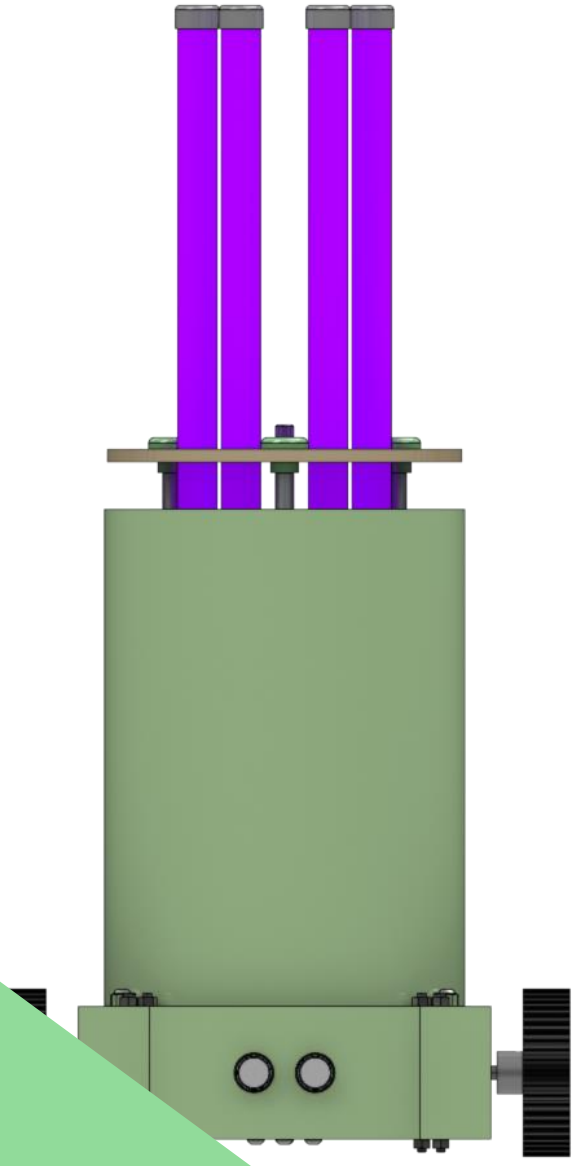
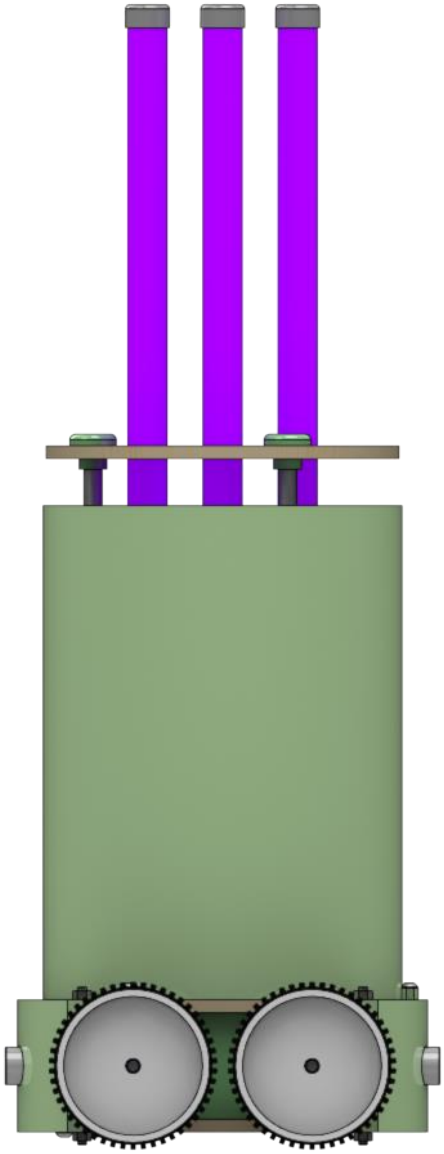
INDUSTRIAL INTERNSHIP REPORT



JEMMA CLEANNING BOT
JULY 2020

PARTH PATEL
(17BEE109)

CONTENTS



ABOUT JEMMA

BASIC DETAILS

Clean efficiently, Clean safely

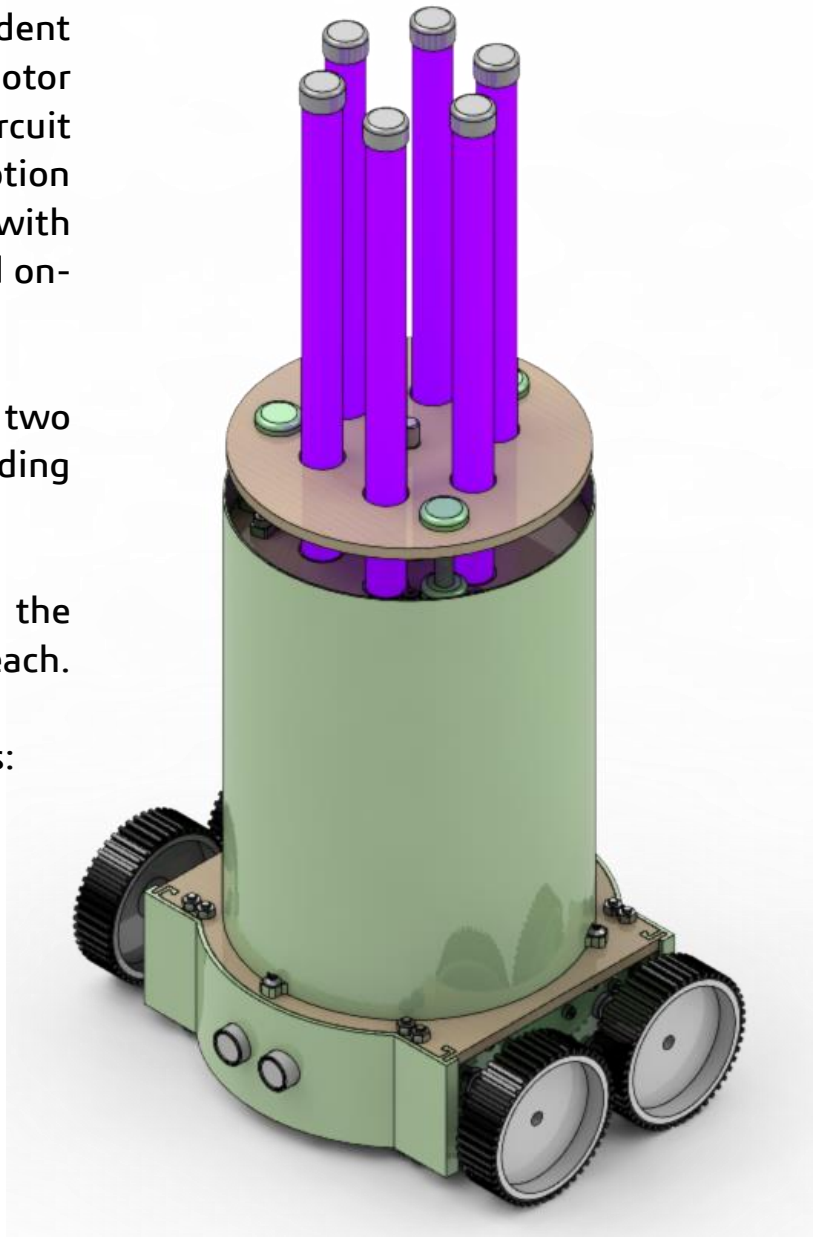
The robot for motion is equipped with four 12V dc motors for independent four-wheel drive with each motor equipped with a separate driver circuit to have complete 2 degree of motion which motion incorporated with lateral motion, circular motion and on-position rotation included.

