Class - 01) The Multimeter

A multimeter is capable of measuring important parameters like voltage, resistance, current etc. It's easy to use and the price for a simple one is affordable.
It has probes.

Resistance measuring:

1) 1st select the ohm sign(Ω).
2) Stick probes into right sockets.
   - Black probes always connects to the common (COM) socket.
   - The red probes must only changed if you measure current.
3) Now measure resistance connecting one probe to one side of the resistor and other probe to other side of the resistor.
4) But, measuring resistance in a built circuit is not easy.

Right next to the ohm sign(Ω) there is another feature, the continuity (•))). The meter will beep when there is almost zero resistance between two probes. It's great for checking cable breaks. If the cable is broken, it will not beep.

Voltage measuring:

- Connect red probe to pos side & black to negative side (parallel)

Current measuring:

- Move the red probe to 10A (max) socket.
- Connect probes to the opening point of the circuit so the current of the circuit will also flow through multimeter (series).
- Higher current can break the fuse. In that case replace it.
- For measuring current in mA/μA unit, connect red probe to mA/μA socket instead of 10A.

Summary:

- How to use a multimeter to measure voltage, resistance, current and continuity was demonstrated.
- We learnt to change fuse.
- We learnt to check for cable breaks using multimeter.

Class-02 : Dimming all kinds of LEDs!?

We can control the brightness of LEDs using PWM (Pulse Width Modulation).

- By lowering the voltage LED can be dimmed.
- Use of potentiometer in series with LED can do so.
  - ↳ is just a variable resistance.
- But in case of high power LEDs, potentiometer get heats up and explodes.

Use of PWM:

- Switching between 5v and 0v. So the LED turn on and off really fast that we can't see with our eyes. The duty cycle describes the on time in one period.

  Lowering the duty cycle, LED got dimmer.

- 50% duty cycle represents 2.5 v.
  20% duty cycle represents 1 v. (20% ON 80% OFF)

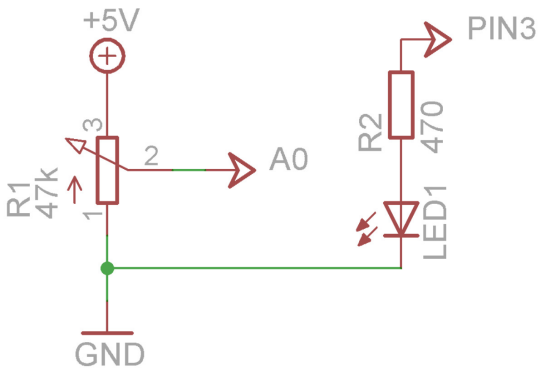
To create this PWM square signal, we use arduino code.

```
ArduinoPWMGreatScott_§
int ledpin=3;
int potentiometer=A0;
int potentiometervalue;

void setup() {
pinMode(ledpin, OUTPUT);
pinMode(potentiometervalue, INPUT);
}

void loop() {
potentiometervalue=analogRead(potentiometer);
potentiometervalue=map(potentiometervalue,0,1023,0,255);
analogWrite(ledpin, potentiometervalue);
}
```

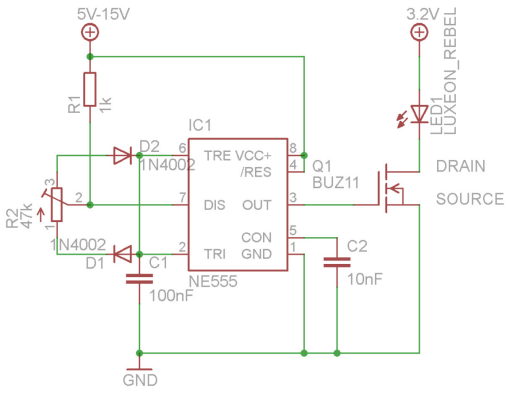
0v 5v

100 ≃ 1.95v

We are using potentiometer for analog input for controlling the value of analogwrite func.



