Application Note

BQ25180 and BQ25181 I²C Controlled Linear Battery Chargers Small Form Factor Design

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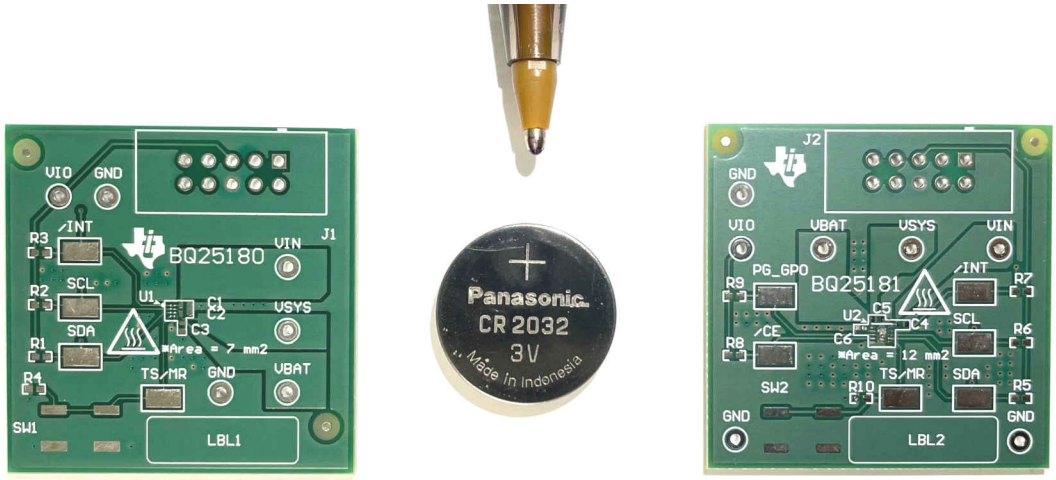
ABSTRACT

This application note showcases the BQ2518x family of linear chargers in a compact small form factor battery charger application design. The BQ25180 and BQ25181 are I²C controlled, 1-cell 1-A linear battery chargers with power-path which focuses on small solution size and low quiescent current. The BQ2518x devices are well suited for wearables, medical, gaming accessories, trackers, and building automation applications. Available on a *Wafer-level Chip-Scale* (WCSP) and *Quad-flat No-Leads* (QFN) packages. The total solution size area of the BQ25180 (8-pin WCSP) design is 7 mm² and for the BQ25181 (10-pin QFN) the total solution size area is 12 mm². The solution size encompasses all the key components needed for operation.

Incorporated for functional evaluation on the board there is access to all pins of the BQ2518x via test points and it also includes the USB2ANY connector, used for communicating with the device via the *TI Chargers GUI* software. The total size of the 2-layer circuit board is 38 mm × 38 mm for both BQ25180 and BQ25181 designs.



BQ25180 and BQ25181 Small Form Factor Boards

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Trademarks

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1 Introduction

The BQ2518x are a 1-cell 1A linear battery chargers integrated circuit (IC) focusing on small solution size and ultra low quiescent current for optimal battery life. The BQ25180 and BQ25181 are the I^{2}C controlled versions of the BQ2518x family of linear chargers. This board design demonstrates the smallest functional solution size for both the BQ25180 and BQ25181.

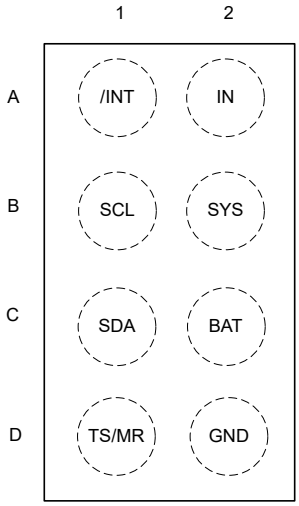


Figure 1-1. BQ25180 (WCSP) Pinout

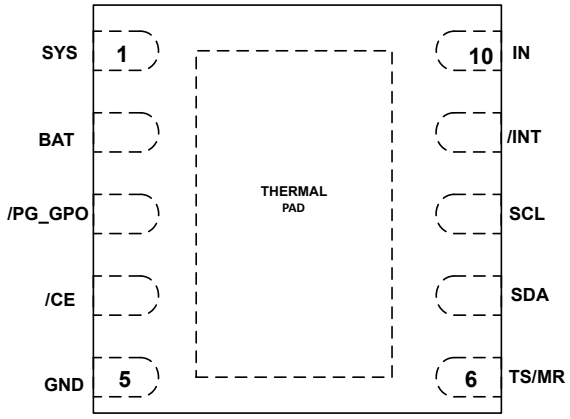


Figure 1-2. BQ25181 (QFN) Pinout

The BQ25180 is an 8-pin WCSP (1.6 × 1.1 mm) and the total solution size area is 7 mm^2, including all the key components needed for operation. On the other hand, the BQ25181 is a 10-pin QFN (2 × 2.2 mm) and the total solution size area is 12 mm^2.

The BQ25180 in the WCSP package with the smallest solution size is ideal for wearables applications where the overall footprint is a critical design consideration. The BQ25181 in the QFN package with thermal-pad provides the best thermal performance in a small solution size for those applications which needs to operate at the high-end of power dissipation or need the additional two pins for extra configurability.