The robot is equipped with two ultrasonic sensors for avoiding collisions.

There exists six UV-C Lamps on the robot with 34V operating voltage each.

The robot operates in three modes:

1. Autonomous Mode
2. Remote controlled Mode
3. Pre-planned Route Mode



ACKNOWNLEDGMENT

I would like to express my deepest appreciation to all those who provided me the possibility to complete this report. A special gratitude I give to our mentor, Mr. Vipin Shukla, whose contribution in stimulating suggestions and encouragement, helped me to coordinate my project especially in designing this project.

A special thanks goes to my team mate, Parin Patel, who helped me to assemble the parts and gave suggestion about the project Jemma Cleaning Bot. I have to appreciate the guidance given by other supervisor as well as the panels especially in our project presentation that has improved our presentation skills thanks to their comment and advices.

CERTIFICATION

This is to certify that the project report entitled **Jemma Cleaning Bot**, submitted to the Department of Electrical Engineering, Pandit Deendayal Petroleum University, under the event for Industrial Internship for Innovation and Incubation Cell, PDPU details accomplishment of the Problem statement **COVID 8 "UV Sanitization using Robot"**.

The report certifies that **Mr. Parth Patel (17BEE109)** has successfully completed the project and has along with it submitted the report under the supervision of **Mr. Vipin Shukla** on his successful build and design within.

Mr. Vipin Shukla
Assistant Professor
Dept. of Electrical Engineering
Project Mentor

Dr. Praghnesh Bhatt
Associate Professor
Dept. of Electrical Engineering
Head of the Department

PROBLEM STATEMENT

There exist four major problems when it comes to current cleaning methods:

- **TIME** is essential when it comes to cleaning homes. It needs to be done as soon as a person visits home. Manual cleaning takes a lot of time which can increase the risk of exposure to virus to residents.
- **AVAILIBILITY** of proper cleaning appliances and chemicals are not accessible to many people.
- The current cleaning solution using Alcohol based disinfectants causes **DAMAGE** to the cleaning surface and the human skin as alcohol is a strong dehydrator.
- Proper cleaning **PROCEDURE** is not known to many people in country.

MECHANICAL SPECIFICATION OF ROBOT

The robot is designed to be scalable with minimal resources available. The mechanical design can be made using just two processes:

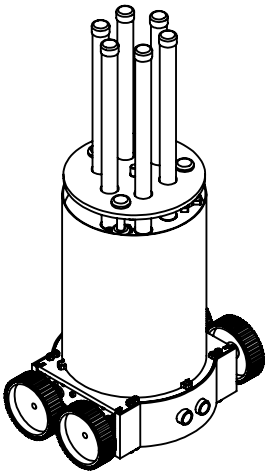
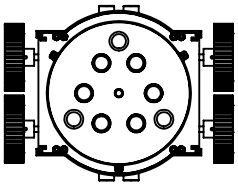
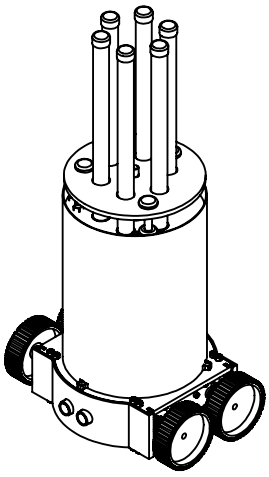
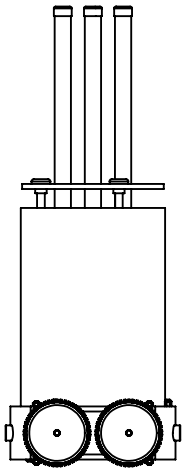
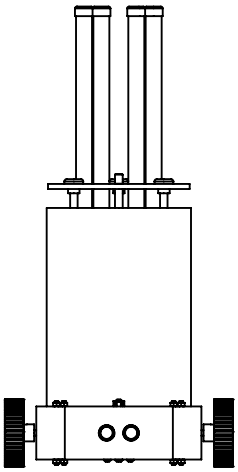
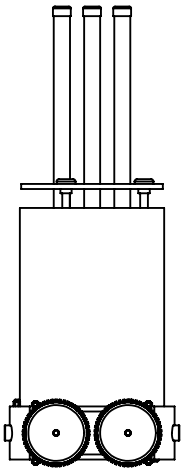
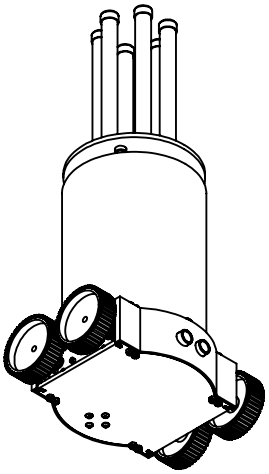
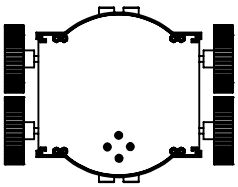
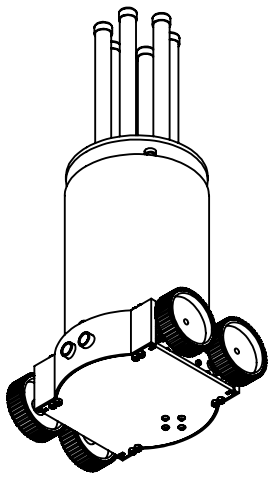
1. FDM Manufacturing
2. Laser Cutting

The 3D printed parts are built using PETG Material which enables it to be manufactured on any 3D printer because it being easy to print at high speeds.

The Bottom and Top can be Laser Cut on 5.5mm MDF Board using a cheap 50W CO_2 Laser Cutter at a high speed of 75 mm/s.

