0.8-A, Single-Input, Single-Cell Li-Ion Battery Charger

This user's guide describes the bq24050/2/5 evaluation module (EVM), how to perform a stand-alone evaluation or interface with a host or system. The charger is designed to deliver up to 800mA of continuous current to the battery output when programmed with a resistor on the ISET pin and is programmed for ~540mA at the factory. The USB current limit modes are selected by the ISET2 pin and limits current to a maximum of 500mA (logic high) or 100mA (float or high impedance). A low on the ISET2 pin programs the charge current using the ISET resistor.

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1 Introduction

The bq2405x series of devices are highly integrated Li-ion linear chargers devices targeted at space-limited portable applications. The devices operate from either a USB port or AC adapter.

The bq2405x has a single power output that charges the battery. A system load can be placed in parallel with the battery as long as the average system load does not keep the battery from charging fully during the 10 hour safety timer.

The bq24050/2/5 have an integrated USB detect routine that looks for an USB connection on power-up and initially sets the charge input control to either the programmed ISET level, if an adaptor is detected, or to USB100 mode if an USB port is detected. This aides in a faster charge if the battery is discharged and the USB device transceiver is not powered and an adaptor is connected.

The battery is charged in three phases: conditioning, constant current and constant voltage. In all charge phases, an internal control loop monitors the IC junction temperature and reduces the charge current if an internal temperature threshold is exceeded.

The charger power stage and charge current sense functions are fully integrated. The charger function has high accuracy current and voltage regulation loops, charge status display, and charge termination. The pre-charge current and termination current threshold are programmed via an external resistor on the bq24050/2/5. The fast charge current value is also programmable via an external resistor

2 Considerations With Evaluating the bq24050/2/5

Refer to the data sheet for specific details on the charger ICs. The main differences between the bq24050/2/5 spins is: (1) The '50 uses a 10k NTC thermistor, (2) the '52 uses a 100k NTC thermistor, and (3) the '55 uses a 10k NTC thermistor and has a PG pin.

The ISET current control loop sets the maximum charge current. This maximum programmed current level can be further reduced by entering a USB mode, selected by the ISET2 pin.

A system load may be connected to the OUT pin which will take away some of the charge current. Normally it is not recommended to operate the system in pre-charge mode since the system load keeps the battery from recovering, but since the PRE_TERM pin can program a higher pre-charge current this restriction is not necessary.

3 Performance Specification Summary

Specificaton	Test Conditions	Min	Typ	Max	Units
Input DC voltage, Vin	Recommended input voltage range	4.45		6.45	V
Reduced Performance, Vin(1)	Will not charge with Over Voltage input condition. Limited charging with under voltage input.	3.5		28	V
Power Dissipation(2)	$P_{DISS} = (V_{IN} – V_{OUT}) \times I_{OUT}$			1.5	W
I_{OUT}	RISET = 1k		0.54	0.8	A

(1) Input voltage range is specified for normal operation. Input voltage between UVLO and 4.75 V has limited functionality, but does not damage the IC nor present any safety issue with the battery. Input voltage above OVP and less than 30 Vdc has no operation and will not damage the IC. Lower input voltage (closer to dropout operation) produces less heat dissipation and potentially better performance.

(2) The junction temperature rise above ambient is proportional to the power dissipation. Once the junction temperature reaches ~125°C, thermal regulations reduces the programmed charge current.

4 Test Summary

The bq24050/2/5 EVM board requires a 5-VDC, 1-A power source to provide input power and a single-cell Li-ion or Li-polymer battery pack. The test setup connections and jumper setting selections are configured for a stand-alone evaluation but can be changed to interface with external hardware such as a microcontroller.

4.1 Equipment

- Power supply +5.1 ±0.1 V, current limit set to 1.5 ±0.1 A
- Battery: 4.2 V LiCoO2 or equivalent
- Two Fluke 75 DMMs (equivalent or better)
- Oscilloscope, Model TDS220 (equivalent or better)

4.2 Equipment and EVM Setup

Jack/Component	Connect or Adjustment To:
J1-DC+	Power supply positive, preset to 5 VDC, 1-A current limit.
J1-DC–	Power supply ground
J2-BAT+	Positive Battery Pack Terminal
J2-BAT–	Negative Battery Pack Terminal
JMP1	Apply shunt between IN_IC and DC+; allows use of J1 input.
JMP2	Apply shunt for Pre-Term connection.
JMP3	Remove shunt for USB100 mode operation.
JMP4	Apply shunt for CHG LED connection.
JMP5	Apply shunt for TS potentiometer connection.
JMP6 (bq24050/2)	Apply shunt to simulate an adaptor connection when using J1 as an input.
JMP6 (bq24055)	Apply shunt for PG LED connection.
JMP7 (bq24055)	Apply shunt to simulate an adaptor connection when using J1 as an input.
R2 (R_{ISET})	Adjust R2 for 1k between TP2 and GND
R4 ($R_{PRE-TERM}$)	Adjust R3 for 2k between TP4 and GND
R8 (R_{TS})	Adjust R11 for 10k between TP9 and GND

