NiMH and NiCd battery management

To allow the high performance of battery packs using high-capacity rechargeable cells to be fully exploited, Philips has developed a range of highly integrated single-chip battery management circuits which safely control fast charging and indicate the state of charge of NiMH or NiCd batteries.

Keywords: battery management, NiMH, NiCd

As people become increasingly reliant on rechargeable-battery-powered products such as cordless/mobile telephones, portable computers and pagers, there is an urgent need to exploit new and refined technologies to maximize the available operating time between battery charges and to reduce charging times. To meet this need, the power consumed by system components such as ICs, display devices and RF modules is being continually reduced, and battery manufacturers have introduced several types of high-capacity rechargeable cells.

To allow the high performance of battery packs using high-capacity rechargeable cells to be fully exploited, Philips has developed a range of highly integrated single-chip battery management circuits which safely control fast charging and indicate the state of charge of NiMH or NiCd batteries.

Rechargeable batteries

Apart from being small, durable, lightweight and efficient, an ideal rechargeable battery must also be safe, reliable, environmentally friendly, and able to operate for long periods between charges.

To meet these requirements, manufacturers of rechargeable batteries developed NiCd (nickel-cadmium or nicad) cells which are in widespread use because of their good price/performance ratio. However, to achieve higher energy densities, thereby decreasing size and weight, battery manufacturers have recently introduced the NiMH (nickel metal-hydride) cell onto the high-volume mass market. Most NiMH cell manufacturers use Philips patents to achieve the higher energy densities in an environmentally acceptable manner. The main advantages of NiMH cells are:

- They store 30% to 50% more energy per unit volume than NiCd cells.
- They are compatible with NiCd and primary (disposable) cells. All three types have the same voltage discharge profile.
- They are safer for the environment than NiCd cells because they do not contain poisonous cadmium.

Lithium ion (Li-ion) is another technology innovation especially intended for the high-end portable market. Although Li-ion offers potentially higher energy densities, the drawbacks of today's Li-ion batteries are their high price and the complex charging electronics they require to prevent cell degradation or explosion.

Even further in the future, zinc-air and lithium-polymer batteries will become available for mass-market portable consumer applications.

Battery management

Despite all the advances in battery technology, continued reliable operation of rechargeable batteries often still relies on uncontrolled trickle-charging with a stand-alone battery charger, or from the mains supply via simple circuitry inside the equipment. This charging method causes much inconvenience because the user never knows how much energy is left in the battery until it is fully discharged and the equipment ceases to work. The equipment must then be plugged into the mains supply to be recharged for up to 16 hours before re-use.

It is possible to recharge a battery faster by increasing the charging current. However, this can be hazardous and can cause permanent damage unless the battery voltage, temperature or the charging time is monitored so that the charging current can be automatically switched-off or reduced at the appropriate time (battery management).

Battery management improves the user-convenience of portable equipment by decreasing the battery recharge time without endangering their reliability, reducing their life or compromising safety. It involves using electronic control and monitoring circuits to accurately measure the charge condition of the battery, and to automatically control dedicated fast-charge/trickle charge circuitry to ensure optimum charging.
Battery management consists of two main groups of functions:
- state of charge monitoring and display;
- charging current control with safety precautions by an SMPS or linear series regulator.

Single-chip solutions

It is possible to use a microcontroller-based system for battery management but, unless a microcontroller already exists within the equipment which contains the charging electronics, this solution is space consuming and is not economically feasible. The microcontroller would require a regulated power supply and a crystal, and would have to work together with an SMPS control IC for controlling the battery charging current. This two-chip arrangement would be far too costly for most consumer products, especially those with a sparse rechargeable battery pack, or for a stand-alone 'intelligent' desktop charger, both of which need the charging electronics to be separate from the equipment being powered.

The Philips range of highly integrated single-chip battery monitor and control ICs are well-proven and require few peripheral components. They provide a more reliable, smaller, less costly and easier to implement alternative to microcontroller-based systems. On a single chip, they perform all the functions for battery management in 'intelligent' chargers for equipment powered by small rechargeable NiMH or NiCd batteries.

