

# 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°C die temperature
- IC over temperature protection
- TQFN4x4-24 package

### SPECIFICATION

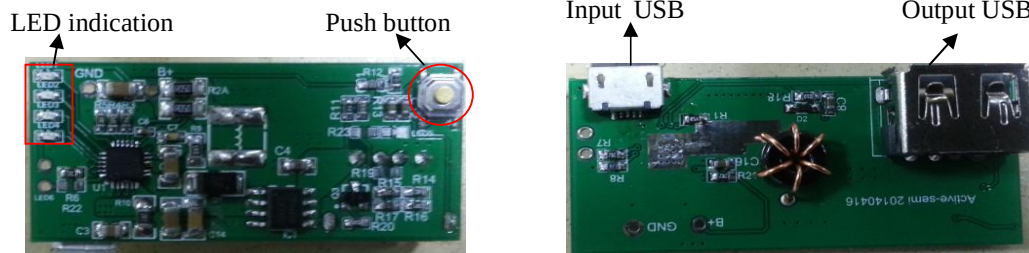
| Input voltage | Boost output voltage | Input current limit | Battery charge current | Boost output current limit |
|---------------|----------------------|---------------------|------------------------|----------------------------|
| 4.7 - 5.5V    | 5.0V                 | 3.0A                | 2.0A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

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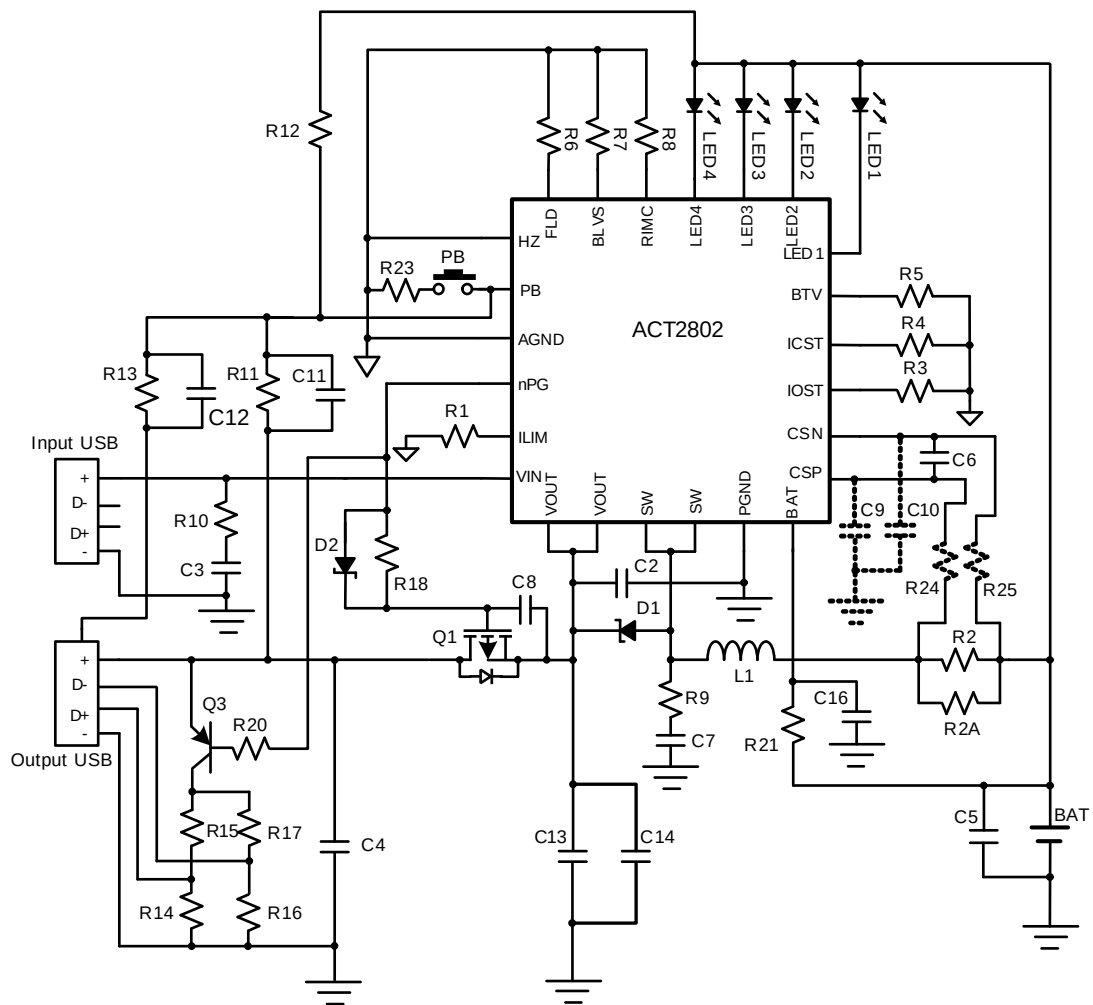
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## 1 DEMO BOARD PHOTOS

