Automatic Solar Tracker

Group 04

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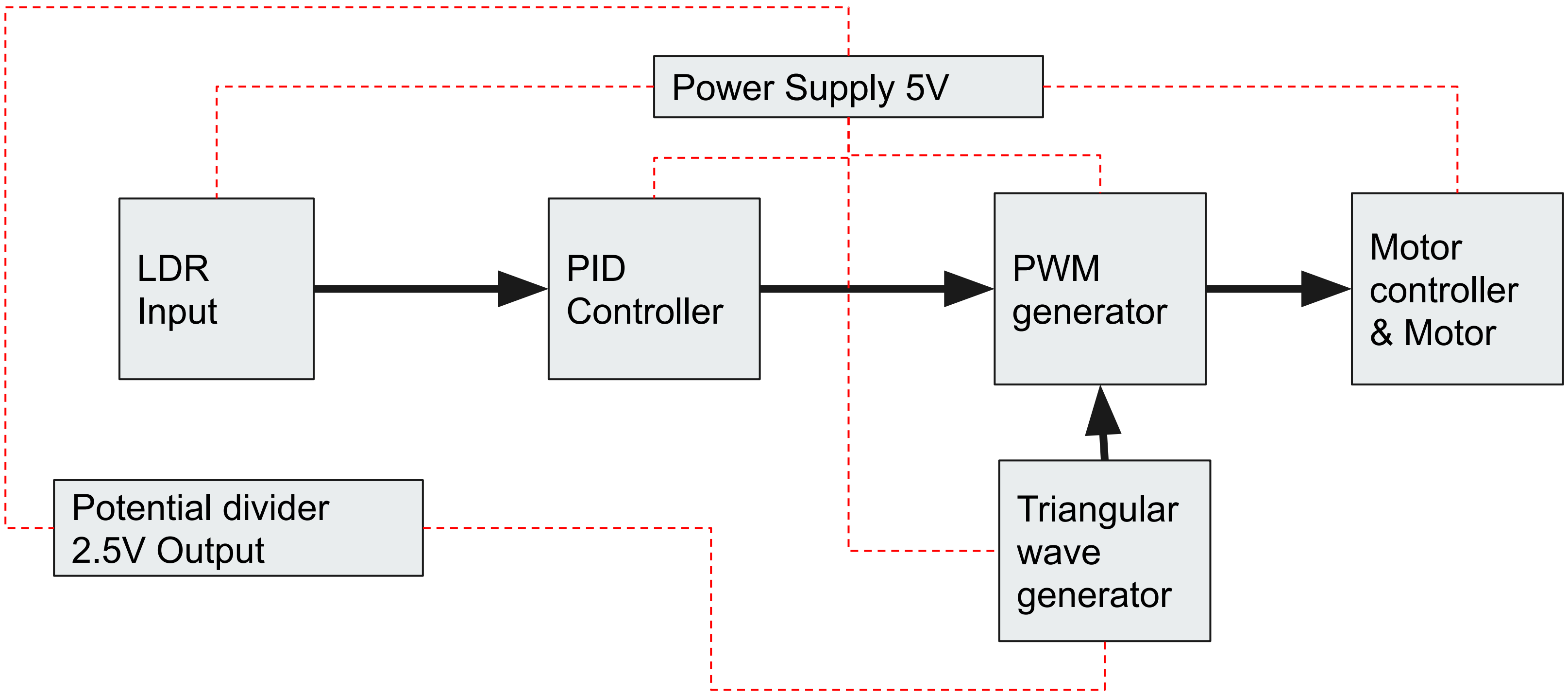
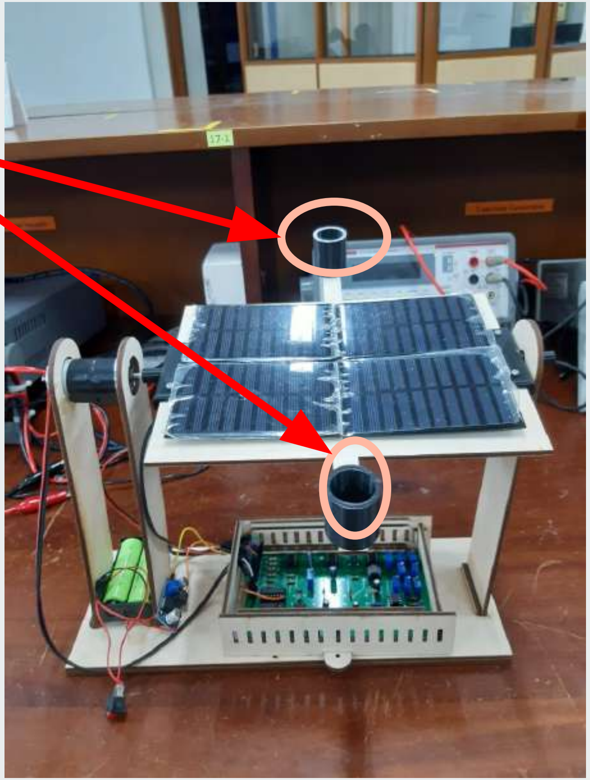
Block Diagram of the Circuit

