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VARTA micro batteries for wireless telecommunication devices

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Abstract

Newly developed nickel–metal hydride (Ni/MH) micro cells that are capable of high rates, meet the requirements of main power sources for modern wireless telecommunication devices, like GSM hand phones, PDAs and others. Besides having the capability to give high continuous and pulse discharge currents, they also ensure the realisation of a device with slim design and low cost.

For the back-up of the RTC function, a lithium-ion cell based on the carbon–manganese dioxide system provides high reliability by having a long cycle life and complete tolerance to deep discharge.

For MBU (which require higher rates), a Ni/MH cell only 2 mm thick is now being introduced. Other wireless devices, like headsets for comfortable use of mobiles whilst driving, wireless mice and keyboards and the upcoming ''Bluetooth'' technology will need suitable power sources. Besides the rather high currents, which exclude low-power lithium systems, miniaturisation is limiting the space available for the battery.

Some concepts using Ni/MH micro batteries will be discussed in this paper.

Keywords: Nickel–metal hydride batteries; Lithium-ion batteries; Portable communications; Miniaturization

1. The 450 and 600 mAh Ni/MH cells

The design of new GSM phones, PDAs and other wireless devices is driven by the need to minimise dimensions as well as weight and, being a mass market consumer product, by continuous cost reduction.

To power these devices from a very fast growing market, Varta has developed two new Ni/MH cells, the V450HR and V600HR, with nominal capacities of 450 and 600 mAh

The main features of these cells are:

- slim design only about 5 mm thick;
- high short-duration discharge current capability, up to 10 C;
- fast charge capability, 1 C charge with $-dV$ termination;
- low self-discharge characteristics, ~20% per month at room temperature;
- long service life;
- attractive price/performance ratio;
- environmentally friendly: 0% lead, 0% mercury and 0% cadmium.

A successful GSM phone requires a total thickness of <20 mm so a slim battery is needed. The alternatives, prismatic Ni/MH or Li-ion cells (the latter with an advantage in weight) are rather costly.

The V450HR cell gives the design engineer the possibility of using a battery pack with a total thickness of 6–7 mm, but at a reasonable cost. A 3.6 V pack, using three V450HR cells to give dimensions of 34 mm × 24 mm × 5 mm, in a plastic case or as a shrink–sleeved version can have either wire connectors or, to save costs, embedded directly onto the PCB of the phone.

Improvements in the chip technology have resulted in very long standby times, consequently the user usually needs only one battery and the option of a second battery is no longer needed. In addition the battery lifetime is improved, so this embedded option can used. The battery is shown in Fig. 1.

Micro (button) cells are usually regarded as low power cells. The 450 HR cell was developed also to discharge at high currents. Its design, with a multi-electrode stack, enables it to be pulse discharged at up to 10 and 5 C continuously. Therefore, it can be used in GSM phones.

The performance of the V450HR under different loads is illustrated in Fig. 2. Cell impedance is about 2 mΩ and that of the complete pack is far below 10 mΩ. This ensures sufficient operational run time, even for digital devices with high pulse currents. In talk mode, GSM mobiles require up to 2 A pulses and standby currents in the range of 50–

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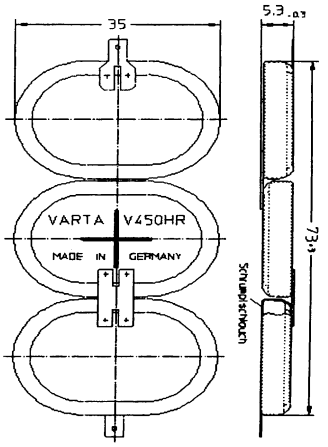

Fig. 1. Embedded version of three-cell V450HR Ni/MH cell.

200 mA, and under these conditions this battery provides more than 90% of the nominal capacity of 450 mAh (Fig. 3).

For convenience of use, a mobile phone requires a short recharging time. This battery can be recharged with currents up to 1 C, the decrease of the voltage ($-dV$) when the battery is fully charged being used for termination, to avoid overcharging with such high currents. This performance is comparable to cylindrical and prismatic Ni/MH cells and the charging characteristic of the 450HR is shown in Fig. 4.

Compared to other Ni/MH micro batteries showing an extreme low self discharge rate of only 20% capacity loss after 1 year, the multi-electrode design of this high rate cell resulted in a self discharge of 20% per month.

