

## Battery Charge Controller for Low Power Charging

### FEATURES

- Fast charge control of NiMH/NiCd batteries.
- Fast charge termination by:  $-\Delta V$ ,  $0 \Delta V$  safety timer, or maximum voltage.
- Protection against battery voltage faults.
- Pulsed trickle-charge mode.
- Quick and easy testing for production.
- 8-pin DIP or SO packages.

### APPLICATIONS

Battery Fast Chargers for:

- Mobile Phones.
- Notebook and Laptop Personal Computers.
- Portable Power Tools and Toys.
- Portable Communication Equipment.
- Portable Video & Stereo Equipment.

### DESCRIPTION

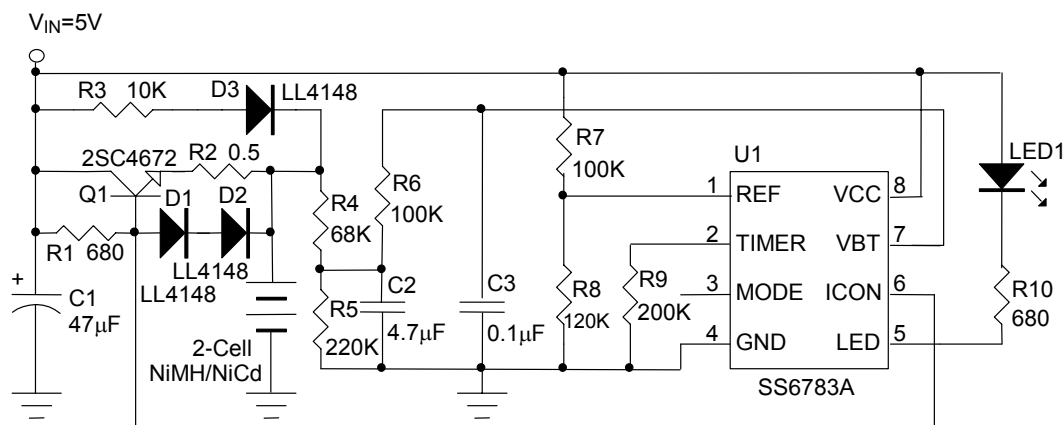
The SS6783A fast charge controller IC is designed for intelligent charging of NiMH or NiCd batteries without the risk of overcharge.

$-\Delta V$  detection (-0.25%) and  $0 \Delta V$  detection (peak voltage timer) are the primary methods employed by the SS6783A to terminate fast charging. Fast charging can also be cut off using the maximum battery voltage along with the safety timer to prevent charging under fault conditions of the charging system or the battery itself.

The safety timer period is adjustable for flexible usage allowing the SS6783A to be used with a wide range of battery capacities. A test mode is provided for charger manufacturers to dramatically reduce production test time.

 This device is available with Pb-free lead finish (second-level interconnect) as SS6783AGS.

### TYPICAL APPLICATION CIRCUIT



\*Note:  $I_{CHARGE}=380mA @V_{BAT}=2.8V$

**Linear Charger for 2-Cell NiMH/NiCd Batteries**

## ORDERING INFORMATION

SS6783AXXXX

- Packing
  - TR: Tape and reel (not for PDIP-8 (CN))
  - TB: Tubes
- Package type
  - N: Plastic PDIP-8 (only available in tubes)
  - S: Small outline SO-8
- C: Commercial
  - G: Commercial, Pb-free lead finish  
(Available for SO-8 (GS) only)

Examples: SS6783ACSTR

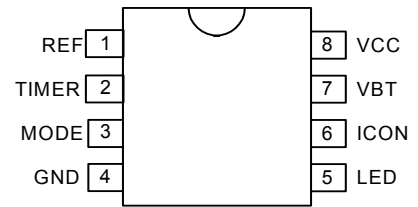
→ in SO-8 package, shipped on tape and reel

