ACT2813 Demo Board Application Report

Rev 0, 12-Mar-2015

Dedicated 5V/2.4A Power Bank Solution

FEATURES

- **2.4A battery charge current**
- **5V/2.4A boost output current**
- **5.0V+/- 100mV output voltage**
- **Single chip integration solution with minimal component count**
- **Prioritized power path from input to output**
- **91% charge efficiency and 94% discharge efficiency**
- **Accommodation for 10mA-3000mA input current**
- **Patent-pending constant output current control**
- **Battery disconnected at output short to ground**
- **<10uA battery drain current in HZ mode**
- **Automatic shut-down at no load and turns on by push button or device plug-in**
- **4 LEDs indicating battery level and charge status with battery impedance compensation**
- **Preconditioning, fast charge, top off and end of charge in battery charge mode**
- **Battery OTP, OVP and OCP**
- **Charge current foldback at 110℃ die temperature**
- **IC over temperature protection**
- **FCQFN4x4-20 package**

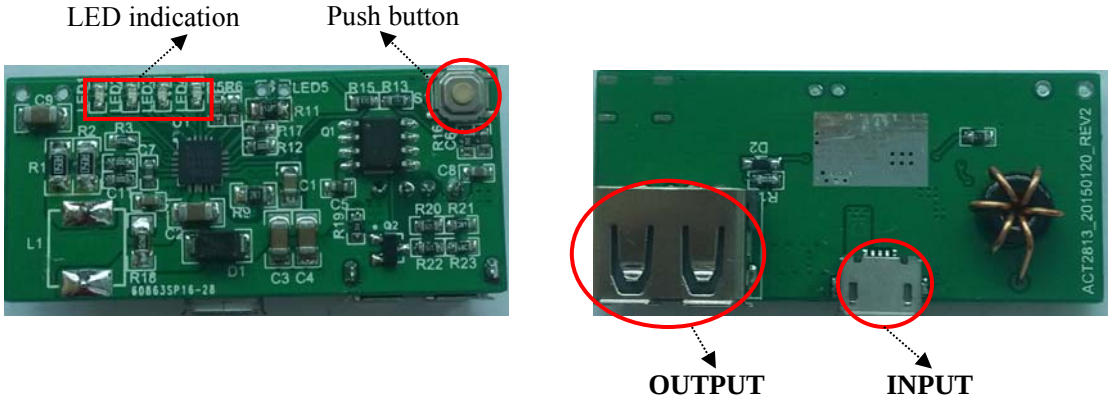
SPECIFICATION

Input voltage	Boost output voltage	Battery charge current	Boost output current
4.7 - 5.5V	5.0V	2.4A	2.4A

