EA2801QL-T1028 User's Guide

5V/1.5A Power Bank Solution

Description

This document supports the **EA2801QL-T1028** Evaluation Kit. The kit is a proven application-circuit design for the ACT2801QL-T1028 charger IC with power path and single USB output. The EVK contains a single micro-USB input and USB-A output. It provides a 1A system output. It is configured to charge a battery with 1.0A. The EVK operates with very high charge efficiency of 92% and discharge efficiency of 95% (Vbat=4.1V). The EVK is specifically designed to evaluate the ACT2801QL-T1028. The EVK can also be used to evaluate the ACT2801BQL-T1028 and ACT2801CQL-T1028 ICs. The table below highlights the difference between the three ICs.

PART NUMBER	OUTPUT	FLASHLIGHT /TH	PB TURN OFF BOOST	LEDS ALWAYS ON IN BOOST	BOOST LIGHT LOAD OFF	PACKAGE
ACT2801QL-T1028	5V/1.5A	TH	Yes	No	16s	QFN44-24
ACT2801BQL-T1028	5V/1.5A	Flashlight	No	Yes	16s	QFN44-24
ACT2801CQL-T1028	5V/1.5A	Flashlight	No	No	16s	QFN44-24

Features

The EVK contains a high efficiency Buck and Boost DC/DC converter that operates either in CV (Constant Voltage) mode or CC (Constant Current) mode. The EVK provides up to 5V/1.0A system output at 550kHz switching frequency. It operates from Vin=4.5V to 5.5V to charge a Li-Ion battery. Gerber files are available to minimize time-to-market for applications that want to use the EVK layout.

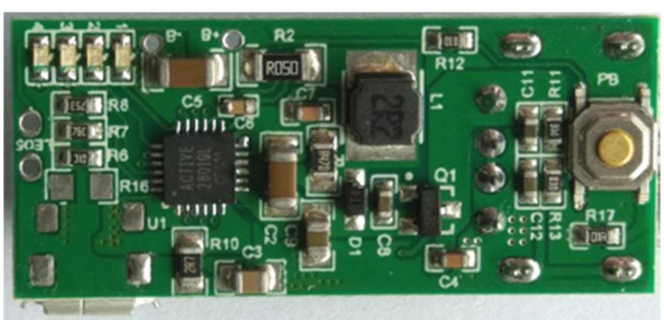


Figure 1 – EVK PCB – Top

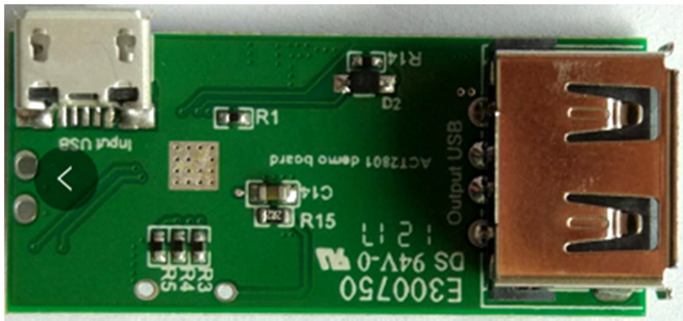


Figure 2 – EVK PCB – Bottom

Setup

Required Equipment

EA2801QL-T1028 EVK

Power supply – 5V @ 2A for full power operation

Oscilloscope – >100MHz

Loads – Electronic/resistive load with 1.5A minimum current capability.

Digital Multimeters (DMM)

