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EN2532 - Robot Design and Competition

Power source for Your Mobile Robot

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Battery type selecting: -

Rechargeable / Non-rechargeable: -

First, we must make a choice between Non-rechargeable or rechargeable battery. According to the phenomena, the power source of a mobile robot needs to be reusable. Hence there are lots of testing drives in the building procedure. So, it is cost effective to use a rechargeable battery. Rather than Non-rechargeable battery with regular replacement.

Battery model:-

The selected actuators are working in 12V (Maximum). There for power source voltage is preferred to 12V for better performance.

Then the choices are,

1. 12V NiMH battery pack
2. 12V lead acid battery pack
3. 11.1V 3 cells Lipo battery pack
4. 11.1V Li-ion battery

There are three choices in the 12V range, when we are looking for a battery, which used in mobile robot. It needs to be light weight as well as small. Instead of that the battery could be recharged quickly as such. Because of above mentioned aspects the 12V lead acid battery is drawn back.

Remaining choices are,

1. 12V NiMH battery pack
2. 11.1V 3 cells Lipo battery pack
3. 11.1V Li-ion battery

When it comes to the discharge rate, high power gear motors are power hungry. Drive motor stall current is rated as 5.6A. Two motors are used in the robot design to achieve the task. We need to select battery for the worst case. If we assumed that two motors are drawn stall current. The battery discharge rate must be high at least 12A. There for NiMH battery pack and Li-ion battery pack are drawn back.

Remaining battery pack is 11.1V lipo battery. This battery has higher current discharge rate within range 10C to 100C. And it is a lightweight battery. Therefore, 11.1V lipo battery is the most suitable battery. However, we should calculate capacity and the discharge rate of the battery.

Battery capacity and discharge rate calculation: -

Drive motors: -

Let us assume that, the maximum acceleration and expected speed of the robot will be 2.5cm/s^{-2} and 5 cm/s respectively. And the dimension of a wheel is approximately 5cm. The total weight of the robot is going to be 800g. Let us assume the coefficient of friction is 0.5, when we consider the worst case.

Let us calculate required torque for the acceleration by applying F = ma to the robot,

$F = m \times a$

$F = 0.8 \times 0.025$

$F = 0.02N$

If we assume mor than 0.02N force fore the needed linear force for the robot, we can achieve constant speed for the robot considering worst case.

Assume 0.03N as linear force.

Let us calculate required additional force to maintain constant speed at the ramp,

Ramp anlage is 20 degrees.

$F = mg \times \sin(\theta)$

$F = 0.8 \times 9.81 \times \sin(20)$

$F =$2.684 N

Considering above situations let's assume total force as 4N. Because we need to calculate considering worst. Air resistance may have effect on the robot

Then one motor should generate 1.4N force on the surface.

Let us calculate maximum torque needed from the motor,

$\tau = 2N \times 2.5 \times 10^{-2}$m

$\tau = 0.05Nm$

Needed rotational speed,

$\omega = \frac{V}{r}$

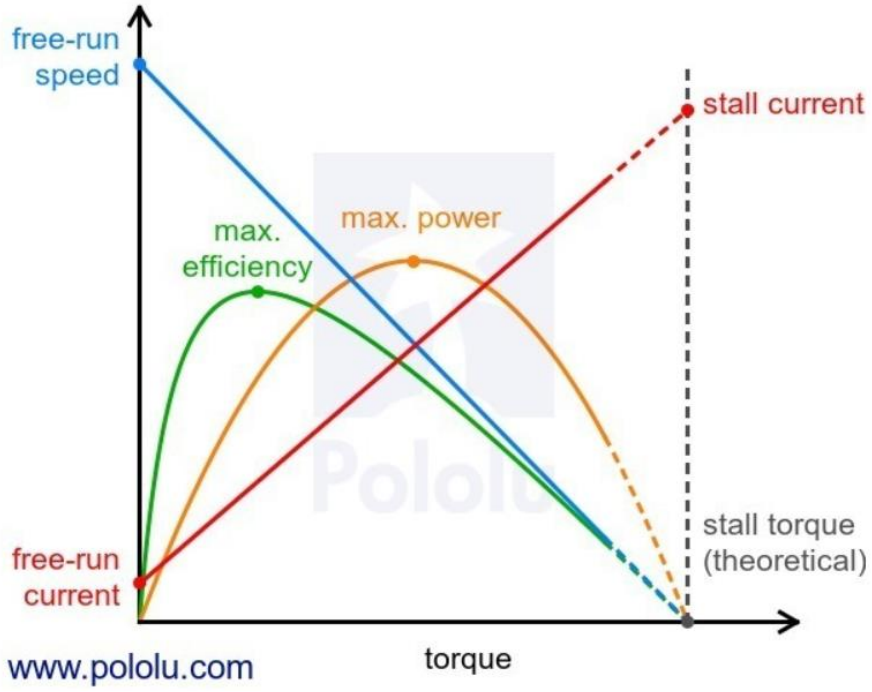
$\omega = \frac{5}{2.5}$

$\omega = 2rad/s$ z(120rpm)

