

# EA2813QY-T User's Guide

## 5V/2.4A Power Bank Solution

### Description

This document supports the **EA2813QY-T** Evaluation Kit. This kit is a proven application-circuit design for the ACT2813QY-T charger with power path and single USB outputs. The EVK contains a single micro-USB input and USB output. It provides a 2.4A output. It is configured to charge a battery with 2.4A. The EVK operates with very high charge efficiency of 91% and discharge efficiency of 95% (Vbat=4.1V). This EVK demonstrates the ACT2813QY-T charger, but other ACT2813xxx options can be evaluated on this EVK by replacing the IC and any other necessary components. The following table shows the differences between these ICs.

| PART NUMBER      | OUTPUT  | CHARGE CURRENT | BATTERY VOLTAGE | FLASHLIGHT /TH | PB TURN OFF BOOST | PACKAGE      |
|------------------|---------|----------------|-----------------|----------------|-------------------|--------------|
| ACT2813QY-T      | 5V/2.4A | 2.4A           | 4.2V            | TH             | Yes               | FCQFN 4x4-20 |
| ACT2813QY-T0435  | 5V/2.4A | 2.4A           | 4.35V           | TH             | Yes               | FCQFN 4x4-20 |
| ACT2813CQY-T     | 5V/2.4A | 2.4A           | 4.2V            | Flashlight     | No                | FCQFN 4x4-20 |
| ACT2813CQY-T0435 | 5V/2.4A | 2.4A           | 4.35V           | Flashlight     | No                | FCQFN 4x4-20 |

### 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/2.1A output at 550 kHz switching frequency. It operates from VIN=4.5V to 5.5V to charge a 1S Li-Ion battery. Gerber files are available to minimize time-to-market for applications that want to use the EVK as an end product.

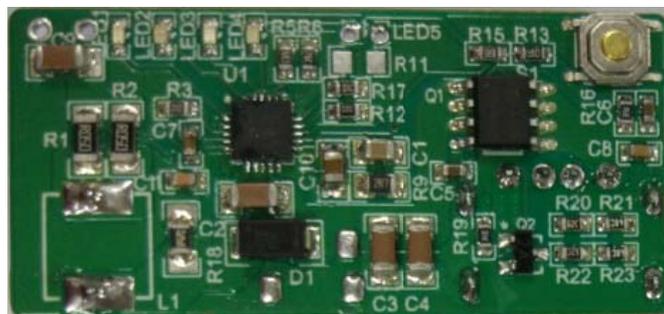


Figure 1 – EVK Picture - Top



Figure 2 – EVK Picture – Bottom

## Setup

### Required Equipment

EA2813QY-T EVK

Power supply – 5V @ 3A for full power operation

Oscilloscope – >100MHz

Loads –Electronic/resistive load with 3A minimum current capability.

Digital Multimeters (DMM)

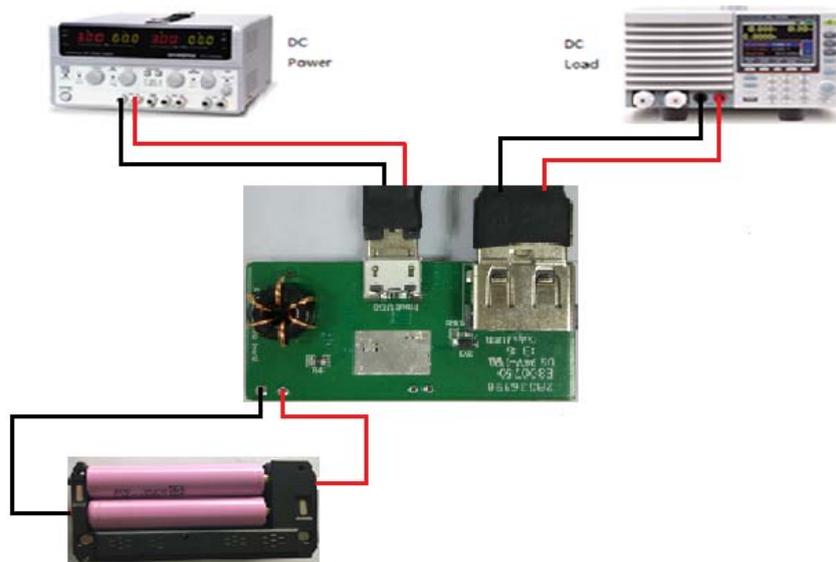


Figure 3 – EVK Setup

## Hardware Setup

1. Connect a DC power supply to the input USB connector.
2. Connect the EVK output to an electronic load using the USB connector.
3. Connect battery across C9 terminals as shown in Figure 3. Pay close attention to the battery polarity.

