ACT2802 Demo Board Application Report

Rev 2.0, 05-Aug-2014

Dedicated 5V/2.1A Power Bank Solution

FEATURES

- **5V/3.0A input current limit**
- **2.0A battery charge current**
- **5V/2.1A boost output current**
- **2.5A boost output constant current limit**
- **5.0V+/- 100mV output voltage**
- **Programmable 4.1V to 4.35V battery voltage**
- **Single chip integration solution with minimal component count**
- **Prioritized power path from input to output**
- **92% charge efficiency and 95% efficiency for boost**
- **Accommodation for 10mA-2400mA input source**
- **Battery disconnected at output short to ground**
- **550kHz switching frequencies allowing 2.2µH inductor**
- **<10uA battery drain current in HZ mode**
- **Boost shuts down at no load and turns on by push button**
- **4 LEDs indicating battery level and charge status with impedance compensation**
- **Preconditioning, fast charge, top off and end of charge in battery charge mode**
- **Battery temperature monitoring and thermal protection**
- **Low battery level alarm**
- **4.6V battery over voltage protection**
- **Charge current foldback at 110℃ die temperature**
- **IC over temperature protection**
- **TQFN4x4-24 package**

SPECIFICATION

Input voltage	Boost output voltage	Input current limit	Battery charge current	Boost output current limit
4.7 - 5.5V	5.0V	3.0A	2.0A	2.5A

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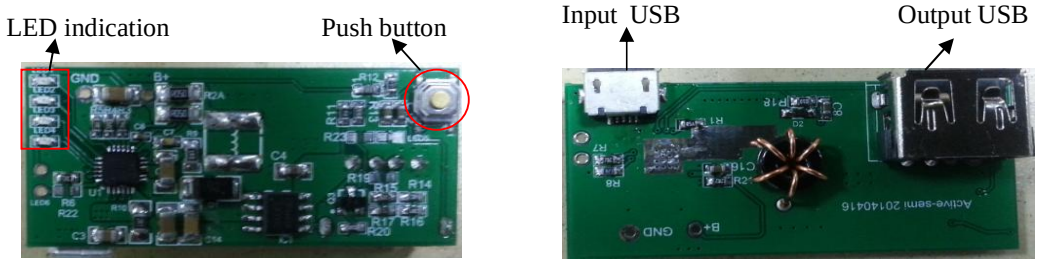
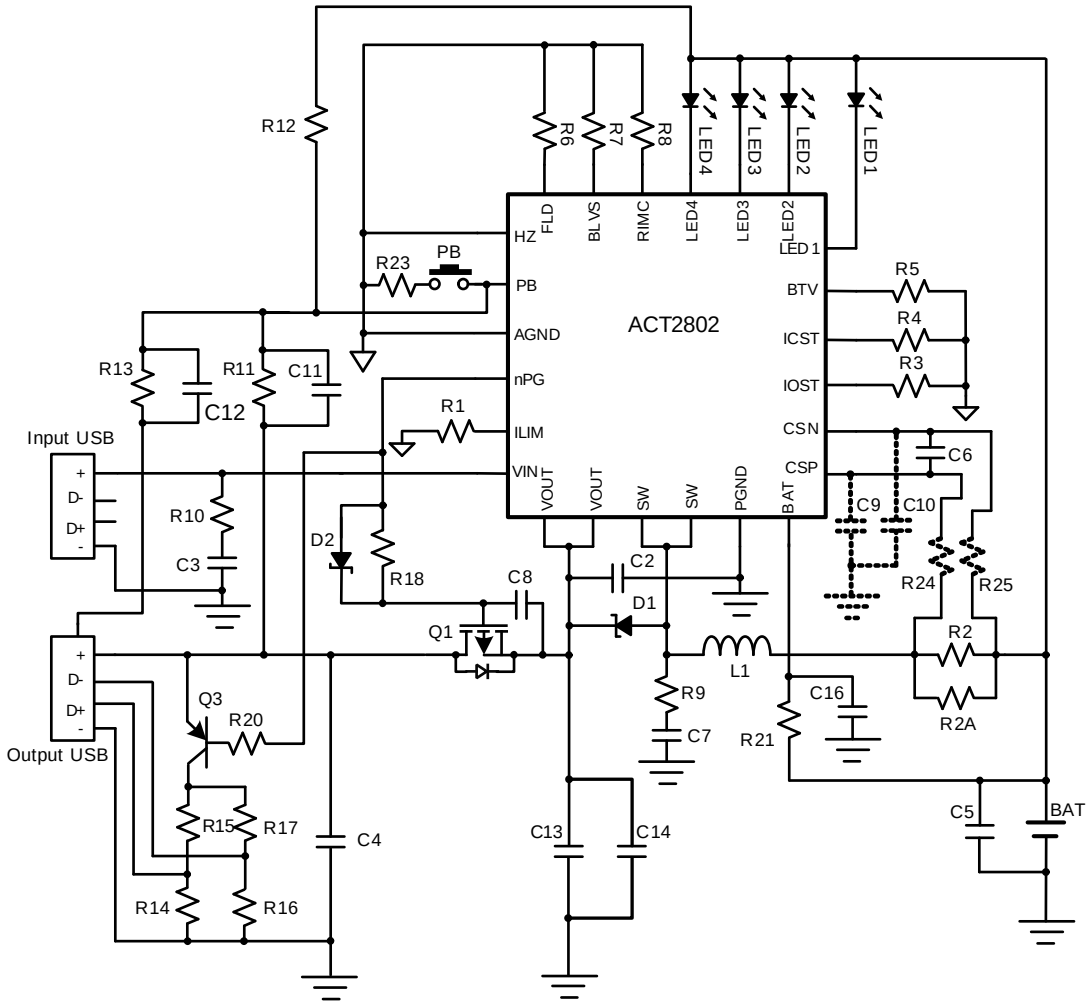
1 DEMO BOARD PHOTOS