Arduino Schematic



NE555 Schematic

? ↳ IC

Key Concepts:

Modulation

1) **Modulation:** Signal modulation is the process of varying one or more properties of a periodic waveform in electronics and telecommunication for the purpose of transmitting information.

2) **Duty Cycle:** A duty cycle or power cycle is the fraction of one period in which a signal or system is active.

3) **Square wave:** A square wave is a non-sinusoidal periodic waveform in which the amplitude alternates at a steady frequency between fixed minimum and maximum values.

Summary:

- Lowering voltage can dim LED.
- Potentiometer can be used for controlling brightness of low-power LEDs.
- For high power LEDs, PWM is better.
- We learnt how PWM works.
- We learnt about signal modulation, how to produce square wave and use it to control LED's brightness.

Task: Use potentiometer to control LED's brightness

Class-03: Programming an ATtiny + Homemade Arduino Shield

Key Concept:

SPI

Serial Peripheral Interface (SPI): Serial Peripheral Interface is a de facto standard for synchronus serial communication, used primarily in embedded systems for short-distance wired communication between integrated circuits.

ATTiny Library

ATtiny 85 is a smaller & more affordable microcontroller with 5 IOs & 8kbytes space.

These are pins can be used as forms.

* Need to place a capacitor (10 MF in video) between reset pin and the ground in arduino.

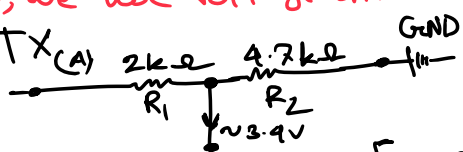
Summary:
- How to install and setup ATtiny Board?
- How to use it?
- We learnt about its pins.

Class-04) Arduino + Bluetooth + Android = Awesome

Bluetooth Transceiver Module → 3.3V logic levels

When Arduino wants to talk to the module

TX(A) —5V→ RX(module)
↳ lots of 5V data will cause the module to stop.
so, we use voltage divider:



[receives 3.4 V & works fine]

TX(module) —3.3V→ RX(A)
↓
Arduino receives 3.3V & it's okay.

Common anode RGB LED: It has one anode & 3 cathodes.
Each cathodes has a resistor of 460Ω.
Connect cathode to pins, anode to 5V

S2 Terminal (App): Use for ASCII convertion.

Arduino Codes → didn't understand (in Github)

Class-05: How to multiplex:

Key Concept:

Mosfet

MOSFET: In electronics, the "Metal-Oxide-Semiconductor Field-Effect Transistor" is a type of field-effect transistor.

Constant Current

Constant Current: A constant current is a type of direct current that does not change its intensity with time.

Sine Wave: A sine wave, sinusoidal wave, or sinusoid is a periodic wave whose waveform is the trigonometric sine function.

- How to control a 4x4x4 RGB LED cube or a 5x10 RGB LED Matrix using
  - Arduino Nano
  - TLC5940 LED driver
  - five P channel MOSFETs (F9540N)
  - 2k Ω(1), 1k Ω(5)

- G to IO
  S to 5V
  D to anode rows
  | Gate
  Source
  Drain

Class-06: Standalone Arduino Circuit:

(Check the schematics)

Key Concept:

Pinout

Pinout: In electronics, a pinout is a cross-reference between the contacts, or pins, of an electrical connector or electronic component, and their functions.

- External Components: 1) 16 MHz Clock Crystal
  2) two 22 PicoFarad Capacitors to generate external clock signals.
  3) 10k Ω resistor (connects btw reset pin of ATmega & 5V)

- Crystal connects to pin 9 and 10 and one capacitor between each pin and gnd.
- Pin 7, 20 & 21 connect to 5 volts and pin 8 and 22 connect to grounds.