The small form factor area on this design incorporates the battery chargers and the bypass capacitors for IN, SYS and BAT pins, which are the key components needed for the charger to operate. In addition, the printed circuit board (PCB) includes the pads for the SDA and SCL pull up resistors, these however are not included on the solution size as they are typically shared on the I^{2}C bus alongside the rest of the system.

The TS/MR pin on the BQ2518x devices, act as a dual function input which monitor the battery pack temperature and function as a manual reset pin to the part. On this board design the TS/MR pin includes a push button for resetting the device in parallel with a 10-kΩ resistor which simulates an attached battery pack at 25°C working under normal operation. On the BQ25181 board, also included are the external resistors pads for the charge enable (/CE) and the power good/general purpose output (PG/GPO) pins, which are the additional pins included on the QFN device.

The boards are standard 62 mil 2-layer PCB with 1-oz copper, including mostly 6-mil traces with a 6-mil clearance and 26 mil diameter vias with a hole size of 10 mil. The 2-layer board design allows for an easy and cost-effective fanout routing without the need to use high density interconnect layout techniques. Figure 1-3 shows the BQ25180 fanout, which includes 5 mil traces extending to 6 mil away from the pads and vias. Figure 1-4 shows the BQ25181 fanout, which include 8-mil traces with one via with a hole size of 10 mil on the power-pad to aid with power dissipation. The total board size is 38 mm × 38 mm for both the BQ25180 and BQ25181.

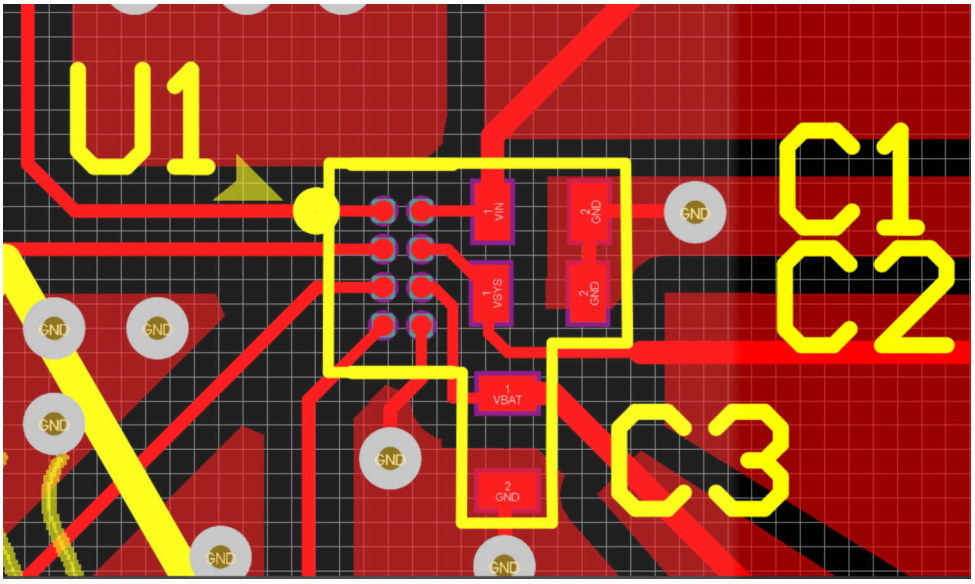


Figure 1-3. BQ25180 Fanout, 5-mils to 6-mils on Pads

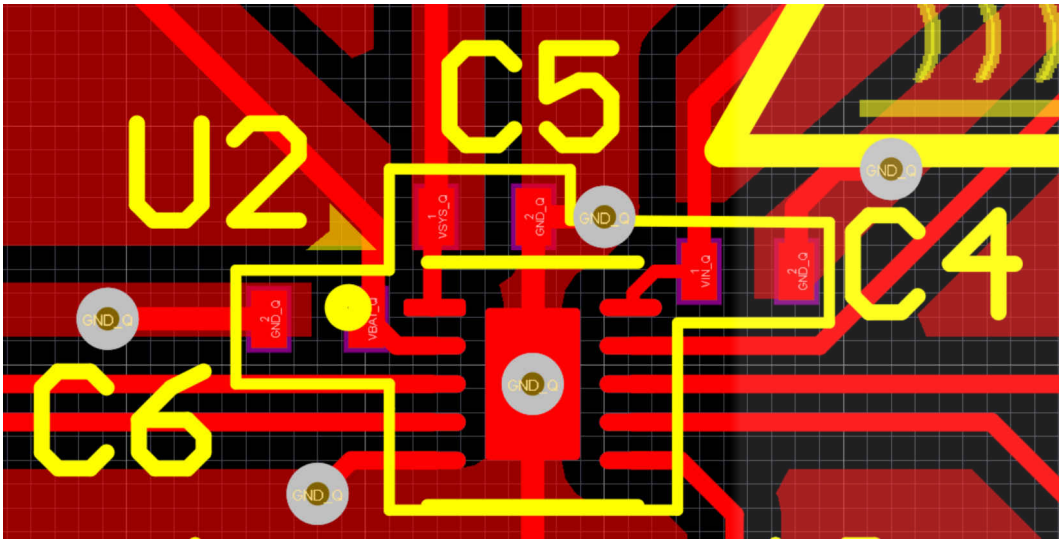


Figure 1-4. BQ25181 Fanout, 8-mils on Pads

2 Features

Some of the BQ2518x charger key features are:

