User's Guide
SLUU290–March 2008

bq24705EVM (HPA297) For Multicell Synchronous Notebook Charger

The purpose of the bq24705EVM is for evaluating a multicell, synchronous notebook charge and path selection solution using bq24705 devices. This document includes a test summary, EVM schematic diagram, bill of materials, and printed-circuit board layouts.

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1 Introduction

1.1 EVM Features

- Evaluation module for bq24705
- High-efficiency NMOS-NMOS synchronous buck charger with 600-kHz frequency
- Battery/adapter to system power selector function
- User-selectable 2-cell, 3-cell, or 4-cell Li-ion battery voltage
- User-programmable battery regulation voltage with external voltage source (4.2/cell by default)
- User-programmable charge current with external voltage source (3 A by default)
- User-programmable input current limit with external voltage source (4.5 A by default)
- Pin-programmable interface for control and status communications with host
- AC adapter operating range 18 V to 22 V
- LED indication for control and status signals
- Test points for key signals available for testing purpose. Easy probe hook-up
- Jumpers available. Easy to change connections

1.2 General Description

The bq24705 evaluation module is a complete charger module for evaluating a multicell synchronous notebook charge and path selection solution using the bq24705 devices. It is designed to deliver up to 6 A of charge current to Li-ion or Li-polymer applications. The charge current is programmable by external voltage input.

The bq24705 has a highly integrated battery charge controller designed to work with external host commands. The battery voltage, charge current, input current limit, and other system parameters are pin programmable.

The dynamic power management (DPM) function modifies the charge current depending on system load conditions, avoiding ac adapter overload.

High-accuracy current sense amplifiers enable accurate measurement of the ac adapter current, allowing monitoring of overall system power.

For details, see bq24705 data sheet (SLUS779).

1.3 I/O Description

Jack		Description
J1–ACPWR		AC adapter, positive output
J1–PGND		AC adapter, negative output
J2–1	} BYPASS	BYPASS drive signal on EVM
J2–2	} BYPASS_EX	Gate of Q2
J2–3		External BYPASS drive signal
J3–1	} ACDRV	ACDRV drive signal on EVM
J3–2	} ACDRV_EX	Gate of Q1
J3–3		External ACDRV drive signal
J4–BYPASS_EX		External BYPASS drive signal
J4–ACDRV_EX		External ACDRV drive signal
J4–GND		Ground
J5–1	} BATDRV_EX	External ACDRV drive signal
J5–2	} BATDRV	Gate of Q3
J5–3		ACDRV drive signal on EVM
J6–VPULLUP		Pullup Voltage Source
J6–$\overline{\text{CHGEN}}$		$\overline{\text{CHGEN}}$ pin output
J7–PULLUP		Pullup voltage source
J7–LEDPWR		LED pullup power line
J8–$\overline{\text{ACGOOD}}$		$\overline{\text{ACGOOD}}$ pin
J8–GND		Ground
J8–BAT		Connected to battery pack
J8–SYS		Connected to system
J9–1	} 4.2V REG	REGN pin
J9–2		VADJ pin
J10–VEXT		External power supply, positive output
J10–GND		External power supply, negative output
J11–$\overline{\text{CHGEN}}$		$\overline{\text{CHGEN}}$ pin
J11–VREF		VREF pin
J11–CELLS		CELLS pin
J12–VADJ		VADJ pin
J12–ACSET		ACSET pin
J12–SRSET		SRSET pin

Jack	Description
J13–VPULLUP	Pullup voltage source
J13–CELLS	CELLS pin output
J13–GND	Ground
J14–IADPTF	R25 terminal connected to C18
J14–VREF	IC reference voltage VREF
J14–$\overline{\text{DPMDET}}$	$\overline{\text{DPMDET}}$ pin
J15–BYPASS	BYPASS pin
J15–LED	LED drive
J16–EXT BATDRV	External BATDRV drive signal
J16–GND	Ground
J17–ACDRV	ACDRV pin
J17–LED	LED drive
J18–BATDRV	BATDRV pin
J18–LED	LED drive

1.4 Control and Key Parameters Setting

Jack	Description	Factory Setting
J2	BYPASS drive setting 1-2: Use onboard BYPASS drive 2-3: Use external BYPASS drive	Jumper on 1-2
J3	ACDRV drive setting 1-2: Use onboard ACDRV drive 2-3: Use external ACDRV drive	Jumper on 1-2
J5	BATRDRV drive setting 1-2: Use External BARDRV drive 2-3: Use onboard BATDRV drive	Jumper on 2-3
J6	Disable charge process when on	Jumper On
J7	The pullup power source supplies the LEDs when on. LED has no power source when off.	Jumper On
J9	Connect REGN to VADJ when on	Jumper On
J13	Number of cells selection 1-2 (PULLUP-CELLS) : 4 cells 2-3 (GND-LO) : 3 cells Open: 2 cells	Jumper on 2-3 (3 cells)
J15	The conduction of the BYPASS MOSFET is indicated by LED when on.	Jumper On
J17	The conduction of the AC MOSFET is indicated by LED when on.	Jumper On
J18	The conduction of the battery MOSFET is indicated by LED when on.	Jumper On

1.5 Recommended Operating Conditions

SYMBOL		DESCRIPTION	MIN	TYP	MAX	UNIT	Notes
V_{IN}	Supply voltage	Input voltage from ac adapter input	18	19	22	V	
V_{BAT}	Battery voltage	Voltage applied at VBAT terminal of J8	6	7–16.8	20	V	
I_{AC}	Supply current	Maximum input current from ac adapter input	0		4.5	A	
I_{chrg}	Charge current	Battery charge current	2	3 or 4	6	A	
T_J	Operating junction temperature range		0		125	°C	

2 Test Summary

2.1 Definitions

This procedure details how to configure the HPA297 evaluation board. On the test procedure the following naming conventions are followed. See the HPA297 schematic for details.

VXXX :	External voltage supply name (VADP, VBT, VSBT)
LOADW:	External load name (LOADR, LOADI)
V(TPyyy):	Voltage at HPA297 internal test point TPyyy. For example, V(TP12) means the voltage at TP12.
V(Jxx):	Voltage at HPA297 jack terminal Jxx.
V(TP(XXX)):	Voltage at test point *XXX*. For example, V(ACDET) means the voltage at the test point which is marked as *ACDET*.
V(XXX, YYY):	Voltage across point XXX and YYY.
I(JXX(YYY)):	Current going out from the YYY terminal of jack XX.
Jxx(BBB):	Terminal or pin BBB of jack xx
Jxx ON :	HPA297 internal jumper Jxx terminals are shorted
Jxx OFF:	HPA297 internal jumper Jxx terminals are open
Jxx (-YY-) ON:	HPA297 internal jumper Jxx adjacent terminals marked as *YY* are shorted
Measure: → A,B	Check specified parameters A, B. If measured values are not within specified limits the unit under test has failed.
Observe → A,B	A,B Observe if A, B occur. If they do not occur, the unit under test has failed.

Assembly drawings have location for jumpers, test points, and individual components.