SS6783AGSTR

→ in SO-8 package with Pb-free lead finish, shipped on tape and reel

## PIN CONFIGURATION

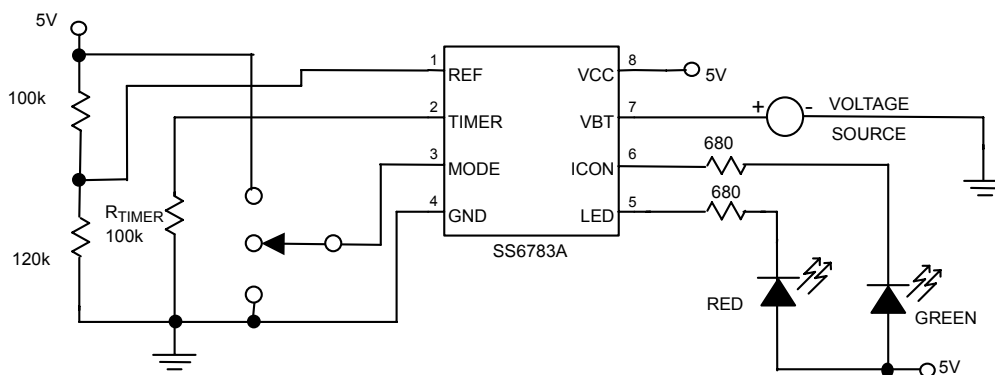
TOP VIEW



## ABSOLUTE MAXIMUM RATINGS

|   |              |
|---|--------------|
| Supply Voltage .....                    | 5.5V         |
| DC Voltage Applied on any pin .....     | 5.5V         |
| Sink current of ICON pin, LED pin ..... | 20mA         |
| Operating Temperature Range .....       | -40°C~ 85°C  |
| Storage Temperature Range .....         | -65°C~ 150°C |

## TEST CIRCUIT



**ELECTRICAL CHARACTERISTICS** (T<sub>A</sub>=25°C, V<sub>CC</sub>=5V, unless otherwise specified.)

| PARAMETER                                  | TEST CONDITIONS  | SYMBOL             | MIN.         | TYP.         | MAX.         | UNIT     |
|--|--|--------------------|--------------|--------------|--------------|----------|
| Supply Voltage                             |  | V <sub>CC</sub>    | 4.5          | 5.0          | 5.5          | V        |
| Supply Current                             |  | I <sub>CC</sub>    |              | 1.1          |              | mA       |
| Voltage Protection Limit                   | Battery Low<br>During Initial Timer<br>After Initial Timer | V <sub>BT</sub>    | 0.11<br>0.63 | 0.16<br>0.69 | 0.21<br>0.75 | V        |
|  | Battery High   |                    | 2.6          | 2.7          | 2.80         |          |
| Output Impedance                           | LED, ICON Pins<br>ON                                       |                    | 1            | 25           | 50           | Ω<br>MΩ  |
|  | OFF  |                    |              |              |              |          |
| Input Impedance                            | MODE pin   |                    | 1            | 300          |              | kΩ<br>MΩ |
|  | VBT pin  |                    |              |              |              |          |
| Recommended External Resistor of TIMER pin |  | R <sub>TIMER</sub> | 2            | 100          | 1000         | kΩ       |
| -ΔV Detection accuracy                     | VBT=2V   |                    | -0.15        | -0.25        | -0.35        | %        |

## TYPICAL PERFORMANCE CHARACTERISTICS (T<sub>A</sub>=25°C, R<sub>TIMER</sub>=100kΩ, V<sub>CC</sub>=5V, refer to Test Circuit)

