

Display Mode Options

Introduction

The bq2007 Fast Charge IC provides flexibility with a wide variety of charge status monitor display mode formats. The bq2007 internal charge status monitor can be configured to support up to a seven-segment bargraph or a single BCD digit display. The bargraph display indicates up to seven monotonic steps, whereas the BCD digit indicates ten steps of 10% increments. The bq2007 output drivers can direct-drive either LCD or LED interface levels.

Display Driver Modes

The bq2007 is designed to interface directly with LCD or LED type displays. The display driver mode is selected with the soft-programmed input MSEL and is independent of the state-of-charge monitor format or indications. The LED signal levels are driven when the MSEL soft-programmed input is pulled to V_{CC} at initialization. The output pin COM is the common-anode connection for LED SEG_{A-G} . See Figure 1.

The LCD interface mode is enabled when the MSEL soft-programmed input is pulled to V_{SS} at initialization. An internal oscillator generates all timing signals required for the LCD interface. Output pin COM is the common connection for static direct-driving of the LCD display backplane and is driven with an AC signal at the

frame period. When enabled, each of the SEG_{A-G} pins are driven with the correct-phase AC signal to activate the LCD segment. See Figure 1.

Charge Status Indication

Table 1 summarizes the bq2007 charge status display indications. The charge status indicators include the DIS output, which can be used to indicate the discharge state, the audio ALARM output, which indicates charge completion and fault conditions, and the dedicated status outputs, LED₁ and LED₂.

Outputs LED₁₋₂ have three display modes that are selected at initialization by the input pins DSEL₁ and DSEL₂. The DSEL₁ and DSEL₂ input pins, when pulled down to V_{SS} , are intended for implementation of a simple two-LED system, where LED₁ indicates the precharge status (i.e., charge pending and discharge) and LED₂ indicates the charge status (i.e., charging and completion). DSEL₁ pulled up to V_{CC} and DSEL₂ pulled down to V_{SS} mode allows the implementation of a single tri-color LED such that discharge, charging, and completion each have a unique color. DSEL₁ pulled down to V_{SS} and DSEL₂ pulled up to V_{CC} mode allows for fault status information. See Figure 2.