Motion design:

1. 8mm Stainless Steel Rod
2. LM8UU Linear Bearing
3. 8mm Threaded Rod for Lead Screw

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APPV'D							
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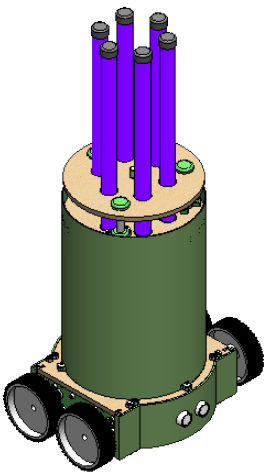
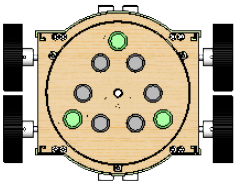
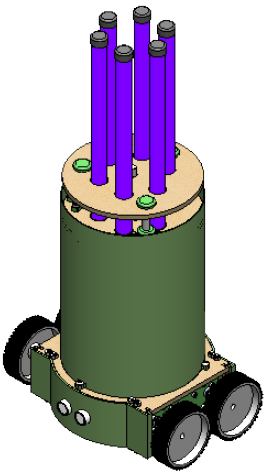
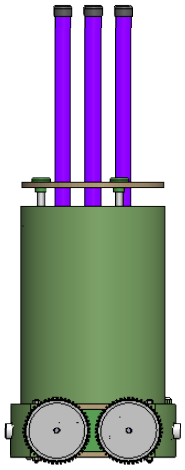
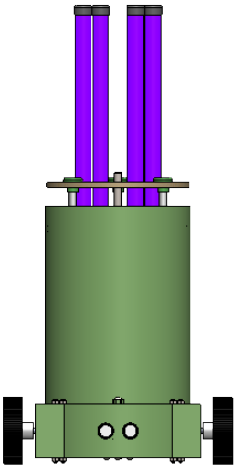
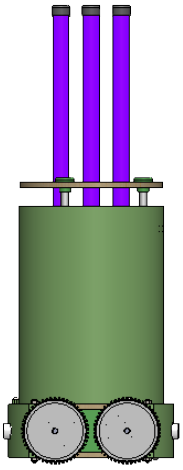
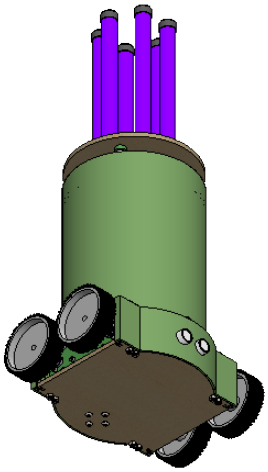
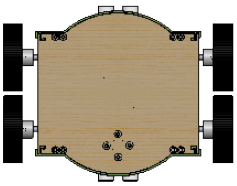
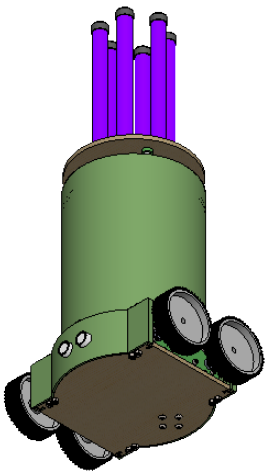
						Complete Assembly	
				WEIGHT:		SCALE:1:8	SHEET 1 OF 1

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CHK'D							
APPV'D							
MFG							
Q.A				MATERIAL:		DWG NO.	
						Complete Assembly	A4
				WEIGHT:		SCALE:1:8	SHEET 1 OF 1

ELECTRICAL SPECIFICATION OF ROBOT

1. Robot Specification
2. Alarm Circuit
3. 555 Datasheet
4. 556 Datasheet
5. Motor Datasheet
6. Motor Driver Circuit
7. MOSFET Datasheet
8. UV-C Tube Datasheet

1. ROBOT SPECIFICATION

- Robot Specification:
  - Maximum Weight: 15.5kg
  - Maximum Speed: 0.8 m/s

- Motors:
  - Name: HC315MG-004 dc motor
  - Operating Voltage: 12V
  - Maximum Current: 7.5A
  - Maximum Torque: 100m N-m
  - Maximum Power: 40W
  - Maximum Speed: 18,000 rpm
  - Required Speed: 1.8A
  - Required Efficiency: 68%
  - Required Speed: 12,800 rpm
  - Required Torque: 22.468m N-m
  - No. of Units: 4

- UV-C Lamp Specification:
  - Rated Voltage: 34V
  - Rated Current: 0.6A
  - Rated Output Power: 11W
  - No. of Units: 6

- MOSFET Specifications
  - Name: STP55NF06L
  - V_{DS} max: 60V
  - I_{DS} max: 55A
  - R_{DS} ON:18mΩ
  - V_{GS}:16V

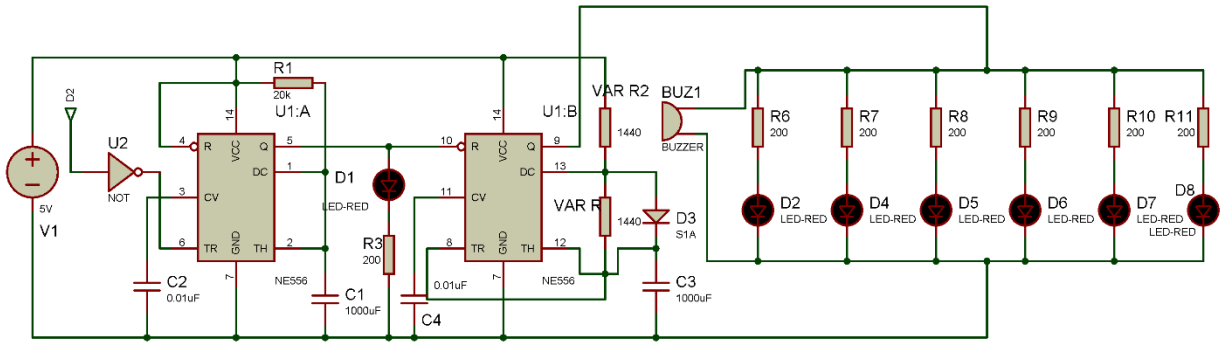
2. ALARM CIRCUIT

To reduce the load off the **ATMEGA 328P** microcontroller modular circuit design was kept in focus. Due to this, the alarm system is controlled by two 555 Timers integrated in a single **NE556 IC** working with:

1. Timer 1: Monostable mode
2. Timer 2: Multi stable Mode

555 triggers at the ACTIVE LOW edge signal, due to this, a **NOT GATE** is attached in front of the **TRIGGER PIN** of the Timer 1. This enables to Atmega 328P to remain in **LOW STATE** when not in need. When the UV sanitization process is about to start, the **D2** digital pin triggers to **ACTIVE HIGH** which results output of NOT gate to ACTIVE LOW which enable the Timer 1 to function.

Timer 1 works in Monostable mode with a duration of **20s** which turns **ON** the Timer 2 by supplying the **5V** to the **RESET** pin of Timer 2 which enables it to operate at a frequency of **1Hz**.

