Application Report
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Selection of Multi-Cell Standalone Switching Battery Chargers

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ABSTRACT

This application report provides a comparison among BQ241x0/3/4/5/8/9, BQ24170/1/2, BQ24133, and BQ246xx multi-cell standalone switching battery charge devices. The document presents the main differences and describes the key features of each part. This document can assist design engineers with selecting the most suitable IC for their multi-cell standalone switching battery charge applications.

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1 Multi-Cell Standalone Switching Charger Comparison

Table 1 compares different parameters of the BQ241x0/3/4/5/8/9, BQ24170/1/2, BQ24133, and BQ246xx. It provides the input voltage range, the maximum charging current during the fast-charge phase of each charger, the power path, the availability of the Dynamic Power Management function, temperature qualification range, and the packaging type and size.

Table 1. Summary of Comparison on Multi-Cell Standalone Switching Charger ICs

Device	Vin (OVP)	Fast-Charge Current	V-charge	Power-Path Gate Drive	DPM IIN	Switching MOSFET	Frequency	Battery	Temperature Qualification Profile	Package
BQ241x0/3/4/8/9	4.3-16 V (N/A)	Max 2 A	1-3 Cell 4.2 V/cell	N/A	N/A	Internal	1.1 MHz	Li-ion or Li-polymer	0°-45°C or wider	3.5x4.5 QFN-20
BQ24105/15/25	4.3-16 V (N/A)	Max 2 A	1-3 Cell Adjustable	N/A	N/A	Internal	1.1 MHz	Li-ion or Li-polymer	0°-45°C or wider	3.5x4.5 QFN-20
BQ24170	4.5-17 V (OVPSET)	Max 4 A	1-3 Cell 4.2 V/cell	ACFET NMOS BATFET PMOS	Yes	Internal	1.6 MHz	Li-ion or Li-polymer	0°-40°C or wider	3.5x5.5 QFN-24
BQ24171	4.5-17 V (OVPSET)	Max 4 A	1-3 Cell Adjustable	ACFET NMOS BATFET PMOS	Yes	Internal	1.6 MHz	Li-ion or Li-polymer	JEITA	3.5x5.5 QFN-24
BQ24172	4.5-17 V (OVPSET)	Max 4 A	1-3 Cell Adjustable	ACFET NMOS BATFET PMOS	Yes	Internal	1.6 MHz	Li-ion or Li-polymer	0°-40°C or wider	3.5x5.5 QFN-24
BQ24133	4.5-17 V (OVPSET)	Max 2.5 A	1-3 Cell 4.2 V/cell	ACFET:NMOS BATFET:PMOS	Yes	Internal	1.6 MHz	Li-ion or Li-polymer	0°-40C or wider	3.5x5.5 QFN-24
BQ24610	5-28 V (32 V)	Max 10 A (10 mΩ Rsns)	1-6 Cell Adjustable	ACFET PMOS BATFET PMOS	Yes	External	600 kHz	Li-ion or Li-polymer	0°-40°C or wider	4x4 QFN-24
BQ24616	5-28 V (32 V)	Max 10 A (10 mΩ Rsns)	1-6 Cell Adjustable	ACFET PMOS BATFET PMOS	Yes	External	600 kHz	Li-ion or Li-polymer	JEITA	4x4 QFN-24
BQ24630	5-28V (32 V)	Max 10 A (10 mΩ Rsns)	1-7 Cell Adjustable	ACFET PMOS BATFET PMOS	Yes	External	300 kHz	LiFePO4	LiFePO4	4x4 QFN-24
BQ24640	5-28 V (32 V)	Max 10 A (10 mΩ Rsns)	2.1~26 V	N/A	No	External	600 kHz	Super capacitor	0°-40°C or wider	3.5x3.5 QFN-16
BQ24650	5-28 V (32 V)	Max 4 A (10 mΩ Rsns)	1-6 Cell Adjustable	N/A	Input voltage (Vin) DPM	External	600 kHz	Li-ion or Li-polymer	0°-40°C or wider	3.5x3.5 QFN-16

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2 BQ241x0/3/4/8/9

The BQ241x0/3/4/8/9 series are highly integrated charge management devices for single-, two-, or three-4.2-V cells of Li-ion and Li-polymer batteries. They have integrated power FETs capable of a charging rate up to 2 A with high-accuracy voltage and current regulation. This part is featured with charge status outputs STAT1 and STAT2 to indicate varied charge operation conditions, charge enable (CE) pin to disable or enable the charging process, open-drain power good (PG) to indicate the presence of the ac-to-dc adapter, sleep mode for low-power consumption if the Vcc pin is removed from the circuit, and an output overvoltage protection to protect the device from high voltages of the battery terminals.