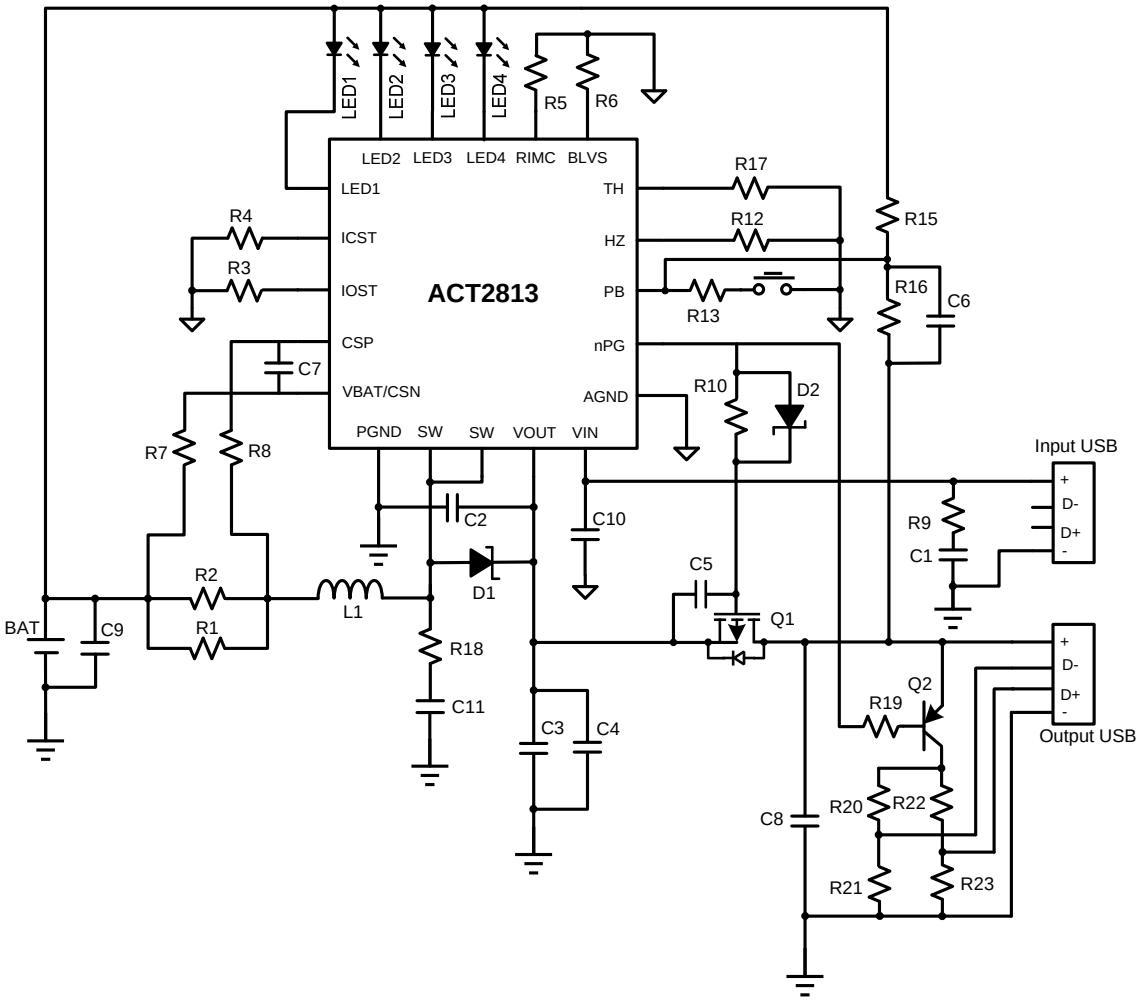
TABLE OF CONTENT

1. Demo Board Photos

(DEMO BOARD SIZE: 46.4mm*21.2mm)



