# HOLTEK

HT7470
Fast Battery Charger

Features

- Fast charge NiCd battery
- High resolution -ΔV detector to determine peak charging voltage
- Auto cutoff for defective battery
- Fast charge from C/2 to 4C rate
- C/10 trickle charge rate
- Adjustable thermo protection
- Built-in safety timer

- Direct drive LED display and alarm buzzer
- Automatic switching from fast to trickle charge
- Warm up option for battery
- Maximum voltage protection
- Auto-start function
- 12-bit A/D converter

General Description

The HT7470 is a 4-bit single-chip microcomputer specially designed for NiCd battery fast charge/discharge control. The advanced unique design and multiple protection features of the HT7470 eliminate excessive external components in application circuits, and ensure battery safety and high performance.

Pin Assignment
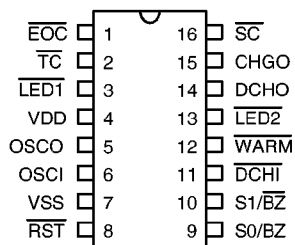
Block Diagram
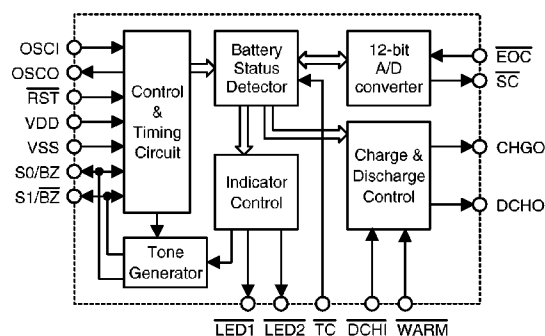
Pin Description

Pin No.	Pin Name	I/O	Description
1	$\overline{EOC}$	I	End of A/D conversion. The A/D conversion process takes place during the high period on this pin. When this pin falls low, this indicates the end of the A/D conversion.
2	$\overline{TC}$	I	Over temperature input, active low.
3	$\overline{LED1}$	O	LED 1 indicates the charge, discharge and battery status.
4	VDD	—	Positive voltage supply. (5V)
5 6	OSCO OSCI	O I	OSCI and OSCO are connected to a resistor to generate the system clock. The frequency of the system clock is 1MHz.
7	VSS	—	Negative power supply.
8	$\overline{RST}$	I	Input to reset internal LSI, active low.

Pin No.	Pin Name	I/O	Description
9 10	S0/BZ S1/$\overline{BZ}$	I/O I/O	S0, S1 are charge rate inputs. BZ, $\overline{BZ}$ are a buzzer driving pair.
11	$\overline{DCHI}$	I	Discharge input, active low. Discharge before charging, active low.
12	$\overline{WARM}$	I	Warm-up key, active low. Used only to warm up the battery.
13	$\overline{LED2}$	O	LED2 indicates the charge, discharge and battery status.
14	DCHO	O	Discharge control output, active high.
15	CHGO	O	Charge control output, active high.
16	$\overline{SC}$	O	A/D converter start conversion control output, active low.

Absolute Maximum Ratings

Supply Voltage ....−0.3V to 5.5V

Input Voltage................. V_{SS}−0.3V to V_{DD}+0.3V

Storage Temperature ....−50°C to 125°C

Operating Temperature .... −20°C to 70°C

Electrical Characteristics

Symbol	Parameter	Test condition		Min.	Typ.	Max.	Unit
		V_{DD}	Condition				
V_{DD}	Operating voltage	—	—	3.5	5	5.5	V
I_{DD}	Operating current	5V	No load f_{SYS}=1MHz	—	1.5	3	mA
V_{IL}	Input low voltage	5V	—	V_{SS}	—	$0.2V_{DD}$	V
V_{IH}	Input high voltage	5V	—	$0.8V_{DD}$	—	V_{DD}	V
I_{OL}	$\overline{LED1}$, $\overline{LED2}$ output sink current	5V	V_{OL}=0.5V	2.5	—	—	mA
I_{OH}	$\overline{LED1}$ output source current	5V	V_{OH}=4.5V	−2.5	—	—	mA
I_{OL1}	CHGO, DCHO, BZ, $\overline{BZ}$, $\overline{SC}$ output sink current	5V	V_{OL}=0.5V	2.5	—	—	mA
I_{OH1}	CHGO, DCHO, BZ, $\overline{BZ}$, $\overline{SC}$, LED2 output source current	5V	V_{OH}=4.5V	−1.5	—	—	mA
R_{PH}	Pull-high resistance	5V	S0, S1, $\overline{WARM}$ $\overline{DCHI}$, $\overline{RST}$, $\overline{EOC}$, $\overline{TC}$	—	50	—	KΩ
f_{SYS}	System clock	5V	R_{OSC}=18KΩ	—	1	—	MHz

Fundamental Function

Charge Function

The charge function of the HT7470 consists of two periods, the charging period and the status detection period. During the charging period, current is supplied to the battery for charging, while during the status detection period, the battery voltage and temperature are measured to determine if the battery is fully charged, open, shorted or damaged.

