MEZS7-4.5APDCharger

PD Application with Wide Input Voltage and OTG Supported Solution Module

DESCRIPTION

The MEZS7-4.5APDCharger is a solution module for PD applications with the MP2731 and CCG3PA, supporting PD3.0 and BC1.2 protocols. MPS's MP2731 is a wide input, 4.5A switching mode NVDC battery charger IC for single-cell Li-ion or Li-polymer batteries. It offers USB On-the-Go (OTG) capabilities, which are used as the power stage in this board. The CCG3PA is a Cypress PD controller, which handles the PD protocol.

The board contains a DRP Type-C port. When an adapter is inserted, the port acts as a UFP to charge the battery with a 3A charge current. When a load is inserted, the port acts as a DFP to power the USB from the battery with a 5.1V/2.4A output capability.

The board supports NVDC architectures with power path management, which makes this board suitable for different portable applications, such as tablets, MIDs, and smartphones. Its low-impedance power path optimizes efficiency, reduces battery charging time, and extends battery life.

ELECTRICAL SPECIFICATIONS

Parameter	Symbol	Value	Units
Input voltage	V_{IN}	5 to 12	V
Charge full voltage	V_{BATT_REG}	4.2, I^2C-configurable	V
Charge current	I_{CC}	3.0, I^2C-configurable	A
Input voltage regulation	V_{IN_MIN}	4.6, I^2C-configurable	V
Input current limit	I_{IN_LIM}	0.5, I^2C-configurable	A
OTG voltage regulation	V_{IN_DSCHG}	5.1, I^2C-configurable	V
OTG current limit	I_{IN_DSCHG}	2.4, I^2C-configurable	A

FEATURES

- 5V to 12V Operating Input Voltage Range
- Up to 22V Sustainable Voltage
- High-Efficiency, 4.5A, 1.35MHz Buck Charger
- Supports PD3.0 and BC1.2 Protocols
- USB On-the-Go (OTG) Supported to Power the USB Port from the Battery
- Up to 9A Battery Discharge Current
- Narrow Voltage DC (NVDC) Power Path Management
  - Instant On Works with No Battery or Deeply Discharged Battery
  - Ideal Diode Operation in Battery Supplement Mode
- I^2C Port for Flexible System Parameter Setting and Status Reporting
- Full DISC Control to Support Shipping Mode and System Restart
- **High Accuracy:**
  - ±0.5% Charge Voltage Regulation
  - ±5% Charge Current Regulation
  - ±5% Input Current Regulation
  - ±2% Output Regulation in Boost Mode
- **Safety:**
  - Configurable JEITA for Battery Temperature Protection
  - Battery Charging Safety Timer
  - Thermal Regulation and Thermal Shutdown
  - Input/System Over-Voltage Protection
  - Supports Temperature Protection in the Battery Side
- Charging Operation Indicator

APPLICATIONS

- Tablet PCs
- Smartphones
- Mobile Internet Devices

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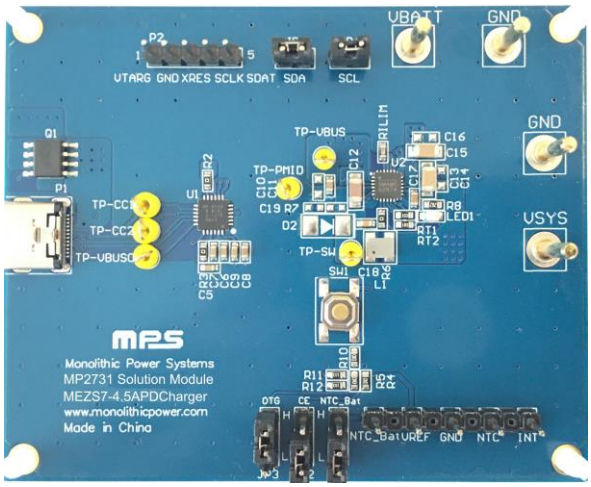
MEZS7-4.5APDCHARGER SOLUTION MODULE

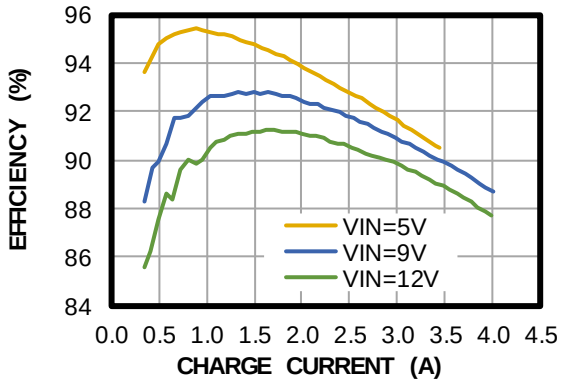


(LxWxH) 7.8cmx6.3cmx1.3cm

Board Number	MPS IC Number
MEZS7-4.5APDCharger	MP2731GQC-0000

Efficiency vs. Charge Current

MP2731 only, V_{IN} = 5V/9V/12V,
V_{BATT} = 3.8V, R_{L_DCR} = 21mΩ



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QUICK START GUIDE

The MEZS7-4.5APDCharger is an MP2731 reference design for PD applications, and includes a DRP Type-C port. Its layout accommodates most commonly used capacitors. The charge current is preset at 3A, and the charge-full voltage is preset to 4.2V for a single-cell Li-ion battery. In On-the-Go (OTG) mode, the output is preset at 5.1V/2.4A. All of the charging/discharging parameters are set by the CCG3PA. The user can also download their own codes to the CCG3PA through the configuration header in this board. Table 1 lists the possible jumper connections.