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    |     | 2.4 |     | A    |

## EVK Operation

### Boost Mode (Discharge Mode)

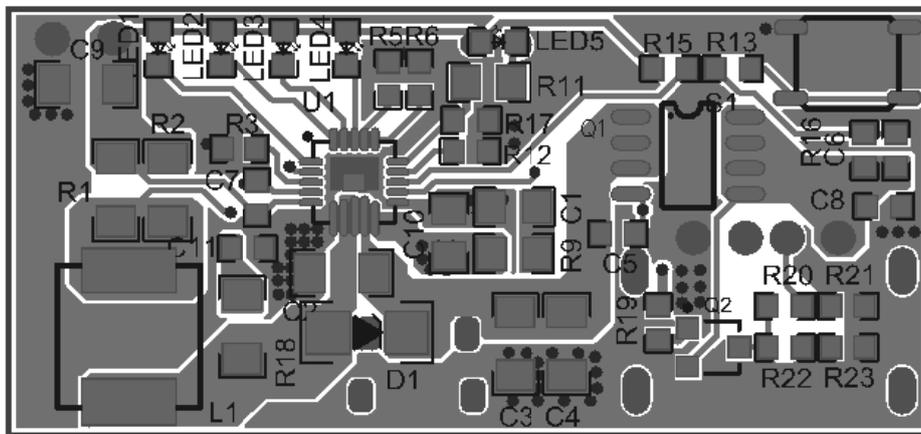
With the battery connected and a load connected, press the pushbutton to force the IC from the HIZ Mode to Discharge Mode. In Discharge Mode, the IC boosts the battery to a 5V output.

Note if no load is applied for 16s, the IC enters HIZ Mode due to light load cutoff. Press the pushbutton to exit HIZ mode.

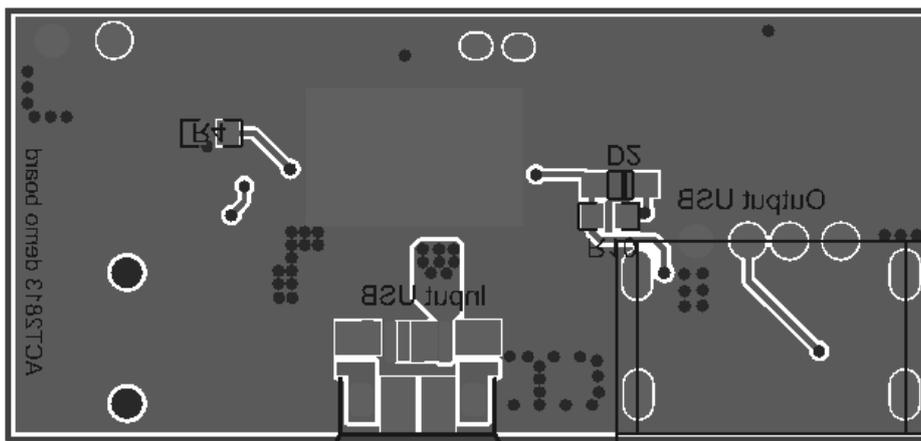
### Charge Operation

With the battery connected, apply 5V to the input USB connector. The IC automatically transitions from HIZ Mode to Charge Mode