2.2 Equipment

2.2.1 Power Supplies

Power supply #1 (PS#1): a power supply capable of supplying 20 V at 5 A is required.
Power supply #2 (PS#2): a power supply capable of supplying 5 V at 1 A is required.
Power supply #3 (PS#3): a power supply capable of supplying 20 V at 1 A is required.

2.2.2 Load #1

A 30-V (or above), 5-A (or above) electronic load that can operate at constant current mode

2.2.3 Load #2

A HP 6060B 3- to 60-V/0-to 60-A, 300-W system DC electronic load or equivalent

2.2.4 Meters

Seven Fluke 75 multimeters, (equivalent or better)
or four equivalent voltage meters and three equivalent current meters.

The current meters must be capable of measuring a 5-A+ current.

2.3 Equipment Setup

A. Set the power supply #1 for 0 V ± 100 mVDC, 5 V ± 0.1-A current limit and then turn off supply.
B. Connect the output of power supply #1 in series with a current meter (multimeter) to J1 (ACPWR, GND).
C. Connect a voltage meter across J1 (ACPWR, GND).
D. Set the power supply #2 for 3.3 V ±100 mVDC, 1 ±0.1-A current limit and then disable the output.
E. Set the power supply #3 for 10.5 V ±100 mVDC, 1 ±0.1-A current limit and then disable the output.
F. Connect the output of power supply #2 to J10 (VEXT, GND).
G. Turn off Load #1.
H. Turn off Load #2.
I. Connect a voltage meter across J8 (BAT, GND).
J. Connect a voltage meter across J8 (SYS, GND).
K. J2 (BYPASS): ON, J3 (ACDRV): ON, J5 (BATDRV): ON, J6: ON, J7: ON, J9: ON, J13 (CELLS, GND): ON, J15: ON, J17: ON, J18: ON.

After the preceding steps, the test setup for HPA297 (bq24705EVM) is shown in Figure 1.

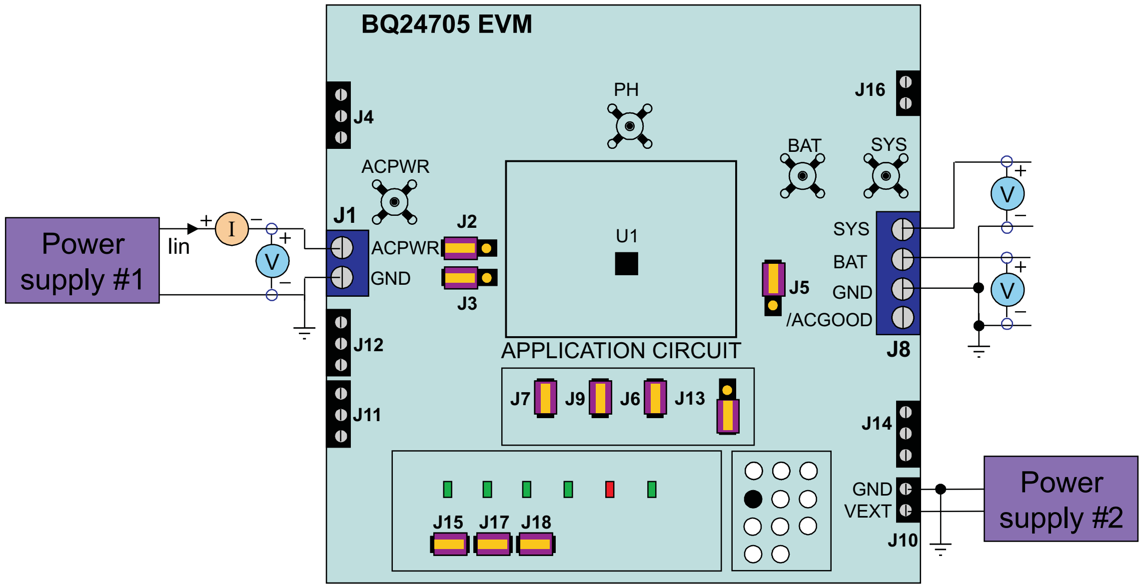


Figure 1. Original Test Setup for HPA297 (bq24705EVM)

2.4 Procedure

2.4.1 AC Adapter Detection Threshold

1. Make sure the Equipment Setup steps of the previous section are followed.
2. Enable the output of PS#2.
3. Turn on PS#1.
   Measure → V(J8(VSYS)) = 0 ±500 mV
   Measure → V(TP(VREF)) = 0 ±1 V
   Measure → V(TP(REGN)) = 0 V ±500 mV
4. Increase the output voltage of PS#1 until D7 ($\overline{\text{ACGOOD}}$) is on, but do not exceed 20 V.
   Measure → V(TP(ACDET)) = 2.4 V ±200 mV
   Measure → V(J1(ACPWR)) = 17.9 V ±1 V
   Measure → V(J8(SYS)) = 17.9 V ±1 V
   Measure → V(TP(VREF)) = 3.3 V ±200 mV
   Measure → V(TP(REGN)) = 0 V ±1 V
   Measure → D2 (BYPASS) on. D3 (ACDRV) on.

2.4.2 Selection of Regulation Voltage

1. Increase the voltage of PS#1 until V(J1(ACPWR)) = 19 V ±0.1 V.
   Measure → V(J8(BAT, GND)) = 0 V ±2 V
   Uninstall J6 (enable the charging)
   Observe → D5 (CHG EN) on
   Measure → V(J8(BAT)) = 12.6 V ±200 mV
   Measure → V(TP(REGN)) = 6 V ±500 mV
2. Install J13 (CELLS, VPULUP)
   Measure → V(J8(BAT)) = 16.8 V ±200 mV
3. Install J13(CELLS, GND)
   Measure → V(J8(BAT)) = 12.6 V ±200 mV

2.4.3 Charge Current and AC Current Regulation (DPM)

1. Install J6. (Disable the charging.)
2. Connect the Load #2 in series with a current meter (multimeter) to J8 (BAT, GND). Ensure that a voltage meter is connected across J8 (BAT, GND). Turn on the Load #2. Use the constant voltage mode. Set the output voltage to 10.5 V.
3. Connect the output of the Load #1 in series with a current meter (multimeter) to J8 (SYS, GND). Ensure that a voltage meter is connected across J8 (SYS, GND). Turn on the power of the Load #1. Set the load current to 4 A ±50 mA but disable the output. The setup is now like Figure 2 for HPA206. Ensure that Ibat = 0 A ±10 mA and Isys = 0 A ±10 mA.