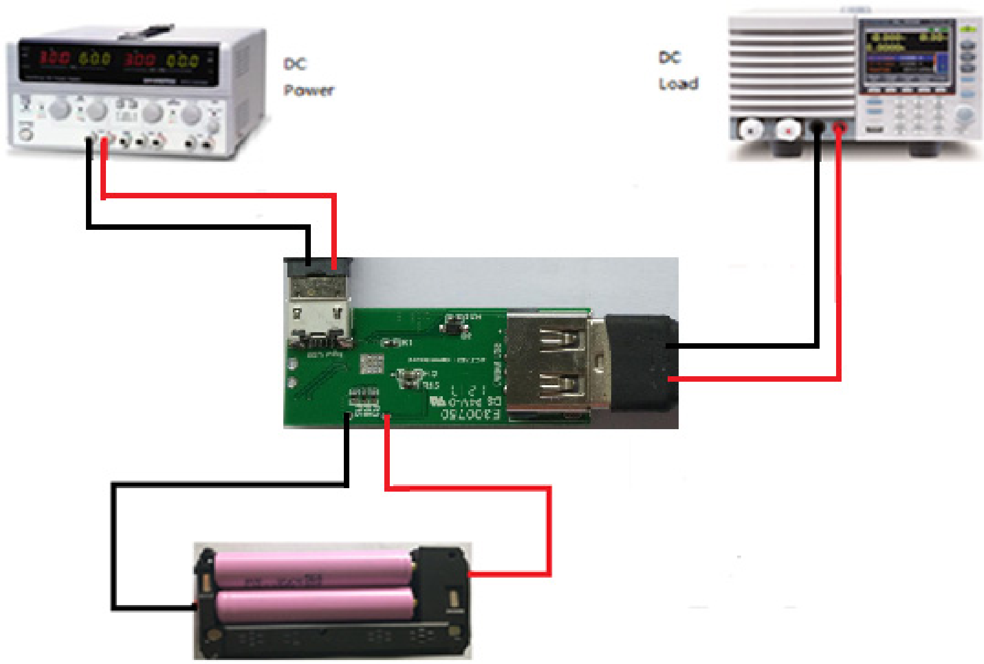


Figure 3 – EVK Setup

Hardware Setup

1. Connect a DC power supply across Vin and GND (Micro USB) on the EVK.
2. Connect the electronic load to the EVK output (Type A USB connector).
3. Connect a single cell Li-Ion battery across B+ and B-. B+ is the positive terminal and B- is the negative terminal.
4. Recommended Operating Conditions.

Table1. Recommended Operating Conditions

Parameter	Description	Min	Typ	Max	Unit
VIN	All buck input voltages	4.5	5	5.5	V
IOUT	Maximum load current		1.5		A

EVK Operation

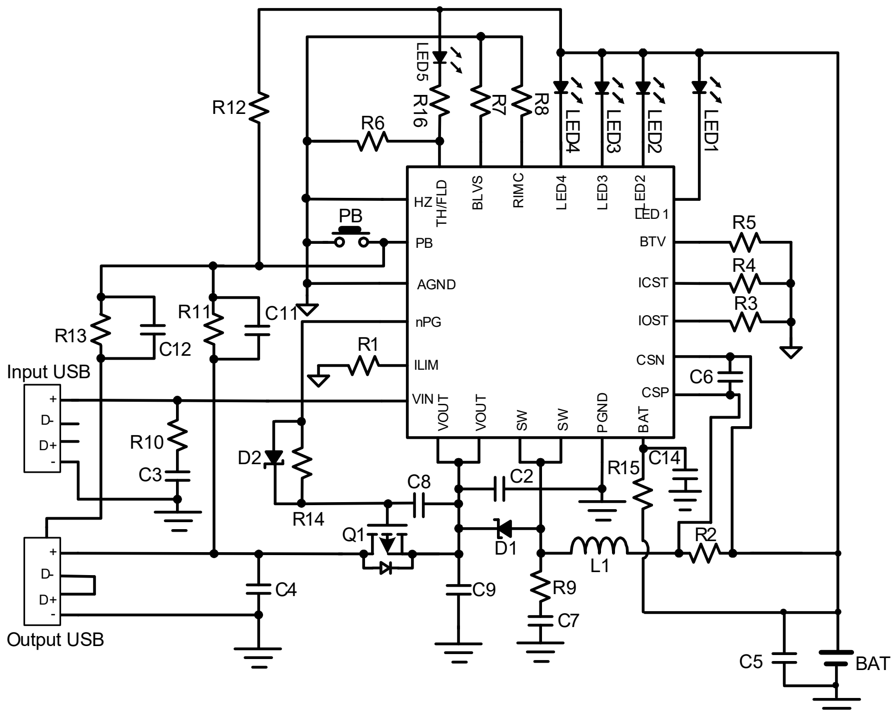
Initial Setup

During the initial setup, the EVK becomes active and goes into Boost mode to supply 5V on the output from the battery. If the load is less than ~45mA for 16s, the EVK turns off and goes into HiZ mode. Pressing the pushbutton moves the EVK back into Boost mode again. If the load is greater than ~45mA, then the EVK stays in Boost mode.