2. Schematics



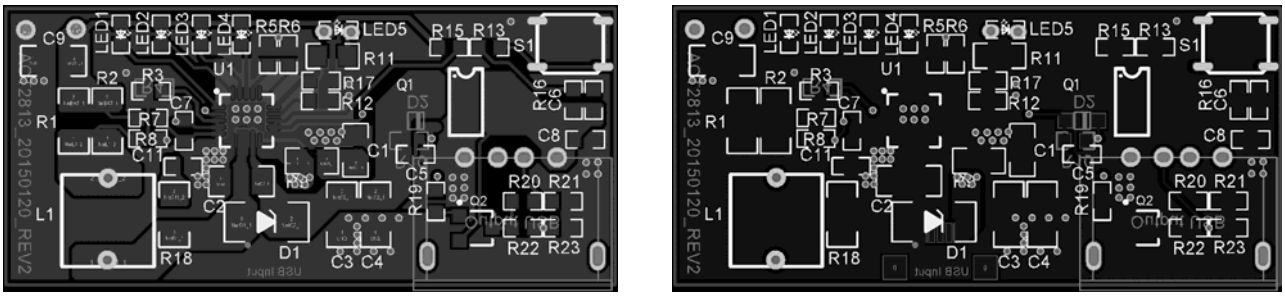
3. Bill of Materials

ITEM	REFERENCE	DESCRIPTION	QTY	MANUFACTURER
1	L1	Core, 6.5*3*3 Dip, 2.2uH, 6A, Rdson=5mΩ	1	Sunlord
2	Q1	AO4453, Rdson=19mΩ at VGS = - 4.5 V	1	AOS
3	Q2	MMBT3906	1	Vishay
4	D1	SBR3U20SA, 20V/3A Schottky	1	Diodes
5	D2	1N4148, Vf=0.7V, 75V Schottky	1	Vishay
6	C1	Ceramic capacitor, 4.7uF/10V, X7R, 0805	1	Murata/TDK
7	C2,C3,C4,C9	Ceramic capacitor, 22uF/10V, X7R, 1206	4	Murata/TDK
8	C5,C6	Ceramic capacitor, 2.2uF/10V, X7R, 0603	2	Murata/TDK
9	C7	Ceramic capacitor, 10nF/10V, X7R, 0603	1	Murata/TDK
10	C8	Ceramic capacitor, 0.1uF/10V, X7R, 0603	1	Murata/TDK
11	C10	Ceramic capacitor, 10uF/10V, X7R, 0805	1	Murata/TDK
12	C11	Ceramic capacitor, 4.7nF/10V, X7R, 0603	1	Murata/TDK
13	R1,R2	Chip Resistor, 50mΩ, 1/4W, 1%, 1206	2	Murata/TDK
14	R3,R10	Chip Resistor, 100kΩ, 1/10W, 1%, 0603	2	Murata/TDK
15	R4	Chip Resistor, 48kΩ, 1/10W, 1%, 0603	1	Murata/TDK
16	R5	Chip Resistor, 68kΩ, 1/10W, 5%, 0603	1	Murata/TDK
17	R6	Chip Resistor, 60.4kΩ, 1/10W, 1%, 0603	1	Murata/TDK
18	R7,R8,R12	Chip Resistor, 0Ω, 1/10W, 1%, 0603	3	Murata/TDK
19	R9	Chip Resistor, 2.7Ω, 1/8W, 1%, 0805	1	Murata/TDK
20	R13	Chip Resistor, 100Ω, 1/10W, 1%, 0603	1	Murata/TDK
21	R15	Chip Resistor, 715kΩ, 1/10W, 5%, 0603	1	Murata/TDK
22	R16,R19	Chip Resistor, 200kΩ, 1/10W, 5%, 0603	2	Murata/TDK
23	R17	Chip Resistor, 10kΩ, 1/10W, 5%, 0603	1	Murata/TDK
24	R18	Chip Resistor, 0.47Ω, 1/4W, 1%, 1206	1	Murata/TDK
25	R20,R22	Chip Resistor, 43.2kΩ, 1/10W, 1%, 0603	2	Murata/TDK
26	R21,R23	Chip Resistor, 49.9kΩ, 1/10W, 1%, 0603	2	Murata/TDK
27	LED1,LED2 LED3,LED4	LED, 0603, Blue	4	LED Manu
28	PB	Push Button	1	LED Manu
29	USB	10.2*14.6*7mm, 4P, DIP	1	
30	Micro-USB	MICRO USB 5P/F SMT B	1	
31	U1	IC, ACT2813, FCQFN 4x4-20	1	ACT

4. PCb Layout Guidance

When laying out the printed circuit board, the following checklist should be used to ensure proper operation of the IC.