Table 1: Jumper Connections

Jack	Description	Factory Setting
JP1	NTC pin setting: pull low to set the NTC to the fixed ratio: 50%	Pulled low
JP2	CE pin setting: pull low to enable the charge	Pulled low
JP3	OTG pin setting: pull high to enable the OTG	Pulled high
JP4	Connect the SCL line between MP2731 and CCG3PA	Install
JP5	Connect the SDA line between MP2731 and CCG3PA	Install
P2	CCG3PA programming header	N/A

Test Procedure

1. Connect the load to:
   a. Positive (+): VSYS
   b. Negative (-): GND
2. Connect the battery terminals to:
   a. Positive (+): VBATT
   b. Negative (-): GND
3. If using a battery simulator, preset the battery voltage between 0V and 4.2V, then turn it off. Connect the battery simulator output to the VBATT and GND pins, respectively.
4. Ensure the battery voltage is present (if using a battery simulator, turn the battery simulator on). Then connect the board to an adapter with a USB Type-C to Type-C, or Type-A to Type-C cable.
5. Figure 1 shows the original set-up for the MEZS7-4.5APDCharger.

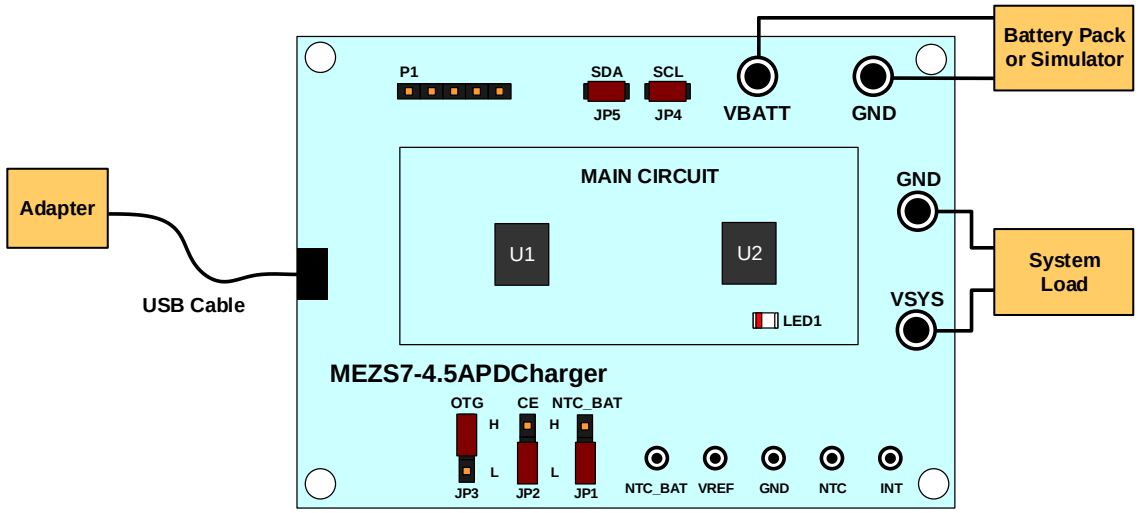

Figure 1: Test Set-Up for the MEZS7-4.5APDCharger

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Charge Mode

SCP, CDP, DCP, and PD charge modes can be tested on this board. For SCP mode, follow step 1. For CDP or DCP mode, follow step 2. For PD mode, follow step 3.

1. Connect a USB SCP port to the board with a USB Type-A to Type-C cable. There is a 5V input, and the input current limit is set to 500mA.
2. Connect a USB CDP/DCP port to the board with a USB Type-A to Type-C cable. There is a 5V input, and the input current limit is set to 1.5A.
3. Connect a PD adapter to the board with a USB Type-C to Type-C cable. There is a 12V maximum input, and the input current limit is set according to the adapter's output capability.

Discharge Mode

The Type-C port in this board is a DRP port. When a load is attached, it can work as a DFP to power the USB from the battery. The output voltage is 5.1V, and the output current limit is preset to 2.4A.

Disconnect the adapter from the board, and connect a smartphone to the board with a USB Type-C to Type-C cable. The board should start outputting 5.1V to charge the phone. When the smartphone is removed, the output of the board should be disabled automatically.

