

## ACT4529EVK1 User's Guide

### USB Type C Car Charger Solution

#### Description

This document describes the characteristic and operation of the Active Semi ACT4529EVK1 evaluation kit (EVK). It provides setup and operation instructions, schematic, layout, BOM, and test data. This EVK demonstrates the ACT4529YH-T1011. Other ACT4529YH-Txxx options can be evaluated on this EVK by replacing the IC and any other necessary components.

#### Features

The EVK is a complete, stand-alone USB-PD and QC2.0 car charger solution. It is built with an automotive car charger form factor to show performance in a real form factor application. The EVK contains the high efficiency ACT4925 step-down DC/DC converter that operates in either CV(Constant Output Voltage) mode or CC(Constant Output Voltage) mode.

The EVK features a USB Type C output connector with USB-PD, QC2.0, and USB Auto Detect decoding protocols. Decoding is implemented with an on-board FUSB302TMPX USB Type-C controller and STM32F030F4P6 MCU. The EVK provides up to 3.0A output current at 125kHz switching frequency. It operates from  $V_{in}=12V$  to 36V and provides an output voltage of 5.1V, 9.1V, or 12.1V depending on the load's requested voltage. It charges Samsung and BC1.2 charging protocols at full charge current. 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

ACT4529EVK1 EVK

Power supply – 40V @ 4A for full power operation

Oscilloscope – >100MHz, >2 channels

Loads –Electronic/resistive load with 3.5A minimum current capability.

Digital Multimeters (DMM)

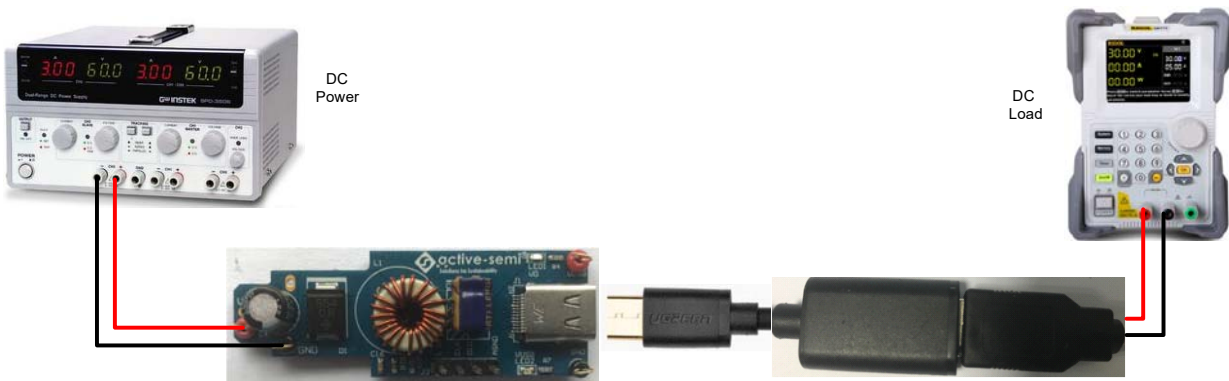


Figure 3 – EVK Setup

## Hardware Setup

1. Connect a DC Power to the VIN and GND jumpers on the left side of the EVK.
2. Using a USB Type C connector, connect the EVK output to an electronic load.
3. Do not connecting anything to J2. J2 is a programming header.

## Recommended Operating Conditions

Table 1. Recommended Operating Conditions

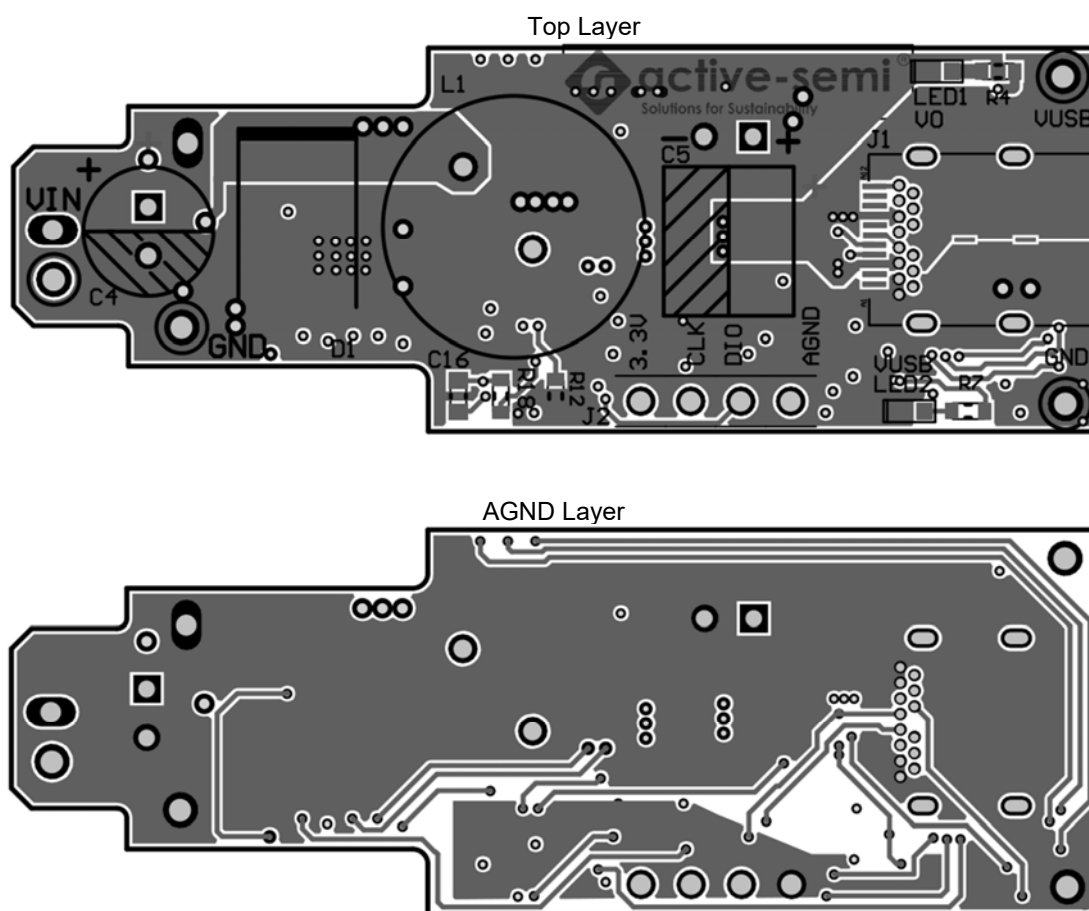
| Parameter | Description             | Min | Typ | Max | Unit |
|-----------|-------------------------|-----|-----|-----|------|
| VIN       | All buck input voltages | 10  | 12  | 36  | V    |
| IOUT      | Maximum load current    |     | 3.0 |     | A    |

