Power Source Selection

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1 Calculations

Note : Calculations were done assuming the worst case scenario where all the components are working at the same time drawing the respective maximum currents.

According to the calculations done in the ***Motor Selection*** stage (*in order to choose the motor*) we observed that a torque of 28.7472 $oz - in$ per one motor is more than enough to drive our mobile robot without any problem and corresponding required current will be lying in the range of 1000 mA -2000 mA. Therefore the maximum current that may be drawn by the motor can be approximated to be **2000 mA** which is the critical factor when choosing a battery. For other motors their stall currents are used while for the sensors and drivers their normal currents are used.

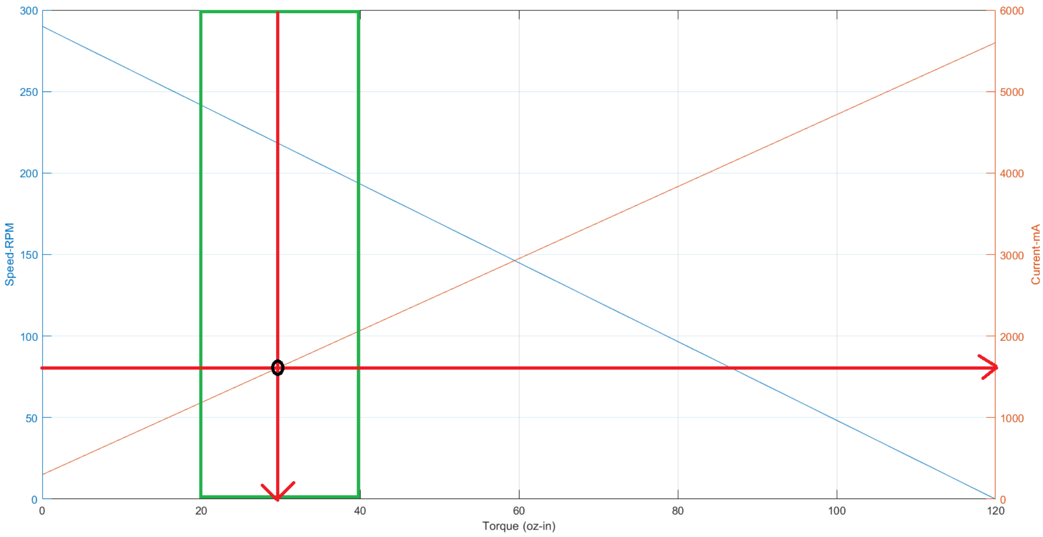

Figure 1: Torque vs. Speed and Torque vs. Current curves for Pololu Metal Gear motor 25Dx67L mm HP 12V with 48 CPR Encoder.

Component	Operating Voltage (V)	Max Current (mA)	Quantity	Total Current (mA)
Gear Motor	12	2000	2	4000
MG996R servo Motor	5	1400	2	2800
Arduino Mega2560(Rev3)	5	800	1	800
MG90S servo Motor	5	700	1	700
TCRT5000 IR Sensor	5	60	8	480
HC-SR04 Ultrasonic Sensor	5	15	3	45
L298N Motor Driver	5	36	1	36
MPU-6050 Gyroscope	3.3	4	1	4
TCS34725 Color Sensor	3.3	0.152	1	0.152
Total Current Consumption				8865.152

Table 1: Current Consumption of Components

Maximum current related to the Arduino Mega2560(Rev3) board was decided depending on the maximum allowable current (which is 800 mA) of its LD1117S50CTR Voltage Regulator IC.

For the convenience of further calculations let's assume that total current consumption is 9000 mA and we need to operate the robot with this current rate for half an hour.

Therefore the required capacity,

$$\begin{aligned} Reqired\ Capacity &= 9000\ mA * 0.5h \\ &= 4500\ mAh \end{aligned}$$

Since the battery should not be discharged more than 80% of its capacity due to safety issues the last 20% of its capacity must not be used and therefore the actual capacity a battery should have,

$$\begin{aligned} Actual\ required\ Capacity &= 4500\ mAh * 120\% \\ &= 5400\ mAh \end{aligned}$$

Required minimum discharging rate ($C\ value$)

$$\begin{aligned} Dischaging\ rate &= \frac{9000\ mA}{5400\ mAh} \\ &= 1.6667 \end{aligned}$$

Although the nominal voltage of the gear motor is 12V it is able to operate in any voltage in the range of 6V - 12V. Therefore we hope to provide about 9V to the motors . Therefore a Li-Po battery with 3 cells i.e 11.1V will be an ideal solution because we can provide that 9V requirement continuously by using proper voltage regulator.

$$Reqired\ Voltage = 11.1V$$

According to the above calculations we need to choose a battery with 11.1 voltage which has a capacity in the range of 5400 mAh with a discharging rate greater than 1.666C.

2 Battery Selection

Considering above requirement we selected XK Detect X380 11.1V 3S 5400mAh Lipo battery. This battery is designed with 3 cells placed in series.

Figure 2: Selected battery

2.1 Advantages and Specifications of our selection

We can identify several advantages including High energy density, high discharge rate, and no memory effect. Due to the small size, flat cell design, and the lightweight reduce the weight of our robot and ease the handling of the robot. There is no need for maintenance and have a long cycle life. Not like other batteries, this is pollution-free. Though this is expensive than other batteries, this is reliable and has high quality. With short circuit production function, it increases the safety.

Battery type	Lithium Polymer (Lipo Battery)
C rate	20C
Cell configuration	3S2P
Continuous Discharge	20C (108A)
Max burst rate	40C (216A)
Max volts per pack	12.6V
Min volts per pack	9V
Charge rate	1C (5.4A)
Dimensions	102mm*34mm*42mm
Weight	0.309 kg

Table 2: Specification of selected battery

2.2 Comparison

There are two main types of batteries, rechargeable, and non-rechargeable. As non-rechargeable batteries can use only once and have to replace we consider rechargeable batteries. We can identify Lead-acid, NiCd, NiMH, Li-ion, and Lithium-ion polymer as rechargeable batteries most commonly used.

	NiCd	**NiMH**	**Lead-acid**	**Li-ion**	**Li-ion polymer**
Cell voltage (V)	1.25	1.2	2	3.6	3.7
Overcharge tolerance	Moderate	Low	High	Very low	Low
Maintenance requirement	30-60 days	60-90 days	3-9 months	Not required	Not required
Cost per cycle (US $)	0.04	0.12	0.10	0.14	0.29
Fast charge time	1h	2-4h	8-16h	2-4h	2-3h
Energy density (Wh/kg)	45-80	60-120	30-50	110-160	100-130
Operating temperature (C)	-40 t0 60	-20 to 60	-20 to 60	-20 to 60	0 to 60

3 Drawbacks of other batteries

3.1 Nickel Cadmium (Ni-Cd)

- elative low energy density
- Memory effect
- Environmentally unfriendly (contains toxic metals)
- High self-discharge rate

3.2 Nickel Metal Hydride (NiMH)

- High self-discharge rate
- Memory effect
- Need to store in cool place as performance degrades with elevated temperatures
- High maintenance
- Have less life cycle
- Limited discharge current
- Generate more heat during charge

3.3 Lead Acid

- Low energy density
- Environmentally unfriendly
- Transportation restrictions
- Thermal runaway with improper charging

3.4 Lithium Ion

- Require protection circuit
- Aging even if not in use
- Heavier
- More explosive

3.5 Lithium Polymer

- Expensive
- Lower energy density
- Can be dangerous if handled incorrectly