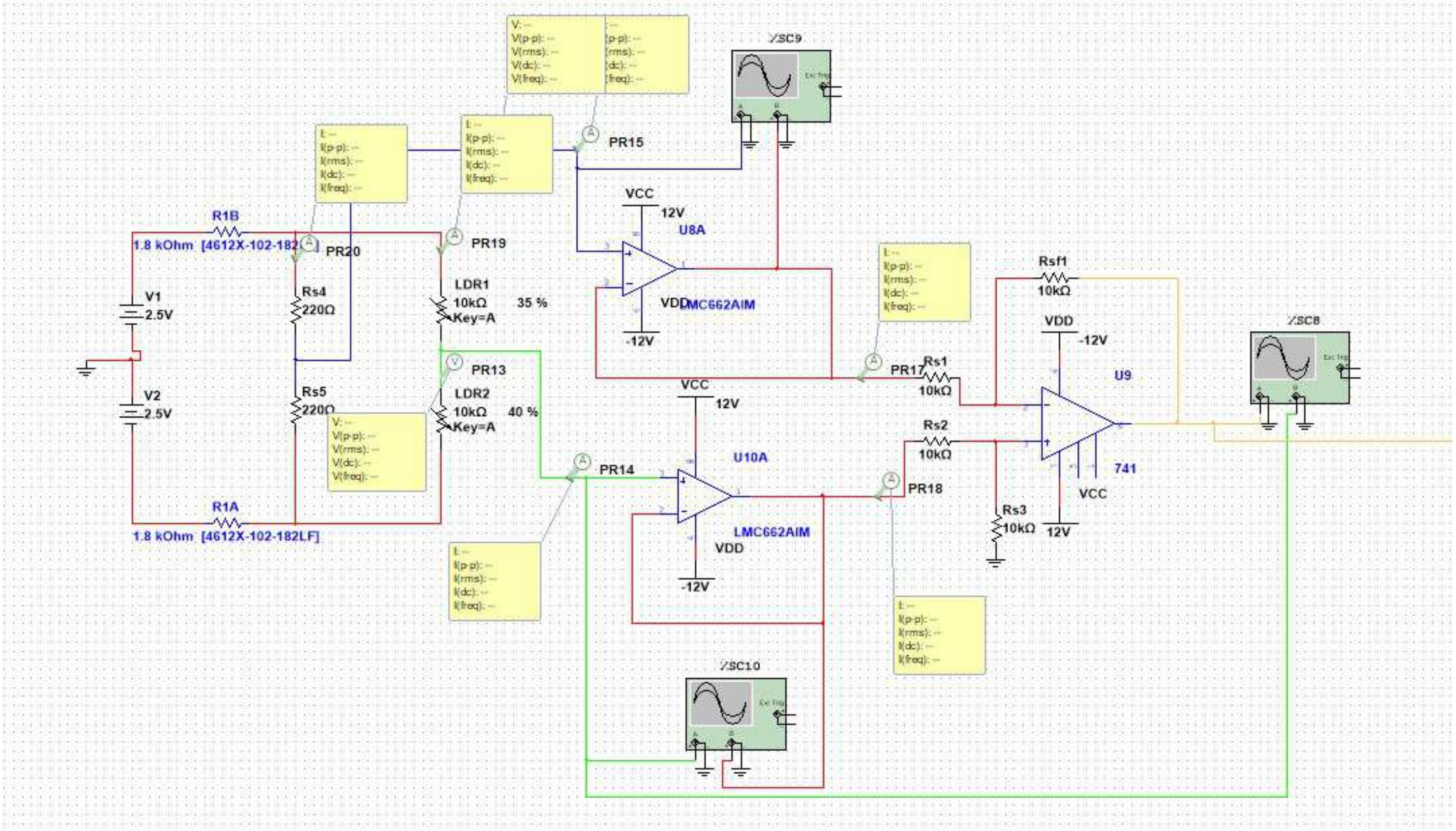


LDR Placement

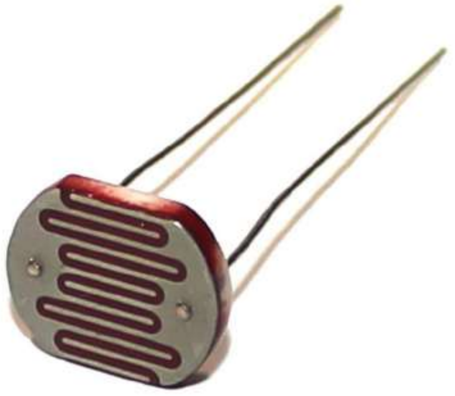
LDR



Feeding Error to the circuit using LDR

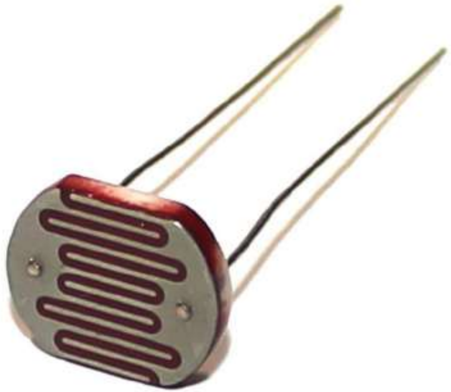


LDR - GL5516 (Choosed)



- High Sensitivity
- Light Resistance (10 Lux) 5-10 KOhm
- Dark Resistance 0.5MOhm
- Fast response
  - Response time 30 ms for both increasing and decreasing
- Working Environmental temperature -30~+70

LDR - Used



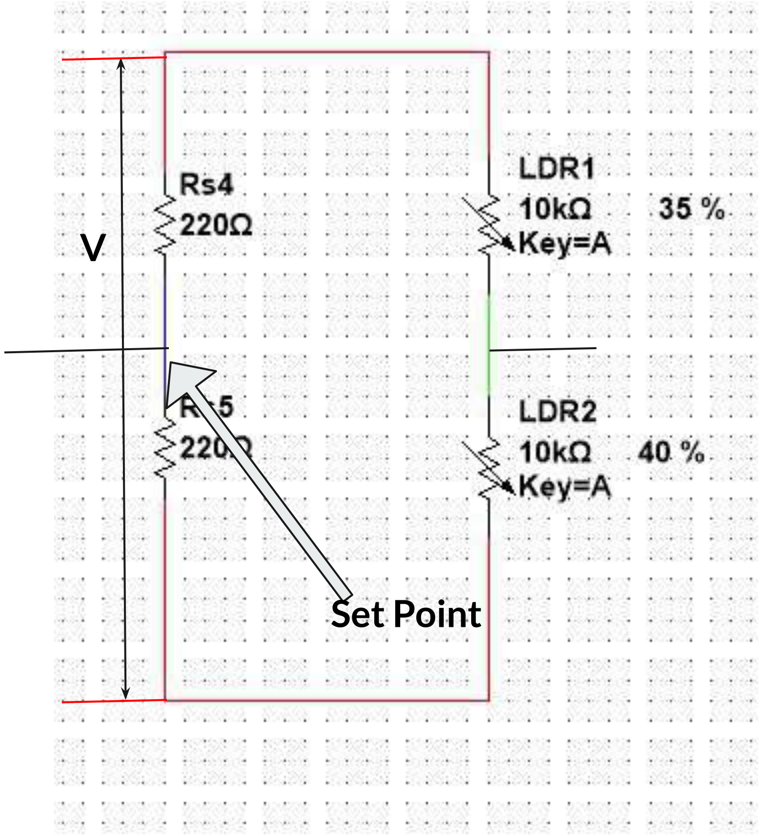
- Size 10mm
- Light Resistance arround 100 Ohm
- Dark Resistance 50-70 KOhm
- At low intensity of light resistance of LDR is arround 4mm

Calculations

Here Set Point is virtual Ground.