The company has also solved the problem of the user not knowing how much energy is left in the battery, through remaining energy indicator ICs for use in 'intelligent' applications or 'intelligent' batteries powering various types of load.

BEHAVIOUR OF NiMH AND NiCd RECHARGEABLE BATTERIES

In general, the same principles apply to charging systems for NiMH or NiCd cells, and constant current charging is recommended. There are, however, differences in the electro-chemical effects that occur during charging of the two types of cell that raise the following three important considerations for designers of electronic NiMH cell charging systems:

- The voltage drop that occurs after NiMH cells are fully charged is less pronounced than that for NiCd cells (Figure 1). This is significant for NiMH charging systems using $-\Delta V$ or $V_{peak}$ detection for terminating the charge. To ensure precise $-\Delta V$ detection, Philips battery management ICs for 'intelligent' chargers use digital filtering and close-tolerance $-\Delta V$ detection with the charge current switched-off. This 'currentless' $-\Delta V$ detection allows reliable and accurate measurement of small voltage drops to prevent over-charging.

- The lower tolerance of NiMH cells to overcharging is of particular importance for charging at rates between C (the '1-hour' rate) and C/6, or trickle charging with continuous low current.

- Unlike NiCd cells, which absorb heat during charging, NiMH cells release heat (Figure 2). Furthermore, the temperature of a battery can be increased by external influences such as exposure to strong sunlight and to the heat dissipated by the charging system. A further temperature-related consideration is that battery manufacturers sometimes specify an upper temperature limit which is higher or lower than 45°C. For these reasons, fast-charging systems for NiMH cells must incorporate time-out and thermal protection to avoid reduction of...
battery life due to overcharging causing the upper temperature limit of the battery to be exceeded. To avoid the growth of dendrites (crystalline fingers) on the battery electrodes causing partial or total short-circuits, trickle charging should be with a high pulsed current rather than with a low continuous current.

All the Philips battery charging management ICs mentioned in this application note have been designed with these considerations in mind and are suitable for use with NiMH or NiCd batteries.

**CHARGE TERMINATION METHODS**

Because of the dangers of overcharging a battery, and the different charging requirements for NiMH and NiCd batteries, an electronically controlled charging system should incorporate more than one method of determining when to terminate fast-charging, thereby eliminating all possibility of damaging the battery due to non-termination of a fast-charge.

The simplest method is to time the charge, but it is also possible to monitor the voltage and/or temperature characteristics of a battery to determine when to automatically switch-off the fast-charge current. The advantages and drawbacks of the main fast-charge termination methods will now be examined to show why it was chosen to implement the $\Delta V$ method of determining the fast charge termination point in battery management ICs for 'intelligent' chargers. These ICs also facilitate battery temperature sensing as a protection measure to switch-off the battery when the temperature is too cold or too hot. Other protective measures are time-out and under/over voltage sensing to detect open/short-circuit batteries.

**Timed charge termination**

The simplest method of determining when to terminate the fast-charge is shown in Figure 3. It involves using an electronic timer to switch off the charging current after a present charging period. This method is not recommended as the primary means of terminating a fast-charge because it could result in serious overcharging if an almost fully charged battery were to be put on charge. However, time-out protection should be provided as a backup for the primary charge termination method. An electronic timer should also be used to terminate an 'overnight charge'. This is because it is essential to use charge termination for an NiMH battery when charging it at rates between C/4 and C/10.

**Temperature-based charge termination**

Temperature-based termination of a fast-charge when the battery reaches an absolute preset temperature ($T$) is not recommended because it does not compensate for fluctuations of ambient temperature. A cold battery would therefore be overcharged and a hot one would be undercharged.

Alternatively a method that measures the difference between the ambient and battery temperatures ($\Delta T$) could be used. Again, this method is not recommended since the charge termination point would have to be battery/application-specific. Battery-specific influences arise because the difference between the ambient and battery temperatures depends on many factors such as the size of the cells, the number of cells in the battery and its shape. Application-specific influences include increased temperature of the battery if the equipment is exposed to strong sunlight, or if the batteries are installed in the equipment where they absorb heat from the charging electronics.