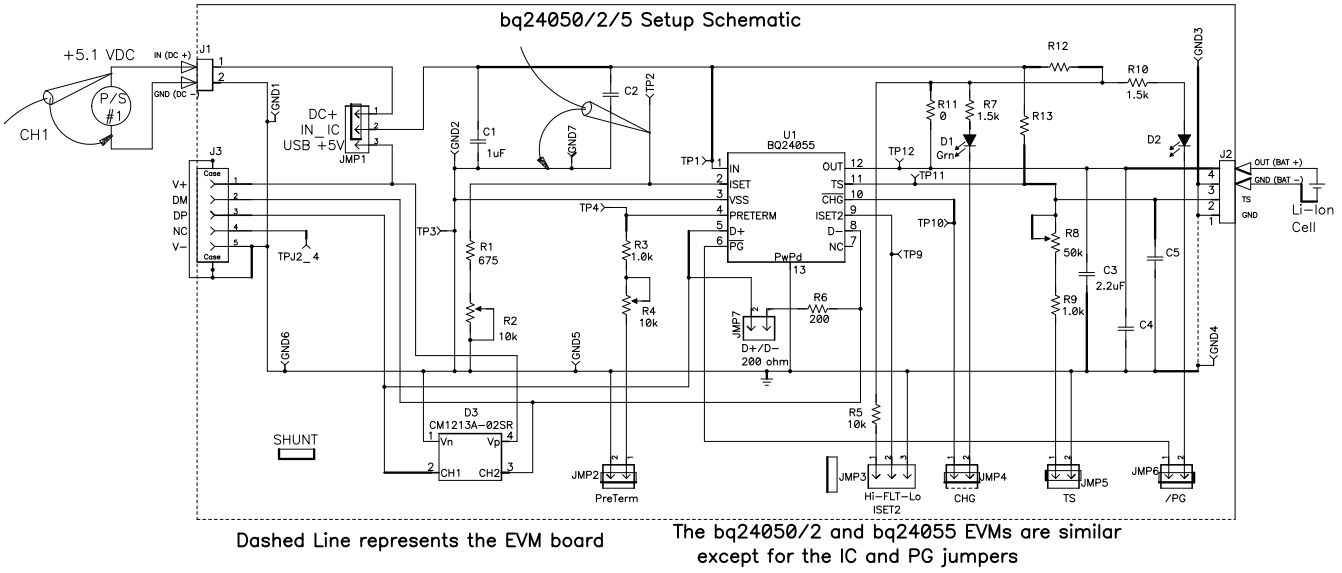

Figure 1. bq24050/2/5 Setup Schematic

4.3 Test Procedure Using a Single Cell Li-Ion Battery

1. Connect one DMM across the BAT+ to BAT– connection at J2. Since this is a linear charger the output current display on the input power supply is approximately the current delivered to the OUT pin. The charge current may be monitored independently by placing a 100mΩ resistor in the battery pack return and using a DMM to monitor the sense resistor.

2. Verify that the setup was performed correctly and turn on the power supply, which was preset to 5 VDC, and 1 A for the current-limit setting. The current was programmed for ~540 mA fast charge, or ~108 mA if in pre-charge, from the factory.
3. Shunt JMP6 (bq24050/2) and JMP7 (bq24055) short the D+ and D– input together simulating an adaptor connection. After applying input power the USB detection routine will detect an adaptor and start charging as if an adaptor is applied. One will notice about 540ma once the battery voltage charges above the $V_{(LOWV)}$ threshold. The ISET2 pin voltage is proportional to the amount of programmed current delivered to the OUT pin. The voltage on the ISET2 pin is 1.5V when the output current is 100% of the programmed value.
4. The bq24050/2/5 enters preconditioning mode if the battery is below the $V_{(LOWV)}$ threshold. In this mode, the bq24050/2/5 pre-charges the battery with a low current programmed by the PRE-TERM resistor (typically set to 10% of fast charge) until the battery voltage reaches the $V_{(LOWV)}$ threshold or until the pre-charge timer expires. If the timer expires, then the charge current is terminated and the bq24050/2/5 enters fault mode. The CHG LED turns off when in timer fault mode (Toggling input power, toggling TS low or battery replacement resets fault mode).
5. Once the battery voltage is above the V(LOWV) threshold, the battery enters fast-charge constant current mode. This EVM is programmed, by the ISET resistor for 0.54 A of fast-charging current. The IC should be in this mode since the USB detection routine detected an adaptor.
6. Apply a shunt to JMP3 ISET2-HI and see (charge current drops) the IC go into USB500 mode, remove the shunt and see the mode change to USB100, place the shunt between ISET2 and GND to see the programmed current mode. The USB detection routine always sets the mode at power-up and the user (processor) has to change the state of the ISET2 pin for the IC to unlatch the charge mode and set according to the ISET2 pin.
7. Once the battery reaches the voltage regulation threshold (4.2 V), the voltage control loop takes over and the current tapers down as the battery reaches its full capacity.
8. The battery remains at the fast charge mode until either the charge timer expires or the charge termination current threshold is reached.
9. Once the charge terminates, the CHG LED will turn off.
10. Remove JMP5 (TS) and the charger will turn on. This mode is Termination and Timer Disable Mode (TTDM). This allows continuous power applied from the input to the output, regulated to 4.2V with a maximum current programmed by the ISET resistor (may be restricted further if in USB mode). The system can operate without a battery in this mode as long as the system does not exceed the supplied input current.
11. If the battery discharges to the recharge threshold, the charger starts fast charging, but the CHG LED will not come on for the subsequent chargers. Cycling the input power, replacing the battery, or toggling the TS pin low will start a new charge with the CHG LED on.
12. Discharge the battery below 4.0 V and above 3.0 V, remove Shunt 6 (bq24050/2) or Shunt 7 (bq24055). Remove and re-apply input power and verify the USB mode is detected. Remove shunt from JMP3 and replace on JMP3: ISET2-GND. Verify current is set to the ISET resistor programmed level.
13. Procedure may be repeated using a mini USB cable connected to J3 on the EVM, and to either a USB port or adapter for the power source. Remove shunt JMP6 (bq24050/2) or JMP7 (bq24055), and move JMP1 to IN_IC / USB +5V prior to applying power with the USB mini cable.

