Application Report
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BQ24040 Application Report

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ABSTRACT

This application report discusses common standalone application circuits for the BQ24040 device. The BQ24040 is a single cell Li-Ion/Li-Pol battery charger that can charge at up to 1 A from a 5-V input source. The device is highly integrated and requires a minimum number of external parts and can be standalone or interface with a microcontroller.

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Trademarks

1 Introduction

Three designs are presented in the following sections: 1-A Fast Charge, 500-mA Fast Charge, and 100-mA Fast Charge. These designs can be implemented as is or modified to meet your requirements. Note this is a simplified explanation of the device and typical values are used and descriptions are brief. The data sheet (SLUS941) provides a full explanation with min and max values.

2 1-A Fast Charge Design

Figure 1 provides a solution that will charge at 1 A with termination at 5% or 50 mA.

- R-ISET will set fast charge current to 1 A, 549 Ω.
- R-PRE-TERM will set termination current to 5%, 1.0 kΩ.
- R-TS is required and 10k NTC in battery pack is typical value.
- CHG LED is used to indicate charge status, this is optional not required.
- PG LED is used to indicate input and output voltage is good, this is optional and not required.
- ISET2 – Grounded to set regulate current using R-ISET

This application will support larger batteries that can be charged at a 1-A fast charge, typically 1.0 Ahr or greater capacity.

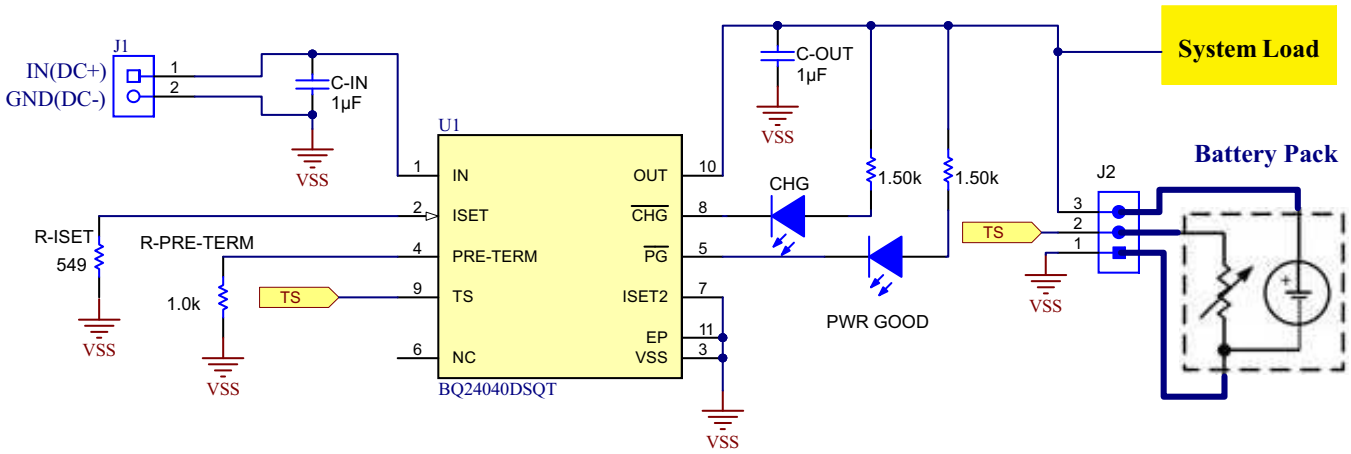

Figure 1. BQ24040 1-A Fast Charge and 5% Termination

3 500-mA Fast Charge Design

Figure 2 provides a lower power charging solution for smaller batteries with input current limited to 500 mA compatible with most USB ports / adapters.

- R-ISET will set fast charge current to 490 mA, 1.1 kΩ.
- R-PRE-TERM will set termination current to 10%, 2.0 kΩ.
- If the pin is open default is 10%
- R-TS is required and 10k NTC in battery pack is typical value.
- In lower power applications the NTC may not be needed or can be on PCB
- CHG LED is used to indicate charge status, this is optional and not required.
- PG LED optional not shown on this design.
- ISET2 – Pulled high to set regulate current to 500mA

This application will support medium power batteries.