- Linear charger with up to 1A of charge current
- Ultra-low IDDQ for maximum battery life:
  - 15 nA shutdown mode
  - 3.2 uA shipmode with button wake
  - 4 uA battery-only mode
- Configurable battery regulation voltage from 3.5 to 4.65 V
- Configurable termination current down to 0.5 mA
- Dynamic power path management allows for simultaneously charging the battery and powering the system through the regulated system rail (SYS)
- Configurable NTC charging profile thresholds
- WCSP and QFN package options available

3 Test Results

This section shows some of the test results obtained with the small form factor designs on the BQ2518x devices. Figure 3-1 shows the register map view of the BQ2518x chargers, while interacting with the *TI Chargers GUI* using the USB2ANY as the I²C interfacing device.

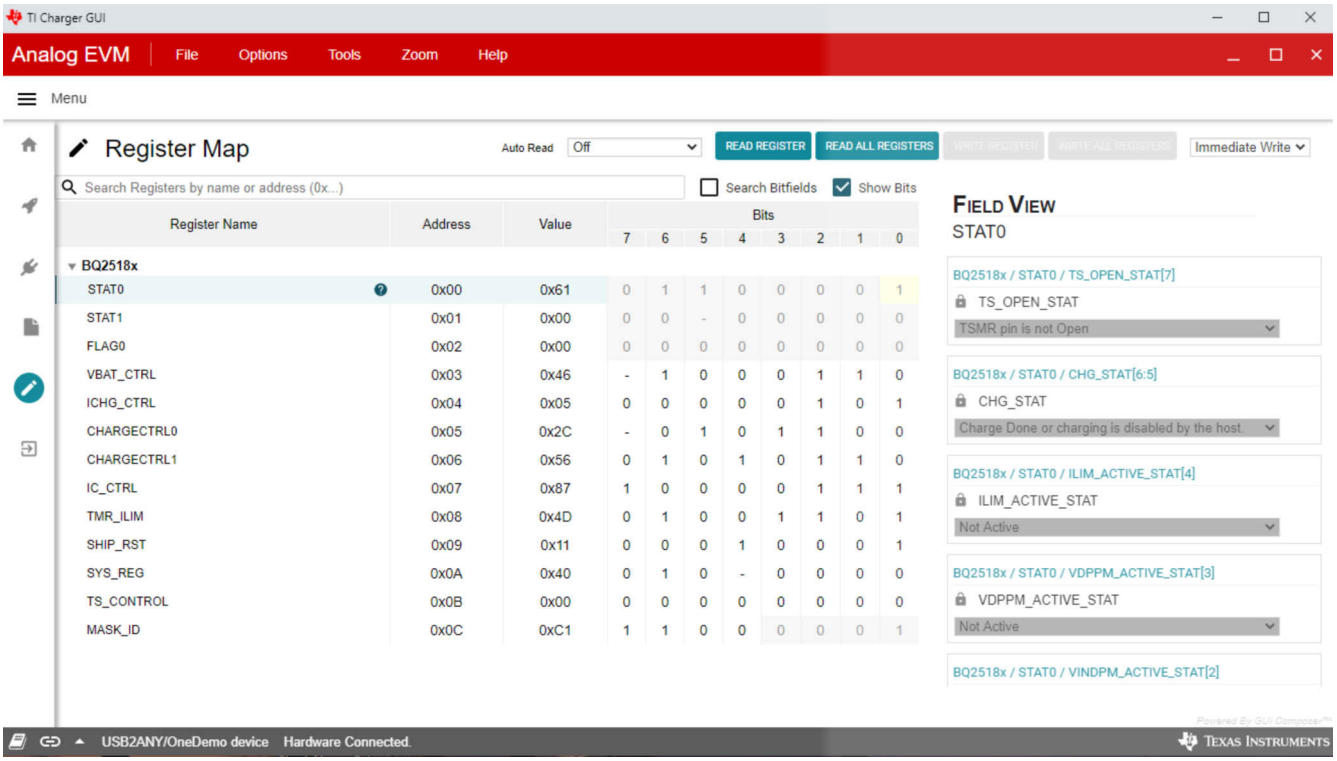


Figure 3-1. TI Chargers GUI Registers View

Figure 3-2 to Figure 3-9 shows the devices when power up via adapter, power up via battery, ship mode entry and wake with push-button input, and waking out of shutdown mode with adapter plug in.

