Video 1

- **Objective**: Improve a simple DIY audio amplifier by increasing power and replacing the BJT transistor with a MOSFET.
- **Issue with Original Design**: Works but lacks power; modern smartphones no longer have wired headphone jacks.
- **First Upgrade (BJT - TIP142 Darlington Transistor)**:
  - Increased supply voltage and adjusted resistor values.
  - Faced inefficiencies and overheating, requiring a heatsink.
- **Second Upgrade (MOSFET - IRFZ44N)**:
  - Lower resistance and better efficiency potential.
  - Required gate voltage biasing adjustments via a potentiometer.
  - Slightly louder but introduced non-linearity and possible distortion.

Video 2

Introduction to Haptic Feedback & I3C

- Haptic feedback systems can create various vibration patterns.
- The BOS1921 haptic driver IC is affordable (€4) compared to the expensive dev board (€240).
- The IC uses **I3C**, the successor to **I2C**, which is widely used in electronics.

Creating a Breakout Board for the BOS1921

- Referenced the datasheet and dev board design.
- Designed a **4-layer PCB** for better component placement and power distribution.
- Ordered PCBs and assembled them using a mini hot plate for **reflow soldering**.
- Faced an issue where a **capacitor was placed incorrectly**, causing excessive current flow.
- After fixing the capacitor polarity, the board worked as expected.

Testing & Comparison of I3C vs. I2C

- I3C offers significant advantages over I2C:
  - **Faster Speed:** 12.5 MHz vs. 1 MHz for I2C.
  - **Push-Pull Drivers:** Faster switching with lower power consumption.
  - **Dynamic Addressing:** Automatically assigns addresses instead of using hardware resistors.
  - **Common Command Codes (CCC):** Quick execution of basic commands.

- **Hot Join:** Allows devices to connect without resetting the microcontroller.
- **In-Band Interrupts:** Eliminates the need for extra interrupt pins.

Video 3

1. **Types of Overvoltage Protection Components**
   - **TVS Diodes (Transient Voltage Suppressors)**
     - Small components that clamp excessive voltage and dissipate energy as heat.
     - Can be in diode or IC form (TVS diode arrays).
     - Used in circuits to protect microcontrollers and sensitive electronics.
     - Quick response time, ideal for small voltage surges.
   - **MOVs (Metal Oxide Varistors)**
     - Look similar to capacitors and have variable resistance.
     - Absorb and dissipate energy as heat when voltage exceeds a threshold.
     - Commonly used in AC power supplies and high-energy applications.
     - Can handle larger surges compared to TVS diodes.
   - **GDTs (Gas Discharge Tubes)**
     - Contain inert gas that ionizes at high voltage, creating a conductive arc.
     - Designed for very high voltage protection (not effective for low-voltage circuits).
     - Slower response compared to TVS diodes but useful for large surge protection.
2. **Overvoltage Testing**
   - Initially used an insulation tester, but it was too weak.
   - Switched to an ESD generator with controlled 15,000V pulses.
   - Tested microcontroller circuits with and without protection:
     - **Without protection** → Immediate destruction.
     - **With protection** → Circuits survived voltage pulses.

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Video 4

1. Introduction to the Knob Interface

- The presented knob interface is a **mock-up** inspired by the open-source **Smart Knob** project.
- The original **Smart Knob** video gained attention on YouTube nearly **two years ago**.
- The creator was familiar with the **hardware** except for the **magnetic encoder**, which they decided to integrate into their mock-up.

2. Comparison: Magnetic vs. Rotary Encoders

- **Magnetic encoders** work similarly to **rotary encoders**, but they offer **higher precision** and unique advantages.
- A **magnetic encoder** can transform any motor into a **precise input device** or even convert a **BLDC motor** into a kind of **stepper motor**.

3. Sponsored Segment – Solo Motor Controllers

- **Solo Motor Controllers** provided a **motor controller board** for testing.
- The setup was **quick (15 minutes)**, with **high precision** and support for **Arduino & Raspberry Pi**.
- The controller requires **minimal external components** for functionality.

4. Understanding Rotary Encoders

- A **rotary encoder** has a **conductive metal pad** and two **metal pins** that sweep across it (Clock & Data or Pin A & B).
- As the encoder turns:
    - The pins **complete a circuit** at different times, generating a **pulsed signal**.
    - By observing **which pin triggers first**, the **direction** of rotation can be determined.
    - Some encoders also have an **index pin (X)** that signals **one full rotation**.