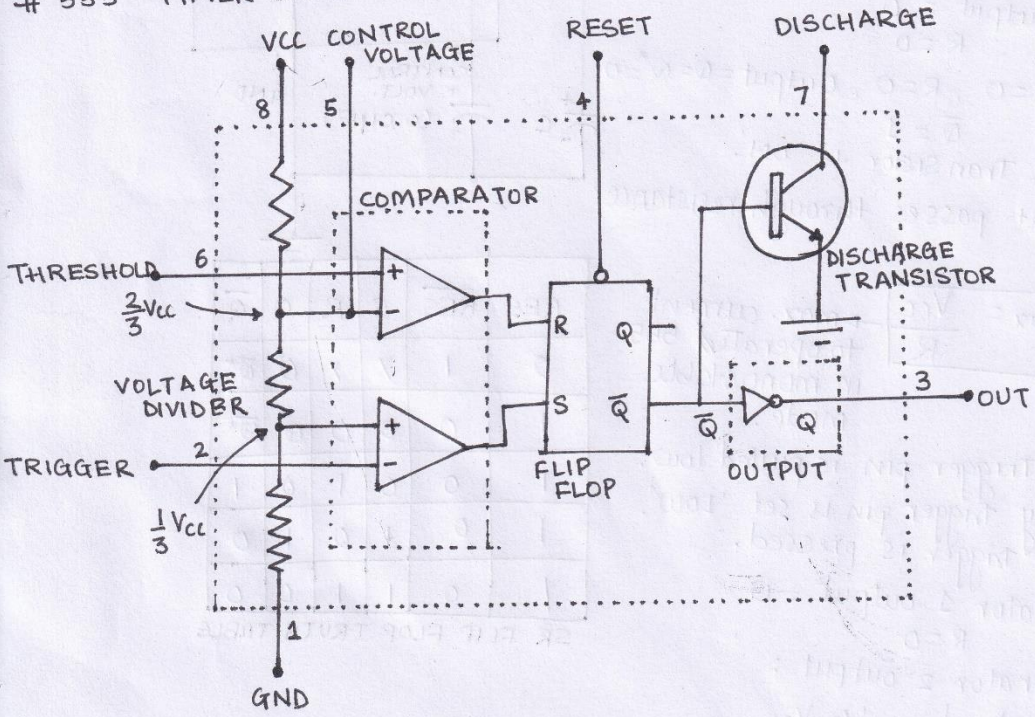


LED FLASHER CIRCUIT

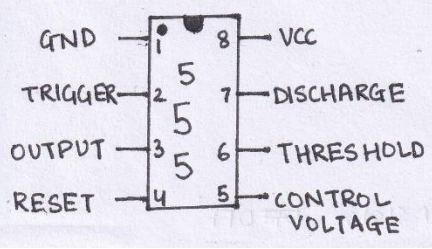
#INTRODUCTION

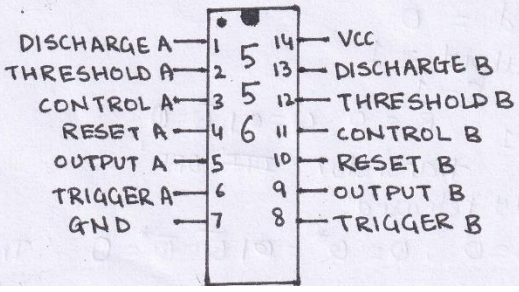
- When the cleaning sequence is to be initiated, before that, a siren with Red Lights is blinked @ frequency of 1 Hz for a period of 20 sec. A set of six 10 mm Red LEDs are used for lights along with a dc active buzzer.
- The blinking circuit is performed using NE 556 Timer which is a set of two 555 timers built in one.
  - → One will be working in Mono-stable Mode activated by the central Atmel Atmega328P-AU IC. The timer will Turn 'ON' for 20 sec and then Shut-down.
  - → Second will function in Astable Mode which will always remain in RESET Mode till the first 555 chip turns 'ON' the timer to function for 20 sec at frequency of 1 Hz.

555 TIMER BLOCK DIAGRAM



TIMER PINOUT





555 TIMER IN MONOSTABLE MODE

- 555 timer in monostable mode works when the trigger pin is trigger.
- Pin 2 (Trigger) is natively high & is activated w/ a -ve edge trigger.

→ Case I

- when the supply is connected initially, Trigger pin is high,

∴ for comparator 2,

+ve lead → 1/3 Vcc
-ve lead → Vcc
∴ output = 0
∴ S = 0

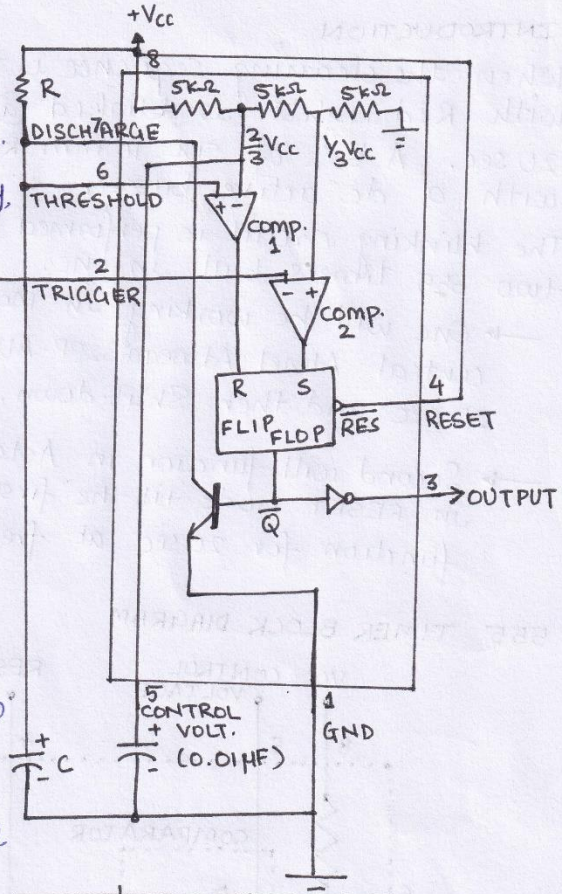
for comparator 1,

+ve lead → Threshold = 0V
-ve lead → 2/3 Vcc
∴ output = 0
∴ R = 0

∴ S = 0, R = 0, Output = Q = Q* = 0
∴ $\bar{Q} = 1$
∴ Transistor is 'ON'.

∴ Current passes through resistance R.

∴ $I_{max} = \frac{V_{cc}}{R}$ → max. current to operated 555 in monostable mode.



RES	$\overline{RES}$	S	R	Q	$\bar{Q}$
0	1	X	X	Q^*	$\bar{Q}^*$
1	0	0	0	Q^*	$\bar{Q}^*$
1	0	0	1	0	1
1	0	1	0	1	0
1	0	1	1	0	0

SR FLIP FLOP TRUTH TABLE

→ Case-II : Trigger pin is pulled low.

- momentarily trigger pin is set 'LOW'.

i.) while trigger is pressed.

→ comparator 1 output = 0
R = 0

→ comparator 2 output :

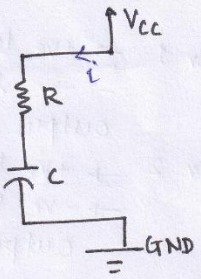
+ve lead = 1/3 Vcc
-ve lead = 0
∴ output = 1
S = 1

S = 1, R = 0, Q = 1, $\bar{Q}$ = 0
transistor ~~'ON'~~ 'OFF'

ii.) Trigger is just released.