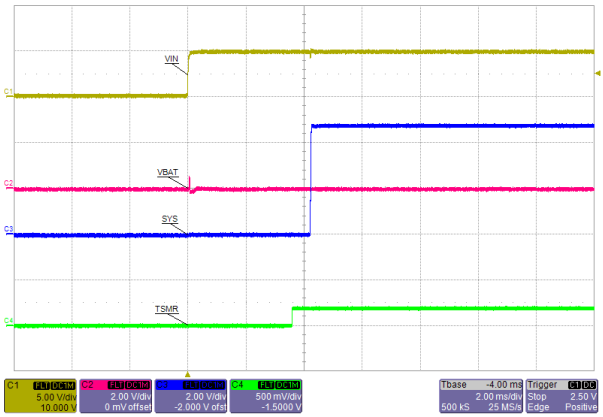


Figure 3-2. BQ25180 VIN Applied

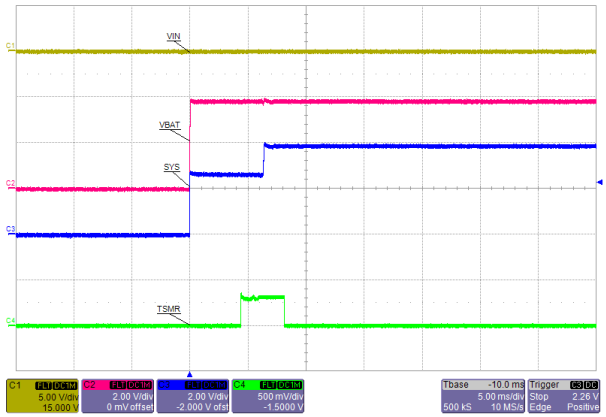


Figure 3-3. BQ25180 VBAT Applied

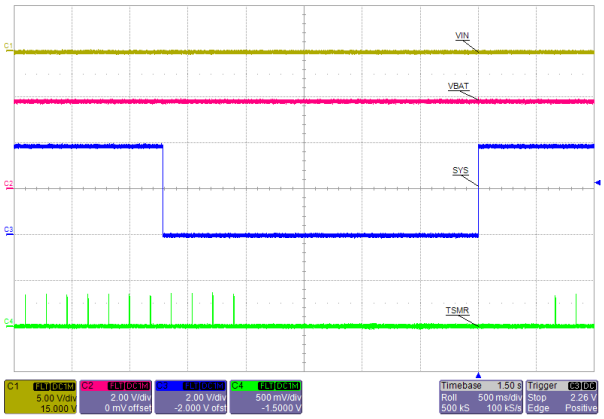


Figure 3-4. BQ25180 Shipmode Entry and Exit with MR

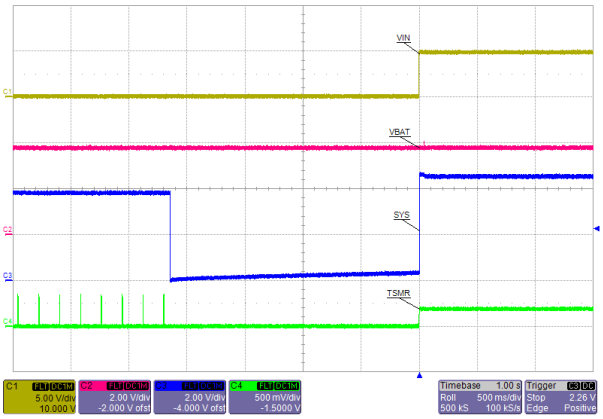


Figure 3-5. BQ25180 Shutdown Entry and Exit with VIN Applied

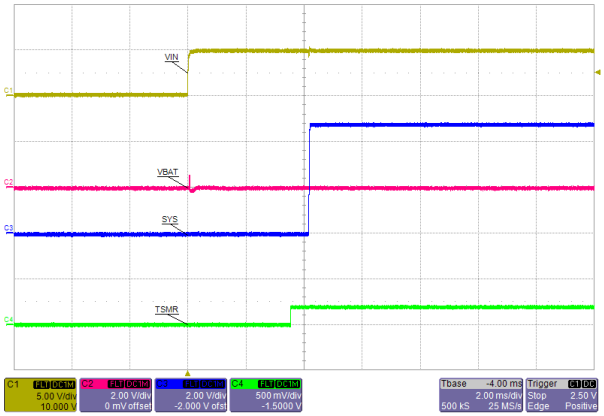


Figure 3-6. BQ25181 VIN Applied

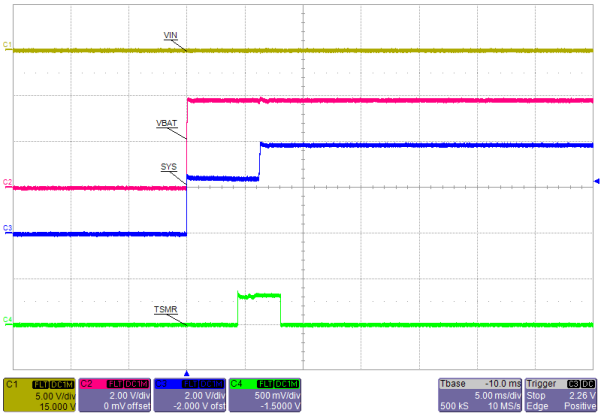


Figure 3-7. BQ25181 VBAT Applied

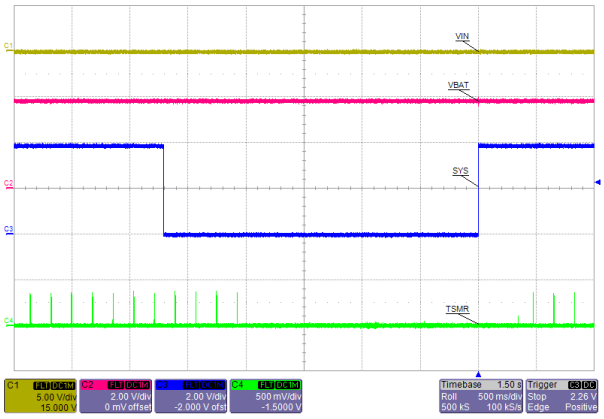


Figure 3-8. BQ25181 Shipmode Entry and Exit with MR

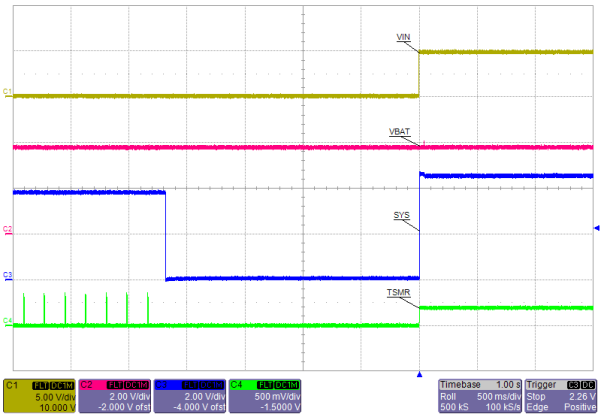


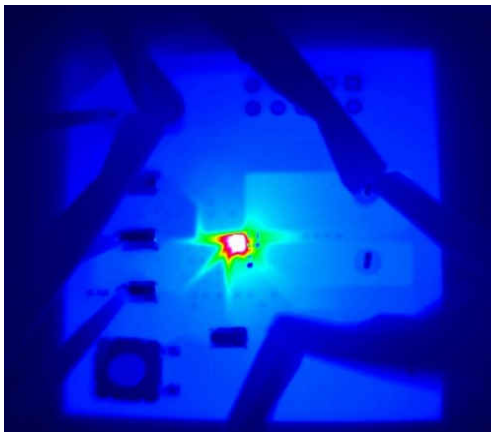
Figure 3-9. BQ25181 Shutdown Entry and Exit with VIN Applied

4 Thermal Results

The small form factor design of the BQ2518x boards were used to measure thermal dissipation using a thermal camera. The following data shows the thermal results for both boards design.

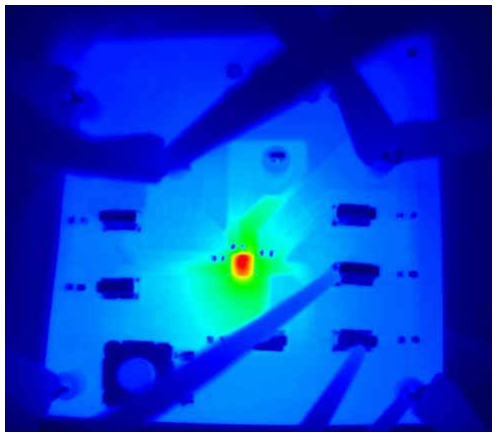