-That is basically an Arduin on a breadboard But there are some downsides in comparison to Arduino board like: —No reset switch
—Only 5V input

- No USB to serial conversion
- No short circuit protection
- No over-voltage protection

To change the code:

- Remove ATmega from board and plug it in your Arduino and reprogram it.
- T_x (Arduino) → pin 3 | reset to pin 1
  R_x (") → Pin 2 |
  Make sure, no microcontroller is plugged in.
- Use FTDI chip (USB to serial conversion
  Power it up. Then,
  RX to TX, TX to RX and Reset to Reset.
  Now, you can use Arduino IDE to sketch.
- In-circuit serial programming (ICSP)
  But it's messy and requires special programmer and another software.

Class-07: 7 Segment Display:

Key Concept:

BCD

Binary Coded Decimal: In computing and electronic systems, binary-coded decimal is a class of binary encodings of decimal numbers where each digit is represented by a fixed number of this.

Multiplexing

Multiplexing : In telecommunications and computer networking, multiplexing is a method by which multiple analog or digital signals are combined into one signal over a shared medium.

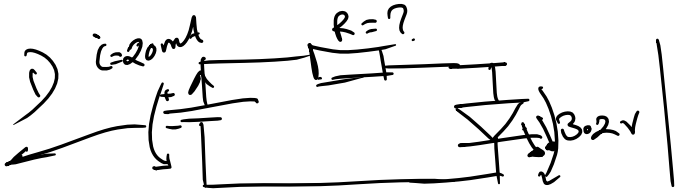
* 4 bit binary Counter → SN74LS290N
  It has BCD count sequence
  (check the schematics)
* Infrared sensor project with this.
* SAA1064 IC (for multiplexing)
* BC337 NPN Transistor
* SAA1064 Library

কিছু বুঝি নাই

Class-08) Everything about LEDs and current limiting resistors:

While buying LEDs – check out for datasheets
– Forward voltage (3.2V) & the current (20mA)

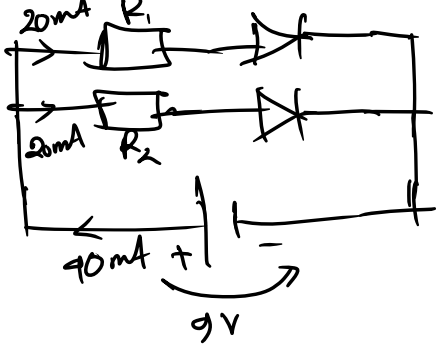
Now, connection:



$V_R = (9 - 3.2)V$
$= 5.8\ V$
$R = \frac{5.8V}{20mA} = 0.29\ k\Omega$

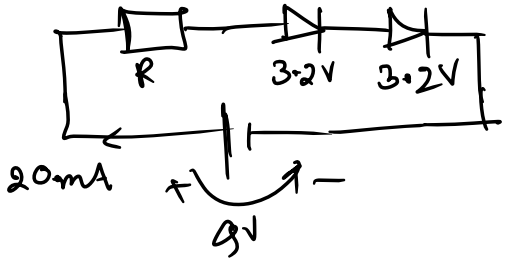
And Resistor has another rating which is power.
So, if we use two resistor of 0.15 kΩ which has power rating of 0.25 watt & the power loss is $5.8 \times 0.02\ W \geq 0.116\ W < 0.25$
So, the resistors will not get burnt.

II)



But it will be a waste of power.

III) Most power efficient way:



$V_R = 9 - (3.2 + 3.2)$
$= 9 - 6.4$ V
$= 2.6$ V

then, $R = (2.6/20)$ kΩ
$= 0.13$ kΩ

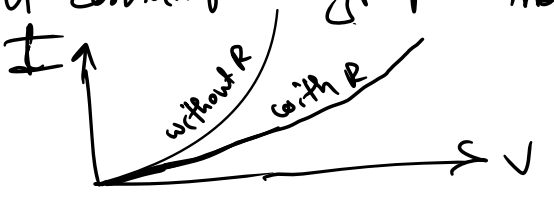
And power loss $= (2.6 \times 0.02)$ W
$= 0.052$ W

which saves 45% power than case (I) and also lights up two LEDs. But we can't put 3 LEDs in series. Cuz there is not enough supply voltage.