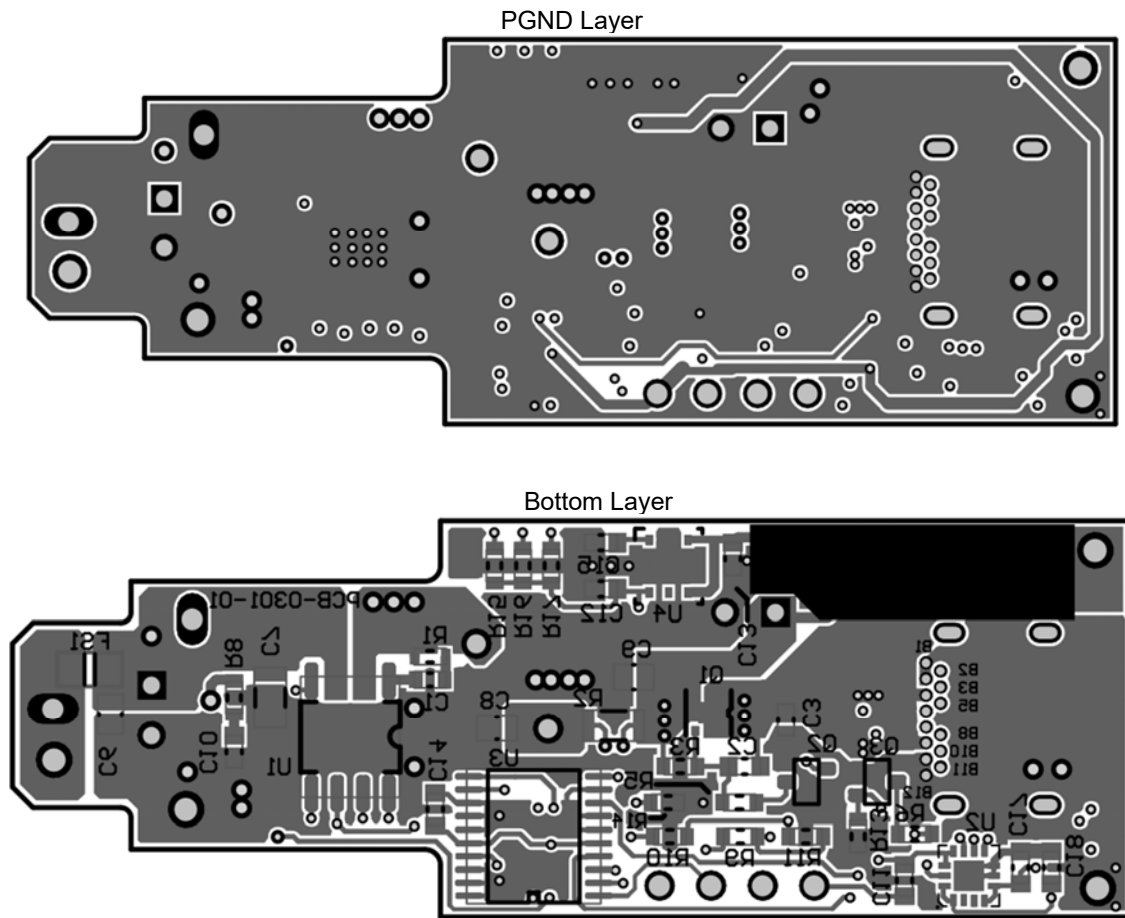
## EVK Operation

### Turn on

Apply the 12V input voltage. The portable load can be connected before or after the input voltage is applied. LED1 turn on to indicate that the buck converter is operational. LED2 turns on to indicate that the IC has properly communicated with output load and is delivering power to the output connector.

## PCB Layout

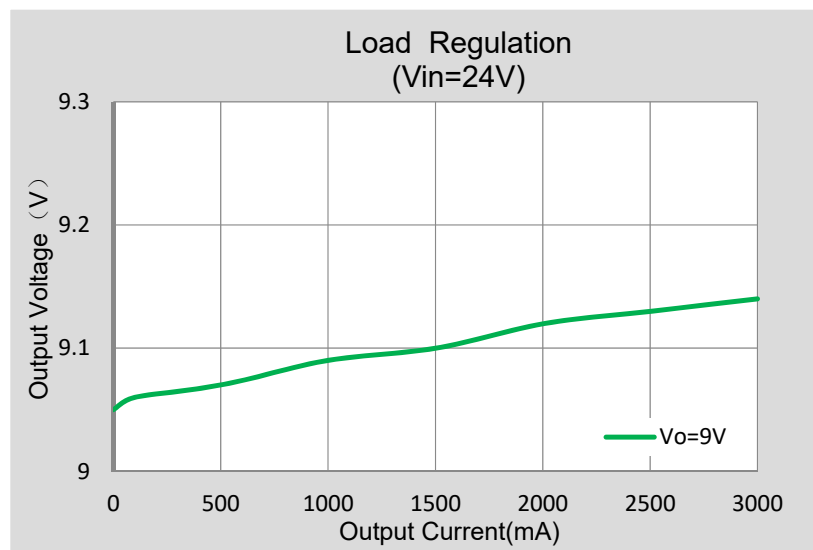
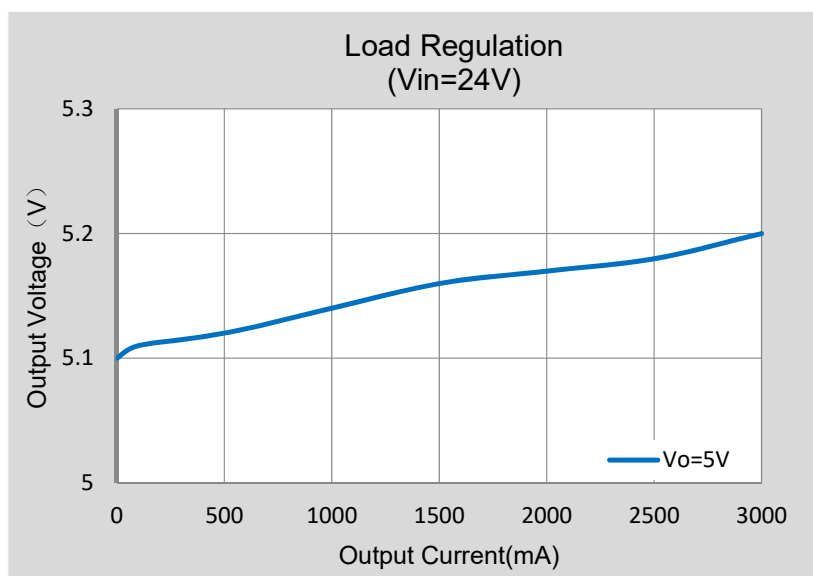