NOTE: Loads across the battery can affect termination. The pre-term pin can be adjusted to offset the system current. See data sheet for more details.

4.4 Alternate Test Methods

A 4 quadrant power supply which can source and sink current can be used in place of the battery pack to evaluate the charger. It will allow each transfer between pre-charge, constant-current and constant voltage fast charge. Keep leads short to avoid adding too much inductance which make cause an interaction between the power supply and charger. A large capacitor across the output will help cancel the inductance if long leads are necessary.

5 Schematics, Physical Layouts, and Bill of Materials

5.1 Schematics – HPA388A

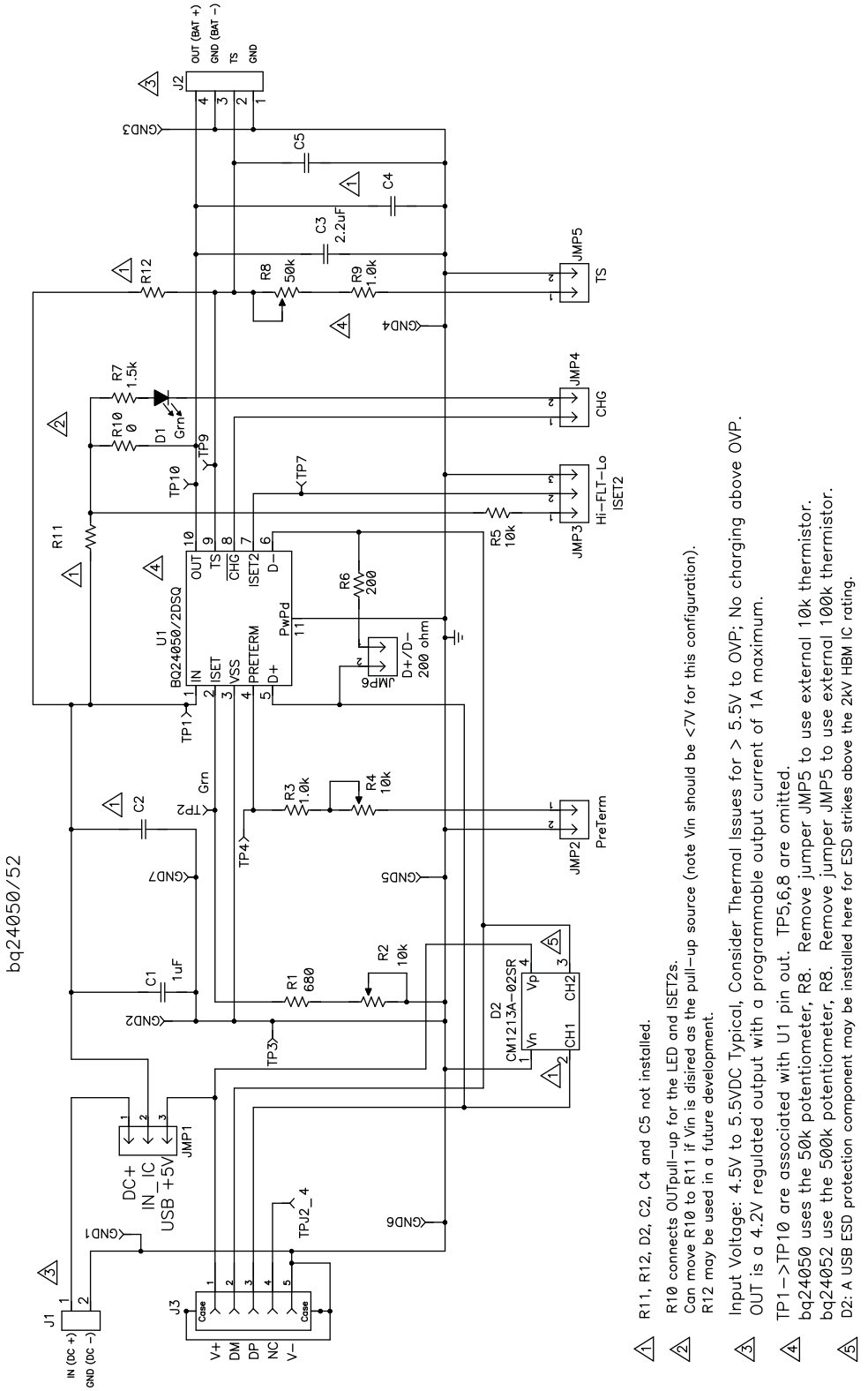

Figure 2. bq24050/2 EVM Schematic

5.2 Physical Layouts – HPA388A

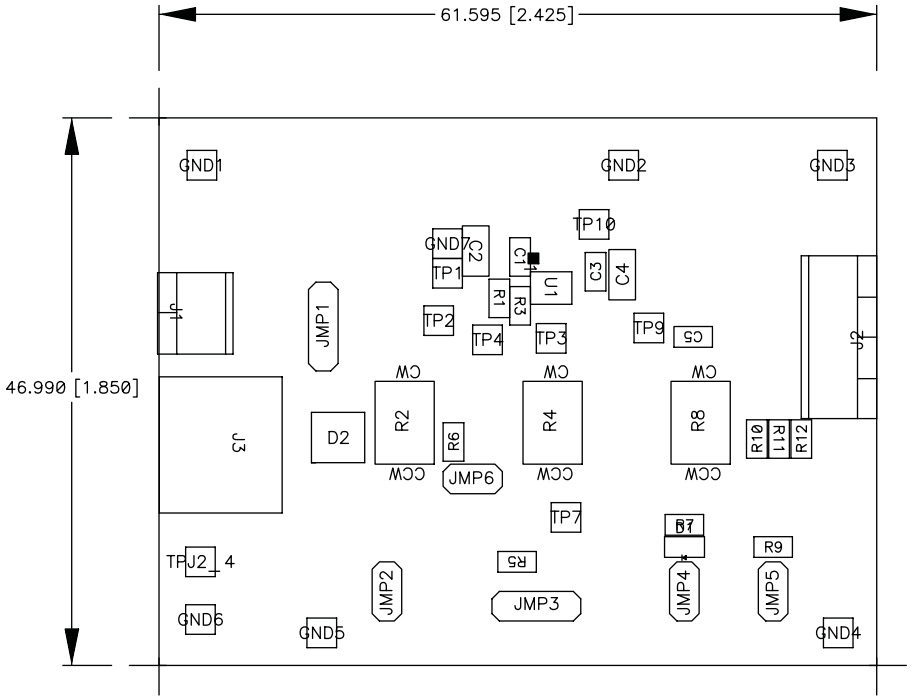

Figure 3. Top Assembly

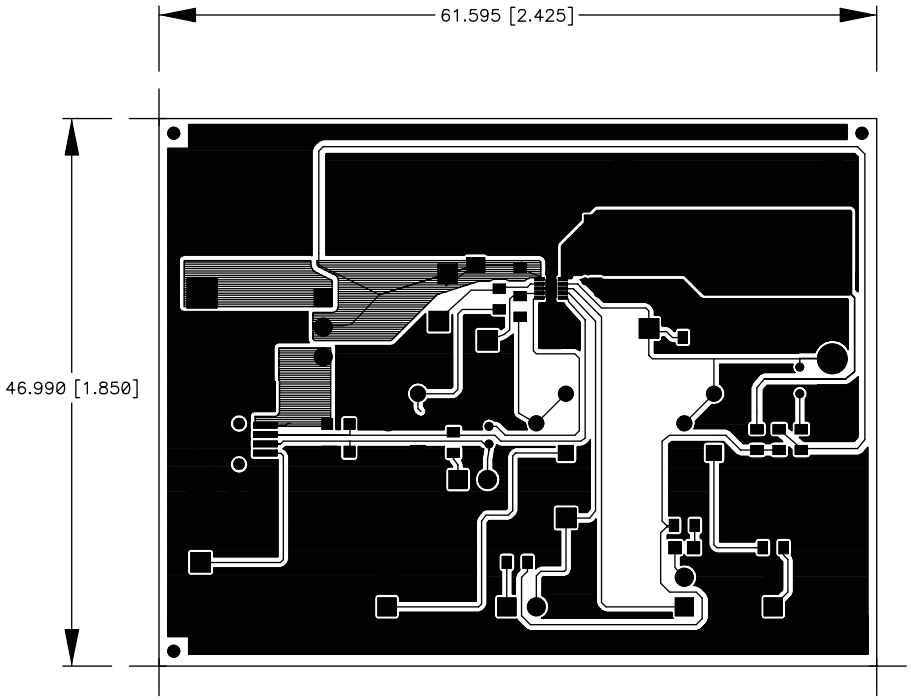

Figure 4. Top View

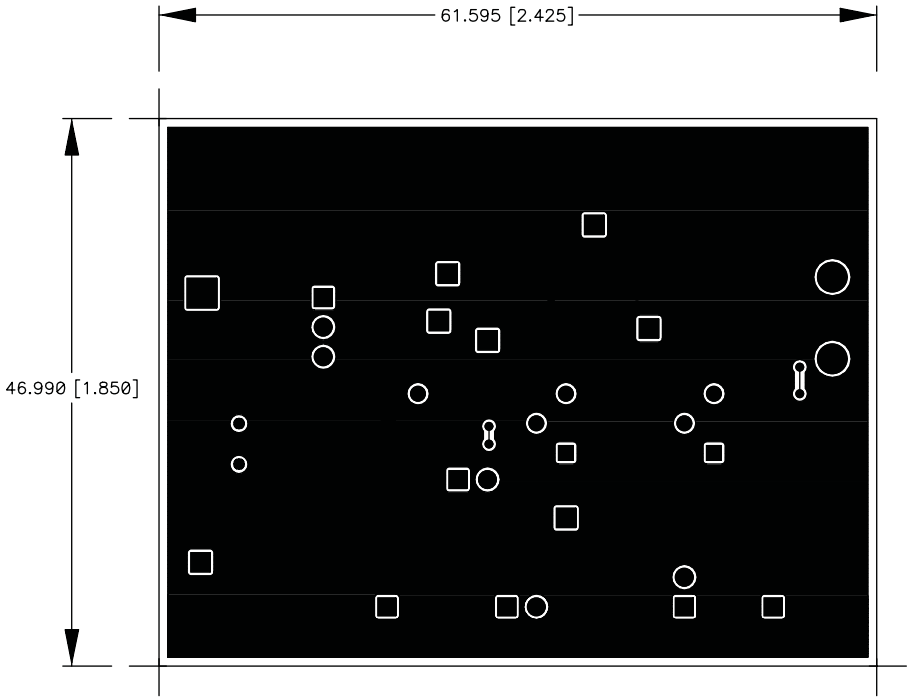

Figure 5. Bottom View

5.3 Bill of Materials – HPA388A

Table 1. HPA388A BOM – bq24050/2

-001	-002	RefDes	Value	Description	Size	Part Number	MFR