As in other button-type Ni/MH cells, a pressure relief vent is integrated at the bottom of the cell to avoid the built-up of high pressure inside the cell arising from abusive conditions. Under normal conditions the cell remains sealed, and even under abusive short-circuit conditions no activation of the safety vent is noticed. This cell offers the designers of wireless telecommunication devices an attractive option to realise a slim design without loosing the target of cost reduction.

2. Micro Li-ion cells for RTC back-up in GSM phones and pagers

When the main battery is changed or completely discharged, the RTC (or other) function of the device has to be backed-up by an additional battery. This requires a 3 V supply, but at very low currents in the range of micro amperes. The size of this battery should be as small as possible and a good cycle life even with deep discharges is required. For this purpose Li-ion cells, based on a carbon anode and a manganese dioxide cathode have been developed. Two sizes, both having a diameter of 6.8 mm and a height of 2.1 (the MC621) and 1.3 mm (MC614) enable the engineer to design in a 3 V back-up cell with minimum space requirement. The smaller cell, with tags, has a maximum height of 1.65 mm, which is a suitable size for mounting onto the PCB of many mobile phones.

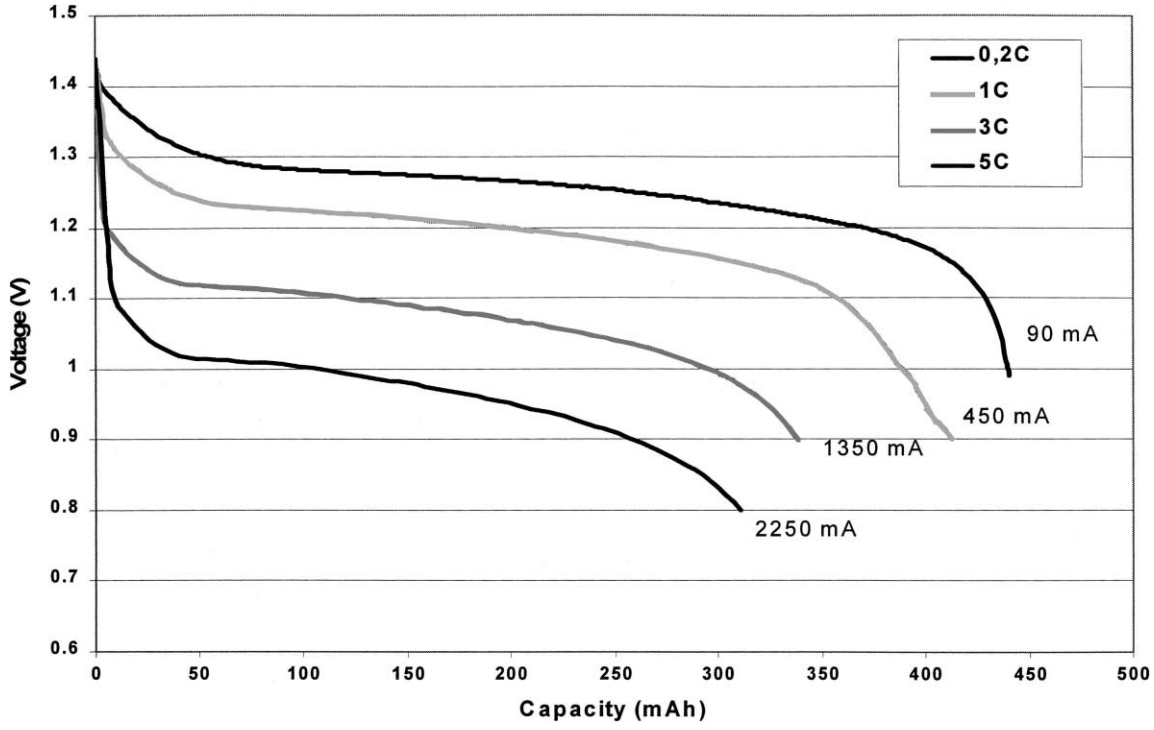

Fig. 2. High rate performance of V450HR Ni/MH cell.