$$Error = \frac{V \times \{RLDR1 - RLDR2\}}{2 \times \{RLDR2 + RLDR1\}}$$

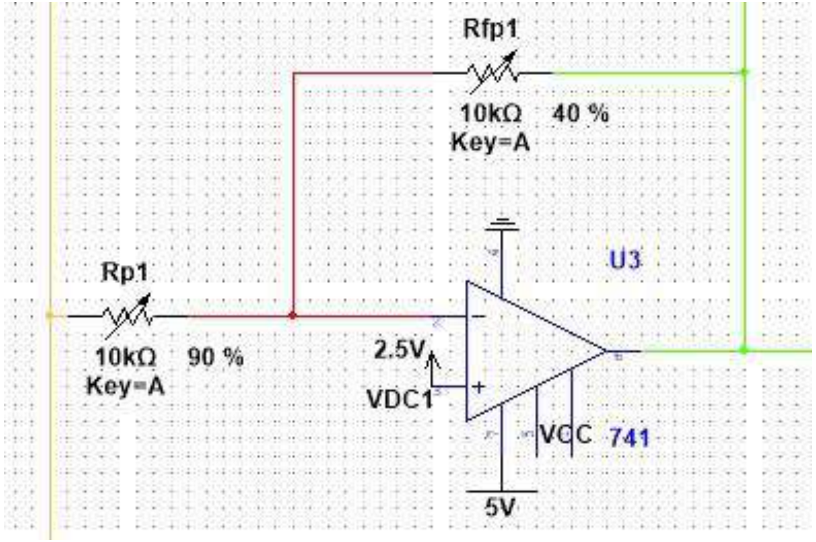
By Using the Differential amplifier Error is feeded To the input of the PID controller.

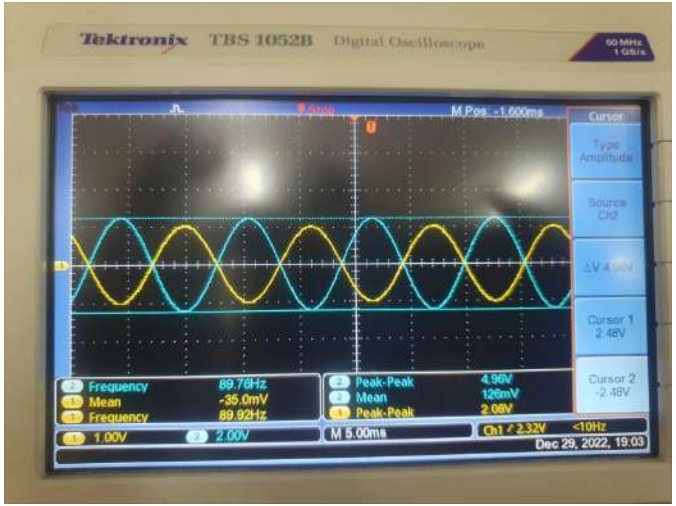


PID Controller

Proportional

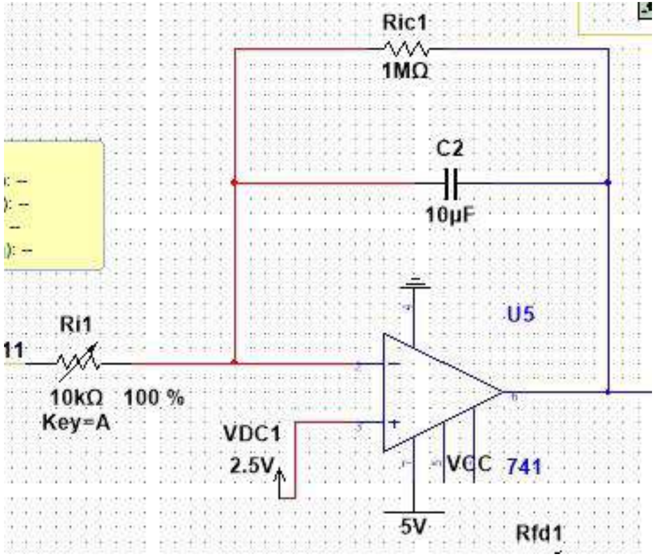
$$V1out = -Verror \times \frac{Rfp1}{Rp1}$$

