Transmitter Pack Low Battery Alarm

Introduction

This Project Article describes a simple general purpose Nickel-Cadmium (NiCAD) or Nickel-Metal Hydride (NiMH) battery monitor, originally designed to monitor the battery voltage of a R/C transmitter, but also capable of being used for other purposes.

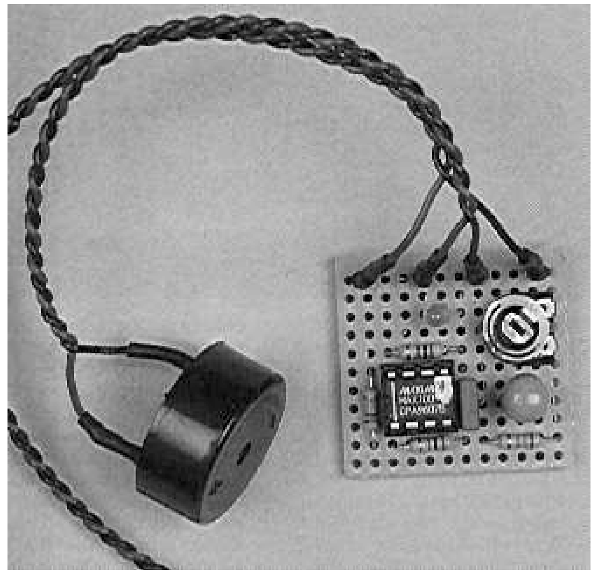
It is designed to provide a progressive audible warning of low battery charge level which can be especially useful if your eyes are more interested in far-away objects than the battery level meter on your transmitter!

Although originally designed for transmitter battery packs with a terminal voltage of around 9V it may be 'programmed' to operate with any battery pack containing between 3 and 12 cells. This is achieved by choosing the appropriate values for two of the resistors used in the design.

It may, therefore, be used with almost any R/C battery pack, the only proviso being that the battery terminal voltage never exceeds 15V, the maximum rated voltage of the IC used in the design.

Simplicity was a key issue during the design along with versatility. To this end the circuit consists of only one low-cost IC and a handful of passive components and the setup, or calibration, procedure has been kept very simple.

Note that the photograph above shows an early prototype constructed on matrix-board. It is representative of the final version, both in terms of size and layout, as the component positions are the same as those on the PCB.



Features

- Audible Warning of Low Battery
- Progressive Warning Sound
- Optional Visual Warning
- Programmable Trip Point
- Works with Packs from 3.6V to 15V
- Small Size
- Low Power Consumption
- Simple to Build

Description

The heart of the circuit is a MAX700 type integrated circuit, or IC, originally designed for monitoring micro-processor power supplies and providing a RESET signal to the micro-processor should the supply rail fall below a preset level. This mode of operation provides an output in either of two logic states, a logic 1 or logic 0, depending on the state of the power supply.

This is exactly the sort of functionality necessary to operate an alarm in the event of a low battery.

Choosing the 'trip point', however, is a difficult decision…a low trip point gives maximum operating time but minimum warning and a high trip point may lead to a reduced flying time.

The circuit presented in this Project Article uses a little ingenuity to overcome this dilemma and provides both a gentle early warning of low battery condition and a more insistent 'alarm' at very low battery level.

No. of Cells	R1 Value	R3 Value
3	33k	330k
4	47k	470k
5	56k	680k
6	82k	680k
7	100k	1M0
8	120k	1M0
9	120k	1M0
10	150k	1M2
11	180k	1M2
12	180k	1M2

Table 1: Typical R1/R3 Values for Various Battery Packs
The values given in this table are calculated for a Trip Point of 1.0V/cell and Alarm Point of 0.9V/cell

Theory of Operation

The MAX700 contains, amongst other circuit functions, a precision reference voltage generator, set at 1.29V, and a comparator. One of the comparator input connections is made internally to the 1.29V reference and the other brought out to the SENSE pin. As the voltage present on the SENSE pin crosses 1.29V, the internal trip point of the MAX700, the comparator output changes to the opposite logic state. The comparator output drives an internal mono-stable circuit that provides the signals at the two RESET outputs.

The resistor chain formed from R1, R2 and VR1 is arranged to divide the supply voltage to a level of about 1.3V when the battery pack voltage is low with the value of R1 chosen to suit the pack in use.

Thus the unit may be 'programmed' to operate with most battery packs.