R = 0, S = 0, Q = Q* = 1, $\bar{Q} = \bar{Q}^* = 0$ ∴ Transistor ~~'ON'~~ 'OFF'

iii.) After some time, transistor is 'OFF'.



$$V_{cc} - iR - \frac{\int i\,dt}{C} = 0$$

$$\frac{dV_{cc}}{dt} - \frac{di}{dt}\cdot R - \frac{i}{C} = 0$$

$$\int_{i}^{i} \frac{di}{i} = -\frac{1}{RC}\int_{0}^{t} dt$$

$$\ln i = -\frac{kt}{RC}$$

$i = k \cdot e^{-t/RC}$ → at $t=0$, $i = V_{cc}/R$ (∵ cap. is discharged)

$$\boxed{i = \frac{V_{cc}}{R} e^{-t/RC}}$$ → Current through capacitor.

$$Q = \int i\,dt = \frac{V_{cc}}{R}\int e^{-t/RC}\,dt = -V_{cc}\cdot C\, e^{-t/RC} + K$$

at $t=0$ $Q=0$

$0 = -C\cdot V_{cc} + K$ ∴ $K = C\cdot V_{cc}$

$$\boxed{Q = C\cdot V_{cc}\left(1 - e^{-t/RC}\right)}$$ → Charge accross capacitor

$Q_c = C\cdot V_c$

$$V_c = Q_c/C = V_{cc}\left(1 - e^{-t/RC}\right)$$

$$\boxed{V_c = V_{cc}\left(1 - e^{-t/RC}\right)}$$ → ~~Charge~~ Voltage across Capacitor

- Capacitor keeps on charging till $V_c = \frac{2}{3}\cdot V_{cc}$.

at $V_c = \frac{2}{3}V_{cc}$ → ~~Cap~~ Comparator 1 change state.

for time required for cap. to charge from $0 - \frac{2}{3}V_{cc}$,

$$\frac{2}{3}V_{cc} = V_{cc}\left(1 - e^{-t/RC}\right)$$

$$e^{-t/RC} = 1/3$$

$$\ln\left(e^{-t/RC}\right) = \ln(1/3)$$

$$-t/RC = -1.093$$

$$t = 1.093\,RC \cong RC$$

$$\boxed{T = RC}$$ → Time needed to charge capacitor and for output to be high.

• at $V_c = \frac{2}{3} V_{cc}^{+}$,

→ ~~Capacitor 1~~ → Comparator 1 → +ve lead = $2/3\ V_{cc}^{+}$
→ -ve lead = $2/3 V_{cc}$
output = 1, R = 1

→ Comparator 2 → +ve lead = $1/3\ V_{cc}$
→ -ve lead = V_{cc}
output = 0, S = 0

S = 0, R = 1, Q = 0, $\bar{Q}$ = 1.

∴ As soon as ~~+~~ voltage on capacitor reaches $\frac{2}{3} V_{cc}$, Transistor turns 'ON'.

∴ Capacitor shorts as reaches 0V instantly.

→ Next time the ~~capacito~~ trigger pin is pressed, the cycle restarts.

∴ for a time period of 20 sec,

$t = R \cdot C = 20$ sec

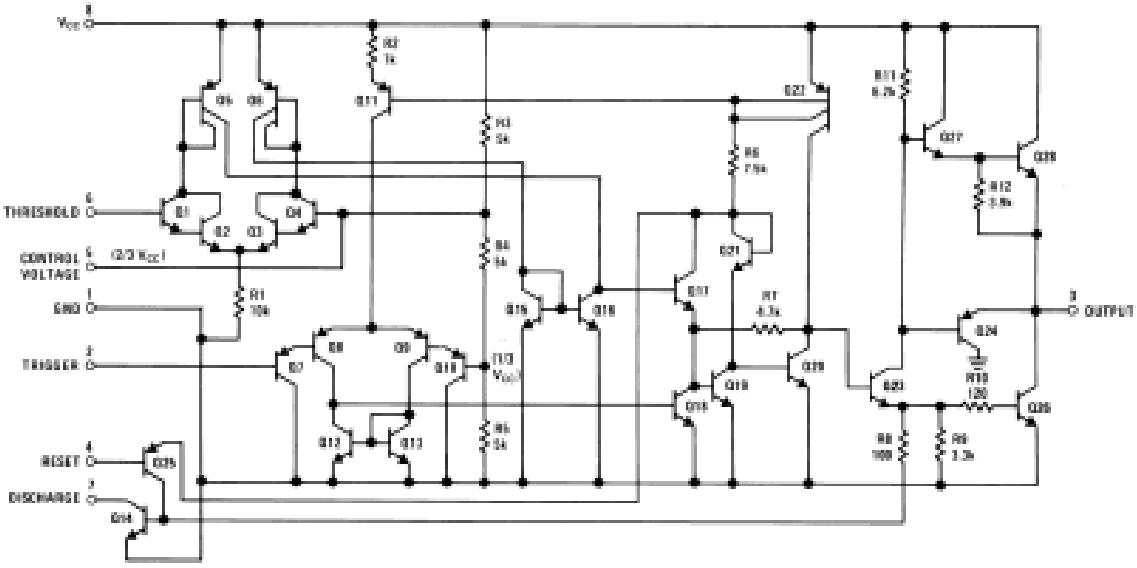
Let $C = 1000\mu F$

$R = \frac{20}{C} = \frac{20}{1000\ \mu} = 20\ k\Omega$

∴ $\boxed{R = 20\ k\Omega,\ C = 1000\mu F}$

3. 555 Datasheet

555 Internal Schematic Diagram



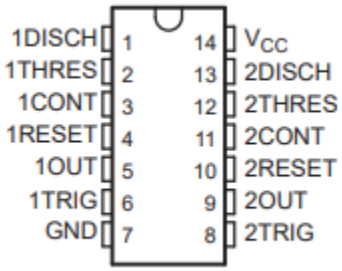
555 Electrical Characteristics

(T_A = 25°C, V_{CC} = 5 V to 15 V, unless otherwise specified)[1][2]

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Supply Voltage		4.5		16	V
Supply Current	V_{CC} = 5 V, R_L = ∞		3	6	mA
	V_{CC} = 15 V, R_L = ∞ (Low State) [3]		10	15	
Timing Error, Monostable					
Initial Accuracy			1 %		
Drift with Temperature	R_A = 1 k to 100 kΩ,		50		ppm/°C
	C = 0.1 µF, [4]				
Accuracy over Temperature			1.5 %		
Drift with Supply			0.1 %		V
Timing Error, Astable					
Initial Accuracy			2.25		
Drift with Temperature	R_A, R_B =1 k to 100 kΩ,		150		ppm/°C
	C = 0.1 µF, [4]				
Accuracy over Temperature			3.0%		
Drift with Supply			0.30 %		/V
Threshold Voltage			0.667		x V_{CC}
Trigger Voltage	V_{CC} = 15 V		5		V
	V_{CC} = 5 V		1.67		V
Trigger Current			0.5	0.9	µA
Reset Voltage		0.4	0.5	1	V
Reset Current			0.1	0.4	mA
Threshold Current	[5]		0.1	0.25	µA
Control Voltage Level	V_{CC} = 15 V	9	10	11	V
	V_{CC} = 5 V	2.6	3.33	4	
Pin 7 Leakage Output High			1	100	nA
Pin 7 Sat [6]					
Output Low	V_{CC} = 15 V, I_7 = 15 mA		180		mV
Output Low	V_{CC} = 4.5 V, I_7 = 4.5 mA		80	200	mV
Output Voltage Drop (Low)	V_{CC} = 15 V				
	I_{SINK} = 10 mA		0.1	0.25	V
	I_{SINK} = 50 mA		0.4	0.75	V
	I_{SINK} = 100 mA		2	2.5	V
	I_{SINK} = 200 mA		2.5		V
	V_{CC} = 5 V				
	I_{SINK} = 8 mA				V
	I_{SINK} = 5 mA		0.25	0.35	V