(DEMO BOARD SIZE: 46.5mm*23mm)



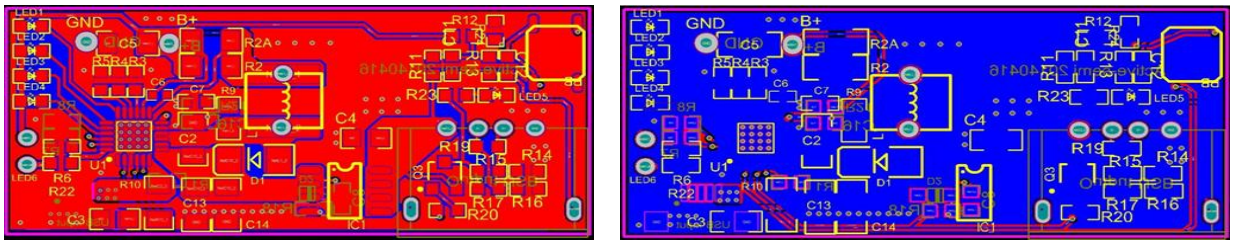
2 SCHEMATICS



3 BILL OF MATERIALS

Item	Reference	Description	QTY	Manufacturer
1	L1	Core 6.5*3*3 Dip 2.2uH 6A	1	Sunlord
2	Q1	AO4503, Rdson=19mΩ at VGS = - 4.5 V	1	Vishay
3	Q3	MMBT3906	1	Vishay
4	D1	SBR3U20SA, 20V/3A Schottky	1	Diodes
5	D2	1N4148, Vf=0.7V, 75V Schottky	1	Vishay
6	C2,C5,C13,C14	Ceramic capacitor, 22uF/10V, X7R, 1206	4	Murata/TDK
7	C3	Ceramic capacitor, 4.7uF/10V, X7R, 1206	1	Murata/TDK
8	C4	Ceramic capacitor, 0.1uF/10V, X7R, 0603	1	Murata/TDK
9	C6	Ceramic capacitor, 10nF/10V, X7R, 0603	1	Murata/TDK
10	C7	Ceramic capacitor, 4.7nF/10V, X7R, 0603	1	Murata/TDK
11	C8,C11,C12	Ceramic capacitor, 2.2uF/10V, X7R, 0603	3	Murata/TDK
12	C9,C10	Ceramic capacitor, 39pF/10V, X7R, 0603, Optional	2	Murata/TDK
13	C16	Ceramic capacitor, 4.7uF/10V, X7R, 0603	1	Murata/TDK
14	R1	Chip Resistor, 750Ω, 1/10W, 1%, 0603	1	Murata/TDK
15	R2,R2A	Chip Resistor, 50mΩ, 1/4W, 1%, 1206	2	Murata/TDK
16	R3	Chip Resistor, 93.1kΩ, 1/10W, 1%, 0603	1	Murata/TDK
17	R4,R15	Chip Resistor, 43.2kΩ, 1/10W, 1%, 0603	2	Murata/TDK
18	R5	Chip Resistor, 25kΩ, 1/10W, 1%, 0603	1	Murata/TDK
19	R6	Chip Resistor, 10kΩ, 1/10W, 5%, 0603	1	Murata/TDK
20	R7	Chip Resistor, 60kΩ, 1/10W, 1%, 0603	1	Murata/TDK
21	R8	Chip Resistor, 80kΩ, 1/10W, 1%, 0603	1	Murata/TDK
22	R9	Chip Resistor, 0.47Ω, 1/8W, 5%, 0805	1	Murata/TDK
23	R10	Chip Resistor, 2.7Ω, 1/4W, 5%, 1206	1	Murata/TDK
24	R11	Chip Resistor, 200kΩ, 1/10W, 5%, 0603	1	Murata/TDK
25	R12,R13	Chip Resistor, 715kΩ, 1/10W, 5%, 0603	2	Murata/TDK
26	R14,R16	Chip Resistor, 49.9kΩ, 1/10W, 5%, 0603	2	Murata/TDK
27	R17	Chip Resistor, 75kΩ, 1/10W, 1%, 0603	1	Murata/TDK
28	R18,R20	Chip Resistor, 100kΩ, 1/10W, 5%, 0603	2	Murata/TDK
29	R21	Chip Resistor, 2.2Ω, 1/10W, 5%, 0603	1	Murata/TDK
30	R23	Chip Resistor, 100Ω, 1/10W, 5%, 0603	1	Murata/TDK
31	R24,R25	Chip Resistor, 22Ω, 1/10W, 5%, 0603, Optional	2	Murata/TDK
32	LED1,LED2, LED3,LED4	LED, 0603, Blue	4	LED Manu
33	PB	Push Button Switch	1	Nikkai Omron
34	USB	10.2*14.6*7mm, 4P	1	
35	Micro-USB	MICRO USB 5P/F SMTB	1	
36	U1	IC, ACT2802, T-QFN 44-24	1	ACT