(DEMO BOARD SIZE: 46.5mm\*23mm)



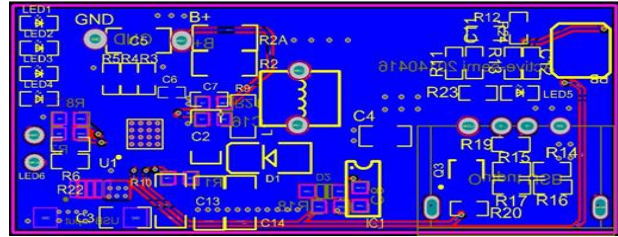
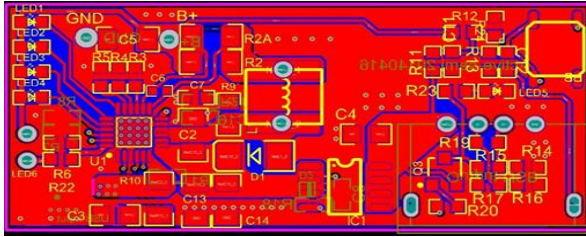
## 2 SCHEMATICS



## 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          |

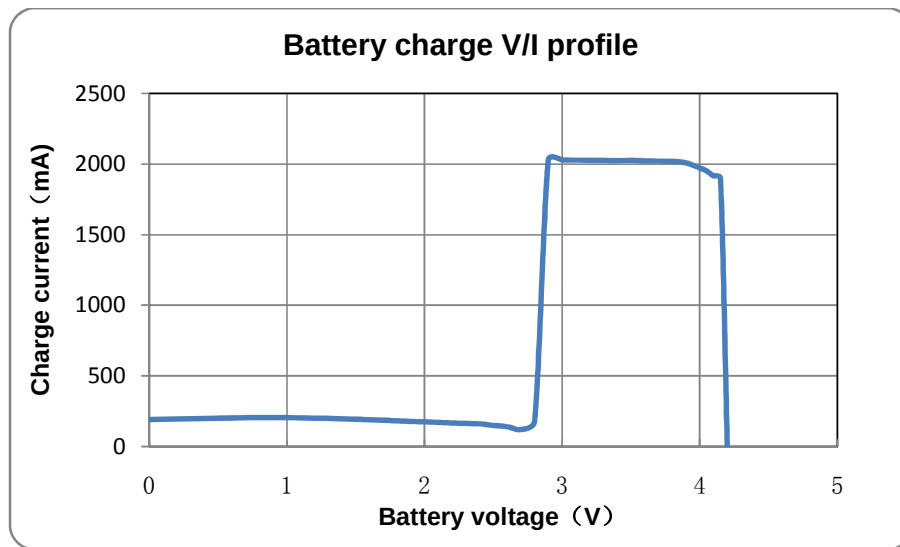
## 4 PCB LAYOUT



\*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