## PCB Layout



Top Layer

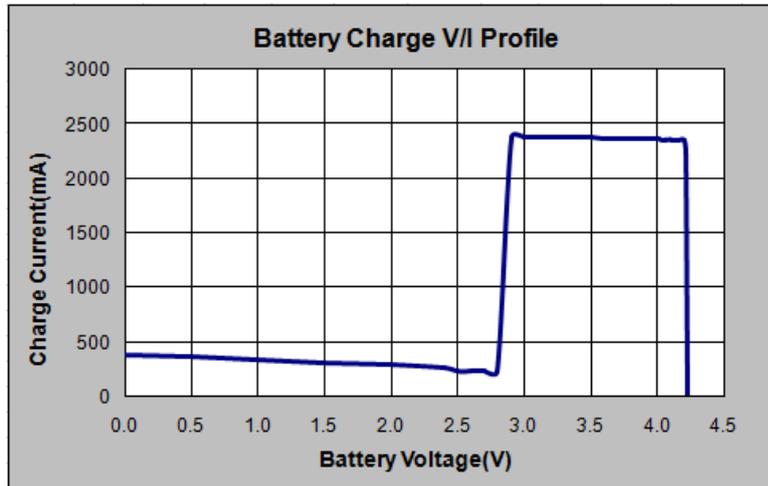


Bottom Layer

## Test Results

### Battery Charge Feature

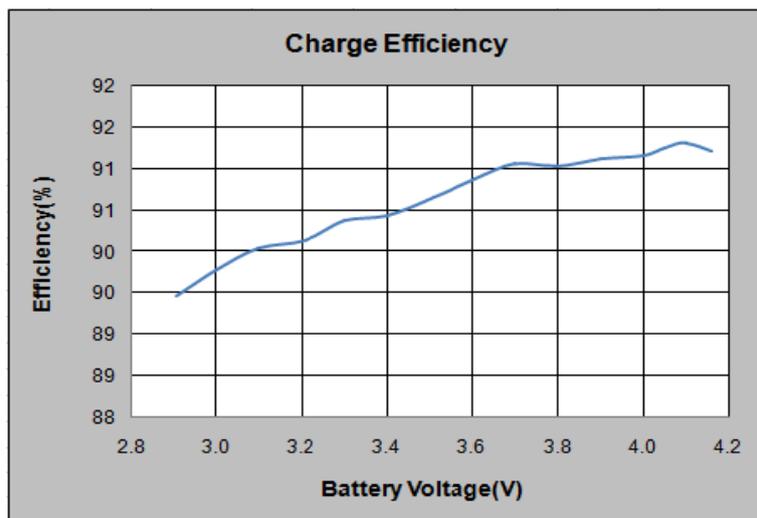
|              |     |     |     |     |     |     |      |      |      |      |      |      |
|--------------|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| Vbat (V)     | 0   | 1.0 | 2.0 | 2.4 | 2.5 | 2.8 | 2.9  | 3.4  | 3.8  | 4.0  | 4.21 | 4.22 |
| Icharge (mA) | 380 | 331 | 290 | 260 | 228 | 227 | 2381 | 2372 | 2367 | 2356 | 2235 | 0    |



### Charge Efficiency

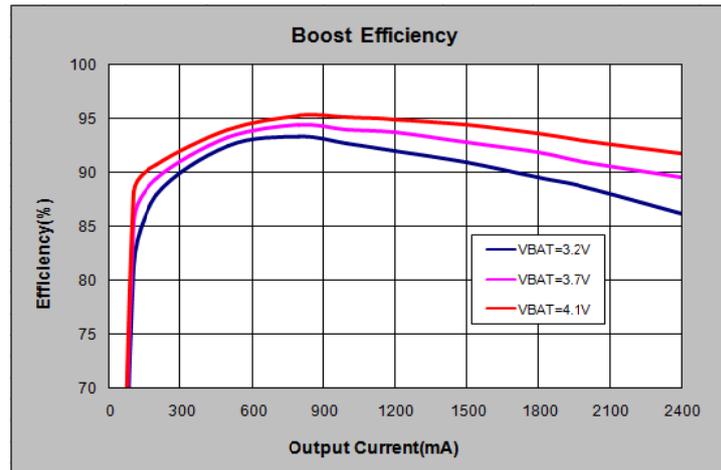
(Vin=5V and charge current set at 2400mA)

|                     |      |      |      |      |      |      |
|---------------------|------|------|------|------|------|------|
| Battery Voltage (V) | 3.0  | 3.2  | 3.5  | 3.7  | 3.9  | 4.1  |
| Efficiency (%)      | 89.8 | 90.1 | 90.6 | 91.1 | 91.1 | 91.3 |