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SOLUTION MODULE SCHEMATIC

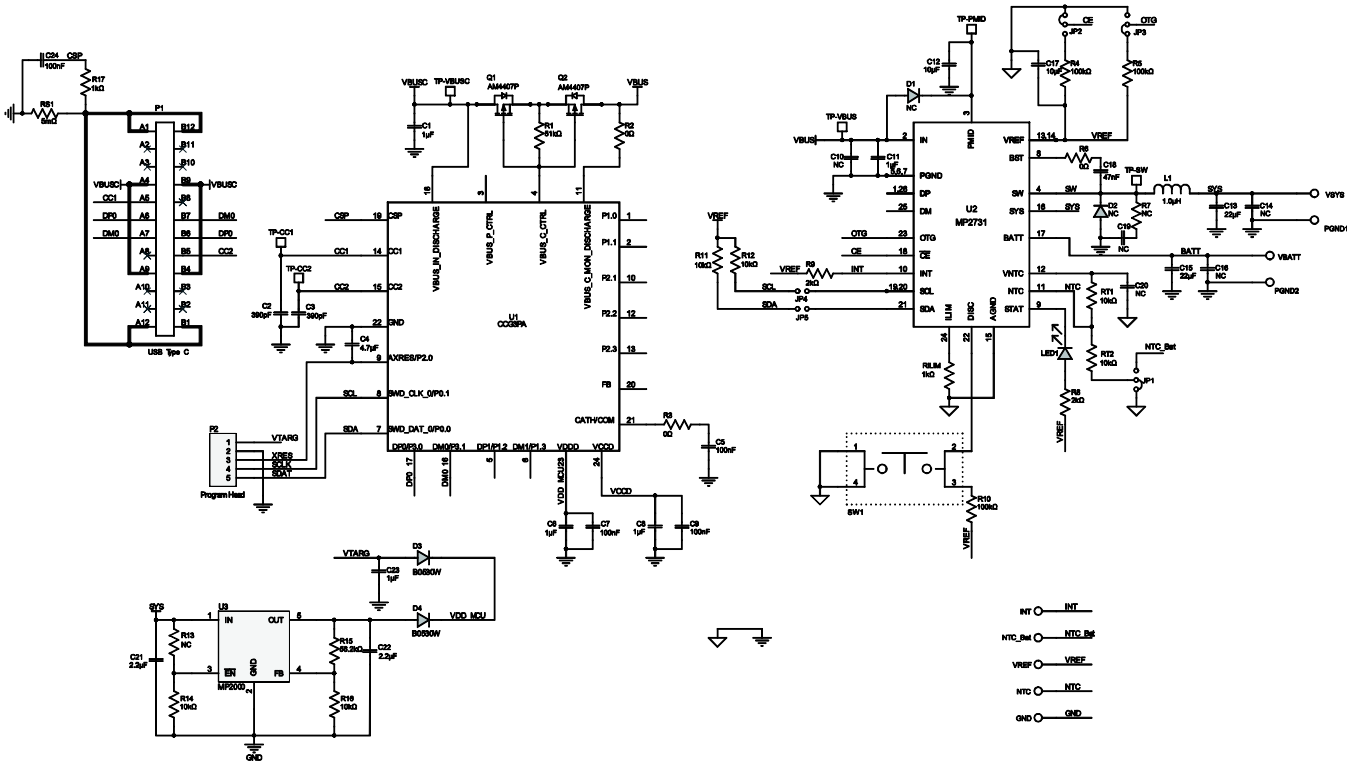

Figure 2: Solution Module Schematic

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MEZS7-4.5APDCHARGER BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer P/N
1	C1	1μF	Ceramic capacitor, 50V, X7R, 0805	0805	Murata	GRM21BR71H105KA12L
2	C2, C3	390pF	Ceramic capacitor, 50V, C0G, 0603	0603	Murata	GRM1885C1H391JA01D
1	C4	4.7μF	Ceramic capacitor, 25V, X5R, 0805	0805	Murata	GRM21BR61E475KA12L
4	C5, C7, C9, C24	100nF	Ceramic capacitor, 16V, X7R, 0603	0603	Murata	GRM188R71C104KA01D
4	C6, C8, C11, C23	1μF	Ceramic capacitor, 25V, X7R, 0603	0603	Murata	GRM188R71E105KA12D
1	C10	NC	Ceramic capacitor, 50V, X5R, 1206	1206	Murata	
1	C12	10μF	Ceramic capacitor, 50V, X5R, 1206	1206	Murata	GRM31CR61H106KA12L
2	C13, C15	22μF	Ceramic capacitor, 16V, X5R, 1206	1206	Murata	GRM31CR61C226KE15L
2	C14, C16	NC	Ceramic capacitor, 16V, X5R, 0805	0805	Murata	
1	C17	10μF	Ceramic capacitor, 16V, X5R, 0603	0603	Murata	GRM188R61C106KAALD
1	C18	47nF	Ceramic capacitor, 50V, X7R, 0603	0603	Murata	GRM188R71H473KA61D
2	C19, C20	NC	Ceramic capacitor, 16V, X5R, 0603	0603	Murata	
2	C21, C22	2.2μF	Ceramic capacitor, 10V, X7R, 0603	0603	Murata	GRM188R71A225KE15D
2	D1, D2	NC	Diode, 50V, 3A	SMA	Any	
2	D3, D4	B0530W	Schottky diode, 30V, 0.5A	SOD-123	Diodes	B0530W
1	L1	1.0μH	Inductor, 1.0μH	SMD	Cyntec	HTEP32251B-1R0MIR-89
1	LED1	Red	Red LED	0805	Bright LED	BL-HUF35A-TRB
1	R1	51kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0751KL
3	R2, R3, R6	0Ω	Film resistor, 1%	0603	Yageo	RC0603FR-070RL
3	R4, R5, R10	100kΩ	Film resistor, 5%	0603	Yageo	RC0603JR-07100KL
2	R7, R13	NC	Film resistor, 1%	0603	Yageo	
2	R8, R9	2kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-072KL
6	R11, R12, R14, R16, RT1, RT2	10kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0710KL
1	R15	56.2kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0756K2L
2	R17, RILIM	1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-071KL
1	RS1	5mΩ	Film resistor, 1%	1206	Yageo	PA1206FRF070R005L
2	Q1, Q2	AM4407P	P-channel MOSFET, -30V, 15A	SO-8	Analog Power	AM4407P

