

OVERVIEW

The SM6781BV is a quick charge control IC for Nickel Metal Hydride (NiMH) and Nickel-Cadmium (NiCd) rechargeable batteries. Quick charging ends in response to negative delta voltage detection ($-\Delta V$) and maximum charging time detection functions. Also, quick charge mode is placed on hold if the battery voltage becomes abnormal, until normal conditions are restored. The SM6781BV requires few external components to realize a high-stability quick charge battery charger.

FEATURES

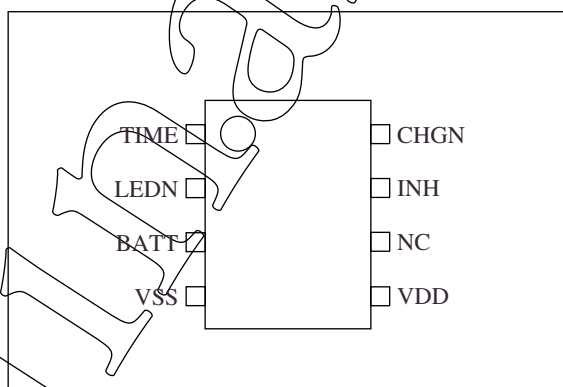
- Ni-MH/Ni-Cd battery quick charge control
- $-\Delta V$ and maximum charge time cutoffs
- 15min (typ) $-\Delta V$ detection invalid time
- $-4mV$ (typ) $-\Delta V$ detection accuracy
- Inhibit function
- Charge condition LED indicator output (on, pulsed, off)
- Low power dissipation standby mode ($< 1\mu A$)
- 8-pin VSOP package

ORDERING INFORMATION

| Device | Package |
|----------|------------|
| SM6781BV | 8-pin VSOP |

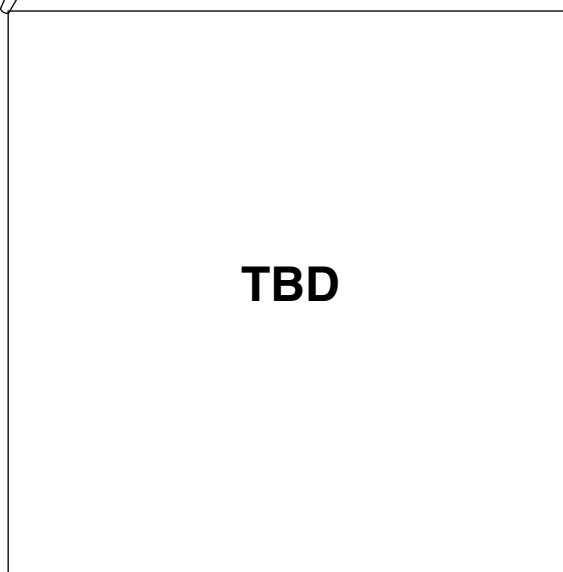
PINOUT

(Top view)

