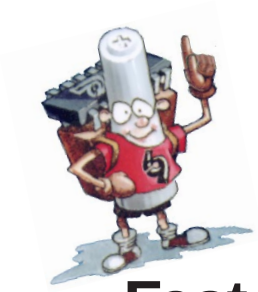
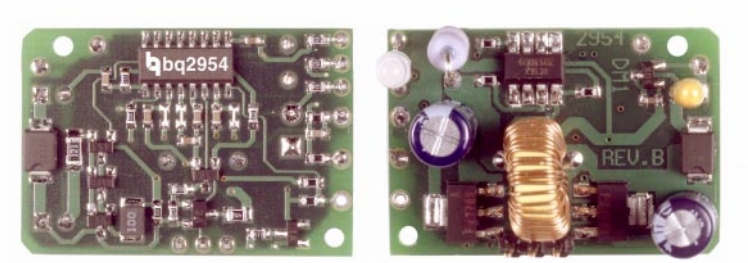
Designed to GO . . .

Practical and Cost-Effective Battery Management Design Examples by Benchmarq
Series 2954, Number 1



20W Miniature Dual-Stage Fast Lithium-Ion Charger Using bq2954



Features

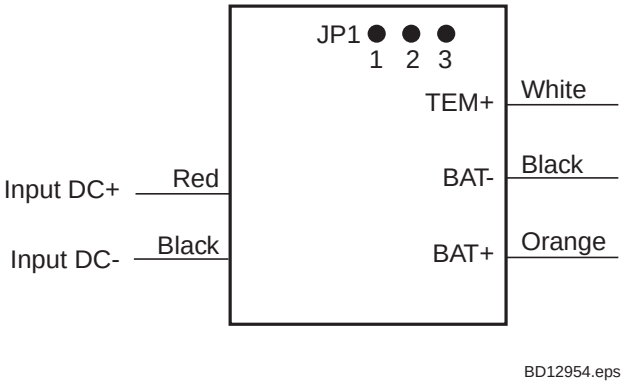
- Circuit board only 1.4 x 0.9” (35 x 24mm)
- Supports up to 4 Li-Ion cells and 1.25A of charging current
- Dual-stage algorithm reduces charging time
- Safe fast-charge termination by minimum current, maximum time-out
- Pre-charge qualification by checking battery temperature and voltage
- Configurable for unregulated input voltages from 7 to 24 V_{DC}
- Bicolor LED charge status indicator
- High-efficiency pulse-width modulated buck converter with high-side current sensing
- Estimated production material cost of less than $3.00*
- Schematic, bill of materials, and board layout available from Benchmarq for immediate implementation

*Estimated for high production volume only

Typical Applications

- Cigarette-lighter adapter chargers
- Low-cost fast chargers for cellular and handheld electronic equipment

Functional Block Diagram



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General Description

In this example, the bq2954 is used to design a cost-effective and high-efficiency miniature Li-Ion fast charger. This implementation is suitable for any application requiring a fast charger in a small footprint such as cigarette-lighter adapters for cellular phones or other portable electronic devices.

This design takes advantage of various built-in features of the bq2954 to initiate and terminate high-speed charging of single- or multi-cell Li-Ion packs:

Circuit topology: Switching buck regulator with high-side current sensing with over 90% efficiency

Charge algorithm: The bq2954 charges a battery in two stages. A constant-current stage replenishes approximately 70% of battery capacity. A high-accuracy voltage-regulation stage completes the charge

Battery chemistry supported: Lithium-Ion

Maximum number of cells: 4

Maximum charging current: 1.2A

Input requirements:

Number of Cells	Minimum Unregulated Input	Regulated Output
1	7.00 V_{DC}	4.20 V_{DC}
2	11.50 V_{DC}	8.40 V_{DC}
3	17.00 V_{DC}	12.60 V_{DC}
4	23.00 V_{DC}	16.80 V_{DC}

Pre-charge qualification: Battery temperature and voltage

Charge termination:
Minimum current: Can be set at 1/10, 1/15, or 1/20 of the charging current by the designer
Maximum time-out (MTO): Programmed for 2.5 hours, but can be changed by the designer
Maximum temperature: Requires an NTC thermistor in the battery pack

Status Indication: Bicolor LED indicates various charge conditions such as battery absent, qualification, fast charge in progress, full battery detected, or charge complete.