The BQ25181 shows a better thermal dissipation across the charge current (ICHG) range. The BQ25181 is typically 12°C/W better than the BQ25180 version at ambient (25°C) temperature while dissipating 1 watt across the die. Is important to point out this board design focus is to showcase and optimize solution size, in order to obtain better thermal performance in both devices some layout tradeoff could be implemented on your design. Refer to the data sheet for layout recommendations.

Figure 4-1 and Figure 4-2 shows the thermal results for the BQ25180 and BQ25181 at 1W dissipation, respectively.



IN =5 V, BAT=3.6 V, Thermal Regulation = Disable, T = 25°C, Power loss = 1 W, $R_{\Theta JA}$ = 50.5°C/W

Figure 4-1. BQ25180 Power Dissipation at 1 W

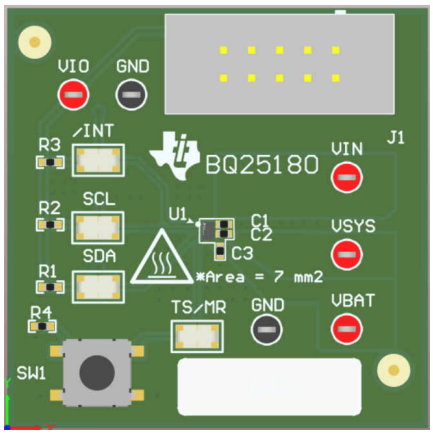


IN =5 V, BAT=3.6 V, Thermal Regulation = Disable, T = 25°C, Power loss = 1 W, $R_{\Theta JA}$ = 38.1°C/W

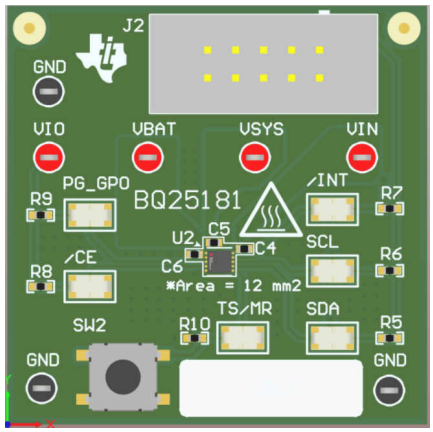
Figure 4-2. BQ25181 Power Dissipation at 1 W

5 Board Design Files

This section includes the key component of the design: schematics, bill of materials, and layout images for both the BQ25180 and the BQ28181 boards.