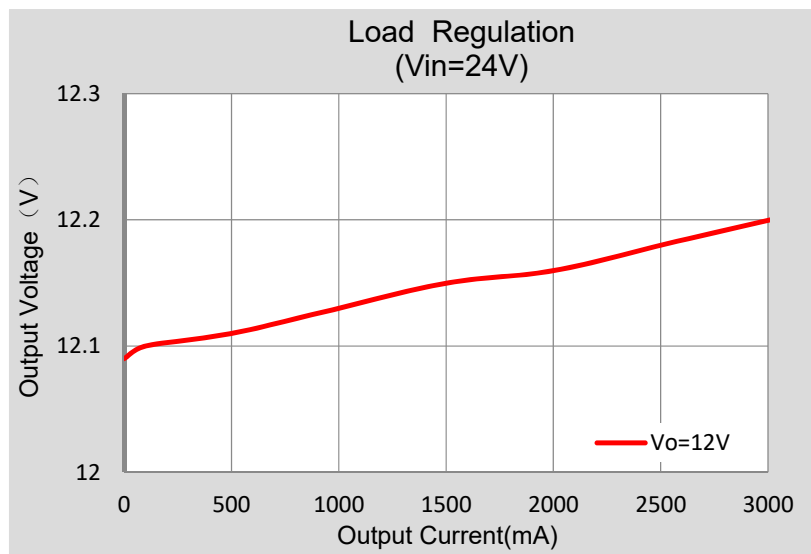


## Test Results

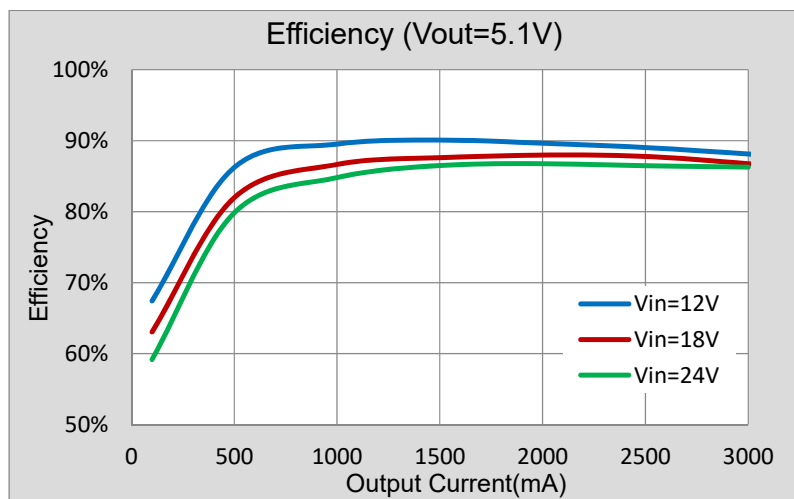
### Output Regulation

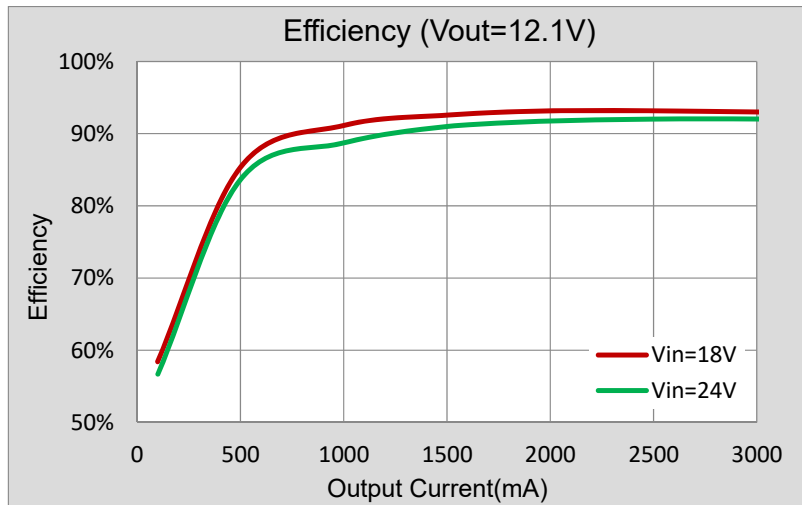
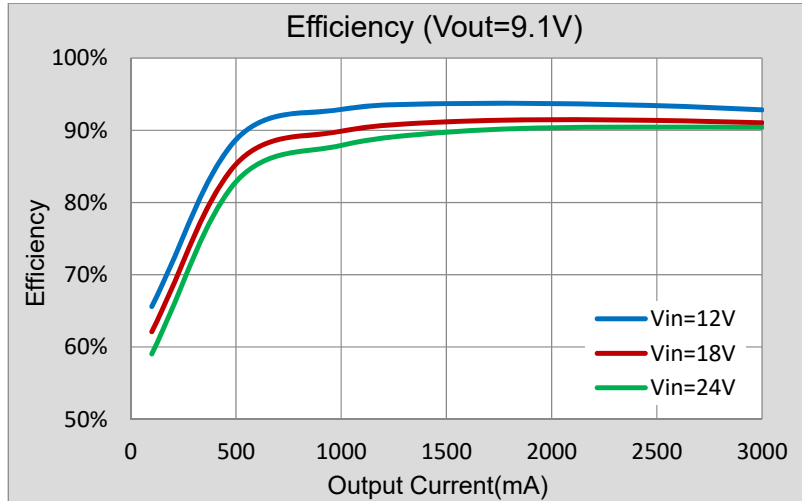
Float the PDC pin Vout is 5.1V, Connect the PDC pin to GND Vout is 9.1V, Connect the PDC pin to 3.3V(connect to C14) Vout is 12.1V. Set DC electronic load to CC mode. Increase output current from 0A to 3A and measure the output voltage on C3 capacitor.