But here is the problem: Don't trust the manufacturer(!!!

They said with 3.2V supply voltage it will draw 20mA current. But when we checked it, we saw it drew 33 mA current and for 3V it drew 18 mA

Now, what if we connect 3.3 V LED direct to the supply voltage 3.3V. If it will work fine. But small changes in voltage can destroy the LEDs. Cuz the current consumption graph increases exponentially in this case.



So, try using small resistor to linearize current consumption.

If we work with many LEDs, the best way to drive LEDs is to drive it in constant current mode, not constant voltage mode. Cuz as the voltage differs current consumption varies. The LEDs with less forward voltage will get less current

than others and die sooner.

Key Concept:

Lead Acid Battery

Lead-Acid battery: The lead-acid battery is a type of rechargeable battery first invented in 1859 by french physicist Graston Planté.

Constant Current

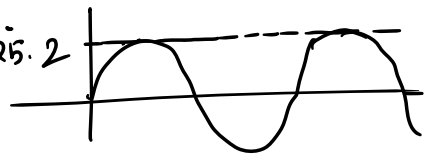
Constant Current: A constant current is a type of direct current that doesn't change its intensity with time.

Class-09: Diodes & Bridge Rectifiers:

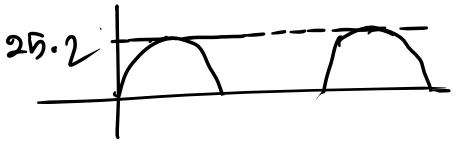
Old Linear power supply and new switching power supply still have them[old had four]. Consumer electronics are consist of them as well. Diode converts AC to DC.

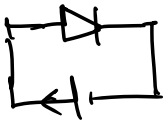
✱ 220 V to 15 V transformers:

Without load we get sine wave with max voltage of 25.6 V. But the rating was 15V. This because the rating is given in RMS value. So, we know, $V_{RMS} = \frac{V_{max}}{\sqrt{2}} \simeq 18.1$ V. This also does not match the rating. Actually after adding a load, the voltage collapses to 15 v(RMS; not max; oscillometer shows max value).



Lets put our diode in series:





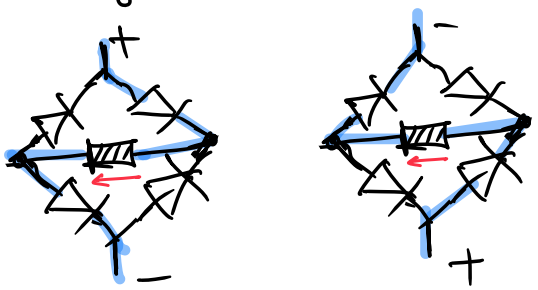
It's DC but still only positive voltage.

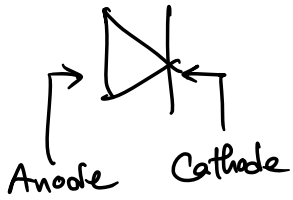
Lets put a capacitor in series with diode and it will produce perfect DC.

But when we draw just a bit of current, it gets bumpy again. It is problematic that the negative waves are gone as capacitor can only be charged with the positive one and then it gets discharged until the next wave comes.

So, to do this we need bridge rectifier.

Bridge Rectifier:





For Both of these polarities output current flow only one way through the load.