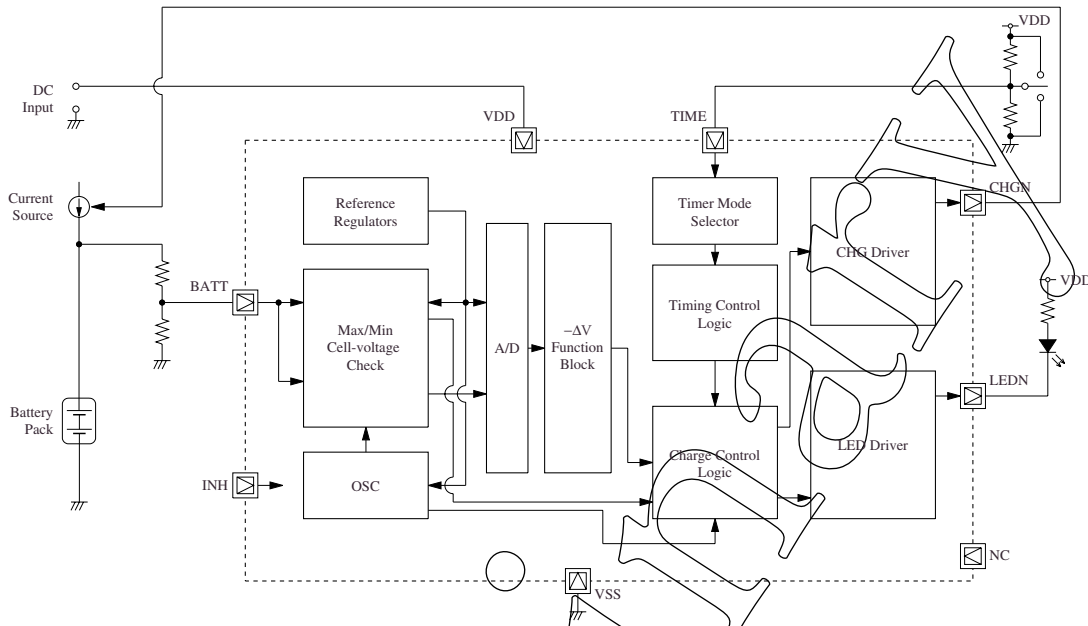


PACKAGE DIMENSIONS

(Unit: mm)



BLOCK DIAGRAM



PIN DESCRIPTION

| Number | Name | I/O | Description |
|--------|------|-----|--|
| 1 | TIME | I | Timer mode select input (3-level). HIGH and LOW levels applied using pull-up and pull-down, respectively. MID-level is applied using a voltage divider resistor network with voltage VDD/2. |
| 2 | LEDN | O | Charge status display LED driver output (open-drain output). LOW-level output in quick-charge mode. 1Hz pulse output when abnormal battery voltage is detected during quick charge. High impedance when charging finishes. |
| 3 | BATT | I | Battery voltage detector input. Connect a high-impedance resistor voltage divider between the poles of the battery for voltage detection. |
| 4 | VSS | - | Ground |
| 5 | VDD | - | Supply |
| 6 | NC | - | No connection (must be open) |
| 7 | INH | I | Inhibit input. Charging operation is stopped when HIGH. Charging recommences with the same charging parameters when INH goes LOW again. |
| 8 | CHGN | O | Charge control (open-drain output). High impedance output when charging current is flowing. LOW-level output when charging current stops. |

SPECIFICATIONS

Absolute Maximum Ratings

$$V_{SS} = 0V$$

| Parameter | Symbol | Condition | Rating | Unit |
|-----------------------------|-----------|-----------|-------------|------|
| Supply voltage range | V_{DD} | | -0.3 to 7.0 | V |
| Input voltage range | V_{IN} | | -0.3 to 7.0 | V |
| Storage temperature range | T_{stg} | | -55 to 125 | °C |
| Operating temperature range | T_{opr} | | -25 to 85 | °C |
| Power dissipation | P_D | | 150 | mW |

DC Characteristics 1

$$V_{DD} = 4.0 \text{ to } 5.5V, V_{SS} = 0V, T_a = 25^\circ C$$

| Parameter | Symbol | Condition | Rating | Variation | Unit |
|-------------------------|-----------|---|--------|-----------|------|
| Minimum battery voltage | V_{MNV} | $V_{BATT} < V_{MNV}$ charge cutoff or prohibition | 0.6 | ± 0.2 | V |
| Maximum battery voltage | V_{MXV} | $V_{BATT} > V_{MXV}$ charge cutoff or prohibition | 2.0 | ± 0.1 | V |

DC Characteristics 2

$$V_{DD} = 4.0 \text{ to } 5.5V, V_{SS} = 0V, T_a = 0 \text{ to } 85^\circ C \text{ unless otherwise noted}$$

| Parameter | Symbol | Condition | Rating | | | Unit |
|--|------------|--|--------------------|-----|--------------------|---------|
| | | | min | typ | max | |
| VDD supply voltage | V_{DD} | | 4.0 | 5.0 | 5.5 | V |
| BATT input voltage | V_{BATT} | | 0 | - | V_{DD} | V |
| INH HIGH-level input voltage | V_{IH1} | | 0.7 | - | - | V |
| INH LOW-level input voltage | V_{IL1} | | - | - | 0.1 | V |
| TIME HIGH-level input voltage | V_{IH2} | | $V_{DD} - 0.5$ | - | - | V |
| TIME MID-level input voltage | V_{IM} | | $(V_{DD}/2) - 0.5$ | - | $(V_{DD}/2) + 0.5$ | V |
| TIME LOW-level input voltage | V_{IL2} | | - | - | 0.5 | V |
| BATT $-\Delta V$ detection voltage range | V_{DET} | | 1 | - | 2 | V |
| LEDN output pulse frequency | f_{LED} | | - | 1 | - | Hz |
| BATT standby voltage | V_{STB} | | $V_{DD} - 1.5$ | - | $V_{DD} - 0.5$ | V |
| VDD current consumption | I_{DD} | $V_{DD} = 5V$, no load | - | - | 0.5 | mA |
| VDD standby current | I_{STB} | $V_{DD} = 5V$, $V_{BATT} = V_{DD}$, no load | - | - | 1 | μA |
| LEDN, CHGN sink current | I_{OL} | $V_{OL} = V_{SS} + 0.8V$ | 10 | - | - | mA |
| INH, TIME input leakage current | I_L | $V_{INH} = V_{TIME} = V_{SS} \text{ to } V_{DD}$ | - | - | ± 1 | μA |
| LEDN, CHGN output leakage current | I_{OZ} | | -5 | - | - | μA |