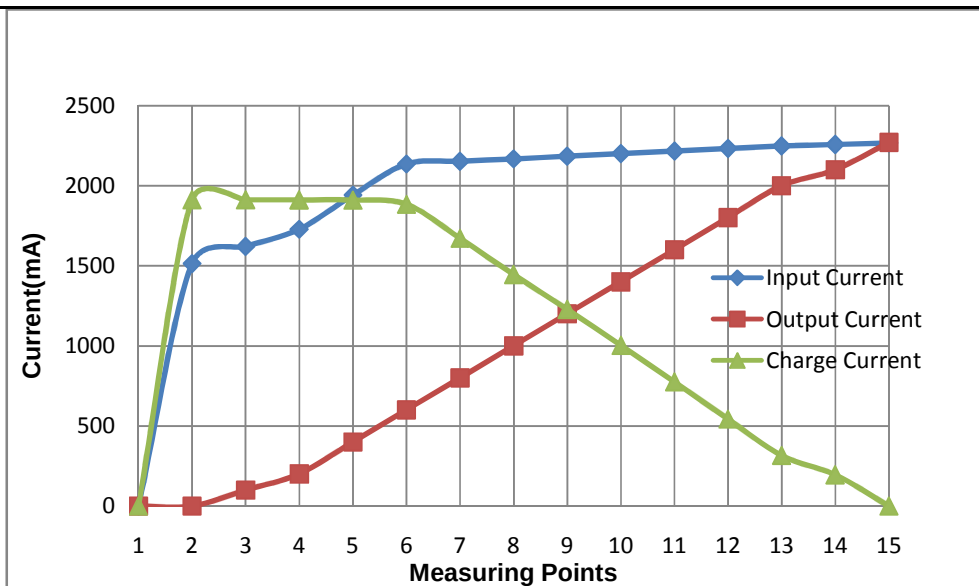


### 5.2 Power Path Function

|                    |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|--------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 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)

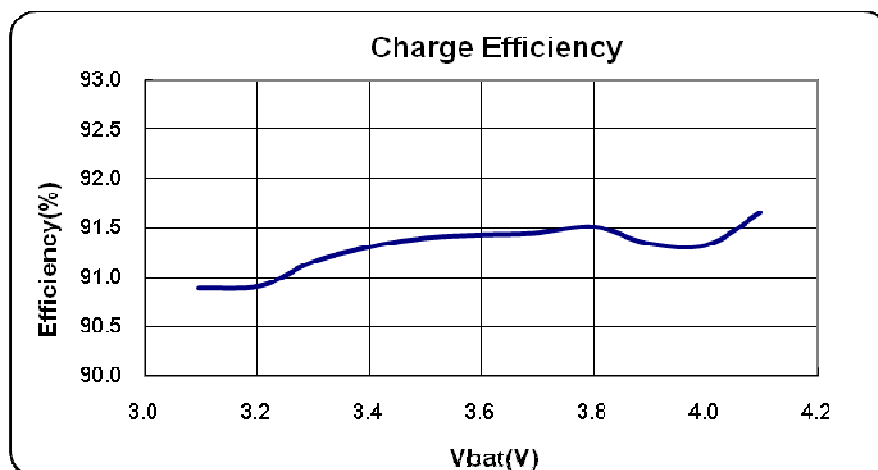
## ACT2802: Dedicated 5V/2.1A Power Bank Solution