5. Limitations of Traditional Rotary Encoders

- **Low resolution**: Only **20 steps per rotation → 18° per step**.
- **Limited application**: Not precise enough for **high-resolution positioning tasks**.

6. Introducing the Magnetic Encoder (AS5600)

- Uses **Hall effect sensors** to detect the position of a **special magnet**.
- Offers a **12-bit resolution (4096 steps per rotation) → 0.088° per step**.
- **Higher precision** than a rotary encoder but requires **precise magnet placement**.

7. Magnetic Encoder Setup & Testing

- Magnet is **secured on the motor shaft**, and the sensor is **mounted above it**.
- Connected via **I2C** to a **microcontroller**.
- Successfully detects the **exact rotation angle** with much **greater accuracy**.

8. Using Encoders for Motor Control

- **Encoders enable position control** in motors, similar to **stepper motors** but with higher power.
- Example:
  - **Small robots** with **DC motors** struggle to move straight due to motor differences → **Encoders can fix this**.
  - **BLDC motors** with encoders can function like **stepper motors** for precise **positioning**.

9. Testing a Capacitive Encoder (AMT102)

- Uses **capacitive sensing** instead of magnetic or optical detection.
- Provides a **resolution of 2048 steps → 0.176° per step**.
- Produces **quadrature signals** similar to a **rotary encoder**.

10. Integrating the Encoder with a BLDC Motor

- Uses a **Solo Uno motor driver** (supports **up to 58V and 100A**).
- Steps for setup:
  1. **Connect motor and encoder** to the driver.
  2. **Power up** and connect to a **PC software interface**.
  3. **Fine-tune PID control values** for **optimal performance**.

11. Controlling the BLDC Motor with an Encoder

- The system supports **three modes**:
  1. **Torque mode** – Controls force applied by the motor.
  2. **Speed mode** – Uses the encoder to **precisely measure speed**.
  3. **Position mode** – Moves to **specific angles** for precise **stepper-like control**.

Video 5

1. Soil as a Conductor

- Regular garden soil can conduct electricity.
- Increasing the surface area of metal contacts improves conductivity.

2. Importance of Grounding in Electricity

- Grounding is essential for electrical safety and stability.
- Many electrical systems (household wiring, circuits, appliances) rely on grounding.

3. Ground Wire in AC Power Cables

- The green-yellow **Protective Earth (PE) wire** ensures safety.
- Appliances like toasters work fine with just **Live (L1)** and **Neutral (N)** wires, but the **Earth wire prevents electric shocks**.

4. Role of Grounding in Safety

- If the live wire touches the metal chassis, the **earth wire directs current safely**.
- This **triggers circuit breakers** and **Residual Current Breakers (RCB)** to **prevent electrocution**.

5. Ground Rod Connection to Earth

- Ground wires are connected to **metal rods buried deep in the earth**.
- The earth's **large mass absorbs excess electrical charges**, helping in **static discharge and fault protection**.

6. Static Electricity & Grounding

- Static electricity can **damage electronics and cause shocks**.
- Grounding helps **neutralize excess static charges**, especially in solar panels and large metal structures.

7. Grounding in Circuit Schematics

- Not all "grounds" in schematics refer to actual earth connections.
- Most circuit grounds serve as a **common reference potential (0V)** for the circuit.
- PCBs often use **one entire layer as a ground plane** for better performance.

Video 6

1. **Power Inductors Overview**
    - Power inductors are copper wire wrapped around a ferromagnetic core.
    - Common in power supplies; they come in both standard and surface-mount (SMD) versions.
    - **Color ring inductors** look similar to resistors and are cheaper and easy to identify, often used for low-power applications.
2. **Inductor Tests and Practical Experiments**

- Color ring inductors often lack detailed datasheets, with only basic information like power rating.
- **Boost converter experiment**:
  - Used a 22uH color ring inductor in a boost converter circuit.
  - The inductor worked initially, but the system couldn't handle more than 0.5A without significant voltage breakdown and noise.
- Inductors are used to store energy in magnetic fields and limit current flow. The **saturation current** (point at which inductance decreases) is crucial for determining an inductor's capacity.