4. 556 Datasheet

556 Pinout



556 Electrical Characteristics

V_{CC} = 5 V to 15 V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIONS		NA556 NE556 SA556 MIN	NA556 NE556 SA556 TYP	NA556 NE556 SA556 MAX	SE556 MIN	SE556 TYP	SE556 MAX	UNIT
V_T	Threshold voltage level	V_{CC} = 15 V		8.8	10	11.2	9.4	10	10.6	V
		V_{CC} = 5 V		2.4	3.3	4.2	2.7	3.3	4	
I_T	Threshold current[1]				30	250		30	250	nA
V_{TRIG}	Trigger voltage level	V_{CC} = 15 V		4.5	5	5.6	4.8	5	5.2	V
			T_A = –55°C to 125°C				3		6	
		V_{CC} = 5 V		1.1	1.67	2.2	1.45	1.67	1.9	
			T_A = –55°C to 125°C						1.9	
I_{TRIG}	Trigger current	TRIG at 0 V			0.5	2		0.5	0.9	µA
V_{RESET}	Reset voltage level			0.3	0.7	1	0.3	0.7	1	V
		T_A = –55°C to 125°C							1.1	
I_{RESET}	Reset current	RESET at V_{CC}			0.1	0.4		0.1	0.4	mA
		RESET at 0 V			–0.4	1.5		–0.4	–1	
I_{DISCH}	Discharge switch off-state current				20	100		20	100	nA
V_{CONT}	Control voltage (open circuit)	V_{CC} = 15 V		9	10	11	9.6	10	10.4	V
			T_A = –55°C to 125°C				9.6		10.4	
		V_{CC} = 5 V		2.6	3.3	4	2.9	3.3	3.8	
			T_A = –55°C to 125°C				2.9		3.8	
V_{OL}	Low-level output voltage	V_{CC} = 15 V, I_{OL} = 10 mA			0.1	0.25		0.1	0.15	V
			T_A = –55°C to 125°C						0.2	
		V_{CC} = 15 V, I_{OL} = 50 mA			0.4	0.75		0.4	0.5	
			T_A = –55°C to 125°C						1	
		V_{CC} = 15 V, I_{OL} = 100 mA			2	2.5		2	2.2	
			T_A = –55°C to 125°C						2.7	
		V_{CC} = 15 V, I_{OL} = 200 mA			2.5			2.5		
		V_{CC} = 5 V, I_{OL} = 3.5 mA	T_A = –55°C to 125°C						0.35	
		V_{CC} = 5 V, I_{OL} = 5 mA			0.1	0.25		0.1	0.15	
			T_A = –55°C to 125°C						0.8	
		V_{CC} = 5 V, I_{OL} = 8 mA			0.15	0.3		0.15	0.25	
V_{OH}	High-level output voltage	V_{CC} = 15 V, I_{OH} = –100 mA		12.75	13.3		13	13.3		V
			T_A = –55°C to 125°C				12			
		V_{CC} = 15 V, I_{OH} = –200 mA			12.5			12.5		
		V_{CC} = 5 V, I_{OH} = –100 mA		2.75	3.3		3	3.3		
			T_A = –55°C to 125°C				2			
I_{CC}	Supply current	Output low, No load	V_{CC} = 15 V		20	30		20	24	mA
			V_{CC} = 5 V		6	12		6	10	
		Output high, No load	V_{CC} = 15 V		18	26		18	20	
			V_{CC} = 5 V		4	10		4	8	

556 Ratings

			MIN	MAX	UNIT
V_{CC}	Supply voltage[2]			18	V
V_I	Input voltage	CONT, RESET, THRES, and TRIG		V_{CC}	V
I_O	Output current			±225	mA
θ_{JA}	Package thermal impedance[3][4]	D package		86	°C/W
		N package		80	
		NS package		76	
θ_{JC}	Package thermal impedance[5][6]	J package		15.05	°C/W
T_J	Operating virtual junction temperature			150	°C
	Lead temperature 1,6 mm (1/16 in) from case for 60 s	J package		300	°C
	Lead temperature 1,6 mm (1/16 in) from case for 10 s	D, N, or NS package		260	°C
T_{stg}	Storage temperature range		–65	150	°C

5. Motor Datasheet

HC315MG-004 PMDC Motor

PMDC

Market
Personal Care

Application:
Hair Dryer

Specially designed motor for high power hair dryer requiring high torque

Motor Characteristics:

Diameter	: 27.5 mm
Length	: 38 mm
Shaft Diameter	: 2.305 mm
Weight	: 72.2 g
Nominal Voltage	: 24 V
Torque Constant	: 13.723 m-Nm/A
Dynamic Resistance	: 3.324 Ohms
Motor Regulations	: 172.007 Rpm/m-Nm
Pole Number	: 5

Standard Data:

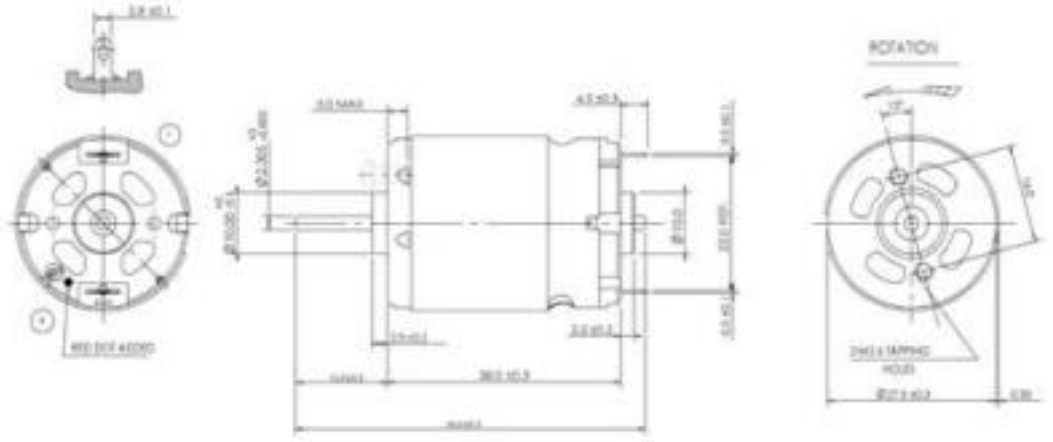
Operation Temperature	: -10 — 50°C
Storage Temperature	: -20 — 100°C
Mounting	: Any position
Electrical Connection	: Terminal
Winding Temperature (Tmax)	: 180 °C
Direction of Rotation	: CCW
Standards	: RoHS

