ELECTRONIC BASICS #1: THE MULTIMETER

- **Ohm's Law:** The relationship between voltage, current, and resistance.

- **Measuring Resistance:** Selecting the correct setting, using probes, and understanding circuit resistance.

- **Continuity Testing:** Checking for cable breaks using the meter's beep function.

- **Voltage Measurement:** Distinguishing between AC and DC voltage and safely measuring battery or power supply voltage.

- **Current Measurement:** Using the correct probe socket and avoiding fuse damage.

ELECTRONIC BASICS #2: DIMMING ALL KINDS OF LEDS!?

Different methods for dimming LEDs are explored, including voltage reduction, potentiometer use, and Pulse Width Modulation (PWM). PWM rapidly switches LEDs on and off to create a dimming effect without wasting power. Techniques using an Arduino, a 555 timer, and MOSFETs are demonstrated, showing efficient ways to control LED brightness in various applications..

ELECTRONIC BASICS #3: PROGRAMMING AN ATTINY + HOMEMADE ARDUINO SHIELD

Programming an ATtiny 85 using an Arduino Uno is demonstrated, covering software setup and board data installation. A custom shield is designed to streamline the process. SPI communication challenges with the WS 2801 LED strip are addressed using a bit-bang approach. The test confirms functionality, with future improvements planned.

ELECTRONIC BASICS #4: ARDUINO + BLUETOOTH + ANDROID = AWESOME

A Bluetooth module is connected to an Arduino Nano to control LEDs using an Android app. Voltage differences between the module and the Arduino are addressed with a voltage divider. An app is recommended for communication, and code is provided for LED control. The importance of disconnecting TX and RX connections before uploading code is emphasized.

ELECTRONIC BASICS #5: HOW TO MULTIPLEX

Multiplexing is used to control many LEDs with fewer microcontroller I/O pins. LEDs are arranged in a matrix, with cathodes connected per column and anodes per row. Power is supplied to specific rows and columns to activate individual LEDs. Rapid switching creates a stable visual effect. P-channel MOSFETs manage row power, while a TLC5940 LED driver controls column brightness. A programming library simplifies coding, enabling animations like a sine wave display. This technique is applicable to LED matrices and RGB LED cubes.

ELECTRONIC BASICS #6: STANDALONE ARDUINO CIRCUIT

Building a standalone Arduino circuit using an ATmega328P microcontroller is demonstrated. Essential components include a 16 MHz clock crystal, capacitors, and a resistor for stability. Different methods for programming the microcontroller are outlined, including using an FTDI chip for USB-to-serial conversion. Advantages and limitations of standalone circuits compared to standard Arduino boards are discussed. A final build is completed in a gadget box with female headers for reprogramming.to create a stable visual effect. P-channel MOSFETs manage row power, while a TLC5940 LED driver controls column brightness. A programming library simplifies coding, demonstrating animations like a sine wave display. The technique is useful for LED matrices and is later applied to an RGB LED cube.

ELECTRONIC BASICS #7: 7 SEGMENT DISPLAY

The use of 7-segment displays is explored, both with and without an Arduino microcontroller. Different types of displays are introduced, highlighting their pin configurations and required voltage levels. Methods for displaying numbers without a microcontroller are demonstrated using a BCD to 7-segment display driver and a 4-bit binary counter. Multiplexing is used to control multiple digits efficiently. The SAA1064 IC is introduced as a dedicated solution for handling 7-segment displays with the I²C communication protocol, reducing the processing load on the microcontroller. A schematic and example code are provided to simplify

integration with an Arduino.MHz clock crystal, capacitors, and a resistor for stability. Different methods for programming the microcontroller are outlined, including using an FTDI chip for USB-to-serial conversion. Advantages and limitations of standalone circuits compared to standard Arduino boards are discussed. A final build is completed in a gadget box with female headers for reprogramming.

ELECTRONIC BASICS #8: EVERYTHING ABOUT LEDS AND CURRENT LIMITING RESISTORS

Key principles of LED operation are explained, including forward voltage, ideal current, and resistor calculations using Kirchhoff's Voltage Law and Ohm's Law. Series and parallel LED connections are compared, highlighting efficiency differences. The risks of voltage variations in LEDs are addressed, emphasizing the importance of current regulation. Simple constant current sources, such as the LM317 and the TLC5940 LED driver, are introduced for improved LED longevity and stability.