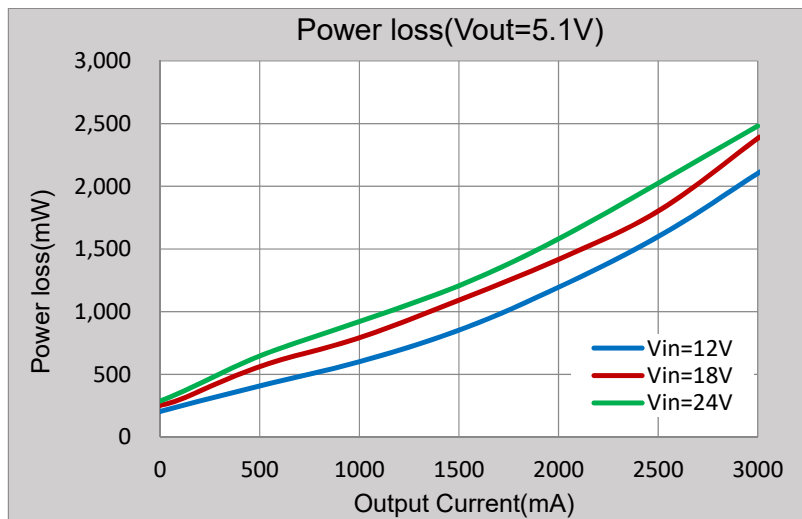


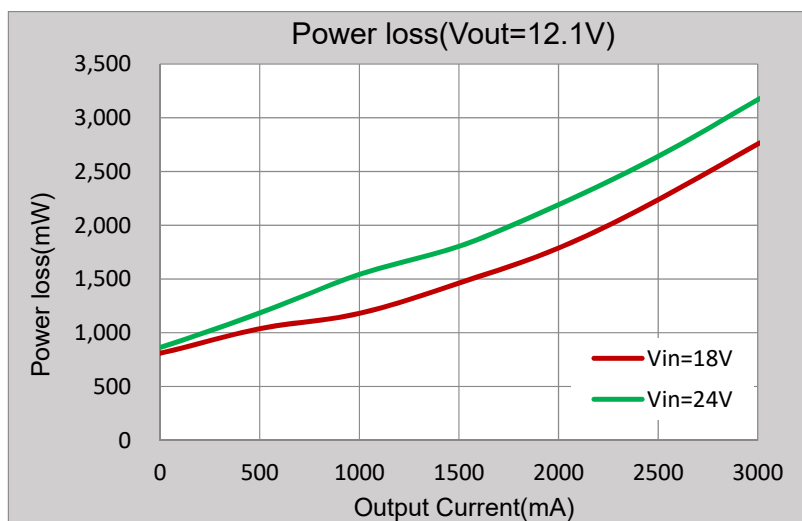
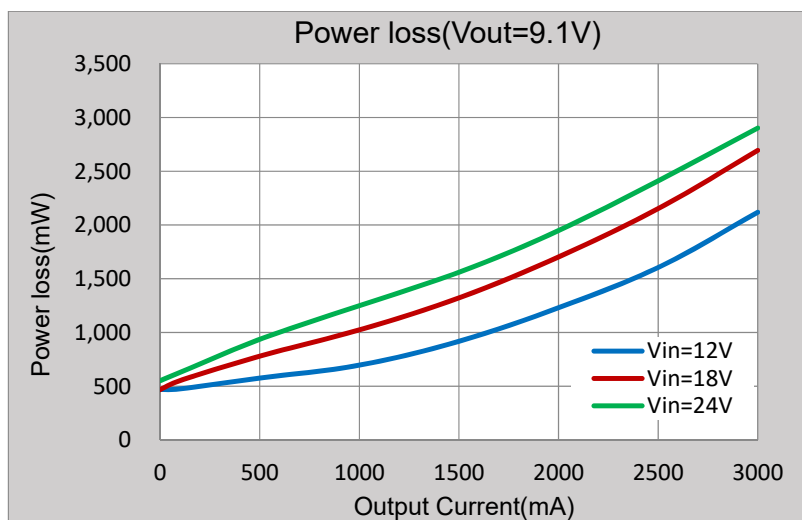
**Efficiency ( $T_a=25^{\circ}C$ )**