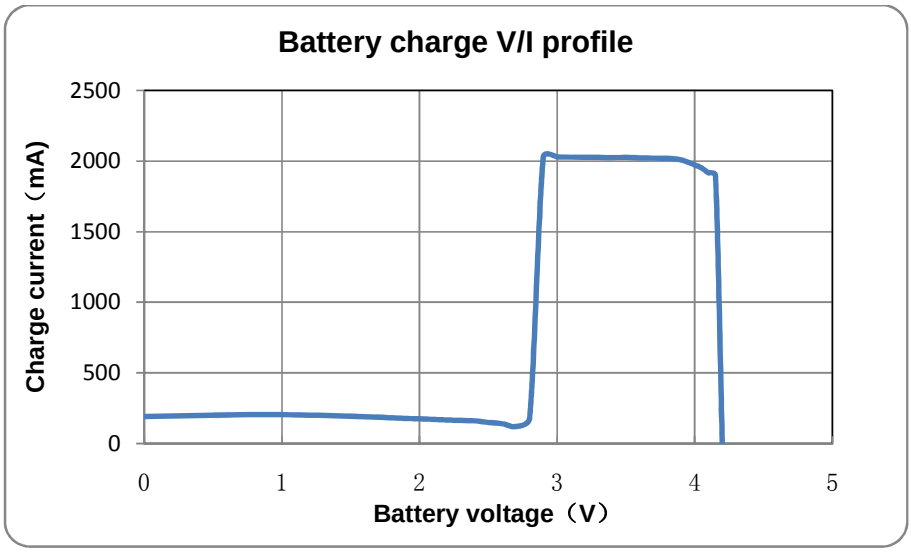
4 PCB LAYOUT



*C3 should be placed close to VIN and PGND; C2 must be placed across VOUT and PGND pins

5 FUNCTIONAL TEST

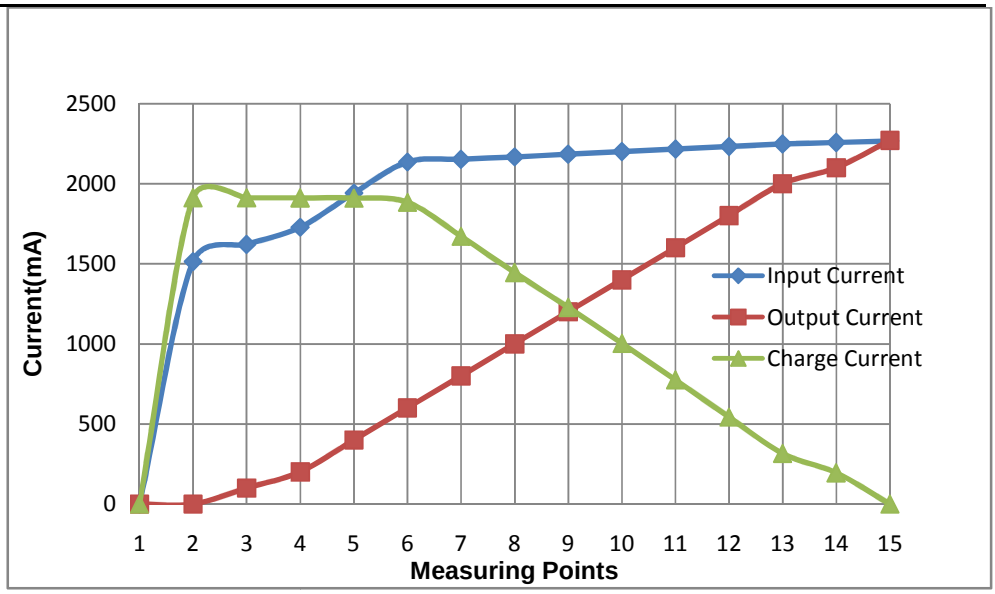
5.1 Battery Charge V/I Profile



5.2 Power Path Function

Input current(mA)	1513	1620	1728	1942	2135	2152	2167	2184	2200	2216	2232	2247	2256	2267
Output current(mA)	0	100	200	400	600	800	1000	1200	1400	1600	1800	2000	2100	2270
Charge current(mA)	1912	1912	1911	1910	1884	1671	1445	1227	1002	775	543	316	194	0

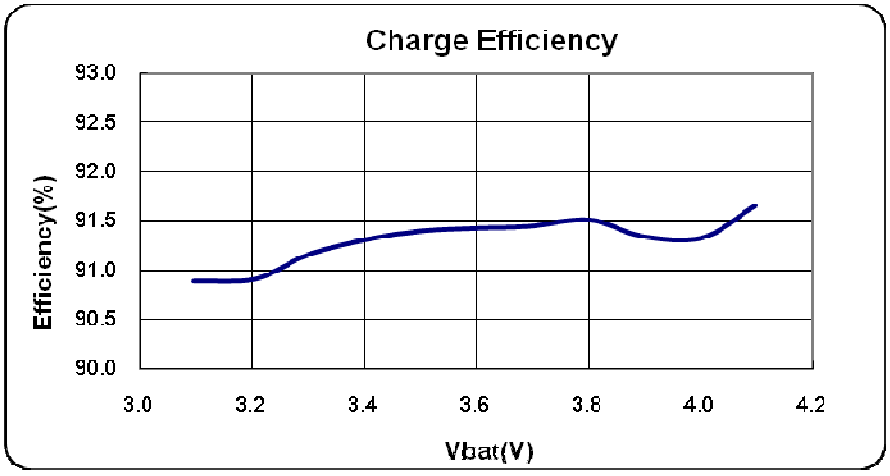
(Test condition: Vin=5V, Vbat=3.7V, input current limit=2.5A, fast charge current=2.0A)