Trickle Function (C/10)

When the battery has been detected to have reached full charge by the HT7470, the charge rate will switch to trickle charge automatically. The trickle charge function is dependent upon the charge inputs and is shown below.

The trickle charge function is different but the trickle charge rate is identical to C/10. This function is accomplished by adjusting the charge duty cycle which is also implemented in the HT7470. The charge rate KC, is calculated by the following equation:

$$K = \frac{\text{Charge current}}{\text{Battery capacity}}$$

C = Battery capacity

Discharge Function

The HT7470 provides a discharge function to prevent battery memory effect from occuring. If battery memory effect has occured this function will eliminate the effect gradually. The discharge input can be selected to discharge the battery before the charge procedure has started. When the battery is empty the HT7470 will start the charge procedure automatically.

Warm-up Function

The HT7470 provides a battery warm-up function to warm up the battery and improve battery efficiency. The warm-up key is enabled only in the warm-up waiting period. A low 20ms pulse in the warm-up waiting period will force the HT7470 to warm-up the battery. During this time the discharge input will be inhibited. The warm-up function is identical to the charge function.

The warm-up interval is dependent on the charge rate inputs and is described below:
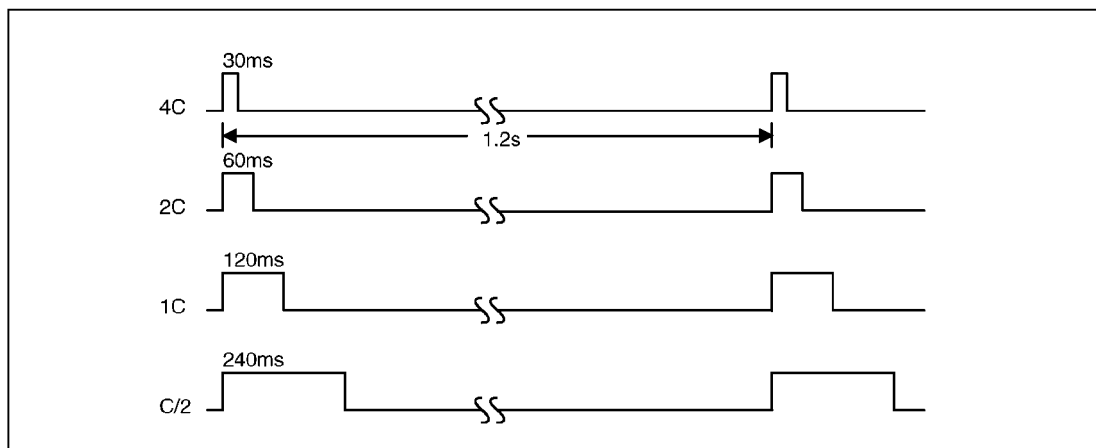
Charge rate inputs	4C	2C	1C	C/2
S1,S0	11	10	01	00
Charge Count	150	300	600	1200
Time (min)	3.5	7	14	28

During battery warm-up, full charge detection and abnormal charge detection are always enabled.

Full Charge Detection

There are four full charge detection methods implemented in the HT7470 as described below:

* -ΔV detection
* Over Temperature: The $\overline{\text{TC}}$ input pin is logical low

Trickle Function (C/10)

- Safety Timer Overflow: Internal event counter has overflowed

Charge rate inputs	4C	2C	1C	C/2
S1,S0	11	10	01	00
Charge Count	1200	2400	4800	9600
Time (min)	28	56	112	224

- Battery Maximum Voltage Protection
  If any of the conditions described above occur the charge rate will switch to trickle charge automatically.

Abnormal Charge Detection (Open, Short, Battery Damage)

The HT7470 can detect abnormal battery states which include charge loop open or short, battery high impedance or short. There is a precharge procedure to pull-up the battery voltage for the detection of abnormal states. The HT7470 precharges the battery and looks for abnormal states before the charge procedure begins. The detection of abnormal states is always enabled when the charge procedure is running. Any abnormal state will force the HT7470 to enter the abnormal mode and display the corresponding indicator or turn on the buzzer. In abnormal mode the HT7470 stops charging until the abnormal battery is removed or the charge loop is open.

A/D Converter

The battery voltage is read into the HT7470 through a 12 bit wide integral type A/D converter. The resolution of the A/D converter is 68 µs/count (1MHz system clock).