3. **Saturation Current**

- The saturation current indicates when an inductor stops behaving like an inductor and starts acting like a resistor, leading to excessive current flow.
- **Test results**:
  - Original inductor from the boost converter had a saturation current around **4A**.
  - The color ring inductor reached saturation at **1.6A**, indicating a much lower capacity for higher current.

Video 7

Color Ring Inductors: These are often used in low-power applications and are inexpensive. They are also easy to identify because of their color rings that indicate the inductance value. However, they lack detailed datasheets and are generally less reliable for high-power applications compared to other inductors.

Inductor Testing: The creator tested the color ring inductors in a boost converter setup, finding that while the inductor worked initially, it could not handle high currents without significant voltage drop and noise. The saturation current, which determines how much current an inductor can handle before it stops behaving like an inductor, was much lower in the color ring inductor compared to others.

Practical Limitations: The color ring inductors can work in basic projects and for learning purposes but are not suited for high-power applications due to their low saturation current and lack of proper datasheet information.

Video 8

1. **Purpose of Fuses**: Fuses protect circuits from overcurrent conditions that can cause components to fail or burn out.

2. **Traditional Glass Fuses**: Glass fuses are commonly used but need to be replaced after they blow, which can be costly and inconvenient.

3. **Resettable Fuses**: Resettable fuses, such as PPTC (Polymeric Positive Temperature Coefficient), are reusable and protect circuits by increasing their resistance when exposed to excess current, stopping the flow to prevent damage.

4. **Advantages of Resettable Fuses**:

    - They can reset themselves after being triggered, eliminating the need for replacement.
    - Ideal for situations where circuits frequently experience overcurrent conditions.
5. **Types of Resettable Fuses**:

    - **Through-hole**: Easier to use and often found in DIY projects.
    - **SMD (Surface-Mounted)**: Smaller, often found in devices like the Raspberry Pi.
6. **Working Principle**:

    - Resettable fuses increase resistance as they heat up due to excessive current, stopping the flow of current and preventing damage to the circuit.
7. **Selecting a Resettable Fuse**:

    - You need to consider four factors: Maximum voltage, Maximum current, Hold current (current it can continuously handle without tripping), and Trip current (current level that triggers the fuse).
8. **Example**: For an LED strip circuit, the fuse should have a max voltage and current rating higher than the circuit's specifications, a hold current just above the normal draw, and a trip current slightly higher than the hold current.

9. **Testing and Performance**:

    - The fuse’s hold current and trip current were tested in the video. A typical resettable fuse has a slow response time compared to traditional glass fuses but still provides good protection.
    - PPTCs reduce current significantly when they trip but do not cut off the flow completely (they limit it).
10. **Leakage Current**: After tripping, a small leakage current may continue to flow, which keeps the fuse in its high resistance state until the current drops and it cools down.

11. **Limitations**:

- The resettable fuse does not provide a complete shutdown of current like a glass fuse would.
- Power losses in a resettable fuse can vary, and they might waste more power when triggered.
- They are slower than traditional fuses in some cases.

12. **eFuses**: Electronic fuses (eFuses) offer faster and more precise protection but are more expensive and not resettable by themselves. They are better suited for high-precision applications.

Video 9

1. **Introduction to Latch Circuits**:
    - A latch circuit is an electronic circuit that can store a state (ON or OFF) and retain that state even after the input signal is removed.
    - Latch circuits are commonly used in applications like lighting systems, overcurrent protection, and microcontroller power management.
2. **Advantages Over Mechanical Switches**:
    - Latch circuits are more efficient than mechanical toggle switches.
    - They are particularly useful in electronics because they require minimal input (a small voltage pulse) to toggle the state, while mechanical switches can be more expensive and require more wiring.
3. **Basic SR Latch with NOR Gates**:
    - The SR latch is a simple latch built with two NOR gates.
    - Inputs are "Set" and "Reset." A high voltage on the Set input turns the output ON, and a high voltage on the Reset input turns the output OFF.
    - A breadboard setup was used to demonstrate this functionality.
4. **Advantages of Building Latch Circuits Using Discrete Components**:
    - While dedicated ICs like the 74LS279 SR Latch IC or 555 timer are available, using discrete components (transistors, resistors, capacitors) for latch circuits is cheaper and more versatile.
    - This allows for higher current capabilities and additional customization.
5. **Practical Example: Latching Relay Circuit**:
    - The video compares the functionality of a mechanical latching relay (used in corridor lighting) with a simple electronic latch circuit.