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MEZS7-4.5APDCHARGER BILL OF MATERIALS *(continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer P/N
4	INT, NTC, NTC_BAT, VREF		2.54mm connector			
3	JP1, JP2, JP3		2.54mm connector			
2	JP4, JP5		2.54mm connector			
5	JP1, JP2, JP3, JP4, JP5		2.54mm connector, shorter			
1	SW1	Push button	Button, SM 4mmx10mm, 1.5mm height			
1	P1	Type-C	Type-C receptacle	DIP	JAE	DX07S024JJ2R1300
1	P2		Header, 5-pin			
4	VBATT, VSYS, PGND, PGND		2mm			
6	TP-CC1, TP-CC2, TP-PMID, TP-SW, TP-VBUS, TP-VBUSC		Test point			
1	U1	CCG3PA	USB Type-C PD controller	QFN24-(4mmx4mm)	Cypress	CYPD3171-24LQXQ
1	U2	MP2731	4.5A I^2C-controlled SW charger	QFN-26 (3.5mmx3.5mm)	MPS	MP2731GQC-0000
1	U3	MP2000	Low input voltage 150mA linear regulator	SOT23-5	MPS	MP2000DJ-ADJ

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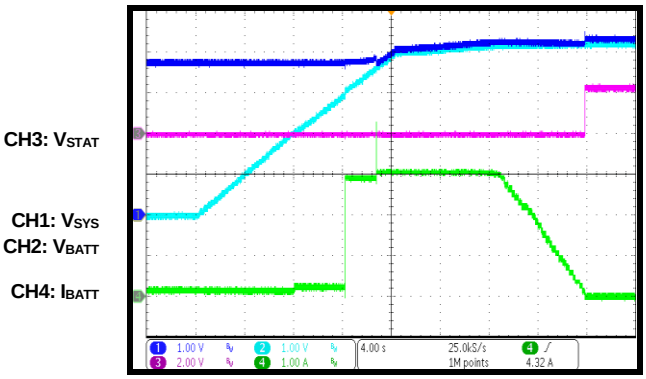
SOLUTION MODULE TEST RESULTS

V_{IN} = 5.0V, V_{BATT} = 0V to 4.2V, I_{CC} = 3A, I_{IN_LIM} = 1.5A, V_{IN_MIN} = 4.6V, L1 = 1.0µH, C_{IN} = 1µF, C_{PMID} = 10µF, C_{BATT} = 22µF, C_{SYS} = 22µF, T_A = 25°C, unless otherwise noted.

