Video 33:

 Measures mechanical force—compression or tension—by detecting tiny changes in electrical resistance of strain gauges bonded to a deformable metal “spring” structure.

The strain gauges form a Wheatstone bridge configuration, outputting a voltage signal proportional to applied force

Digital bathroom scales use multiple strain-gauge load cells to measure body weight.

Video 34:

**Component Name:** Two‑Position Controller (a.k.a. On–Off controller)

Operates in binary mode—switches fully **ON** when the measured variable passes a setpoint and fully **OFF** when it drops below it

It can be used in Simple level control, e.g., filling a water tank via a solenoid valve

**Component Name:** PID Controller (Proportional‑Integral‑Derivative controller)

Continuously monitors the error between a desired setpoint and actual process value. Adjusts output by combining three corrective actions: proportional (P), integral (I), and derivative (D)

Industry control systems for **temperature**, **pressure**, **flow rate**, and **level regulation**.

 **Motor speed and position control**, such as in robotics, motor drives, and cruise control in vehicles .

Video 35

**Component Name:** Schmitt Trigger

Acts as a comparator with built-in hysteresis, meaning it has two distinct threshold voltages—upper and lower—depending on whether the input is rising or falling. This prevents rapid switching from noisy or fluctuating signals, producing a clean digital output from even messy analog inputs

It “remembers” its state until the input crosses the opposite threshold, offering bistability

Cleans up erratic on/off fluctuations from mechanical switches

Schmitt Triggers take unstable analog inputs and give stable digital outputs by using two thresholds, making them ideal for noise immunity, debouncing, waveform shaping, oscillation, and reliable detection circuits.

**Video 36**

**Component Name:** **SPI (Serial Peripheral Interface) bus**

* A synchronous serial communication protocol that enables fast, full‑duplex data exchange between a **master** (e.g., microcontroller) and one or more **slave** devices Utilizes four lines: **SCLK** (clock from master), **MOSI** (data from master to slave), **MISO** (data from slave to master), and **SS** (slave select to activate each device).

 **Where it can be used:**

* **Embedded systems** for connecting sensors, displays, memory chips (e.g., EEPROM, flash), or ADC/DAC converters due to its high-speed capabilities.
* **Industrial control** where multiple SPI devices must be managed reliably and rapidly.
* **Consumer electronics** like SD cards in cameras, TFT screens in handheld devices, and RF modules for wireless communication.

**Video 37**

* **Impedance (Z)** is essentially **AC resistance**—it measures how a circuit opposes alternating current.
* Unlike simple DC resistance, impedance includes the effects of **inductance (L)** and **capacitance (C)**, making it a **complex quantity**.
* At **low frequencies**, capacitors act like open circuits (high XC), and inductors act like short circuits (low XL).
* At **high frequencies**, it's the reverse: capacitors short out, inductors impede current.
* In **resonant circuits**, inductive and capacitive reactances cancel each other (e.g., in LC filters or tuned circuits).

**Video 38**

AC power is multi-faceted: not just “watts” but also reactive and apparent components.

Apparent power (VA) accounts for both P and Q: essential for sizing equipment like transformers.

 Distorted waveforms (due to non-linear loads) introduce deformed power, complicating accurate power measurement.

**Video 39**

 AC power is multi-dimensional: real, reactive, apparent **—and** deformed components when waveforms are distorted.

 Balancing inductive and capacitive loads is vital for effective, economical, and compliant electrical system design.

 Understanding these concepts ensures better control over system sizing, efficiency, and power quality.

**Video 40**

**Component Name:** **RFID (Radio Frequency Identification)**

**What it does:**

* **RFID** enables wireless data exchange between a tag (transponder) and a reader using radio waves. It operates on various frequency bands (e.g., LF, HF, UHF) and can be passive (powered by the reader) or active (battery-powered).
* **NFC (Near Field Communication)** is a subset of RFID, specifically operating at 13.56 MHz, designed for short-range communication (typically up to 10 cm).