This device family charges the battery in three phases: precharge (conditioning), constant-current regulation phase, and constant-voltage regulation phase. Based on the current level, the charger terminates the charging process for any currents below the selected threshold current level.

During the precharge phase, the charging current is regulated to low levels to revive the undercharged cell of the battery. In the current-regulation phase, the current is kept constant and relatively higher than the previous phase to allow a fast-charging time. As the battery voltage reaches the regulation level, the charger maintains the battery voltage regulated at constant level until the current drops below the termination level.

3 BQ241x5

The BQ241x5 is a bqSWITCHER™ series that are highly integrated Li-ion and Li-polymer chargers. The BQ24105 also can be used to charge LiFePO4 battery chemistry. The BQ241x5 is different than BQ241x0/3/4/8/9 series in that it charges 1-to-3 cells with adjustable output voltage instead. The charging phases and other features are similar to the ones described in the previous device family.

4 BQ24170/2

Both devices are highly integrated, stand-alone, Li-ion and Li-polymer chargers. They can be used for 1-to-3 cells with charging current of up to 4 A. The battery charge voltage is fixed to 4.2 V/cell for the BQ24170 and adjustable for the BQ24172. The input operating voltage rate is from 4.5 V to 18 V with 30-V input rating featured with adjustable overvoltage protection. They can operate at up to 94% efficiency with automatic power-path selection between the adapter and the battery.

The BQ24170/2 charges the battery in three phases, the precharge phase, the fast-charge current phase, and the fast-charge voltage phase. During the precharge current-regulation phase, the battery is charged with constant current equal to 10% of the fast-charge current regulation. This phase allows a safe revival of the deeply discharged cells. After the cell's voltage increases above the threshold voltage level, the charging current goes to 100% to allow fast-charging rate. After reaching the regulation voltage, the charger maintains the cell's voltage constant without regulating the current. As the charging current drops below 10% of the full charging level, the termination occurs and the charger stops injecting current into the battery.

5 BQ24171

The BQ24171 is also a highly integrated, stand-alone, Li-ion and Li-polymer, switch-mode battery charger. Its input operating voltage is from 4.5 V to 17 V and capable of charging 1-to-3 cells with a fixed output voltage of 4.2 V per cell with fast-charge current of up to 4 A. This charger is featured with JEITA-compatible battery temperature sensing. It monitors the battery temperature by controlling the charge rate at lower temperature and lower charge voltage at high temperature. It is included with a Dynamic Power Management to decrease or increase the charging current with respect to the system demands and the input current limits. The BQ24171 also charges the battery in the phases as described in the BQ24170/2 section.

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6 BQ24133

The BQ24133 is also a highly integrated, stand-alone charger for Li-ion and Li-polymer chemistries. It is integrated with two N-channel power MOSFETs. As in the previous sections, this charger has three phases: the preconditioning, the constant-current, and the constant-voltage regulation. It features Dynamic Power Management to control the charge current with the limits of the input power and the demanding system power. The allowed input voltage for this part is up to 20 V and has a fixed output voltage of 4.2 V with a maximum charging current of 2.5 A.

Table 2 provides detailed comparison among BQ24103/BQ24133/BQ24172 integrated standalone switching chargers.

Table 2. BQ24103/BQ24133/BQ24172 Comparison

	BQ24103	BQ24133	BQ24172
Package	3.5x4.5 QFN-20	3.5x5.5 QFN-24	3.5x5.5 QFN-24
Maximum Current	2 A	2.5 A	4 A
Input Voltage Range	4.3–16 V	4.5–17 V	4.5–17 V
Output Voltage	1-3 Cell 4.2 V/Cell	1-3 Cell 4.2 V/Cell	1-3 Cell Adjustable
Switching Frequency	1.1 MHz	1.6 MHz	1.6 MHz
Power Path Management	N/A	ACFET NMOS BATFET PMOS	ACFET NMOS BATFET PMOS
Input Current Regulation	N/A	Yes	Yes
Charge Current Regulation	±10%	±5%	±4%
Switching MOSFETs Rdson (typical)	HS PMOS 250mΩ LS NMOS 90mΩ	HS NMOS 80mΩ LS NMOS 95mΩ	HS NMOS 25mΩ LS NMOS 60mΩ
Programmable Input OVP	No	Yes	Yes
Integrated BTST Schottky Diode	No	Yes	Yes
Thermal Regulation	No	Yes	Yes

7 BQ246xx Summary

The BQ246xx product family of battery charge devices consists of a range of individual ICs. Table 3 compares the parameters of the different family members.