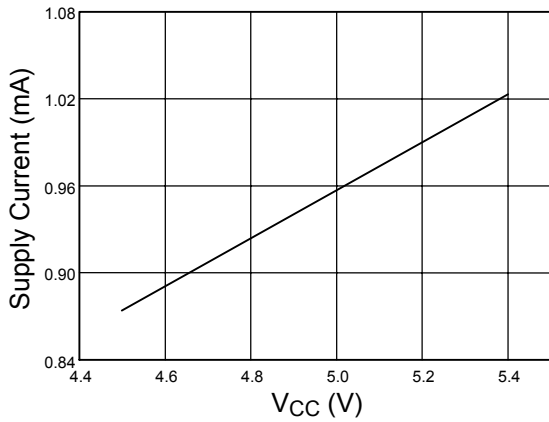


Fig. 1 Supply Current vs. Supply Voltage

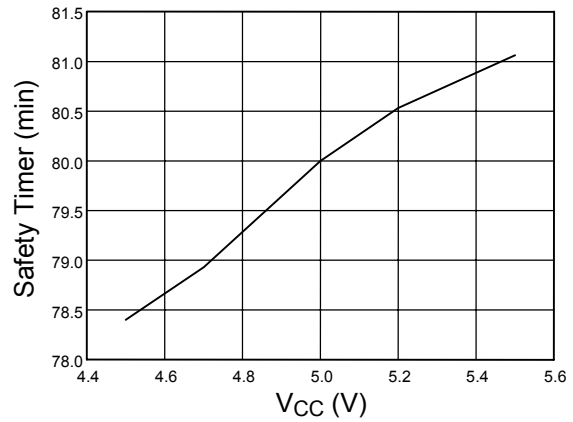


Fig. 2 Safety Timer vs. Supply Voltage

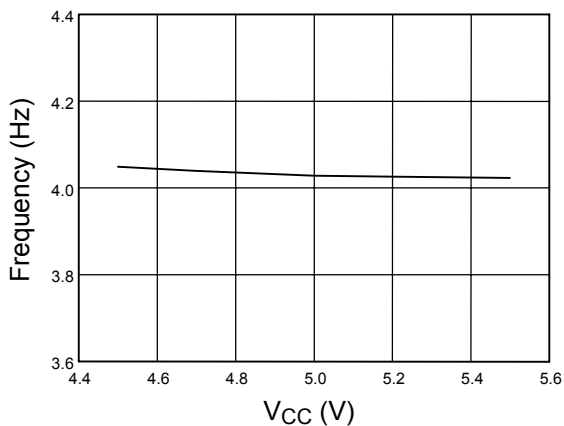


Fig. 3 LED Flashing Frequency vs. Supply Voltage

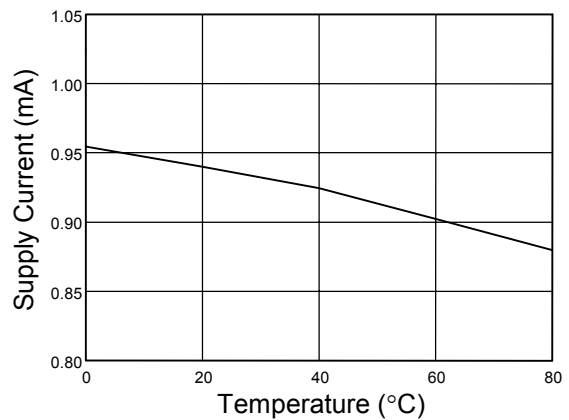


Fig. 4 Supply Current vs. Temperature

