller (ESC).

1. **DC Motor:**
   • Stator: Permanent magnet
   • Rotor (armature): Coils with brushes
   • Brushes and commutator switch current mechanically

2. **Brushless Motor (BLDC):**
   • Stator: Stationary coils
   • Rotor: Rotating permanent magnets

3. **ESC (Electronic Speed Controller):**
   • Controls speed using PWM (Pulse Width Modulation)
   • Sends precisely timed current pulses to the motor coils

Video-19:
Objective:
Learn how I2C (Inter-Integrated Circuit) allows communication between multiple devices using only two wires with Arduino.

1. **I2C Overview:**
   • Master (typically Arduino) manages communication
   • Each slave device has a unique 7-bit address

2. **Advantages of I2C:**
   • Minimal pin usage

• Simplifies connection of multiple devices
• Ideal for sensors, displays, and RTC modules

Video-20:
Objective:
Understand what a thyristor is and how a TRIAC controls AC voltage in practical circuits.

1. **Thyristor:**
   A diode that can be controlled
   • Has three terminals: Anode, Cathode, and Gate
2. **TRIAC:**
   A bidirectional thyristor
   • Controls both positive and negative halves of an AC waveform
   • Commonly used in AC dimming, motor speed regulation, or heating control
3. **TRIAC AC Control Circuit:**
   Components:
   • TRIAC
   • Resistors and capacitor
   • Load (e.g., lamp or fan)
   • AC power source

   Video-21

   Objective:
   Understand how OpAmps function and apply three key rules for circuit design.

   Working:
   An OpAmp amplifies the voltage difference between its two 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 is upheld in feedback systems

Video-22

Objective:
Use 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
• Base HIGH → transistor conducts, load turns ON
• Base LOW → transistor OFF

PNP as High-Side Switch:
• Load connected between Emitter and Vcc
• Base HIGH → transistor OFF

Video-23

Objective:
Use MOSFETs as efficient electronic switches for controlling high-current loads using low-power control signals.

N-Channel MOSFET – Low-Side Switch:
• Load connected between Vcc and Drain
• Source to GND
• Gate LOW → Turns OFF

P-Channel MOSFET – High-Side Switch:
• Load between Source and GND

• Source connected to Vcc
• Gate close to Vcc → Turns OFF

Video-24

Objective:
Understand how hybrid stepper motors work and how to control them with or without a microcontroller (μC).

How It Works:
• Hybrid stepper = combination of variable reluctance and permanent magnet motors
• Rotor has teeth and a permanent magnet → aligns precisely with stator's magnetic field
• Moves in fixed steps (e.g., 1.8° per step)

How to Control:

Without Microcontroller:
• Use stepper motor drivers (e.g., ULN2003, A4988)
• Provide step pulses manually using a 555 timer, switches, or logic gates

With Microcontroller (Arduino, etc.):
• Use driver modules

Video-25

Objective:
Use a standard servo motor for precise angle control in projects, with or without a microcontroller.

How It Works:
• Contains a DC motor, gears, potentiometer, and control circuit
• Controlled using PWM:
o 1 ms = 0°, 2 ms = 180°
o Signal repeated every 20 ms

Control Methods:

Without µC:
• Use a 555 timer to generate PWM
• Vary pulse width to control angle

Video-26

Objective:
Understand how the 555 Timer IC works and how to use it in monostable, bistable, and astable modes for delay, toggle, or PWM generation.

How It Works:
• Contains a flip-flop, discharge transistor, and voltage divider
• Key pins:
o Trigger (2), Threshold (6), Discharge (7), Output (3)

Monostable Mode:
• Trigger pulse → 555 outputs HIGH for a fixed time

Flip-Flop:
• One input sets, another resets
• Used for switching or memory applications

Oscillator:
• In free-running mode → generates a square wave

Video-27

Objective:
Understand ADC (Analog-to-Digital Converter) specifications and how Successive Approximation Register (SAR) ADCs work.

Specifications:
• **Resolution (bits):** Number of discrete output levels
• **Sampling Rate:** Speed at which analog values are converted
• **Accuracy:** How closely output matches actual value

SAR ADC Process:

1. Sample analog input
2. Comparator checks against internal DAC
3. SAR logic adjusts each bit to refine the value

Video-28

Objective:
Use an IGBT (Insulated Gate Bipolar Transistor) to switch loads, and understand when it outperforms MOSFETs.

• IGBT = MOSFET gate + BJT output stage
• Gate is controlled like a MOSFET (voltage-driven)

How to Use:
• Gate drive method is similar to a MOSFET
• Add gate resistor and possibly a gate driver IC

Video-29

Objective:
Wire solar panels, use diodes for protection, and optimize charging using MPPT or PWM charge controllers.

Solar Panel Connections:
• **Series:** Increases voltage
• **Parallel:** Increases current

Bypass Diodes:
• Protect against shading → prevent power loss and hot spots
• Allow current to bypass shaded cells

Blocking Diodes:
• Prevent reverse current flow from battery to panel at night

Maximizing Power Output:
• Keep panels clean, angled properly, and unshaded

• Use MPPT (Maximum Power Point Tracking):
o Dynamically adjusts voltage for max power

PWM Controller:

• Connects panel directly to battery
• Simple and cost-effective, but less efficient

MPPT Controller:

• Converts excess voltage into additional current
• Can be up to 30% more efficient in real-world use

Video-30

Objective:

Perform precise timing tasks and generate PWM signals using microcontroller timers.

1. Timer1 or Timer2:

• ATmega microcontrollers include Timer0, Timer1, and Timer2
• Timer1 is 16-bit

At 8 MHz PWM:

• If TOP = 1 → only 2 clock cycles per PWM cycle
• Duty cycle options are limited (0%, 50%, 100%)

For higher resolution:

• Reduce PWM frequency
• Or use an external timer/FPGA