Maximum Quick Charging Time $V_{DD} = 5V, T_a = 25^\circ C$

| TIME pin | min | typ | max | Unit |
|----------|-----|-----|-----|------|
| HIGH | 192 | 240 | 288 | min |
| MIDDLE | 96 | 120 | 144 | min |
| LOW | 64 | 80 | 96 | min |

– ΔV Detection Voltage $V_{DD} = 5V, T_a = 25^\circ C$

| | min | typ | max | Unit |
|--------------------------------|-----|-----|-----|------|
| – ΔV detection voltage | – | –4 | – | mV |

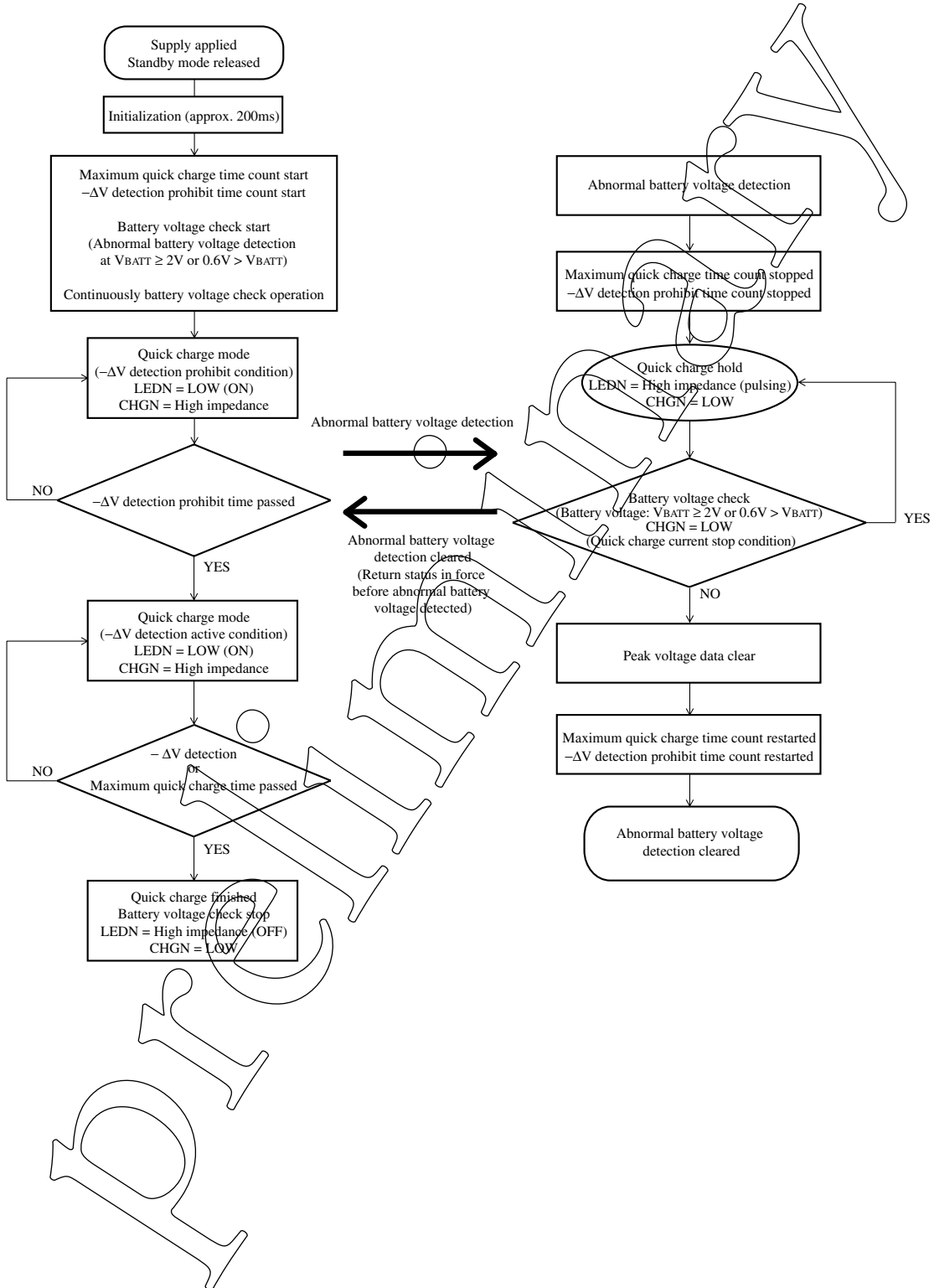
– ΔV detection prohibit time $V_{DD} = 5V, T_a = 25^\circ C$