Class - 10 : Digital to Analog Converter:

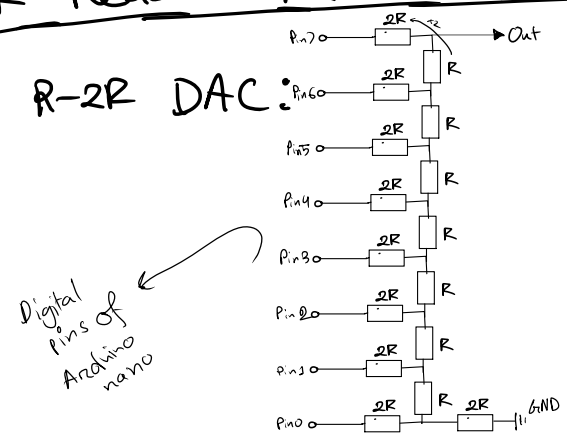
Digital device work on digital logic level (high and low, ON & OFF or 0 & 1).

Digital:

Analog:

R-2R Resistor Ladder method:

8 bit R-2R DAC:



8bit: $2^8 = 256$ (Resolution of the DAC)

sketch_dec04a | Arduino 1.0.5-r2

File Edit Sketch Tools Help

sketch_dec04a §

```
void setup(){
  for (int i=0;i<8;i++){
    pinMode(i, OUTPUT);}}

void loop(){
  PORTD=10000000;}
```

Now, $(10000000)_2 = 128$; which is $\frac{256}{2} = 128$

We get $V_{max} = 2.3\ V$ which is almost half of max input voltage $4.8\ V$. This is not precise due to the tolerance of the resistors

For, PORTD = 200; we get $3.72\ V \rightarrow \frac{4.8\ V}{3.72\ V} = 1.29$

which is same as $\frac{256}{200} = 1.28$

With this knowledge we can easily make ramp function by slowly increasing the port D value up to 255 and then going back to 0.

Or triangle function by 1st increasing the value to 255 and then slowly going back 0.

Ramp8bitladder | Arduino 1.0.5-r2

File Edit Sketch Tools Help

Ramp8bitladder §

```
void setup(){
  for (int i=0;i<8;i++){
    pinMode(i,OUTPUT);}}

void loop(){
  for (int a=0;a<256;a++){
    PORTD = a;
    delayMicroseconds(10);}}
```

Triangle8bitladder

```
int a,b;
void setup(){
  for (int i=0;i<8;i++){
    pinMode(i,OUTPUT);}}

void loop(){
  for (a=0;a<256;a++){
  PORTD=a;
  delayMicroseconds(10);}
  for (b=255;b>=0;b=b-1){
  PORTD=b;
  delayMicroseconds(10);}}
```

We can not connect a speaker directly to the register ladder because then voltage will collapse and change its form completely.

So, we've to use op-Amp, a voltage follower (LM6142 – See datasheet)

---

sketch_dec04a | Arduino 1.0.5-r2

File Edit Sketch Tools Help

sketch_dec04a §

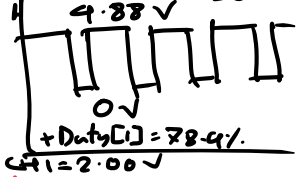
```
int out=9;

void setup(){
  pinMode(out,OUTPUT);}

void loop(){
  analogWrite(out,200);}
```

We know Arduino has a 8bit analogwrite func.

Then, how about using that.

Lets try with value = 200;

We get a PWM signal (Duty cycle = 78.4%)



Now, with duty cycle 78.4%,

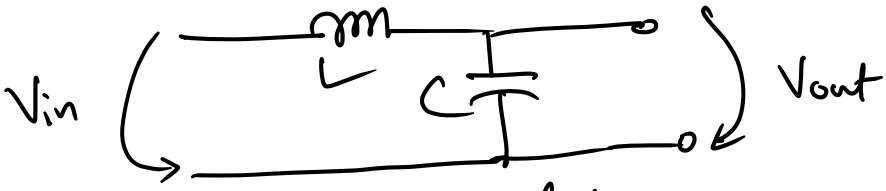
$4.88 \times 78.4\% = 3.8\ V$

which makes sense when we enter 200.