### 5.3 Charge Efficiency

( $V_{in}=5V$  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 |



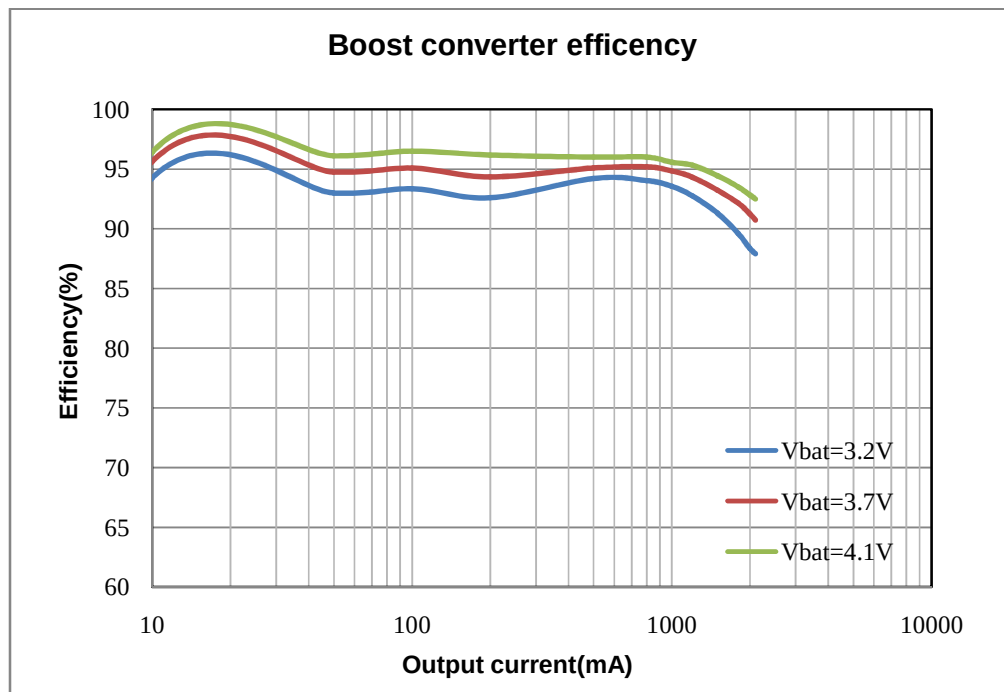
## 5.4 Boost Output Regulation

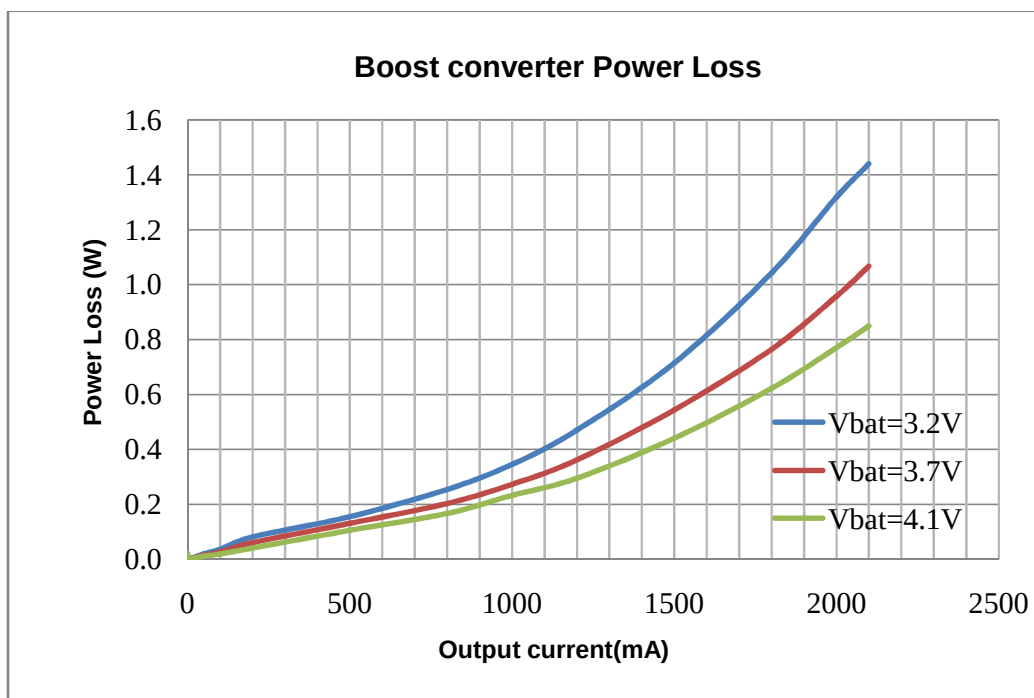
| Battery Voltage (V) | Output Voltage at 2.1A Output (V) | Output Voltage at No Load (V) | Load Regulation (%) |
|---------------------|-----------------------------------|-------------------------------|---------------------|
| 3.2                 | 4.98                              | 5.02                          | 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°C)

| 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°C)

