Tasnimul Hassan Rahat

EEE'23,KUET

Video 1-30 notes

Video 1: Multimeter

- The black probe always connects to the com (common socket), the red one should be changed depending on what we are measuring
- The resistance of a resistor must be measured when it disconnected from a circuit, otherwise it may show a wrong reading
- In case of measuring current, it is better to use the 10A socket because the other one can measure up to 500mA only, so if the current is higher than that, the fuse may blow up

Video 2: Dimming LEDs (PWM Signals)

- Dimming LEDs with a potentiometer is a bad idea as it is just a variable resistor and consumes extra energy
- PWM (Pulse Width Modulation) can be used to dim LEDs by controlling average voltage over a duty cycle
- analogWrite(pin number, value) function is used to control the Arduino PWM pins where the pin number must stand for a PWM pin, and the values should be between 0 to 255

inclusive. Here 255 represents 100% duty cycle(5V) and 0 represents 0% duty cycle(0V).

- A potentiometer can be used to control the PWM pins by giving analog input to one of the analog pins of the Arduino.
- The 555 timer chip can also be used instead of an Arduino for PWM signals, it can be used directly if the current required is less than 20mA. When the current demand is higher, a MOSFET is needed to be used with it.

Video 3: Programming an ATtiny + Homemade Arduino shield

- For controlling an LED strip, it is sufficient to use ATtiny instead of an Arduino as it is cheaper and has more than enough I/O pins
- ATtiny has 5 I/O pins, pin 0 and pin 1 are PWM pins and pins 2,3 and 4 are analog input pins
- Pin 1 of the IC is reset, the remaining 2 pins are VCC and GND pins

Video 4: Bluetooth+Arduino+Android

- Arduino uses 5V logic while the HC-05 Bluetooth module uses 3.3V logic. The Arduino can handle the 3.3V signal in the RX pin from the TX pin of the module, but the module may get damaged when the Arduino sends 5V signal from its TX pin to the Module's RX pin

Video 5: How to multiplex

- The number of I/O pins in an Arduino is not sufficient to control a lot of LEDs
- An LED matrix can be built by connecting all the cathode(negative) pins in columns and the positive(anode) pins in rows
- A normal LED matrix fails when someone wants to light up A1 and E5 simultaneously, it also lights up A5 and E1.
- To solve this, multiplexing is used, we light up each row one after the other so fast that our eyes don't notice.

Video 6: Standalone Arduino Circuit

- The atmega328p controller can be independently used without the full Arduino board, it makes it usable for compact projects but at the same time takes many safety features away.

Video 7: Segment Display

- A one-digit display has eight individual LEDs, these are connected by a common anode
- The bars are marked from A to G and the dot is marked as DP

- 2.1 volts should be used while checking individual LEDs instead of 5 volts
- Without a microcontroller, the numbers can be showed using BCD to seven-segment display driver
- The 4 inputs can be controlled by a 4-bit binary counter
- For tracking time, a 4-digit display can be used

Video 8: Everything about LEDs and current limiting resistors

- LEDs generally work at 3.2V. Connecting them in high voltage can instantly cause it to burn
- Best way to use LEDs is in constant current(20mA) mode and not in constant voltage mode.

Video 9: Diodes and Bridge Rectifiers

- Diodes can prevent reverse flow of current
- Diodes cause a voltage drop across them which means energy gets wasted through them
- It can be used as safety measure where reverse polarity connection can cause an issue
- It can also turn AC into DC
- A bridge rectifier can do the job of turning AC to DC better where 4 diodes are needed, here the current flows in the same direction regardless of the phase of the AC wave

Video 10: Digital to Analog Converter (DAC)

- In case of 8-bit R 2R DAC, 8-bit means there are 256 values of voltages between 0V and 4.8V
- It works on the fundamentals of voltage divider rule
- Arduino has a similar feature called analogWrite() function
- LC low pass filter can turn it into an ADC

Video 11: Sending SMS with Arduino || TC 35 GSM Module

- TC 35 GSM Module can be used to send SMS using an Arduino
- It is better to first put the SIM card in a phone and remove the SIM lock (if it is locked using a PIN)
- The MAX232 IC in the module cannot withstand more than 6 volts. So, if we want to use the module at a higher voltage and we do not need to use the RS232 port, we can remove it and use the module as usual.
- The module runs at 3.3 volts using a voltage regulator
- Though the module runs at 3.3 volts, it can withstand the 5V signal from the Arduino