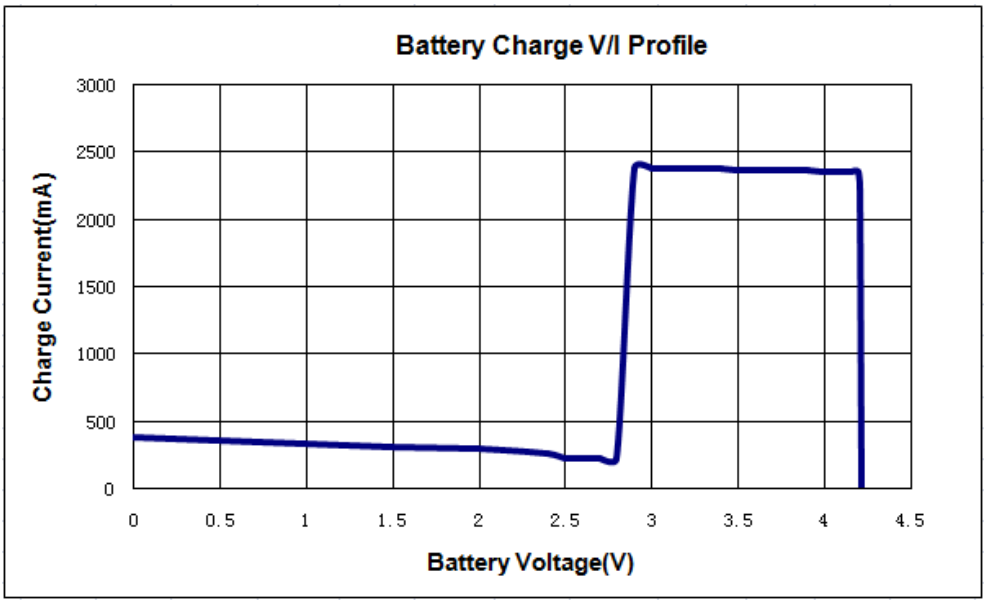
1. Place input decoupling ceramic capacitor C1 and R9 as close to VIN pin as possible. Resistor R9 is added in series with capacitor C1 to damp the potential LC resonance.
2. Use copper plane for power GND for best heat dissipation and noise immunity.
3. Place CSP and CSN capacitor C7 (10nF) close to CSP and CSN pin as possible, use Kevin Sense from sense resistor R1 and R2 to CSP and CSN pins. 22uF decoupling capacitor is added close to VBAT pin.
4. Place the ceramic capacitor C2 and D1 as close to VOUT and PGND as possible, SW goes under the C2 (recommend C2 to use 1206 size). SW pad is a noisy node switching. It should be isolated away from the rest of circuit for good EMI and low noise operation.
5. RC snubber is recommended to add across SW to PGND to reduce EMI noise.



*C2 must be placed close to VOUT and PGND pins

5. Functional Test

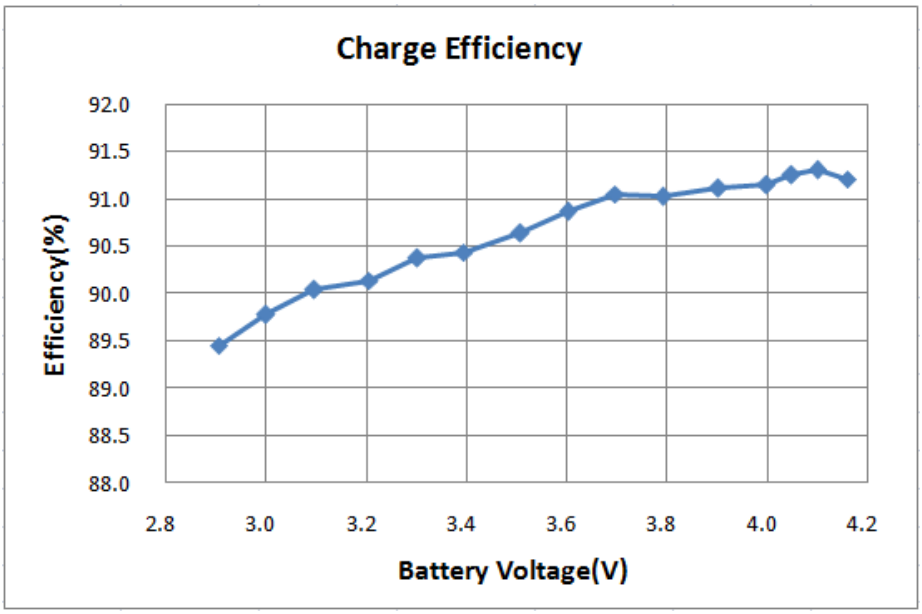
5.1 Battery Charge V/I Profile



5.2 Charge Efficiency

(Vin=5V and charge current set at 2400mA)