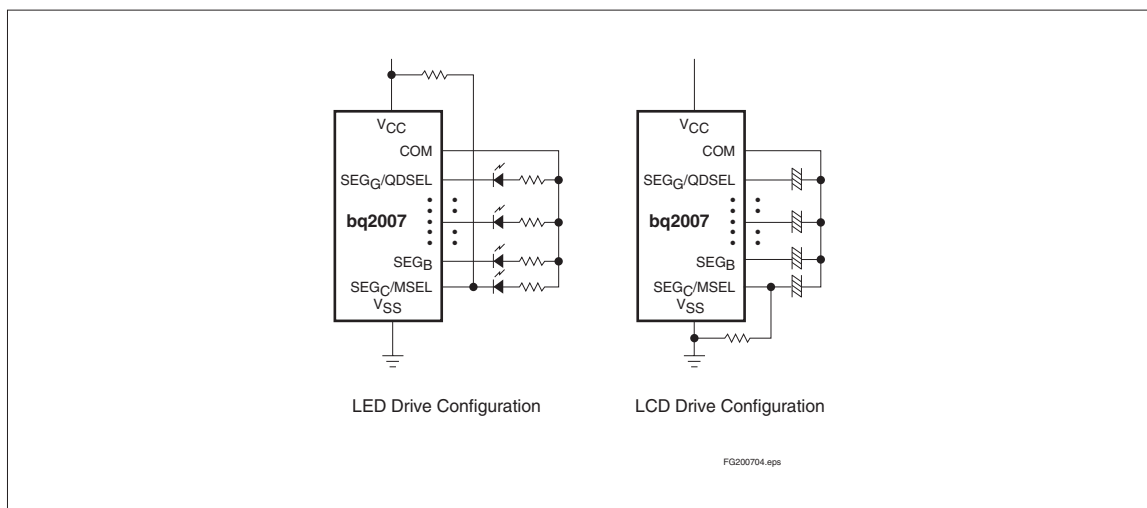


Figure 1. Display Driver Configurations

Using the bq2007 Display Mode Options

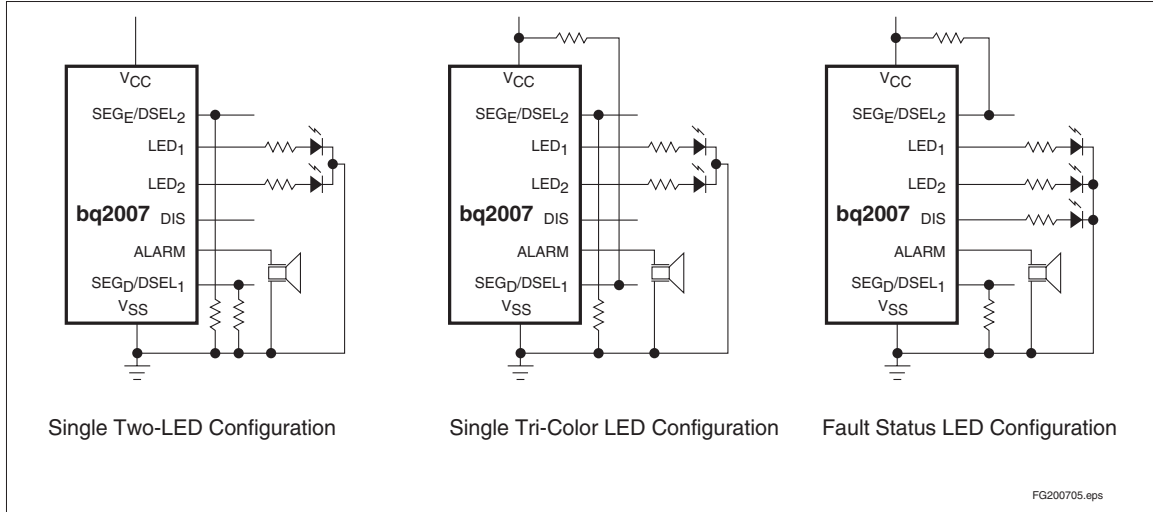


Figure 2. Charge Status Display Configurations

Table 1. bq2007 Charge Status Display Summary

Mode	Charge Action State	LED ₁	LED ₂	DIS	ALARM
DSEL ₁ = L DSEL ₂ = L (Mode 1)	Battery absent	0	0	0	0
	Charge pending (temp. limit, low voltage)	0	Flashing	0	0
	Discharge in progress	0	1	1	0
	Charging	Flashing	0	0	0
	Charge complete	1	0	0	High tone
	Fault (low-voltage time-out)	0	0	0	High tone
DSEL ₁ = H DSEL ₂ = L (Mode 2)	Battery absent	0	0	0	0
	Discharge in progress, pending	1	1	1	0
	Charging	1	0	0	0
	Charge complete	0	1	0	High tone
	Fault (low-voltage time-out)	0	0	0	High tone
DSEL ₁ = L DSEL ₂ = H (Mode 3)	Battery absent	0	0	0	0
	Charge pending (temp. limit, low voltage)	0	Flashing	0	0
	Discharge in progress	0	Flashing	1	0
	Charging	Flashing	0	0	0
	Charge complete	1	0	0	High tone
	Fault (low-voltage time-out)	0	1	0	High tone

Note: 1 = on; 0 = off; L = pulled down to V_{SS}; H = pulled up to V_{CC}.

Using the bq2007 Display Mode Options

Audio Output Alarm

The bq2007 audio alarm output generates an audio tone to indicate a charge completion or fault condition. The audio alarm output is a symmetrical duty-cycle AC signal that is compatible with standard piezoelectric alarm elements. A valid battery insertion is indicated by a single 3.5kHz beep of $\frac{1}{2}$ -second typical duration. The charge completion and fault conditions are indicated by a 9.5- to 15-second high-tone sequence of $\frac{1}{2}$ -second typical duration at a 2-second typical repetition rate.

Charge Status Monitoring

The bq2007 charge status monitor may display the battery voltage or charge safety timer as a percentage of the full-charged condition. These options are selected with the MULT soft-programmed input pin.

When MULT is pulled down to V_{SS}, the battery charge status is displayed as a percentage of the battery voltage, and the single-cell battery voltage at the BAT pin is compared with internal charge voltage reference thresholds. When V_{BAT} is greater than the internal thresholds of V₂₀, V₄₀, V₆₀, or V₈₀, the respective 20%, 40%, 60%, or 80% display outputs are activated. The battery voltage directly indicates 20% charge increments, while the 10% charge increments use a timer that is a function of the charge safety timer.