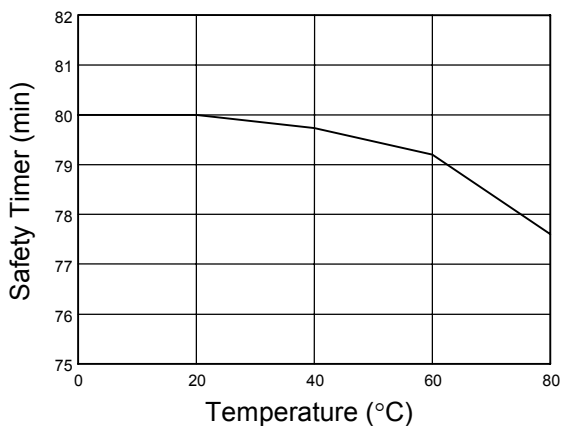


Fig. 5 Safety Timer vs. Temperature

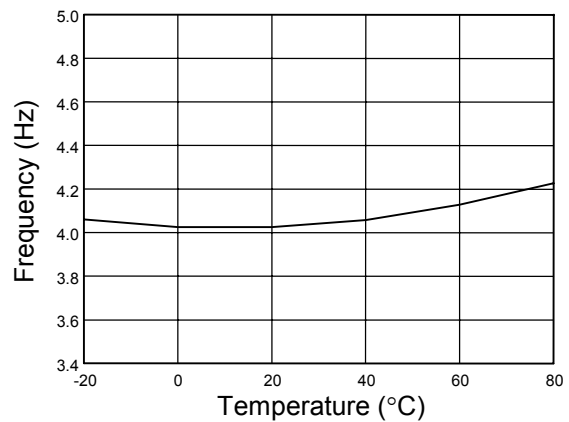
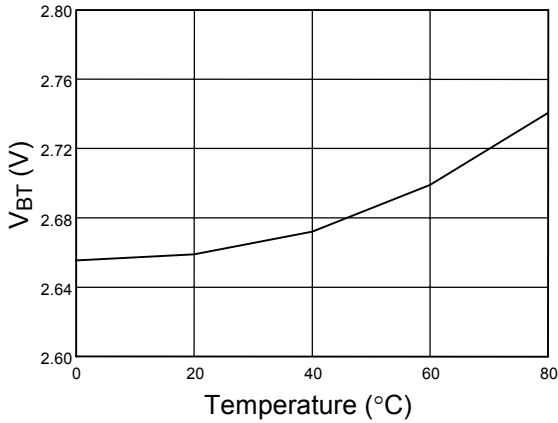
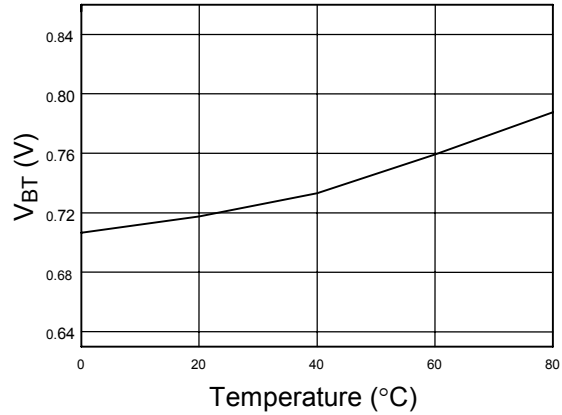
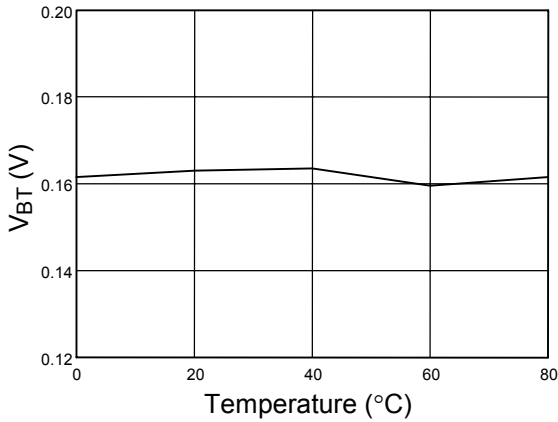
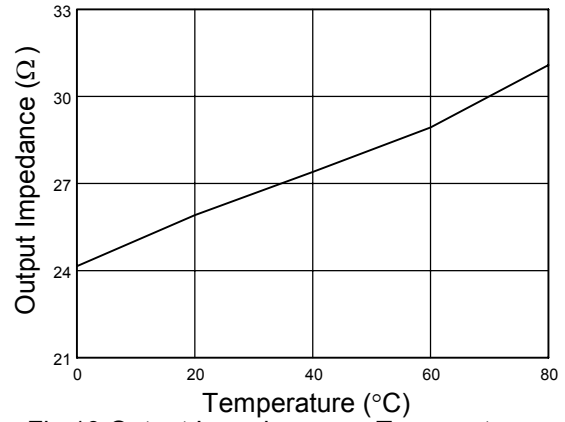
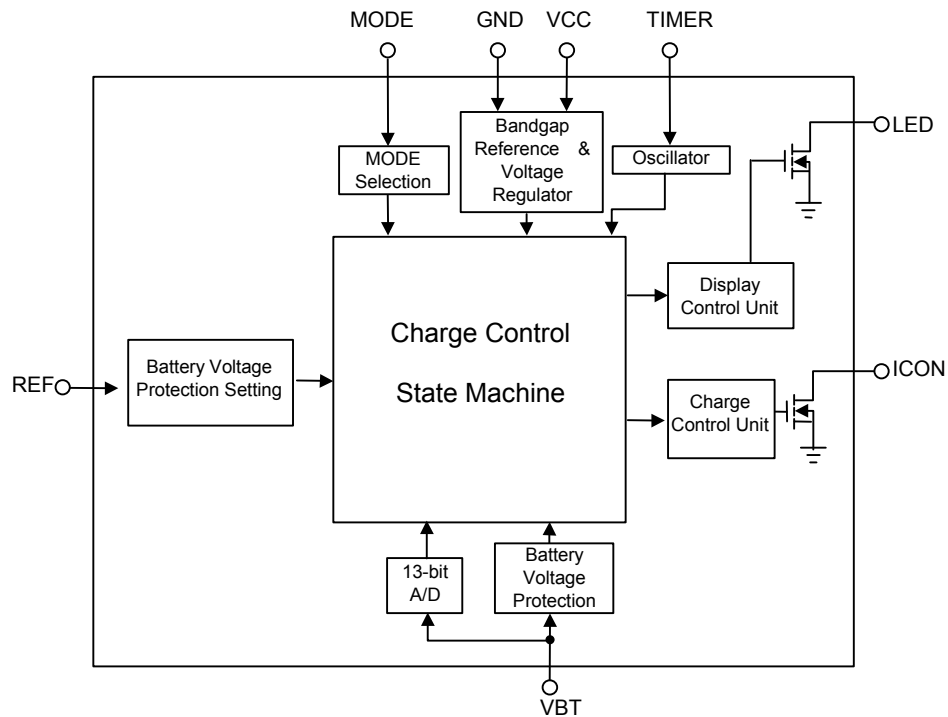