Furthermore, temperature-based fast-charge termination is not always practical because some battery packs do not include an integral NTC thermistor.

Temperature-based fast charge termination is not used by Philips battery-management ICs. Only temperature range protection is used. Figure 4 shows an example in which the temperature range protection has been set to restrict fast-charging to the temperature limits of 10°C and 40°C.

**Absolute cell-voltage-based charge termination**

Figure 5 shows the charging current being switched off when the cell voltage reaches the fully charged level (1.5 V). This method is not recommended for fast-charge termination because the fully charged cell voltage...

![Figure 3 Terminating fast charging after a preset time](image1)

![Figure 4 Fast-charging restricted to the temperature range 10°C to 40°C](image2)

![Figure 5 Terminating the charge at the fully charged cell voltage](image3)
NiMH and NiCd battery management

![Graph showing charge termination after sensing the negative-going slope (−ΔV) of the cell voltage]

Figure 6 Charge termination after sensing the negative-going slope (−ΔV) of the cell voltage

varies inversely with temperature and the age of the cell. As shown in Figure 5, there is even a possibility of continuous overcharge at high temperatures.

−ΔV-based charge termination

Figure 6 shows the method used for terminating fast-charging in battery management ICs for 'intelligent' chargers. Here, the fast-charging current is switched off by detecting the negative-going slope of cell voltage (−ΔV) that occurs after the cell is fully charged.

The main advantage of using −ΔV sensing as the main charge termination method are:

- Compatible with NiCd battery-packs which often do not include a temperature sensor.
- No problems with external non-battery-related thermal effects which can effect charging systems with temperature-based charge termination. Such effects include:
  - charger in the sun
  - cold battery in hot/cold charger
  - hot battery in hot/cold charger
- Not influenced by EMI from sources such as SMPS charger.
- No problems due to different types of thermal sensors in NiMH battery packs.

There are, however, some potential drawbacks associated with this method of fast-charge termination. As shown in Figure 1, the negative-going slope of the cell voltage is less pronounced for NiMH batteries than it is for NiCd batteries. Also, the slope of the voltage decrease is inversely proportional to temperature. These effects combine to make it difficult to use traditional methods to differentiate between detector noise and normal voltage fluctuations. These problems are avoided by the −ΔV sensing circuitry in Philips battery management ICs for 'intelligent' chargers by filtering/sampling the battery voltage in a sample-and-hold circuit with the charge current switched off and then digitizing it before detecting −ΔV with 12.5-bit accuracy.

EXTRA SAFEGUARDS FOR FAST-CHARGE TERMINATION

Additional considerations that must be taken into account to guarantee long battery charge/discharge cycle-life are:

- Timed fast-charging cut-off should be used to back up the −ΔV charge termination.
- The fast-charge circuitry should incorporate load identification to detect if a battery is short/open-circuit or damaged.
- Thermal protection should be provided because charging at less than 15°C may cause a rise in internal pressure and result in venting. Charging at above 30°C may cause premature ageing of internal components. Both phenomena will reduce the life of the battery. The following example indicates typical temperature limits for charging NiMH and NiCd batteries:
  - C (fast) rate:
    - +10 to +40°C
  - C/4 to C/16 (standard) rate:
    - +5 to +45°C max.
    - +15 to +30°C recommended
  - C/20 to C/40 (trickle) rate:
    - +10 to +35°C.

The company's battery-management ICs for 'intelligent' batteries incorporate facilities for implementing all these extra safeguards.

BATTERY CHARGING-RATE CONSIDERATIONS

C-rate fast-charging

If the previously described differences between the behaviour of NiMH and NiCd batteries, and the recommendations regarding charge termination are taken into account, both types of battery can be fast-charged at the one-hour rate (C-rate). The optimum fast-charging regime is to charge at the C-rate for 1 to 1.5 h, and to use −ΔV detection to terminate the charge.

Since both NiMH and NiCd batteries self-discharge at about 1% each day, fast charging should be followed by trickle charging at C/20 to C/40 to maintain the battery in the fully charged state until it is needed for use.