1	1	C1	1µF	Capacitor, Ceramic, 25V, X5R, 10%	0603	ECJ-1VB1E105K	Panasonic
0	0	C2	Optional	Capacitor, Ceramic, 25V, X5R, 10%	0805	ECJ-2FB1E***K	Panasonic
1	1	C3	2.2µF	Capacitor, Ceramic, 10V, X5R, 10%	0603	ECJ-1VB1A225K	Panasonic
0	0	C4	Optional	Capacitor, Ceramic, 10V, X5R, 10%	0805	ECJ-2FB1A***K	Panasonic
0	0	C5	Optional	Capacitor, Ceramic, 25V, X5R, 10%	0603	ECJ-1VB1E224K	Std
1	1	D1	LTST-C190GKT	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	0603	LTST-C190GKT	Lite On
0	0	D2	CM1213A-02SR	Diode, ESD Protection Arrays, 2 Channel	SOT143	CM1213A-02SR	CMD
1	1	J1*	ED555/2DS	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 × 0.25 inch	ED555/2DS	OST
1	1	J2*	ED555/4DS	Terminal Block, 4-pin, 6-A, 3.5mm	0.55 × 0.25 inch	ED555/4DS	OST
1	1	J3	UX60-MB-5ST	Connector, Recpt, USB-B, Mini, 5-pins, SMT	0.354 × 0.303 Inches	UX60-MB-5ST	
2	2	JMP1, JMP3	PEC03SAAN	Header, Male 3-pin, 100mil spacing	0.100 inch × 3	PEC03SAAN	Sullins
4	4	JMP2, JMP4, JMP5, JMP6	PTC02SAAN	Header, Male 2-pin, 100mil spacing	0.100 inch × 2	PEC02SAAN	Sullins