ELECTRONIC BASICS #9: DIODES & BRIDGE RECTIFIERS

Diodes are widely used in electronics, particularly in power supplies and circuit protection. Their function in preventing damage from reversed polarity is explained, along with their voltage drop characteristics. The conversion of AC to DC using diodes is demonstrated, highlighting the role of rectifiers in power supply designs. A bridge rectifier circuit is introduced, showing how it efficiently converts both halves of an AC waveform into a continuous DC output.

ELECTRONIC BASICS #10: DIGITAL TO ANALOG CONVERTER (DAC)

Different methods for converting digital signals into analog waveforms are explored. The R-2R resistor ladder technique is introduced, demonstrating its ability to generate varying voltage levels. An experiment is conducted using an Arduino Nano to output different digital values, resulting in a corresponding analog signal. Triangle and sine waves are generated through gradual voltage adjustments. The importance of buffering the output using an operational amplifier is highlighted to maintain signal integrity. Alternative DAC solutions, including integrated circuits like the DAC0800 and MCP4725, are mentioned for more precise applications.

ELECTRONIC BASICS #11: SENDING SMS WITH ARDUINO || TC 35 GSM MODULE

The process of using a TC 35 GSM module to send SMS messages with an Arduino Uno is demonstrated. The setup begins with inserting a prepaid SIM card into the module and removing the SIM lock using a smartphone. Powering the module correctly is explained, with a recommendation to use 5V to avoid voltage regulation issues. The login process for connecting the module to a mobile network is automated using a jumper wire linked to an Arduino pin.

Communication between the GSM module and Arduino is established via AT commands, with an FTDI breakout used for

initial testing. The process of sending an SMS is outlined, requiring a specific command format and ending with a dot for proper execution. A simple schematic and example code are provided for integration into various projects, including an alarm system that sends SMS notifications.

ELECTRONIC BASICS #12: COILS / INDUCTORS (PART 1)

Inductors, also known as coils, play a fundamental role in electronics. Current flowing through a wire generates a magnetic field, which can be intensified by winding the wire into coils and using a ferromagnetic core. Lenz's Law explains how inductors resist changes in current flow by inducing opposing voltage. Applications include electromagnetic switches, motor control, and DC-DC converters. Energy stored in inductors is utilized in boost converters to raise voltage, while flyback diodes protect circuits from voltage spikes caused by inductive loads. The behavior of inductors in AC circuits is explored in the next part of the series.

ELECTRONIC BASICS #13: COILS / INDUCTORS (PART 2) || REACTANCE

The concept of reactance is explored, demonstrating how inductors create a form of resistance that differs from conventional resistors. A small LED circuit powered by a transformer is tested with and without an inductor, showing how inductance affects current flow. Changes in inductance influence reactive power, impacting efficiency in power systems. Increasing frequency is shown to raise reactance, reducing current flow. Applications such as noise filters, phase

shifts in AC circuits, and inductive loads in motors are discussed. An affordable transistor tester is introduced for measuring inductance, resistance, and capacitance.

ELECTRONIC BASICS #14: CAPACITORS

Capacitors are explained through a demonstration, beginning with the construction of a basic capacitor. Capacitance, voltage rating, and the role of dielectric materials in increasing charge storage are discussed. Behavior in DC and AC circuits is analyzed, showing how capacitors stabilize voltage, create signal filters, and compensate for inductive loads. The importance of selecting appropriate capacitance values for specific applications is highlighted, along with practical examples in electronic circuits.

ELECTRONIC BASICS #15: TEMPERATURE MEASUREMENT (PART 1) || NTC, PT100, WHEATSTONE BRIDGE

Various methods for measuring temperature are explored, including NTC thermistors, PT100 sensors, and the Wheatstone bridge circuit. NTC thermistors decrease resistance with increasing temperature, while PT100 sensors offer a more linear response. Accurate measurement techniques using voltage dividers and operational amplifiers are demonstrated. A pre-made transmitter is introduced to simplify the process, reducing errors and improving precision. The advantages of integrated circuits such as the LM35 and DS18B20, which provide direct temperature readings, are highlighted. Thermal inertia and response speed limitations of resistance-based

sensors are discussed, with alternative solutions mentioned for faster measurements.