Specification of the motor: -

Free-run speed @ 6V:	105 rpm[1]
Stall current @ 6V:	2800 mA[1]
Stall torque @ 6V:	80 oz·in[1]
Free-run speed @ 12V:	210 rpm
Free-run current @ 12V:	300 mA
Stall current @ 12V:	5600 mA
Stall torque @ 12V:	165 oz·in
Lead length:	8 in[2]
Motor type:	5.6A stall @ 12V (HP 12V)
Encoders:	Y

For pretty much any DC motor, the current, speed, power, and efficiency curves as a function of torque will look like those in the graph below (assuming motor voltage and temperature are constant)



Full datasheet is not given for this product. But rotational speed of the motor at the no load condition linearly very with voltage. So, we need to give motor voltage which can run 120rpm with load condition so free run speed of a motor should be more than 120rpm. And also stall torque should much higher than the required toque. So, assuming linearity we can calculate free run speed, free run RPM and stall torque for the given voltage

Assuming 10V,

Stall torque = (165 0z-in/12V) X 10V
= 137.5 oz-I (0.970963373Nm)

Free run rpm = (210/12) X 10V
= 175 rpm

Free run current = (300/12) X 10
= 250mA

Stall current = (2800/6) X 12
= 5600 mA

With the calculated load = 250 – (250/0.97) X 0.05

= 237 rpm

At the worst case if we can achieve this much of rotational speed. It will be better. At the 12V, the motors give a rotational speed more than needed. There for we can assume that tis current draw can consider as worst case.

Drawn current,

I = 250+ (5600-250)/ 0.97 X 0.05

=525.77mA

We have calculated require current for one motor as 525.77mA with assumption so, battery should draw 1.1A current for drive motors. So, considering worst case scenario and considering power consumption of motor modules, let assume 2A/s current for motor drive unit.

Battery discharge rate = 2A/s

Battery capacity for one-hour use = 2000mAh

Finally, we can calculate discharge rate of the battery**.** Maximum current which needed the robot can be stall current of the both high power motors. Let assume little bit more than stall current of both motors.

12A = Discharge rate X 2000mAh

Discharging rate = 6C

Arduino board and sensors: -

Arduino board and sensors does not consume much current relatively motors and other actuators. Average power consumption of an Arduino mega board is 0.27W. This value is given for idle situation. So, we assume all sensors and Arduino board consume 0.5W by considering worst case.

Let us calculate discharge rate and battery capacity per hour,

Discharging rate = (0.5/5) X 1000mA

= 100mA

Battery capacity = 100mAh

Servo motors power consumption: -

Specifications of needed motors.

MG90S

- Operating voltage -4.8 – 6 V DC
- Operating Current -10mA (at stopped)

  -250mA (No load)

  -360mA (Stall)

We planned to use 3 SG90 servo motors and 3 MG90S servo motors for now. In worst case scenarios, we need to prepare to supply highest supply voltage,

Needed Voltage = 6V

Let's assume that arm works with load for 15 minutes and without load for 15 minutes for every working hour of the robot.

Therefore, needed capacity for six servos(C),

MG90S

$C_1 = 3 \times \{5mA \times 0.5h + 140mA \times 0.25h + 350mA \times 0.25h\}$

= 375mAh

SG90S

$C_2 = 3 \times \{10mA \times 0.5h + 250mA \times 0.25h + 360mA \times 0.25h\}$

= 472.5mAh

Total needed battery capacity = 847.5mAh

Voltage = 6V

Selected Battery: -

Total capacity = 847.5mAh + 100mAh + 2000mAh

= 2947.5mAh

Discharge rate = 6C

Voltage = 11.1 V

According to above requirements, we can select one power source for above requirements. The selected battery is "Lithium Polymer (LiPo) Rechargeable Battery 11.1V 3300mAh 25C with xt60 connector"

Ref:

http://www.tpcdb.com/product.php?id=2304#:~:text=Arduino%20Mega%202560%20(Microcontroller)%20uses%200.27%20watts

https://www.robotgear.com.au/Product.aspx/Details/4646-47-1-Metal-Gearmotor-25Dx52L-mm-HP-12V-with-48-CPR-Encoder

https://www.microchip.lk/product/lithium-polymer-lipo-rechargeable-battery-11-1v-3300mah-25c-with-xt60-connector/