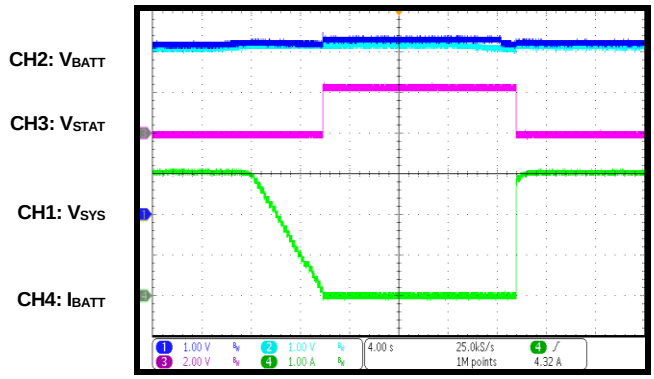
Battery Charge Curve

V_{IN} = 9V, I_{IN_LIM} = 2A, V_{BATT_REG} = 4.2V, I_{SYS} = 0A



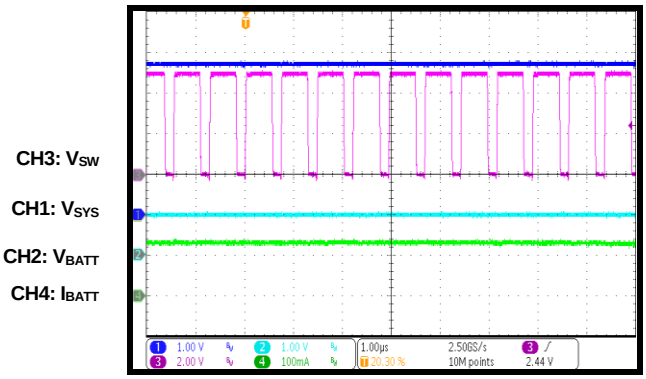
Auto-Recharge

V_{IN} = 9V, I_{IN_LIM} = 2A, V_{BATT_REG} = 4.2V, I_{SYS} = 0A



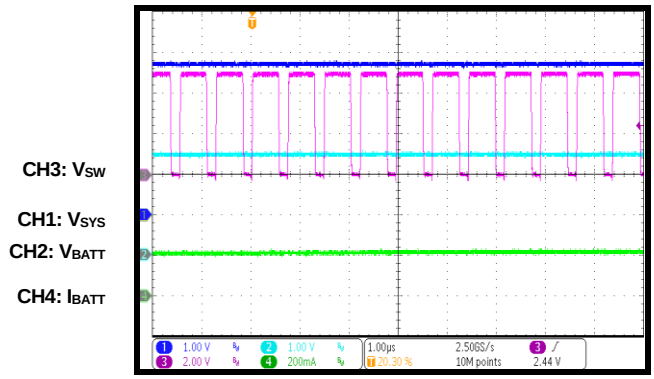
Trickle Charge

V_{IN} = 5V, V_{BATT} = 1.0V, I_{SYS} = 500mA



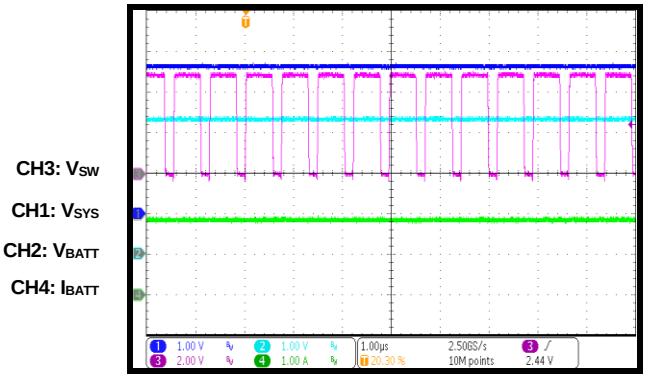
Pre-Charge

V_{IN} = 5V, V_{BATT} = 2.5V, I_{SYS} = 500mA



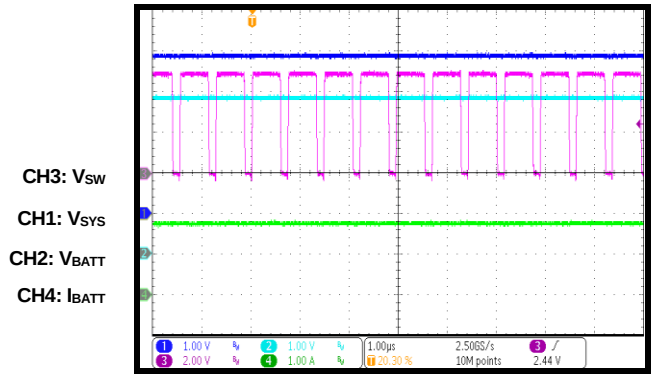
Constant Current Charge

V_{IN} = 5V, I_{IN_LIM} = 1.5A, V_{BATT} = 3.3V, I_{CC} = 3A



Constant Current Charge

V_{IN} = 5V, I_{IN_LIM} = 1.5A, V_{BATT} = 3.8V, I_{CC} = 3A



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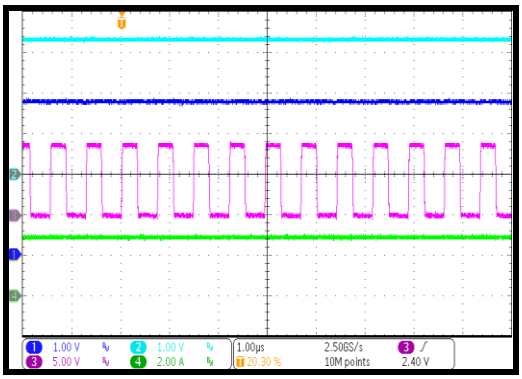
SOLUTION MODULE TEST RESULTS *(continued)*

V_{IN} = 5.0V, V_{BATT} = 0V to 4.2V, I_{CC} = 3A, I_{IN_LIM} = 1.5A, V_{IN_MIN} = 4.6V, L1 = 1.0µH, C_{IN} = 1µF, C_{PMID} = 10µF, C_{BATT} = 22µF, C_{SYS} = 22µF, T_A = 25°C, unless otherwise noted.

Constant Current Charge

V_{IN} = 9V, I_{IN_LIM} = 2A, V_{BATT} = 3.3V, I_{CC} = 3A

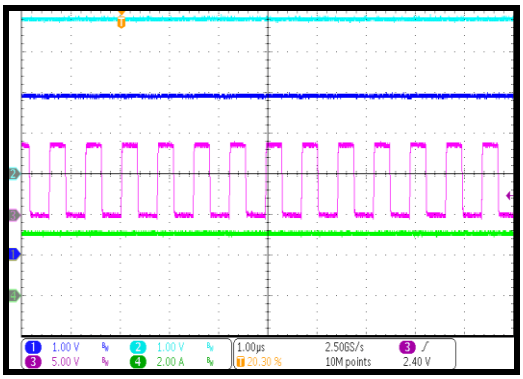
CH2: V_{BATT}
CH3: V_{SW}
CH1: V_{SYS}
CH4: I_{BATT}