Fig. 6 LED Flashing Frequency vs. Temperature

**TYPICAL PERFORMANCE CHARACTERISTICS (Continued)**

**Fig. 7 V<sub>BT</sub> (High) Limit vs. Temperature**

**Fig. 8 V<sub>BT</sub> (Low) Limit vs. Temperature (After Initial Timer)**

**Fig. 9 V<sub>BT</sub> (Low) Limit vs. Temperature (During Initial Timer)**

**Fig.10 Output Impedance vs. Temperature (LED, ICON Pins)**

## BLOCK DIAGRAM



## PIN DESCRIPTIONS

- |   |   |
|---|---|
| <p>PIN 1: REF- Reference voltage input, acceptable voltage range : <math>(V_{CC}-1.4V) \sim (0.5V_{CC}+0.4V)</math></p> | <p>PIN 5: LED- Open-drain output used to indicate the battery charging status.</p>          |
| <p>PIN 2: TIMER- Determining the period of safety timer with an external resistor connected to GND.</p>                 | <p>PIN 6: ICON- Open-drain output, used to control the charging current to the battery.</p> |
| <p>PIN 3: MODE- Determining the mode of operation for the SS6783A.</p>  | <p>PIN 7: VBT- Divided battery voltage input to sense the battery voltage.</p>              |
| <p>PIN 4: GND- Power ground.</p>  | <p>PIN 8: VCC- Power supply input at <math>5V \pm 10\%</math>.</p>                          |

## APPLICATION INFORMATION

### OPERATION

#### Power-On and Battery Pre-Qualifying

When power is first applied to the SS6783A, all internal digital circuit blocks of the SS6783A are reset by the internal power-on-reset circuitry and the output LED flashes 3 times to indicate the initiation of power-on. The internal control unit then examines the battery condition through the VBT pin.

The acceptable range of VBT pin is 0.16V to 2.7V. If the voltage of VBT pin fails to fall within the predetermined acceptable limits, the SS6783A enters a charge-suspending mode, in which all the internal circuitry remains in reset state.

#### Fast Charge

After the battery passes fault checks, fast charging begins while the initial timer and safety timer of the SS6783A start counting. The functions of  $-\Delta V$  detection, peak voltage timer, and maximum battery voltage are, however, disabled temporarily until the initial timer period in the initial stage of a charge cycle elapses. The initial timer period is equal to 1/80 of the safety timer.

Since the low limit of acceptable VBT voltage is only about 0.16V during the initial timer period, even deeply discharged batteries can easily qualify to be subsequently fast charged.

In the course of fast charge, the SS6783A constantly monitors the voltages at VBT pin. The fast charge process is switched to trickle charge when any one of the following situations is encountered, which are explained below:

- Negative delta voltage ( $-\Delta V$ )
- Peak voltage timer ( $0\Delta V$ )
- Maximum charge time
- Maximum battery voltage

#### $-\Delta V$ Cutoff

The SS6783A makes a voltage sampling at VBT pin every 4 seconds when safety timer period is set equal to 80 minutes. If a negative delta voltage of 0.25% compared to its peak value is detected at VBT pin, the fast charge cycle is terminated.

#### $0\Delta V$ Cutoff

If the battery voltage stays at its peak value or decreases very slowly for the duration determined by the peak voltage timer which is 6% of safety timer, the fast charge action is terminated.

#### Maximum Safety Timer Cutoff

The maximum fast charge period is determined by the safety timer, which is set by a resistor connected from TIMER pin to GND. Safety timer,  $-\Delta V$ , sampling rate will be longer if the resistor value is larger. When the value of the resistor is 100k $\Omega$ , the safety timer period equals 80 minutes. After the safety timer period is finished, the fast charge action is terminated.

#### Maximum Voltage Cutoff

The SS6783A guards against the maximum limits for battery voltage during fast charging. If either of these limits is exceeded, fast charge action is terminated.

#### Trickle Charge

Trickle charge starts after the fast charge to prevent the loss of charge due to battery self-discharge.

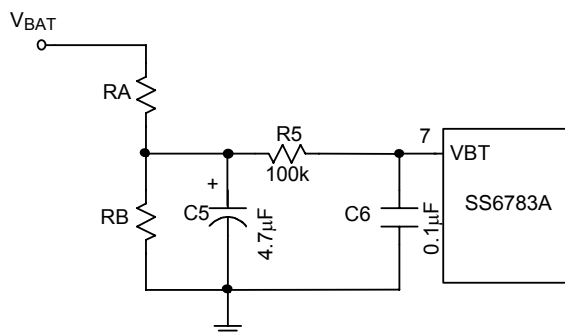
The duty cycle is set to 1/128 by internal circuitry.