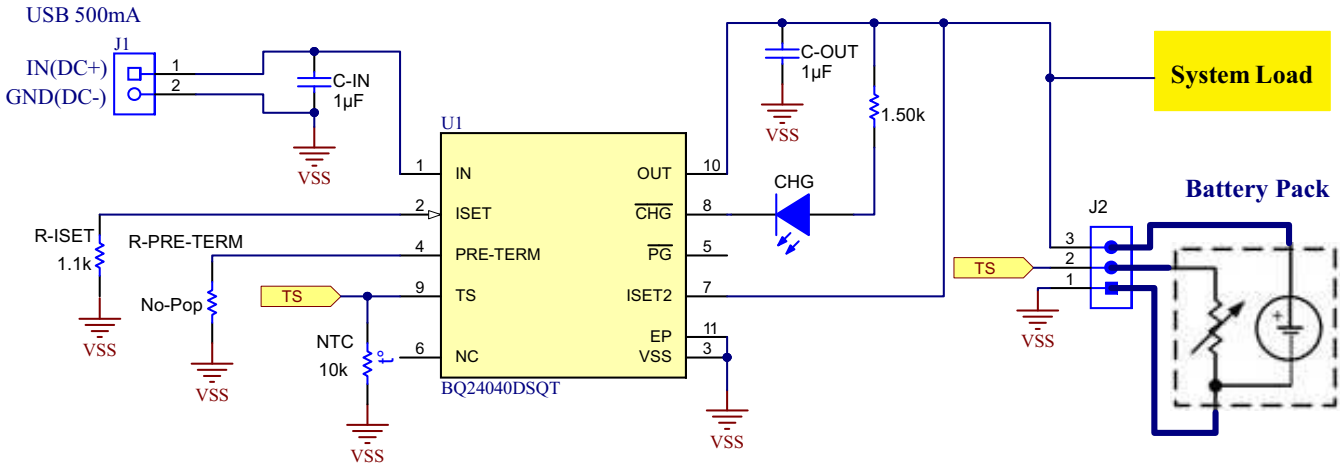

Figure 2. 500-mA Fast Charge Design

4 100-mA Fast Charge Design

Figure 3 provides a low power charging solution for smaller batteries with input current limited to 100 mA. The BQ24040 is a 2 mm x 2 mm package and requires few external components allowing a very small solution for small solution size space limited applications.

- R-ISET will set fast charge current to 100 mA, 5.49 kΩ.
- R-PRE-TERM will set 10%, open to reduce parts count.
- R-TS 10k NTC is shown on the board, typically not on smaller battery pack.
- CHG LED is used to indicate charge status, this is optional and not required.
- PG LED not used.
- ISET2 – Float to set input current to 100 mA
- Power in resistors are very low and a 0201 or 0402 package can be used.

Care should be take on the input and output capacitors and an effective value of 1 µF is required and smaller package performance due to DC bias may be a problem.