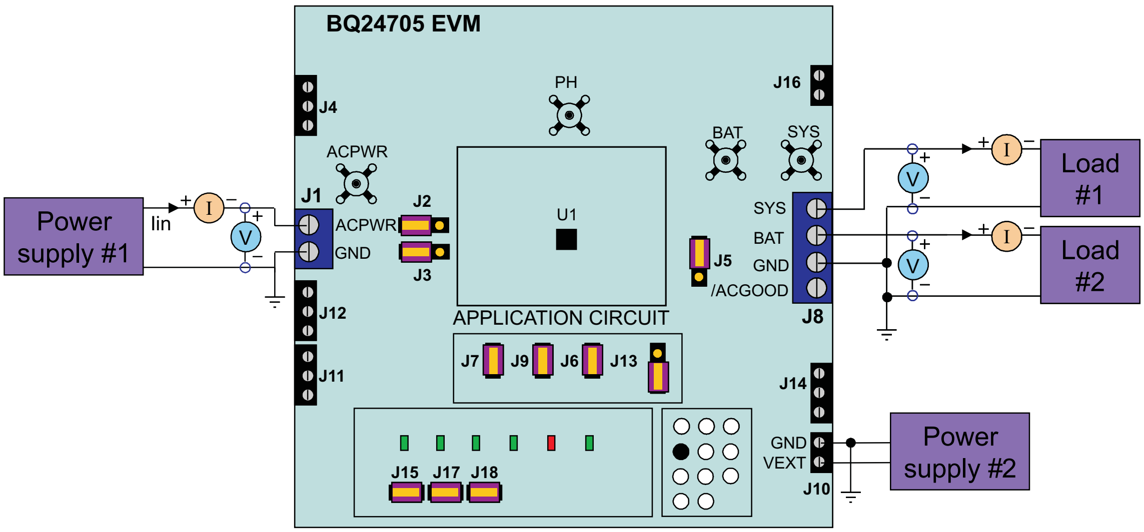


Figure 2. Test Setup for HPA297 (bq24705EVM)

4. Uninstall J6. (Enable the charging.)
   Observe → D5 (CHG EN) on
5. Measure → Ibat = 3000 mA ±200 mA
   Measure → V(TP(IADAPT)):= 350 mV ±100 mV
6. Enable the output of the Load #1.
   Observe → D6 (DPMDET) on
   Measure → Isys = 4000 mA ±200 mA, Ibat = 800 mA ±500 mA, Iin = 4500 mA ±400 mA
7. Turn off the Load #1.
   Measure → Isys = 0 ±100 mA, Ibat = 3000 mA ±200 mA

2.4.4 Power Path Selection

1. Install J6. (Disable the charging.)
   Observe → D5 (CHG EN) off.
2. Replace Load #2 and current meter with PS#3. Ensure that a voltage meter is connected across J8 (BAT, GND). Enable the output of the PS #3. Ensure that the output voltage is 10.5 V±500 mV.
3. *Measure* → V(J8(SYS)) = 19 V ±1 V (adapter connected to system)
   Observe → D2(BYPASS) on, D3 (ACDRV) on, D4 (BATDRV) off
4. Turn off PS#1.
   Measure → V(J8(SYS)) = 10.5 V ±1 V (battery connected to system)
5. *Observe* → D2(BYPASS) off, D3 (ACDRV) off, D4 (BATDRV) on.

3 PCB Layout Guideline

1. It is critical that the exposed power pad on the backside of the bq24705 package be soldered to the PCB ground. Ensure that sufficient thermal vias are right underneath the IC, connecting to the ground plane on the other layers.
2. Route the control stage and the power stage separately. At each layer, the signal ground and the power ground are connected only at the power pad.
3. AC current sense resistor must be connected to ACP and ACN with a Kelvin contact. Minimize the area of this loop. Place the decoupling capacitors for these pins as close to the IC as possible.
4. Connect the charge current sense resistor to SRP, SRN with a Kelvin contact. Minimize the area of this loop. Place the decoupling capacitors for these pins as close to the IC as possible.
5. Place the decoupling capacitors for PVCC, VREF, REGN underneath the IC (on the bottom layer), and make the interconnections to the IC as short as possible.
6. Place the decoupling capacitors for BAT, IADAPT close to the corresponding IC pins, and make the interconnections to the IC as short as possible.
7. Decoupling capacitor(s) for the charger input must be placed close to Q4 drain and Q5 source.

4 Bill of Materials, Board Layout, and Schematics

4.1 Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
0	C1, C3, C11, C18	Open	Capacitor, Ceramic, 50V, X7R, 10%	805	Std	Std
5	C2, C7, C10, C16, C27	0.1 µF	Capacitor, Ceramic, 50V, X7R, 10%	805	Std	Std
1	C4	1 µF	Capacitor, Ceramic, 25V, X5R, 10%	603	Std	Std
1	C5	100 pF	Capacitor, Ceramic, 50V, COG, 10%	603	Std	Std
2	C6, C8	1 µF	Capacitor, Ceramic, 25V, X5R, 10%	805	Std	Std
6	C9, C17, C21, C30, C33, C34	0.1 µF	Capacitor, Ceramic, 50V, X7R, 10%	603	Std	Std
2	C12, C13	10 µF	Capacitor, Ceramic, 25V, X5R, 10%	1206	Std	Std
4	C14, C15, C28, C29	10 µF	Capacitor, Ceramic, 25V, X5R, 10%	1210	Std	Std
1	C19	2.2 µF	Capacitor, Ceramic, 25V, X5R, 10%	1210	Std	Std
0	C20, C26	Open	Capacitor, Ceramic, 25V, X5R, 10%	603	Std	Std
2	C22,C23	10 nF	Capacitor, Ceramic, 25V, X5R, 10%	603	Std	Std
0	C24,C31	Open	Capacitor, Ceramic, 25V, X5R, 10%	1210	Std	Std
0	C25, C32	Open	Capacitor, Ceramic, 25V, X5R, 10%	1206	Std	Std
1	D1	BAT54	Diode, Schottky, 200-mA, 30-V	SOT23	BAT54	Vishay-Liteon
5	D2–D5, D7	LTST-C190GKT	Diode, LED, Green, 2.1-V, 20-mA, 6-mcd	603	LTST-C190GKT	Lite On
1	D6	LTST-C190CKT	Diode, LED, Red, 1.8-V, 20-mA, 20-mcd	603	LTST-C190CKT	Lite On
2	J1, J8	D120/2DS	Terminal Block, 2-pin, 15-A, 5.1mm	0.40 × 0.35 inch	D120/2DS	OST
2	J10, J16	ED555/2DS	Terminal Block, 2-pin, 6-A, 3.5mm	0.27 × 0.25 inch	ED555/2DS	OST
4	J4, J11, J12, J14	ED555/3DS	Terminal Block, 3-pin, 6-A, 3.5mm	0.41 × 0.25 inch	ED555/3DS	OST
4	J2, J3, J5, J13	PTC36SAAN	Header, 3-pin, 100mil spacing, (36-pin strip)	0.100 inch × 3	PTC36SAAN	Sullins
6	J6, J7, J9, J15, J17, J18	PTC36SAAN	Header, 2-pin, 100mil spacing, (36-pin strip)	0.100 inch × 2	PTC36SAAN	Sullins
1	L1	4.7 µH	Inductor, SMT	0.255 × 0.270 inch	IHLP2525CZ-01	Vishay

