ON Semiconductor®

Automotive Dual 100W USB-PD Test Report

Strata
Developer Studio

December, 2018 – Rev. 0

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Introduction

USB-PD is the latest and most advanced fast charging protocol to date. The enclosed design is an Automotive Dual Port 100W per port design targeted for in-dash and infotainment systems to allow for future proof fast charging for all future devices, from ultra-low power wearable to power hungry notebook computers. This design uses ON Semiconductor’s NCV81599, Automotive 4-switch Buck-Boost, with ON’s FUSB302T USB Type-C Port Controller. Each rail is capable of providing the full 100W (20V at 5A), while providing additional protection logic to allow for a robust design and safe in-cabin fast charging. There is a power fold back curve implemented based on battery voltage and board temperature, to ensure that the battery isn’t excessively drained, leading to a dead battery and high on-board temperatures. This design is available in a consumer grade version and is suitable for USB Type-C DC-DC power applications in notebook and desktop computers, point-of-sale systems, or any USB Type-C system.

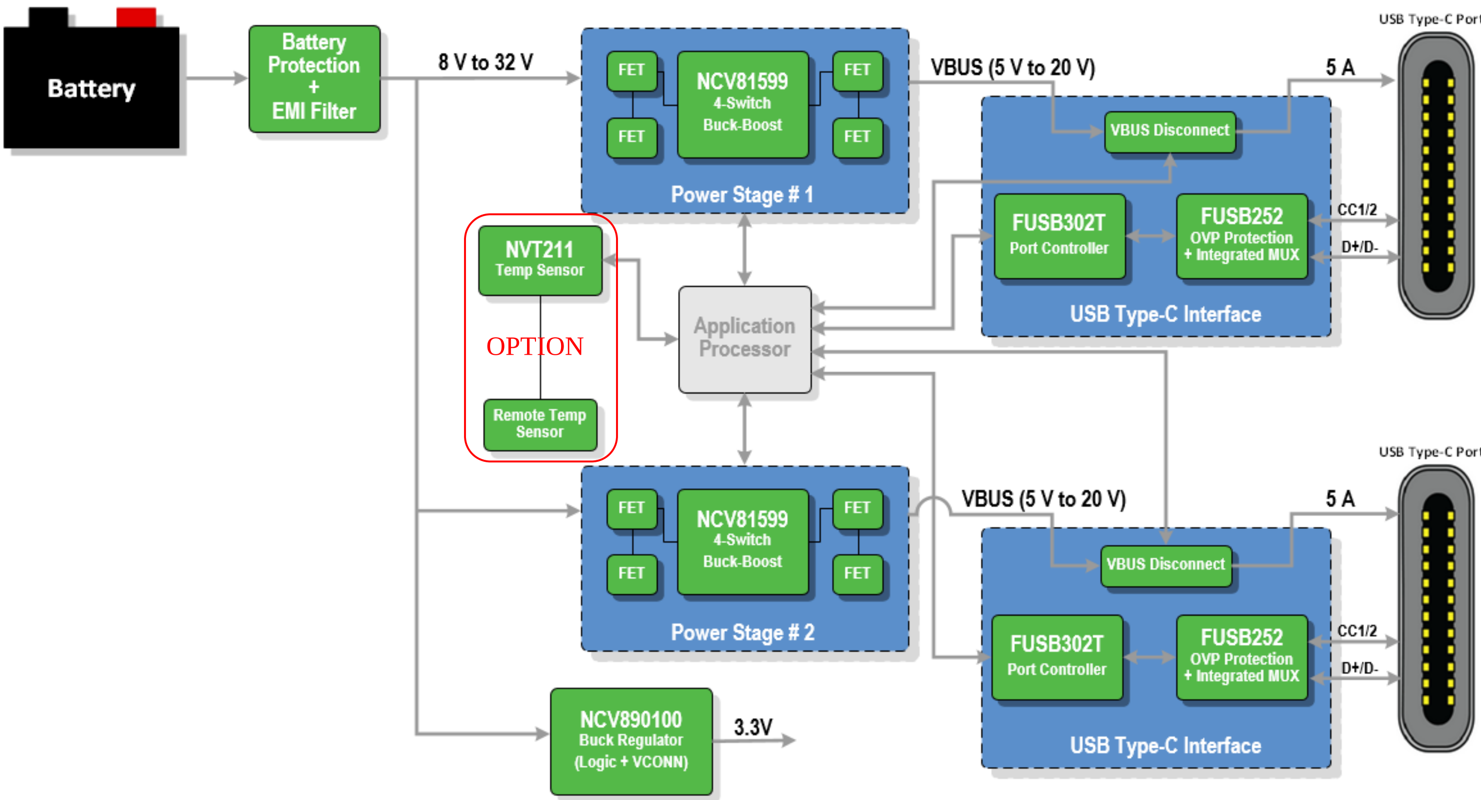
Features

- Dual USB Type-C Outputs
- Supports USB Power Delivery up to 100W per port
- Automotive Qualified Components
- Default PDO’s = 5V, 7V, 8V, 9V, 12V, 15V, 20V at 5A
- Input and Output Power Management / Monitoring
- Thermal and Battery Protection
- NCV81599 Buck-Boost + FUSB302T Port Controller More

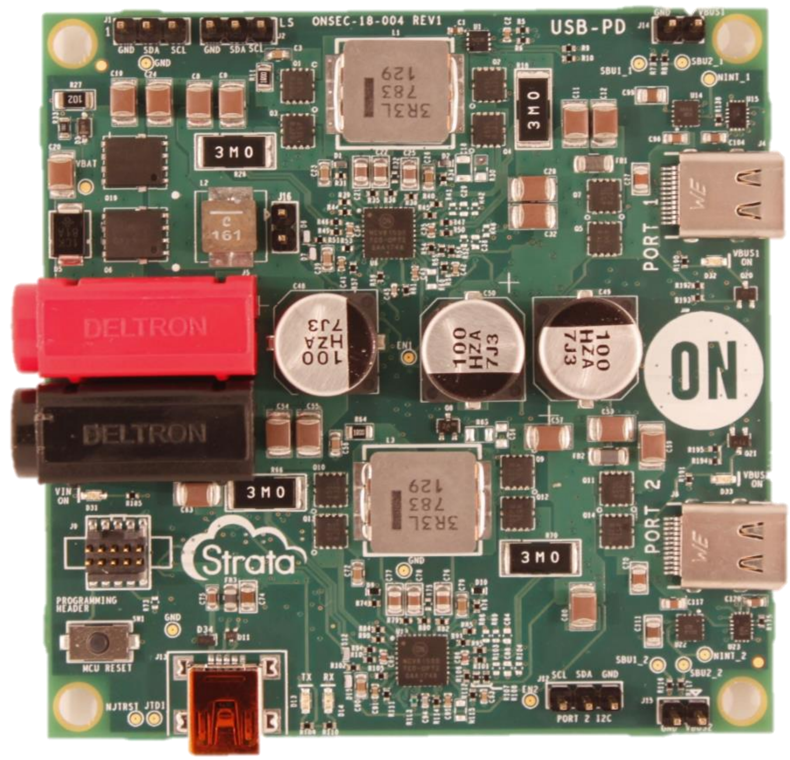
Applications

- Automotive Infotainment and Charging Systems
- Industrial and Commercial Transportation
- Marine Applications

Block Diagram



Board Picture



System Performance

Cable Attach / Detach

In USB Type-C systems there is no power in the cable while no device is attached (0V on VBUS). When a device is attached, VBUS will transition to 5V.

Below are images of an attach and detach event occurring.