C/4 to C/16 standard-rate charging

NiMH and NiCd batteries can be charged at the C/4 to C/16-rate for 4 to 16 h which can be very convenient for 'over-night' charging. However, unlike NiCd batteries, NiMH types require automatic charge termination to prevent severe overcharging at these charging rates. Unfortunately, the charge voltage and temperature profiles for NiMH batteries at these reduced charging rates are too flat to allow the use of voltage or temperature-based charge termination. Simple timed charging can be used, but this could expose the battery to significant overcharging and reduce its cycle life.

Philips low voltage CMOS IC 74LV4799N(D) is an economy timer for NiCd and NiMH chargers which provides a good solution to the problem. This IC allows battery charging for a period which is inversely proportional to the actual energy remaining in the battery which it calculates by timing the charge/discharge periods. It then automatically switches to trickle charging to compensate exactly for the self-discharge of the battery.

ELECTRONIC BATTERY-CHARGING SYSTEMS

Configuration

An electronic battery charging system comprises the functional blocks shown in Figure 7. The power module, which is the source of the charging current, can be anything from a simple
transformer/rectifier circuit for a 16-h continuous current trickle charging system, to a switched-mode power supply (SMPS) for advanced 15-min boost charging, up to 2 h fast charging, and unlimited duration pulsed trickle charging. The various stages in the charging profile (e.g. fast-charge or trickle-charge) are selected and controlled under supervision of the control module which monitors the state of the battery and/or the load.

The features most important to users of portable equipment with rechargeable batteries are:

- Sufficient power to operate the equipment must always be available from the battery.
- The charge state of the battery must be known at all times.

To provide these features, and to ensure the longest possible cycle life is attained for a rechargeable battery, the charging system should use battery management.

**Battery management**

There are two major approaches to battery management:

- An ‘intelligent’ charger in which the battery charging electronics are separate from the equipment containing the battery pack. An example of this configuration is a standalone desktop charger.
- An ‘intelligent’ battery (for an exchangeable battery) or an ‘intelligent’ application (battery permanently integrated in the equipment) in which the battery charging electronics are permanently connected to the battery and therefore able to continuously monitor and indicate the state-of-charge.

An ‘intelligent’ charger configuration is shown in Figure 8. It is intended for applications which require an external unit for charging the battery. All the intelligence required to monitor the state-of-charge of the battery and control the power module to safely and rapidly effect regulated fast/trickle charging is in the battery management IC, which is in the charger and therefore not permanently connected to the battery.

**State-of-charge indication.** As shown in Figure 10 and Figure 11, the charge/discharge profiles of NiMH batteries vary too much with load, temperature and age to allow measurement of the terminal voltage as a means of determining the remaining energy for state-of-charge indication. This is why Philips’ state-of-charge indicators SAA150XT use ‘coulomb counters’ (i.e. coulombs of charge) flowing into and out of the battery during the charge/discharge cycles. It is necessary to determine the remaining energy in this way by recording the charge/discharge history of a battery-pack for three reasons:

- Fast-charging. If the amount of energy remaining in the battery is
known, the required fast-charge
time can be calculated

- C/4 to C/10 standard-rate charging.
  At these low charging rates, the
  voltage and temperature profiles of
  NiMH batteries are too flat too be
  of use for determining the charge
  termination point to prevent over-
  charging. In this case, it is only
  possible to use timed charging
  controlled by calculation of the
  energy remaining in the battery.

**Charge monitoring**

- ∆V detection with the charge
  current switched off and digital
  filtering of the battery voltage. This
  avoids accidental non-termination
  of the charge due to noise (arching
  or SMPS radiation) or to a poorly
  defined negative-going voltage
  slope, particularly with NiMH-
  batteries and at high temperatures.
- An initial inhibit period before
  -∆V detection to allow for the
  initial charge behaviour of fully
  discharged batteries.
- Adjustable (min./max.) temperature
  range monitoring to prevent fast-
  charging if the battery is too hot/cold.
- Protection against open-circuit and
  short-circuit batteries.
- An adjustable timer for time-out
  back-up of the -∆V detection.