BQ25180 Board Front View



BQ25181 Board Front View

5.1 BQ25180 Schematic

Figure 5-1 illustrates the BQ25180 design schematic. The components highlighted in a black box are those required for operation and are included on the 7 mm^2 solution size for the charger. These components are also outlined on white silkscreen box on the physical board.

Components outside the black box are not essential for operation and are included to facilitate the end user interaction with the board. A test point for monitoring purposes is included in each pin of the BQ25180 device. Also available is the USB2ANY connector for performing I^2C communication with the *TI Chargers GUI* Software, and a 10.2-KΩ resistor on the TS/MR pin which disables temperature monitoring by simulating normal operation of the charger for evaluation.

The pads for the 10-kΩ pull up resistors for SDA and SCL pins (R1 and R2) are populated on this board, as well as the pull up resistor for the INT pin (R3).

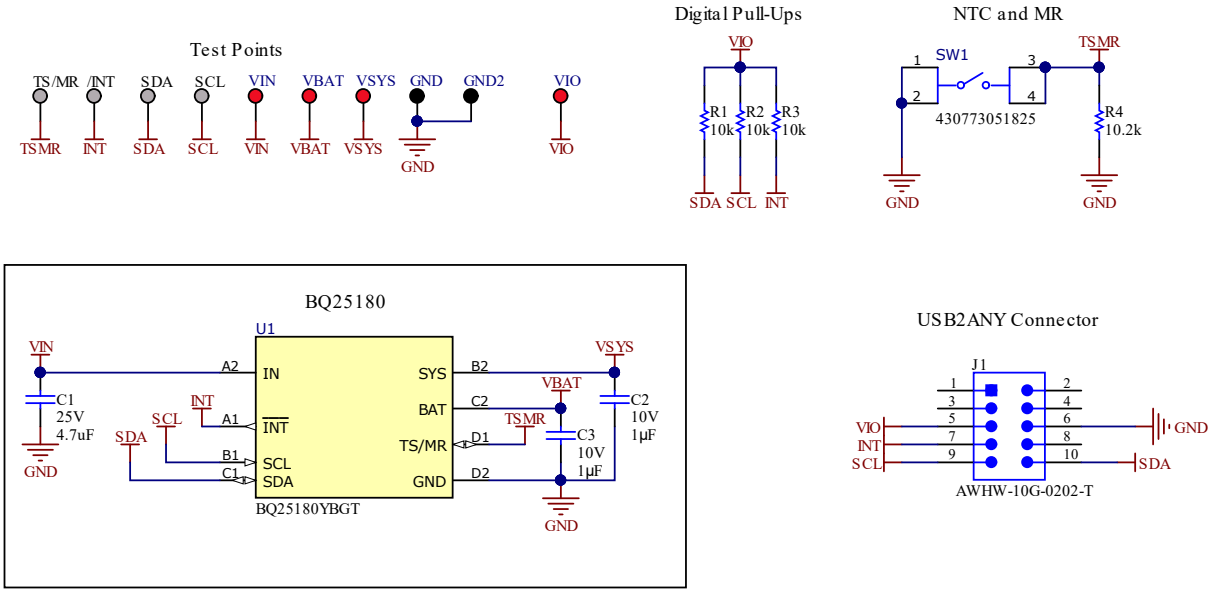


Figure 5-1. BQ25180 Schematics

5.2 BQ25180 Bill of Materials

Table 5-1 lists the PCB bill of materials (BOM).

Table 5-1. BQ25180 Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
/INT, SCL, SDA, TS/MR	4		Test Point Miniature	SMT	5019	Keystone
C1	1	4.7uF	CAP, CERM, 4.7 µF, 25 V, +/- 20%, X5R, 0402	0402	GRM155R61E475ME15	MuRata
C2, C3	2	1uF	CAP, CERM, 1 µF, 10 V, +/- 20%, X5R, 0402	0402	CC0402MRX5R6BB105	Yageo America
GND, GND2	2		Test Point, Miniature, Black, TH	TH	5001	Keystone
J1	1		Header (Shrouded), 2.54 mm, 52, Gold, TH	Header, 2.54 mm, 5×2, TH	AWHW-10G-0202-T	Assman WSW
R1, R2, R3	3	10k	RES, 10 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K0JNED	Vishay-Dale
R4	1	10.2k	RES, 10.2 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K2FKED	Vishay-Dale
SW1	1		WS-TASV 6 × 6 MM J-HOOK SMD HERM	SMT_SW_6MM2_6MM2	430773051825	Wurth
U1	1		BQ25180YBGR Battery Charger	DSBGA8	BQ25180YBGR	Texas Instruments
VBAT, VIN, VIO, VSYS	4		Test Point, Miniature, Red, TH	TH	5000	Keystone

5.3 BQ25180 PCB Layers

Figure 5-2 through Figure 5-9 show the design layout images for the BQ25180 board.