Auto - Start and Reset Key (RST)

The HT7470 can detect whether the battery is ready or not. When the battery has been detected to be ready the HT7470 charge procedure will run automatically. The $\overline{RST}$ pin is used for system initialization. This reset pin has an in-

ternal pull-high resistor. In order to guarantee all circuits are reset it is combined with an external 0.1µF capacitor to provide an internal reset pulse. If the charge loops is open the HT7470 will enter the stand-by mode. In this mode the HT7470 continues to detect whether the battery is ready or not.

Charge and Discharge Inputs

Charge rate inputs: 4C, 2C, 1C, C/2

S1 and S0 are the charge rate inputs with internal pull-high resistors. The HT7470 adjusts the internal parameters such as safety timer, trickle charge duty cycle, and warm-up interval by referring to these charge rate inputs to make the system safe. These charge rate inputs are determined by the external charge current. The relationship between the inputs "S1,S0" and charge rate are listed in the following table.

Charge rate inputs	4C	2C	1C	C/2
S1,S0	11	10	01	00

Discharge Input: Discharge before charge procedure.

The $\overline{DCHI}$ pin is the discharge input with internal pull-high resistor. The user can force this pin low to select the discharge function of the HT7470.

Warm-Up Key

The $\overline{WARM}$ pin is the warm-up input with internal pull-high resistor and 20ms debounce time.

The warm-up function is activated by a low pulse on the $\overline{WARM}$ pin. The pulse width must be larger than 20ms during the warm-up waiting period.

Note that the discharge input will be inhibited if the warm-up key is pushed.

The charge and discharge inputs are enabled until the warm-up key is pushed or until the end of the warm-up waiting period.

Indicator

The HT7470 can indicate all the battery's states with the indicators LED1, LED2 and the buzzer (BZ, $\overline{BZ}$). Each state is represented in the following table.

| Mode	LED1*	LED2*	Buzzer
Charging	on	off	off
Warming	on	off	off
Discharging	on	on	off
Full charge	Flash (slow)	off	off
Warm-up waiting period	Flash (fast)	off	off
Abnormal	Flash	Flash	Flash tone (1 minute)
Standby	off	off	off

* Note: LED1 and LED2 are active low.

Input RC-Network

The HT7470 is a universal fast charge controller for NiCd batteries. It can be used to charge batteries of any rated voltage by adjusting the CR resistance of the RC-network and the integral time constant of the A/D converter. The RC-network is configured as shown and the CR resistance is listed in the table. Note that the integral time constant of the A/D converter is 38.54ms and the minimum battery rated voltage is 2.4V in this case.

$$CR = \frac{\text{Battery rated voltage} - 2.4}{2.4} * 2K$$

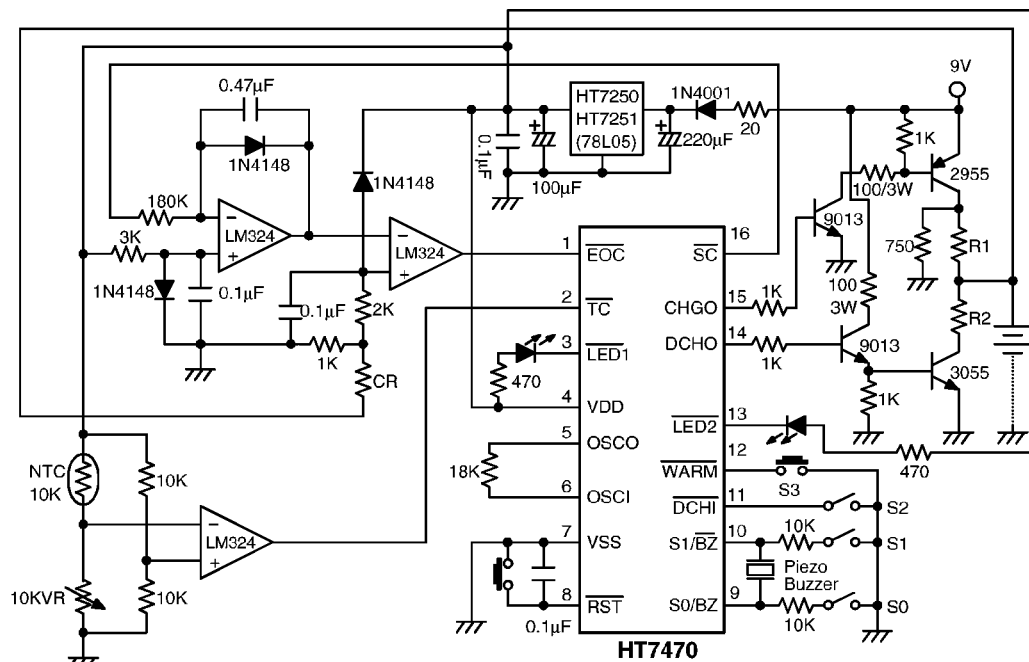| Battery Voltage	CR
2.4	0
3.6	1K
4.8	2K
6.0	3K
7.2	4K
⋮	⋮
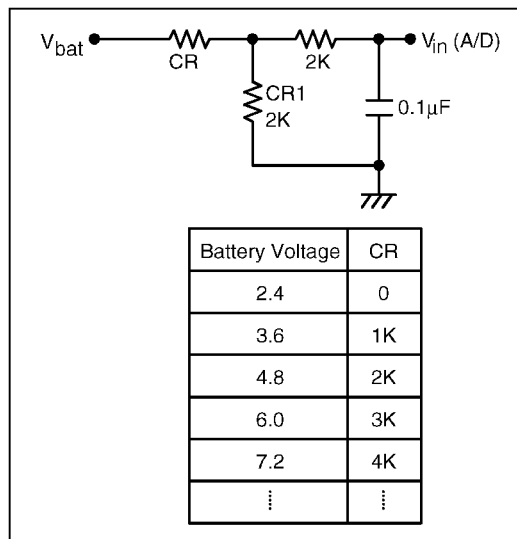
Input RC-Network