Video 12: Coils / Inductors (Part 1) (DC)

- A current carrying conductor has a magnetic field around it. The higher the value of the current, the stronger the magnetic field around it
- But there is a limit to the value of the current, otherwise the conductor may get burnt
- We induce a voltage if the conductor moves inside the magnetic field (Like AC motor and DC motor) or the magnetic field changes its intensity
- The magnetic field of a plain wire is very weak, that is why we wind up the wire to increase the power of the magnetic field, we further use a ferromagnetic core like iron to enhance the power of the magnetic field
- This property is represented with the value inductance(L); the unit of which is Henry(H)
- Boost converters use this property to provide higher voltage from a lower voltage source

Video 13: Coils / Inductors (Part 2) (AC)

- Inductor coils try to prevent current flow like resistors, this property is called inductive reactance, unlike normal resistors, the energy turns into magnetic field of the coil which builds and collapses
- In this case, the power oscillates between the load and the source, which strains the power grid. It is called reactive power
- The higher the frequency, the higher the reactance
- It can be used to make frequency filter (RL filter)
- An ideal inductor can cause a phase shift of 90 degrees where the current lags voltage

Video 14: Capacitors

- Capacitors can store and supply energy like batteries, but for a very small duration
- It stores energy in the form of electric field, the higher the capacitance, the more energy it can store
- Bringing the plates closer to each other without touching or increasing the size of the plates can increase the capacitance of a capacitor
- Putting dielectric material in between the plates of a capacitor can increase its capacitance
- Electrolytic capacitors have a fixed polarity and maximum voltage limit. Connecting them in a reverse polarity or exceeding the voltage limit can ruin the capacitors
- Capacitors can be used to maintain a fixed voltage at the output of a power supply or to decouple a IC
- We can use resistors with capacitors to charge them up in a specific time
- Similar to inductors, capacitors also create reactance called inductive reactance
- The value of frequency is inversely proportional to the value of capacitive reactance
- These can be used to build frequency filters (RC filters)
- It causes a phase shift between voltage and current (Ideally 90 degrees) where current leads voltage

Video 15: Temperature Measurement (Part 1) || NTC, PT100, Wheatstone Bridge

- NTC (Negative Thermal Co-efficient) resistors decrease their resistance when the temperature increases
- PT100 is an industrial classic which has a resistance of 100 Ohms at 0 degree Celsius temperature. The resistance increases when the temperature decreases
- The analog pin of the Arduino is used to measure the value of the changing resistance through the value of the voltage with the help of a Wheatstone Bridge
- LM35 can be also used to measure temperature from 2 degrees up to 150 degrees

Video 16: Resistors

- Resistors are used in series with an LED to avoid excessive current flow which damages the LED
- For high power components, normal resistors do not work; Power resistors are instead used in this case
- Two resistors in series can be used as a voltage divider, though the voltage value will not exceed that of the power source
- Pull up or pull down resistors are used to maintain logic levels in Arduino

- Resistors do not cause any phase shifts in current and voltage in AC.

Video 17: Oscillators || RC, LC, Crystal

- An oscillator is an electronic circuit that generates a periodic waveform (sine, square etc) without requiring an external input signal.
- RC oscillators utilize resistors and capacitors to create phase shifts, commonly in configurations like the RC phase shift oscillator
- LC oscillators use inductors and capacitors to form a resonant (tank) circuit that determines the oscillation frequency.

Video 18: DC & Brushless DC Motor + ESC

- In case of brushed DC motor, there are a metal casing, two permanent magnets(stators), rotor and carbon brushes
- In the rotor, there are coils and commutators
- On the other hand, BLDC motors have four permanent magnets with alternating polarities in the rotor
- The coils are in stators which use the metal body as a heat sink to increase longevity
- Lower RPM of a brushless motor can cause higher torque

Video 19: I2C and how to use it

- I2C is a two-wire protocol
- It helps a master device like an Arduino nano to talk up to 112 slave devices to either tell them to what to do or receive data from them which they acquired
- TEA5767 is an FM Radio IC