Turn on

When the 5V input supply is turned on, the EVK automatically moves to the Charge mode and starts charging the battery at 1A. It also provides 5V on the EVK output connector. If the EVK is in charge mode and Vin is removed, the EVK transitions back to Boost mode.

Schematic



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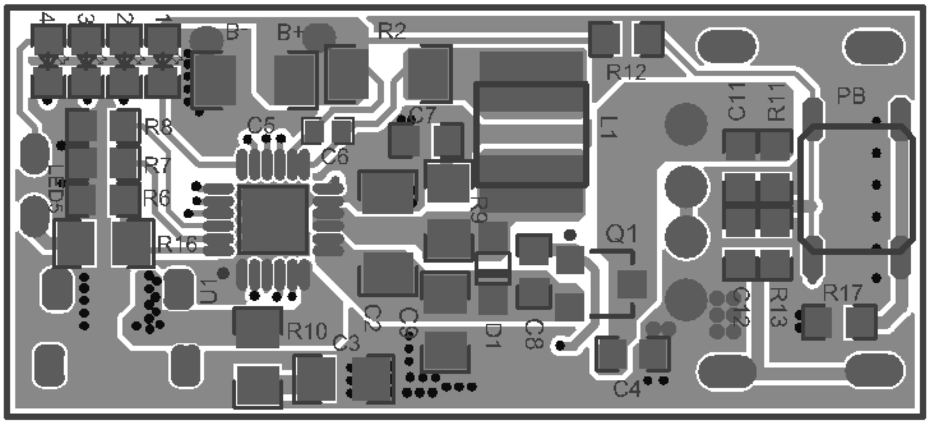
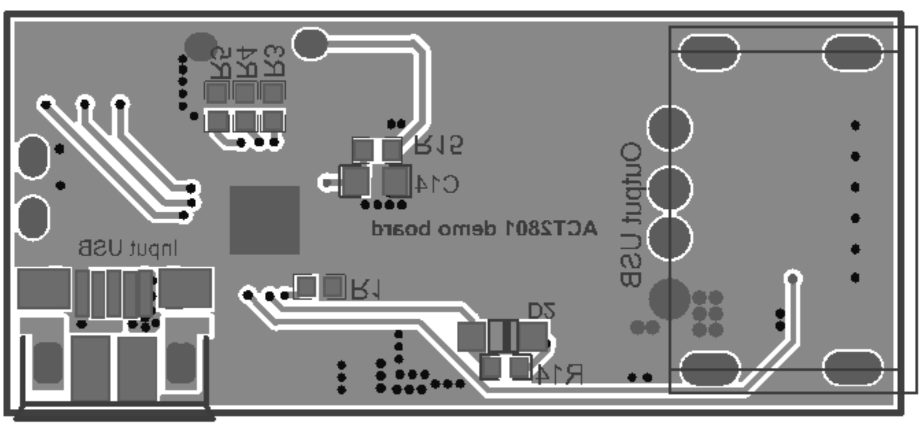
PCB Layout