**Charge current regulation**

- PWM output with fixed frequency
  and variable duty-factor for
  controlling an efficient SMPS-based
  power module.
- Adjustable and regulated continu-
  ous fast-charge current.
- Pulsating trickle charge current to
  prevent battery cells becoming
  short-circuit due to growth of
dendrites (crystalline fingers) on the
  battery electrodes.

**TEA110X(T): versatile monitor
and control circuits with thermal protection**

The TEA110X(T) acts as a battery
charge monitor (adapted to the differ-

<table>
<thead>
<tr>
<th>IC type</th>
<th>Battery monitor</th>
<th>Charge current regulator</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEA1101(T)</td>
<td>-∆V detection: &lt;0.25% V_peak</td>
<td>PWM drive</td>
</tr>
<tr>
<td></td>
<td>High/low temp. protection</td>
<td>Analogue drive</td>
</tr>
<tr>
<td></td>
<td>Open/short-circuit battery</td>
<td>Digital drive</td>
</tr>
<tr>
<td></td>
<td>protection</td>
<td>Mains isolation/non-</td>
</tr>
<tr>
<td></td>
<td>Time-out protection</td>
<td>mains-isolation possible</td>
</tr>
<tr>
<td>TEA1100(T)</td>
<td>-∆V detection: &lt;1% V_peak</td>
<td>PWM drive</td>
</tr>
<tr>
<td></td>
<td>High/low temp. protection</td>
<td>Analogue drive</td>
</tr>
<tr>
<td></td>
<td>Open/short-circuit battery</td>
<td>Digital drive</td>
</tr>
<tr>
<td></td>
<td>protection</td>
<td>Mains isolation/non-</td>
</tr>
<tr>
<td></td>
<td>Time-out protection</td>
<td>mains-isolation possible</td>
</tr>
<tr>
<td>TEA1088T</td>
<td>-∆V detection: &lt;1% V_peak</td>
<td>PWM drive</td>
</tr>
<tr>
<td></td>
<td>Open/short-circuit battery</td>
<td>Only non-mains-isolation</td>
</tr>
<tr>
<td></td>
<td>protection</td>
<td>possible</td>
</tr>
<tr>
<td></td>
<td>Time-out protection</td>
<td>Load regulation</td>
</tr>
<tr>
<td></td>
<td>Battery ‘low’ indication</td>
<td>Battery ‘low’ indication</td>
</tr>
</tbody>
</table>
ent characteristics of NiCd and NiMH batteries) and a charge current regulator which controls the power module in an 'intelligent' charger. The charge monitor function decides whether fast, trickle or no charging is required. The charge current regulator function then acts on this decision and forms a regulation loop with the power module.

Features specific to the TEA110X(T) family of ICs are:

**Charge monitoring**
- A fully charged battery is detected by monitoring $-\Delta V$ to within $<1\%$ of the maximum voltage of the battery for the TEA1100(T), and within $<0.25\%$ for the TEA1101(T).
- Input current for battery monitoring is less than 1 nA.
- Wide range (1:10) of $-\Delta V$ detection using a 12-bit ADC to accommodate battery packs of different voltages.
- Monitoring the temperature of the battery with a thermistor to prevent damage to the battery due to exceeding its upper or lower temperature limits by excessive fast-charging. The upper and lower temperature limits (with hysteresis) can be defined externally. Above or below these limits, only pulsating trickle charging is possible.

**Charge current regulation**
- PWM output for controlling an efficient power module with mains-isolated or non-mains-isolated SMPS using a forward or flyback converter.
- Analogue output for controlling a power module with a linear series regulator.
- Digital output for switching a non-regulated power module.

**Other features**
- Advanced BiCMOS technology
- Supply voltage range 5.65 V to 11.5 V.
- Supply current $<4.3\ mA$.
- Very low standby current.

The TEA110X ICs are pin- and application-compatible.

DIL16 or SO16 package.

**Figure 12** Single-chip 'intelligent' charger using TEA110X(T) and an SMPS power module

Figure 12 shows an example of an 'intelligent' charger in which a TEA110X(T) IC is controlling a power module consisting of a non-mains-isolated SMPS with a forward converter. In a mains-isolated power module, the SMPS switching drive signal would be connected to the SMPS drive transistor via an opto-coupler or a pulse transformer.