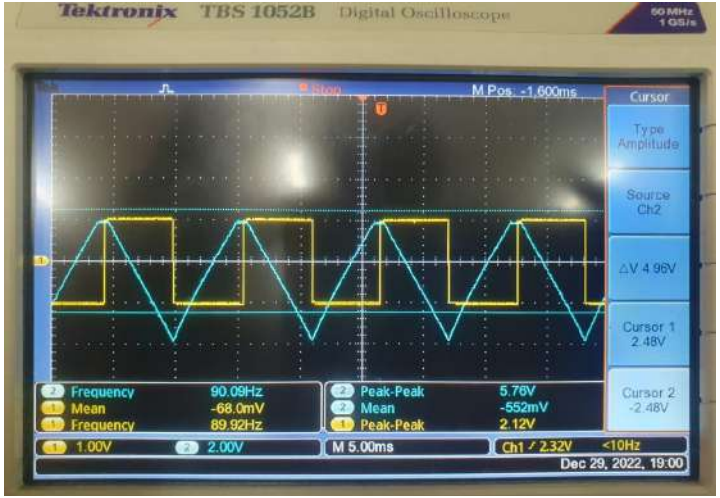




Integral

$$V2_{out} = -\frac{1}{R_{i1}C_{i1}}\int \text{Verror}\, dt$$

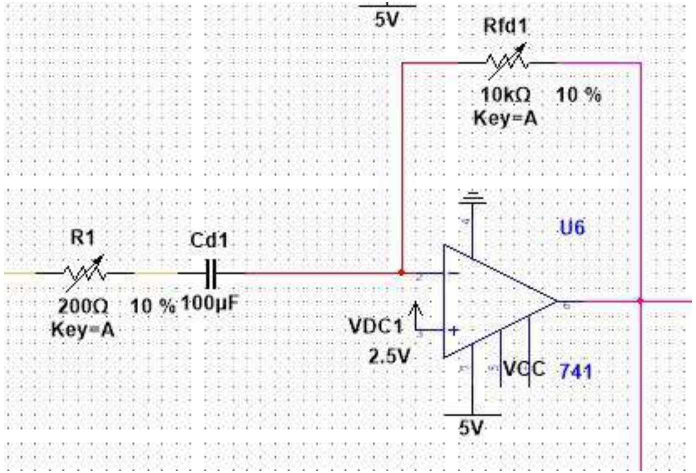


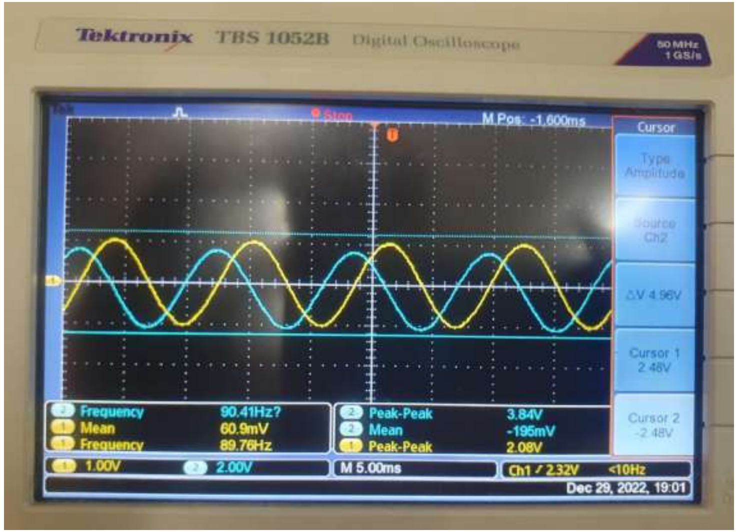


Ric1- Controls the DC voltage gain

Derivative

$$V2_{out} = -R_{fd1}C_{d1}\frac{dV\text{error}}{dt}$$



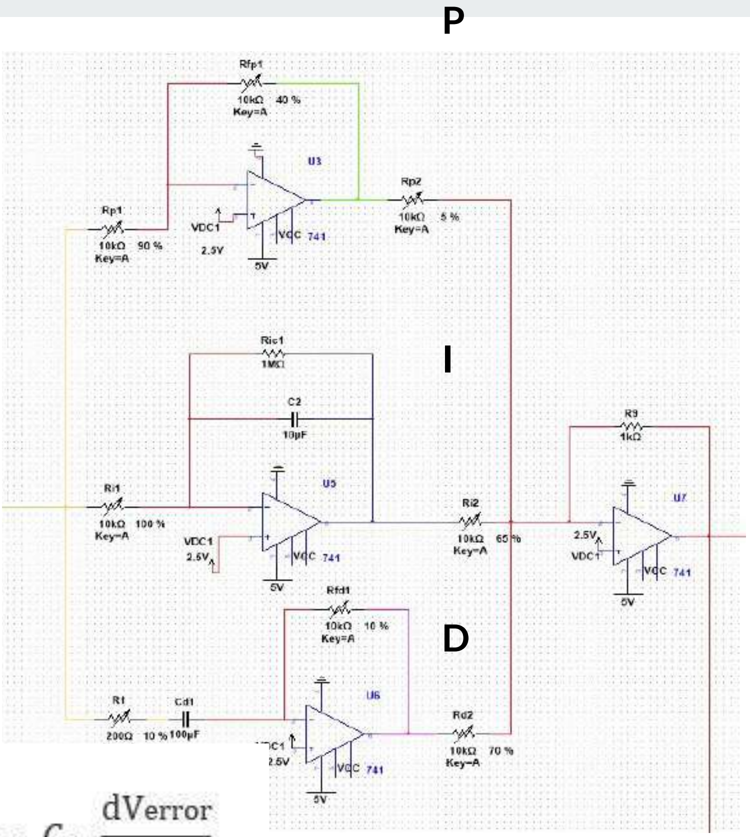


R1- To decrease high frequency gain

PID Output

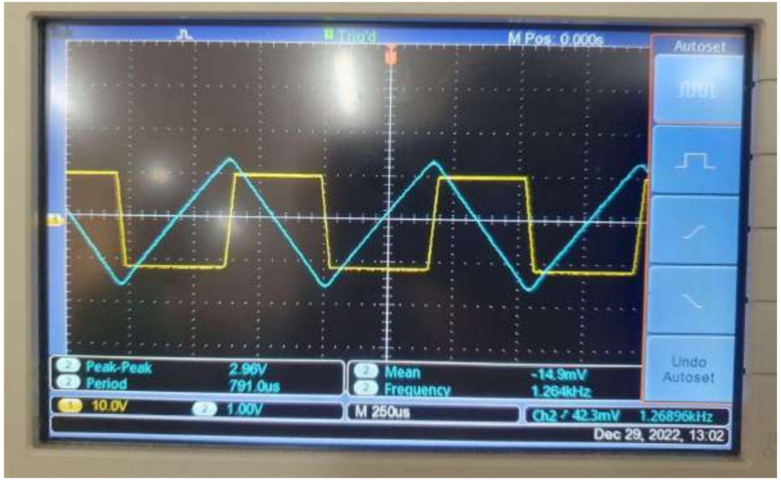
$$V_{out} = -R_9\left(\frac{V1_{out}}{R_{p2}} + \frac{V2_{out}}{R_{i2}} + \frac{V3_{out}}{R_{d2}}\right)$$

$$V_{out} = \frac{R_9}{R_{p2}} \cdot \frac{Rfp1}{Rp1} Verror + \frac{R_9}{R_{i2}} \cdot \frac{1}{R_{i1}C_{i1}} \int Verror\, dt + \frac{R_9}{R_{d2}} \cdot R_{fd1}C_{d1} \frac{dVerror}{dt}$$



Generating the triangular waveform.

To produce the PWM signal, we compare the output of the PID circuit with a triangular wave. In producing the triangular wave, we first generate a square wave and then use an integrator circuit to get the triangular waveform.



The first part of this circuit is the schmitt trigger circuit, then comes the integrator circuit. The schmitt trigger circuit is basically a comparator circuit. When the non inverting input rises or falls about the inverting input, the output of the schmitt trigger will be the two saturated supply voltages. This output is applied to the integrator circuit and it integrates this voltage for a finite time. The output of the integrator circuit is fed back as input into the schmitt trigger.

Suppose initially output of schmitt trigger is +Vs. This is integrated by the integrator circuit and fed into the schmitt trigger input and when this integrated voltage crosses the lower threshold value, the output of the schmitt trigger will shift from +Vs to -Vs. Now the integrator will integrate –Vs and its value is fed into the schmitt trigger. When this crosses the upper threshold voltage, the output will again shift to +Vs.

Here the resulting triangular waveform will be symmetric .

V+ depends on both V1 and Vx.