Top Layer



Bottom Layer

Bill of Materials

Item	Reference	Description	QTY	Manufacturer
1	C2,C5,C9	Ceramic capacitor, 22uF/10V, X7R, 1206	3	Murata/TDK
2	C3	Ceramic capacitor, 4.7uF/10V, X7R, 0805	1	Murata/TDK
3	C4	Ceramic capacitor, 0.1uF/10V, X7R, 0603	1	Murata/TDK
4	C6	Ceramic capacitor, 10nF/10V, X7R, 0402	1	Murata/TDK
5	C7	Ceramic capacitor, 1nF/10V, X7R, 0603	1	Murata/TDK
6	C8	Ceramic capacitor, 1uF/10V, X7R, 0603	1	Murata/TDK
7	C11,C12,C14	Ceramic capacitor, 2.2uF/10V, X7R, 0603	3	Murata/TDK
8	D1	SS12,Vf=0.5V, 20V Schottky	1	Mccsemi
9	D2	IN4148, Vf=0.7V, 75V Schottky	1	Philips
10	L1	SWPA4020S1R0NT2.2uH3.4A (4*4*2mm)	1	Sunlord
11	LED1,LED2,LED3,LED4	LED, 0603, Blue	4	LED Manu
12	LED5	Flashlight (ACT2801BQL-T1028/ACT2801CQL-T1028)	0	LED Manu
13	Micro-USB	MICRO USB 5P/F SMT B	1	
14	PB	Push Button	1	
15	Q1	SSC8013, Rdson=38mΩ at VGS = - 4.5 V	1	SPIRIT
16	R1	Chip Resistor, 1.5kΩ, 1/16W, 1%, 0402	1	Murata/TDK
17	R2	Chip Resistor, 50mΩ, 1/4W, 1%, 1206	1	Sart
18	R3	Chip Resistor, 100kΩ, 1/16W, 1%, 0402	1	Murata/TDK
19	R4	Chip Resistor, 39kΩ, 1/16W, 1%, 0402	1	Murata/TDK
20	R5	Chip Resistor, 25kΩ, 1/16W, 1%, 0402	1	Murata/TDK
21	R6	Chip Resistor, 10kΩ, 1/16W, 1%, 0402(ACT2801QL-T108)	1	Murata/TDK

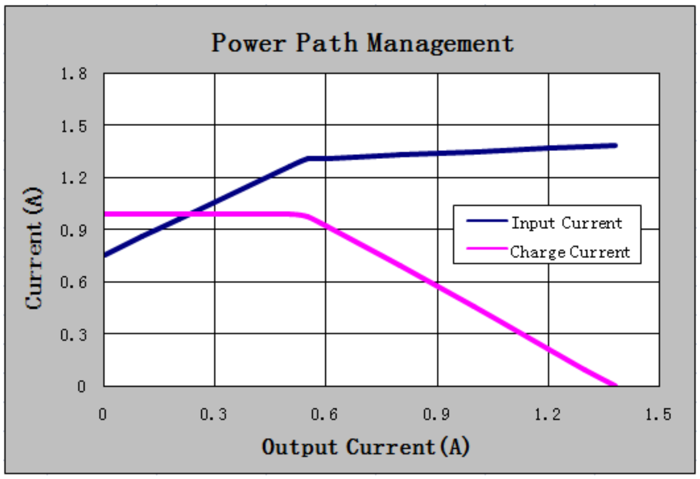
22	R7	Chip Resistor, 60kΩ, 1/16W, 1%, 0402	1	Murata/TDK
23	R8	Chip Resistor, 50kΩ, 1/16W, 1%, 0402	1	Murata/TDK
24	R9	Chip Resistor, 1Ω, 1/10W, 5%, 0805	1	Murata/TDK
25	R10	Chip Resistor, 2.7Ω, 1/8W, 5%, 1206	1	Murata/TDK
26	R11	Chip Resistor, 200kΩ, 1/16W, 5%, 0603	1	Murata/TDK
27	R12, R13	Chip Resistor, 715kΩ, 1/16W, 5%, 0603	2	Murata/TDK
28	R14	Chip Resistor, 100kΩ, 1/16W, 5%, 0603	1	Murata/TDK
29	R15	Chip Resistor, 2.2Ω, 1/16W, 5%, 0603	1	Murata/TDK
30	R16	Chip Resistor, 100Ω, 1/8W, 5%, 0805 (ACT2801BQL-T1028/ACT2801CQL-T1028)	1	Murata/TDK
31	USB	10.2*14.6*7mm,4P, DIP, 90°	1	
32	U1	IC, ACT2801QL-T1028 T-QFN 44-24	1	Active Semi

