Radiometrix

04 November 2008

Hartcran House, 231 Kenton Lane, Harrow, HA3 8RP, England

Tel: +44 (0) 20 8909 9595, Fax: +44 (0) 20 8909 2233

Application note 024

Power for your module: Primary cells

By Myk Dormer - Senior RF design engineer, Radiometrix

First published in Electronics World magazine. April 2008 issue

High spec personal consumer electronics (your MP3 player, your cellular phone, your portable computer) are now usually powered by rechargeable batteries, with lithium ion and lithium polymer predominating over the older nickel hydride and nickel cadmium chemistries.

Simple consumer products (torches, cameras, remote controls) on the other hand are frequently still powered by primary cells, mostly alkaline or non-rechargeable lithium with a few niche applications using silver oxide.

The reasons for this difference are key to understanding the correct choice of power source for your low power radio project, and it’s generally simpler than you’d think.

Duty cycle and **self-discharge rate** are the most important issues to consider:

If a unit draws significant power for hours at a time (a portable computer, a music player), is turned on for most of the day (cellular phone), or draws very high currents periodically (power tools), then rechargeable batteries are far superior in terms of economy, and often in power density too.

But if a device is turned off for most of it’s life (a torch is usually used for tens of minutes at a time, a remote control or a camera for seconds), or if a long lifetime at very low (microamp) currents is desirable (alarms, clocks) then primary cells are the correct choice. They are cheaper to install initially, and their low self discharge rates allow the engineer to design for service life between battery changes measured in years.

Many ISM band applications require this sort of profile. Environmental sensors, security transmitters and data logging devices frequently need month or year-long battery life, at very low duty cycles (often less than a transmission per minute).

Hand held control devices (“keyfobs” and their larger, industrial cousins) frequently are operated on a daily (or even less frequently) basis, while fire alarms, personal distress alarms and other safety devices might be activated fully only once in their service life. This article concerns itself with the primary batteries used for these low average power drain applications.

Alkaline: By this we refer to the generic class of ‘one and a half volt’ common usage primary cells. Historically, these are ‘Leclanche’ or ‘zinc-carbon’ cells, although modern construction and chemistry has resulted in far higher performance units.

Commonly available in a small range of single cell sizes (AAA, AA, C and D) and a few higher voltage multiple cell designs (the small 9v PP3 is the most common survivor of what was once a far larger range of types, and small, very low capacity 6v and 12v tubular batteries are seen in older remote control designs) the alkaline cell is inexpensive, and capable of producing large pulses of current. Holders, boxes and clips for these common forms are available in a bewildering variety.

Shortcomings of this cell type include a relatively short shelf life (2-3 years), capacity degradation at low temperatures and at high current, unimpressive energy density and a non-constant terminal voltage (an alkaline cell delivers over 1.5v when new, but falls to 0.9v at the end of it’s life)

Although cheap, the cheapest examples ought to be avoided, as performance can be uncertain, and leakage of corrosive electrolyte materials far more likely. Most of the higher end manufacturer’s products are interchangeable, and have similar cell capacities (despite deliberately vague advertising claims by competing makers)

Lithium: There are two basic families of lithium primary cells: low discharge current lithium manganese dioxide or lithium polycarbon monoflouride (intended primarily for memory backup supplies) and the more useful, higher discharge current lithium thionyl chloride parts.

In addition to the standard alkaline sizes, lithium cells are made in 1/2 and 2/3AA, and the larger diameter 2/3A sizes. In addition to plain ‘holder’ type cells, versions are available with pcb mounting tags, and with axial wires. AAA lithium cells are not made, but there is a wide range of smaller ‘button’ cells, with the larger examples (often used in led torches) having useful capacities, and some ‘camera’ battery forms which do not have alkaline equivalents.

Characteristics of the lithium cells are: very long shelf life (10 years or more, with correspondingly low self discharge rates, of less than 1% per year), high terminal voltage (3.5 to 3.7v, reasonably constant throughout the battery life) and very wide operating temperature range (to at least -30 degrees, with many type going to below -55)

Shortcomings are: high cost (a good alkaline AA cell costs 40-60p, a lithium thionyl AA will be over £4), and strictly limited maximum current. Considerable care must be taken when selecting a lithium battery, as maximum discharge currents vary from maker to maker (typical maximum current for an AA cell is 55-100mA, but some are as low as 20mA) Lithium batteries also suffer from a perceived chemical hazard, although modern examples are **not** prone to exploding under overload, as some earlier types were.

A recently introduced variant on the basic chemistry delivers much higher maximum current, of over 5A for an AA type, at 4.1 volts. These parts are very expensive.

Other: While the two preceding categories cover the majority of primary cell applications, there are a few others:

Lithium iron disulphide. A battery with the characteristics of a high current lithium thionyl cell, but a terminal voltage of 1.5v. These are sold as deliberate ‘upgrades’ for more demanding alkaline cell applications, but are considerably more costly. Only seen in AA and occasionally PP3 sizes.

Silver oxide. Usually limited by the price of silver to button cell sizes (watch, or hearing aid batteries) the basic chemistry has a terminal voltage of 1.55v and a flat voltage/discharge curve. Peak current is better than a similar sized lithium, but energy density is somewhat lower. Self discharge is negligible and shelf life is long.
Avoid confusion with alkaline cells sold in the same sizes (for example, an SR44 is a silver oxide part, but the identical looking LR44 is a simple alkaline)

Zinc/air. Optimum for constant moderate current drain applications, these cells are rarely seen outside of hearing aid applications. They require oxygen from the air, and once the ‘seal’ is removed their self discharge is very high (unsealed shelf life is in months).

Mercuric oxide. No longer used, owing to the toxicity of the mercury, these cells were functionally equivalent to modern silver oxide cells but had a very constant 1.35v terminal voltage.

So which battery should be used ? As usual, there is no absolute rule:

If cost is the overwhelming consideration, use alkaline and work around it’s limitations.
If maximum performance, or a specific operating spec (lifetime, operating environment, minimum size) is required, then use lithium (or occasionally silver oxide) and accept the bigger price tag.

Realistically, you’ll always be in a compromise between these two extremes. But if it was easy, you wouldn’t *be* an engineer, would you?

Radiometrix Ltd
Hartcran House
231 Kenton Lane
Harrow,
Middlesex
HA3 8RP
ENGLAND
Tel: +44 (0) 20 8909 9595
Fax: +44 (0) 20 8909 2233
sales@radiometrix.com
www.radiometrix.com

Limitation of liability

The information furnished by Radiometrix Ltd is believed to be accurate and reliable. Radiometrix Ltd reserves the right to make changes or improvements in the design, specification or manufacture of its subassembly products without notice. Radiometrix Ltd does not assume any liability arising from the application or use of any product or circuit described herein, nor for any infringements of patents or other rights of third parties which may result from the use of its products. This data sheet neither states nor implies warranty of any kind, including fitness for any particular application. These radio devices may be subject to radio interference and may not function as intended if interference is present. We do NOT recommend their use for life critical applications.

The Intrastat commodity code for all our modules is: 8542 6000