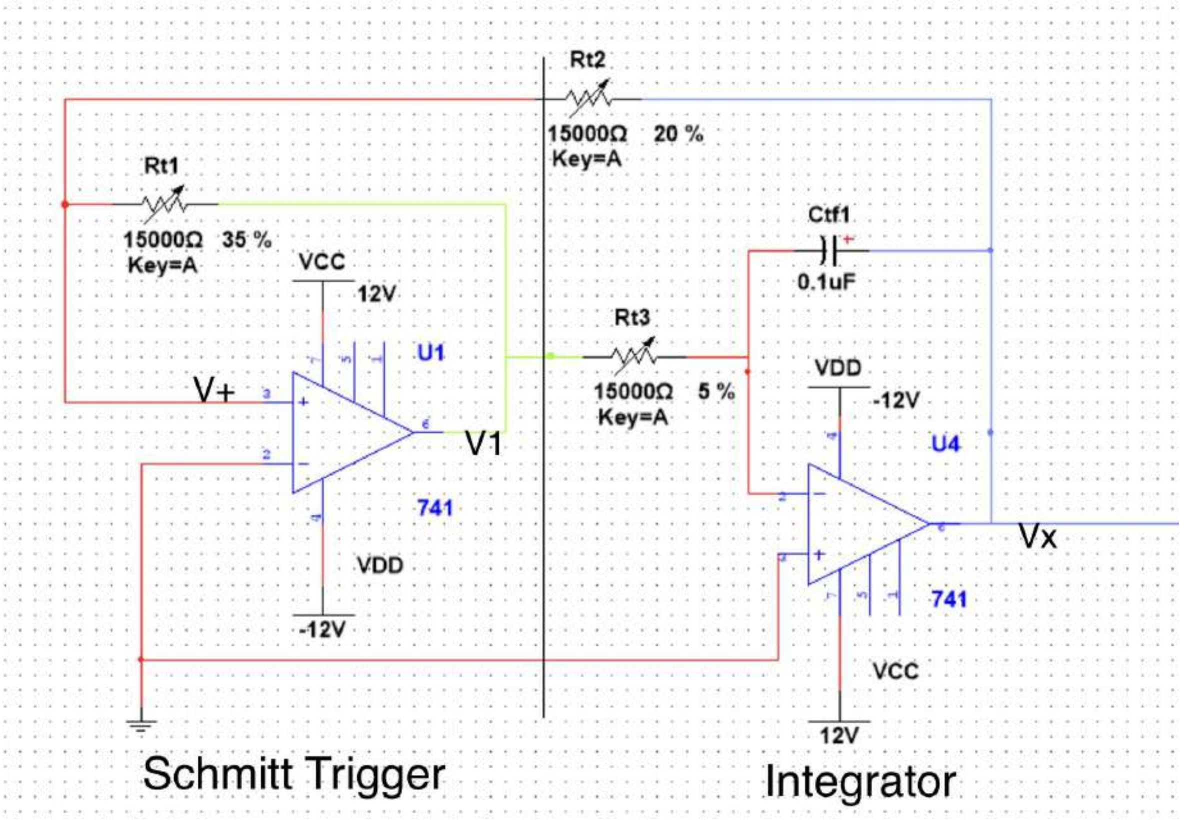
By principle of superposition,

$$V_+ = \frac{R_1}{R_1+R_2}V_x + \frac{R_2}{R_1+R_2}V_1$$

The upper and lower threshold voltages,

$$V_{x_2} = \frac{R_1+R_2}{R1}V_{ref} + \frac{R_2}{R_1}V_{sat}$$

$$V_{x_1} = \frac{R_1+R_2}{R1}V_{ref} - \frac{R_2}{R_1}V_{sat}$$



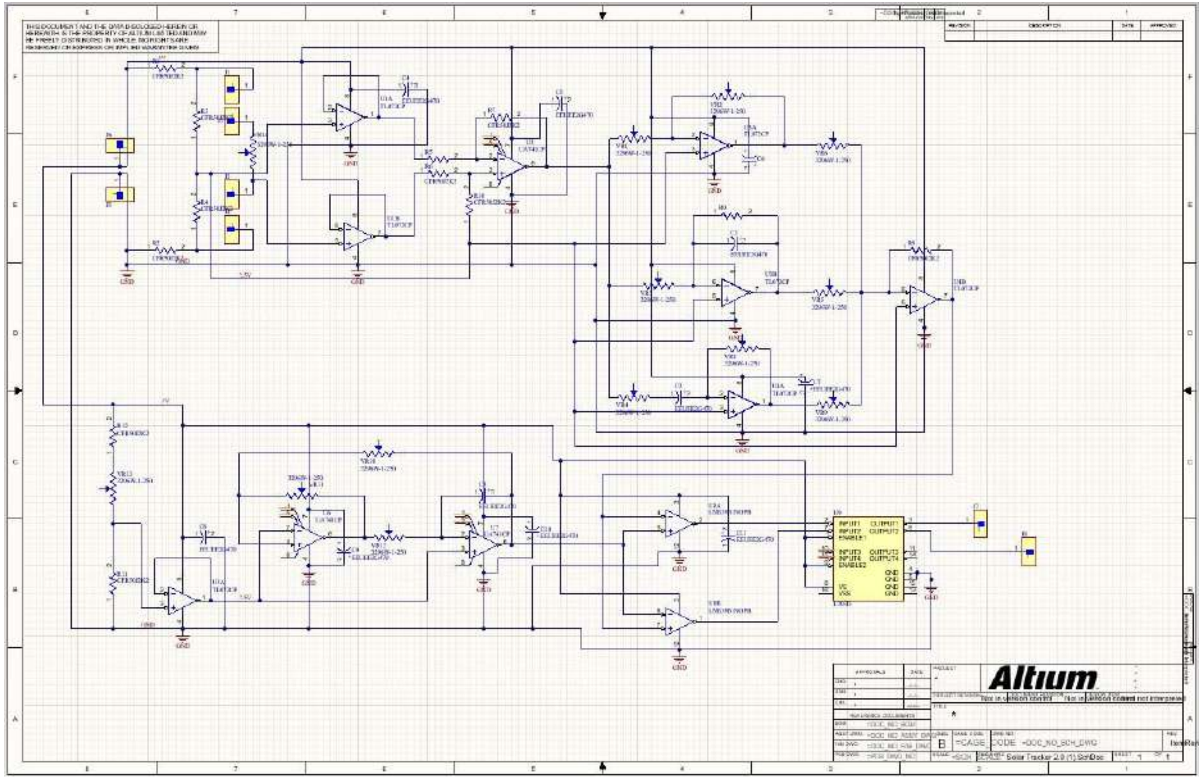
The peak to peak voltage of triangular waveform,

$$V_{p-p} = 2\frac{R_2}{R_1}V_{sat}$$

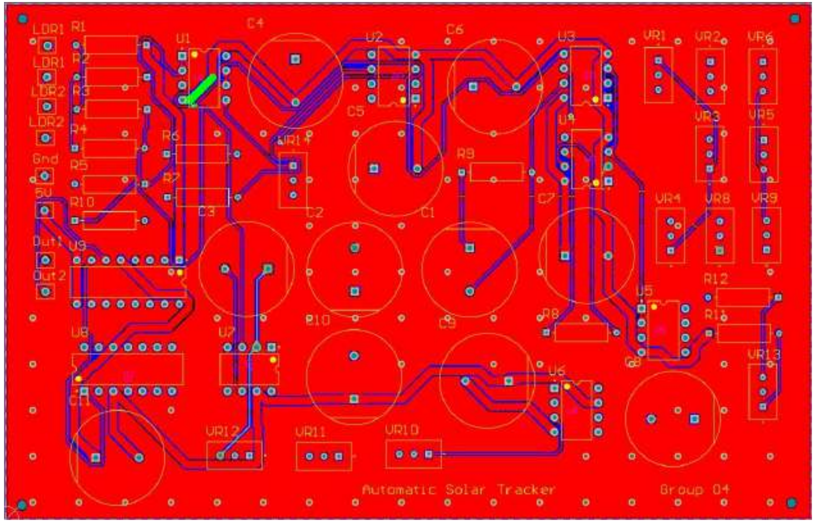
The frequency of the triangular wave is given by,