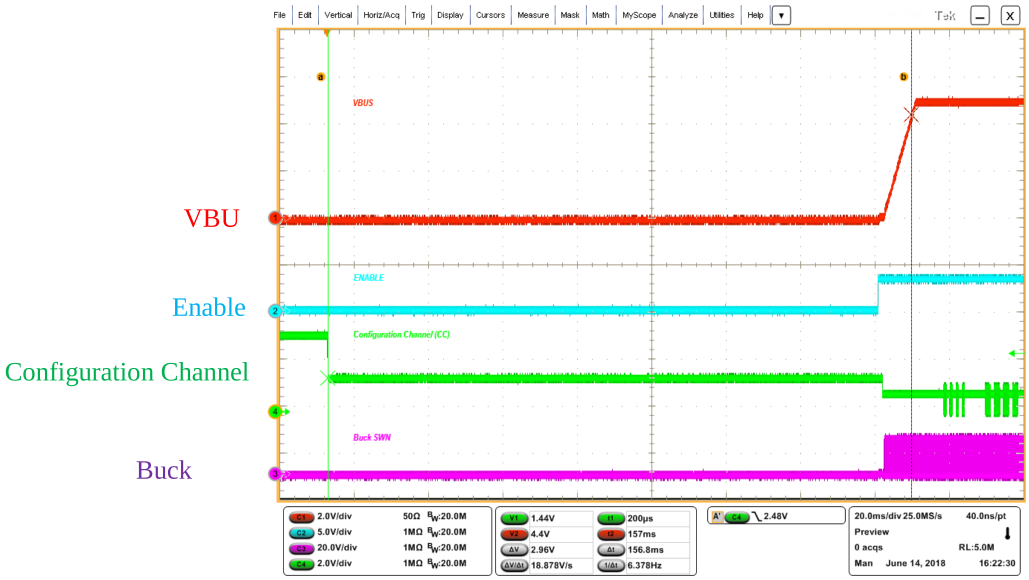


Figure 1 - Startup Waveform on Type-C Attach

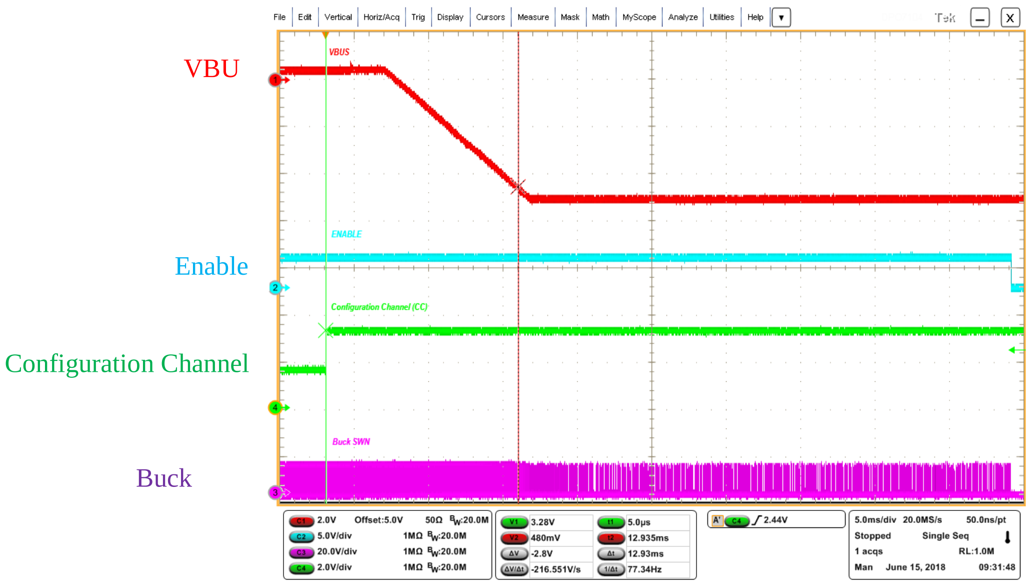


Figure 2 - Shutdown Waveform on Type-C Detach

USB-PD PDO Voltage Transitions

After USB Type-C attach, if USB Power Delivery is implemented, the Sink device is able to negotiate with the Source to get a higher voltage on VBUS to enable fast charging. All PD communications is done on the CC lines in the Type-C cable.