    - The electronic latch uses MOSFETs and BJTs to toggle the state of a load (e.g., a light) based on a push button.
6. **Set and Reset Latch for Microcontrollers**:
    - The video explains a set/reset latch circuit that can be used to turn off a microcontroller after a certain event (like a distance sensor detecting an object).
    - The set pulse turns on a BJT that triggers the MOSFET, while the reset pulse turns everything off.

Video 10

1. **DC Voltages and Exceptions**: Most devices use a single DC output voltage (positive voltage), but some applications need both positive and negative voltages, such as audio amplifiers, sensors, operational amplifiers, and DACs.

1. **Dual Rail Power Supplies**: To power these applications, a dual rail power supply is used. These supplies have both positive and negative voltage rails, allowing them to provide voltage both above and below ground (GND).

2. **Ways to Create Dual Rail Power Supplies**:
    - **Simple Solution**: The easiest way to create a dual rail power supply is by using commercially available boards that convert a 5V input into +12V and -12V outputs.
    - **Boost Converter + Charge Pump**: A boost converter can be used to increase a voltage, and with the addition of an inverting charge pump, you can generate a negative voltage. However, this method has limitations, such as low output current and noise.
    - **Center-Tapped Transformer**: A more advanced approach involves using a center-tapped transformer, which provides a symmetrical AC signal. After rectifying this with a full bridge rectifier, you can create positive and negative DC rails. This method offers higher output current without significant noise.
    - **Resistor Divider with Op-Amp**: A simple method is to use two resistors and capacitors to create a virtual ground. However, this method is not very stable under load. Adding an operational amplifier (Op-Amp) as a buffer stabilizes the virtual ground, allowing the system to provide a more stable dual rail power supply.
    - **Other Solutions**: Other methods like the TLE2426 IC or a discrete transistor solution can also be used to create dual rail power supplies.

Video 11

1. **What is a Dual Rail Power Supply?**
    - It's a power supply that provides both positive and negative voltages. This is necessary for certain electronics like waveform generators, audio amplifiers, ADCs, and DACs, which require both voltage polarities.
2. **Basic Dual Rail Power Supply Setup:**
    - One simple way to achieve dual rail voltage is by using a board that can output +12V and -12V after inputting a 5V supply. This method is easy and widely available.
3. **Boost Converter and Inverting Charge Pump:**
    - A normal boost converter can be modified into a dual rail power supply using an inverting charge pump circuit. The charge pump creates a negative voltage by charging capacitors in a way that inverts the voltage. This setup, however, has limitations such as noise and low current output.
4. **Center-Tapped Transformer:**
    - For more stable and higher current output, a center-tapped transformer is used. This method provides a more efficient solution and can output more current (500mA) without noticeable noise. The AC voltage is rectified and split to create the dual rails.
5. **Resistor Divider with Operational Amplifier:**
    - A simple resistor divider can be used to generate dual rail voltages, with the middle point acting as a virtual ground. However, this method is unstable under load. To stabilize the virtual ground, an operational amplifier (Op-Amp) is used as a buffer, allowing for more stable voltage output.

Video 12

1. **Switched-Mode Power Supplies**: These devices efficiently convert AC mains voltage to a lower DC voltage, which is essential for powering modern electronic devices. Their

efficiency, often around 84%, is one reason why they are commonly used in many household items.

2. **TL431 in SMPS**: The TL431 acts as a voltage reference and feedback regulator. In a flyback converter, for instance, it helps maintain a stable output voltage by comparing the output to a reference voltage and adjusting the feedback loop.

3. **TL431 Operation**: The IC has a built-in comparator, transistor, diode, and voltage reference. When the voltage at the reference pin exceeds the internal reference (typically 2.495V), it turns on the internal transistor, pulling the output voltage low. This behavior is useful for creating adjustable voltage regulation and feedback loops in power supplies.

4. **Applications**: Beyond power supplies, the TL431 can be used in circuits like over-discharge protection for batteries, constant current sinks, and voltage regulation systems. The adjustable voltage feature, using a voltage divider, makes it particularly versatile.

5. **Feedback Loop in SMPS**: The TL431 helps form a feedback loop with the optocoupler and other components. This setup allows the power supply to adjust the duty cycle of its PWM signal, ensuring stable output voltage.