duty cycle 78.4% means 78.4% ON, Rest% OFF

$\frac{200}{256} = 0.782 = 78.2\%$

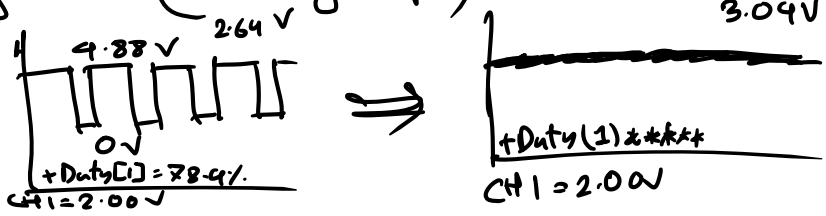
But, the magic ingredient which makes it DAC is,



A LC Low Pass filter

the coil resists sudden change in current and the capacitor resists sudden change in voltage.

Then it makes the bumpy ride (PWM graph) kind of smooth

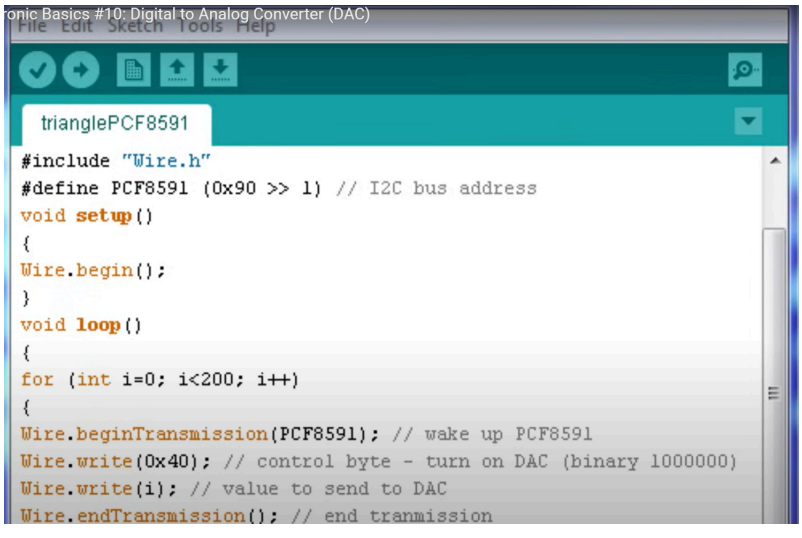


For sine wave we can also use LC filter but this will be not so easy.

→ this is 12 bit DAC and better

Still be easy to use I²C devices (MCP4725 DAC; PCF8591 8bit DAC. They need only two pins of arduino → Serial data and serial clock. which can be pin A4 and A5.

DAC is used for Analog audio and video. Also useful to build frequency generator and auto taste audio filters.



Class-11) Sending SMS with Arduino || TC35 GSM Module

- We can power up the module by DC jack or VCC and gnd pins on the board. Other pins must not be used.
- Use 5V. Cuz Max232 IC in the board which is necessary to communicate with the module through a RS232 DB9 serial converter directly connected to VCC and GND. There's no voltage regulator for it and that IC can endure maximum 6V.
- For using 12V which is possible cuz module use 3.3V from a voltage regulator, you'd have to remove max232 IC before powering it and it'll also save power. So, if we don't use RS232 port we can remove and use 12V.
- The board stands 6 mA in standby mode but it's not ready for action yet.
- Made a system to start login process to the mobile network using arduino for controlling the switch.

* FTDT breakout → TX to TXDO
  RX to RXDO
  GND to GND
  → This is exceptional. They have messed the pin's names.

* Even though TC35 uses 3.3 voltage lev; it is compatible with the 5V signal of FTDI and the arduino.
* Check AT Command Reference.
* Check sketch and schematic.