LECTURE-8

Batteries

Introduction:-

Batteries are going to be our energy source for all practical purposes.

There are a number of variables to be considered when looking at the battery choice. For economy, we will almost certainly want to choose rechargeable cells. These are more expensive in terms of initial outlay but will soon pay for themselves after a few charging cycles.

Size is another important consideration. in general, larger cells last longer. Higher voltages require more cells. While the processor probably only needs a 5 volt supply at a few tens of milliamps, the motors and sensors may require high voltages and large capacities.

Take, for example, a stepper motor driven robot. For best dynamic performance, we may want to use a dozen or more cells to give a 15 or so volts. The steppers may draw 2 amps when fully energised and robot will need to stay running for at least 15 minutes. For this example, 600mAhr will just about do the trick but with no margin for error. Power management will become important under these circumstances. *Motors must be turned off when not needed, sensors will need to be pulsed for minimal periods and avoid too many flashing lights.* With this setup, an easy way to waste energy is in the voltage regulator for the processor. Dropping, say, 8 volts at 200mA is going to make the regulator pretty hot so be sure to heat sink it well.

If, on the other hand, we use DC motors, they may run perfectly well at only 7 volts, using 6 cells and drawing a mere couple of hundred milliamps. Now we can use half as many cells and make them a third the capacity. All this equates to major weight savings and improved performance.

Types:-

Battery size is really going to be determined by the choice of motor. Steppers will need higher capacity batteries than DC motors.

Nickel Cadmium (NiCd) cells are rechargeable with a terminal voltage of 1.2v per cell. They are capable of quite high current delivery. Selecting the correct type can

allow currents of several amps from an AA sized cell (not for long though). NiCds can be recharged between 500 and 1000 times with care and are cheap in the long run for the power to weight they offer. When selecting NiCds be careful as capacities vary quite considerable for similar looking cells.

NiMH cells are like more expensive NiCds and have, perhaps, twice the capacity but cannot deliver such high currents. Nevertheless, an AA cell can still deliver a couple of amps without too much strain. This really should not be a problem in a robot even if driving powerful stepper motors.

NiMH cells are available in all the same physical sizes as NiCd cells and can often be used as drop-in replacements. They share the same 1.2v terminal voltage per cell which is constant through most of the battery life the difference is in the capacity. It is not hard to find AA size NiMH cells with 1500mAh capacity and AAA cells at 700mAh.

Dry cells (alkaline) have higher voltages and relatively huge capacities - probably twice that of NiMH. Too expensive for use during development, they are not necessarily a bad choice for a competition run if desperate. But be careful for poor voltage regulation during discharge though. There are circumstances where dry cells, in spite of their apparent high capacity, appear to last less long than rechargeable cells.

Rechargeable alkaline manganese cells have recently become available at about twice the price of non-rechargeable alkaline cells. These boast at least 25 charge-

discharge cycles - more if they are not allowed to completely discharge before being recharged. Terminal voltage is 1.5v rather than the 1.2v of NiCd and NiMH cells. Special chargers are needed for these cells.

Charging of Batteries:-

It is a good idea, at the design stage, to make provision for recharging. Good designs incorporate a charging socket in the circuit to keep the batteries topped up or even give them a fast charge between runs. Even if it is done, it is probably sensible to make it easy to change the batteries in an emergency. There are plenty of design patterns with battery packs glued in. I would not be comfortable with that as cells can fail leaving me with a potentially serious rebuild at a critical time.

Both NiCd and NiMH cells can be recharged with the same equipment but one must be prepared to wait. The standard way of recharging these cells is with a constant current charger. They must not be plugged in to a car battery charger.

Standard charging of these cells is for 16 hours at a current of C/10 where C is the battery capacity. Thus, for a 700mAh battery pack, you would charge at 70mA for 16 hours. This is enough to bring the battery from fully discharged to fully charged. Clearly, partly discharged batteries will need less time. For all common NiCd and NiMH batteries, this charge rate can be maintained indefinitely without harming the battery.

When they reach full charge, the current going into the battery will just generate heat so a fairly easy way to see if your battery is recharged is to feel it. If it is noticeably warm, it is probably ready.

Constant current chargers designed for NiCd (and NiMH) charging are easy to find and relatively cheap. They do, however, expect to be used for removable cells which might not suit your needs.

Ideally, the charger will provide an electronically regulated current to the battery pack. We can make a charger from a plug-in 'wall wart' power supply, but it reduces the battery life. First, find a plug in supply which can comfortably give a voltage that is at least a couple of volts higher than the battery terminal voltage (1.2V per cell) at the desired charging current. Pick a current that is up to about C/4 without too much danger so long as one doesn't leave the charger running too long. At C/4 the time for a full charge would be about 6 hours. Now add a series resistor between the power supply positive and the battery. This resistance will have to be calculated from:

$$R = (V_p - V_b) / I_c$$

Where Vp is the power supply voltage under load, Vb is the battery terminal voltage and Ic is the charging current.

For example:

For a 6 cell battery pack with a terminal voltage of 6 x 1.2V = 7.2 V and to charge it at 100mA. The power supply is rated at 9V at 100mA. The series resistor will be

$R = (V_p - V_b) / I_c = (9 - 7.2) / 0.1 = 18$ Ohm

Remember that the resistor will be generating heat. In this case the heat generated will be about 180mW. Not too much but it would be sensible to choose a 1 Watt resistor to help ensure long life.

An LED placed in parallel with the current limiting resistor will provide a visual indication of charging. This can all be incorporated into the robot electronics so one can have the beast on charge while working with it. It would be sensible in this case to ensure that the charge rate is at least as great as the average current consumption of the circuit.

Main Concerns While Choosing a Battery:-

- Geometry of the batteries. The shape of the batteries can be an important characteristic according to the form of the robots.

- Durability. Primary (disposable) or secondary (rechargeable)

- Capacity. The capacity of the battery pack in milliamperes-hour is important. It determines how long the robot will run until a new charge is needed.

- Initial cost. This is an important parameter, but a higher initial cost can be offset by a longer expected life.

- Environmental factors. Used batteries have to be disposed of and some of them contain toxic materials.

- The weight of battery is crucial in robot. It is important to know the power-to-weight, energy-to-weight and capacity-to-weight ratios of batteries, the higher the better.