$$f = \frac{R_1}{4R_2R_3C}$$

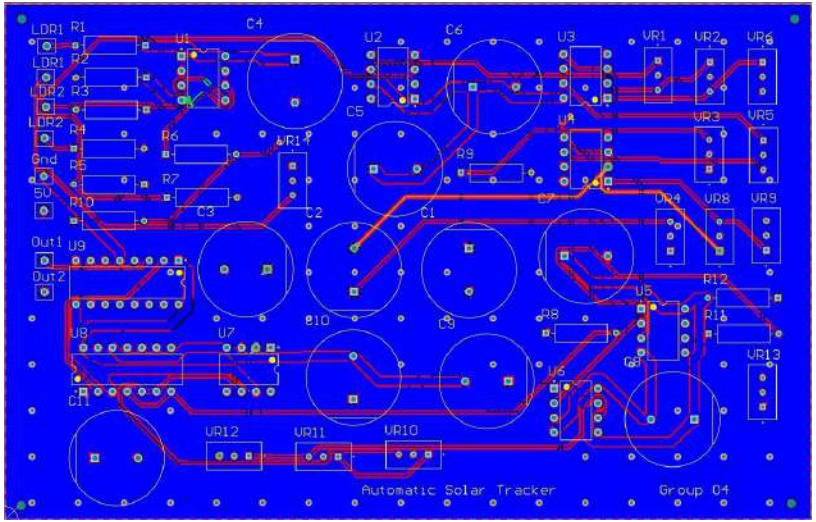
Schematic Diagram



PCB Design

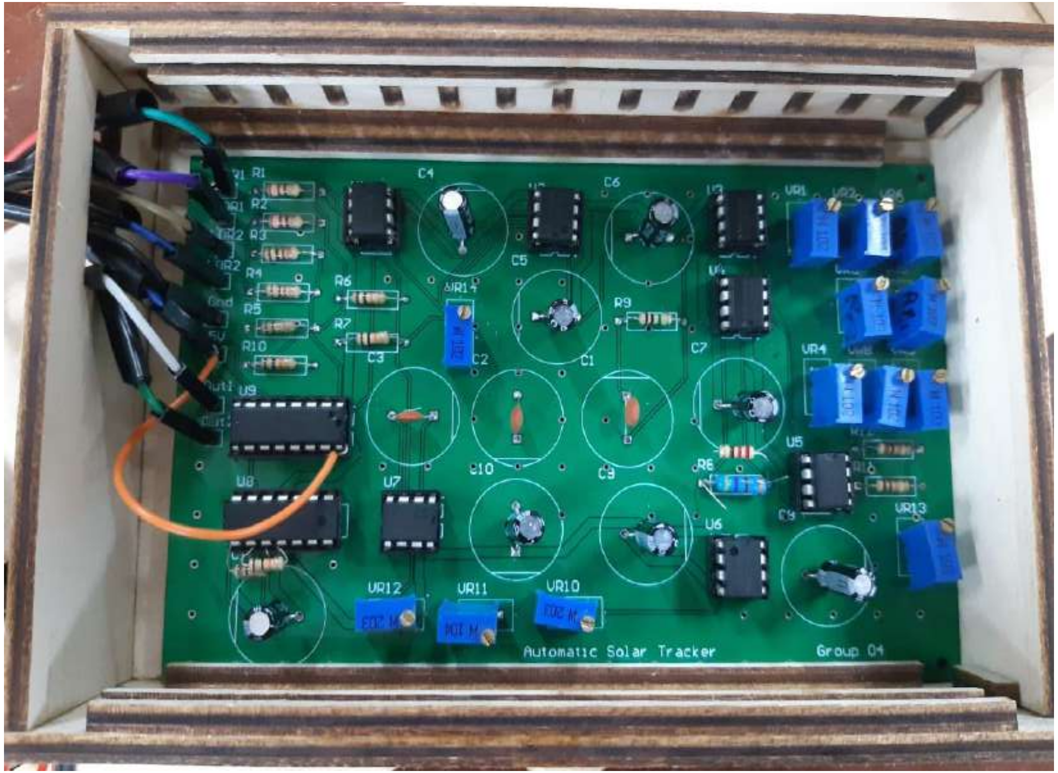


Top layer



Bottom layer

PCB



Enclosure Design

1 st step of enclosure design

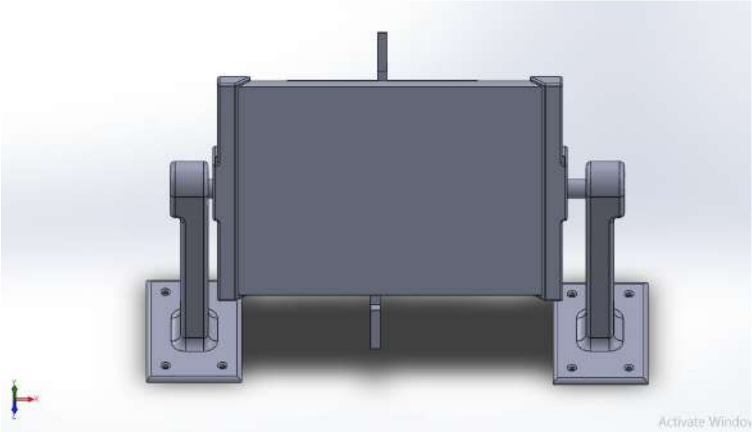


Figure 1

2nd step of enclosure design

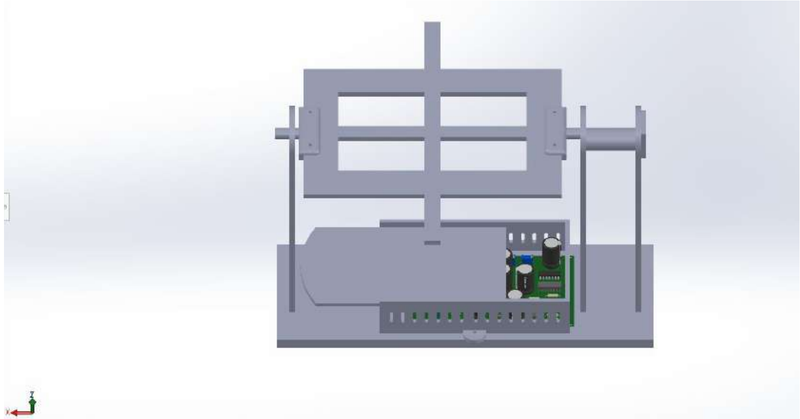
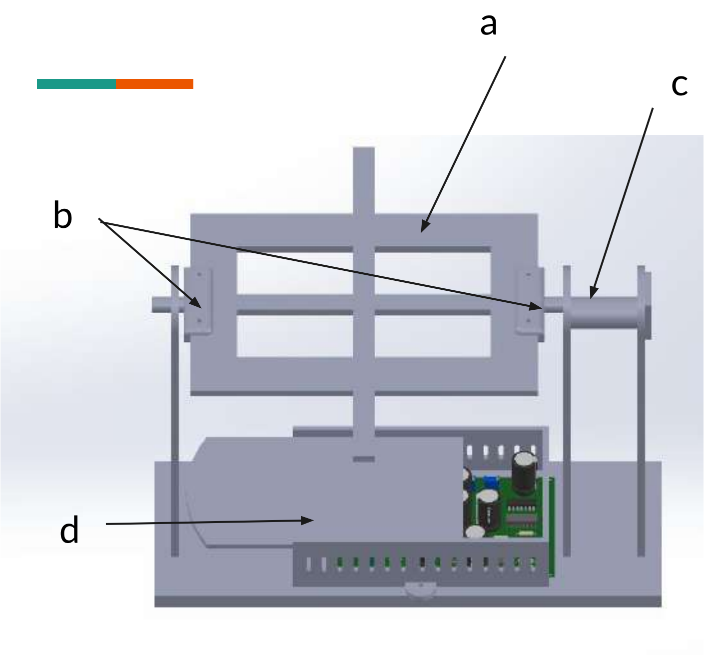


Figure 2

To reduce the cost we updated our enclosure in figure 1 to a 2nd step as shown in figure 2



a= Solar panel holder - To hold the solar panels.

b= Side connectors- To connect the solar panel holder to two side supports

c= Motor

d= To mount PCB

Op Amp Selection

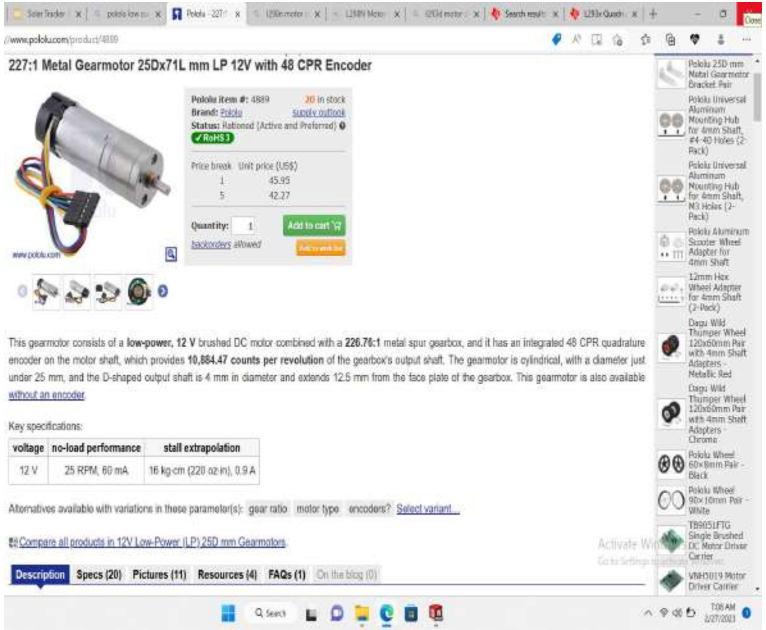
	LM741 (For general purpose)	LMC660 (For buffer)	LM339N (For comparator)