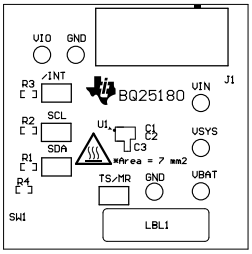


Figure 5-2. BQ25180 Top Overlay

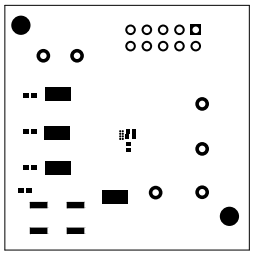


Figure 5-3. BQ25180 Top Solder Mask

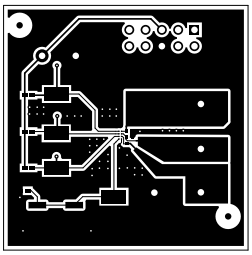


Figure 5-4. BQ25180 Top Layer

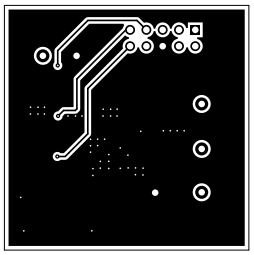


Figure 5-5. BQ25180 Bottom Layer

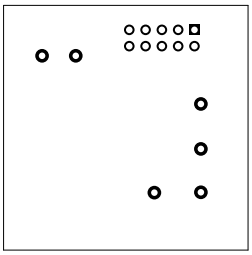


Figure 5-6. BQ25180 Bottom Solder Mask

Figure 5-7. BQ25180 Bottom Overlay

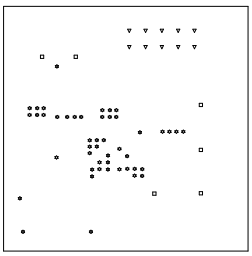


Figure 5-8. BQ25180 Drill Drawing

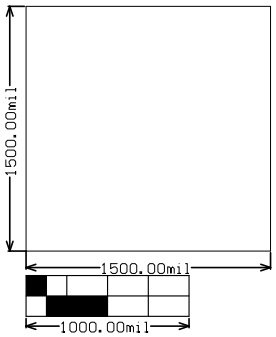


Figure 5-9. BQ25180 Board Dimensions

5.4 BQ25181 Schematic

Figure 5-10 illustrates the BQ25181 design schematic. The components highlighted in a black box are those required for operation and are included on the 12 mm^2 solution size for the charger. These components are also outlined on white silkscreen box on the physical board.

Components outside the black box are not essential for operation and are included to facilitate the end user interaction with the board. A test point for monitoring purposes is included in each pin of the BQ25181 device. Also available is the USB2ANY connector for performing I^2C communication with the *TI Chargers GUI* Software, and a 10.2-KΩ resistor on the TS/MR pin which disables temperature monitoring by simulating normal operation of the charger for evaluation.

The pads for the 10-kΩ pull up resistors for SDA and SCL pins (R5 and R6) are populated on this board, as well as the pull up resistor for the INT pin (R3) and the PG/GPO (R9) pin. The pull-up resistor for the /CE pin (R8) is unpopulated on the board.

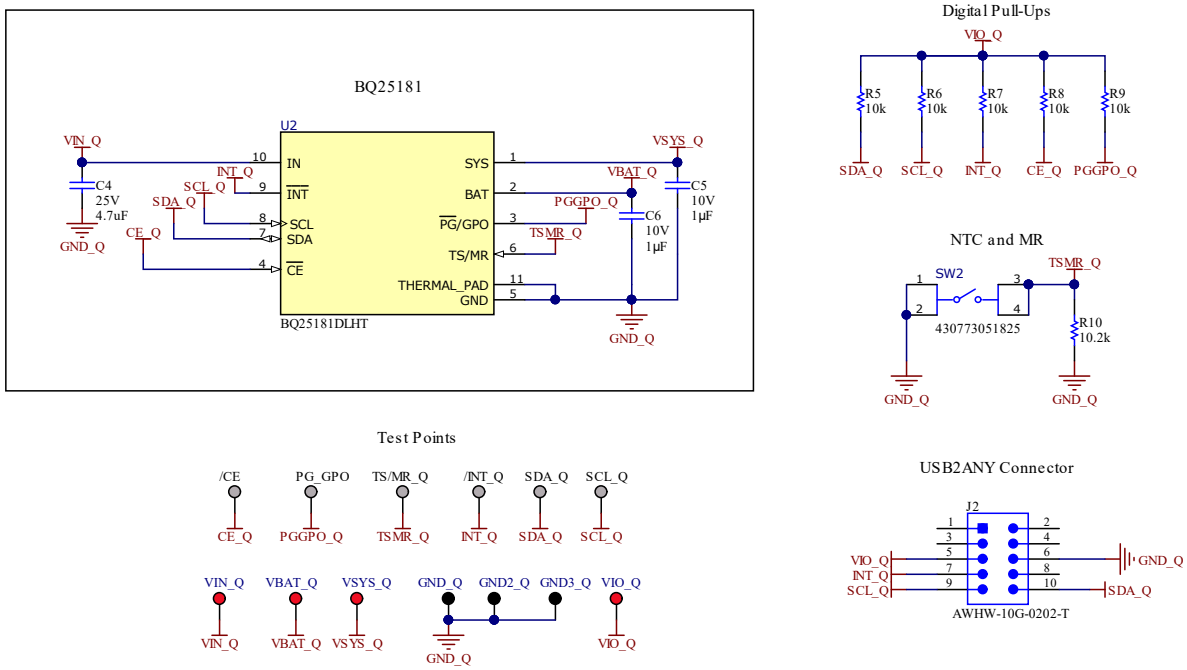


Figure 5-10. BQ25181 Schematic

5.5 BQ25181 Bill of Materials

Table 5-2 lists the PCB bill of materials (BOM).