**Where it can be used:**

* **Contactless Payments:** Secure transactions using NFC-enabled cards or smartphones.
* **Access Control:** Managing entry to buildings or rooms via RFID badges.
* **Inventory Management:** Tracking goods in warehouses with RFID tags.
* **Public Transport:** Enabling ticketing systems using NFC-enabled devices.
* **Healthcare:** Patient identification and medication tracking using RFID wristbands.

**Video 41**

 **Component Name:** **Passive Audio Crossover**

 **What it does:**

* A passive audio crossover divides an audio signal into different frequency ranges (e.g., bass, midrange, treble) using passive components like capacitors, inductors, and resistors.
* It ensures that each speaker driver (woofer, midrange, tweeter) receives only the frequencies it is designed to handle, improving sound clarity and efficiency.

 **Where it can be used:**

* **DIY Audio Systems:** Building custom speaker systems with multiple drivers.
* **Home Audio:** Enhancing home theater or stereo systems for better sound distribution.
* **Car Audio:** Upgrading car speaker systems for improved audio performance.
* **Professional Audio Equipment:** Designing PA systems, studio monitors, and other audio equipment requiring frequency-specific driver management.

**Video 42**

 **Component Name:** **Transformer**

 **What it does:**

* A transformer is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction.
* It can increase (step-up) or decrease (step-down) voltage levels in AC circuits, allowing for efficient power distribution and adaptation to different voltage requirements.

 **Where it can be used:**

* **Power Distribution:** In electrical grids to adjust voltage levels for efficient transmission over long distances.
* **Consumer Electronics:** In devices like chargers, adapters, and audio equipment to provide the necessary voltage for operation.
* **Industrial Equipment:** In machinery and control systems to match voltage levels with operational needs.
* **Renewable Energy Systems:** In solar and wind power systems to convert generated voltage to usable levels for storage or grid connection.

**Video 43**

* **Component Name:** **Mechanical 7-Segment Display**
* **What it does:**
  + A mechanical display that uses physical segments to form numbers or characters.
  + Each segment is typically a rotating or flipping element that moves into position to display the desired digit.
* **Where it can be used:**
  + **Clocks and Timers:** Displaying time in various devices.
  + **Counters:** Showing counts in industrial or laboratory equipment.
  + **Indicators:** Providing numerical information in control panels or machinery.
* **Component Name:** **RS-485 Communication Protocol**
* **What it does:**
  + A differential serial communication standard used for long-distance and high-speed data transmission.
  + Supports multiple devices on a single bus, making it suitable for industrial applications.
* **Where it can be used:**
  + **Industrial Automation:** Connecting sensors, actuators, and controllers in a network.
  + **Building Automation:** Managing HVAC systems, lighting, and security systems.
  + **Data Acquisition Systems:** Collecting data from remote sensors or instruments.
* **Component Name:** **UART (Universal Asynchronous Receiver-Transmitter)**
* **What it does:**
  + A hardware communication protocol that facilitates asynchronous serial communication.
  + Converts parallel data from a microcontroller into serial data for transmission and vice versa.
* **Where it can be used:**
  + **Microcontroller Communication:** Connecting microcontrollers to peripherals like sensors or displays.
  + **Serial Communication:** Enabling communication between computers and other devices.
  + **Embedded Systems:** Facilitating communication in embedded applications.

**Video 44**

**Component Name:** **CAN Bus (Controller Area Network)**

**What it does:**

* A robust, multi-master, message-oriented serial communication protocol designed for embedded systems.
* Facilitates real-time data exchange between microcontrollers and devices in vehicles and industrial automation systems.
* Operates on a differential two-wire bus, ensuring high noise immunity and reliable communication over long distances.

**Where it can be used:**

* **Automotive Systems:** Connecting ECUs (Electronic Control Units) for engine control, braking systems, infotainment, and lighting.
* **Industrial Automation:** Linking sensors, actuators, and controllers in manufacturing equipment.
* **Embedded Systems:** Enabling communication in robotics, drones, and other embedded applications requiring reliable data exchange.

**Video 45**

**Component Name:** **I2S (Inter-IC Sound)**

**What it does:**

* I2S is a serial bus interface standard used for connecting digital audio devices, such as audio DACs (Digital-to-Analog Converters) and ADCs (Analog-to-Digital Converters), to microcontrollers or processors.
* It facilitates the transfer of audio data in a synchronous manner, ensuring high-quality audio playback and recording.