Video 13

1. **Prototype Creation**: The creator built a Switched Mode Power Supply (SMPS) that converts 230V AC to 5V DC and tested it successfully without any explosions.
2. **Introduction to Oscilloscope**: The oscilloscope is essential for visualizing voltage or current values over time, crucial for diagnosing and repairing electronics.
3. **Oscilloscope Selection**:
    - **Channels**: Prefer 4 channels for simultaneous signal monitoring.
    - **Bandwidth**: Choose one with sufficient bandwidth (e.g., 200MHz) for high-frequency signals.
    - **Sampling Rate**: A 2GSa/s sampling rate is typically sufficient.
4. **Probe Types**:
    - Passive probes are commonly used with scaling factors of x1 or x10.
    - **x10 Scaling**: Preferred for higher bandwidth.
5. **Triggering**: Used to stabilize waveforms at the same point. Common options include edge triggering, pulse width, or rise/fall time.
6. **Vertical/Horizontal Settings**:
    - **Vertical**: Adjust voltage division to get the correct amplitude for waveforms.

    - **Horizontal**: Adjust time/division to capture the right waveform frequency.
7. **Frequency and Rise Time Measurement**: Use the oscilloscope's measurement features to calculate signal frequency and rise time.
8. **AC Coupling for Ripple Measurement**: AC coupling helps remove DC offset when analyzing AC signals like ripple.
9. **Single Mode for Capturing Charging Curves**: Use single mode to capture and analyze the capacitor charging curve.
10. **Current Measurement**: Use a current shunt or current clamp for measuring current.
11. **Mains Voltage Measurement**: Mains voltage can be measured with proper precautions, such as using a scaling factor of 10:1.
12. **Safety with Mains Voltage**: Never connect the ground reference directly to mains. Use differential probes for safe mains voltage measurement.
13. **Advanced Functions**: The oscilloscope's math and FFT functions are useful for analyzing complex signals and power electronics.
14. **Precautions**: Always handle high voltage measurements carefully to avoid damaging equipment or causing injuries.

Video 14

1. **Powering a Circuit with USB**: The speaker recommends using a USB port for easy powering of projects via power banks, as they are portable and offer essential electrical protections (e.g., overcurrent, reverse voltage protection).

2. **Protection in DIY Projects**: When using other power sources (e.g., batteries, solar panels), it's important to include protection circuits to prevent issues like undervoltage, overvoltage, reverse voltage, and overcurrent.

3. **Using eFuse ICs**: The speaker uses an eFuse IC in their LiPo Supercharger circuit to solve these protection problems, ensuring safe operation by limiting overcurrent, undervoltage, and overvoltage.

4. **Selecting the Right eFuse IC**: For their project (Arduino Nano blinking an LED), they chose the **TPS259621 eFuse IC**, which supports voltages from 2.7V to 19V, has an adjustable current limit, and includes undervoltage and overvoltage protection.

5. **Connection to the Project**:

    - **IN, OUT, GND Pins**: Connect the input, output, and ground pins as expected.

- **Undervoltage Protection**: Achieved by adding a resistor network to the undervoltage pin, which ensures the project gets powered only when the input voltage is above 4.5V.
- **Overvoltage Protection**: Set by connecting the overvoltage pin to GND through a resistor (470kΩ), limiting output voltage to 5.35V if it exceeds the threshold.
- **Current Limiting**: Achieved through a resistor connected to the current limit pin, setting the current to 200mA for the project.

6. **Additional Pins**: The IC also has a **Fault pin** for indicating errors and a **dVdt pin** for reducing inrush current, but these are not critical for the current project.

7. **Reverse Voltage Protection**: The IC lacks reverse voltage protection, but a separate circuit using a P-Channel MOSFET is used for this purpose in the speaker's previous videos.

8. **Recommendation**: The speaker highly recommends the eFuse IC for DIY projects due to its affordability, ease of use (hand-solderable), and effective protection features.

9. **Advanced eFuse ICs**: For more advanced features like reverse voltage protection, you can invest in more expensive eFuse ICs, but they might come in harder-to-solder packages.