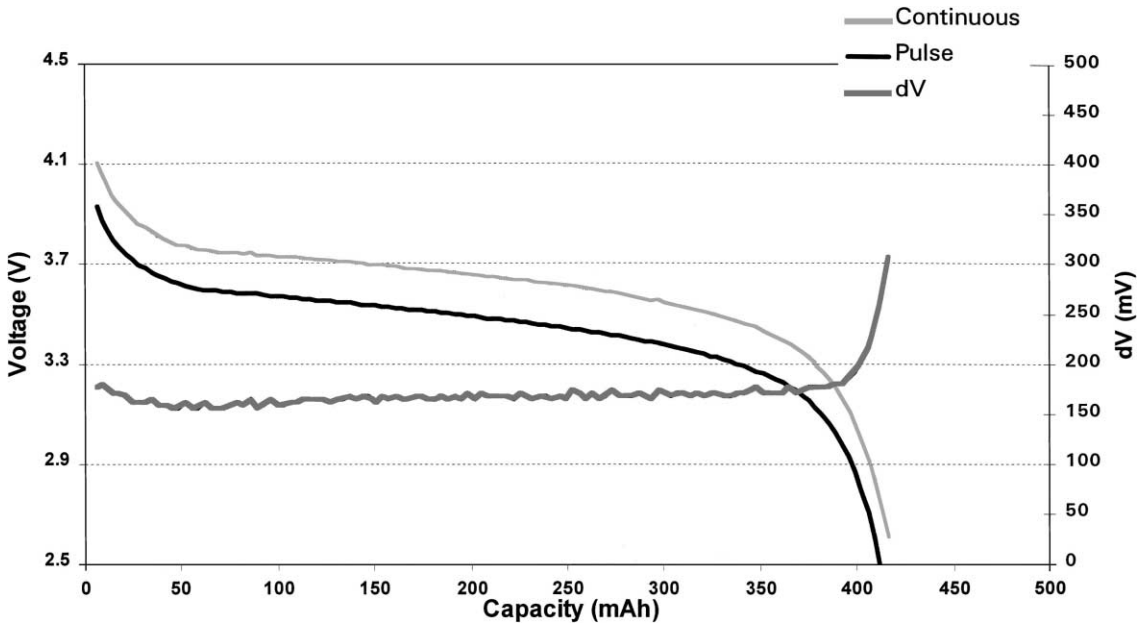

Fig. 3. GSM pulse discharge test on a three-cell V450HR battery. Repetitive regime: pulse, 1800 mA/0.6 ms. Continuous: 200 mA/4 ms.

The main advantages of these cells are:

- excellent cycle life (>200), even at 100%DOD to 1.8 V;
- insensitive to deep discharge, dischargeable down to 0.0 V (cycle life at 100% DOD to 0.0 V > 100);
- wide operational temperature range (−10 to +60°C);
- very low self discharge, <10% per year at room temperature;
- no safety risk, no metallic lithium is present;
- evironmentally friendly.