Operation of the circuit may be understood by considering the following :-

The divided battery voltage present at the SENSE pin is above the 1.29V internal trip point, and falling gradually, which means the RESET output at pin 6 is at a logic 0, i.e. inactive. At the moment the SENSE input voltage falls below 1.29V for the first time the RESET signal will go to a logic 1 causing current to flow into C2 through R3. This increases its charge and raises its voltage to slightly above 1.29V.

At the end of the mono-stable period the RESET signal will return to a logic 0. C2 then discharges slowly through R2 and VR1 until its voltage falls below 1.29V once again whereupon the cycle repeats.

With a typical circuit trip point of 8V the RESET signal is active for approximately 0.5 seconds and inactive for approximately 4 seconds. This action gives a slowly repeating beep from the piezo sounder and provides a gentle warning of an impending battery failure.

As the battery voltage falls still further the operation of the circuit is to increase the frequency of the beeps until, at very low battery voltage, the buzzer is on continuously.

The LED (D1) and the buzzer (Y5) are used to provide both a visible and an audible indication of the state of the battery pack and are connected to the active low /RESET signal at pin 5. This pin, which follows the RESET signal at pin 6 but with the opposite logic sense, is used to drive the LED and buzzer because of its higher output capability. The LED performs an additional function in the circuit, that of regulating the drive voltage to the piezo sounder. In this way the sound volume produced is largely independent of the battery voltage. A green LED is chosen due to its slightly higher volt-drop when conducting.

Choosing the Component Values

Resistors are only readily available in a range of standard values, the so-called 'preferred values' and in both the examples given here the graph returns values for R1 that are non-preferred and are thus, at best, difficult to obtain. This problem is overcome by using the nearest preferred value for R1 and re-calibrating the trip point of the circuit by adjusting VR1.

There are two voltages that are important in this circuit and these are known as the 'trip point' and the 'alarm point'.

The trip point is the battery voltage at which the buzzer first starts to sound and the alarm point is the battery voltage at which the piezo sounder is on continuously. Both of these voltages are 'programmable' to offer maximum flexibility.

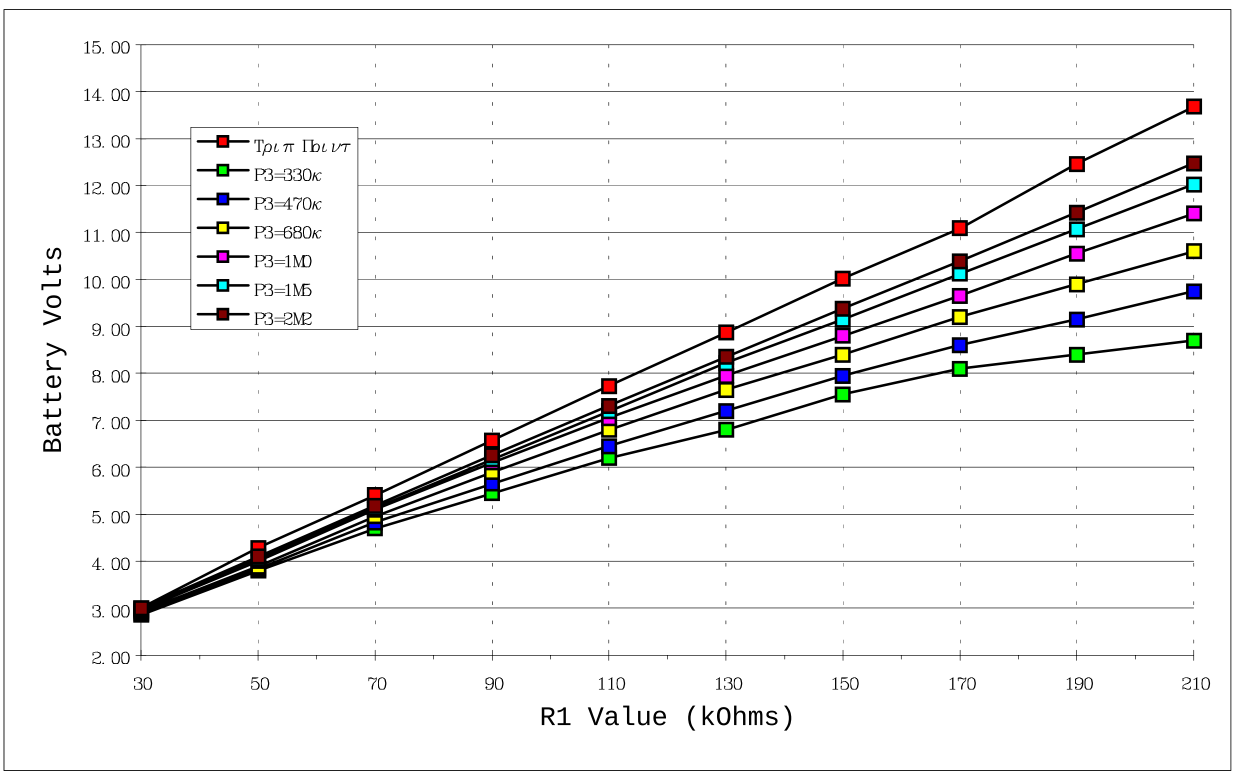
Typically a NiCAD cell is considered to be approaching flat if its terminal voltage has fallen to 1.0V, and completely flat at 0.9V. Using these two figures for an 8-cell battery pack would yield a trip point of 8.0V and an alarm point of 7.2V. The graph shown below permits the determination of values for R1 and R3.