Video 15

1. **Creator's Confession**: The creator reads all the comments on their videos, and viewers have been asking for a tube amplifier video.
2. **What are Tube Amplifiers?**: Tube amplifiers use vacuum tubes (triodes), which were invented in 1906, and are often replaced by transistors nowadays.
3. **Modern Use of Tube Amplifiers**: Despite being old technology, tube amplifiers are still available for sale today.
4. **The Appeal of Tube Amplifiers**: The video aims to investigate why tube amplifiers are still in use after 100 years.
5. **Unboxing the Tube Amplifier**: The creator purchased an 80€ tube amplifier and likes its design, quality, and ability to connect via Bluetooth or wired stereo signals.
6. **Sound Comparison**: Comparing the tube amplifier to a phone's audio output, the tube amplifier offers a more pleasant sound spectrum.
7. **Inside the Amplifier**: After opening the amplifier, the creator discovers multiple ICs (amplifiers) for various functions like headphone amplification and speaker output.
8. **Role of the Vacuum Tube**: The tubes are only responsible for pre-amplifying the audio signal because they can't handle enough current to drive speakers directly.

9. **How Triode Vacuum Tubes Work**: Triodes amplify audio signals using the plate, cathode, grid, and heater. They require high voltage (100–150V DC) to operate.
10. **Class A Amplifier Test**: The creator builds a simple class A amplifier circuit using the triode tube and compares it with a transistor-based amplifier (BJT).
11. **Challenges with Vacuum Tubes**: Vacuum tubes produce excess heat (1.8W), whereas transistors don't, which is a disadvantage of tube amplifiers.
12. **Distortion and Sound Quality**: Vacuum tubes add distortion, but some people find it warm or pleasant, and they don't clip like transistors when overdriven.
13. **Conclusion**: The creator concludes that while tube amplifiers might add distortions, they are not interested in building one themselves due to the extra work and inefficiency. However, tube amps are still relevant for those who prefer their sound characteristics.
14. **Further Learning**: Links to more videos on amplifier classes and transistors are provided for viewers who want to dive deeper into the topic.

Video 16

1. **Introduction to Asynchronous Motors**: These motors are widely used worldwide and are much larger than typical hobbyist motors like stepper, DC, or BLDC motors.

2. **Motor Construction**: The motor features a stator with coils (U1U2, V1V2, W1W2) and a rotor with a squirrel cage design.

3. **Motor Configuration**: The coils can be wired in either a delta or star configuration to accommodate different voltage levels.

4. **Voltage Requirements**: Asynchronous motors typically require a 3-phase AC voltage (230V or 400V). The voltage type and wiring configuration (star or delta) influence the motor's performance and the voltage applied to each coil.

5. **Working Principle**:

    - The motor operates with a rotating magnetic field created by the 3-phase AC current flowing through the stator.
    - This rotating field induces a current in the rotor, creating an opposing magnetic field that causes the rotor to spin.
6. **Speed of the Rotor**:

    - The rotor’s speed is slightly slower than the stator’s frequency due to the induction process, which is why it's called an "asynchronous" motor. This difference in speed is known as "slip."

7. **RPM Control**: The motor's RPM can be altered by using motors with different pole configurations or by using an expensive electronic frequency converter.

8. **Single-Phase Version**: Some asynchronous motors, like those used in small appliances, use a capacitor to simulate a 3-phase system and create a rotating magnetic field with just a single-phase supply.

9. **Advantages of Asynchronous Motors**: They are robust, inexpensive, and easy to use without the need for complex drivers or controllers.

Video 17

1. **Recording the Sound Clip**: First, an audio clip ("Stay Creative!") is recorded. The clip's data (in PCM format) is stored in a microSD card connected to the ESP32 via the SPI interface. The data retains a resolution of 16 bits and a sampling rate of 44.1 kHz, ensuring good audio quality.

2. **Using the I2S Interface**: The ESP32 is capable of converting digital audio data into an analog signal using its internal DAC (Digital to Analog Converter), but its resolution (8 bits) limits audio quality. To improve this, the MAX98357A amplifier board is used, which communicates through the I2S protocol, supporting higher-quality audio output. I2S is a specialized protocol for transmitting digital audio data, often used in audio devices like microphones and amplifiers.

3. **Microphone Setup**: The INMP441 I2S microphone board is used for input in the video. The microphone board uses three main I2S pins: Word Select (for channel selection), Serial Clock (to synchronize data transmission), and Serial Data (the actual audio data). These pins are connected to the ESP32, which reads the data.