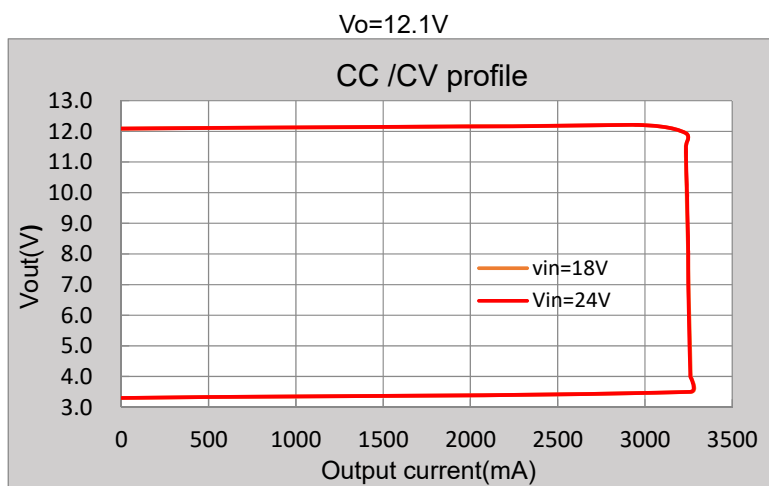
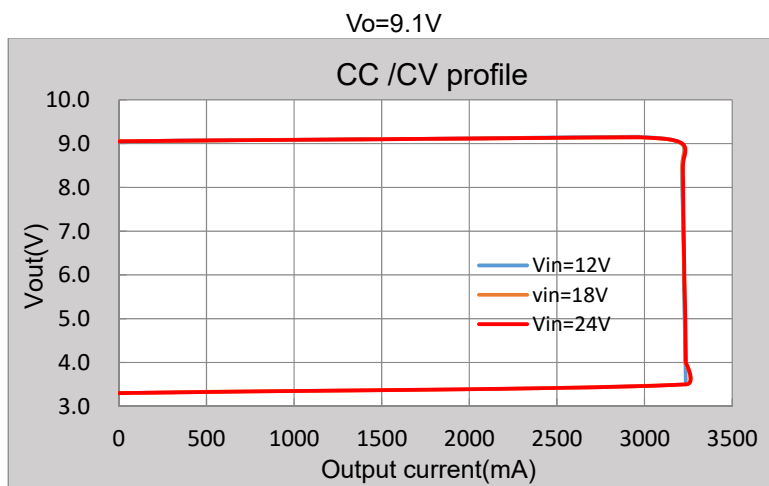
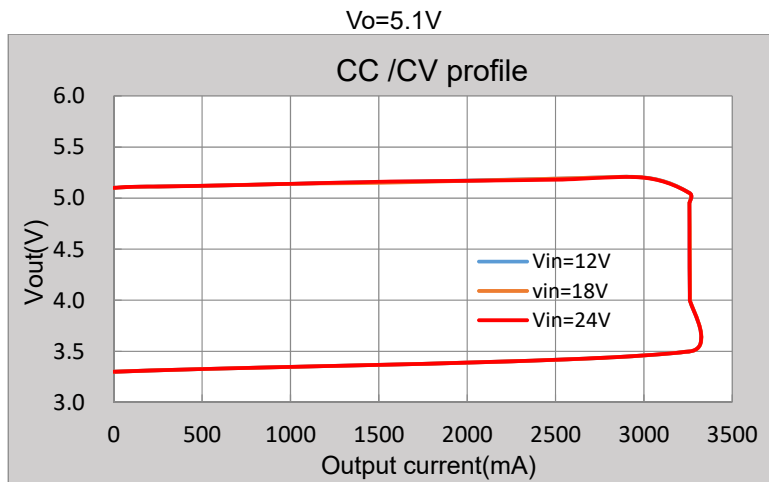
## Power Loss



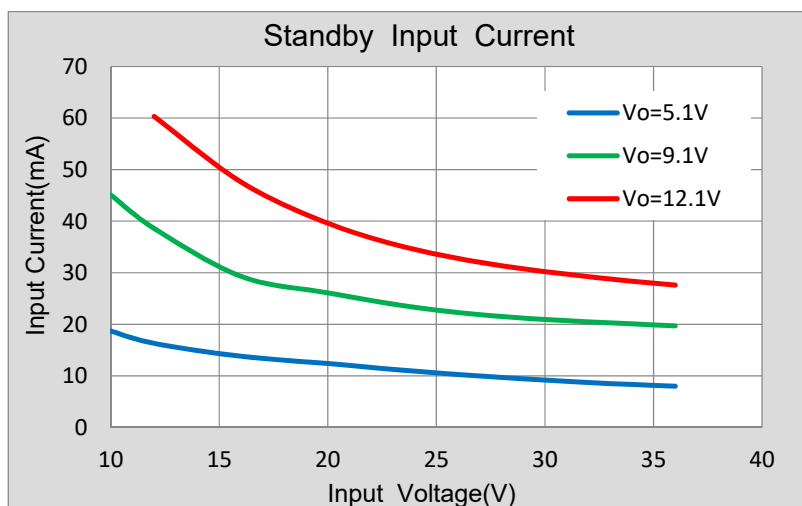


### Output Constant Current and Constant Voltage ( $T_a=25^{\circ}C$ )

Set DC load to CC mode, increase output current from 0A to the maximum load current and measure the voltage on the C3 capacitor. Then set DC electronic load to CV mode, decrease output voltage from maximum load voltage to 0V and measure the output current and the output voltage on the C3 capacitor.

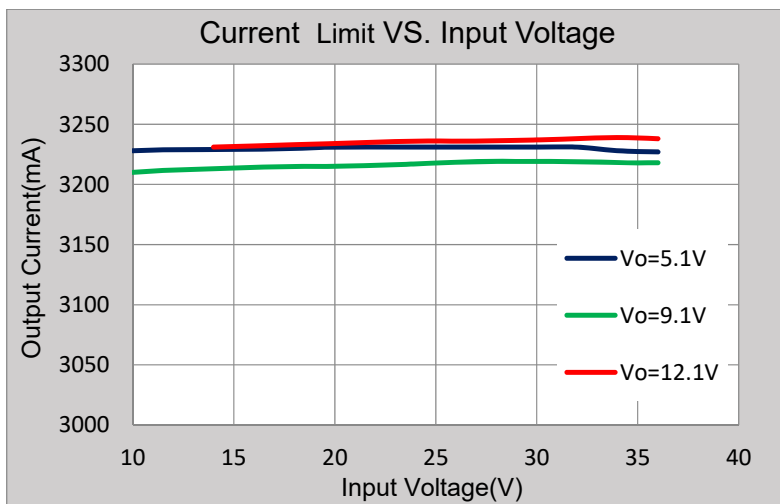


## Standby Input Current



## Current Limit vs. input voltage

Set DC electronic load to CV mode to measure the output current.