Proceed as follows :-

1. Find 8.0V on the Battery Volts axis.
2. Move to the right along this line until you cross the upper curve, the Trip Point curve.
3. Draw a vertical line down to the R1-Value axis and obtain the ideal value for R1 of about 115kΩ.
4. Find 7.2V on the Battery Volts axis.
5. Move to the right along this line until you cross your vertical line.
6. Taking the nearest of the 'R3' curves look up its value in the key contained within the graph and establish R3 to be 1MΩ.
7. Use the nearest preferred value for R1 of 120kΩ.

However, there is no rule that says that the 1.0V per cell and 0.9V per cell are the figures to use but they do represent a reasonable choice. The more cautious may prefer a larger voltage difference between trip point and alarm point with the consequent longer warning time.

For example, this time using a 6-cell battery pack, one might prefer a trip point of 1.1V per cell and 0.9V per cell for the alarm point. Following the procedure above will establish the ideal value for R1 as 90kΩ and R3 to be 330kΩ. The nearest preferred value for R1 is 82kΩ.



Assembly

Assembling the parts onto the PCB is straightforward. However some of the components must be inserted in the correct orientation and the notes below should help:-

U1 This component is a CMOS device and should be treated accordingly. It has a semi-circular 'notch' in the end that marks pin 1. The IC should be inserted such that pin 1 connects with the square pad.

Y5 This component is not fitted to the PCB and its body is marked with polarity signs. It should be wired to pins Y3 (+ve) and Y4 (-ve) using lengths of small gauge 'hook-up' wire.

D1 This component may be fitted to the PCB or, equally, may be wired to the PCB in a manner similar to Y5 above. A possibility is to fit D1 into a suitable hole in the transmitter case such that it may be observed. It has a flat on its body adjacent to one of its leads and the component should be inserted/wired with this lead connected to the square pad.

C2 This component will have either a '+' sign or a 'bar' adjacent to one of its leads. The component should be fitted such that this lead connects with the square pad i.e. the pad marked with a '+' sign.

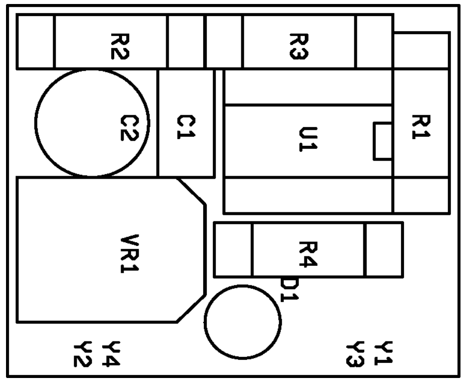


Fig. 1:
Component Placement Drawing
(Top Side View)

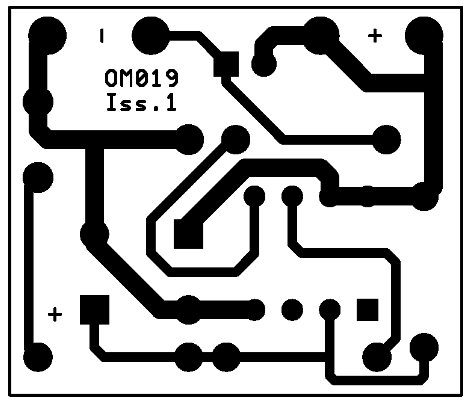


Fig. 2:
PCB Copper Trace Detail
(Underside View)