Count	RefDes	Value	Description	Size	Part Number	MFR
3	Q1–Q3	Si4435DY	MOSFET, P-ch, 30-V, 8.0-A, 20-mΩ	SO8	Si4435DY	Siliconix
2	Q4, Q5	FDS6680A	Transistor, MOSFET, NChan, 30V, 12.5A, Rds 9.5 mΩ	SO8	FDS6680A	Fairchild
11	Q6, Q7, Q10, Q13, Q15, Q17–Q22	2N7002DICT	MOSFET, N-ch, 60-V, 115-mA, 1.2-Ω	SOT23	2N7002DICT	Vishay-Liteon
3	Q8, Q9, Q11	NDS0605	MOSFET,P-ch, –60 V, 180-mA, 5 Ω	SOT-23	NDS0605	Vishay
3	Q12, Q14, Q16	TP0610K	Mosfet, P-Ch, 60V, Rds 6 Ω, Id 185 mA	SOT-23	TP0610K	Vishay-Siliconix
1	R1	430K	Resistor, Chip, 1/16W, 1%	603	Std	Std
1	R2	66.5K	Resistor, Chip, 1/16W, 1%	603	Std	Std
8	R3–R5, R14, R18, R19, R22, R27	10K	Resistor, Chip, 1/16W, 1%	402	Std	Std
1	R6	24.9K	Resistor, Chip, 1/16W, 1%	402	Std	Std
1	R7	10K	Resistor, Chip, 1/16W, 1%	603	Std	Std
3	R8, R13, R24	100K	Resistor, Chip, 1/10W, 1%	805	Std	Std
1	R9	68.0K	Resistor, Chip, 1/10W, 1%	805	Std	Std
2	R10, R11	4.02	Resistor, Chip, 1/4W, 1%	1210	Std	Std
1	R12	43.0K	Resistor, Chip, 1/10W, 1%	805	Std	Std
3	R15, R37, R40	20K	Resistor, Chip, 1/16W, 5%	603	Std	Std
1	R16	82.0K	Resistor, Chip, 1/10W, 1%	805	Std	Std
5	R17, R20, R21, R23, R26	100K	Resistor, Chip, 1/16W, 1%	402	Std	Std
2	R25, R42	0 Ω	Resistor, Chip, 1/16W, 5%	402	Std	Std
6	R28, R29, R31, R32, R34, R35	100K	Resistor, Chip, 1/16W, 5%	402	Std	Std
6	R30, R33, R36, R38, R39, R41	2.2K	Resistor, Chip, 1/16W, 5%	603	Std	Std
2	R43, R44	0.01	Resistor, Chip, 1/2W, 1%	2010	Std	Std
10		929950-00	Shorting jumpers, 2-pin, 100 mil spacing,		929950-00	3M/ESD
4			6-32 NYL nuts			
4		4816	STANDOFF M/F HEX 6-32 NYL .500"	sf_thvt_325_rnd	4816	Keystone
4	TP1, TP2, TP18, TP19	131-4244-00	Adaptor, 3.5-mm probe clip (or 131-5031-00)	0.200 inch	131-4244-00	Tektronix
10	TP4, TP5, TP7–TP10, TP13, TP15–TP17	5002	Test Point, White, Thru Hole Color Keyed	0.100 × 0.100 inch	5002	Keystone
2	TP6, TP26	5001	Test Point, Black, Thru Hole Color Keyed	0.100 × 0.100 inch	5001	Keystone
1	U1	BQ24705RGE	IC, Hot-Controlled Multi-Chemistry Battery Charger	DGN24	BQ24705RGE	TI
1	--	HPA297	PCB		PCB	Any