Test Results

Power Path Function

Input current(mA)	756	858	959	1265	1307	1312	1330	1349	1367	1376	1382
Output current(mA)	0	100	200	500	550	600	800	1000	1200	1300	1380
Charge current(mA)	990	990	990	990	978	922	693	456	214	93	0

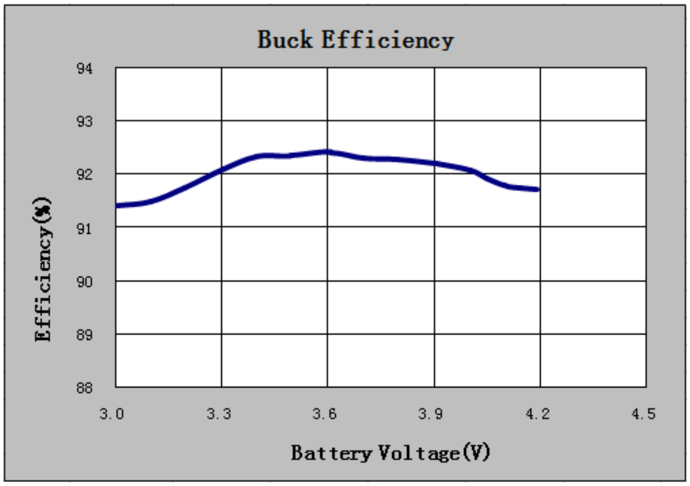
(Test condition: Vin=5 V, Vbat=3.7V, input current limit=1.6A, fast charge current=975mA)



Charge Efficiency

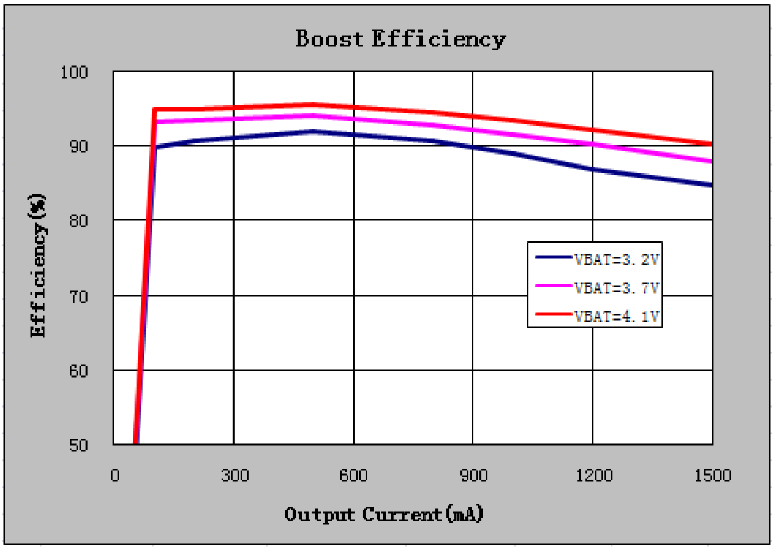
(Vin=5V and charge current set at 975mA)

Battery Voltage (V)	3.0	3.2	3.5	3.7	4.1
Efficiency (%)	9.14	91.7	92.4	92.3	91.8

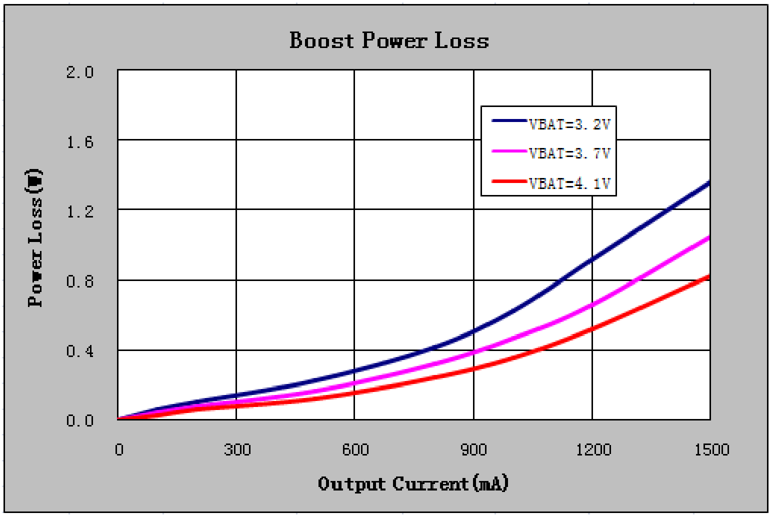


Boost Efficiency and Power Loss (Ta=25□)