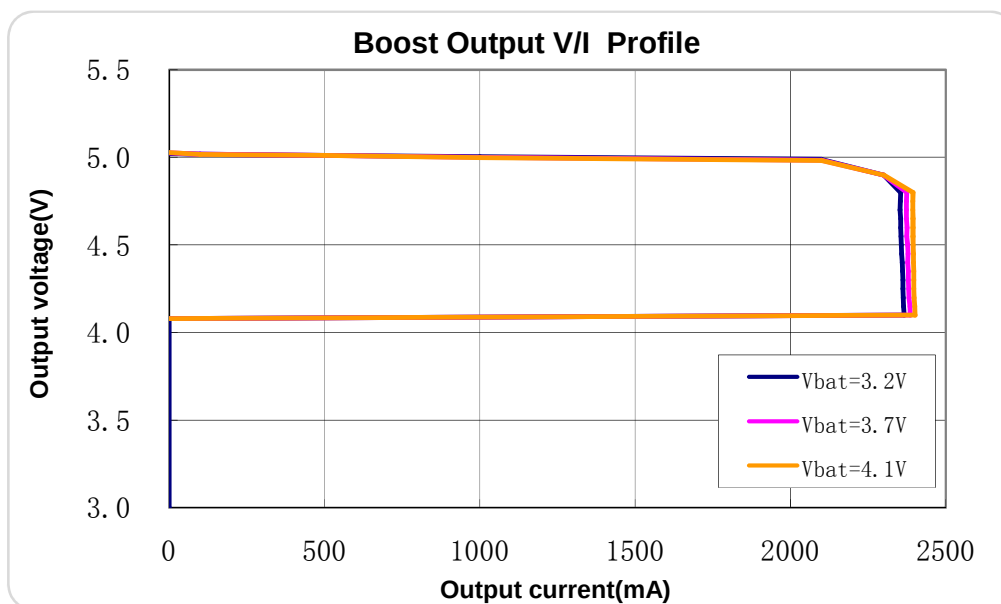
| Battery Voltage(V)        | 3.2  | 3.7  | 4.1  |
|---------------------------|------|------|------|
| Boost Standby Current(mA) | 0.54 | 0.52 | 0.52 |
| Boost Standby Power(mW)   | 1.73 | 1.92 | 2.18 |

## 5.7 Boost Constant Current and Constant Voltage Regulation (Ta=25°C)

|         | 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 ( $\mu A$ ) | Power Loss ( $\mu W$ ) |
|-----------------|-----------------------------------|------------------------|
| 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                   |

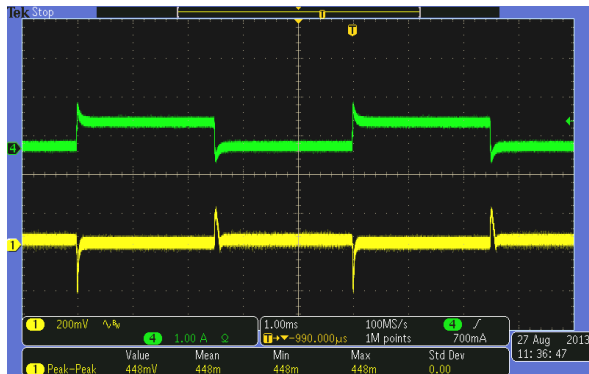
## 5.9 Ripple and Noise

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

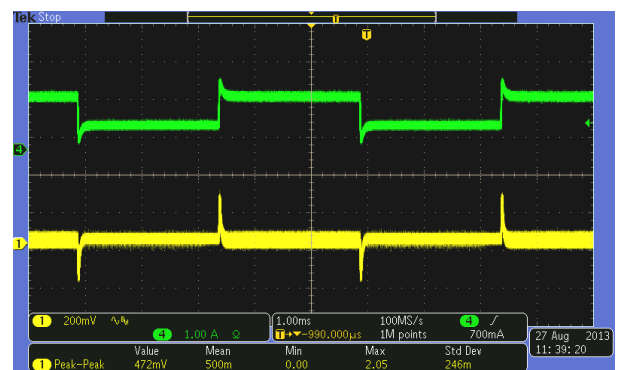
| Test Conditions | Output Ripple at 1A Load (mV) | Output Ripple at 2.1A Load (mV) |
|-----------------|-------------------------------|---------------------------------|
| Vbat=3.2V       | 20                            | 64.8                            |
| Vbat=3.7V       | 16.8                          | 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