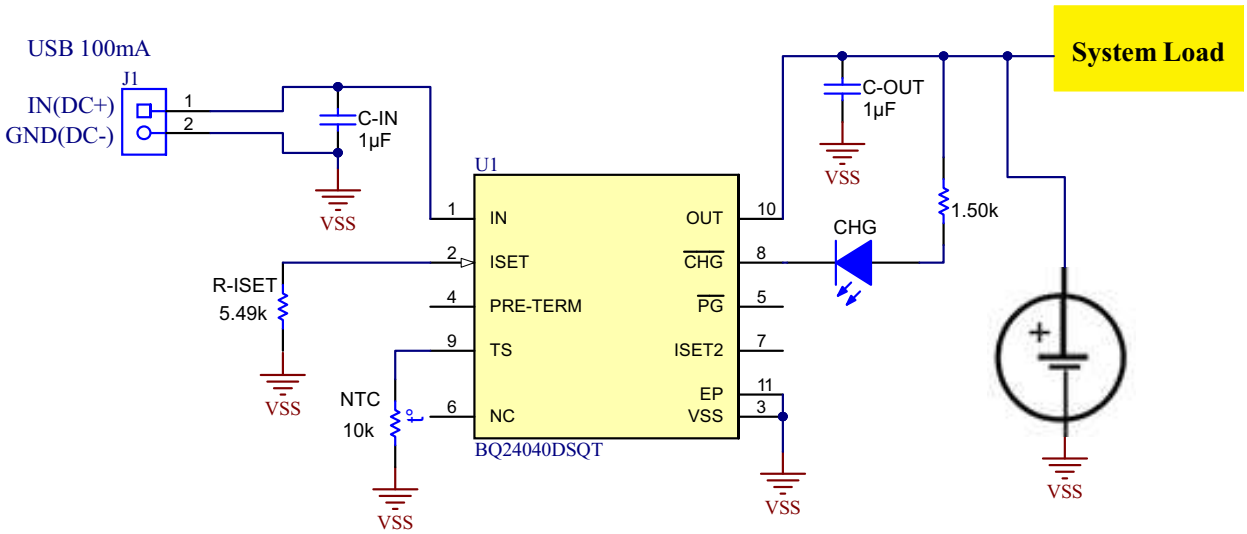

Figure 3. 100-mA Fast Charge Design

5 Pin Configuration

The table below lists a quick summary of the pins of the device.

Table 1. BQ24040 Pin Configuration

Pin - Name	Description	Comments
Pin 1 – IN	Input power USB or AC adapter	Operating range to 6.45 V with Max Vin 28 V
Pin 10 – OUT	Battery Connection / System Load	Battery Voltage 4.2 V
Pin 2 – ISET	Resistor R-ISET Sets Fast Charge Current, 549 Ω = 1 A	K-Set 540 A/Ω
Pin 7 – ISET2	Sets Input Current limit	Hi = 500 mA, Low = ISET, Float = 100 mA
Pin 4 – Pre-Term	Resistor R-Pre-Term Sets Charge Termination current, 2 k =10% of fast charge	K-Term 200 Ω/%Open = 10%
Pin 9 – TS	NTC Thermistor or 10-kΩ resistor	10 k = Safe
Pin 8 – $\overline{CHG}$	Open Drain output, Low = Charging	
Pin 5 – $\overline{PG}$	Open Drain output, Low = Input and Output voltage good	
Pin 6 – NC	No Connection	
Pin 3 – VSS/GND	Ground Terminal	
Thermal Pad – VSS/GND	Exposed thermal pad and ground connection	

6 FAQ / Tips and Tricks:

- During OVP unit cannot operate --- see Data Sheet (SLUS941) section 8.3.5
  - Max input voltage is 28 V but unit turns off above 7.5 V and will not operate above that point. Device will not be damaged up to 30 V, absolute maximum rating.
- Min input voltage --- Input to output voltage difference --- see Electrical Characteristics table VDO(IN-OUT)
  - Typical value is 325 mV but test condition is 50% reduction from 1-A output to 500 mA as V-in is reduced.
  - To hold output current at 1 A will require about 700 mV.
- Float TERM pin to set pre-charge and termination to typical value --- see Data Sheet section 8.4.6.
  - Termination can be set with a resistor at TERM pin, but if a typical value of pre-charge to 20% and termination to 10% is desired the pin can be floated.
- Limited output current at low battery voltage.
  - Battery voltage less than 0.8-V output current is limited to 15 mA, Battery Short Protection.
  - Battery voltage between 0.8-V and 2.5-V output current is limited to precharge current set by TERM pin typically 20% of fast charge.
  - Battery voltage above 2.5-V current will be a maximum value set by ISET pin.
- Termination disable (TTDM) using TS pin --- see Data Sheet section 8.4.8
  - 4.2-V power supply mode when battery is fully charged.
  - Start up in this mode will require very light load, must pass Battery Short Protection and Precharge to provide full current.
  - If no battery is present it may require load disable or load switch to allow voltage to reach 2.5 V to start up.
- Efficiency of charge, what is power dissipation, how to reduce power dissipation
  - Linear charger will act as a LDO and efficiency will be Vout / Vin.
  - Closer Vin is to Vout the better the efficiency and lower the power dissipation.
- Power good pin — see Data Sheet section 8.3.6
  - Open drain output and low indicates input power good.
  - Input power above UVLO (3.5 V) and VBAT +VDT (VDT = 80 mV)

- Charge complete pin — see Data Sheet section 8.3.7
  - Open drain output and low indicates charge in progress.
  - Active only for first charge, no indication on recharge.
  - Can be reset by cycling input power.
- Output current monitor at ISET — see Data Sheet section 8.4.5
  - ISET is a current source that is proportional to output current. Voltage developed on the R-ISET resistor will represent output current and can be monitored by external circuit.
- Open Battery — see Data Sheet section 8.4.12
  - With no battery present open battery detect circuit will result in a 50-ms square wave at OUT.
- Thermal Regulation, limit output current
  - If the die temperature reaches 125°C, the output current is reduced to control temperature.
  - If the die temperature increases to 155°C, the unit shuts down until temperature decreases.
- Thermal Pad for improved heat dissipation.
  - The device has an exposed thermal pad that should be soldered to PCB with sufficient copper area to manage power dissipation. Electrical connection is to ground.
- TS pin in a battery temperature application will use JEITA standard
  - The operating temperature range is 0°C to 60°C, with reduced current 0°C to 10°C, and reduced voltage from 45°C to 60°C.