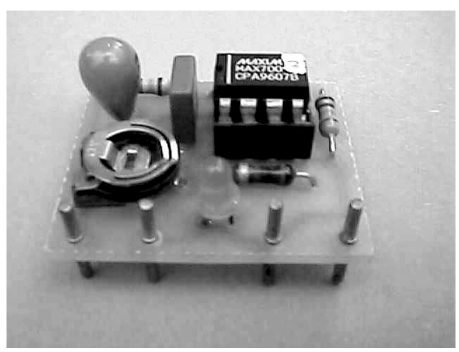
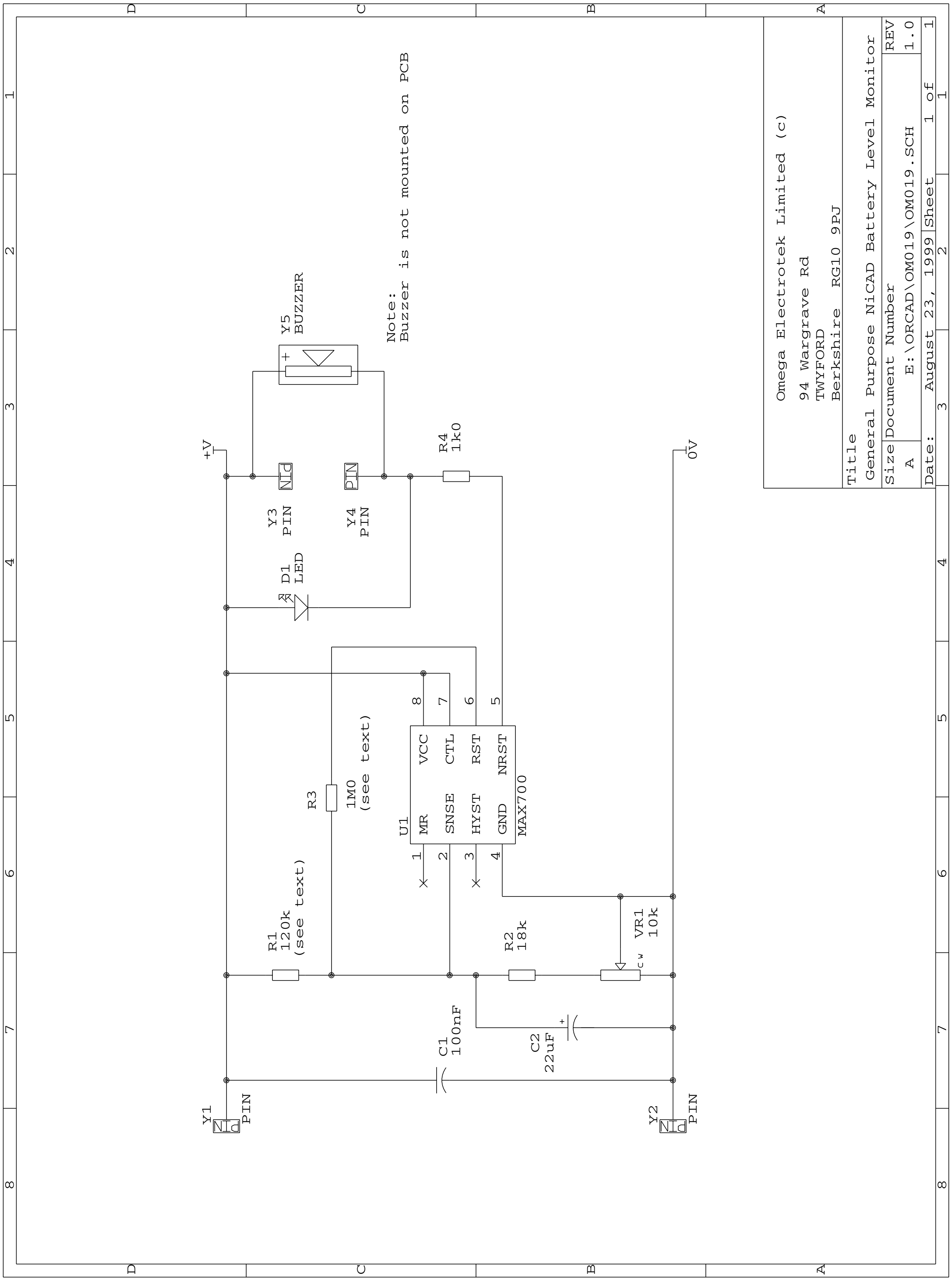


Fig. 3:
Assembled PCB

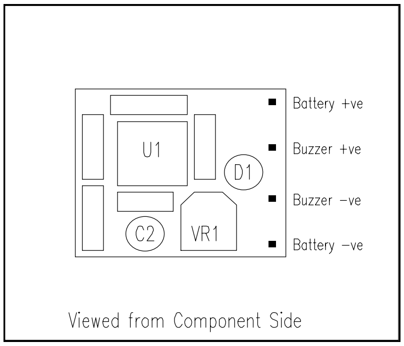
Schematic Diagram



Initial Power-up and Calibration

Having carefully checked that all the components are correctly located, orientated and soldered, and in particular the flying leads, the assembled unit may be tested.