| | min | typ | max | Unit |
|--------------------------------------|-----|-----|------|------|
| – ΔV detection prohibit time | 720 | 900 | 1080 | sec |

Preliminary

FUNCTIONAL DESCRIPTION

Charging Flowchart



Initialization

The SM6781BV charging operation commences when power is applied or when a battery is inserted (standby mode released). Approximately 200ms are required when operation starts to initialize all internal circuits. When initialization finishes, the charging mode is determined by the BATT input voltage and the timer mode.

Battery Voltage Check

When the BATT input voltage is outside the permitted range, quick charge stops. At this point, the maximum quick charge time count and $-\Delta V$ prohibit time counters also stop. When the BATT input voltage comes back within the permitted range, quick charge and timer stop conditions are released. When quick charge mode is restarted, the saved peak voltage data is reset (cleared to 0V).

$-\Delta V$ Detection Prohibit Time

$-\Delta V$ detection is not performed for approximately 15 minutes from when quick charge commences (quick charge cumulative time).

CHGN Output

CHGN becomes high impedance during quick charge. CHGN goes LOW when quick charge mode finishes or when abnormal battery voltage is detected.

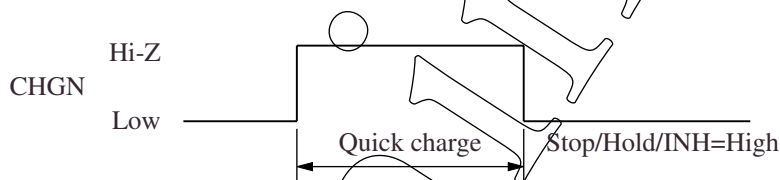


Figure 1. CHGN state

LEDN Output

LEDN is LOW during quick charge (LED is ON), and high impedance after quick charge finishes (LED is OFF). When an abnormal battery voltage is detected before quick charge finishes, a pulse of approximately 1Hz is output (LED flashes). Also, a 1Hz pulse is output when INH is HIGH.

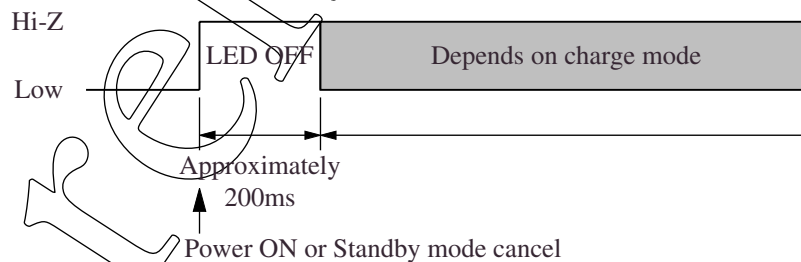


Figure 2. LEDN output

Quick Charge Termination

Quick charge finishes when either $-\Delta V$ voltage is detected or the maximum charging time has elapsed.

–ΔV Detection Function

A –ΔV condition is detected when the BATT voltage (V_{BATT}) falls 4mV (typ) or more below the peak battery voltage, at which point the battery is deemed to be fully charged and quick charge finishes (valid for $1V < V_{BATT} < 2V$).

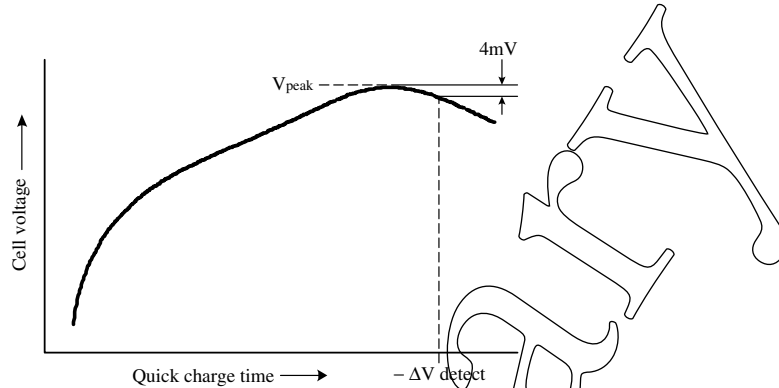


Figure 3. Battery voltage change

–ΔV Detection A/D Converter

The A/D converter employs double integration A/D conversion, and converts samples taken approximately every 1.17 seconds.