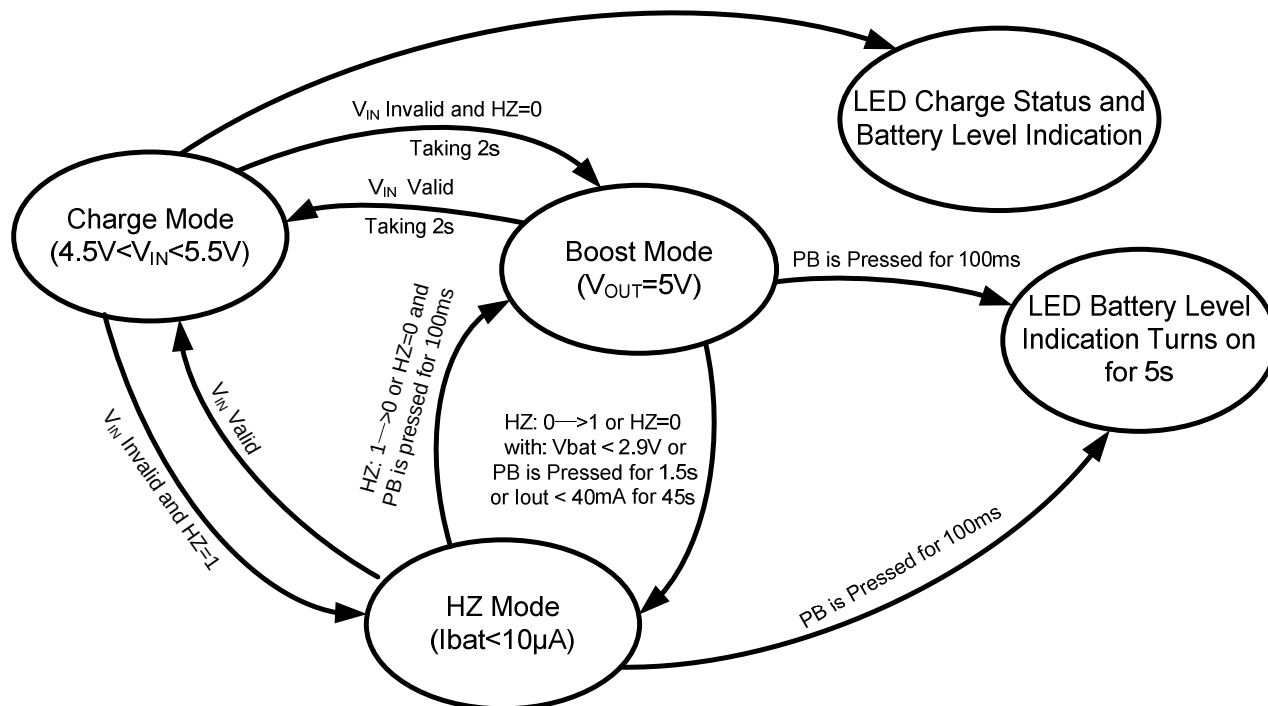


## 5.11 LED Indication

|                                           | Charge Mode |       |       |       | Boost or HZ Mode<br>PB time>100ms |      |      |      |
|-------------------------------------------|-------------|-------|-------|-------|-----------------------------------|------|------|------|
| LED                                       | LED1        | LED2  | LED3  | LED4  | LED1                              | LED2 | LED3 | LED4 |
| V <sub>BAT</sub> <2.9V                    | Flash       | Off   | Off   | Off   | Off                               | Off  | Off  | Off  |
| 2.9V≤V <sub>BAT</sub> <LED1               | Flash       | Off   | Off   | Off   | Flash                             | Off  | Off  | Off  |
| LED1≤V <sub>BAT</sub> <LED2               | On          | Flash | Off   | Off   | On                                | Off  | Off  | Off  |
| LED2≤V <sub>BAT</sub> <LED3               | On          | On    | Flash | Off   | On                                | On   | Off  | Off  |
| LED3≤V <sub>BAT</sub> <LED4               | On          | On    | On    | Flash | On                                | On   | On   | Off  |
| V <sub>BAT</sub> ≥LED4                    | On          | On    | On    | Flash | On                                | On   | On   | On   |
| V <sub>BAT</sub> ≥LED4<br>(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°C, burning for 2 hours)

Charge mode, 2.0A charge current

| V <sub>in</sub> (V) | I <sub>C</sub> (°C) | Inductor(°C) | PCB(°C) | V <sub>bat</sub> (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