Differential voltage gain		126 dB	200 V/mV
Input resistance	2 M ohm	>1 Tera Ohm	
GBP		1.4 MHz	
CMRR	95 dB	83 dB	
Slew rate	0.5 V/us	1.1 V/us	
Input offset voltage	1 mV	1 mV	1 mV
Input bias current	80 nA	0.002 pA	25 nA
PSRR	96 dB	83 dB	
Supply voltage	Dual supply 15V	Single supply 4.75V – 15.5 V	Single supply 2V –36V
Applications	Comparators, Multivibrators, DC Amplifiers, Summing Amplifiers, Integrator / Differentiators	High-Impedance Buffer or Preamplifier, Precision Current-to-Voltage Converter	High precision voltage comparator

Motor selection

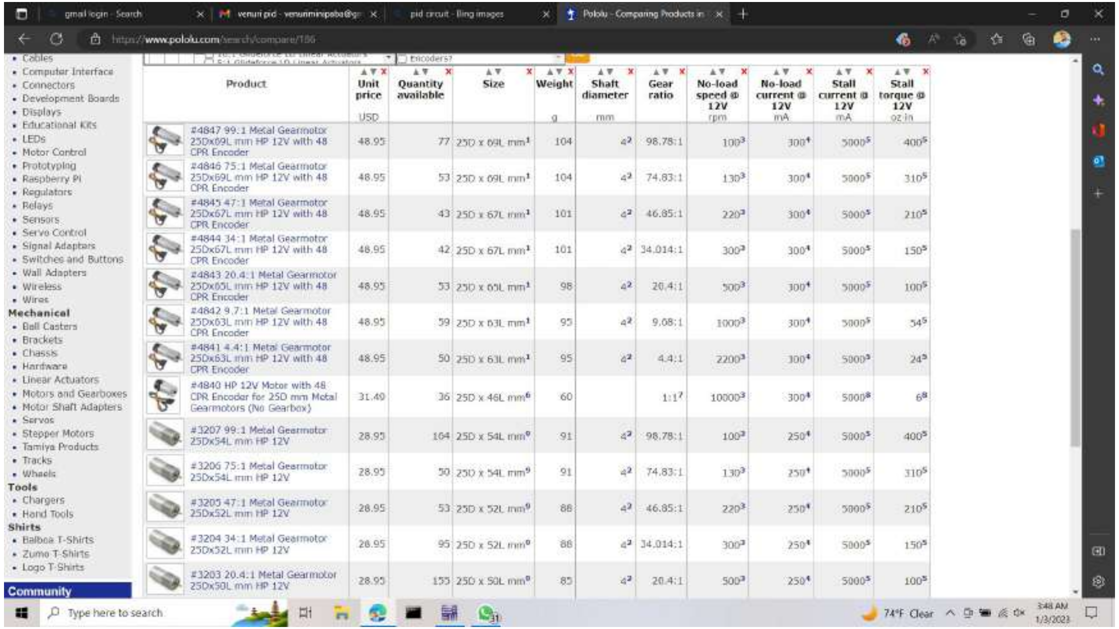
Motor designs for solar power applications, therefore, must stand up to extremes in temperature (both absolute and over a broad range), humidity and highly corrosive salt sprays, wind loads and abrasive airborne particulate matter.