Vbat	Efficiency (%)					
	Io=100mA	Io=500mA	Io=800mA	Io=1000mA	Io=1200mA	Io=1500mA
3.2V	89.9	91.9	90.6	88.9	86.8	84.7
3.7V	93.1	93.9	92.7	91.5	90.2	87.8
4.1V	94.9	95.5	94.4	93.4	92.0	90.1

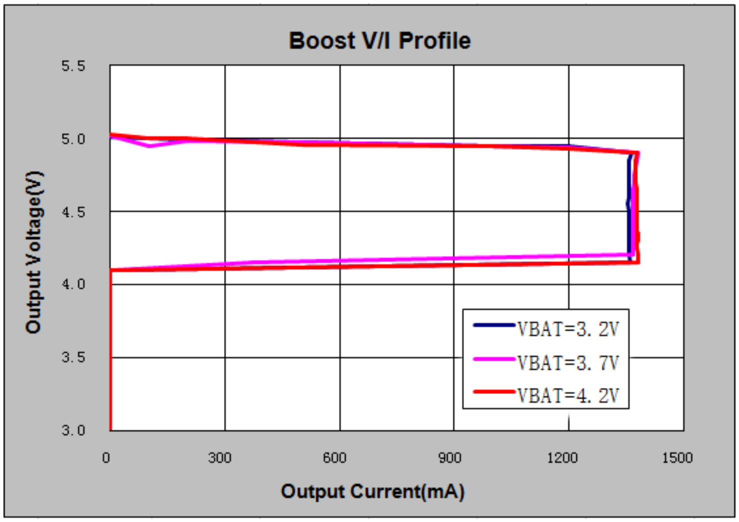


Vbat	Power Loss (W)					
	Io=100mA	Io=500mA	Io=800mA	Io=1000mA	Io=1200mA	Io=1500mA
3.2V	0.06	0.22	0.42	0.63	0.91	1.36
3.7V	0.04	0.16	0.32	0.46	0.66	1.04
4.1V	0.03	0.12	0.24	0.35	0.52	0.82



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

	Vbat=3.2V		Vbat=3.7V		Vbat=4.2V	
	Vout(V)	Iout(mA)	Vout (V)	Iout(mA)	Vout(V)	Iout(mA)
CC Load	5.008	0	5.017	0	5.024	0
	5.004	100	4.944	100	4.999	100
	4.988	200	4.987	200	4.997	200
	4.975	500	4.972	500	4.96	500
	4.95	1000	4.95	1000	4.946	1000
	4.944	1200	4.936	1200	4.932	1200
	4.937	1300	4.929	1300	4.924	1300
CV Load	4.9	1363	4.9	1381	4.9	1376
	4.85	1357	4.85	1376	4.85	1375
	4.8	1358	4.8	1373	4.8	1375
	4.7	1357	4.7	1370	4.7	1375
	4.6	1356	4.6	1369	4.6	1376
	4.5	1356	4.5	1368	4.5	1376
	4.35	1357	4.35	1368	4.35	1378
	4.3	1357	4.3	1369	4.3	1378
	4.25	1358	4.25	1369	4.25	1379
	4.2	1358	4.2	1369	4.2	1380
	4.15	1359	4.15	370	4.15	1380
	4.1	0	4.1	0	4.1	0
	3	0	3	0	3	0
	2	0	2	0	2	0