The fast charging current (1.1 A) from the power module is regulated in accordance with information derived by measuring the $-\Delta V$ of the battery. The $-\Delta V$ detection is backed up by a timer and thermal protection via an NTC thermistor.

After detecting by $-\Delta V$ that the battery is fully charged, or that the time-out period has elapsed, the TEA110X(T) automatically switches over to pulsating trickle-charging.

**Figure 13** Single-chip 'intelligent' charger using TEA110X(T) and a linear series regulator power module

The TEA1088T acts as a battery charge/discharge monitor and a charge current regulator which controls a non mains-isolated SMPS power module in an 'intelligent' charger.

The charge monitor function decides whether fast, trickle or no charging is required. The charge current regulator function then acts on this decision.
NiMH and NiCd battery management

Table 2 Comparison of battery management ICs for 'intelligent' batteries/applications

<table>
<thead>
<tr>
<th>Type number</th>
<th>SAA1501T</th>
<th>SAA1500T</th>
<th>74LV4799</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy calculation:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>charge mode</td>
<td>current x time (mAh = coulombs)</td>
<td>Time only</td>
<td>Time only</td>
</tr>
<tr>
<td>discharge mode</td>
<td>Current x time (mAh = coulombs)</td>
<td>Current x time (mAh = coulombs)</td>
<td>Time only</td>
</tr>
<tr>
<td>self-discharge mode</td>
<td>Time only</td>
<td>Time only</td>
<td>Time only</td>
</tr>
<tr>
<td>Mode selection</td>
<td>Automatic</td>
<td>External control</td>
<td>External control</td>
</tr>
<tr>
<td>State-of-charge indication</td>
<td>Five-segment LED/LCD</td>
<td>Five-segment LED/LCD</td>
<td>None</td>
</tr>
<tr>
<td>Battery-low indication</td>
<td>LED</td>
<td>LED</td>
<td>LED</td>
</tr>
<tr>
<td>Charge status indication</td>
<td>LED</td>
<td>LED</td>
<td>LED</td>
</tr>
</tbody>
</table>

Figure 14 Single-chip 'intelligent' charger using TEA1088T and an SMPS power module

'INTELLIGENT' BATTERIES/APPLICATIONS USING PHILIPS ICs

The battery management ICs for 'intelligent' batteries are the SAA1500T, SAA1501T, 74LV4799N(D) and TEA1041T. All except the TEA1041T accurately determine the state-of-charge (remaining energy) of a battery at any instant by keeping account of the charge/discharge time and/or the charge/discharge current in a 'coulomb' counter. This information is then used to determine the required charging time, provide a fast-charge/trickle-charge control signal and/or drive a LED or liquid crystal 'remaining energy' display. The TEA1041T merely monitors the battery voltage to give 'battery low' and 'battery empty' indications.

SAA150XT: remaining energy indicators

To make an accurate calculation of the instantaneous energy remaining in a rechargeable battery, the SAA1501T keeps account of the charge current and time (mAh) in the charge mode, the discharge current and time (mAh) in the discharge mode, and time only in the self-discharge mode. This IC is therefore suitable for 'intelligent' batteries with dynamic (varying) load (battery discharge) current and charge current. Such applications include cellular radios, camcorders and cordless tools.

Like the SAA1501T, the SAA1500T keeps account of the discharge current and time (mAh) in the discharge mode and forms a regulation loop with the power module.

Features specific to the TEA1088T are:

- A voltage control circuit with regulation which compensates for mains voltage and load variations if both the load and batteries are connected.

Charge monitoring

- Detection of a fully-charged battery by detecting $-\Delta V$ to within 1% of the maximum voltage.

Discharge monitoring

- Battery discharge monitoring with drive signal for a battery-low indication LED. The LED flashes if the load is not switched on.