Constant Current Charge

V_{IN} = 9V, I_{IN_LIM} = 2A, V_{BATT} = 3.8V, I_{CC} = 3A

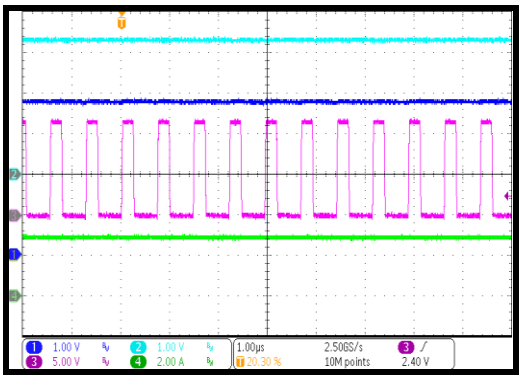
CH2: V_{BATT}
CH3: V_{SW}
CH1: V_{SYS}
CH4: I_{BATT}



Constant Current Charge

V_{IN} = 12V, I_{IN_LIM} = 2A, V_{BATT} = 3.3V, I_{CC} = 3A

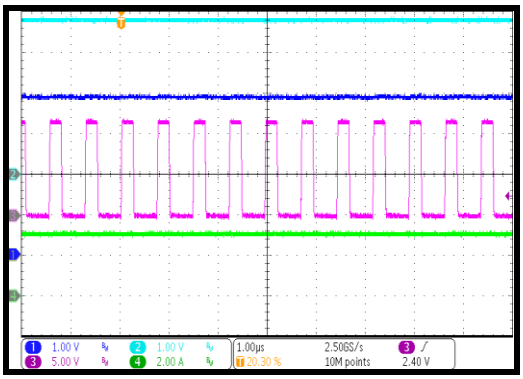
CH2: V_{BATT}
CH3: V_{SW}
CH1: V_{SYS}
CH4: I_{BATT}



Constant Current Charge

V_{IN} = 12V, I_{IN_LIM} = 2A, V_{BATT} = 3.8V, I_{CC} = 3A

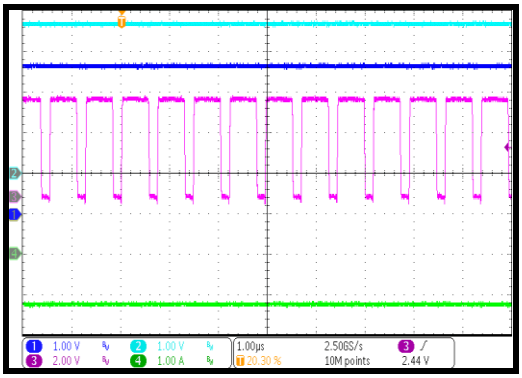
CH2: V_{BATT}
CH3: V_{SW}
CH1: V_{SYS}
CH4: I_{BATT}



Battery Supplement Mode

V_{IN} = 5V, I_{IN_LIM} = 1.5A, V_{BATT} = 3.8V, I_{SYS} = 3A

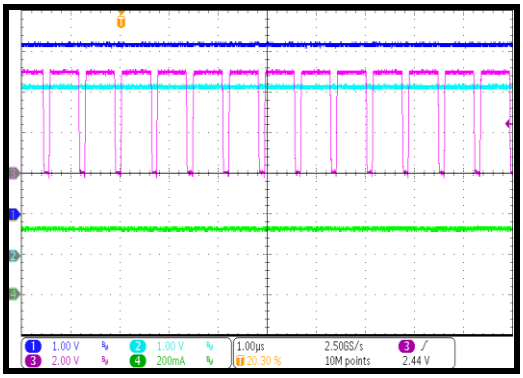
CH2: V_{BATT}
CH3: V_{SW}
CH1: V_{SYS}
CH4: I_{BATT}



Constant Voltage Charge

V_{IN} = 5V, I_{IN_LIM} = 1.5A, V_{BATT} = 4.19V, I_{SYS} = 0A

CH3: V_{SW}
CH1: V_{SYS}
CH2: V_{BATT}
CH4: I_{BATT}



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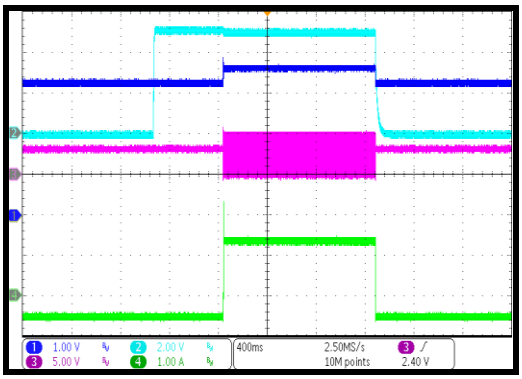
SOLUTION MODULE TEST RESULTS *(continued)*

V_{IN} = 5.0V, V_{BATT} = 0V to 4.2V, I_{CC} = 3A, I_{IN_LIM} = 1.5A, V_{IN_MIN} = 4.6V, L1 = 1.0µH, C_{IN} = 1µF, C_{PMID} = 10µF, C_{BATT} = 22µF, C_{SYS} = 22µF, T_A = 25°C, unless otherwise noted.