Table 3. BQ246xx Device Comparison(1)

Device	Battery	SW Freq	Input (ACOV)	Pre-charge Current	Pre-charge Voltage	Charge Voltage	Recharge Voltage	I_{IN} DPM & PPM	Safety Timer	Temp Qual Profile	Package
BQ24600	Li-Ion Li-polymer	1.2 MHz	5 V to 28 V (32 V)	I_{SET}/10	V_{FB} = 1.55 V	2.1 V to 26 V	V_{FB} – 50 mV	No	Fixed five hours	Li-Ion 0 to +45°C	16-pin, 3.5x3.5 QFN
BQ24610	Li-Ion Li-polymer	600 kHz	5 V to 28 V (32 V)	R PROG (125 mA min)	V_{FB} = 1.55 V	2.1 V to 26 V	V_{FB} – 50 mV	Yes	C PROG TTC	Li-Ion 0 to +45°C	24-pin, 4x4 QFN
BQ24616	Li-Ion Li-polymer	600 kHz	5 V to 28 V (32 V)	R PROG (125 mA min)	V_{FB} = 1.55 V	2.1 V to 26 V	V_{FB} – 50 mV	Yes	C PROG TTC	Li-Ion JEITA	24-pin, 4x4 QFN
BQ24617	Li-Ion Li-polymer	600 kHz	5 V to 24 V (26 V)	R PROG (125 mA min)	V_{FB} = 1.55 V	2.1 V to 22 V	V_{FB} – 50 mV	Yes	C PROG TTC	Li-Ion 0 to +45°C	24-pin, 4x4 QFN
BQ24620	LiFePO4	300 kHz	5 V to 28 V (32 V)	125 mA	V_{FB} = 0.35 V	1.8 V to 26 V	V_{FB} – 125 mV	No	Fixed five hours	LiFePO4	16-pin, 3.5x3.5 QFN
BQ24630	LiFePO4	300 kHz	5 V to 28 V (32 V)	125 mA	V_{FB} = 0.35 V	1.8 V to 26 V	V_{FB} – 125 mV	Yes	C PROG TTC	LiFePO4	24-pin, 4x4 QFN

(1) Shaded cells indicate key differences of each device.

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Table 3. BQ246xx Device Comparison[(1)] (continued)

Device	Battery	SW Freq	Input (ACOV)	Pre-charge Current	Pre-charge Voltage	Charge Voltage	Recharge Voltage	I_{IN} DPM & PPM	Safety Timer	Temp Qual Profile	Package
BQ24640	Super cap	600 kHz	5 V to 28 V (32 V)	n/a	n/a	2.1 V to 26 V	n/a	No	n/a	0 to +45°C Or wide range	16-pin, 3.5x3.5 QFN
BQ24650	Solar panel charge Li-Ion Li-polymer	600 kHz	5 V to 28 V (32 V)	I_{SET}/10 (4 mV on R_{SNS})	V_{FB} = 1.55 V	2.1 V to 26 V	V_{FB} – 50 mV	Input voltage (V_{IN}) DPM	Only keep 30 min Pre-charge time	Li-Ion 0 to +45°C	16-pin, 3.5x3.5 QFN

The BQ24600/61x is highly-integrated Li-ion or Li-polymer switch-mode battery charge controller. The BQ24620/3x is highly-integrated switch-mode battery charge controller designed specifically to charge lithium-phosphate battery chemistries.

The BQ2460x/61x/62x/63x offer a constant-frequency synchronous PWM controller with high accuracy charge current and voltage regulation, adapter current regulation, termination, charge preconditioning, and charge status monitoring,

The BQ2460x/61x/62x/63x charge the battery in three phases: preconditioning, constant current, and constant voltage. Charge is terminated when the current reaches a minimum user-selectable level. A programmable charge timer provides a safety backup for charge termination

The BQ2460x/61x/62x/63x automatically restart the charge cycle if the battery voltage falls below an internal threshold, and enters a low quiescent current sleep mode when the input voltage falls below the battery voltage.

The BQ2461x/BQ2463x offer a Dynamic Power Management (DPM) function that modifies the charge current depending on system load conditions, avoiding ac adapter overload. High accuracy current sense amplifiers enable accurate measurement of the ac adapter current, allowing monitoring of overall system power. The BQ2461x/BQ2463x also offer Power Path Management (PPM) or system power selection that controls external switches to prevent battery discharge back to the input, connects the adapter to the system, and connects the battery to the system using 6-V gate drives for better system efficiency.