If the minimum battery rated voltage is 1.2V the CR1 resistance must be 1K and the integral time constant of the A/D converter must be 77.08ms. The CR resistance can be calculated by the following equation

$$CR = \frac{\text{Battery rated voltage} - 1.2}{1.2} * 1K$$

Application

The battery rated voltage ranges from 1.2V to 3.6V

Battery Voltage	CR
1.2	0
2.4	1K
3.6	2K

Example: Battery rated = 3.6V/0.6Ah
Charge rate = 2C
then S1,S0 = 10 (S1 open, S0 shorted)
and

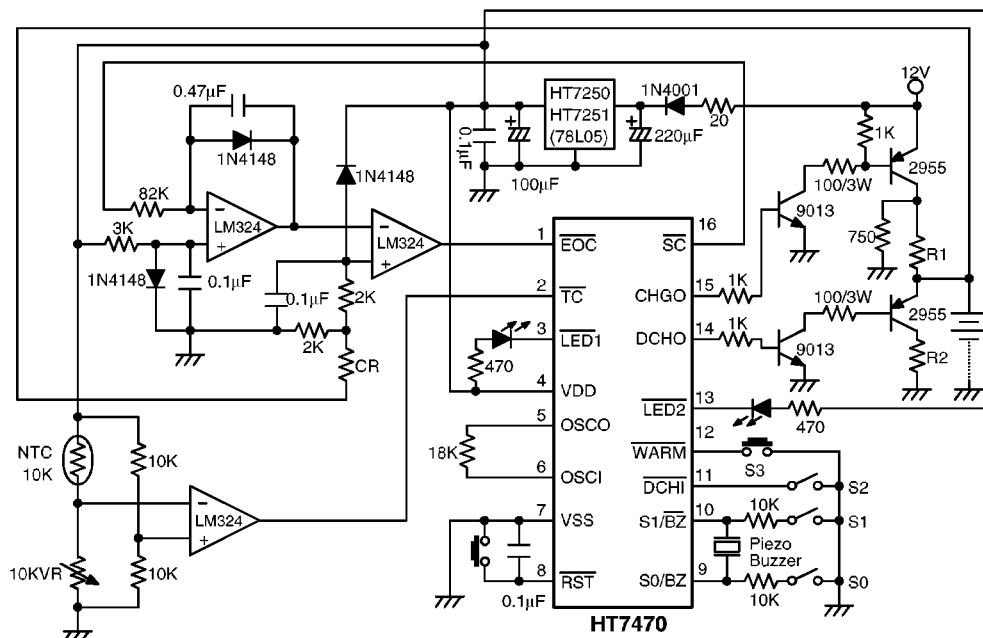$$R1 = \frac{9V - 3.6 \times Ka}{0.6 \times 2} = 3.6\Omega/5W$$

Ka=1.25

$$R2 = \frac{3.6}{0.6 \times 2} = 3\Omega/5W$$

CR = 2K

Charge rate	4C	2C	1C	C/2
Ka	1.5	1.25	1.125	1.063

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The battery rated voltage ranges from 2.4V to 7.2V

Battery Voltage	CR
2.4	0
3.6	1K
4.8	2K
6.0	3K
7.2	4K

Example: Battery rated = 7.2V/0.6Ah

Charge rate = 2C

then S1,S0 = 10 (S1 open, S0 shorted)

and

$$R1 = \frac{12V - 7.2 \times Ka}{0.6 \times 2} = 2.4\Omega/5W$$

Ka=1.25

$$R2 = \frac{7.2}{0.6 \times 2} = 6\Omega/5W$$

CR = 4K

Charge rate	4C	2C	1C	C/2
Ka	1.5	1.25	1.125	1.063