7 R-ISET and R-TERM Common Values

Calculations for resistors ISET and TERM are provided in the data sheet. The following table provides a quick reference. Note that values shown are calculated and are not the nearest standard resistor value.

Table 2. R-ISET and R-TERM Common Values

I-SET (mA)	R-ISET		%-Term	R-TERM
100	5400		5	1000
200	2700		10	2000
300	1800		15	3000
400	1350		20	4000
500	1080		25	5000
600	900		30	6000
700	771		35	7000
800	675		40	8000
900	600		45	9000
1000	540		50	10000

8 Simplified EVM Schematic

The EVM schematic shown is simplified for the BQ24040 application.

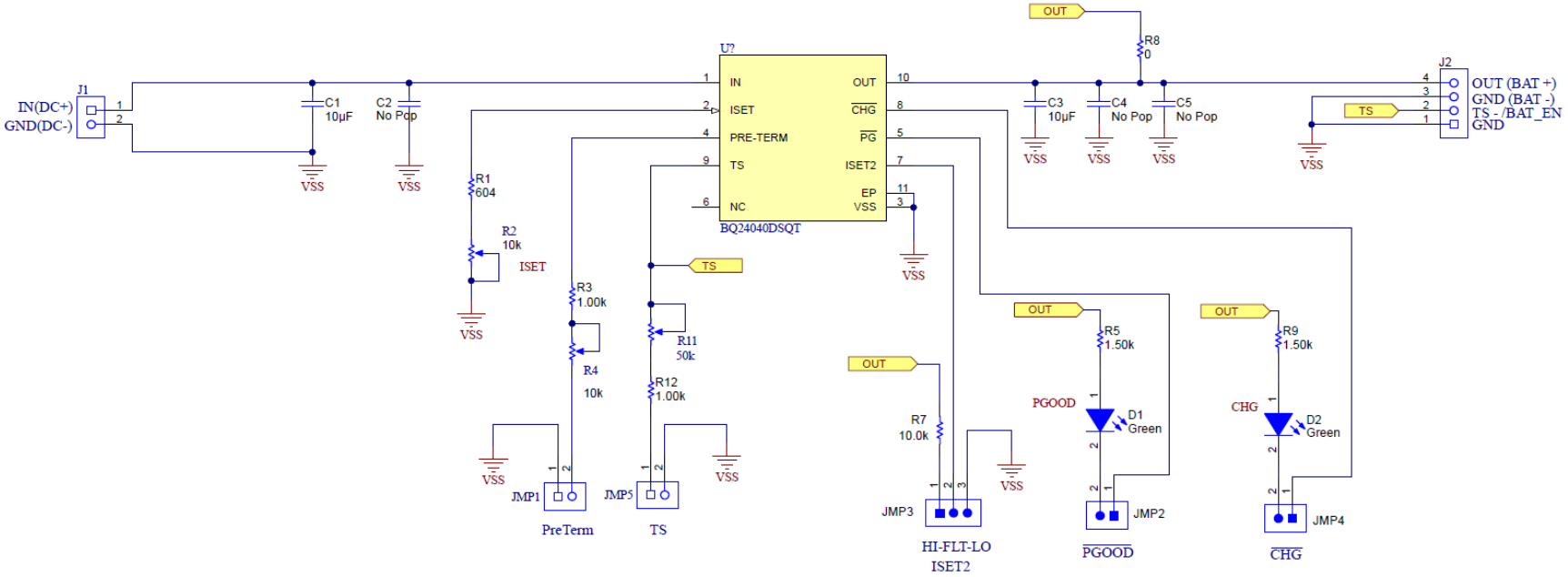

Figure 4. Simplified Schematic of EVM for Reference

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