**Where it can be used:**

* **Embedded Systems:** Integrating audio playback capabilities into microcontroller-based projects.
* **Digital Audio Players:** Enabling high-fidelity audio output in portable music players.
* **Home Audio Systems:** Connecting digital audio sources to amplifiers or speakers.
* **Voice Assistants:** Processing and outputting audio signals in smart devices.

**Video 46**

 **What it does:**

* An induction motor operates on the principle of electromagnetic induction, where a rotating magnetic field induces a current in the rotor, causing it to turn.
* It is called "asynchronous" because the rotor never reaches the speed of the magnetic field; it always lags slightly behind.
* Induction motors are known for their robustness, simplicity, and reliability in various applications.

**Where it can be used:**

* **Industrial Applications:** Driving machinery such as conveyors, pumps, and compressors.
* **Home Appliances:** Found in devices like washing machines, fans, and refrigerators.
* **HVAC Systems:** Used in air conditioning units and ventilation systems.
* **Electric Vehicles:** Employed in electric vehicle drivetrains for propulsion.

**Video 47**

**Tonal Preference Over Precision**  
Tube amps may distort more in measured terms, but this distortion is often subjectively pleasing, not objectively superior.

**Warmth Through Harmonics**  
Even-order harmonics produced by tubes contribute to the often-described “warm tube sound.”

 **Personal and Practical Trade-Offs**  
Choosing tubes means accepting higher cost, maintenance, and less efficiency—but gaining a unique audio character.

 **Modern Alternatives Exist**  
Many amp designers now mimic tube warmth using solid-state or DSP techniques, offering similar sound with greater convenience.

**Video 48**

**What it does:**

* An eFuse is a programmable electronic fuse that provides overcurrent, overvoltage, and thermal protection to electronic circuits.
* Unlike traditional fuses, eFuses can reset themselves after a fault condition is cleared, eliminating the need for manual replacement.

**Where it can be used:**

* **Power Supply Systems:** Protecting power rails in embedded systems and power distribution circuits.
* **Battery-Powered Devices:** Safeguarding battery-operated devices from overcurrent and overvoltage conditions.
* **Consumer Electronics:** Ensuring the safety of devices like smartphones, laptops, and gaming consoles.
* **Automotive Electronics:** Protecting sensitive electronic components in vehicles from electrical faults.

**Video 49**

**What It Does:**

* An oscilloscope is an electronic test instrument that visualizes electrical signals as waveforms, displaying voltage over time.
* It helps in analyzing the behavior of signals, measuring parameters like frequency, amplitude, rise time, and noise.

**Where It Can Be Used:**

* **Electronics Development:** Designing and debugging circuits.
* **Signal Analysis:** Studying waveform characteristics in various applications.
* **Education:** Teaching and learning about electrical signals and circuits.
* **Maintenance and Repair:** Troubleshooting and repairing electronic equipment.

**Video 50**

Component: **TL431 Adjustable Shunt Regulator**

* **What it does:**
  + The TL431 is a precision adjustable shunt regulator that maintains a stable reference voltage, typically 2.495V, with high accuracy.
  + It operates as a voltage reference and error amplifier, commonly used in feedback loops of power supplies to regulate output voltage.
* **Where it can be used:**
  + **Switching Power Supplies:** In feedback circuits to regulate output voltage.
  + **Battery Chargers:** To monitor and control charging voltage.
  + **Voltage Monitoring:** For over-voltage and under-voltage detection in various applications.
  + **Microcontroller Systems:** Providing stable reference voltages for ADCs and DACs.