Battery voltage (V)	3.0	3.2	3.7	4.1
Efficiency (%)	89.8	90.1	91.1	91.3



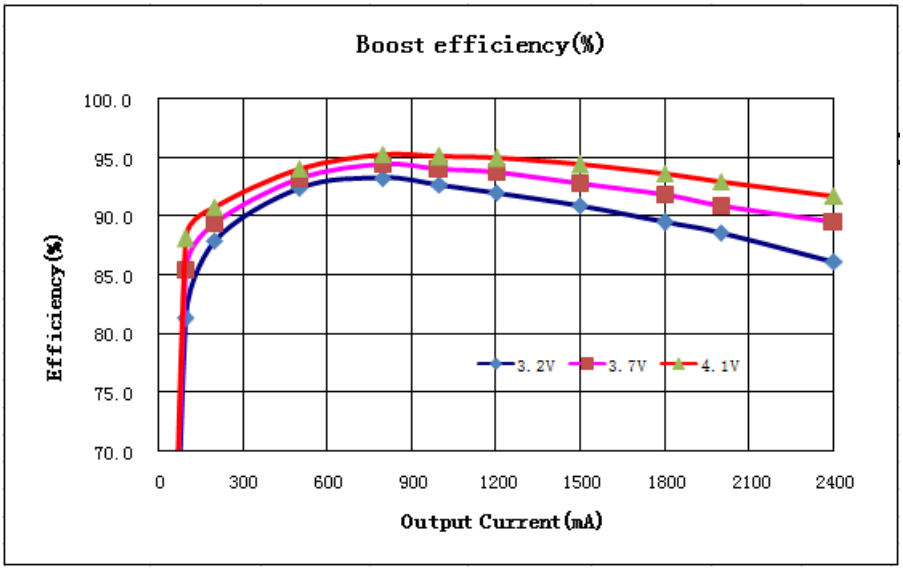
5.3 Boost Output Regulation

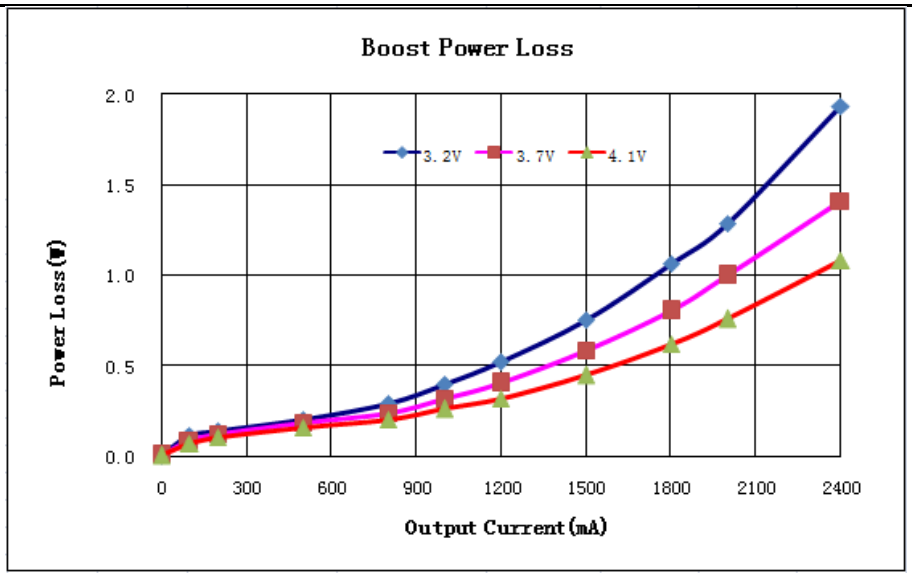
Battery Voltage (V)	Output Voltage at 2.4A Output (V)	Output Voltage at No Load (V)	Load Regulation (%)
3.2	5.01	5.05	0.79
3.7	5.01	5.05	0.79
4.1	5.01	5.05	0.79

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

Vbat	Efficiency (%)				
	Io=500mA	Io=1000mA	Io=1500mA	Io=2000mA	Io=2400mA
3.2V	92.5	92.7	90.9	88.7	86.2
3.7V	93.2	94.0	92.8	91.0	89.5
4.1V	94.0	95.1	94.4	93.0	91.8

(Note: bigger inductor size can improve efficiency further)