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

Ripple and Noise

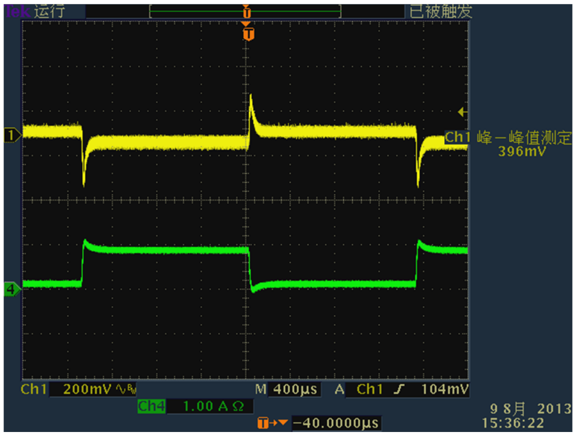
Ripple & noise are measured by using 20MHz bandwidth limited oscilloscope.

Test Conditions	Output Ripple at 0.5A Load (mV)	Output Ripple at 1A Load (mV)
Vbat=3.2V	18.0	25.2
Vbat=3.7V	18.4	25.2
Vbat=4.2V	18.5	24.9

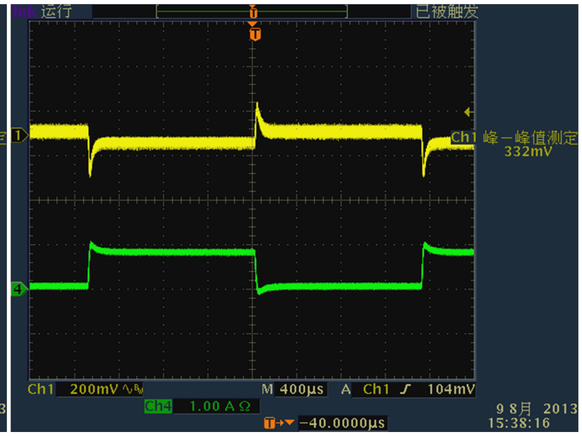
Load Dynamic Response Load Step(Vbat=3.7V)

CH1: output voltage CH4:output current
80mA-1000mA-80mA load step

Vbat=3.7V



Vbat=4.2V



LED Indication

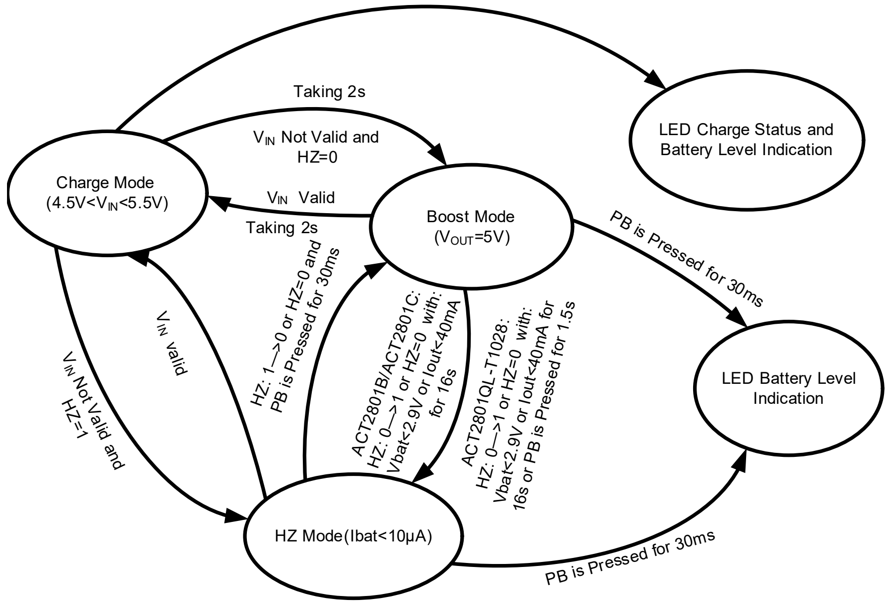
Conventional LED indication

PB time>30ms (HZ Mode)	LED1	LED2	LED3	LED4
VBAT<VLED1	Off	Off	Off	Off
VLED1⩽VBAT<VLED2	On	Off	Off	Off
VLED2⩽VBAT< VLED3	On	On	Off	Off
VLED3⩽VBAT< VLED4	On	On	On	Off
VBAT⩾VLED4	On	On	On	On