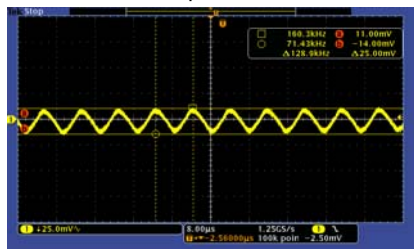


## Ripple and Noise

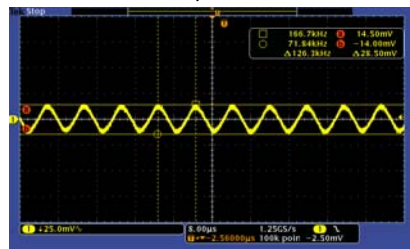
CH1 : Vout

Vo=5V

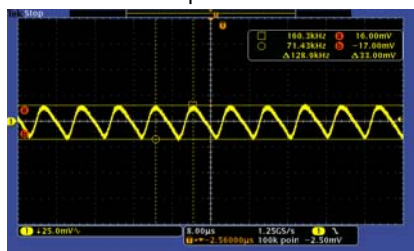
Vin=12V 1A output load



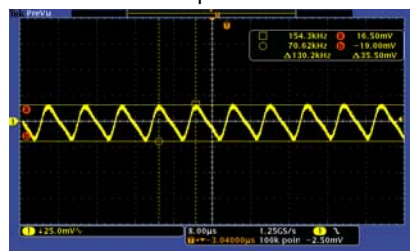
Vin=12V 3A output load



Vin=24V 1A output load

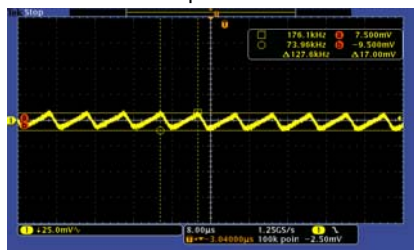


Vin=24V 3A output load

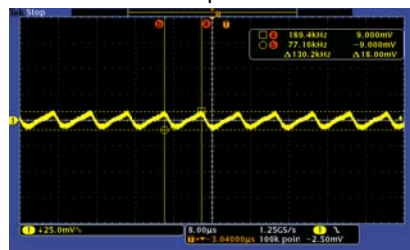


Vout=9V

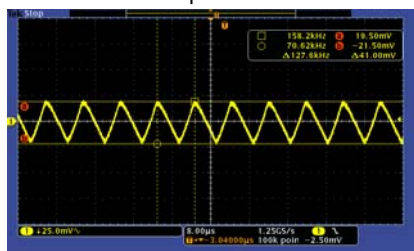
Vin=12V 1A output load



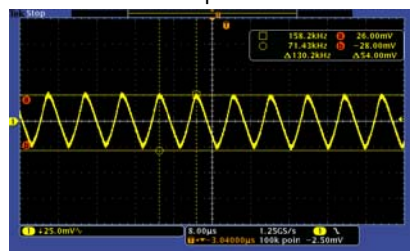
Vin=12V 3A output load



Vin=24V 1A output load

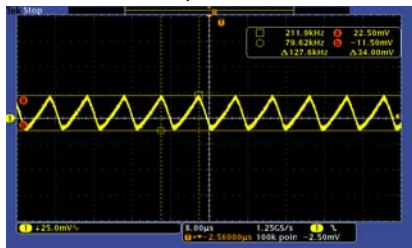


Vin=24V 3A output load

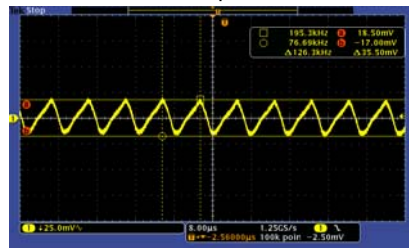


Vo=12V

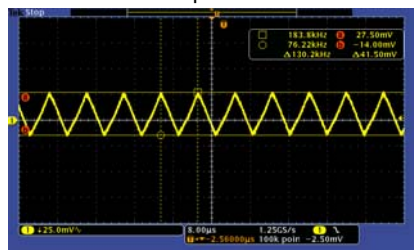
Vin=18V 1A output load



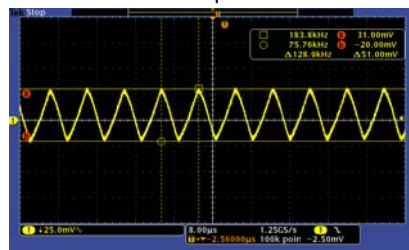
Vin=18V 3A output load



Vin=24V 1A output load



Vin=24V 3A output load



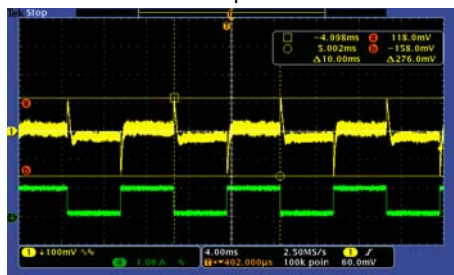
Ripple & noise are measured by using 100MHz bandwidth limited oscilloscope.

| Test Conditions |         | Output Ripple |           |
|-----------------|---------|---------------|-----------|
| Vout (V)        | Vin (V) | Io=1000mA     | Io=3000mA |
| 5.1             | 12      | 25.0mV        | 28.5mV    |
|                 | 24      | 33.0mV        | 35.5mV    |
| 9.1             | 12      | 17.0mV        | 18.0mV    |
|                 | 24      | 41.0mV        | 54.0mV    |
| 12.1            | 18      | 34.0mV        | 35.5mV    |
|                 | 24      | 41.5mV        | 51.0mV    |