5.5 Battery Leakage Current in HZ Mode

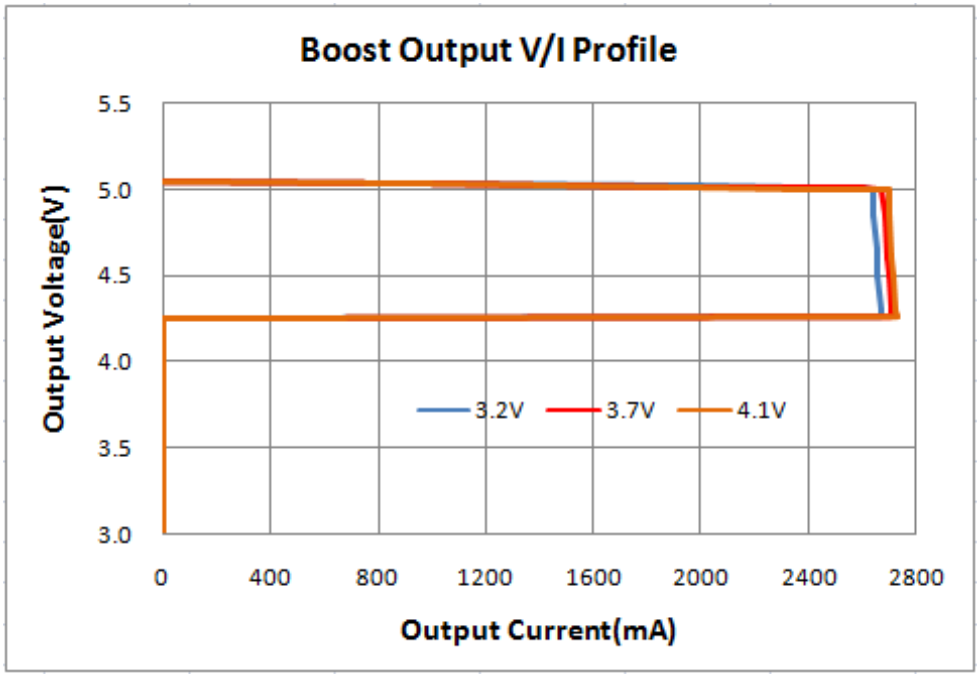
Test Conditions	Battery Leakage (μA)	Power Loss (μW)
Vbat=2.8V	5.3	14.8
Vbat=3.2V	5.8	18.6
Vbat=3.7V	6.6	24.4
Vbat=4.1V	7.4	30.3

5.6 Boost Standby Power (Ta=25℃)

Battery Voltage(V)	3.2	3.7	4.1
Boost Standby Current(mA)	0.86	0.76	0.72
Boost Standby Power(mW)	2.75	2.81	2.95

5.7 Boost Constant Current and Constant Voltage Regulation (Ta=27℃)

	Vbat=3.2V		Vbat=3.7V		Vbat=4.1V	
	Vout(V)	Iout(mA)	Vout (V)	Iout(mA)	Vout(V)	Iout(mA)
CC Load	5.05	0	5.05	0	5.05	0
	5.03	1000	5.03	1000	5.03	1000
	5.02	2000	5.01	2000	5.01	2000
	5.01	2400	5.01	2400	5	2400
	5.01	2600	5.01	2600	5	2600
CV Load	5	2636	5	2670	5	2696
	4.85	2643	4.85	2681	4.85	2696
	4.65	2653	4.6	2694	4.6	2707
	4.5	2658	4.5	2698	4.5	2714
	4.3	2668	4.3	2705	4.3	2720
	4.27	2673	4.27	2708	4.27	2726
	4.25	0	4.25	0	4.25	0