Charge Mode	LED1	LED2	LED3	LED4
VBAT<VLED1	Flash	Off	Off	Off
VLED1≤VBAT< VLED2	Flash	Off	Off	Off
VLED2≤VBAT< VLED3	On	Flash	Off	Off
VLED3≤VBAT ≤VLED4	On	On	Flash	Off
VLED4≤VBAT ≤ EOC Mode	On	On	On	Flash
LED4 ≤VBAT(EOC Mode)	On	On	On	On

System Management

ACT2801 System Operation Flow Chart



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

Charge mode, 1.0A charge current

Vin(V)	IC(℃)	Inductor(℃)	PCB(℃)	Vbat(V)
5.0	67.4	62.3	58.8	3.2
5.0	65.6	60.6	57.3	3.7
5.0	63.7	59.3	56.0	4.2

Boost mode, 1.2A output current

Vbat(V)	IC(℃)	Inductor(℃)	PCB(℃)	Vout(V)
3.2	80.4	84.2	72.9	5.0
3.7	70.0	72.4	65.2	5.0
4.2	63.3	64.9	60.1	5.0

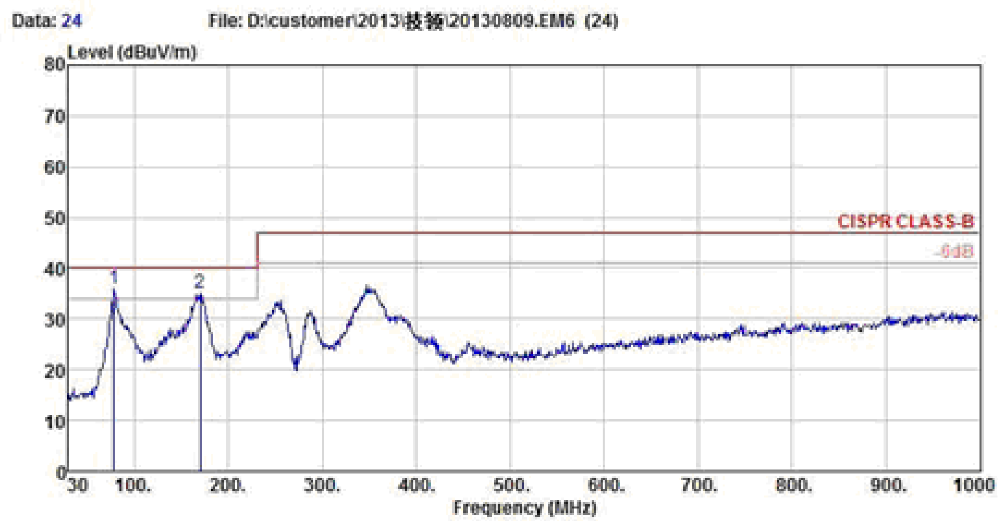
PCB Layout Guidance

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. Route the SW node trace under C2 as shown in the following layout figure.
2) Use a copper plane for PGND for best heat dissipation and noise immunity. AGND and PGND are connected under the IC thermal pad with 4x4 via matrix.
3) The SW copper area should be limited to minimize EMI.
4) Use Kevin sensing from the sense resistor R2 to CSP and CSN pins as shown in the layout figure.
5) Use a separate PCB trace from the VBAT input to the BAT pin for battery voltage sense accuracy.
6) An RC snubber is recommended to add across SW to PGND to reduce EMI noise. This can be left unpopulated if not needed
7) A 10V/1A schottky is added from inductor terminal to VOUT to reduce EMI noise.

EMI Test

Vbat=4.1V, Output: 5V/1A Horizontal



Site : chamber
Condition : CISPR CLASS-B 3m VULB9160 HORIZONTAL
EUT :
Model Name : ACT2801 BOOST LOAD 1A 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	78.50	25.87	9.14	1.09	0.00	36.10	40.00	-3.90	Peak
2 !	169.68	20.04	13.33	1.84	0.00	35.21	40.00	-4.79	Peak