4.2 Board Layout

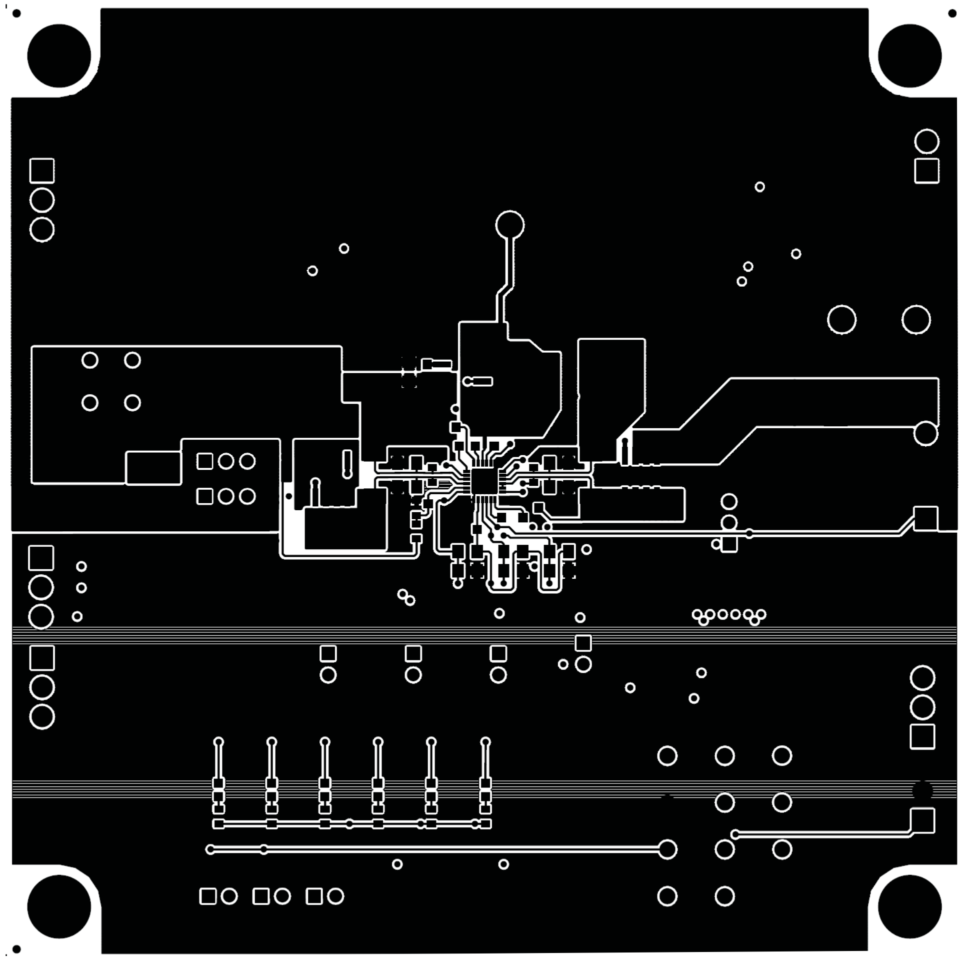


Figure 3. Top Layer

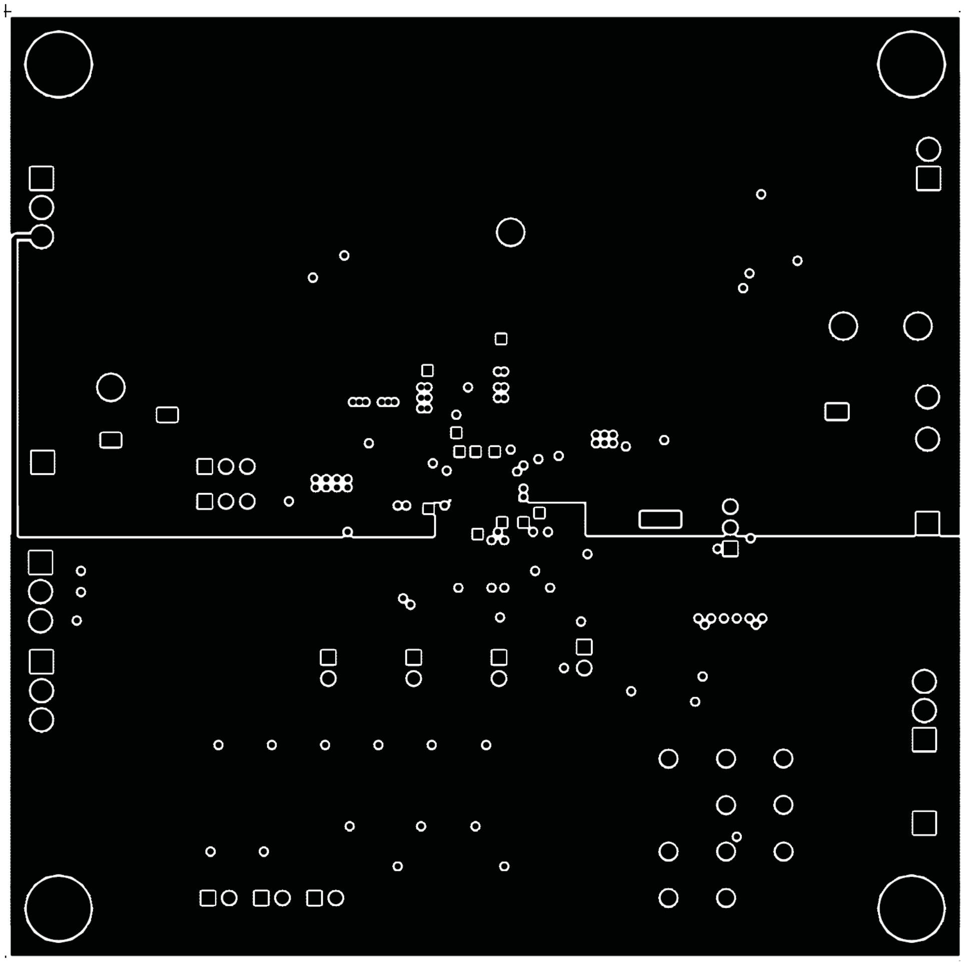


Figure 4. Second Layer

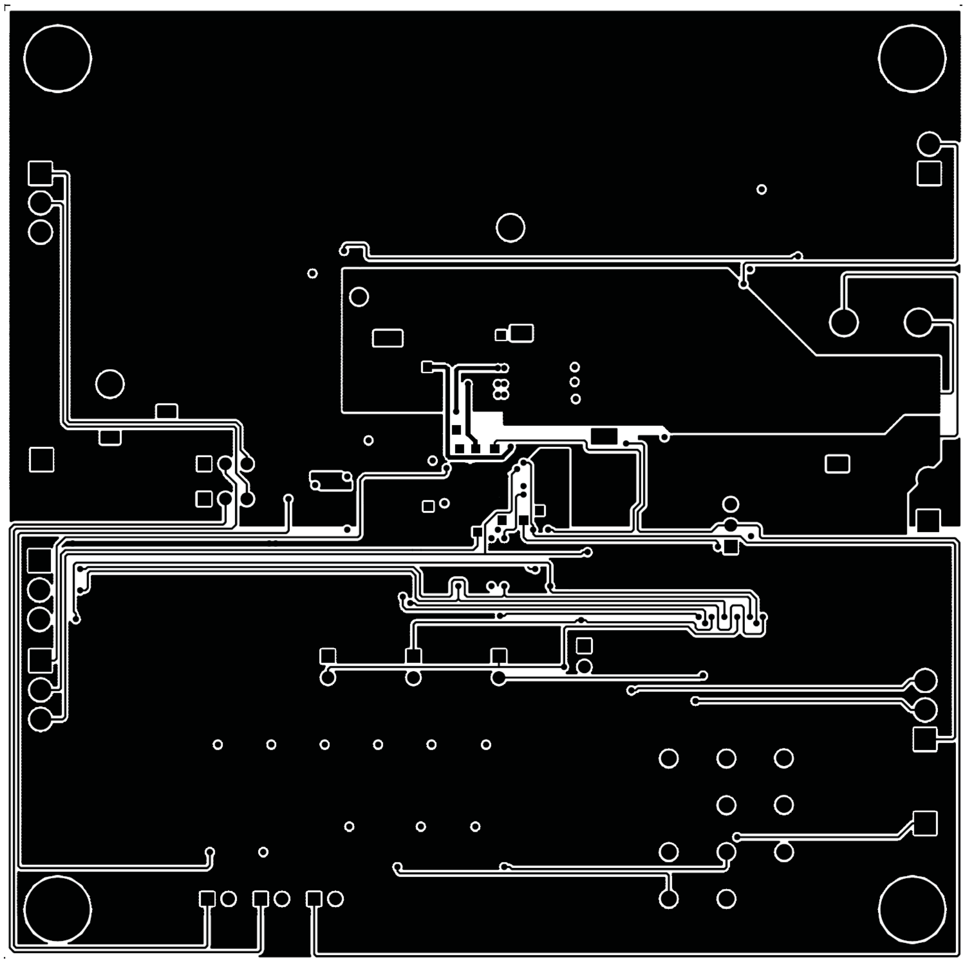