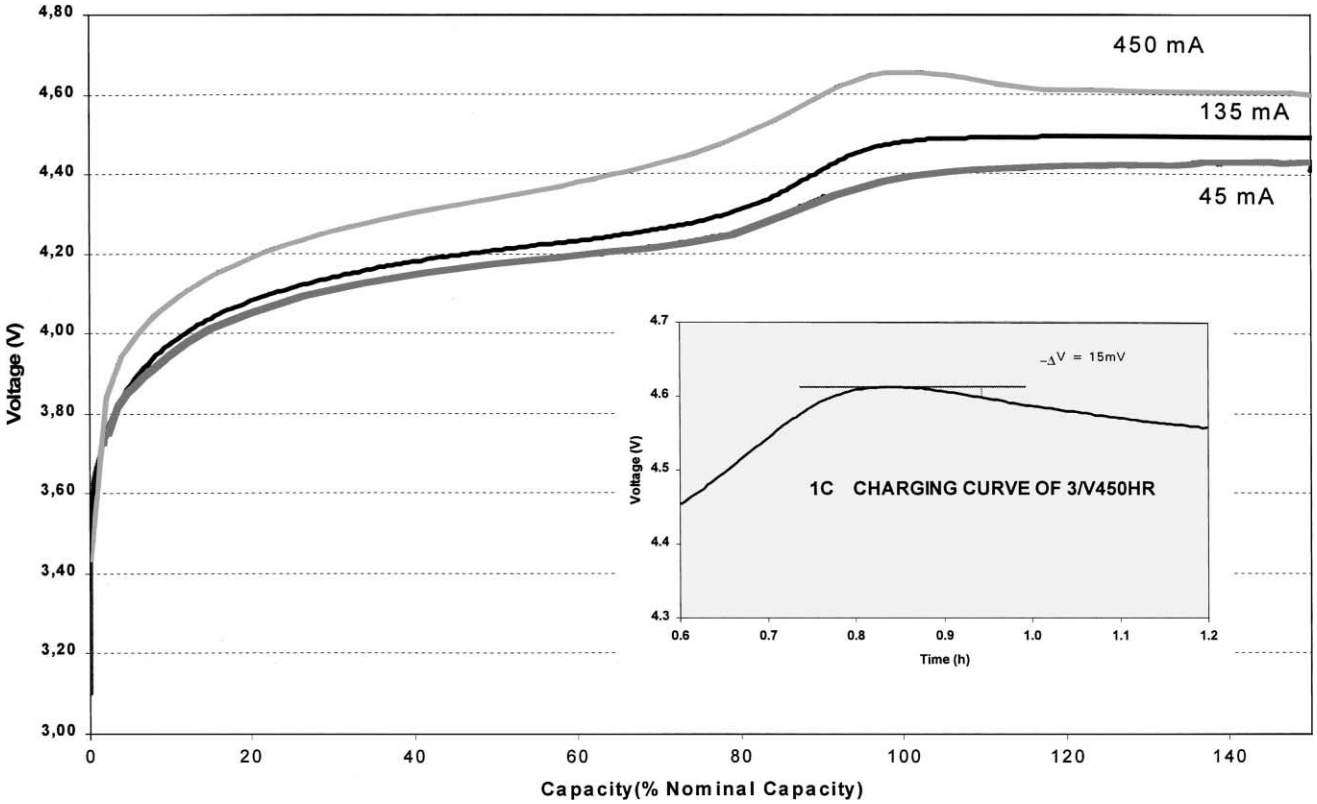

Fig. 4. Charging characteristics of a three-cell V450HR battery.

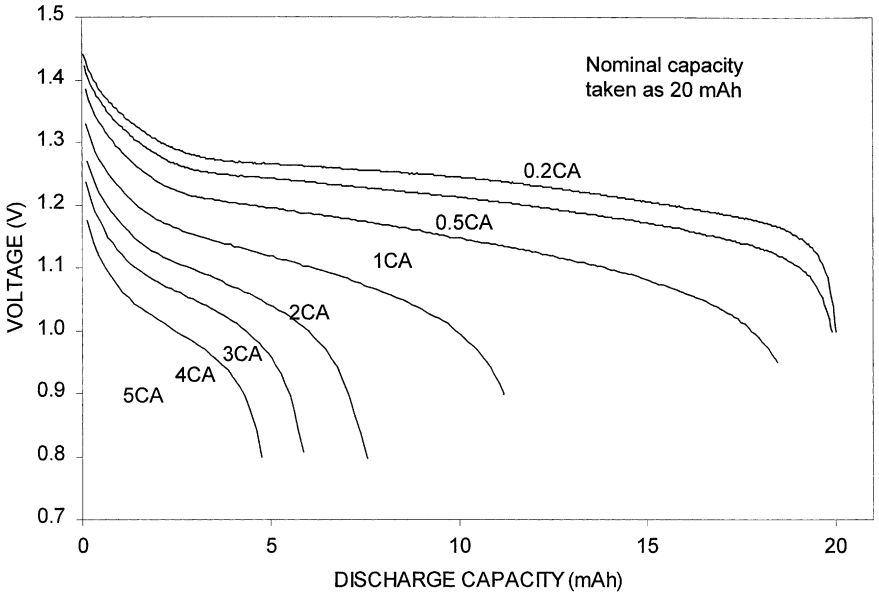

Fig. 5. Discharge curves for a V20HR cell.