8 BQ24616

The BQ24616 is a JEITA (Japan Electronic Information Technology Association) guideline-compatible, stand-alone, synchronous, switch-mode battery charger for Li-ion and Li-polymer battery chemistries. The charger continuously monitors the battery temperature by measuring the battery temperature and controls both the charge voltage and charge current. Also the part is featured with the Dynamic Power Management (DPM) to reduce the battery charge current as the input current reaches its limits. The allowed input voltage range for this part is from 5 V to 28 V and the output is adjustable for 1-to-6 cells with a maximum charging current of 10 A. The switching MOSFETs are externally implemented in this part

9 BQ24610

The BQ24610 is an integrated Li-ion and Li-polymer charger. It charges batteries in three phases as described in the BQ24170. It supports 1-to-6 battery cells from 5-V to 28-V input voltage with adjustable charge voltage. The charging current can go up to 10 A. The switching MOSFETs are externally implemented. This part features a low-input, quiescent current of less than 1.5 mA at off-state and low, battery-discharge current of less than 15 μA at off-state.

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10 BQ24630

This device is a switch-mode, battery charge controller designed specifically for a lithium phosphate battery. The BQ24630 controls external switches to prevent battery discharge back to the input, to connect the adapter to the system, and to connect the battery to the system using 6-V gate drives for better system efficiency. It features Dynamic Power Management (DPM). These features reduce battery charge current when the input power limit is reached to avoid overloading the ac adapter when supplying the load and the battery charger simultaneously. A highly accurate current-sense amplifier enables precise measurement of input current from the ac adapter to monitor the overall system power.

11 BQ24640

The BQ24640 is a highly integrated, switch-mode, super-capacitor charger. Its input voltage can vary from 5 V to 28 V. This device charges super capacitors in two phases based on the state of charge of the battery at any given time as shown in Table 3. The first phase is the constant-current mode. The charger in this mode can start charging the super capacitor from 26 V down to 0 V at constant current set by the ISET pin. The second phase is the constant-voltage mode where the charging voltage is set using a resistor divider from the output to the ground. The charge current starts tapering down, when the voltage on VFB reaches an internal reference.

12 BQ24650

The BQ24650 is a highly-integrated, switch-mode, battery-charge controller that supports input voltage from 5 V to 28 V and battery voltage from 2.1 V to 26 V. The charging current can be adjusted using a sense resistor. It offers a constant-frequency, synchronous, PWM controller with high-accuracy current and voltage regulation.

It also provides input voltage regulation, which reduces charge current when input voltage falls below a programmed level. When the input is powered by a solar panel, the input regulation loop lowers the charge current so that the solar panel can provide maximum power output.

13 References

Unless otherwise noted, all documents are available for download at www.ti.com.

1. *BQ241xx, Synchronous Switchmode, Li-Ion and Li-Polymer Charge-Management IC With Integrated Power FETs (bqSWITCHER™)* data sheet
2. *BQ24171, JEITA Compliant Stand-Alone Switch-Mode Li-Ion and Li-Polymer Battery Charger With Integrated MOSFETs and Power Path Selector* data sheet
3. *BQ24170/2, 1.6-MHz Synchronous Switch-Mode Li-Ion and Li-Polymer Stand-Alone Battery Charger With Integrated MOSFETs and Power Path Selector* data sheet
4. *BQ24133, 1.6-MHz Synchronous Switch-Mode Li-Ion and Li-Polymer Stand-Alone Battery Charger with Integrated MOSFETs and Power Path Selector* data sheet
5. *BQ24600 Stand-Alone Synchronous Switch-Mode Li-Ion or Li-Polymer Battery Charger with Low Iq* data sheet
6. *BQ2461x Stand-Alone 1- to 6-Cell Synchronous Buck Battery Charger Controller* data sheet
7. *BQ24620 Stand-Alone Synchronous Switched-Mode Lithium Phosphate Battery Charger With Low Iq* data sheet
8. *BQ24630 Standalone Synchronous Switched-Mode Lithium Phosphate Battery Charger With System Power Selector and Low Iq* data sheet
9. *BQ24616 JEITA Guideline Compatible Stand-Alone Synchronous Switched-Mode Li-Ion or Li-Polymer Battery Charger With System Power Selector and Low Iq* data sheet
10. *BQ24618, Stand-Alone USB-Friendly Synchronous Switch-Mode Li-Ion or Li-Polymer Battery Charger with System Power Selector and Low Iq* data sheet
11. *BQ24640 High-Efficiency Synchronous Switched-Mode Super Capacitor Charger* data sheet
12. *BQ24650 Synchronous Switch-Mode Battery Charge Controller for Solar Power With Maximum Power Point* data sheet

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