5.3 Charge Efficiency

(Vin=5V and charge current set at 2000mA)

Battery voltage (V)	3.0	3.2	3.7	4.1
Efficiency (%)	90.65	90.91	91.44	91.65



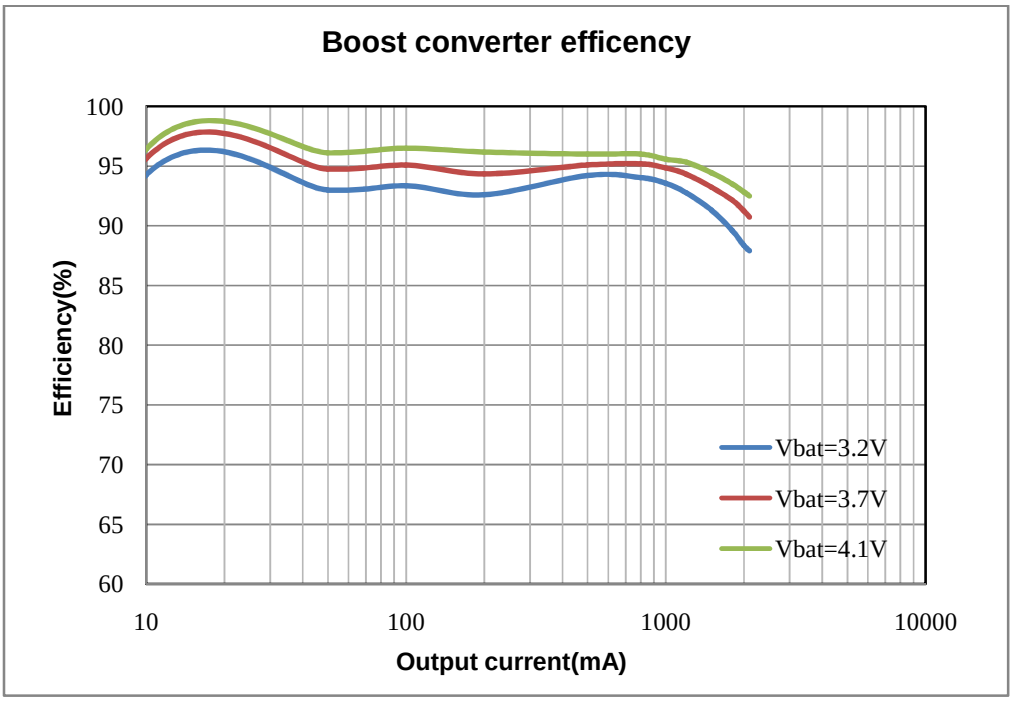
5.4 Boost Output Regulation

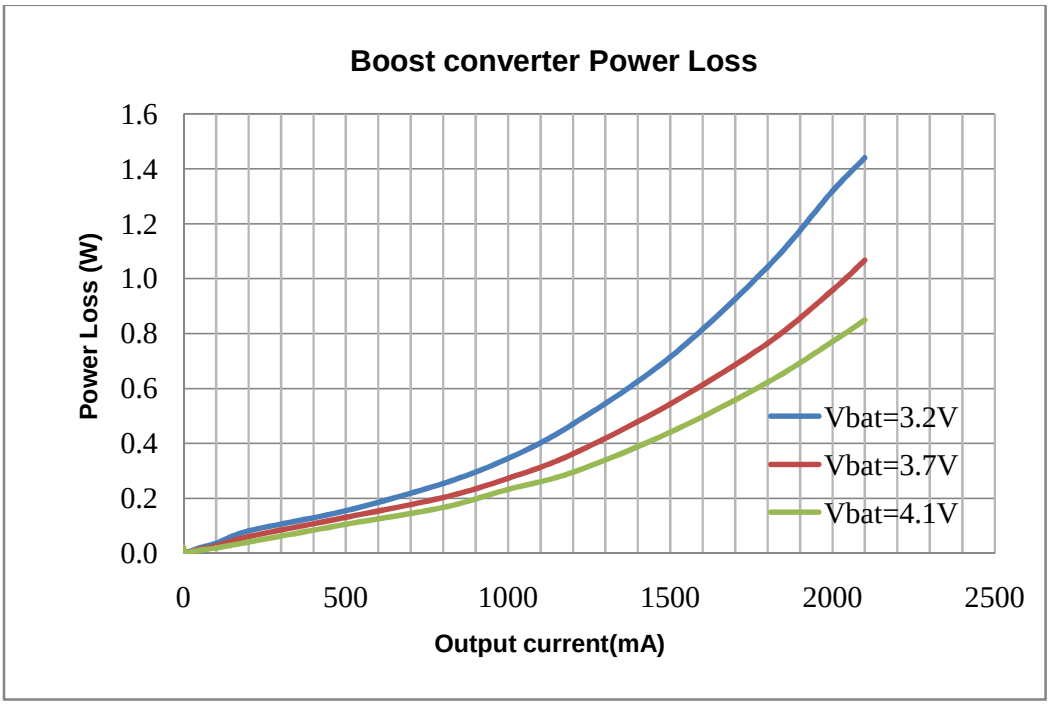
Battery Voltage (V)	Output Voltage at 2.1A Output (V)	Output Voltage at No Load (V)	Load Regulation (%)
3.2	4.98	5.02	0.80
3.7	4.98	5.02	0.80
4.1	4.98	5.02	0.80