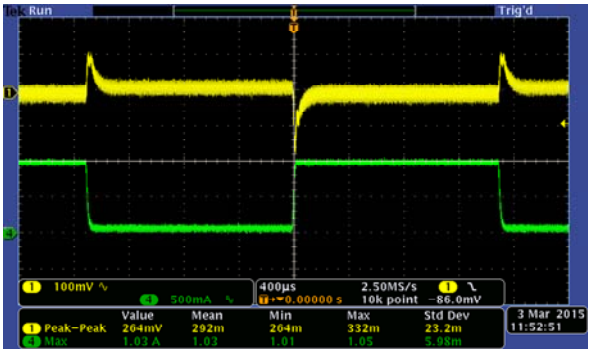
5.8 Ripple and Noise

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

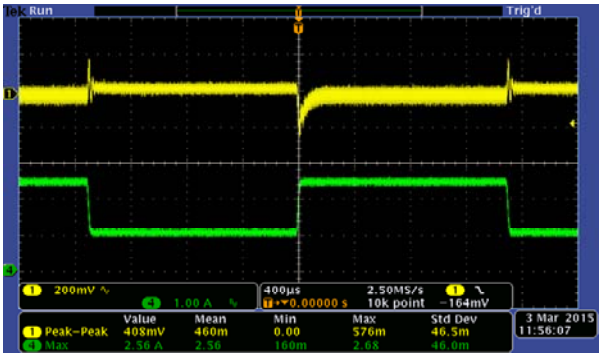
Test Conditions	Output Ripple at 1A Load (mV)	Output Ripple at 2.4A Load (mV)
Vbat=3.2V	32	76
Vbat=3.7V	31	59
Vbat=4.1V	27	54

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

80mA-1000mA-80mA load step

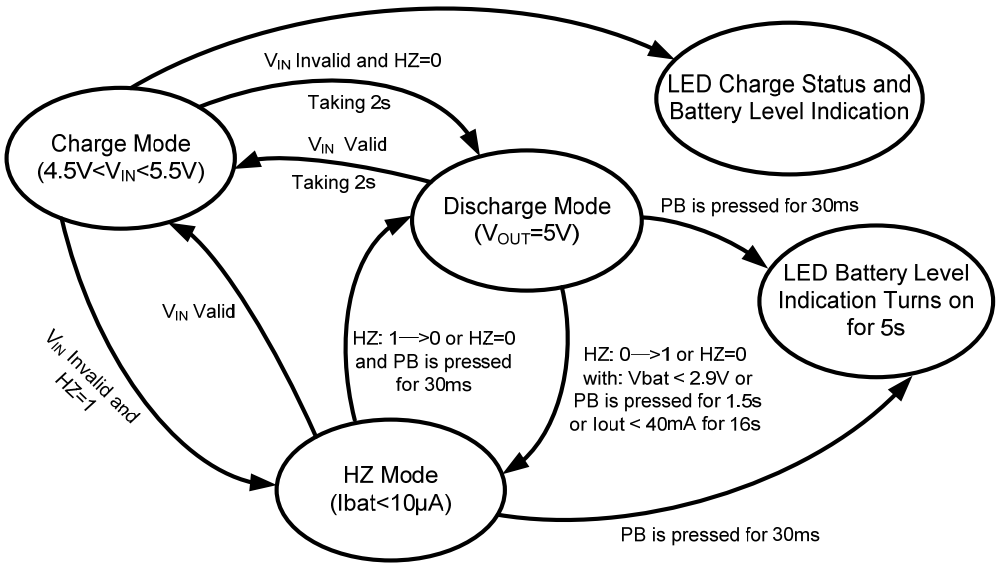


1000mA-2400mA-1000mA load step



5.10 System Management

ACT2813 System Operation Flow Chart



5.11 LED Indication

PB time>30ms (Boost mode or HZ Mode)	LED1	LED2	LED3	LED4
VBAT<2.9V	Off	Off	Off	Off
2.9V≤VBAT<LED1	Flash	Off	Off	Off
LED1≤VBAT<LED2	On	Off	Off	Off
LED2≤VBAT<LED3	On	On	Off	Off
LED3≤VBAT<LED4	On	On	On	Off
VBAT≥LED4	On	On	On	On

Charge Mode	LED1	LED2	LED3	LED4
VBAT<LED1V	Flash	Off	Off	Off
LED1≤VBAT<LED2	On	Flash	Off	Off
LED2≤VBAT<LED3	On	On	Flash	Off
LED3≤VBAT<LED4	On	On	On	Flash
VBAT>LED4 (End of Charge)	On	On	On	On