The diagram below shows the four vero-pins and their pin functions.



NOTE: There is no reversed polarity protection provided and connecting the unit to a battery pack with the wrong polarity will probably destroy it.

Initial testing may be performed with a battery pack of the appropriate voltage and using the following procedure:-

1. Set VR1 to its middle position.
2. Connect the unit to the battery pack using terminal pins Y1 and Y2 ensuring the correct polarity is observed.
3. If the battery voltage is higher than the trip point the buzzer should sound, and the LED should light, for about a second by way of a self-check.
4. If the battery voltage is lower than the trip point the buzzer and LED will either be pulsing or on continuously.
5. Adjusting VR1 slowly throughout its range should cause the buzzer to operate in each of its 3 modes.

Assuming that the sounder can be made to operate in all its 3 modes, i.e. off, pulsing and on, this completes the initial testing of the unit using a battery pack.

Fitting to the Txmtr

The unit should be wired into the transmitter using the terminal pins marked **'+'** and **'-'** (Y1 and Y2) on the PCB. These should be connected, with the correct polarity, to somewhere on the switched side of the transmitter On-Off switch. This may be to the terminals of the switch itself or to a convenient place on the transmitter PCB.

As space inside R/C transmitter housings can be a little limited the buzzer is not mounted on the PCB to allow it to be placed in a different location.

Note that connecting this unit to your transmitter may invalidate its warranty. Additionally, if you do not feel confident in performing this operation, please refer to someone who is.

Final Calibration

This may be done using the existing battery level meter fitted to the transmitter thus providing a useful correlation between the audible and visual battery state monitors. The following procedure is suggested:-

1. With the unit connected to the transmitter switch the transmitter on.
2. While keeping an eye on the transmitter battery level meter allow the battery to drain.
3. When the meter indicates just above the red section adjust R4 anti-clockwise until the buzzer is on continuously.
4. Carefully adjust R4 clockwise until the buzzer is just heard to pulse.

Once set-up in this way the buzzer will begin to sound at a voltage when there is still sufficient power left in the battery pack for an unhurried landing.

Alternative Uses

There are a number of alternative uses to which this unit may be put with one example being its use as part of a low-cost 'battery restoration' tool-kit. Part of the process of restoring a NiCAD battery pack is to ensure that periodically the pack is discharged completely, but not over discharged. Suitably calibrating the unit described here, and connecting it to a battery pack being discharged using a simple power resistor, would provide an audible signal when the discharged state had been reached. The LED flashing would identify the sounding unit if more than one unit were in use simultaneously.

Components

Complete kits of the components required to build this project are available from the Model Electronics Company. Alternatively just the PCB may be purchased and the remaining parts obtained from other sources using the Parts List table as a guide.

Because it is the intention that the buzzer be fitted inside the transmitter it needs to be loud enough to be heard through the case. The specified buzzer was chosen because it produces an acceptable sound level even when operated at just over 2V. It is, however, fairly large and may be difficult to accommodate. An alternative may be used but any device selected should be specified to operate down to at least 3V.

For those people not wishing to undertake the assembly of the PCB this is available pre-assembled and tested. Please see the price list for details.

Item	Manufacturer	Specification or Part Number
C1	N/A	100nF 63V 10%
C2	N/A	22uF 10V 20% Tantalum Bead
D1	LED Technology	L02R3000F1 - T1 (3mm) Green
R1,3	N/A	See Text
R2	N/A	18k 0.25W
R4	N/A	1k0 0.25W
U1	Maxim	MAX700CPA
VR1	Meggitt	PT10V103 - 10k 0.15W
Y1-4	Vero	0.052" Double Sided Pin
Y5	N/A	12V (3-20V) 90dB @ 30cm

Table 2: Parts List

Note that where manufacturers part numbers are given their continued accuracy cannot be guaranteed.

Notes

This Project Article is issued by :-

The Model Electronics Company
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Berkshire RG10 9PJ

For information on placing an order for this project please see our price list which gives details of prices and payment methods. The price list may be obtained from the address above or from our web-site.

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