–ΔV Detection Timing

The –ΔV detection and peak voltage detection are determined by the average value of 16 A/D converted samples. Consequently, –ΔV detection timing occurs approximately every 18 seconds (16-sample length).

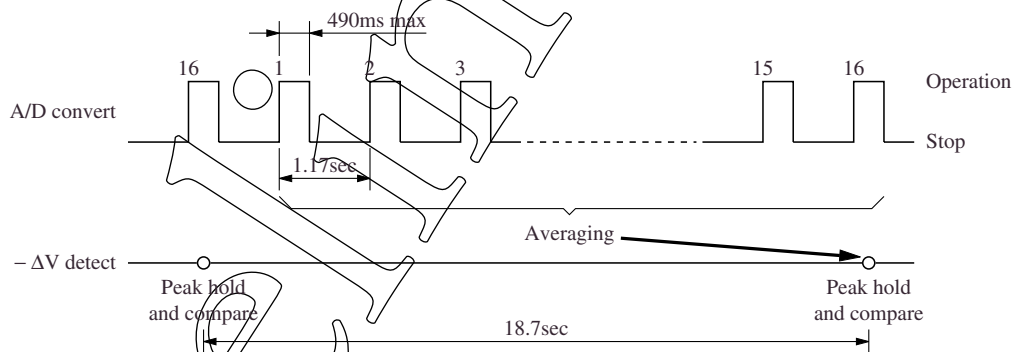


Figure 4. –ΔV detection and A/D convert

Standby Mode

When the BATT input voltage exceeds the standby voltage V_{STB} , the device enters standby mode.

In this mode, the maximum charging time timer, –ΔV detection prohibit timer, and peak voltage data are all reset to zero. At this time, the CHGN and LEDN outputs both become high impedance.

Charge Inhibit (INH)

When INH goes HIGH, charge mode operation stops. While INH is HIGH, the internal timer stops, CHGN goes LOW and LEDN outputs 1Hz pulse (LEDN flashes). When INH goes LOW, the SM6781BV is restored to the previous state and the internal timer restarts. If INH is connected to temperature switch (NPC SM6611), it realizes simple temperature control.

BATT Input

The voltage applied to the BATT input, used for battery voltage detection, is a voltage potential, derived by a voltage divider resistor network (100kΩ or higher recommended) or other means, that represents the voltage of a single battery cell during charging. If a single cell only is under charge, a current limiting resistor (100kΩ or higher is recommended) should be connected between the battery and BATT input.

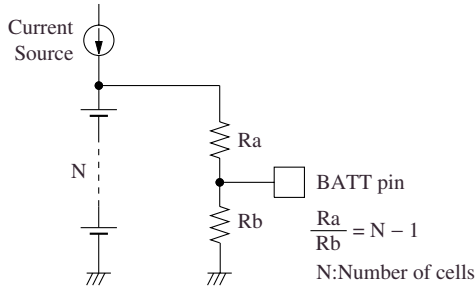


Figure 5. BATT connection example (multiple)

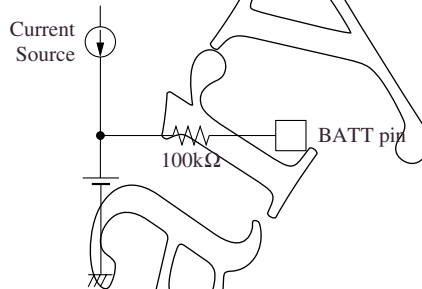
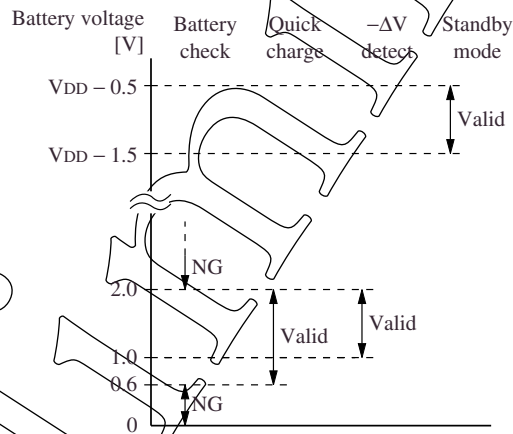