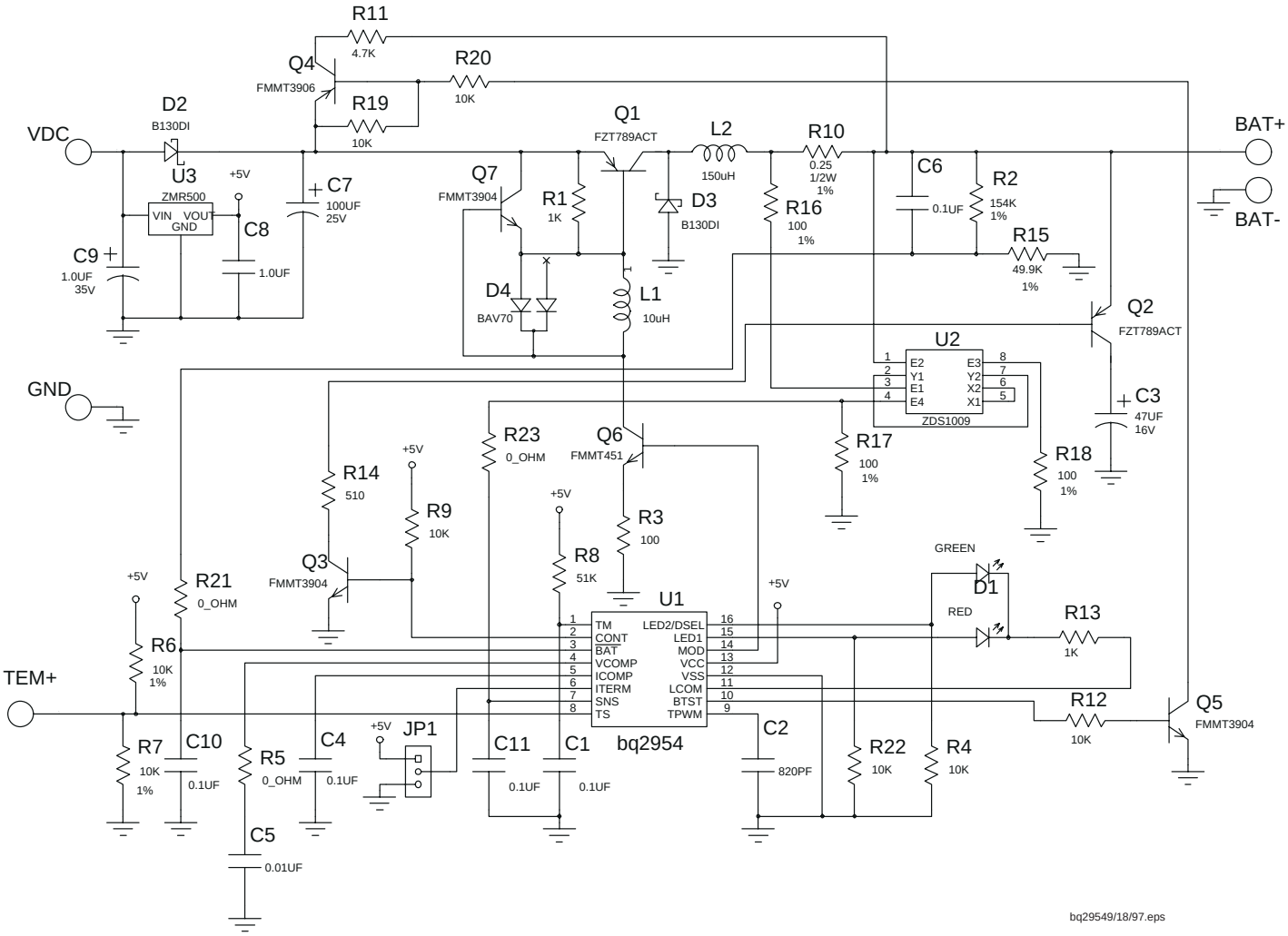
Please refer to the bq2954 data sheet for full specifications.