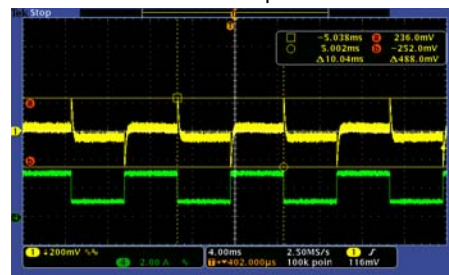
## Load Transient Response

CH1:Vout CH4:Iout

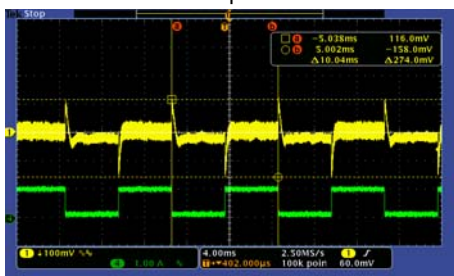
Vin=12V load step 80mA-1A -80mA



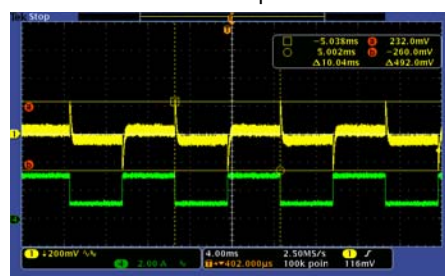
Vin=12V load step 1A-3A-1A



Vin=24V load step 80mA-1A -80mA



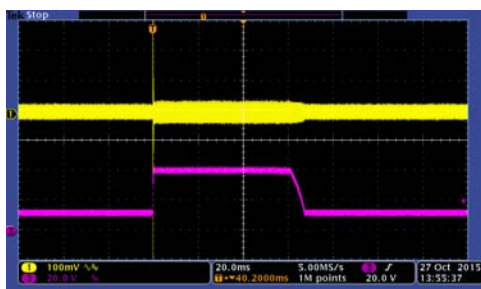
Vin=24V load step 1A-3A-1A



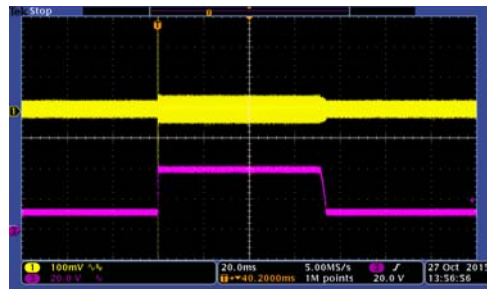
### Line Transient Response(Vin change from 12V to 40V, 1V/us)

CH1:Vout CH3:Vin

I<sub>out</sub>=1A



I<sub>out</sub>=3A



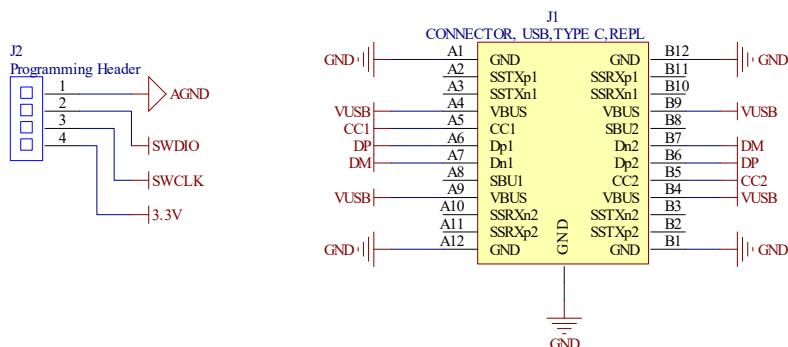
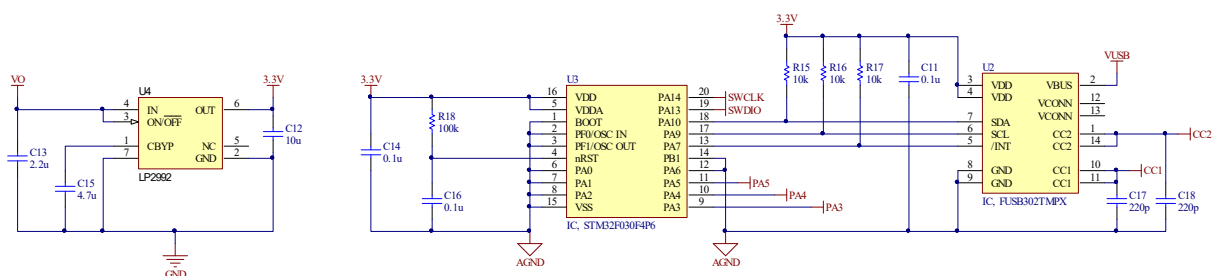
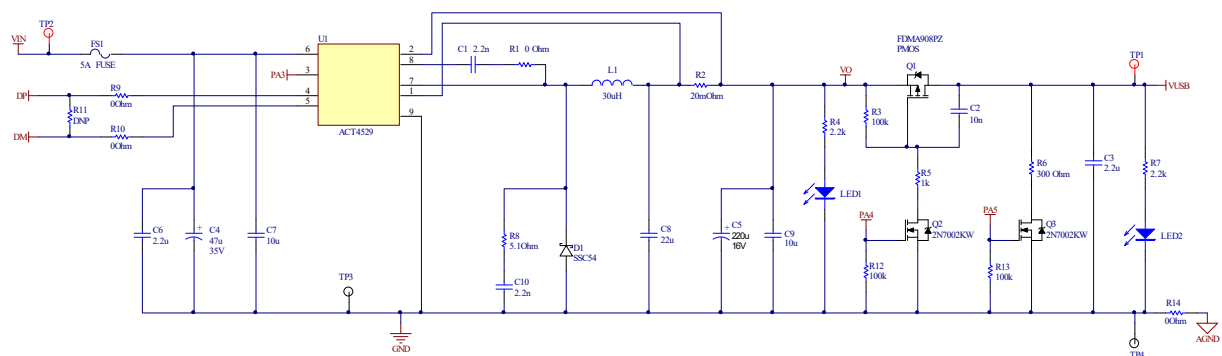
**Key Component Temperature Test**

(Ta=27deg C, after 1 hour steady state operation)

| Vout | Test condition<br>(Iout=3A) | Component temperature(°C) |     |               |     |       |          |
|------|-----------------------------|---------------------------|-----|---------------|-----|-------|----------|
|      |                             | Temp in CLA               | PCB | Output<br>Cap | IC  | Diode | Inductor |
| 5V   | 12V                         | 75                        | 90  | 89            | 96  | 105   | 103      |
|      | 24V                         | 81                        | 96  | 95            | 103 | 115   | 112      |
| 9V   | 12V                         | 85                        | 97  | 94            | 102 | 108   | 106      |
|      | 24V                         | 95                        | 111 | 108           | 122 | 129   | 122      |
| 12V  | 12V                         | 83                        | 105 | 104           | 114 | 114   | 116      |
|      | 24V                         | 89                        | 112 | 110           | 125 | 129   | 125      |