When MULT is pulled down to V_{SS} and when V_{BAT} exceeds V₂₀ during charging, the 20% charge indication is activated and the timer begins counting for a period equal to $\frac{1}{64}$ to $\frac{1}{32}$ of the charge safety time-out period. When the timer count is completed, the 30% charge indication is activated. Should V_{BAT} exceed V₄₀ prior to the timer count completion, the charge status monitor activates the 30% and 40% indications. This technique is used for all the odd percentage charge indications to assure a monotonic charge status display.

When MULT is pulled up to V_{CC}, the bq2007 charge status monitor directly displays $\frac{1}{32}$ of the charge safety timer as a percentage of the full-charge time. This method is recommended over the voltage-based method when charging packs with different cell configuration (i.e. 5-cell or 6-cell pack) where the battery terminal voltages will vary greatly between packs. This method offers an

accurate charge status indication when the battery is fully discharged. When using the timer-based method, discharge-before-charge is recommended.

During discharge with MULT pulled down to V_{SS}, the charge status monitor indicates the percentage of the battery voltage by comparing V_{BAT} to the internal discharge voltage reference thresholds. In BCD format, the discharge thresholds V₈₀, V₆₀, V₄₀, and V₂₀ correspond to a battery charge state indication of 90%, 70%, 50%, and 30%, respectively. In bargraph format, the same discharge thresholds correspond to a battery charge state indication of 90%, 60%, 40%, and 30%, respectively. Differences in the battery charge state indications are due to the finer granularity of the BCD versus the bargraph format.

During discharge and when MULT is pulled up to V_{CC}, the state-of-charge monitor BCD format displays the discharge condition, letter “d,” whereas the bargraph format has no indication.

The charge status display is blanked during the charge pending state and when the battery pack is removed.

Charge Status Display Modes

The bq2007 charge status monitor can be displayed in two modes summarized in Table 2. The display modes are a seven-segment monotonic bargraph or a seven-segment BCD single-digit format. When QDSEL is pulled down to V_{SS}, pins SEG_{A-G} drive the decoded seven segments of a single BCD digit display, and when QDSEL is pulled up to V_{CC}, pins SEG_{A-G} drive the seven segments of a bargraph display.

In the bargraph display mode, outputs SEG_{A-G} allow options for a three-segment to seven-segment bargraph display. The three-segment charge status display uses outputs SEG_B, SEG_D, and SEG_F for 30%, 60%, and 90% charge indications, respectively. The four-segment charge status display uses outputs SEG_A, SEG_C, SEG_D, and SEG_E for 20%, 40%, 60%, and 80% indications, respectively. The seven-segment charge status monitor uses all segments. See Figure 3.

The BCD display mode drives pins SEG_{A-G} with the decoded seven-segment single-digit information. The display indicates in 10% increments from a BCD zero count at charge initiation to a BCD nine count indicating 90% charge capacity. Charge completion is indicated by the letter “F,” a fault condition by the letter “E,” and the discharge condition by the letter “d.” See Figure 4.

Using the bq2007 Display Mode Options

Table 2. bq2007 Charge Status Display Summary

Mode	Display Indication	SEG _A	SEG _B	SEG _C	SEG _D	SEG _E	SEG _F	SEG _G
QDSEL = H	20% charge	1	0	0	0	0	0	0
	30% charge	1	1	0	0	0	0	0
	40% charge	1	1	1	0	0	0	0
	60% charge	1	1	1	1	0	0	0
	80% charge	1	1	1	1	1	0	0
	90% charge	1	1	1	1	1	1	0
	Charge complete	1	1	1	1	1	1	1
QDSEL = L	0% charge—digit 0	1	1	1	1	1	1	0
	10% charge—digit 1	0	1	1	0	0	0	0
	20% charge—digit 2	1	1	0	1	1	0	1
	30% charge—digit 3	1	1	1	1	0	0	1
	40% charge—digit 4	0	1	1	0	0	1	1
	50% charge—digit 5	1	0	1	1	0	1	1
	60% charge—digit 6	1	0	1	1	1	1	1
	70% charge—digit 7	1	1	1	0	0	1	0
	80% charge—digit 8	1	1	1	1	1	1	1
	90% charge—digit 9	1	1	1	1	0	1	1
	Charge complete—letter F	1	0	0	0	1	1	1
	Fault condition—letter E	1	0	0	1	1	1	1
	Discharge—letter d	0	1	1	1	1	0	1

Note: 1 = on; 0 = off; L = pulled down to V_{SS}; H = pulled up to V_{CC}.