The functions and charging state control mentioned above are illustrated in the function flow-chart of the SS6783A (Fig. 12)

## DESIGN GUIDE

### Battery Voltage Measurement

The SS6783A measures the battery voltage through VBT pin, which is connected to the battery positive terminal through a resistor-divider network, as shown in Fig. 11.



**Fig. 11 Battery Voltage Divider**

The suggested divider resistance of RA and RB for the corresponding number of battery cells are as below:

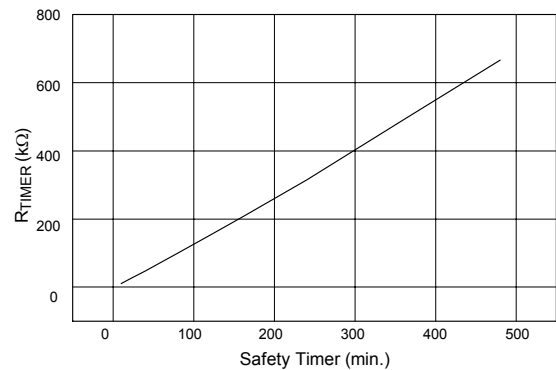
**TABLE 1**

| BATTERY CELLS | RA/RB | RA (kΩ) | RB (kΩ) |
|---------------|-------|---------|---------|
| 2~4           | 2     | 240     | 120     |
| 3~6           | 3.3   | 300     | 91      |
| 4~8           | 4.9   | 300     | 62      |
| 5~10          | 6.4   | 300     | 47      |
| 6~12          | 7.8   | 310     | 39      |
| 8~16          | 10.8  | 390     | 36      |