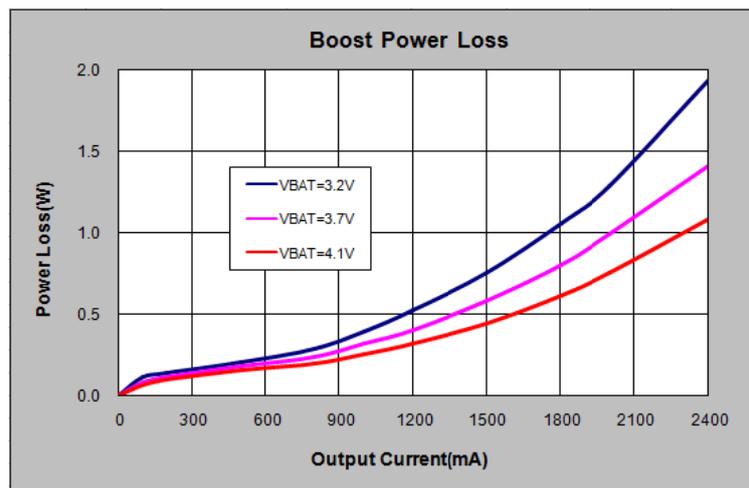


**Boost Efficiency and Power Loss (Ta=25°C)**

| Vbat | Efficiency (%) |          |           |           |           |           |
|------|----------------|----------|-----------|-----------|-----------|-----------|
|      | Io=100mA       | Io=500mA | Io=1000mA | Io=1500mA | Io=2000mA | Io=2400mA |
| 3.2V | 81.3           | 92.5     | 92.7      | 90.9      | 88.7      | 86.2      |
| 3.7V | 85.5           | 93.2     | 94.0      | 92.8      | 91.0      | 89.5      |
| 4.1V | 88.1           | 94.0     | 95.1      | 94.4      | 93.0      | 91.8      |

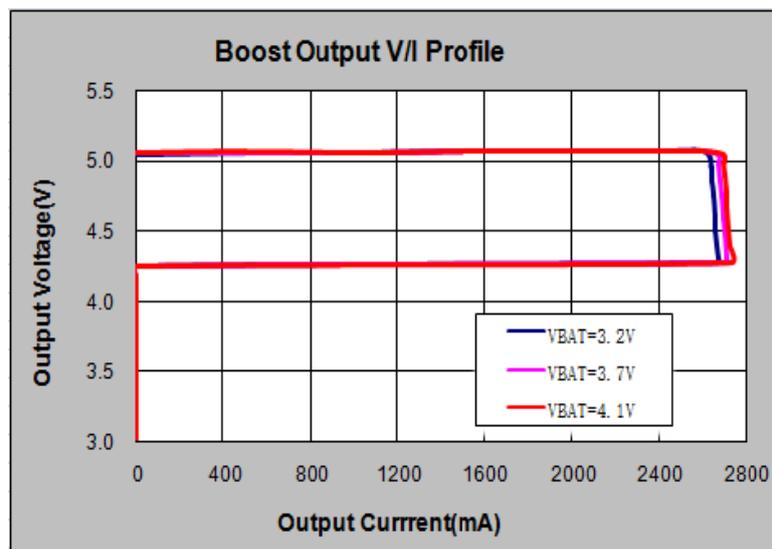


| Vbat | Power Loss (W) |          |           |           |           |           |
|------|----------------|----------|-----------|-----------|-----------|-----------|
|      | Io=100mA       | Io=500mA | Io=1000mA | Io=1500mA | Io=2000mA | Io=2400mA |
| 3.2V | 0.12           | 0.21     | 0.39      | 0.75      | 1.29      | 1.93      |
| 3.7V | 0.09           | 0.18     | 0.32      | 0.58      | 0.99      | 1.41      |
| 4.1V | 0.07           | 0.16     | 0.26      | 0.45      | 0.76      | 1.08      |



**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 | 5.05      | 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     |
|         | 4.75      | 2650     | 4.75      | 2686     | 4.75      | 2705     |
|         | 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        |


**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            |

## Ripple and Noise

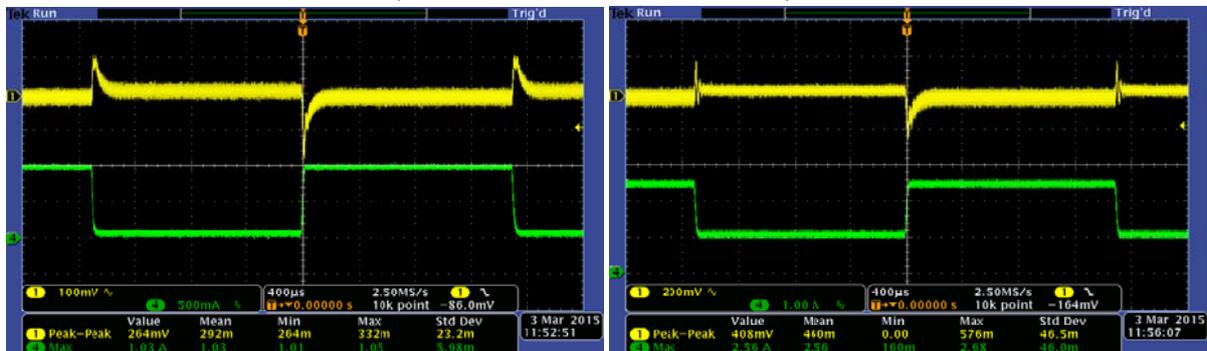
Ripple & noise are measured by using 20MHz bandwidth limited oscilloscope.