Below are images of VBUS voltage transitions from 5V to 12V, 5V to 20V, 12V to 5V, and 20V to 5V.

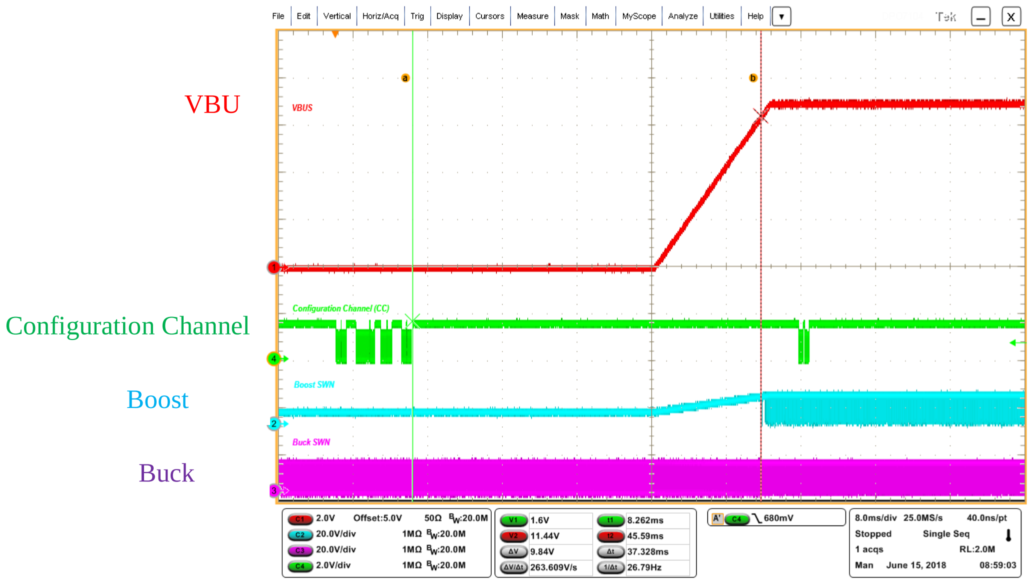


Figure 3 - 5V to 12V VBUS Transition

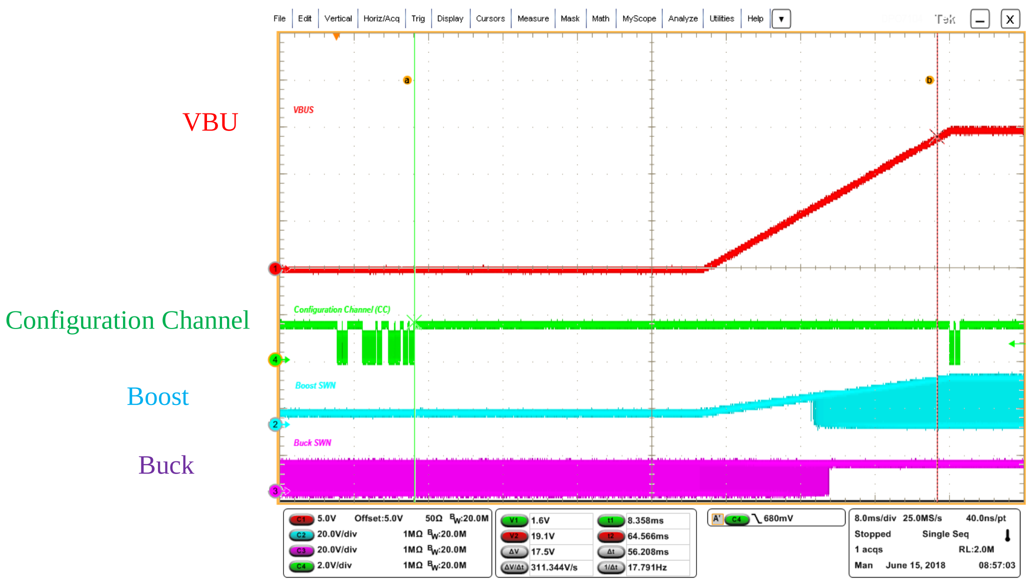


Figure 4 - 5V to 20V VBUS Transition

Figure 4 - 12V to 5V VBUS Transition

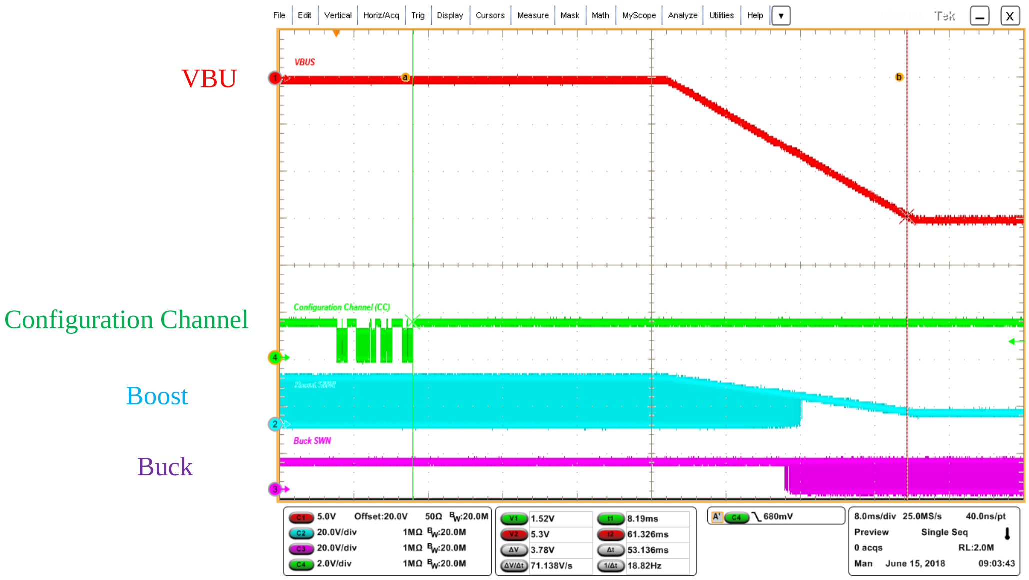


Figure 5 - 20V to 5V VBUS Transition

Cable Compensation

Due to higher current charging than legacy USB devices, there is a significant voltage drop in USB-PD systems. To combat this problem we have an active algorithm that monitors the output current and biases the VBUS voltage to account for the voltage drop seen by the sink device.

Below is an oscilloscope shot and Voltage v. Current plot showing cable compensation active.

Cable Comp default setting = 50mV bias @ 0.33A intervals.