ELECTRONIC BASICS #16: RESISTORS

Resistors are essential components in electronic circuits, used for limiting current, dividing voltage, and acting as pull-up or pull-down resistors in logic circuits. Their resistance value is calculated using Ohm's Law. Power ratings are important, as excessive power dissipation requires high-wattage resistors. Voltage dividers are formed by connecting resistors in series, allowing signal level adjustments. Potentiometers serve as adjustable resistors for fine-tuning voltage outputs. Low-value resistors, known as shunt resistors, enable current measurement through voltage drop analysis. Additional applications include circuit protection, light detection using photoresistors, and temperature sensing with PT100 sensors. While resistors behave predictably in DC circuits, parasitic inductance and capacitance affect performance in high-frequency AC circuits. Considering these effects is crucial in circuit design.

ELECTRONIC BASICS #17: OSCILLATORS || RC, LC, CRYSTAL

Oscillators generate periodic signals used in timing circuits, clock generation, and radio communication. RC oscillators create waveforms through capacitor charging and discharging, demonstrated with an astable multivibrator and a 555 timer circuit. LC tank circuits utilize inductors and capacitors to form resonant oscillations, maintaining frequency stability. Crystal

oscillators rely on piezoelectric vibrations to achieve precise clock signals, commonly found in microcontrollers and communication systems. Frequency adjustments are achieved by modifying resistance, capacitance, or inductance, influencing circuit behavior for different applications.

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ELECTRONIC BASICS #18: DC & BRUSHLESS DC MOTOR + ESC

Brushless DC motors and electronic speed controllers (ESCs) are examined, comparing them to conventional DC motors. The internal structure of both motor types is explored, showing how electromagnetism generates rotational motion. ESCs regulate motor speed using pulse width modulation, ensuring efficient power delivery. Differences between outrunner and inrunner motors are highlighted, explaining how magnet placement affects torque and speed. The KV rating is introduced,

indicating the number of revolutions per volt applied. Practical tests are conducted to measure speed and torque variations under different voltage conditions.

ELECTRONIC BASICS #19: I2C AND HOW TO USE IT

The I²C communication protocol is explained, highlighting its ability to connect multiple master and slave devices. A small breakout board is built to interface an FM radio module with an Arduino Nano. Proper wiring is established, including pull-up resistors to stabilize data lines. Data transmission principles are outlined, covering start conditions, address selection, and bit formatting. Practical implementation is demonstrated by tuning an FM frequency through hexadecimal calculations. An oscilloscope is used to analyze data transmission, confirming the expected output. Reading data from I²C devices follows a similar process, storing received bits in a buffer for evaluation. The importance of understanding datasheets is emphasized for successful integration. Other communication protocols like SPI and One-Wire are mentioned as alternatives.

ELECTRONIC BASICS #20: THYRISTOR, TRIAC || PHASE ANGLE CONTROL

The thyristor, a controllable diode, is introduced with a focus on its function in AC power regulation. Its four-layer structure is explained, along with the addition of a gate terminal to control current flow. A practical example is demonstrated using an LED, highlighting the latching and holding current requirements for maintaining conduction. Methods for turning

off the thyristor, including interrupting current flow with a MOSFET, are outlined.

The triac is then introduced, combining two thyristors in an inverse parallel configuration to enable full-wave AC control. A zero-crossing detection circuit is built using an optocoupler and a full-bridge rectifier, ensuring precise switching at the correct phase angle. A microcontroller-based delay system is implemented using an Arduino Nano and a potentiometer, adjusting the activation timing of the triac. The final circuit allows efficient power regulation for AC appliances, including heating elements and motor speed adjustments. While practical applications are explored, challenges such as reduced power factor due to waveform distortion are acknowledged.

ELECTRONIC BASICS #21: OPERATIONAL AMPLIFIERS (OP-AMPS)

Operational amplifiers (op-amps) are widely used in both analog and digital electronics. Their function is explained through three fundamental principles: maintaining zero voltage difference between inputs, drawing no input current, and amplifying signals based on feedback circuits.

A basic op-amp setup is demonstrated using the LM358 IC, powered by a single 12V supply. A non-inverting amplifier circuit is introduced, where a voltage divider determines the amplification factor. Applications of this setup include signal amplification for sensors such as PT100 temperature sensors and electret microphones.

The limitations of op-amps are highlighted, including voltage output constraints and imperfections in input impedance. Rail-to-rail op-amps are briefly mentioned as alternatives for better performance. An inverting amplifier circuit is explored to improve AC signal amplification, preventing distortion caused by DC voltage levels.