Electrical Performance:

	No Load	Stall	Max Eff	Max Power
Speed (Rpm)	16533		14090	8267
Current (A)	0.22	7.22	1.25	3.72
Torque (mNm)		96.12	14.20	48.06
Efficiency (%)			69.75	
Power (W)			20.95	41.60

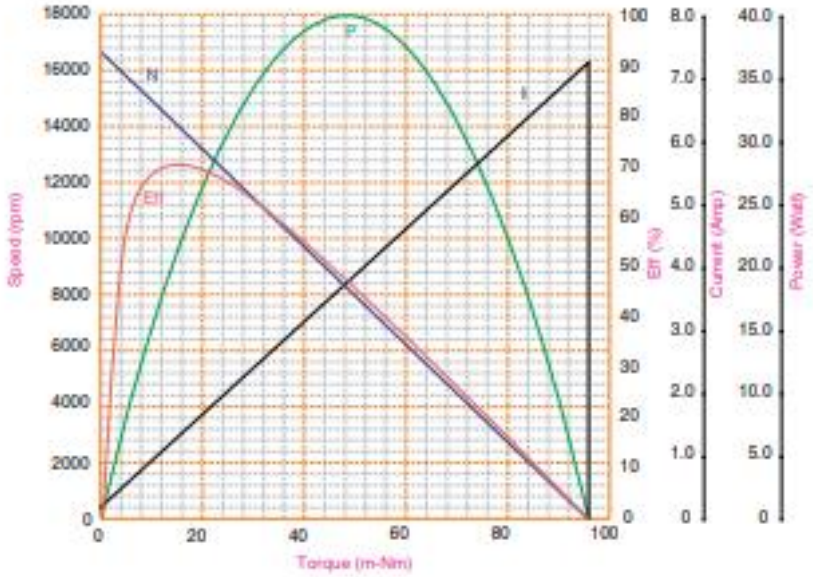
PMDC Motor HC315MG-004

Drawing:



Unit in mm

Performance Data:



6. Motor Driver Circuit

Rating of dc motor drive

Step -1 : Calculation of torque on motor

Item	Weight per Item (g)	Quantity	Total
1.) TUV 11 W 4PSE UV-C Lamp	200	6	~~1800~~ 1200
2.) HC315MG-004 dc motor + gearbox	200	4	800
3.) Material Weight*	1500	1	1500
4.) 12 V Battery**	3000	3	9000
5.) Miscellaneous***	3000	1	3000
		Total Weight	15500

* Assumptions:
  * Material weight includes weight of Nut, Bolts, SS linear rods, NEMA-17 stepper motor, etc. which is estimated to 1.5kg.
  ** Battery weight is counted for max. weight as per the weight of UB12100S Battery for the worst condition possible. Actual Battery weight shall be calculated at end as per the max. current required.
  *** Miscellaneous weight includes weight of circuit boards and future upgrades upto maximum 3 kg.

→ Torque calculation on motor:

Total weight = 15,500g

∴ Weight per wheel = 15,500 / 4 = 3875 g = 3.875 kg

We With the wheel with diameter of 71 mm;

$$|\bar{\tau}_0| = |\bar{F}||\bar{r}|$$

$$|\bar{F}| = \begin{bmatrix}\text{weight per}\\ \text{wheel}\end{bmatrix} \times \begin{bmatrix}\text{gravitational}\\ \text{acceleration}\end{bmatrix}$$

$$|\bar{F}| = 3.875 \times 9.8 = 37.975\ N$$

$$|\bar{\tau}_0| = 37.975 \times \left(\frac{71}{2}\right) \times 10^{-3} = 1.34811\ N\text{-}m = 1348.11\ mN\text{-}m$$

(radius of wheel; ↳ milliNewton-metre)

$|\bar{\tau}_o|$ → mag. of torque on motor wheel hub.

Gearbox Ratio : 1:60

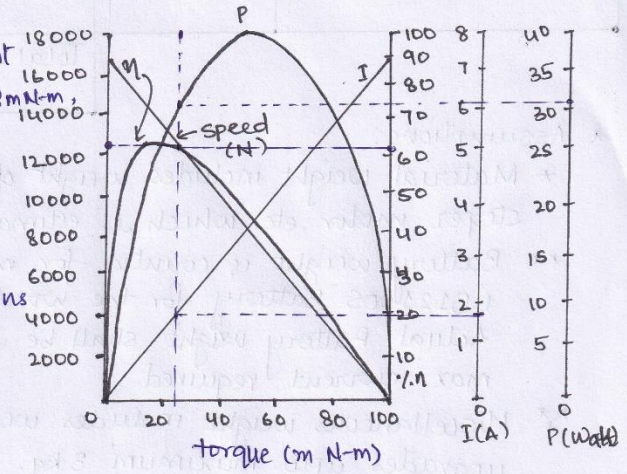
$\therefore |\bar{\tau}_o'| = |\bar{\tau}_o| / N$

($|\bar{\tau}_o|$ → Torque on wheel hub; N → Gearbox Ratio; $|\bar{\tau}_o'|$ → Torque on motor)

$$|\bar{\tau}_o'| = \frac{1348.11}{60} = 22.468 \text{ mN-m}$$

$$\boxed{|\bar{\tau}_o'| = 22.468 \text{ mN-m}}$$

As per the torque-speed-current characteristic, at $|\bar{\tau}_o'| = 22.468$ mN-m, Rated current is approx. 1.8 A; at efficiency of 68% and speed of 12,800 rpm.



$\therefore$ As per the taken assumptions earlier;

$|\bar{\tau}_o'|_{max.} = 22.468$ mN-m

$I_{Rmax} = 1.8$ A

$\%\eta_{min} = 68\%$

$N_{min} = 12,800$ rpm.

N for Robot wheels $= \frac{12,800}{60} = 213.33$ rpm ← min. speed of robot wheel.

$\therefore$ As of 68% min efficiency, the rated current is 1.8A, i.e. that as per the 4 motor configuration, 2 motors are to be connected in parallel.

$\therefore I_{Rtotal}$ per driver $= 2 \times 1.8 = 3.6$ A.