Charge current regulation

- PWM output for controlling an efficient power module with non-mains-isolated SMPS using a flyback converter.
NiMH and NiCd battery management

mode, but only measures time in the charge mode and self-discharge mode. It is therefore suitable for 'intelligent' batteries with a dynamic load (battery discharge) current but pre-determined battery charge current. Such applications include cordless tools and portable audio/video equipment. Features common to both of these ICs are:

- Drive signals for a five-segment LCD/LED state-of-charge indicator.
- Drive signals for 'battery low' and charge status LEDs.
- Drive signal for fast/trickle charge selection.
- Low stand-by current for permanent integration with a battery-pack.
- SO20L package.

Specific features for the SAA1501T (Figure 15) are:

- Accurate measurement of charge/discharge current.
- Handles a wide dynamic range of charge/discharge current.
- Independent settings for charge/discharge efficiency.
- Automatic switch-over between charge/discharge/self-discharge modes.
- Temperature-compensated self-discharge account.
- BiCMOS technology to achieve the required accuracy.

Specific features for the SAA1500T (Figure 16) are:

- Accurate measurement of discharge current.
- Independent setting of discharge efficiency.
- Externally-selected switch-over between charge/discharge/self-discharge modes.

74LV4799N(D): economy timer for NiCd and NiMH chargers

Our 74LV4799N(D) economy timer for NiCd and NiMH battery chargers is a low-voltage CMOS logic IC in a 16-pin DIL (N suffix) or SO (D suffix) package. It determines how much energy remains in a rechargeable battery by keeping account of the charge, discharge and self-discharge periods. It is particularly suitable for use in transformer/rectifier or SMPS chargers for 'overnight' charging at the C/10 rate followed by automatic switch-over to pulsed trickle-charging (essential for NiMH batteries). It can also be used for fast/trickle-charging in 'intelligent' batteries/applications in which the charge and discharge current are not variable. Typical applications are walkie-talkies, notebook/laptop computers, camera flash units, cordless phones, battery-powered video games and personal care items such as shavers, electric toothbrushes etc.

The main features of the 74LV4799N(D) are:

- Timer ranges set by resistor selection;
- Charge: 4 h to 16 h
- Discharge: 10 min. to 16 h
- Self-discharge: 100 to 200 days.
- LED 'battery-low' indication.
- LED charge/battery-full indication.
- Charge current control signal.
- Low standby current for permanent integration in equipment.
- Supply voltage 0.9 V to 6 V allows use with 1-cell to 4-cell batteries.
- DIL16 or SO16 package.

A typical application for the 74LV4799N(D) is shown in Figure 17. The IC keeps a continuous account of the periods during which the battery is being charged, discharged, or is self-discharging by incrementing or decrementing a counter at different rates set by resistors R_C, R_D, and R_E. After
NiMH and NiCd battery management

![Diagram of battery management system](chart)

Figure 17 ‘Intelligent’ application using a 74LV4799N(D) economy timer for NiCd and NiMH chargers

![Diagram of battery-low indicator](chart)

Figure 18 Typical application using battery low-level indicator TEA1041T

counter overflow (full charge), the counter stops and a battery-full indication is given by the LED. The system then automatically switches over to the self-discharge mode and the battery is trickle-charged with pulsed current at a rate which exactly compensates the self-discharge of the battery. When the load is switched-on, the system is set in the discharge mode and the counter decrements at the rate set by $R_D$ until the battery is discharged. A battery-empty indication is then given by the buzzer.

**TEA1041T: battery-low indicator**

The low-cost TEA1041T simply indicates when the battery voltage falls below a pre-set level. This IC filters voltage transients on the supply line to prevent false signalling of ‘battery low’. Several combinations of LED indications are available. Features of the TEA1041T are:

- Visible indication of battery voltage low-level detection.
- ‘Recharge needed’ warning by two alternately flashing LEDs when the battery is fully discharged.
- Adjustable triggering threshold for detection of a low-level battery.
- Insensitive to supply noise.
- Low standby current.
- Few peripheral components.
- SO8 package.

The TEA1041T shown in Figure 18 gives a LED indication if the battery voltage falls below a preset threshold. Voltage transients shorter than a preset interval will not trigger the ‘battery-low’ indication.

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