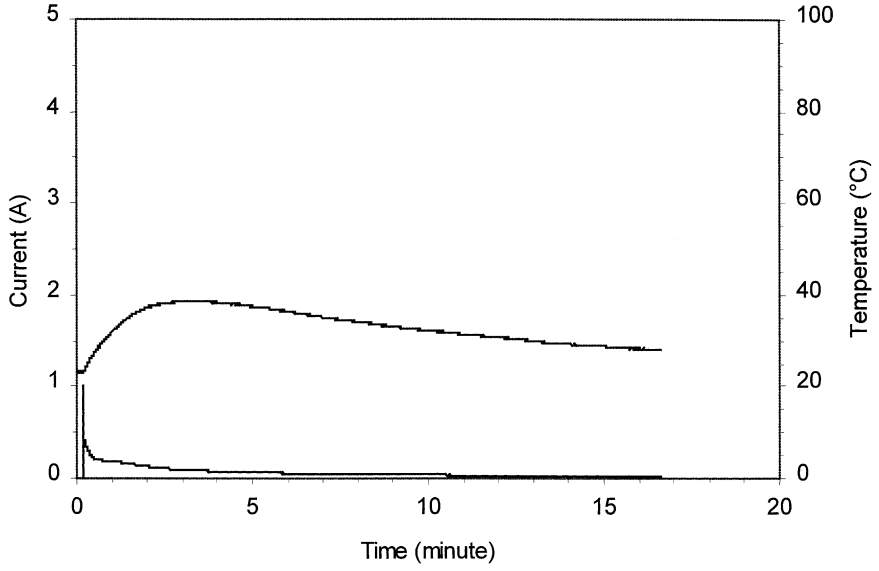

Fig. 6. Short circuit behaviour of a V20HR cell.

	V15H	V40H	V80H	V150H
Diameter/Length (mm)	$11.5_{-0.1}$	$11.5_{-0.2}$	$15.5_{-0.1}$	$25.6_{-0.2}$
Height (mm)	$3.1_{-0.2}$	$5.35_{-0.3}$	$6.0_{-0.2}$	$5.9_{-0.25}$
Width (mm)	-	-	-	$14.1_{-0.2}$
Weight, approx. (g)	1.3	1.7	4	6

Fig. 7. Range of small Ni/MH button cells.