| 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                              |

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

CH1: output voltage CH4:output current

80mA-1000mA-80mA load step 1000mA-2400mA-1000mA load step



## LED Indication

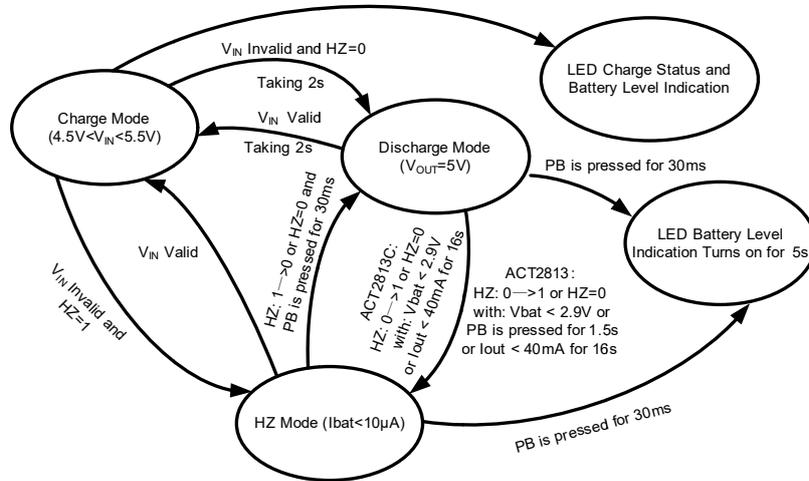
Conventional LED indication

| 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

ACT2813/ACT2813B System Operation Flow Chart



## Key Components Temperature Test ( $T_a=40^\circ C$ , burning for 2 hours)

Charge mode, 2.4A charge current

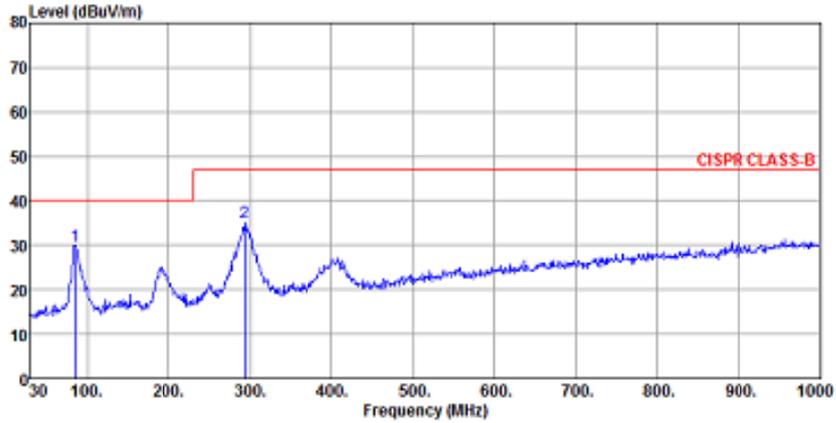
| Vbat(V) | IC(°C) | Diode(°C) | Inductor(°C) | PCB(V) |
|---------|--------|-----------|--------------|--------|
| 3.2V    | 56.8   | 48.6      | 52.6         | 49.7   |
| 3.7V    | 59.0   | 50.1      | 52.3         | 51.5   |
| 4.1V    | 63.1   | 53.2      | 54.0         | 54.9   |

Boost mode, 2.4A output current

| Vbat(V) | IC(°C) | Diode(°C) | Inductor(°C) | PCB(°C) |
|---------|--------|-----------|--------------|---------|
| 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    |