5.12 Key Components Temperature Test (Ta=27℃, burning for 2 hours)

Charge mode, 2.4A charge current

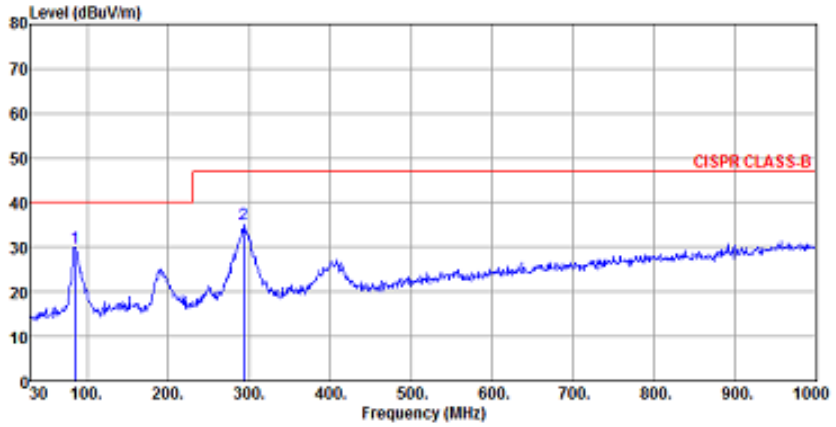
Vbat(V)	IC(℃)	Diode(℃)	Inductor(℃)	PCB(V)
3.2V	56.8	48.6	52.6	49.7
3.7V	59.0	50.1	52.3	51.5
4.1V	63.1	53.2	54.0	54.9

Boost mode, 2.4A output current

Vbat (V)	IC(℃)	Diode(℃)	Inductor(℃)	PCB(℃)
3.2	94.4	80.6	82.0	77.4
3.7	76.6	65.7	67.2	64.2
4.1	68.3	59.9	60.0	58.7

6. EMI TEST

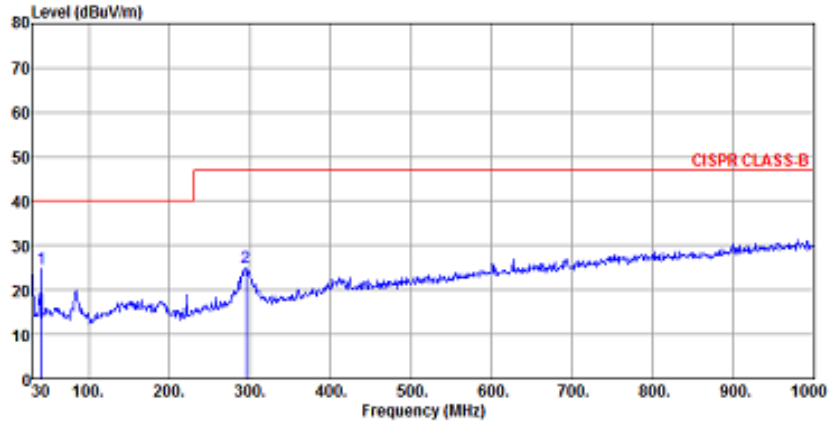
Output: 5V/2.4A Horizontal



Site : chamber
Condition : CISPR CLASS-B 3m VULB9160 HORIZONTAL
EUT :
Model Name : ACT2813 MS-018 #2
Temp/Humi : 23 ℃ / 51 %
Power Rating: BAT=4V
Mode : DISCHARGE 2.4A
Memo : WITH 1N4148

	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	85.29	19.83	8.89	1.09	0.00	29.81	40.00	-10.19	Peak
2	293.84	19.60	13.08	2.37	0.00	35.05	47.00	-11.95	Peak

Output: 5V/2.4A Vertical



Site : chamber
Condition : CISPR CLASS-B 3m VULB9160 VERTICAL
EUT :
Model Name : ACT2813 MS-018 #2
Temp/Humi : 23 ℃ / 51 %
Power Rating: BAT=4V
Mode : DISCHARGE 2.4A
Memo : WITH 1N4148

	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	40.67	11.30	12.71	0.83	0.00	24.84	40.00	-15.16	Peak
2	294.81	9.59	13.11	2.40	0.00	25.10	47.00	-21.90	Peak