Table 5-2. BQ25181 Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
/CE, /INT_Q, PG_GPO, SCL_Q, SDA_Q, TS/MR_Q	6		Test Point Miniature	SMT	5019	Keystone
C4	2	4.7 uF	CAP, CERM, 4.7 uF, 25 V, +/- 20%, X5R, 0402	0402	GRM155R61E475ME15	MuRata
C5, C6	2	1 uF	CAP, CERM, 1 µF, 10 V,+/- 20%, X5R, 0402	0402	CC0402MRX5R6BB105	Yageo America
GND_Q GND2_Q, GND3_Q	3		Test Point, Miniature, Black, TH	TH	5001	Keystone
J2	1		Header(Shrouded), 2.54 mm, 5×2, Gold, TH	Header, 2.54 mm, 5×2, TH	AWHW-10G-0202-T	Assman WSW
R5, R6, R7, R8, R9	5	10k	RES, 10 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K0JNED	Vishay-Dale
R10	2	10.2k	RES, 10.2 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040210K2FKED	Vishay-Dale
SW2	2		WS-TASV 6 × 6 MM J-HOOK SMD HERM	SMT_SW_6MM2_6MM2	430773051825	Wurth
U2	1		BQ25181DLHR Battery Charger	WSON10	BQ25181DLHR	Texas Instruments
VBAT_Q, VIN_Q, VIO_Q, VSYS_Q	4		Test Point, Miniature, Red, TH	TH	5000	Keystone

5.6 BQ25181 PCB Layers

Figure 5-11 through Figure 5-18 show the design layout images for the BQ25181 board.

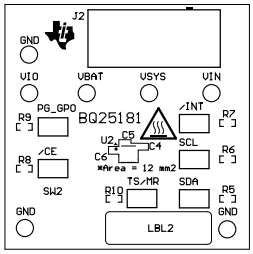


Figure 5-11. BQ25181 Top Overlay

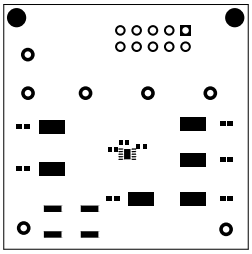


Figure 5-12. BQ25181 Top Solder Mask

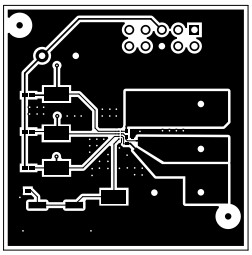


Figure 5-13. BQ25181 Top Layer

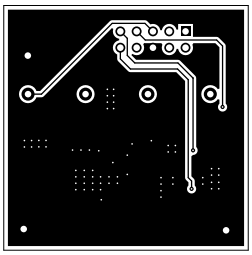


Figure 5-14. BQ25181 Bottom Layer

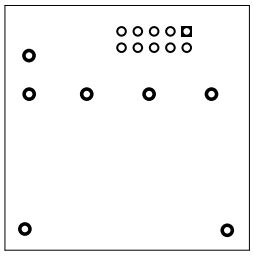


Figure 5-15. BQ25181 Bottom Solder Mask

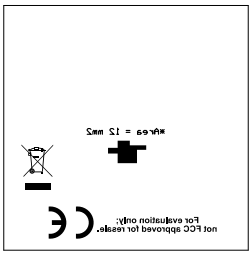


Figure 5-16. BQ25181 Bottom Overlay

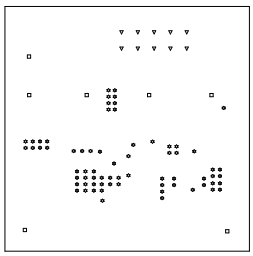


Figure 5-17. BQ25181 Drill Drawing

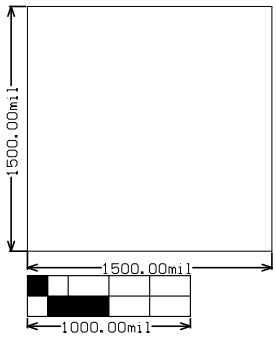


Figure 5-18. BQ25181 Board Dimensions

6 References

- Texas Instruments: *BQ25180* device page.
- Texas Instruments: *BQ25181* device page.
- Texas Instruments: *TI Chargers GUI Software*.
- Texas Instruments: *BQ21061 Small Form Factor Design* application note.
- Texas Instruments: *Semiconductor and IC Package Thermal Metrics* application note.
- Texas Instruments: *BQ25180 EVM User Guide*.
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