**Video 51**

**Component: Digital Potentiometer (Digitally Controlled Potentiometer, or DCP)**

* **What it does:**
  + A digital potentiometer is an electronic component that emulates the functionality of a mechanical potentiometer but is controlled through digital signals, typically via communication protocols like I²C or SPI.
  + It adjusts resistance in a circuit, allowing for precise control over voltage levels, signal attenuation, or gain in various applications.
* **Where it can be used:**
  + **Audio Systems:** Implementing volume control, tone adjustment, or balance settings in audio equipment.
  + **Signal Processing:** Adjusting signal levels in instrumentation and measurement devices.
  + **Power Supplies:** Regulating output voltage or current in programmable power supplies.
  + **Embedded Systems:** Providing adjustable parameters in microcontroller-based projects.

**Video 52**

### Component: ****Inverting DC-DC Converter****

* **What it does:**
  + An inverting DC-DC converter is a type of power supply that converts a positive input voltage into a negative output voltage.
  + It utilizes components like inductors, capacitors, and switches to efficiently invert the polarity of the input voltage.
* **Where it can be used:**
  + **Operational Amplifier Circuits:** Providing negative supply rails for op-amps.
  + **Analog Signal Processing:** Creating dual-supply systems for audio or sensor applications.
  + **Battery-Powered Devices:** Supplying negative voltages in portable electronics.
  + **Test Equipment:** Generating negative voltages for testing purposes.

**Video 53**

### Component: ****Latch Circuit****

* **What it does:**
  + A latch circuit is a type of bistable multivibrator that maintains its output state until an input signal triggers a change.
  + Unlike mechanical switches, which require physical movement, latch circuits provide electronic control, offering faster response times and greater durability.
* **Where it can be used:**
  + **Toggle Switches:** Implementing on/off functionality in devices without mechanical wear.
  + **Memory Storage:** Storing binary information in digital systems.
  + **Signal Processing:** Holding data in circuits to synchronize signals.
  + **Control Systems:** Maintaining system states in automation and embedded systems.

**Video 54**

### Component: ****Resettable Fuse (PPTC - Polymeric Positive Temperature Coefficient)****

* **What it does:**
  + A resettable fuse, also known as a PPTC, is a type of overcurrent protection device that automatically resets after an overcurrent condition is removed.
  + It operates by increasing its resistance when the current exceeds a certain threshold, effectively limiting the current flow.
  + Once the overcurrent condition is cleared and the device cools down, its resistance decreases, allowing normal current flow to resume.
* **Where it can be used:**
  + **Power Supply Circuits:** Protecting power inputs and outputs in electronic devices.
  + **Battery-Powered Devices:** Safeguarding against overcurrent situations in portable electronics.
  + **USB Ports:** Preventing excessive current draw that could damage USB interfaces.
  + **Consumer Electronics:** Ensuring the safety of devices like smartphones, laptops, and gaming consoles.

**Video 55**

### Component: ****Power Factor Correction (PFC) Circuit****

* **What it does:**
  + A Power Factor Correction (PFC) circuit improves the power factor of a power supply by aligning the phase of the input current with the input voltage.
  + It reduces harmonic distortion and ensures that the current drawn from the power source is more sinusoidal, leading to more efficient energy use.
* **Where it can be used:**
  + **Switching Power Supplies:** Enhancing efficiency in devices like chargers, adapters, and LED drivers.
  + **Consumer Electronics:** Incorporating PFC in devices such as televisions, computers, and audio equipment to meet energy standards.
  + **Industrial Equipment:** Improving power quality in machinery and automation systems.
  + **Renewable Energy Systems:** Optimizing energy conversion in solar inverters and wind turbine controllers.

**Video 56**

### Component: ****Color Ring Inductor****

* **What it does:**
  + A color ring inductor is a passive electronic component that stores energy in a magnetic field when electrical current flows through it.
  + It is characterized by its color-coded bands, which indicate its inductance value, tolerance, and sometimes its temperature coefficient.
  + These inductors are commonly used in power supply circuits, signal processing, and filtering applications.
* **Where it can be used:**
  + **Power Supply Filters:** To smooth out fluctuations in voltage and reduce noise.
  + **Signal Processing Circuits:** In applications like audio equipment to filter specific frequencies.
  + **Radio Frequency (RF) Circuits:** For tuning and impedance matching in communication devices.
  + **Switching Regulators:** In DC-DC converters to store and release energy efficiently.