With 150% safety factor, I_R for MOSFET $= 1.5 \times 3.6 = 5.4$ A

$\therefore$ $\boxed{I_R \text{ for MOSFET} = 6 \text{ A minimum.}}$

* Min. specs of MOSFET is 12V @ 6A

* Min. speed of robot :

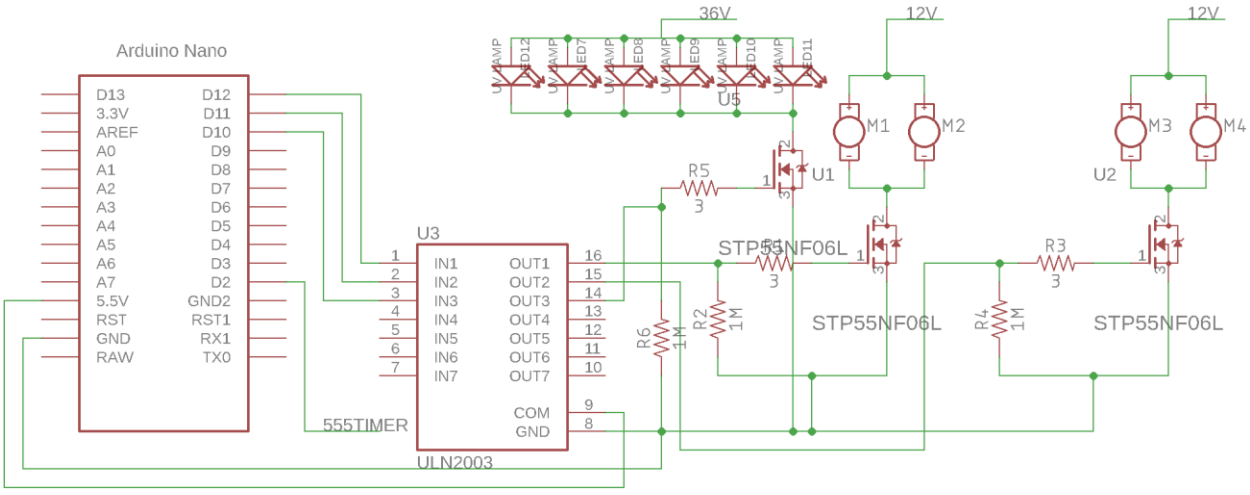
$$v = \omega . R$$

$$\omega = \frac{2\pi N}{60}$$

$$v = \frac{2\pi}{60}\left(213.33\right)\left(\frac{71}{2} \times 10^{-3}\right)$$

$$v = 0.793\ m/s = 79.3\ cms^{-1}$$

$\therefore$ Min. Speed of robot $= 0.793 ms^{-1} \simeq 0.8 ms^{-1}$



7. MOSFET Datasheet STB55NF06L

ON/OFF STATES CHARACTERISTICS

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$V_{(BR)DSS}$	Drain-source breakdown voltage	I_D = 250µA, V_{GS}= 0	60			V
I_{DSS}	Zero gate voltage drain current (V_{GS} = 0)	V_{DS} = Max rating, V_{DS} = Max rating @125°C			1 10	µA µA
I_{GSS}	Gate body leakage current (V_{DS} = 0)	V_{GS} = ±16V			±100	nA
$V_{GS(th)}$	Gate threshold voltage	V_{DS}= V_{GS}, I_D = 250µA	1	1.7		V
$R_{DS(on)}$	Static drain-source on resistance	V_{GS}= 5V, I_D= 27.5A V_{GS}= 10V, I_D= 27.5A		0.016 0.014	0.020 0.018	Ω Ω

ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Value	Unit
V_{DS}	Drain-source voltage (V_{GS} = 0)	60	V
V_{GS}	Gate-source voltage	± 16	V
I_D	Drain current (continuous) at T_C = 25°C	55	A
I_D	Drain current (continuous) at T_C = 100°C	39	A
I_{DM}(1)	Drain current (pulsed)	220	A
P_{TOT}	Total dissipation at T_C = 25°C	95	W
	Derating factor	0.63	W/°C
dv/dt(2)	Peak diode recovery voltage slope	20	V/ns
E_{AS}(3)	Single pulse avalanche energy	300	mJ
T_J T_{stg}	Operating junction temperature Storage temperature	-55 to 175	°C

SWITCHING TIMES

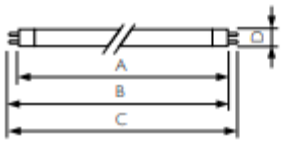
Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
$t_{d(on)}$ t_r	Turn-on delay time Rise time	V_{DD}=30 V, I_D=27.5A, R_G=4.7Ω, V_{GS}= 4.5V *(see Figure 12)*		20 100		ns ns
$t_{d(off)}$ t_f	Turn-off delay time Fall time	V_{DD}=30V, I_D=27.5A, R_G=4.7Ω, V_{GS}=4.5V *(see Figure 12)*		40 20		ns ns

SOURCE DRAIN DIODE

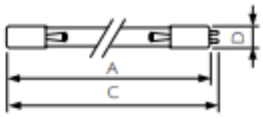
Symbol	Parameter	Test conditions	Min	Typ.	Max	Unit
I_{SD}	Source-drain current				12	A
I_{SDM}(1)	Source-drain current (pulsed)				48	A
V_{SD}(2)	Forward on voltage	I_{SD} = 55A, V_{GS}=0			1.6	V
t_{rr} Q_{rr} I_{RRM}	Reverse recovery time Reverse recovery charge Reverse recovery current	I_{SD} = 55A, di/dt = 100A/µs, V_{DD} = 30V, Tj = 150°C *(see Figure 14)*		80 200 5		ns nC A

8. UV-C Tube Datasheet

Type	Cap-Base	Dim. no	Technical Lamp Wattage (W)	Lamp Voltage (V)	UVC 100 (h)	Lamp Current (A)	Useful life (h)	Depreciation at useful lifetime (%)	Packaging type	Packaging configu-ration	Ordering number
TUV 4W	G5	2	4	29	0.9	0.17	6000	20	1FM	10x25 BOX	928000104013
TUV 6W	G5	3	6	42	1.5	0.16	9000	20	1FM	10x25 BOX	928000704013
TUV 8W	G5	4	8	56	2.1	0.15	11000	15	1FM	10x25 BOX	928001104013
TUV 11W	G5	3	11	34	2.6	0.33	11000	15	1FM	10x25 BOX	928002204013
TUV 16W	G5	5	15	43	3.9	0.40	11000	15	1FM	10x25 BOX	928002004013
TUV 20W	G5	1	20	45	6.0	0.45	11000	15	1FM	10x25 BOX	928003404013
TUV 6W 4P SE	4 Pins Single Ended	7	6.0	42	1.7	0.160	9000	20	UNP	32	927971604099
TUV 11W 4P SE	4 Pins Single Ended	8	11.0	34	2.6	0.330	9000	15	UNP	32	927971204099
TUV 16W 4P SE	4 Pins Single Ended	9	15.0	43	4.0	0.400	9000	15	UNP	32	927971404099



G5



4-Pin Single Ended

Dim.* no.	A max.	B min.	B max.	C max.	D max.
1	398	402.7	405.1	412.2	16
2	135.9	140.6	143	150.1	16
3	212.1	216.8	219.2	226.3	16
4	283.3	293	295.4	302.5	16
5	288.3	293	295.4	302.5	16

Dim. no.	A max.	B max.	C max.	D max.
7	244.1		251.8	19
8	244.1		251.8	19
9	320.3		328	19

* Dimensions (mm)