Video 20: Thyristor, Triac || Phase Angle Control

- Thyristor is like controllable diode
- A thyristor has four layers and adds an additional gate terminal. Example: TYN604
- A thyristor usually stays in its conductive state even when the gate voltage disconnects
- Two thyristors in an inverse parallel configuration is called a Triac
- In order to operate triac properly, we need microcontroller support

Video 21: OpAmp (Operational Amplifier)

- LM358 is a dual OpAmp IC
- For a microphone amplifier, inverting OpAmp is used

Video 22: Transistor (BJT) as a Switch

- Bipolar Junction Transistor (BJT) comes in two types; NPN PNP type
- These can be used as switches and amplifiers
- A BJT's collector current is the product of its base current and Beta
- PNP transistor is more suitable for switching purposes than NPN transistor
- In case of a bigger load, there is a big energy loss in collector-emitter path

Video 23: Transistor (MOSFET) as a Switch

- In case of switching purpose, MOSFETs are more efficient than BJTs
- There are two types of MOSFETS; N-channel type and P-channel type
- N-channel MOSFETs like IRLZ44N are more common
- IRLZ44N has three pins; Gate, drain and source

Video 24: Stepper Motors and how to use them

- The removable rotor of a stepper motor has 4 permanent magnets with alternating polarity
- It has eight physically separated coils (basically two coils which are spread out
- These can be precisely controlled and suitable for 3D printers

Video 25: Servos and how to use them

- Servos have 3 pins; GND, VCC and control pin
- It needs a PWM signal in control pin with 20ms periodic time and a duty cycle of 1ms-2ms
- We can rotate the shaft of a servo motor to 180 degrees
- It has a KC5188 IC

Video 26: 555 Timer IC

- *Connecting the reset pin to ground resets the IC*
- *Pin 1 and Pin 8 of the IC is connected with 3 5kiloOhm resistors in series (Hance the name 555)*
- *These resistors work as voltage dividers*
- *Pin 2 is a trigger pin*
- *The IC can be used to generate PWM signals*

Video 27: ADC (Analog to Digital Converter)

- Analog pins of an Arduino can convert input analog signal in 10-bit digital signal
- Using a higher resolution will make the reconstruction of the sample function more precise
- Flash ADC is more appropriate for DIY

Video 28: IGBT and when to use them

- Full form- Insulated Gate Bipolar Transistor
- Like MOSFETs, there are N-channel IGBT ad P-channel IGBT
- P-channel ones are inferior characteristics, they are rarely used
- Simplified equivalent circuit of a IGBT contains a N-channel MOSFET with PNP transistor
- It can also be used for switching purposes
- Switching speed of MOSFET is faster than IGBT
- IGBT comparatively has more loss at low current
- Better for high voltage, high current, and medium frequency (<200 kHz) applications despite higher voltage drop.
- IGBTs are viable for Tesla coils due to their high current and voltage handling, but not ideal for high-frequency applications.

Video 29: Solar Panel & Charge Controller

- Solar panels convert sunlight into electricity. They can power small or large loads depending on their size. To maximize output, proper wiring and configuration (e.g., for battery charging) are crucial.

- A solar panel consists of individual solar cells (~0.5V each). To achieve usable voltage, many cells (e.g., 36 for 14.3V in a 100W panel) are connected in series. DIY cell assembly is fragile and less reliable than pre-made panels.

- Series connections are sensitive to partial shading. Covering just a few cells drastically reduces power output due to increased resistance, even if only a small portion is shaded.

- Bypass diodes can mitigate power loss from partial shading by allowing current to bypass shaded cells. These are typically integrated into commercial panels.

- Blocking diodes are used when panels are wired in parallel to prevent reverse current. Ideal test conditions (STC) are rarely met in practice, so actual panel output is usually less than rated.

- Different loads draw different voltages and currents. Solar cell behavior can be modeled with an equivalent circuit (current source, diodes, and resistors), showing how load impacts output.

- Using a power logger, the presenter identifies the maximum power point (MPP)—the optimal

voltage/current combination for maximum output. For his setup: ~4.4V, 4mA, 1100Ω.

- To efficiently charge batteries, MPPT (Maximum Power Point Tracking) charge controllers are preferred. They adjust input resistance to stay at MPP. PWM controllers are cheaper but can be up to 40% less efficient.

Video 30: Microcontroller (Arduino) Timers

- The ATMEGA328P IC of an Arduino features timers