**Video 57**

### Component: ****Electrical Grounding****

* **What it does:**
  + Electrical grounding provides a safe path for excess electricity to flow into the earth, preventing potential hazards like electric shocks or fires.
  + It ensures the stability and safety of electrical systems by maintaining a reference point for voltages.
* **Where it can be used:**
  + **Residential Wiring:** In homes to protect occupants from electrical faults.
  + **Industrial Equipment:** In factories to safeguard machinery and personnel.
  + **Consumer Electronics:** In devices like computers and televisions to prevent electrical surges.
  + **Automotive Systems:** In vehicles to ensure the safe operation of electrical components.

**Video 58**

### Component: ****Motor Encoder****

* **What it does:**
  + A motor encoder is a sensor that converts the rotational position or motion of a shaft into an electrical signal.
  + It provides feedback on the motor's speed, direction, and position, enabling precise control in various applications.
* **Where it can be used:**
  + **Robotics:** For precise movement and positioning in robotic arms and mobile robots.
  + **Industrial Automation:** In conveyor systems and CNC machines for accurate control of machinery.
  + **Automotive Systems:** In electric vehicles for motor control and monitoring.
  + **Consumer Electronics:** In devices like printers and cameras for precise movement control.

**Video 59**

### Component: ****Transient Voltage Suppression (TVS) Diode****

* **What it does:**
  + A TVS diode is a semiconductor device designed to protect electronic circuits from transient voltage spikes, such as those caused by lightning or electrostatic discharge (ESD).
  + It operates by clamping high-voltage transients to a safe level, thereby preventing damage to sensitive components.
* **Where it can be used:**
  + **Power Supply Inputs:** Protecting against voltage spikes entering from external power sources.
  + **Data Lines:** Safeguarding communication lines like USB, HDMI, and Ethernet ports.
  + **Automotive Electronics:** Protecting circuits in vehicles from voltage surges.
  + **Consumer Electronics:** Ensuring the longevity and reliability of devices like smartphones, laptops, and gaming consoles.

**Video 60**

### Component: ****I3C (Improved Inter-Integrated Circuit)****

* **What it does:**
  + I3C is a high-speed, low-power serial communication protocol developed by MIPI Alliance as an enhancement over I²C.
  + It supports higher data rates, multiple data lanes, and advanced features like in-band interrupts and dynamic addressing.
* **Where it can be used:**
  + **Mobile Devices:** Connecting sensors, cameras, and other peripherals.
  + **Wearables:** Enabling communication between components with minimal power consumption.
  + **Automotive Applications:** Facilitating communication between various sensors and control units.
  + **Consumer Electronics:** Integrating components in smart home devices and other electronics.

**Video 61**

### Component: ****MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor)****

* **What it does:**
  + A MOSFET is a type of transistor used to amplify or switch electronic signals in various electronic devices.
  + In audio amplifiers, MOSFETs are utilized for their high efficiency and ability to handle large currents, providing better sound quality and performance.
* **Where it can be used:**
  + **Audio Amplifiers:** Enhancing sound quality in home audio systems, car amplifiers, and professional audio equipment.
  + **Switching Power Supplies:** Regulating voltage in power supply units for computers and other electronic devices.
  + **Signal Processing Circuits:** Used in various signal processing applications due to their fast-switching capabilities.
  + **Motor Control Circuits:** Controlling motors in applications like robotics and industrial machinery.
  + MOSFET Amp = a circuit that uses MOSFETs to amplify sound (like a lamp using that bulb)

### ****Video 62****

### ****PLC (Programmable Logic Controller)****

* **What it does:**
  + A PLC is an industrial digital computer designed for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures.
  + It operates by receiving inputs from sensors or switches, processing the information based on a user-defined program, and controlling outputs like motors, lights, or actuators.
* **Where it can be used:**
  + **Manufacturing Plants:** Automating machinery and assembly lines for efficient production.
  + **Building Automation:** Controlling lighting, HVAC systems, and security systems in commercial buildings.
  + **Water Treatment Facilities:** Managing pumps, valves, and chemical dosing systems.
  + **Transportation Systems:** Overseeing traffic lights, railway signals, and airport baggage handling systems.