Figure 5. Third Layer

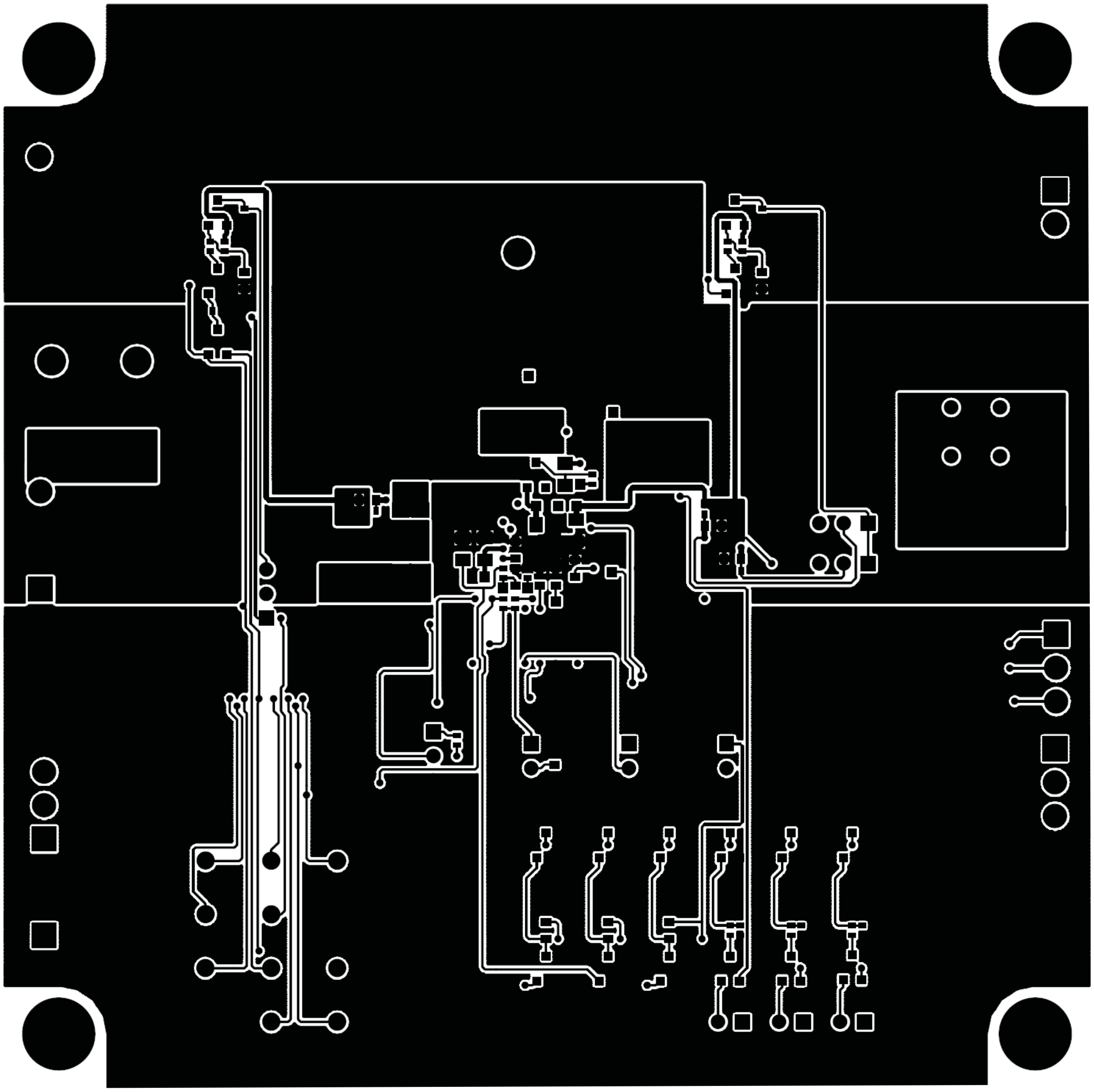


Figure 6. Bottom Layer

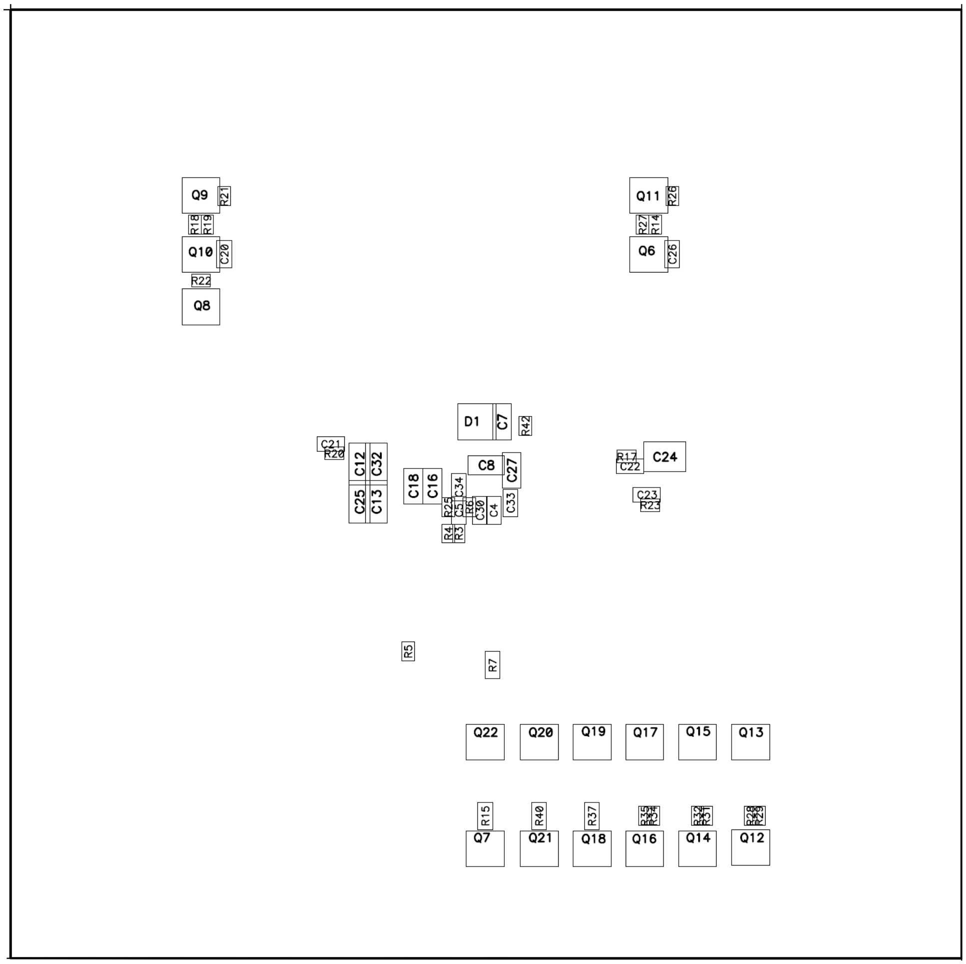


Figure 7. Bottom Assembly