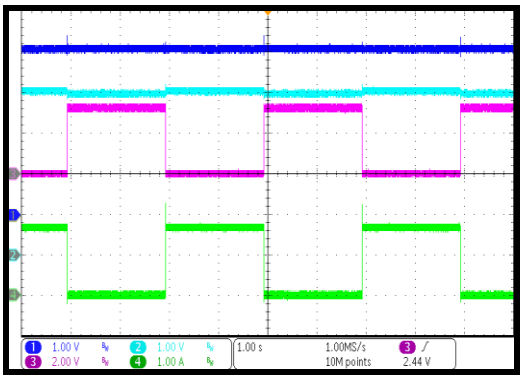
Power On/Off Waveform

V_{IN} = 5V, I_{IN_LIM} = 1.5A, V_{BATT} = 3.3V, I_{SYS} = 0.5A



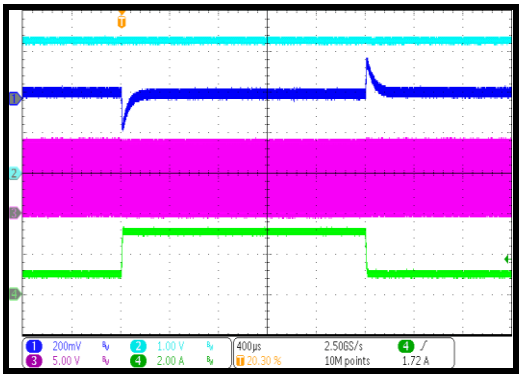
Charge On/Off

V_{IN} = 5V, I_{IN_LIM} = 1.5A, V_{BATT} = 4.0V, I_{SYS} = 0A



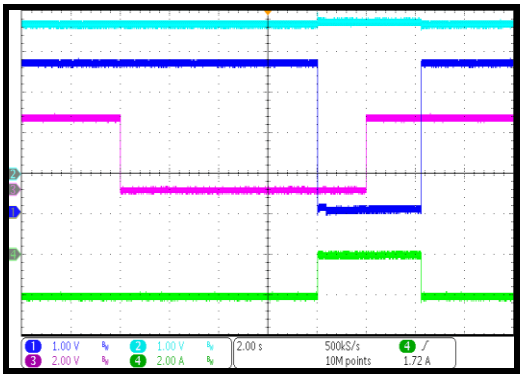
SYS Load Transient

V_{IN} = 9V, V_{BATT} = 3.3V, charge disabled, I_{SYS} = 1A to 3A



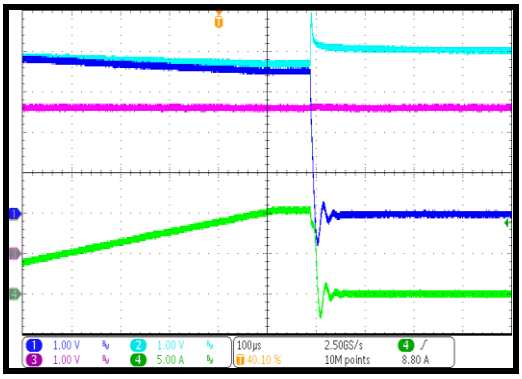
System Reset Mode

V_{IN} = float, V_{BATT} = 3.8V, I_{SYS} = 2A



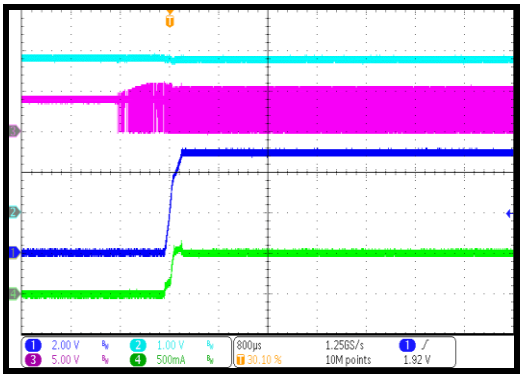
Battery Discharge Current

V_{IN} = float, V_{BATT} = 4.0V, I_{SYS} = up to 10A



OTG Mode On

V_{IN} = float, OTG mode, V_{BATT} = 3.8V, I_{IN_DSCHG} = 2.4A, I_{OTG} = 0.5A



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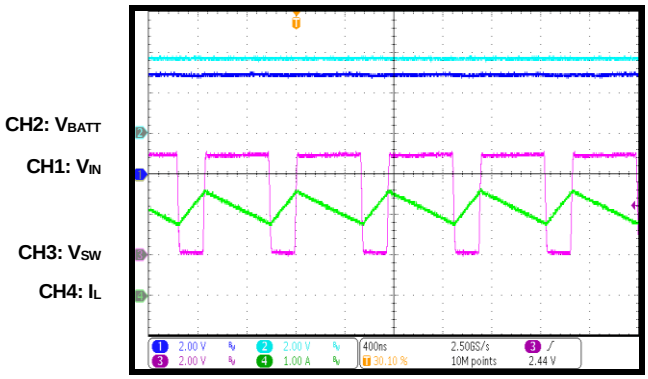
SOLUTION MODULE TEST RESULTS *(continued)*

V_{IN} = 5.0V, V_{BATT} = 0V to 4.2V, I_{CC} = 3A, I_{IN_LIM} = 1.5A, V_{IN_MIN} = 4.6V, L1 = 1.0µH, C_{IN} = 1µF, C_{PMID} = 10µF, C_{BATT} = 22µF, C_{SYS} = 22µF, T_A = 25°C, unless otherwise noted.