The final section introduces op-amps used as comparators, where outputs shift between high and low states based on input voltage differences. This principle is applicable in circuits such as Schmitt triggers and integrators. The versatility of op-amps is emphasized, making them essential in constant current sources, voltage followers, and summing amplifiers.

ELECTRONIC BASICS #22: TRANSISTOR (BJT) AS A SWITCH

Bipolar junction transistors (BJTs) are introduced as switching elements in electronic circuits. NPN and PNP transistor types are explained, with their terminals—emitter, collector, and base—described. The necessity of base current for transistor operation is highlighted, alongside calculations for proper resistor selection to limit current and prevent damage.

The concept of saturation mode is discussed, where the transistor is fully switched on, allowing maximum current flow. Voltage drop across the collector-emitter junction is observed, affecting circuit efficiency. Differences in control methods for NPN and PNP transistors are explained, focusing on circuit polarity and switching behavior.

Higher-power applications require transistors with increased current ratings. The BD535 transistor is demonstrated for

handling larger loads, with considerations for heat dissipation and efficiency. Darlington transistors are introduced to reduce base current requirements, making direct microcontroller control possible.

Power loss in BJTs is analyzed, revealing the limitations of bipolar transistors in high-current switching applications. Alternative solutions, including MOSFETs, are suggested for better efficiency. The fundamental principles of transistor switching are summarized, enabling practical application in various electronic projects.

ELECTRONIC BASICS #23: TRANSISTOR (MOSFET) AS A SWITCH

MOSFETs are introduced as efficient alternatives to bipolar junction transistors (BJTs) for switching applications. Unlike BJTs, MOSFETs rely on voltage at the gate rather than current, reducing power loss and improving efficiency. The video demonstrates an N-channel MOSFET controlled by an Arduino, showing how a pull-down resistor stabilizes gate voltage.

Challenges arise when switching larger loads due to parasitic capacitances and oscillations, causing voltage spikes. Solutions involve adding a gate resistor to manage current flow, increasing rise and fall times to reduce unwanted oscillations. The importance of gate charge and switching losses at higher frequencies is highlighted, emphasizing the role of MOSFET driver ICs for optimized performance. Practical applications include LED dimming and motor control, demonstrating the versatility of MOSFETs in electronics.

ELECTRONIC BASICS #24: STEPPER MOTORS AND HOW TO USE THEM

Stepper motors are commonly used for precise positioning, such as in 3D printers. Their structure is explained, focusing on hybrid synchronous stepper motors with rotor magnets and stator coils. The motor moves in discrete steps, controlled by alternating magnetic fields.

Different driving methods are demonstrated:

- **Wave Driving:** Activates one coil at a time, offering basic functionality.

- **Full-Step Driving:** Uses both coils simultaneously, increasing torque.

- **Half-Step Driving:** Combines the previous methods, doubling the resolution.

- **Micro-Stepping:** Adjusts current flow smoothly, reducing vibration and noise.

A homemade driver circuit using MOSFETs and an Arduino is tested, showing the mechanics of stepper motor control. The A4988 stepper motor driver is introduced, improving efficiency by providing variable current regulation. A 555 timer generates step pulses to drive the motor. The advantages of stepper motors, including their holding torque and precision, make them suitable for robotics and automation.

ELECTRONIC BASICS #25: SERVOS AND HOW TO USE THEM

Servos are compact motor systems that integrate a motor, control electronics, and a feedback mechanism, making them easy to use for precise motion control. The video explains their

basic operation, highlighting the three-wire configuration: ground (brown), power (red, typically 4.8V–7.2V), and control (orange, requiring a PWM signal). The PWM signal's pulse width determines the shaft position, allowing rotation within a 180-degree range.

Inside a typical servo, gears reduce motor speed while increasing torque. A built-in potentiometer provides position feedback, enabling the control circuit to adjust movement accurately. A simple Arduino setup is demonstrated to generate the necessary control signals, showing how a potentiometer can be used to fine-tune positioning.

Alternative control methods without a microcontroller are explored, including a 555 timer circuit for generating a PWM signal. The video also explains modifying a servo for continuous rotation by removing internal position constraints and adjusting the feedback mechanism. Finally, stronger servo models with metal gears and enhanced torque capabilities are introduced, highlighting their advantages in high-power applications.