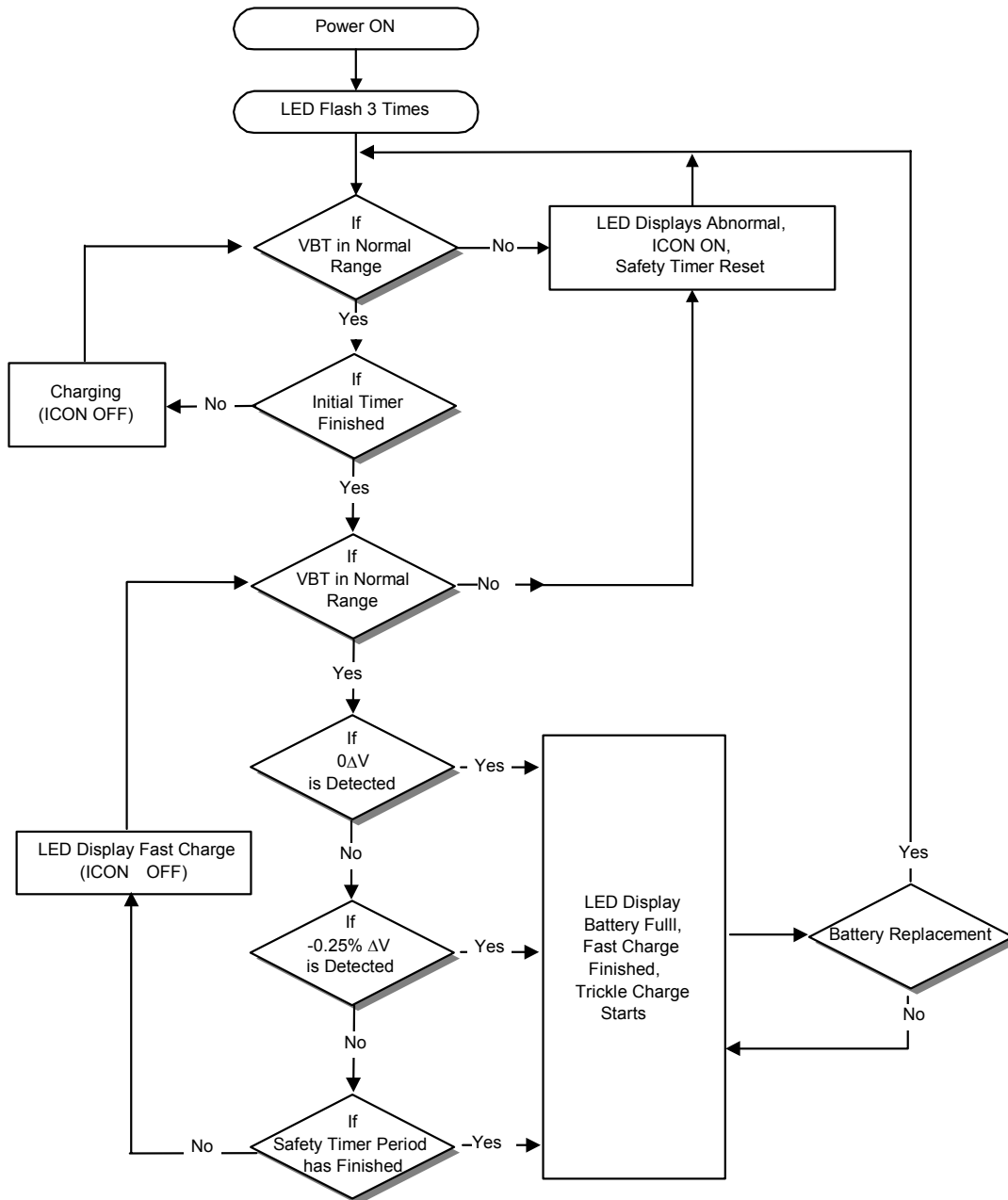
### Setting the Period of Safety Timer

The SS6783A provides a method for linearly adjusting the period of the safety timer with an external resistor connected from TIMER pin to GND.

The relation between safety timer length and the external resistor ( $R_{TIMER}$ ) is shown in Fig. 13. The table following shows the resistor values for some of the commonly chosen safety timer periods. Also shown in the table are their corresponding oscillator frequencies.



**Fig. 13 Safety Timer vs.  $R_{TIMER}$**


**Fig. 12 Function Flow Chart of SS6783A**

**TABLE 2**

| R <sub>TMR</sub> (kΩ) | OSC. Freq.(kHz) | Safety timer (min.) |
|-----------------------|-----------------|---------------------|
| 11                    | 256             | 10                  |
| 23                    | 131             | 20                  |
| 48                    | 65.8            | 40                  |
| 74                    | 43.1            | 60                  |
| 100                   | 32.8            | 80                  |
| 152                   | 21.6            | 120                 |
| 206                   | 16.0            | 160                 |
| 314                   | 10.6            | 250                 |
| 491                   | 6.89            | 380                 |
| 667                   | 5.04            | 520                 |

**Selecting Mode of Operation**

The SS6783A provides three modes of operation: normal, test, and AC mode determined by the setting of MODE pin. The SS6783A will operate normally when the MODE pin is left floating (a 0.1μF capacitor is recommended to be tied to MODE pin if the charge circuit works in a noisy environment). When the MODE pin is biased to GND, the function of -ΔV detection is disabled. When the MODE pin is biased to V<sub>CC</sub>, the SS6783A enters the test mode. The test mode can be used to significantly reduce production test time.

**TABLE 3**

| MODE pin | Mode   | Function                                |
|----------|--------|---|
| VCC      | Test   | Safety timer period scaled down to 1/32 |
| Floating | Normal | Normal operation                        |
| GND      | AC     | -ΔV detection disabled                  |

**Display the Battery Charging Status**

The SS6783A provides an open-drain output at the LED pin, to indicate the battery charging status. The outputs of LED pin are shown in the following table:

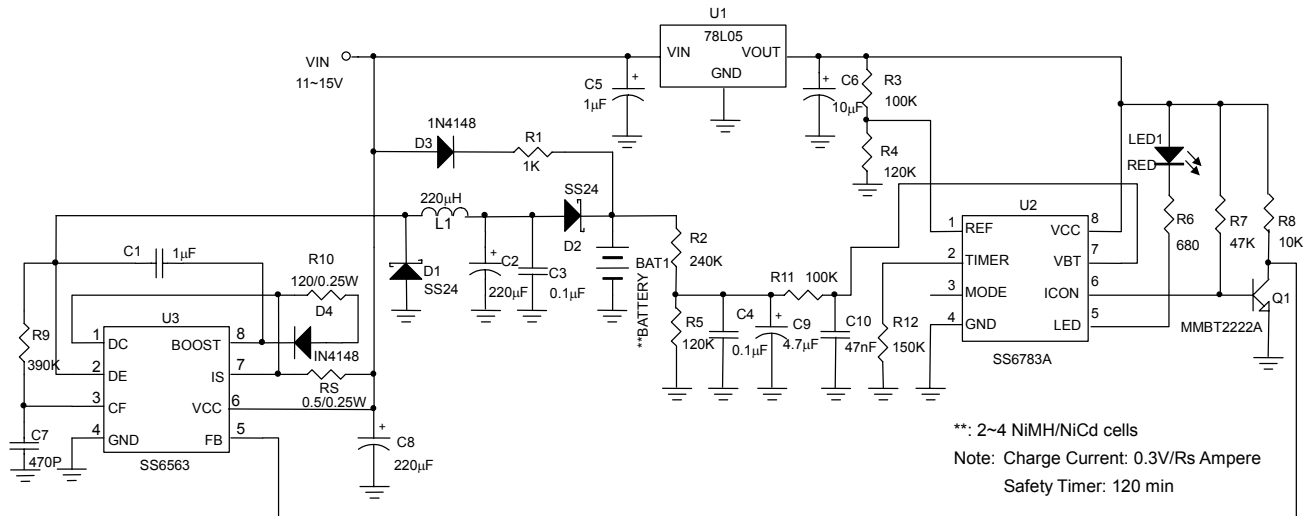
|     | Power ON | Fast Charging | Charge Completed | Fault Conditions |
|-----|----------|---------------|------------------|------------------|
| LED | 1Hz      | 4Hz Flashing  | ON               | OFF              |