**EMI Test**

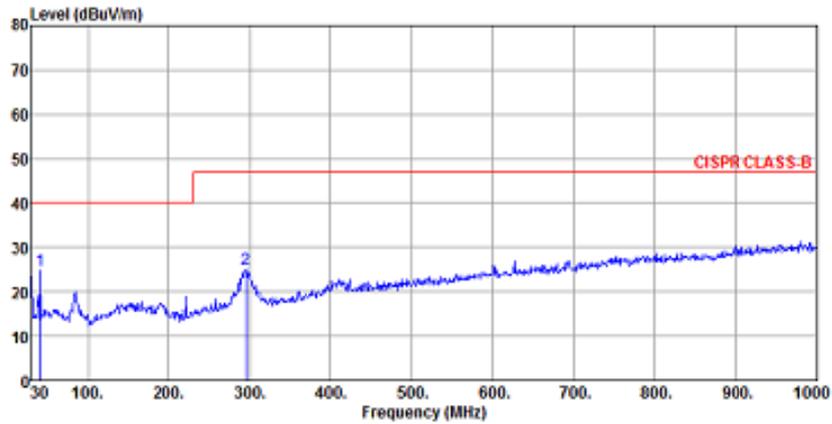
Vbat=4.1V, Output: 5V/2.4A Horizontal



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

|      | 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 | 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 |

Vbat=4.1V, Output: 5V/2.4A Vertical



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

|      | ReadAntenna | Cable  | Preamp | Limit  | Over   |        |       |        |      |
|------|-------------|--------|--------|--------|--------|--------|-------|--------|------|
| Freq | Level       | Factor | Loss   | Factor | Level  | Line   |       |        |      |
| MHz  | dBuV        | dB/m   | dB     | dB     | dBuV/m | dBuV/m |       |        |      |
| 1 pp | 48.67       | 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 |



**EA2813QY-T Bill of Materials**

| ITEM | REFERENCE              | DESCRIPTION  | QTY | MANUFACTURER |
|------|------------------------|--|-----|--------------|
| 1    | L1                     | Core, 6.5*3*3 Dip, 2.2uH, 6A, R <sub>dson</sub> =5mΩ         | 1   |              |
| 2    | Q1                     | AO4453, R <sub>dson</sub> =19mΩ at V <sub>GS</sub> = - 4.5 V | 1   | AOS          |
| 3    | Q2                     | MMBT3906   | 1   | Vishay       |
| 4    | D1                     | SBR3U20SA, 20V/3A Schottky                                   | 1   | Diodes       |
| 5    | D2                     | 1N4148, V <sub>f</sub> =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   | Sart         |
| 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   | R9                     | Chip Resistor, 2.7Ω, 1/8W, 1%, 0805                          | 1   | Murata/TDK   |
| 19   | R11                    | Chip Resistor, 51Ω, 1/8W, 1%, 0805                           | 0   | Murata/TDK   |
| 20   | R12                    | Chip Resistor, 0Ω, 1/10W, 5%, 0603                           | 1   | Murata/TDK   |
| 21   | R13                    | Chip Resistor, 100Ω, 1/10W, 1%, 0603                         | 1   | Murata/TDK   |
| 22   | R15                    | Chip Resistor, 715kΩ, 1/10W, 5%, 0603                        | 1   | Murata/TDK   |
| 23   | R16,R19                | Chip Resistor, 200kΩ, 1/10W, 5%, 0603                        | 2   | Murata/TDK   |
| 24   | R17                    | Chip Resistor, 10kΩ, 1/10W, 5%, 0603                         | 1   | Murata/TDK   |
| 25   | R18                    | Chip Resistor, 0.47Ω, 1/4W, 1%, 1206                         | 1   | Murata/TDK   |
| 26   | R20,R22                | Chip Resistor, 43.2kΩ, 1/10W, 1%, 0603                       | 2   | Murata/TDK   |
| 27   | R21,R23                | Chip Resistor, 49.9kΩ, 1/10W, 1%, 0603                       | 2   | Murata/TDK   |
| 28   | LED1,LED2<br>LED3,LED4 | LED, 0603, Blue  | 4   | LED Manu     |
| 29   | LED5                   | Flashlight   | 0   | LED Manu     |
| 30   | PB                     | Push Button  | 1   |              |
| 31   | USB                    | 10.2*14.6*7mm, 4P, DIP                                       | 1   |              |
| 32   | Micro-USB              | MICRO USB 5P/F SMT B   | 1   |              |
| 33   | U1                     | IC, ACT2813QY-T  | 1   | Active-Semi  |