ELECTRONIC BASICS #26: 555 TIMER IC

The 555 timer IC is one of the most widely used integrated circuits in electronics. Its internal structure consists of voltage dividers, comparators, a flip-flop, and a discharge transistor. Three main configurations are explained:

- **Monostable Mode:** A push-button triggers a temporary high output. A capacitor charges through a resistor, and once it reaches 2/3 of the supply voltage, the output resets. This setup is useful for delays and timing applications.

- **Bistable Mode:** Two stable states are created using the trigger and reset pins. Pressing one button sets the output high, while pressing another resets it low, making it suitable for toggle switches.

- **Astable Mode:** Continuous oscillation is generated, creating a square wave. The charging and discharging cycles are controlled by resistors and a capacitor. By adding diodes and a potentiometer, the duty cycle can be adjusted for PWM applications.

The limitations of the NE555 timer are discussed, particularly its inability to produce a precise 50% duty cycle due to transistor voltage drops. The CMOS-based TLC555 is introduced as a better alternative, offering lower power consumption and improved frequency performance.

ELECTRONIC BASICS #27: ADC (ANALOG TO DIGITAL CONVERTER)

Analog to Digital Converters (ADCs) are essential for transforming analog signals into digital values. The video explains key specifications such as sampling rate and resolution, demonstrating their effects on accuracy. The Nyquist-Shannon theorem is introduced to optimize sampling frequency, ensuring correct signal reconstruction. Successive approximation ADCs, commonly used in microcontrollers, are explored through practical examples. The process involves sampling a voltage, comparing it against a reference, and refining the digital output step by step.

An alternative ADC type, the flash ADC, is explained for DIY applications. It operates using multiple comparators to

generate a quick digital output. Though extremely fast, its resolution is limited due to the large number of required components. The final section discusses integrating a dedicated ADC chip with Arduino, following datasheet guidelines for proper configuration. These concepts provide a foundation for understanding ADC principles and their importance in electronics.

ELECTRONIC BASICS #28: IGBT AND WHEN TO USE THEM

Insulated Gate Bipolar Transistors (IGBTs) are compared to MOSFETs, focusing on their switching speed, efficiency, and power handling capabilities. IGBTs combine characteristics of bipolar junction transistors and MOSFETs, offering high voltage tolerance but slower switching times. Their structure and operation are examined through practical demonstrations, including a test circuit controlling a lamp.

IGBTs are shown to maintain conduction due to gate charge retention, requiring a pulldown resistor or driver IC to manage switching. A comparison of energy losses highlights that MOSFETs dissipate significantly less power at lower currents, while IGBTs become advantageous at high voltage and current levels. Applications in power electronics, including Tesla coil drivers, are discussed, emphasizing the importance of selecting the appropriate transistor based on frequency and efficiency requirements.

ELECTRONIC BASICS #29: SOLAR PANEL & CHARGE CONTROLLER

The operation of solar panels and methods for optimizing their power output are explored. Solar cells generate voltage when exposed to light, with multiple cells connected in series to increase the total voltage. The impact of shading is demonstrated, showing how partial blockage significantly reduces power efficiency. Bypass diodes are introduced to mitigate this issue by allowing current to bypass shaded cells, improving performance in larger panels.

Charge controllers are explained as essential components for battery charging. Maximum Power Point Tracking (MPPT) controllers adjust load resistance to maintain optimal efficiency, while Pulse Width Modulation (PWM) controllers offer a simpler but less effective approach. The importance of considering real-world conditions, such as temperature and sunlight intensity, is highlighted. Practical tests measure voltage, current, and power output under different loads, emphasizing the necessity of proper panel placement and electrical optimization.

ELECTRONIC BASICS #30: MICROCONTROLLER (ARDUINO) TIMERS

Timers on microcontrollers like the Arduino Uno enable precise event timing and PWM signal generation. The video explains the basics of timer operation, demonstrating how to create accurately timed events for applications like clocks, LED matrices, and frequency generation.

Interrupts are introduced as an efficient method for handling multiple timed events without blocking the main loop. The

functionality of an Arduino timer is explored, showing how prescalers modify timing intervals to achieve specific delays. Comparisons between normal, CTC, and fast PWM modes illustrate different approaches to timing control.

A practical implementation generates PWM signals with adjustable duty cycles and frequencies up to 8 MHz. The importance of understanding timer registers and configurations is emphasized, enabling precise timing adjustments for various electronic projects.