1	1	R1	680	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	1	R10	0	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	0	R11, R12	DNI	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	2	R2, R4	10kΩ	Potentiometer, 1/4 in. Cermet, 12-Turn, Top-Adjust	0.25×0.17	3266W-103LF	Bourns
2	2	R3, R9	1.0kΩ	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	1	R5	10kΩ	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	1	R6	200Ω	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	1	R7	1.5kΩ	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	0	R8	50kΩ	Potentiometer, 1/4 in. Cermet, 12-Turn, Top-Adjust	0.25×0.17	3266W-503LF	Bourns

Table 1. HPA388A BOM – bq24050/2 (continued)

-001	-002	RefDes	Value	Description	Size	Part Number	MFR
0	1	R8	500kΩ	Potentiometer, 1/4 in. Cermet, 12-Turn, Top-Adjust	0.25×0.17	3266W-504LF	Bourns
1	0	U1	BQ24050DSQ	IC, 750mA, Single-Input, Single Cell Li-Ion BATTERY CHARGER	SON-10	BQ24050DSQ	TI
0	1	U1	BQ24052DSQ	IC, 750mA, Single-Input, Single Cell Li-Ion BATTERY CHARGER	SON-10	BQ24052DSQ	TI
6	6	Shunt (Note 5)		Shunt, 100-mil, Black	0.1	929950-00	3M
1		–		PCB, 2.45 In × 1.85 In × 0.031 In		HPA388	Any

Notes: 1. These assemblies are ESD sensitive, ESD precautions shall be observed.