## Schematics



## Bill of Materials

| #  | Designator        | QTY | Description                                              | Package           | MFR                  | Manufacturer PN      |
|----|-------------------|-----|----------------------------------------------------------|-------------------|----------------------|----------------------|
| 1  | C1, C10           | 2   | Cap, Ceramic, 2.2nF, 25V, 10%, X5R                       | 0603              | Standard             |                      |
| 2  | C2                | 1   | Cap, Ceramic, 10nF, 16V, 10%, X5R                        | 0603              | Standard             |                      |
| 3  | C3, C13           | 2   | Cap, Ceramic, 2.2uF, 16V, 10%, X5R                       | 0603              | Standard             |                      |
| 4  | C4                | 1   | Cap, Electro, 47uF, 35V, 20%                             | 6.3*7*2.5mm       | SAMWHA               | A1V476M6L07KVR       |
| 5  | C5                | 1   | Cap, Electro, 220uF, 16V, 10%                            | 6.3*7mm           | HUAKAI               | SHK5227K0160607LLHT  |
| 6  | C6                | 1   | Cap, Ceramic, 2.2uF, 35V, 10%, X5R                       | 0805              | Standard             |                      |
| 7  | C7                | 1   | Cap, Ceramic, 10uF, 35V, 10%, X5R                        | 1206              | Standard             |                      |
| 8  | C8                | 1   | Cap, Ceramic, 22uF, 16V, 10%, X5R                        | 0805              | Standard             |                      |
| 9  | C9                | 1   | Cap, Ceramic, 10uF, 16V, 10%, X5R                        | 0805              | Standard             |                      |
| 10 | C11, C14, C16     | 3   | Cap, Ceramic, 0.1uF, 10V, 10%, X5R                       | 0603              | Standard             |                      |
| 11 | C12               | 1   | Cap, Ceramic, 10uF, 6.3V, 10%, X5R                       | 0603              | Standard             |                      |
| 12 | C15               | 1   | Cap, Ceramic, 4.7uF, 6.3V, 10%, X5R                      | 0603              | Standard             |                      |
| 13 | C17, C18          | 2   | Cap, Ceramic, 220pF, 10V, 10%, X5R                       | 0603              | Standard             |                      |
| 14 | D1                | 1   | Diode, Schottky, 40V, 5A                                 | SMC               | Standard             | SSC54                |
| 15 | FS1               | 1   | Fuse, 5A                                                 | 1206              | Littlefuse           | 1206SFS300F/32       |
| 16 | J1                | 1   | Connector, USB, Type C, Recept, Horizontal THT & SMT     | CON,UBS, TYPE-C,  | Wurth                | 632723300011         |
| 17 | J2                | 1   | Header, Unshrouded , 2.54mm, Male, 4P                    |                   | Wurth                | 61300411121          |
| 18 | L1                | 1   | Ind, Torroid, 30uH, 4.5A, 35mohm ESA31-00088F            | 6.5*13.2mm        | E&E Mag-netics       | 831-03915F           |
| 19 | LED1, LED2        | 2   | LED, Green                                               | 0603              | Wurth                | 150060VS75000        |
| 20 | Q1                | 1   | MOSFET, P-FET, 12V, 12.5mohm                             | MicroFET2X2       | FairChild            | FDMA908PZ            |
| 21 | Q2, Q3            | 2   | MOSFET, N-FET, 60V, 310mA                                | SOT323            | Standard             | 2N7002KW             |
| 22 | R1                | 1   | Res, 0Ohm                                                | 0603              | Standard             |                      |
| 23 | R2                | 1   | Res, 20mOhm, 1/4W, 1%                                    | 1206              | Standard             |                      |
| 24 | R3, R12, R13, R18 | 4   | Res, 100k, 1/16W, 5%                                     | 0603              | Standard             |                      |
| 25 | R4, R7            | 2   | Res, 2.2k, 1/16W, 5%                                     | 0603              | Standard             |                      |
| 26 | R5                | 1   | Res, 1k, 1/16W, 5%                                       | 0603              | Standard             |                      |
| 27 | R6                | 1   | Res, 300Ohm, 1/16W, 5%                                   | 0603              | Standard             |                      |
| 28 | R8                | 1   | Res, 5.1Ohm, 1/16W, 5%                                   | 0603              | Standard             |                      |
| 29 | R9, R10, R14      | 3   | Res, 0Ohm                                                | 0603              | Standard             |                      |
| 30 | R11               | 0   | Res, 100Ohm                                              | 0603              | Standard             |                      |
| 31 | R15, R16, R17     | 3   | Res, 10k, 1/16W, 5%                                      | 0603              | Standard             |                      |
| 32 | TP1, TP2          | 2   | TEST POINT PC MINI .040"D RED                            | tpt,keystone-5000 | Keystone Electronics |                      |
| 33 | TP3, TP4          | 2   | TEST POINT PC MINI .040"D BLACK                          | tpt,keystone-5001 | Keystone Electronics |                      |
| 34 | U1                | 1   | IC, ACT4529, Buck with QC2.0, USB Auto-Detect, USB-PD    | SO8-EP            | Active-Semi          | ACT4529YH-T1011      |
| 35 | U2                | 1   | IC, FUSB302TMPX, Programmable USB Type-C Controller w/PD | MLP-14            | FairChild            | FUSB302TMPX          |
| 36 | U3                | 1   | IC, STM32F030F4P6, MCU                                   | TSSOP-20          | ST                   | STM32F030F4P6        |
| 37 | U4                | 1   | IC, LDO, 250mA                                           | WS0N-6            | Standard             | LP2992A1LDX-3.3/NOPB |

|    |   |   |                  |  |           |                                                                                                  |
|----|---|---|------------------|--|-----------|--------------------------------------------------------------------------------------------------|
| 38 | - | 1 | PCB, PCB-0301-01 |  | Standard  | PCB-0301-01                                                                                      |
| 39 | - | 1 | Firmware         |  | FairChild | FUSB302_Release_3p3p4_STM32F03x_CLA_DEMO_5-3_9-3_12-3_36W_Rp-3A_noVDMs_Active-Semi_20APR2017.bin |

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