5.5 Boost Efficiency and Power Loss (Ta=25℃)

Vbat	Efficiency (%)				
	Io=100mA	Io=500mA	Io=1000mA	Io=1500mA	Io=2100mA
3.2V	93.35	94.22	93.55	91.31	87.91
3.7V	95.09	95.09	94.84	93.23	90.75
4.1V	96.50	96.00	95.57	94.45	92.50

(Note: bigger inductor size can improve efficiency further)





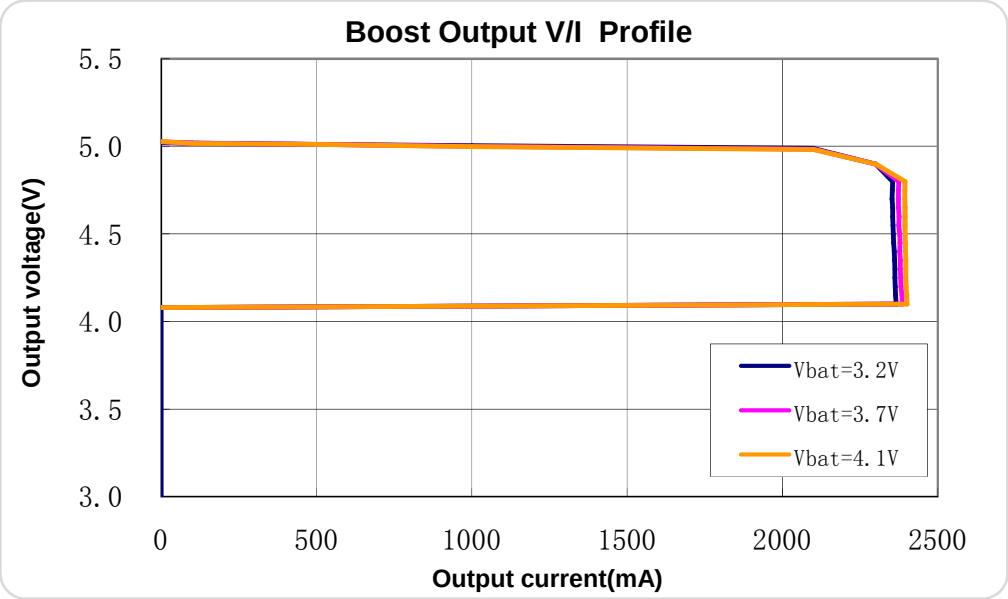
5.6 Boost Standby Power (Ta=25℃)

Battery Voltage(V)	3.2	3.7	4.1
Boost Standby Current(mA)	0.54	0.52	0.52
Boost Standby Power(mW)	1.73	1.92	2.18

5.7 Boost Constant Current and Constant Voltage Regulation (Ta=25℃)

	Vbat=3.2V		Vbat=3.7V		Vbat=4.1V	
	Vout(V)	Iout(mA)	Vout (V)	Iout(mA)	Vout(V)	Iout(mA)
CC Load	5.024	0	5.027	0	5.029	0
	5.011	500	5.011	500	5.011	500
	5.004	1000	5.001	1000	5.000	1000
	4.989	2100	4.984	2100	4.982	2100
CV Load	4.8	2355	4.8	2374	4.8	2394
	4.75	2354	4.75	2373	4.75	2393
	4.7	2353	4.7	2373	4.7	2393
	4.65	2355	4.65	2373	4.65	2394
	4.6	2355	4.6	2375	4.6	2394
	4.55	2356	4.55	2374	4.55	2394

	4.5	2357	4.5	2377	4.5	2395
	4.45	2358	4.45	2378	4.45	2396
	4.4	2360	4.4	2377	4.4	2396
	4.35	2361	4.35	2380	4.35	2397
	4.3	2362	4.3	2380	4.3	2397
	4.25	2362	4.25	2381	4.25	2397
	4.2	2363	4.2	2382	4.2	2398
	4.15	2364	4.15	2385	4.15	2400
	4.08	0	4.08	0	4.08	0



5.8 Battery Leakage Current in HZ Mode

Test Conditions	Battery Input Current (μA)	Power Loss (μW)
Vbat=2.8V	5.1	14.3
Vbat=3.2V	5.8	18.6
Vbat=3.7V	6.4	23.7
Vbat=4.2V	7.2	30.2