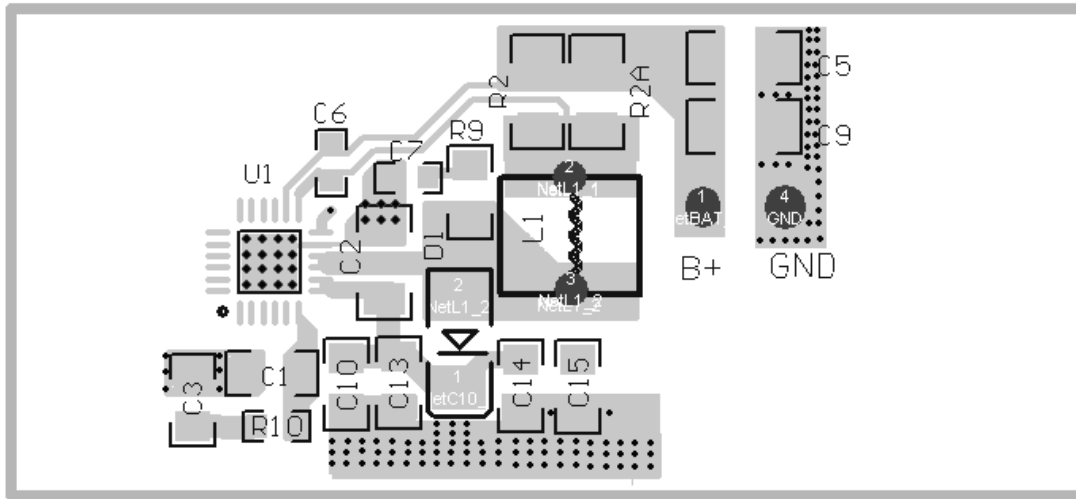
| V <sub>bat</sub> (V) | I <sub>C</sub> (°C) | Inductor(°C) | PCB(°C) | V <sub>out</sub> (V) |
|----------------------|---------------------|--------------|---------|----------------------|
| 3.2                  | 87.5                | 86.5         | 78.2    | 5.0                  |
| 3.7                  | 74.2                | 76.8         | 68.6    | 5.0                  |
| 4.1                  | 65.3                | 68.6         | 62.4    | 5.0                  |

### 6 PCB LAYOUT GUIDANCE

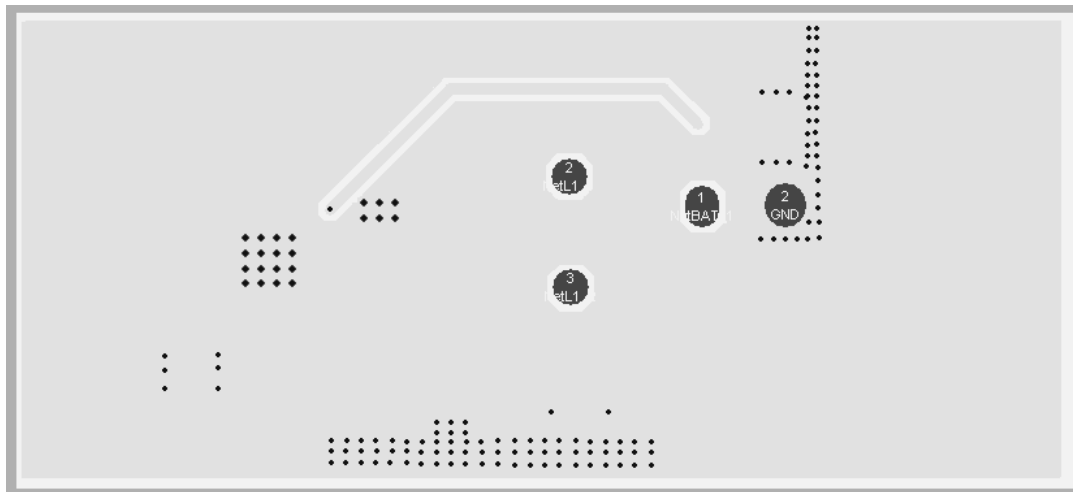
The following guideline is base on the schematic in Section 2.