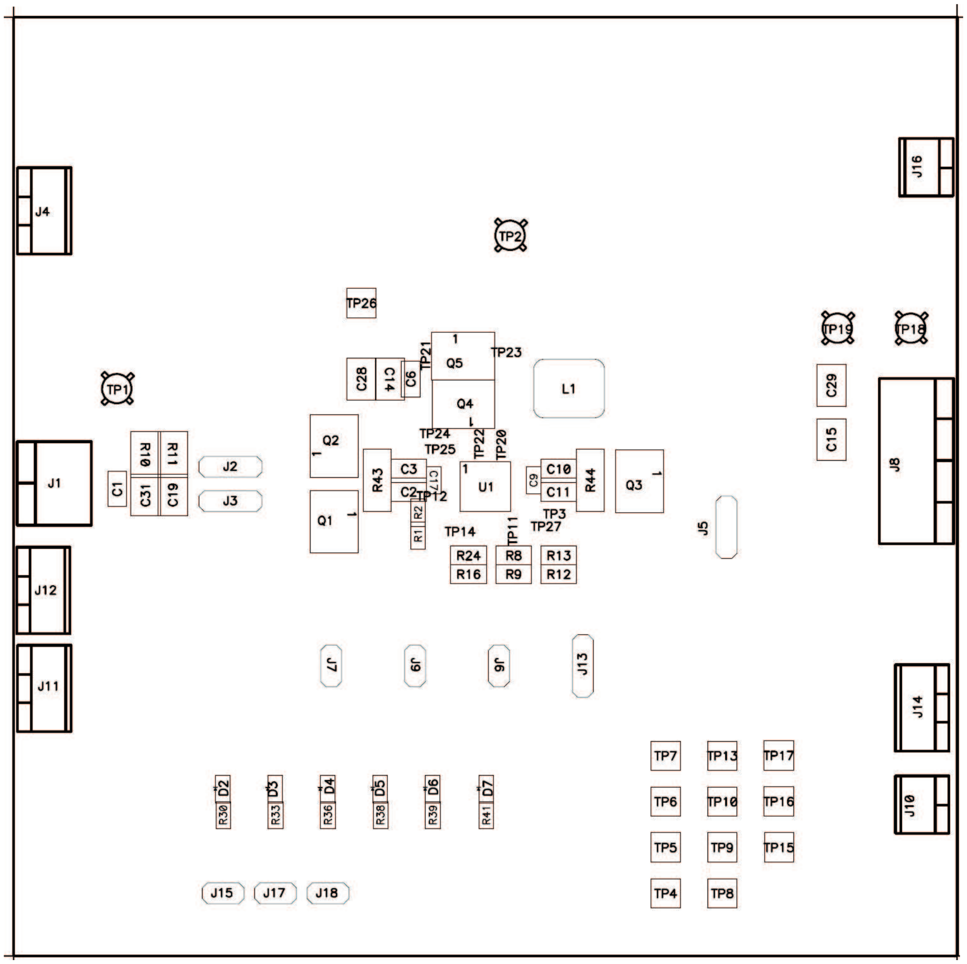


Figure 8. Top Assembly

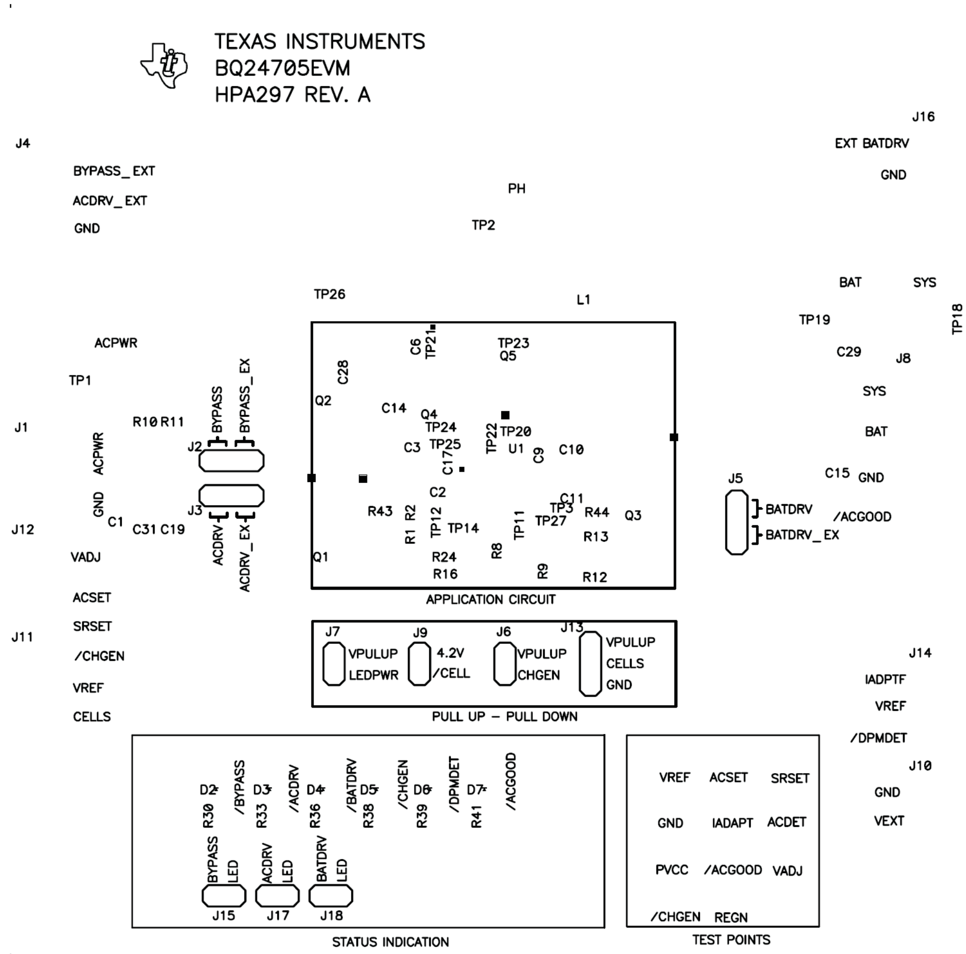
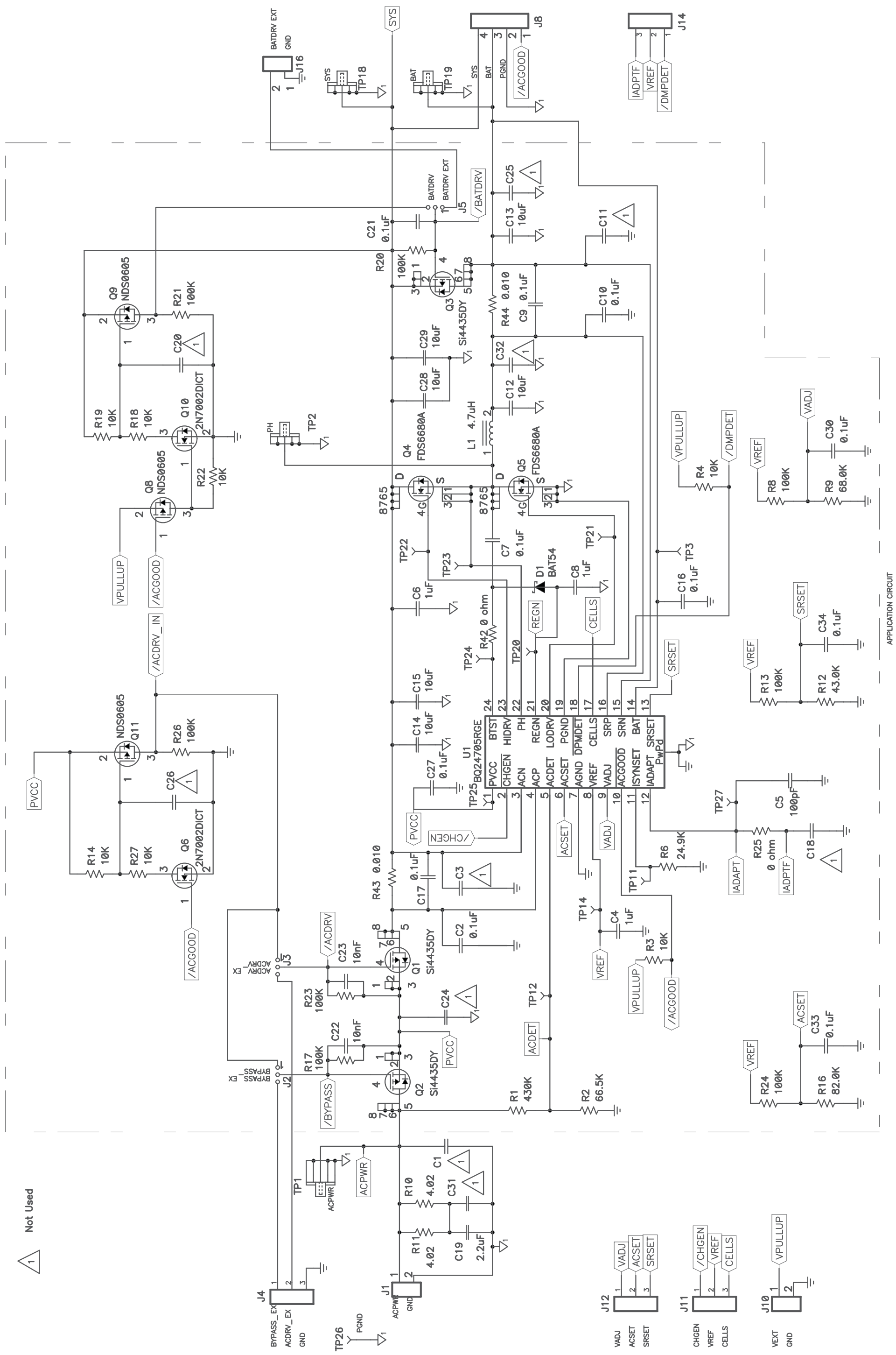
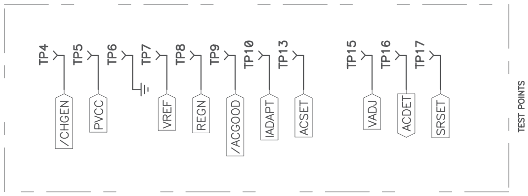