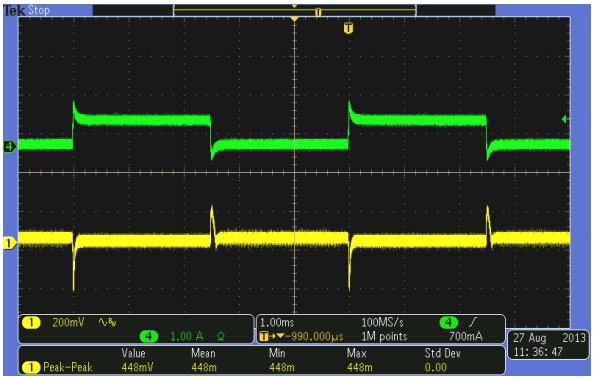
5.9 Ripple and Noise

(Ripple & noise are measured by using 20MHz bandwidth limited oscilloscope)

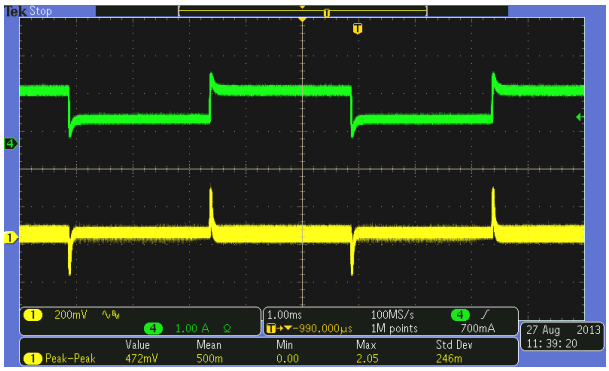
Test Conditions	Output Ripple at 1A Load (mV)	Output Ripple at 2.1A Load (mV)
Vbat=3.2V	20	64.8
Vbat=3.7V	16.8	49.6
Vbat=4.1V	15.2	39.2

5.10 Load Dynamic Response Load Step (Vbat=3.7V)

80mA-1000mA-80mA load step



1000mA-2100mA-1000mA load step

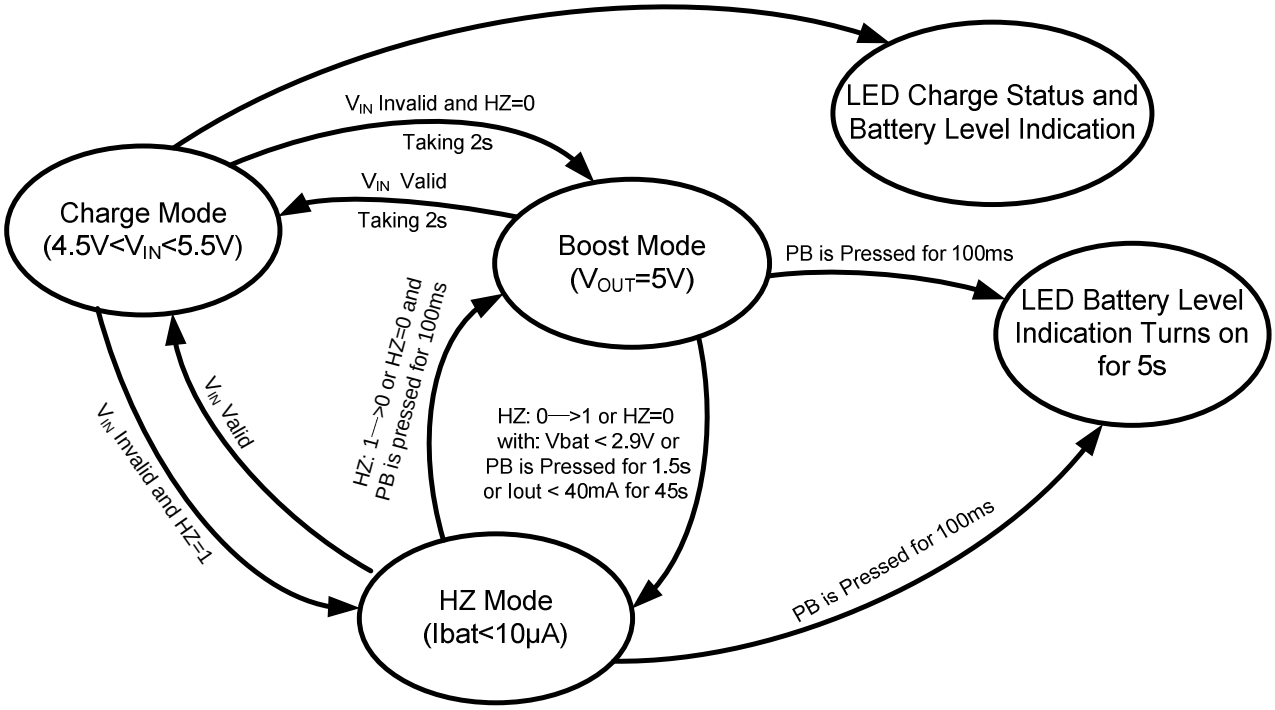


5.11 LED Indication

	Charge Mode				Boost or HZ Mode PB time>100ms			
LED	LED1	LED2	LED3	LED4	LED1	LED2	LED3	LED4
VBAT<2.9V	Flash	Off	Off	Off	Off	Off	Off	Off
2.9V≤VBAT<LED1	Flash	Off	Off	Off	Flash	Off	Off	Off
LED1≤VBAT<LED2	On	Flash	Off	Off	On	Off	Off	Off
LED2≤VBAT<LED3	On	On	Flash	Off	On	On	Off	Off
LED3≤VBAT<LED4	On	On	On	Flash	On	On	On	Off
VBAT≥LED4	On	On	On	Flash	On	On	On	On
VBAT≥LED4 (End of Charge)	On	On	On	On	On	On	On	On