- 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

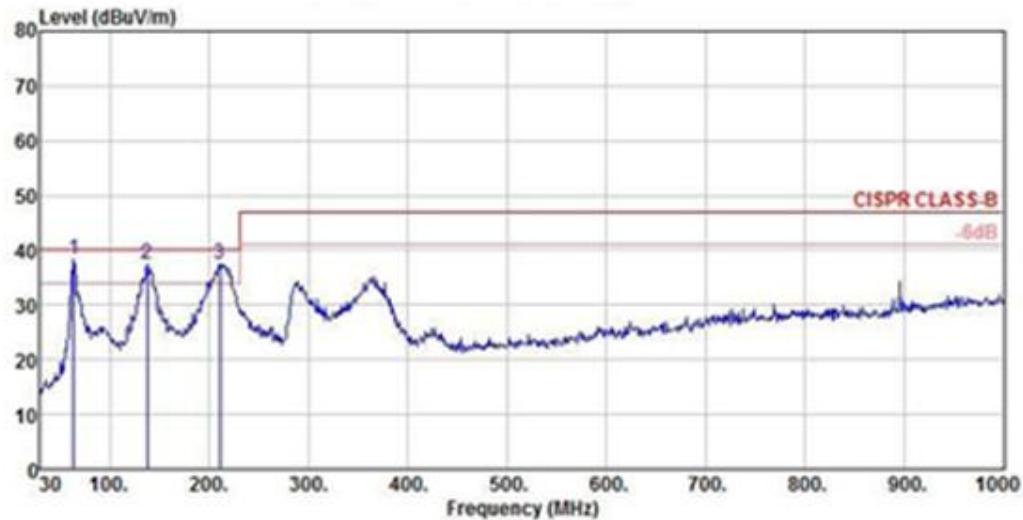


## Bottom Layer



## 7 EMI TEST

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

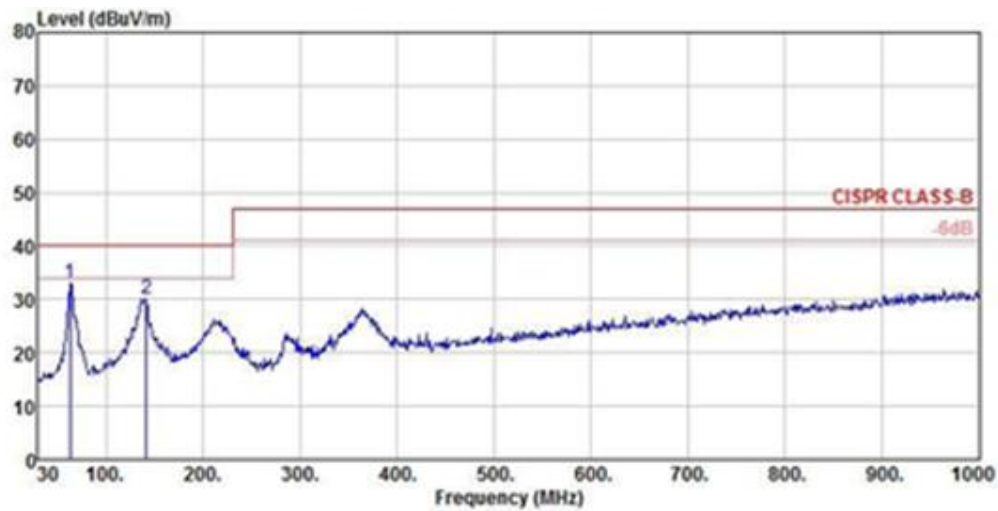


Site : chamber  
Condition : CISPR CLASS-B 3m VULB9160 HORIZONTAL  
EUT :  
Model Name : ACT2802 5V2A BOOST VBAT=4.1V  
Temp/Humi : 24 °C /58%  
Power Rating: dc  
Mode :  
Memo :  
: #2

|   |      | ReadAntenna | Cable  | Preamp |        | Limit  | Over   |                  |
|---|------|-------------|--------|--------|--------|--------|--------|------------------|
|   | Freq | Level       | Factor | Loss   | Factor | Level  | Line   | 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 |

## ACT2802: Dedicated 5V/2.1A Power Bank Solution

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 °C /58%  
Power Rating: dc  
Mode :  
Memo :  
#2

|   | Freq   | Read  | Antenna | Cable | Preamp | Level  | Limit  | Over  |        |
|---|--------|-------|---------|-------|--------|--------|--------|-------|--------|
|   | MHz    | Level | Factor  | Loss  | Factor | dBuV/m | dBuV/m | Limit | Remark |
|   |        | dBuV  | dB/m    | dB    | dB     |        |        | dB    |        |
| 1 | 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   |



**Стандарт  
Электрон  
Связь**

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Благодаря сотрудничеству с мировыми поставщиками мы осуществляем комплексные и плановые поставки широчайшего спектра электронных компонентов.

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