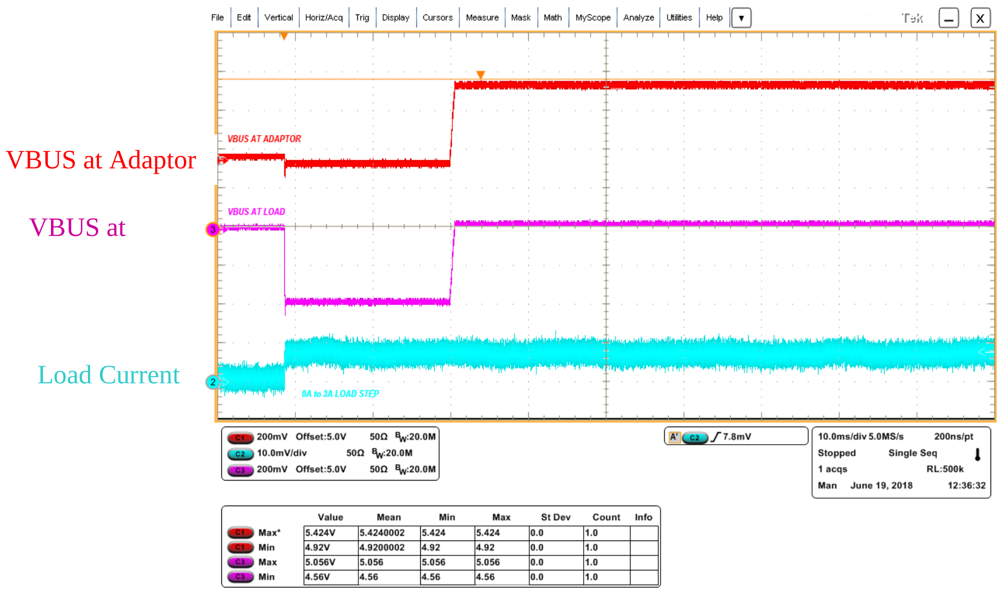


Figure 6 – 0.2A to 3A Load Step Event Resulting in 400MV VBUS Bias to Account for Cable Drop

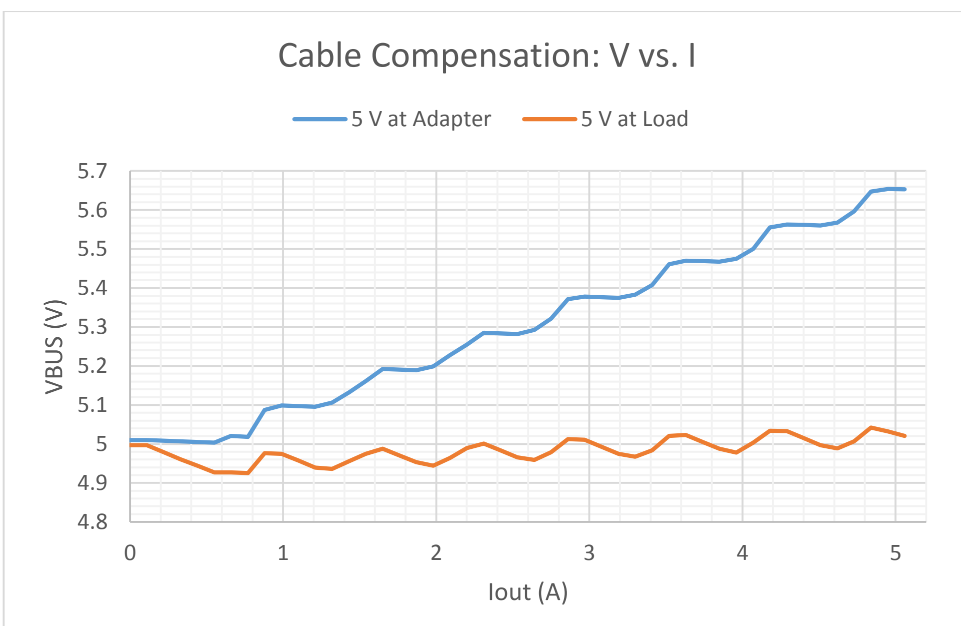


Figure 7 - Voltage vs. Current Plot Showing Default Cable Compensation

System Efficiency

Results Summary					
	5Vout at 12Vin - TC1	9Vout at 12Vin - TC2	15Vout at 12Vin - TC3	20Vout at 12Vin - TC4	12Vout at 12Vin
Load Line - AVERAGE	-	-	-	-	-
Board Resistance - AVERAGE	14.05 mOhm	23.61 mOhm	14.67 mOhm	12.19 mOhm	14.69 mOhm
Efficiency at TDC - POWERTRAIN	94.9%	98.2%	98.2%	97.2%	98.6%
Peak Efficiency - POWERTRAIN	95.2%	98.3%	98.2%	97.3%	98.7%
VR Power Loss at TDC	0.8 W	0.5 W	0.8 W	1.5 W	0.5 W
Board Resistance Loss at TDC	0.1 W	0.2 W	0.1 W	0.1 W	0.1 W

Thermal Performance

All data taken with no cooling and Tsoak time of 15min.