5.12 System Management

ACT2802 System Operation Flow Chart



5.13 Key Components Temperature Test (Ta=40℃, burning for 2 hours)

Charge mode, 2.0A charge current

Vin(V)	IC(℃)	Inductor(℃)	PCB(℃)	Vbat(V)
5.0	68	60.2	52	3.2
5.0	69	62.1	54	3.7
5.0	68.2	61.6	53.7	4.1

Boost mode, 2.1A output current

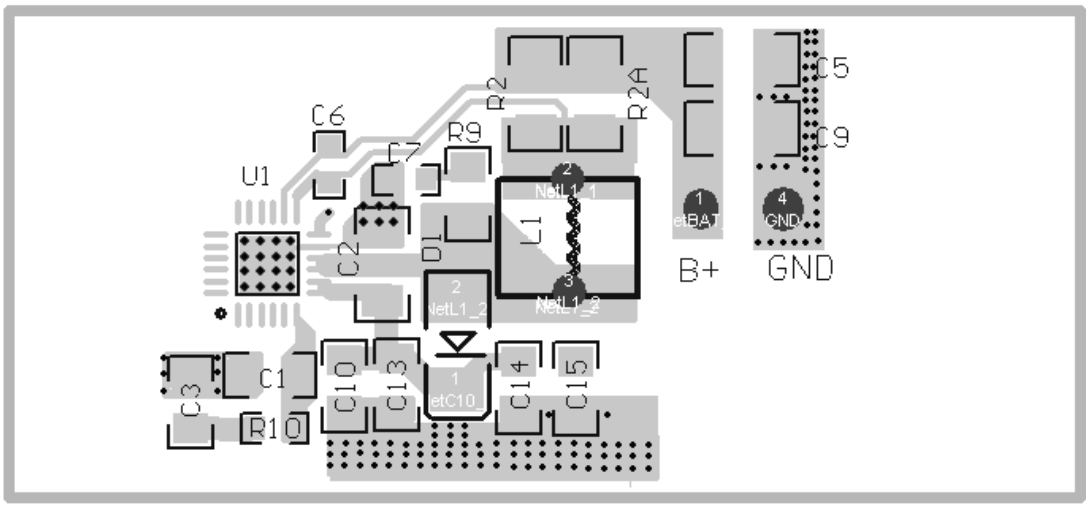
Vbat(V)	IC(℃)	Inductor(℃)	PCB(℃)	Vout(V)
3.2	87.5	86.5	78.2	5.0
3.7	74.2	76.8	68.6	5.0
4.1	65.3	68.6	62.4	5.0

6 PCB LAYOUT GUIDANCE

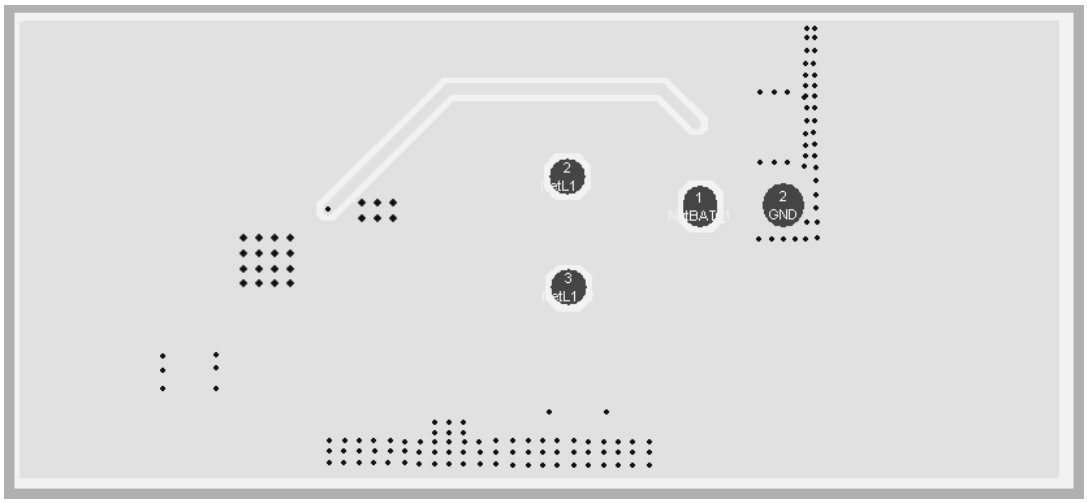
The following guideline is base on the schematic in Section 2.

1) Arrange the power components to reduce the AC loop size that consists of C2, VOUT, SW and PGND. C2 (1206 size) must be placed close to the IC and across the VOUT and PGND traces and SW trace goes under the C2 as shown in the following layout figure.
2) Use copper plane for PGND for best heat dissipation and noise immunity. AGND and PGND are connected under the IC thermal pad with 4x4 vias matrix.
3) SW copper area should be limited due to EMI consideration.
4) Use Kevin sense from sense resistor R2 and R2A to CSP and CSN pins as shown in the layout figure.
5) A separate trace is from VBAT input to BAT pin for battery voltage sense accuracy.
6) RC snubber is recommended to add across SW to PGND to reduce EMI noise.
7) A 20V/3.0A schottky is added from inductor terminal to VOUT to reduce EMI noise.