4. **Code and Pin Configuration**: The ESP32 does not have predefined I2S pins, so the user can select any GPIO pins. In the video, pins 15, 2, and 4 are chosen. The necessary configuration code is written using the ESP32 I2S programming guide. The data from the microphone is read, and its output is monitored using the serial monitor.

5. **Analyzing I2S Signals**: Using an oscilloscope, the video demonstrates how the Word Select line switches between high and low states, signaling whether the data belongs to the left or right audio channel. The Serial Clock (generated by the ESP32) defines the timing for sampling the Serial Data (audio data bits).

6. **Audio Output**: The code is extended to read the audio file from the microSD card and send it to the MAX98357A I2S amplifier. A speaker is connected to the amplifier, and once everything is hooked up, the ESP32 plays the sound file, resulting in the output of the recorded phrase: "Stay Creative!"

Video 18

1. **Project Overview**: The creator is building a giant battery pack for an electric longboard, which was shown in a previous video.
2. **Issue with Motor Sync**: When testing the pack, the hub motors didn't start at the same time, despite receiving the same PWM signal.
3. **Small RPM Misalignment**: The RPM difference is minor and doesn't affect the performance significantly, but it was still addressed.
4. **Solution**: The issue was fixed using the CAN bus of the FS ESCs (electronic speed controllers).
5. **CAN Bus Explanation**:
    - **CAN** stands for Controller Area Network, a serial bus system for communication between microcontrollers and devices.
    - Originally used in cars for connecting various control units, like motors and sensors.
    - It only requires two wires: CAN High (CAN H) and CAN Low (CAN L).
6. **CAN Bus in Action**:
    - **CAN H** swings to a high voltage, and **CAN L** swings to low voltage.
    - CAN bus frames contain a header with device ID, data, and error-checking bits.
    - Frames allow devices to communicate without a host computer.
7. **Priority System**: Devices with lower IDs (higher priority) can override transmissions from devices with higher IDs.
8. **Error Detection**: The CAN protocol uses cyclic redundancy check (CRC) and acknowledgment bits to ensure error-free data transmission.
9. **Robust System**: CAN bus uses twisted pair wires for differential voltage transmission, making it resistant to interference, similar to RS-485.
10. **Half Duplex & Asynchronous**: CAN is a half-duplex system (devices can send or receive, not both simultaneously), and it’s asynchronous (synchronized by baud rate and voltage changes).
11. **Termination Resistance**: CAN bus requires termination resistance, and this setup differs based on the type of CAN used.
12. **CAN Variants**:

- High-Speed CAN: Up to 1 Mbps.
- Low-Speed CAN: 125 kbps.
- CAN FD: 5 Mbps.

Video 19

1. **Mechanical Seven-Segment Displays**: These displays use moving plastic segments controlled by electromagnets, unlike traditional LED-based displays. The segments retain their position after power is removed due to the permanent magnetism in the electromagnets.

2. **Control Circuit**: The display module includes an ATmega32A microcontroller that controls the electromagnets using high-voltage driver ICs and Darlington transistor arrays. These components power individual segments one at a time.

3. **Multiplexing**: The microcontroller powers one display at a time in a multiplexed fashion, switching between them rapidly to display multiple numbers. This saves power and reduces complexity in the circuit.

4. **RS-485 Communication**: The control circuit uses an RS-485 interface for data transfer, which is asynchronous (no clock line). The protocol requires a start command, an address, the data to be displayed, and a stop command. RS-485 uses differential signaling, making it resistant to noise and interference.

5. **Arduino Nano for Control**: The Arduino Nano has a USART interface (Universal Asynchronous Serial Receiver Transmitter), which can be used to communicate with the RS-485 interface. The baud rate is set to 9,600, and simple data is sent to control the display.

Video 20

1. **Warning about Transformer Use**: Mishandling high-voltage transformers can lead to fatal injuries.

2. **Role of Transformers**: Transformers convert high mains AC voltage to lower AC voltage for safe use in devices like phones and laptops.

3. **Size Variability**: Some transformers are smaller than others despite providing more power; design specifications affect this.