Using the bq2007 Display Mode Options

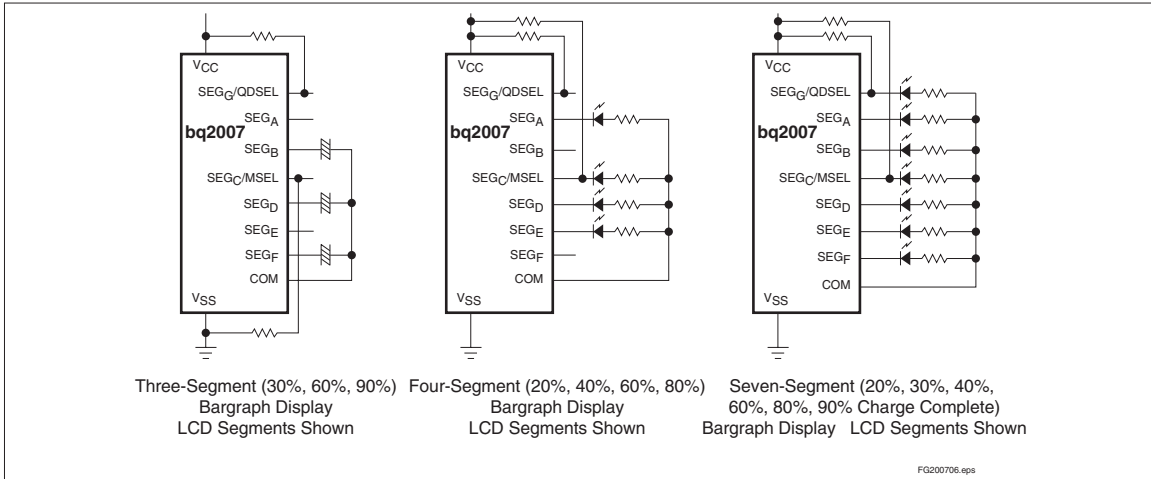


Figure 3. Charge Status Bargraph Display Configurations

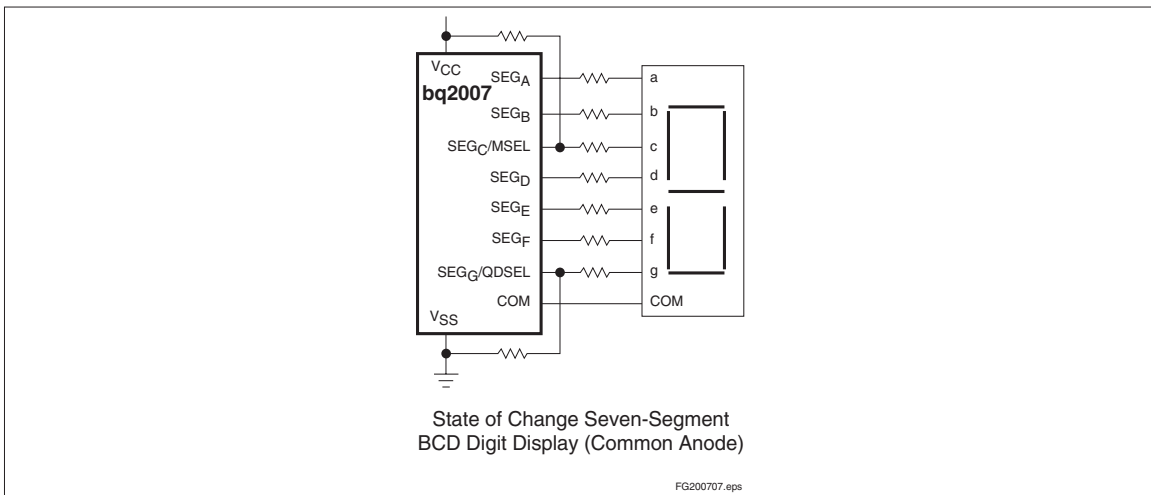


Figure 4. Charge Status BCD Digit Display Mode

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