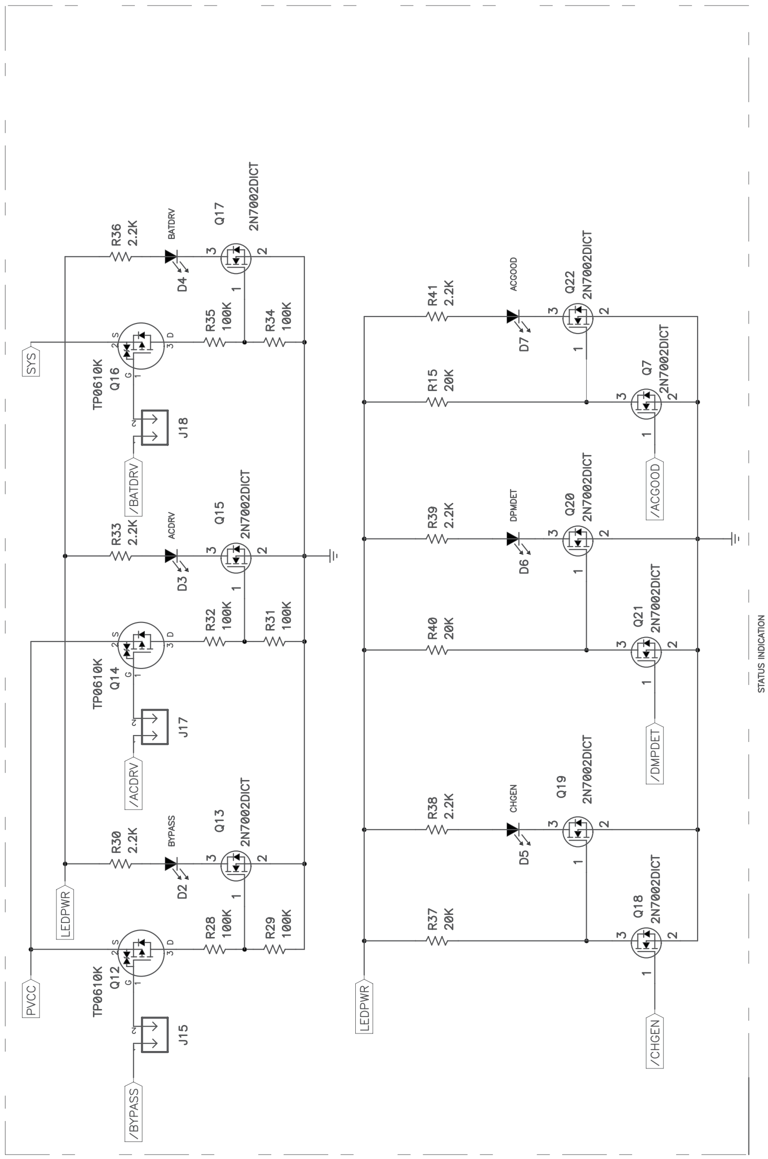
Figure 9. Top Silkscreen

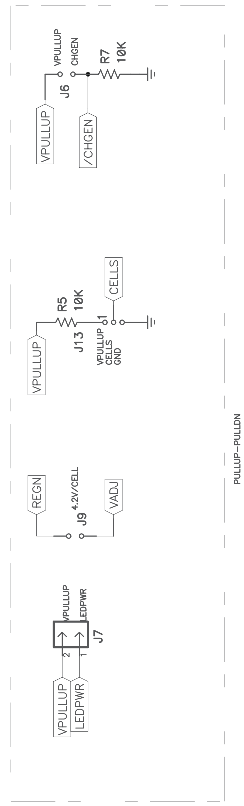
4.3 Schematics

The schematics are affixed to this page.




TEST POINTS
TP4
TP5
TP6
TP7
TP8
TP9
TP10
TP13
TP15
TP16
TP17
/CHGEN
PVCC
VREF
REGN
/ACGOOD
IADAPT
ACSET
VADJ
ACDET
SRSET


STATUS INDICATION
TP0610K
Q12
Q14
Q16
J15
J17
J18
/BYPASS
/ACDRV
/BATDRV
PVCC
SYS
LEDPWR
R28 100K
R29 100K
R30 2.2K
R31 100K
R32 100K
R33 2.2K
R34 100K
R35 100K
R36 2.2K
D2 BYPASS
D3 ACDRV
D4 BATDRV
Q13 2N7002DICT
Q15 2N7002DICT
Q17 2N7002DICT
R37 20K
R38 2.2K
R40 20K
R39 2.2K
R15 20K
R41 2.2K
D5 CHGEN
D6 DPMDET
D7 ACGOOD
Q18 2N7002DICT
Q19 2N7002DICT
Q21 2N7002DICT
Q20 2N7002DICT
Q7 2N7002DICT
Q22 2N7002DICT
/CHGEN
/DMPDET
/ACGOOD


PULLUP–PULLDN
VPULLUP
/CHGEN
J6
R7 10K
VPULLUP
R5 10K
J13
CELLS
REGN
J9
4.2V/CELL
VADJ
J7
VPULLUP
LEDPWR

EVALUATION BOARD/KIT IMPORTANT NOTICE

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EVM WARNINGS AND RESTRICTIONS

It is important to operate this EVM within the input voltage range of 18 V to 22 V and the output voltage range of 0 V to 18 V.

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 125°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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