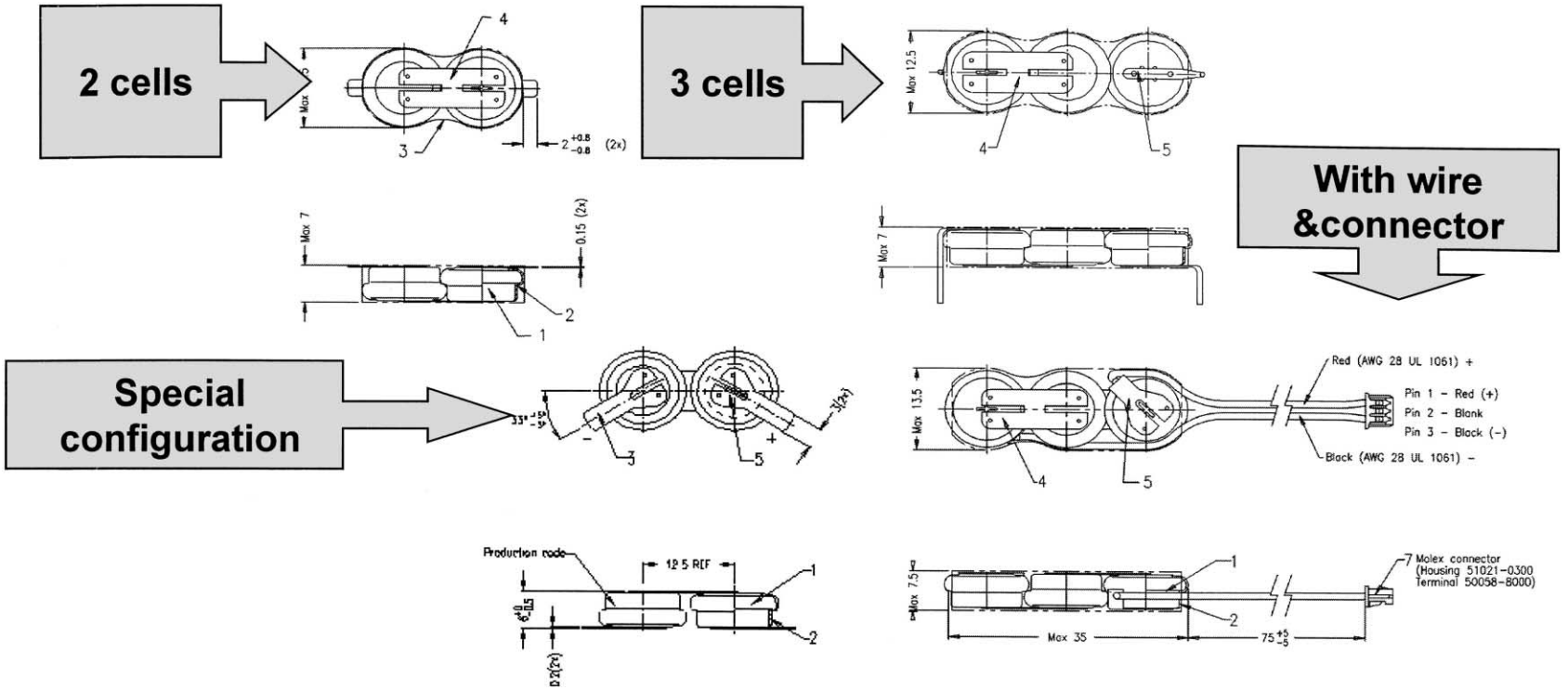

Fig. 8. Design concepts for button cells.

The cycling performance, even under deep discharge, is an especial criterion of enhanced reliability from this electrochemical couple compared to cells having lithium–aluminium alloy as their anodic material.

No protection against deep discharge is necessary, whilst charging can be done by using constant current up to 3.4 V (termination at this voltage) or directly from 3.4 V with a current limiting resistor.

3. V20HR-a back-up battery which meets the requirements for high rate capability and very slim design

For those applications which need more power for back-up, a Ni/MH micro battery, type V20HR, is now being introduced. This extremely slim cell, of thickness 2 mm, ensures a flat design for the device.

PDAs with additional cellular functions (GSM/CDMA) need to back-up memories when the main battery is changed or in case of failure. For this, a battery needs to provide currents in the range 10–20 mA. Advanced super-slim notebooks require, for RTC and/or bridging, a battery that is as flat as possible.

This new cell fulfils both demands. Having a nominal capacity of 20 mAh, it can be discharged up to the 5 C rate, and at 1 C (20 mA) it still delivers 18 mAh. The rate capability is shown in Fig. 5.

Besides these features, the V20HR cell shows the following characteristics

- charging can be done in a ''normal'' mode at 0.1 C (2 mA) within 14–16 h, or accelerated at the 0.5 C (10 mA) rate for 3 h after the cell has been fully discharged;
- continuous overcharge is possible at 2 mA (0.1 C);
- the expected life time under trickle charge of 0.6 mA is up to 6 years at 20°C and up to 3 years at +45°C;
- the cell can be discharged over the temperature range −20 to +65°C;
- the self-discharge rate is around 10% per month at room temperature;
- if short-circuited, the temperature increase is small. Fig. 6 shows an increase of about 12°C for a six-cell battery.

Depending on the requirements for MBU functions, very slim Li-ion or Ni/MH cells are available for back-up power and so help designers keep their devices small, yet reliable when the main battery is disconnected.

4. Main batteries for other wireless telecommunication devices

Other wireless devices like headsets for comfortable (and legally allowed) use of mobile phones whilst driving a car, wireless mice and keyboards, also the upcoming ''Bluetooth'' technology will need suitable power sources. These devices need rather high currents, so Li-ion rechargeable coin cells are not suitable.

Fig. 7 shows a range of Ni/MH button cells that combine light weight (for 3.6 V batteries between 5.5 and 19 g) with small form factors, have the ability to meet the current drain requirements, are ''robust'', safe under abusive conditions and are environmentally friendly.

The main four types have capacities of 15, 40, 80 and 150 mAh. They can be designed into wireless devices or are under consideration. All can be continuously charged at the 0.1 C rate without capacity degradation. They loose only 20% of their capacity by self discharge during a 1-year storage. They will recover after deep discharge and when short circuited, their temperature will rise only by 10–15°C.

For voltage multiples of 1.2 V, single cells can be assembled in flat or stacked configurations, being connected to the device by tags or wire connectors and so conforming to the design criteria. For wireless headsets, the battery can be split, and mounted in different sections of the device to realise a comfortable weight balance. To provide a longer running time, a spare battery is often a consideration, which is charged in the base station when the other pack is in use. For reference, some battery design concepts are shown in Fig. 8.

5. Conclusions

Today's micro (or button) cells are not only for low rate applications, as they are suitable for use as main batteries in devices with rather high current drains. These new high-rate cells can power GSM phones. Depending on the current profile, Li-ion or Ni/MH cells are available to ensure MBU functions. For upcoming wireless telecommunication devices, including mobile phones, the designer will find a potential solution to his power requirements with the micro batteries described in this paper.