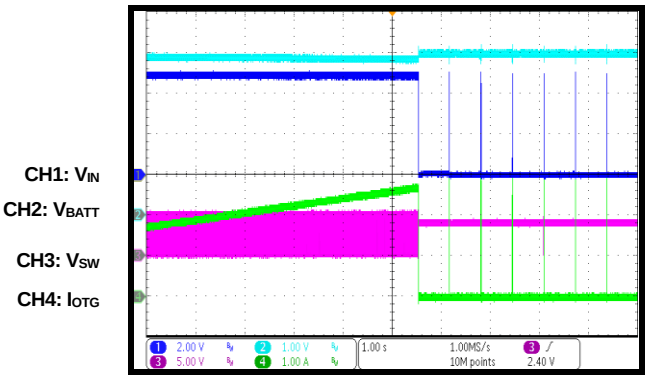
OTG Steady State Operation

V_{IN} = float, OTG mode, V_{BATT} = 3.8V,
I_{IN_DSCHG} = 2.4A, I_{OTG} = 1.5A



OTG Voltage Regulation

V_{IN} = float, OTG mode, V_{BATT} = 4.0V,
I_{IN_DSCHG} = 2.4A, I_{OTG} = 0-2.4A



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PCB LAYOUT

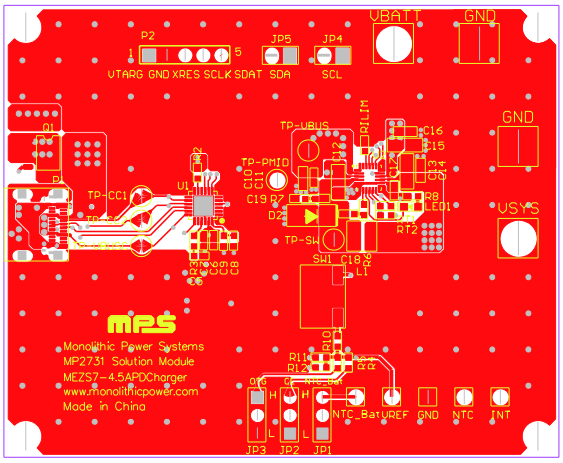

Figure 3: Top Layer

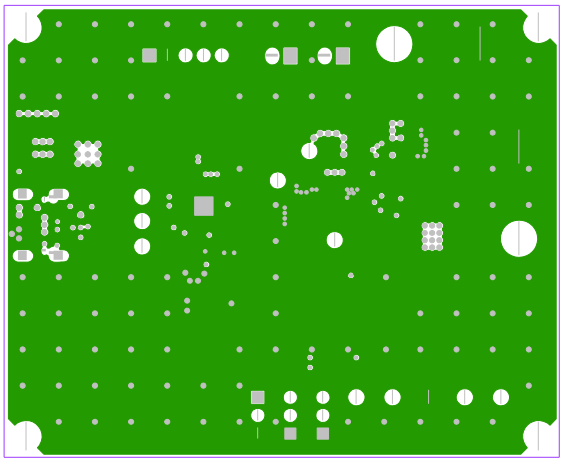

Figure 4: Mid-Layer 1

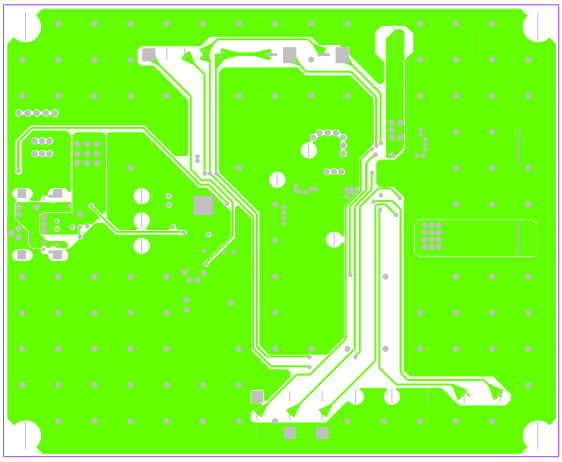

Figure 5: Mid-Layer 2

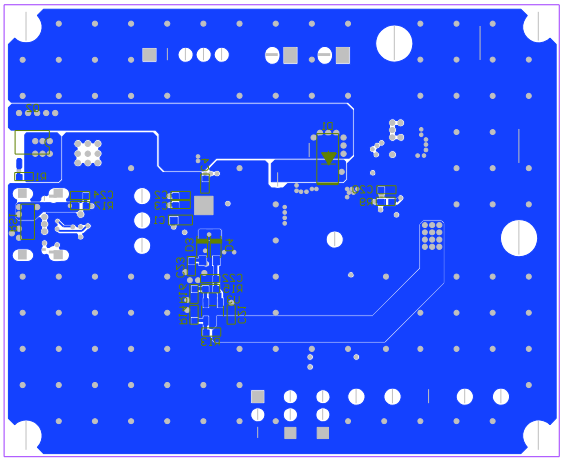

Figure 6: Bottom Layer

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Revision History

Revision #	Revision Date	Description	Pages Updated
1.0	8/3/2020	Initial Release	-

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