**Charging Current Control**

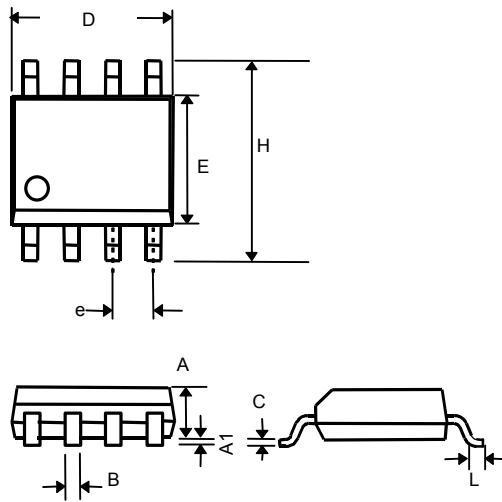
As shown in the typical application circuit, the SS6783A offers an open-drain output at the ICON pin, to control the charging current flow in fast charge state and switch on to inhibit the charging current flow in fault conditions. When fast charge is completed, the SS6783A enters the trickle charge mode. In trickle charge mode, the ICON pin output switches with 1/128 duty cycle.

|      | Power ON | Fast Charging | Charge Completed | Fault Conditions |
|------|----------|---------------|------------------|------------------|
| ICON | ON       | OFF           | 1/128 Duty cycle | ON               |

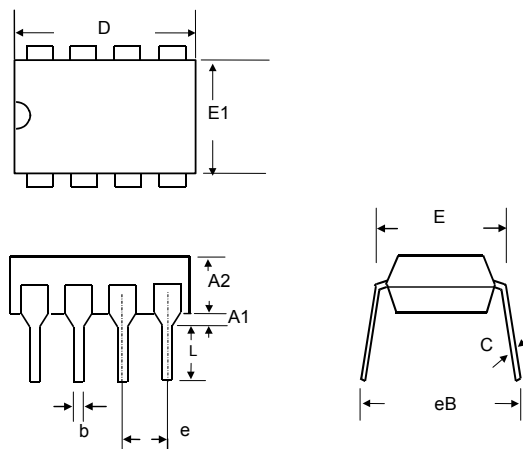
## APPLICATION EXAMPLE



**Fig. 14 Switching Battery Charger Circuit with Wide Input Voltage Range**

**PHYSICAL DIMENSIONS (unit: mm)**
**8 LEAD PLASTIC SO (CS/GS)**


| SYMBOL | MIN       | MAX  |
|--------|-----------|------|
| A      | 1.35      | 1.75 |
| A1     | 0.10      | 0.25 |
| B      | 0.33      | 0.51 |
| C      | 0.19      | 0.25 |
| D      | 4.80      | 5.00 |
| E      | 3.80      | 4.00 |
| e      | 1.27(TYP) |      |
| H      | 5.80      | 6.20 |
| L      | 0.40      | 1.27 |

**8 LEAD PLASTIC DIP (CN)**


| SYMBOL | MIN        | MAX   |
|--------|------------|-------|
| A1     | 0.381      | —     |
| A2     | 2.92       | 4.96  |
| b      | 0.35       | 0.56  |
| C      | 0.20       | 0.36  |
| D      | 9.01       | 10.16 |
| E      | 7.62       | 8.26  |
| E1     | 6.09       | 7.12  |
| e      | 2.54 (TYP) |       |
| eB     | —          | 10.92 |
| L      | 2.92       | 3.81  |

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