Our choice- Brushed DC motors- simple, easy driving method and low cost. Control of dc motor is complex and life is short but we can replace brushes. As the solar panel can be affected by wind power high power motor is selected according to its weight and dimensions.

Selected motor - brushed dc motor
Voltage -12V
No load speed- 25 RPM
No load current- 60mA
Max torque- 16 kgcm
Stall current-0.9 A



We have selected this by considering weight and dimensions of the solar panel and by comparing with other dc motors.



Product	Unit price USD	Quantity available	Size	Weight g	Shaft diameter mm	Gear ratio	No-load speed @ 12V rpm	No-load current @ 12V mA	Stall current @ 12V mA	Stall torque @ 12V oz·in
#4847 99:1 Metal Gearmotor 25Dx69L mm HP 12V with 48 CPR Encoder	48.95	77	25D x 69L mm[1]	104	4[2]	98.78:1	100[3]	300[4]	5000[5]	400[5]
#4846 75:1 Metal Gearmotor 25Dx69L mm HP 12V with 48 CPR Encoder	48.95	53	25D x 69L mm[1]	104	4[2]	74.83:1	130[3]	300[4]	5000[5]	310[5]
#4845 47:1 Metal Gearmotor 25Dx67L mm HP 12V with 48 CPR Encoder	48.95	43	25D x 67L mm[1]	101	4[2]	46.85:1	220[3]	300[4]	5000[5]	210[5]
#4844 34:1 Metal Gearmotor 25Dx67L mm HP 12V with 48 CPR Encoder	48.95	42	25D x 67L mm[1]	101	4[2]	34.014:1	300[3]	300[4]	5000[5]	150[5]
#4843 20.4:1 Metal Gearmotor 25Dx65L mm HP 12V with 48 CPR Encoder	48.95	53	25D x 65L mm[1]	98	4[2]	20.4:1	500[3]	300[4]	5000[5]	100[5]
#4842 9.7:1 Metal Gearmotor 25Dx63L mm HP 12V with 48 CPR Encoder	48.95	59	25D x 63L mm[1]	95	4[2]	9.08:1	1000[3]	300[4]	5000[5]	54[5]
#4841 4.4:1 Metal Gearmotor 25Dx63L mm HP 12V with 48 CPR Encoder	48.95	50	25D x 63L mm[1]	95	4[2]	4.4:1	2200[3]	300[4]	5000[5]	24[5]
#4840 HP 12V Motor with 48 CPR Encoder for 25D mm Metal Gearmotors (No Gearbox)	31.40	36	25D x 46L mm[6]	60		1:1[7]	10000[3]	300[4]	5000[8]	6[8]
#3207 99:1 Metal Gearmotor 25Dx54L mm HP 12V	28.95	164	25D x 54L mm[9]	91	4[2]	98.78:1	100[3]	250[4]	5000[5]	400[5]
#3206 75:1 Metal Gearmotor 25Dx54L mm HP 12V	28.95	50	25D x 54L mm[9]	91	4[2]	74.83:1	130[3]	250[4]	5000[5]	310[5]
#3205 47:1 Metal Gearmotor 25Dx52L mm HP 12V	28.95	53	25D x 52L mm[9]	88	4[2]	46.85:1	220[3]	250[4]	5000[5]	210[5]
#3204 34:1 Metal Gearmotor 25Dx52L mm HP 12V	28.95	95	25D x 52L mm[9]	88	4[2]	34.014:1	300[3]	250[4]	5000[5]	150[5]
#3203 20.4:1 Metal Gearmotor 25Dx50L mm HP 12V	28.95	155	25D x 50L mm[9]	85	4[2]	20.4:1	500[3]	250[4]	5000[5]	100[5]

Alternatives

Stepper motor-precise control and low cost . low efficiency and slow speed increase

Ac induction motors- used earlier as motor can draw current directly from the grid but controlling these motors at slow speeds is difficult. For most solar tracking purposes slow speed is necessary. So not efficient.

Servo motors- the speed variation is less in servo motors

BLDC motor (with planetary gear box) – maintenance free, have a low TCO, has no wear prone brushes, highly efficient. hits 300 rpm. High power. Easy to control. Prize is hgh.

PMDC –efficient than AC induction motors. If properly build they can last a long time up to 5000 hr continuous duty. Drawback- life of carbon brush .

Selecting a motor driver

According to our motor it drives a stall current of 0.9 A . so the maximum current of the motor driver should be greater than 0,9 A. Logic voltage os 5 V. our solar panel is in medium size (22 cm x 14 cm) , L293D is used.

- ### 1 Features

  - Wide Supply-Voltage Range: 4.5 V to 36 V
  - Separate Input-Logic Supply
  - Internal ESD Protection
  - High-Noise-Immunity Inputs
  - Output Current 1 A Per Channel (600 mA for L293D)
  - Peak Output Current 2 A Per Channel (1.2 A for L293D)
  - Output Clamp Diodes for Inductive Transient Suppression (L293D)

  ### 2 Applications

  - Stepper Motor Drivers
  - DC Motor Drivers
  - Latching Relay Drivers

Design Parameters

Operating voltage= 5v
PCB = 2 layer (designed) and then manufactured by JLC (china)
Stall current of the motor= 300 mA
Motor driver = L293D
Op Amps used = UA741CP, TL072CP , LM339N
Enclosure material = wood and PLA

Individual contribution

AMARASINGHE A.M.V.M. 200027R = Enclosure designing (solidworks), simulation , , Circuit testing, documentation. Soldering

GUNAWARDENA M.N. 200201V = Schematic drawing (Altium), Circuit testing, Soldering , Documentation

MALANBAN K. 200373X = Circuit designing, Circuit testing , soldering Documentation

RATHNAYAKE R.N.P. 200537F = PCB designing (Altium), Circuit testing , soldering Documentation

Future Updates

1. Power up the solar tracker using the voltage generated by solar panels.
2. Keeping track of the efficiency using graphs of voltage generated by solar panels and update the user using a mobile app.

Conclusion

To get a smooth motion more tuning should be done.

We can increase the efficiency of power generated using solar panels using this solar tracker with a less power consumption.

It will help to overcome the current energy crisis

THANK YOU!