4. **Basic Transformer Structure**:

    - Composed of a metal core and two coils (primary and secondary).
    - The primary coil is connected to mains voltage and the secondary coil provides the output voltage.
5. **How a Transformer Works**:

    - The primary coil creates a magnetic field due to current.
    - Magnetic flux flows through the core and induces voltage in the secondary coil.
6. **Induction Law**: A changing magnetic flux induces voltage in the secondary coil, creating the output voltage.

7. **Voltage and Power Transformation**:

    - Voltage change is proportional to the turns ratio between primary and secondary coils.
    - Example: A 230V input can produce a 13.5V output with a 1600mA current.
8. **Magnetic Flux and Opposing Voltage**:

    - The current in the primary coil creates a magnetic flux, which also induces voltage that opposes the input voltage.
9. **Self-Regulation**: Transformers self-regulate their current to maintain voltage levels.

10. **Real Power Losses**:

- Even with no load, the transformer consumes real power due to internal resistances and losses in the iron core.

11. **Losses in Transformer**:
- **Eddy Currents**: Induced in the iron core, minimized with laminated steel sheets.
- **Hysteresis Losses**: Occur due to the alternating magnetization of the core material.

12. **Practical Example with Load**:
- Connecting a load to the secondary coil increases the current on the primary side and causes the voltage to drop slightly.
- Efficiency of the transformer changes with load: 82% efficiency at lower loads, 72% at higher loads.

13. **Saturation and Voltage Breakdown**:
- At high loads, magnetic saturation occurs, reducing voltage induction and efficiency.
- Overloading leads to increased power losses and heating, potentially damaging the transformer.

14. **Solutions for Efficiency**:

- To improve voltage induction, increasing the cross-sectional area of the core can help manage power losses better.

Video 21

1. **Basic Audio Signal and Crossover Concept:**
    - An audio signal is a wide-frequency AC signal ranging from 20 Hz to 20,000 Hz.
    - Different speakers are designed to handle specific frequency ranges:
        - **Woofers** are for low frequencies (20-2000 Hz).
        - **Tweeters** are for high frequencies (above 2000 Hz).
    - The job of the crossover is to separate these frequencies and direct them to the appropriate speakers (woofer or tweeter).
2. **Components of an Audio Crossover:**
    - Crossovers use components like **resistors**, **capacitors**, and **inductors** to filter out high and low frequencies.
    - Inductors create a **low-pass filter**, allowing low frequencies to pass while blocking high frequencies.
    - Capacitors create a **high-pass filter**, allowing high frequencies to pass while blocking low frequencies.
3. **Tests and Experiments:**
    - Using resistors, inductors, and capacitors, the creator demonstrates how each component affects the output signal.
    - **Resistors** dampen the signal across all frequencies.
    - **Inductors** reduce signal strength as frequency increases (acts as low-pass filter).
    - **Capacitors** reduce signal strength as frequency decreases (acts as high-pass filter).
4. **RC and RL Filters:**
    - **RC filters** (resistor-capacitor) and **RL filters** (resistor-inductor) are common in audio crossovers.
    - The cutoff frequency of these filters is important, as it determines where the signal begins to decrease in amplitude.

Video 22

- **RFID (Radio Frequency Identification)** technology, which uses wireless communication through magnetic fields and can be used in contactless payments.
- The process behind how RFID tags work, such as how they are powered wirelessly through energy transfer when placed near a reader.
- The **NFC (Near Field Communication)** technology, a subset of RFID, which is used in secure payments due to its limited range (only a few centimeters).
- Safety concerns around RFID tags, mentioning that they can be easily read by any reader in close proximity. However, the presenter also notes that payment cards often use encryption for security.
- The possibility of adding RFID/NFC technology to Arduino-based projects for tasks like authentication or security systems.

Video 23

1. **Connections**: The anodes of the LEDs are connected in parallel across the first three lines of the PCB, and the cathodes are connected to the pins of a 16-bit constant current LED driver IC.
2. **Multiplexing**: The LED matrix uses multiplexing to control all 384 LEDs with fewer pins. By switching between lines rapidly, the human eye perceives a static image.
3. **Shift Registers**: The LEDs are controlled via serial-in parallel-out (SIPO) shift registers. These registers store and shift data, allowing control of multiple LEDs with just two pins.
4. **Shift Register Mechanics**: The IC uses 16 D-type flip-flops connected in a cascade to shift data and control the LEDs. This approach saves GPIO pins on microcontrollers while controlling many LEDs.