Top Layer

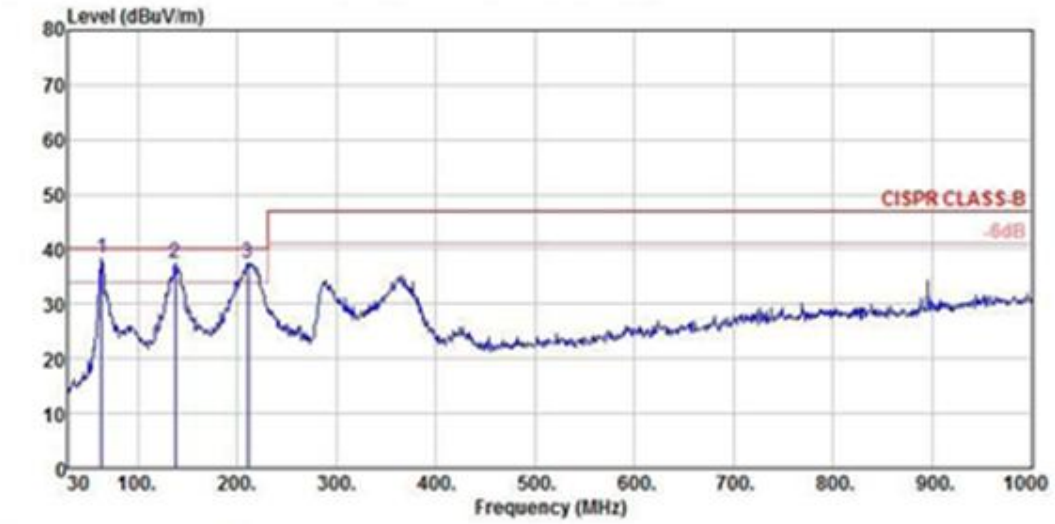


Bottom Layer



7 EMI TEST

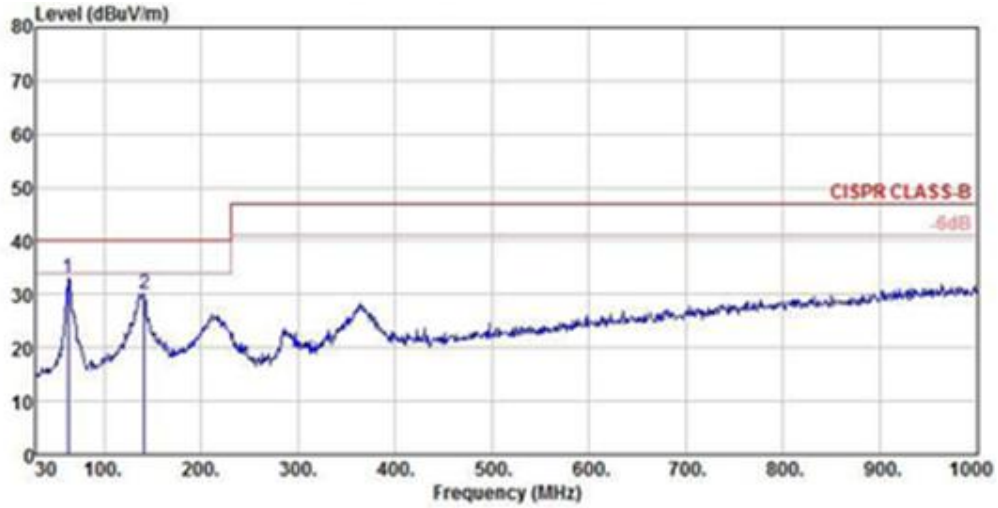
Vbat=4.1V, Output : 5V/2A Horizontal



Site : chamber
Condition : CISPR CLASS-B 3m VULB9160 HORIZONTAL
EUT :
Model Name : ACT2802 5V2A BOOST VBAT=4.1V
Temp/Humi : 24 ℃ /58%
Power Rating: dc
Mode :
Memo :
: #2

	Freq	ReadLevel	Antenna Factor	Cable Loss	Preamp Factor	Level	Limit Line	Over Limit	Remark
	MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB	
1 pp	63.95	24.96	12.34	1.07	0.00	38.37	40.00	-1.63	Peak
2 !	137.67	22.55	13.21	1.62	0.00	37.38	40.00	-2.62	Peak
3 !	210.42	24.86	10.57	1.94	0.00	37.37	40.00	-2.63	Peak

Vbat=4.1V, Output : 5V/2A Vertical



Site : chamber
Condition : CISPR CLASS-B 3m VULB9160 VERTICAL
EUT :
Model Name : ACT2802 5V2A BOOST VBAT=4.1V
Temp/Humi : 24 ℃ /58%
Power Rating: dc
Mode :
Memo :
: #2

	Freq	Read Level	Antenna Factor	Cable Loss	Preamp Factor	Level	Limit Line	Over Limit	Remark
	MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB	
1 pp	62.98	19.62	12.51	1.07	0.00	33.20	40.00	-6.80	Peak
2	141.55	14.97	13.47	1.62	0.00	30.06	40.00	-9.94	Peak