Figure 8 - Single Port: 13.5 Vin, 20 Vout at 3 A (60 W total)

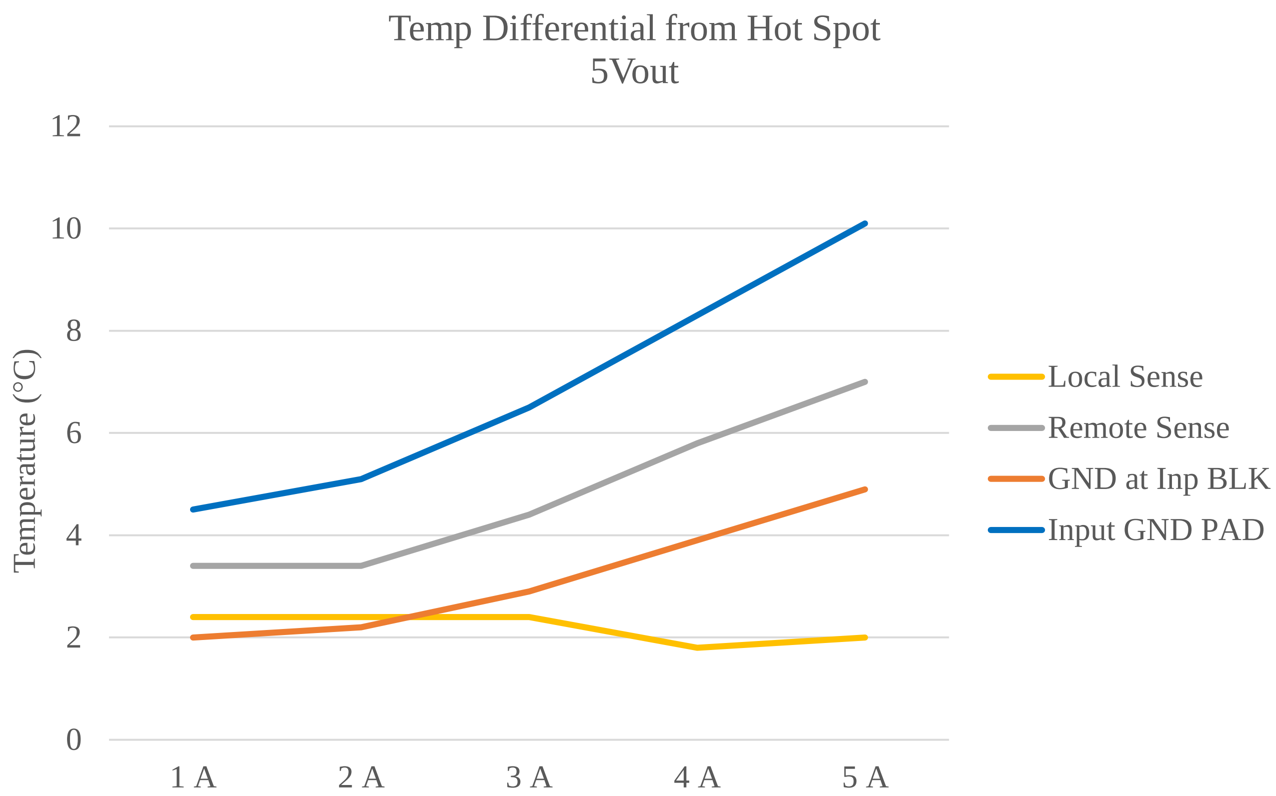
Figure 9 - Dual Port: 13.5 Vin, 20 Vout at 3 A each port (120 W total)

Figure 10 - Single Port: 13.5 Vin, 20 Vout at 5 A (100 W total)

Figure 11 - Dual Port: 13.5 Vin, 20 Vout at 5 A each port (200 W total)

On-Board Temp Sensor

The data below shows the difference in temperature from the boards maximum hot spot to the per port local temperature sense point. When the slope is positive it signifies the hotspot and sense point temperature moving away from each other. When the slope is negative it signifies that the sense point is getting closer to the temperature of the hot spot. All temperatures on the plot represent the temperature at which the sense point is below the max hot spot.



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