2. These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.

3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.

4. Ref designators marked with an asterisk ('**') cannot be substituted. All other components can be substituted with equivalent MFG's components.

5. Apply shunt to JMP2/4/5/6 and JMP1:1/2 and JMP3:2/3.

5.4 Schematics – HPA379A

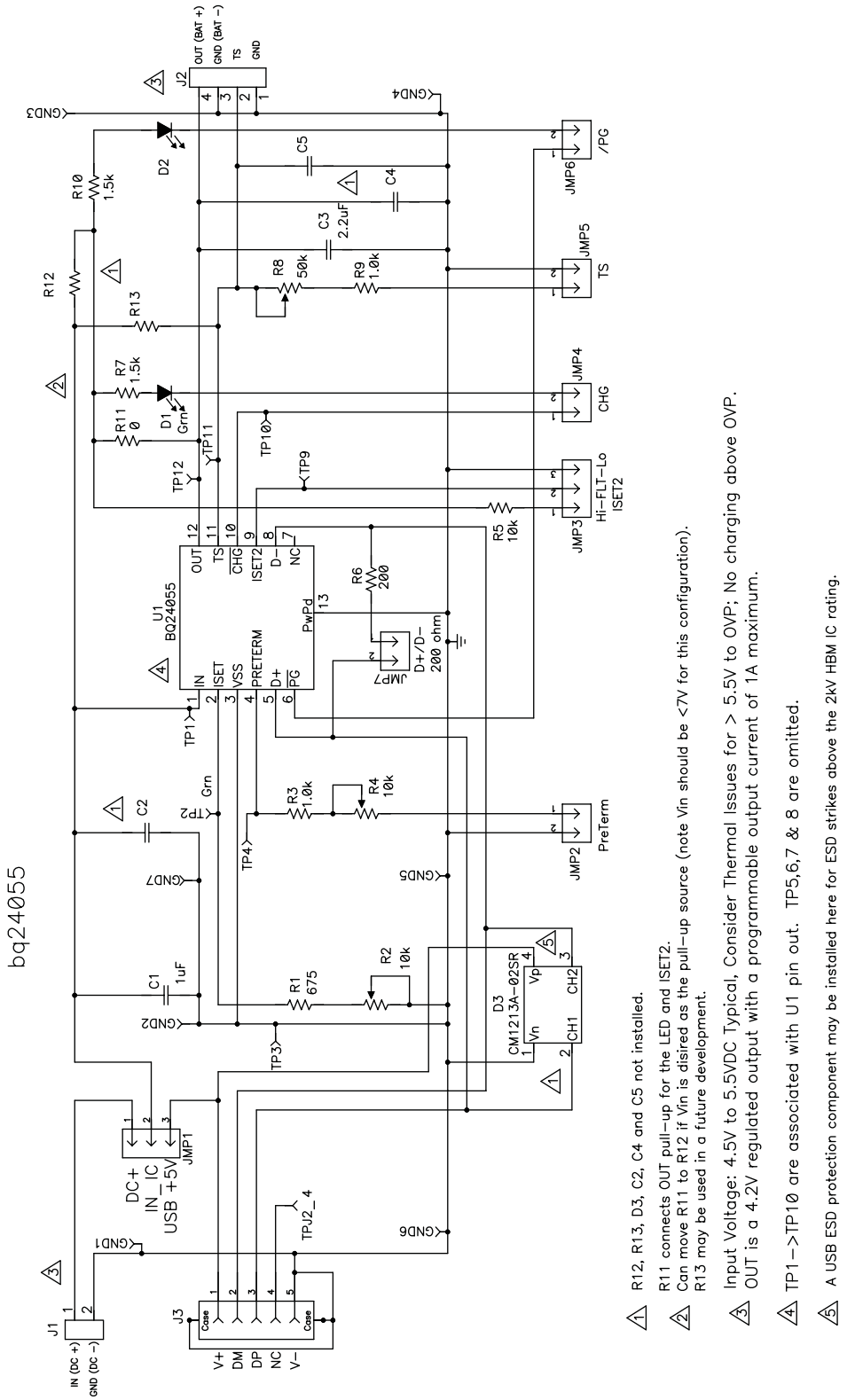

Figure 6. bq24055 EVM Schematic

5.5 Physical Layouts – HPA379A

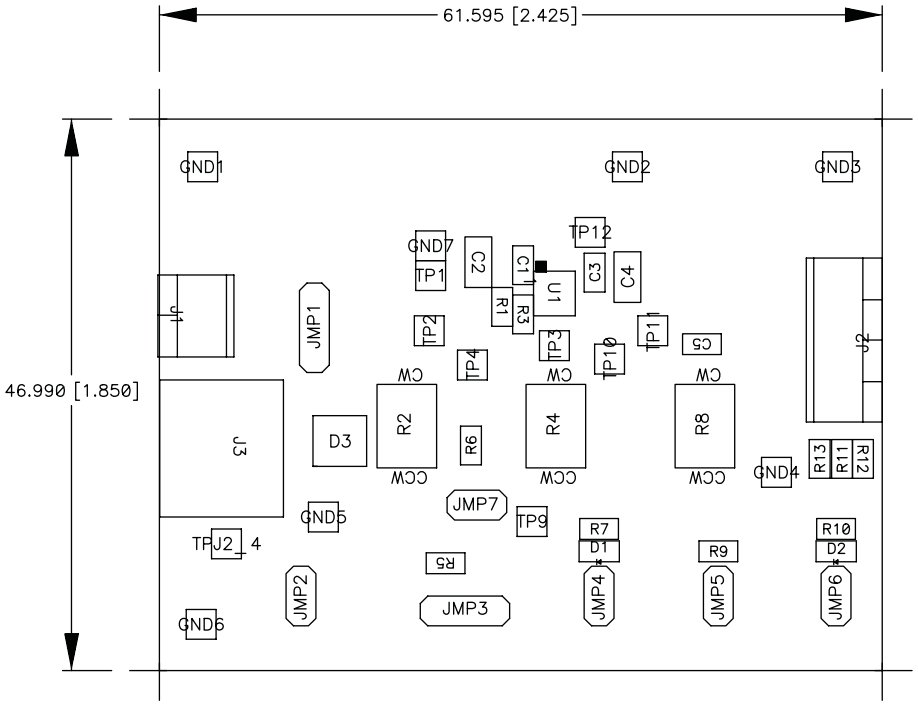

Figure 7. Top Assembly

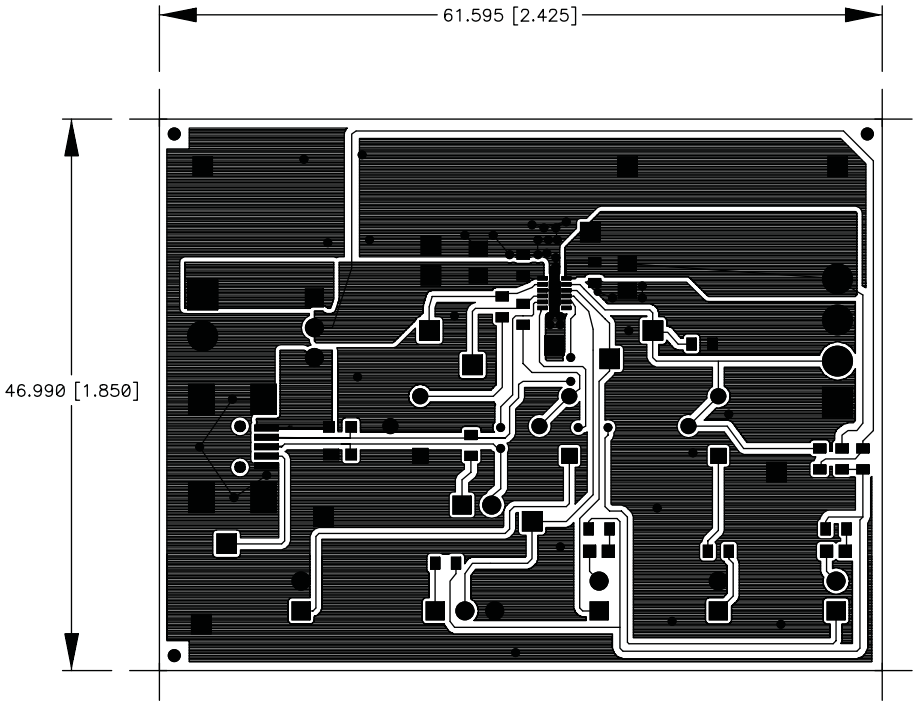

Figure 8. Top View

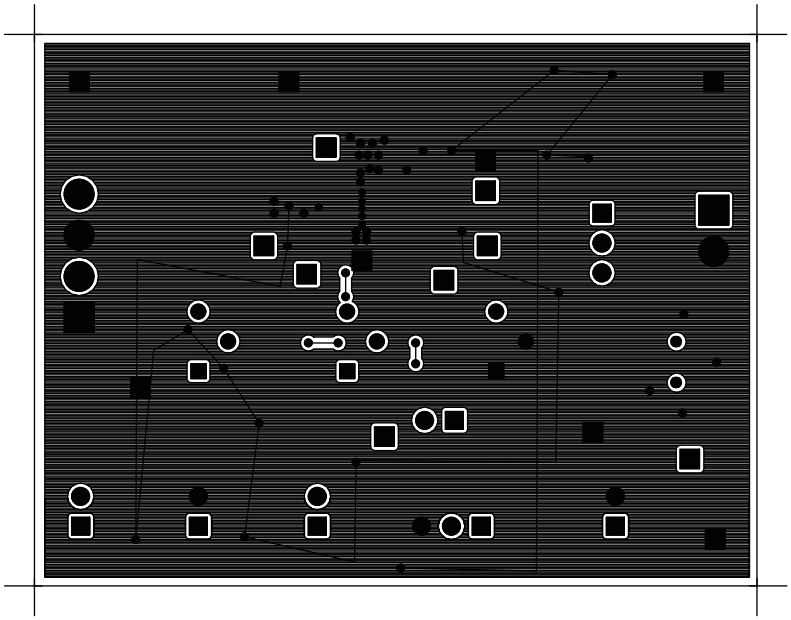

Figure 9. Bottom View

5.6 Bill of Materials – HPA379A

Table 2. HPA379A BOM – bq24055

Count	RefDes	Value	Description	Size	Part Number	MFR
1	C1	1µF	Capacitor, Ceramic, 25V, X5R, 10%	0603	ECJ-1VB1E105K	Panasonic
0	C2		Capacitor, Ceramic, 25V, X5R, 10%	0805		
1	C3	2.2µF	Capacitor, Ceramic, 10V, X5R, 10%	0603	ECJ-1VB1A225K	Panasonic
0	C4		Capacitor, Ceramic, 10V, X5R, 10%	0805		
0	C5		Capacitor, Ceramic, 10V, X5R, 10%	0603		
2	D1, D2	LTST-C190GKT	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	0603	LTST-C190GKT	Lite On
0	D3	CM1213A-02SR	Diode, ESD Protection Arrays, 2 Channel	SOT143	CM1213A-02SR	CMD
1	J1**	ED555/2DS	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 x 0.25 inch	ED555/2DS	OST
1	J2**	ED555/4DS	Terminal Block, 4-pin, 6-A, 3.5mm	0.55 x 0.25 inch	ED555/4DS	OST
1	J3	UX60-MB-5ST	Connector, Recpt, USB-B, Mini, 5-pins, SMT	0.354 X 0.303 Inches	UX60-MB-5ST	Hirose Electric Co Ltd
2	JMP1, JMP3	PEC03SAAN	Header, Male 3-pin, 100mil spacing, (3-pin strip)	0.100 inch x 3	PEC03SAAN	Sullins
5	JMP2, JMP4, JMP5, JMP6, JMP7	PEC02SAAN	Header, Male 2-pin, 100mil spacing, (2-pin strip)	0.100 inch x 2	PEC02SAAN	Sullins