Parts List

Item	Quantity	Reference	Part
1	5	C1, C4, C11, C10, C6	0.1UF
2	1	C2	820PF
3	1	C3	47UF, 25V
4	1	C5	0.01UF
5	1	C7	100UF, 25V
6	1	C8	1.0UF
7	1	C9	1.0UF, 35V
8	1	D1	Bi-Color LED
9	2	D2, D3	B130DI
10	1	D4	BAV70
11	1	L1	10uH (see Note 1)
12	1	L2	140uH (see Note 2)
13	2	Q1, Q2	FZT789ACT
14	1	Q4	FMMT3906
15	3	Q5, Q7, Q3	FMMT3904
16	1	Q6	FMMT451
17	2	R1, R13	1K
18	1	R10	0.20, 1%, 1/2W
19	1	R11	4.7K
20	1	R14	510L
21	1	R15	49.9K, 1%
22	3	R17, R16, R18	100, 1%
23	1	R2	154K, 1%
24	6	R22, R4, R9, R12, R20, R19	10K
25	1	R3	100
26	3	R5, R21, R23	0Ω
27	2	R6, R7	10K, 1%
28	1	R8	51K
29	1	U1	bq2954
30	1	U2	ZDS1009 (zetex)
31	1	U3	ZMR500

Notes:
1. Use Panasonic Part No. ELJ-FA100KF2 or equivalent.
2. Use 3L Global Part No. TC-141M-1.0A-4426 or equivalent.

bq2954 Schematic



Design Notes

The following is intended to assist the designer in configuring the circuit. Please refer to the schematic for details.

Setting Voltage Regulation:

Voltage regulation level is set by the following equation:

$$\frac{R2}{R15} = \left(\frac{N * V_{REG}}{2.05}\right) - 1$$

where N is the number of cells and V_{REG} is the cell voltage. The recommended value for R15 is 49.9KΩ.

Please note the input requirements for this circuit (maximum input ripple of 10% allowed):

Number of Cells	Minimum Unregulated Input	Regulated Output
1	7.00 V_{DC}	4.20 V_{DC}
2	11.50 V_{DC}	8.40 V_{DC}
3	17.00 V_{DC}	12.60 V_{DC}
4	23.00 V_{DC}	16.80 V_{DC}

Setting Current Regulation: Maximum charging current can be set by the following equation:

$$I_{MAX} = \frac{0.250}{R10}$$

Setting Minimum Current: Minimum current is used for charge termination and can be set at 10%, 6.7%, or 5% of maximum charging current. Jumper JP1 can be used to set this value:

Jp1 Jumper	Minimum Current
1 2 3	I_{MAX}/20
[**1 2**] 3	I_{MAX}/15
1 [**2 3**]	I_{MAX}/10

Setting Maximum Time-Out (MTO): MTO is calculated by the following equation:

$$t_{MTO} = 0.5 * R8 * C11$$

where t_{MTO} is in hours, R8 is in KΩ, and C11 is in µF. The recommended value for C11 is 0.1µF.

Setting Temperature Monitoring: The bq2954 temperature-monitoring circuit includes a resistor network and a Negative Temperature Coefficient (NTC) thermistor inside the battery pack. This design uses a Semitec 103AT thermistor. The temperature is set to 0°C–45°C. Temperature sensing can be disabled by replacing R6 and R7 with a 10KΩ resistor.

Display Mode: Display is set for Mode 1 (DESL = L). See the bq2954 data sheet for other modes.

Condition	LED Status
Battery absent	Off
Qualification	Red
Fast charge	Red
Full detect	Green
Charge complete	Green

Dedicated Lithium-Ion battery management products from Benchmarq

Charge Management:

bq2954: The bq2954 simplifies charging of Li-Ion batteries by combining the necessary switch-mode power-supply support and charge-termination control into a single integrated circuit.

bq2056/T/V: These ICs are low-cost linear control devices ideal for designing simple and high-accuracy charge management circuits. Featuring the new proprietary AutoComp™ technique for optimizing the charge algorithm, the bq2056 enables the battery to reach peak capacity in the shortest time without compromising safety or increasing the size of circuit components.

Pack Supervisors:

bq2058 and bq2058T: Designed for battery pack integration, these ICs protect Li-Ion cells from excessive charge or discharge, and short circuits. These functions are critical for safety and longevity of the cells.

Gas Gauges:

bq2040: Designed for battery pack integration, the bq2040 IC monitors critical battery parameters such as remaining capacity, temperature, and voltage in rechargeable battery packs. It supports the System Management Bus (SMBus) and the Smart Battery Data (SBD) specifications and can interface with the host system and battery charger to form a comprehensive battery management system

bq2050: This bq2050 Power-Gauge™ IC provides a total solution for Li-Ion capacity monitoring by providing accurate information in mA hours and mW hours over a wide range of enviromental and use conditions. The bq2050 compensates for temperature, charge and discharge rates, and self-discharge, and communicates with the host processor using a single-line bi-directional serial bus.

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