Figure 6. BATT connection example (single)

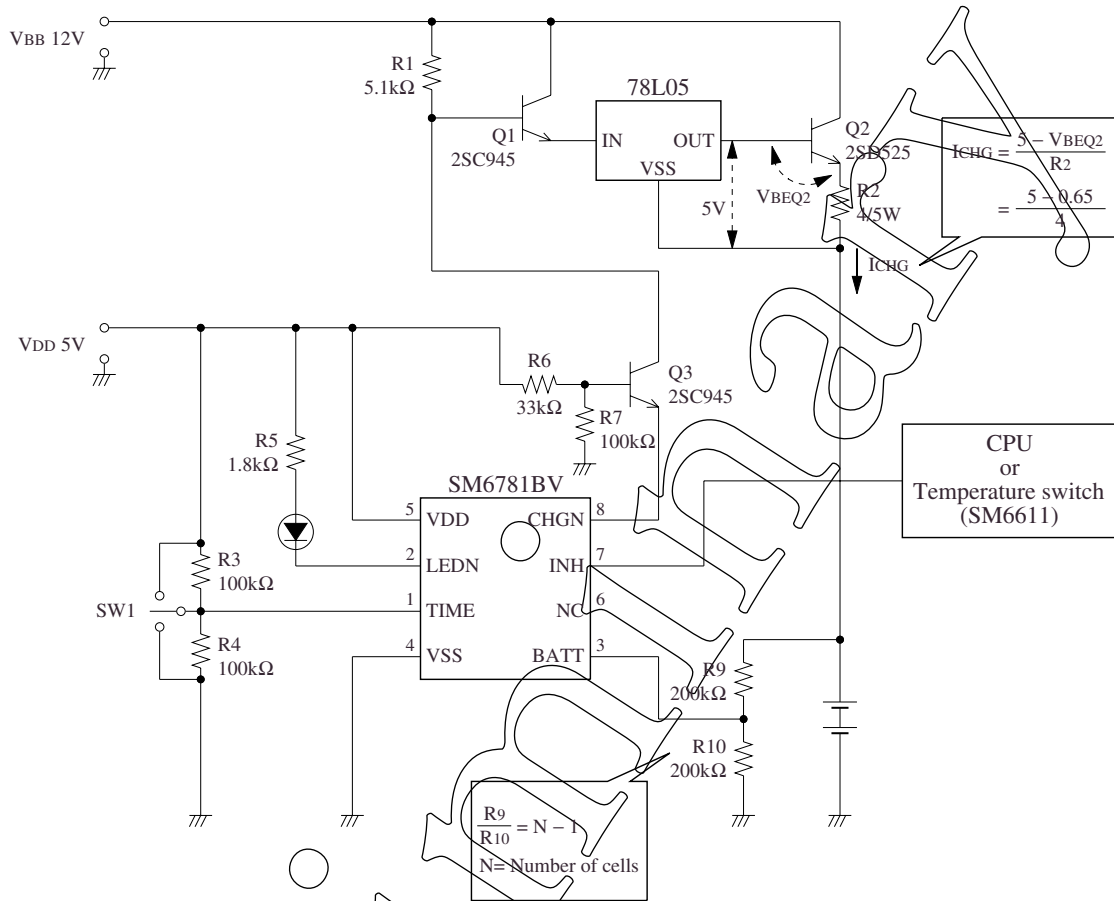
Operating Mode vs. BATT Input Voltage



Charging Operating Status

| Charging status | Conditions | | CHGN output | LEDN output | Internal timer |
|----------------------|------------|------------------|----------------|----------------------|----------------|
| | INH | Battery check OK | | | |
| Quick charge | LOW | Yes | High impedance | LOW (ON) | Count |
| Quick charge hold | LOW | No | LOW | 1Hz (pulsing) | Hold |
| Quick charge inhibit | HIGH | — | LOW | 1Hz (pulsing) | Hold |
| Quick charge finish | LOW | Yes | LOW | High impedance (OFF) | Reset |
| Standby | — | — | High impedance | High impedance (OFF) | Reset |

TYPICAL APPLICATION CIRCUIT



Note that the above circuit is an example circuit to demonstrate the connections for device functions. Battery charger operation is not guaranteed.

PRELIMINARY

Preliminary

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