1	R1	675Ω	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R11	0	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	R12, R13	DNI	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R2, R4	10kΩ	Potentiometer, 1/4 in. Cermet, 12-Turn, Top-Adjust	0.25x0.17	3266W-1-103LF	Bourns
2	R3, R9	1.0kΩ	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R5	10kΩ	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R6	200Ω	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R7, R10	1.5kΩ	Resistor, Chip, 1/16W, 1%	0603	Std	Std

Table 2. HPA379A BOM – bq24055 (continued)

Count	RefDes	Value	Description	Size	Part Number	MFR
1	R8	50kΩ	Potentiometer, 1/4 in. Cermet, 12-Turn, Top-Adjust	0.25x0.17	3266W-1-503LF	Bourns
1	U1	BQ24055	IC, 800mA, Single-Input, Single Cell Li-Ion BATTERY CHARGER with Automatic AC/USB Detection	SON-12	BQ24055DSS	TI
6		929950-00	Shunts	100 mill	Black	3M
1	--		PCB, 2.4 In x 1.9 In x 0.031 In		HPA379	Any

Notes: 1. These assemblies are ESD sensitive, ESD precautions shall be observed.

2. These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.

3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.

4. Ref designators marked with an asterisk ('**') cannot be substituted. All other components can be substituted with equivalent MFG's components.

5. Apply shunt to JMP1:DC+/IN_IC; JMP2:GND/PreTerm; JMP3:GND/ISET2; JMP4:LED/CHG; JMP5:GND/TS; JMP6:LED/PG

Important Notices

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the power supply voltage range of 4.45 V and 6.45 V. Input voltage range is specified for normal operation. Input voltage between UVLO and 4.75 V has limited functionality, but does not damage the IC nor present any safety issue with the battery. Input voltage above OVP and less than 30 Vdc has no operation and will not damage the IC. Lower input voltage (closer to dropout operation) produces less heat dissipation and potentially better performance.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 60°C. The EVM is designed to operate properly with certain components above 60°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

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1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an “EVM” or “EVMs”) to the User (“User”) in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.

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   1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.

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   2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.

   2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.

   2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI’s recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI’s recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI’s instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGREDATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 *Regulatory Notices:*

3.1 *United States*

3.1.1 *Notice applicable to EVMs not FCC-Approved:*

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio/TV technician for help.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

3.3 *Japan*

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。 技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

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東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/lsds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html

3.4 *European Union*

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.

8. *Limitations on Damages and Liability:*

   8.1 *General Limitations*. IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

   8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.

10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

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