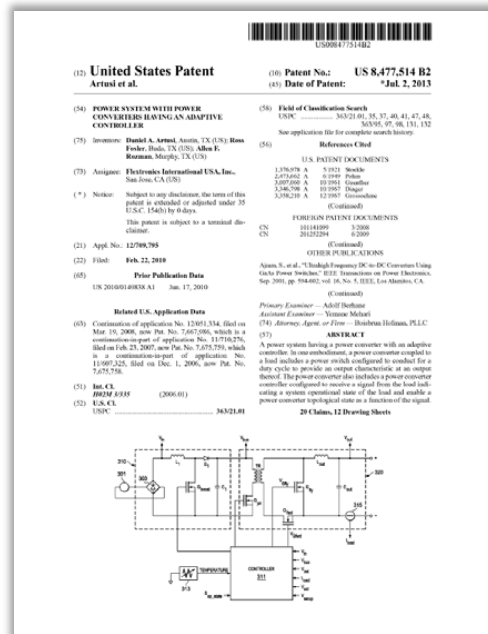


U.S. Patent No. 8,477,514 – Samsung EP-TA845



Title: POWER SYSTEM WITH POWER CONVERTERS HAVING AN ADAPTIVE CONTROLLER

Priority Date: Dec. 01, 2006

Filed Date: Feb. 22, 2010

Issued Date: Jul. 02, 2013

Expiration Date: Dec. 01, 2026

Inventors: Daniel A. Artusi; Ross Fosler; Allen F. Rozman

Claims: 6, 7, 8, 10



- All the claim elements identified herein are literally and equivalently present in the Accused Instrumentalities.
- For clarity, the portion of a cited reference that is relied upon for support may also be reproduced in the chart. Also, earlier, later or otherwise different versions of the reference may be available but not specifically cited.
- The portion of the Accused Instrumentality covered by a claim element is typically identified by an arrow and/or outlined in color. Such identification is exemplary, not exclusive or exhaustive. The Asserted Claims are open ended, not close ended or improperly restricted. Additional portions of the Accused Instrumentality might also be covered by the claim element but might not be identified in the chart.
- All quantitative figures, qualitative figures and data cited in the chart are subject to measurement and/or computational variation.

Claim 6

A **(SYS) power system**, comprising:

a **(PSC) power system controller** configured to provide a **(COM) signal** characterizing a **(PREQ) power requirement** of a **(PRO) processor system**; and

a **(PC) power converter** coupled to said **(PRO) processor system**, comprising:

a **(PS) power switch** configured to conduct for a **(DC) duty cycle** to provide an **(OC) output characteristic** at an **(OUT) output** thereof, and

a **(CON) power converter controller** configured to receive a **(COM) signal** from said **(PSC) power system controller** to control an **(IOC) internal operating characteristic** of said **(PC) power converter** as a function of said **(COM) signal**.

Claim 7

The **(SYS) power system** as recited in claim 6 wherein

said **(CON) power converter controller** is further configured to provide another **(OS) signal** to control said **(DC) duty cycle** of said **(PS) power switch** as a function of said **(OC) output characteristic** and in accordance with said **(COM) signal**.

Claim 8

The **(SYS) power system** as recited in claim 6 wherein said **(CON) power converter controller** is configured to adjust said **(IOC) internal operating characteristic** over a **(TTIM) period of time**.

Claim 10

The **(SYS) power system** as recited in claim 6 wherein said **(IOC) internal operating characteristic** is selected from the group consisting of:

a gate drive voltage level of said **(PS) power switch** of said **(PC) power converter**,

a switching frequency of said **(PC) power converter**, and

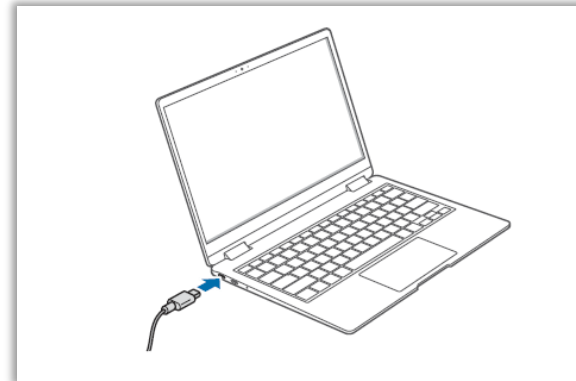
an **(DCBV) internal direct current bus voltage** of said **(PC) power converter**.

Claim 6

A (SYS) power system, comprising:



Samsung Electronics America, Inc., User Manual for Samsung Galaxy S21 5G, S21+ 5G, and S21 Ultra 5G at p. 8 (2021).

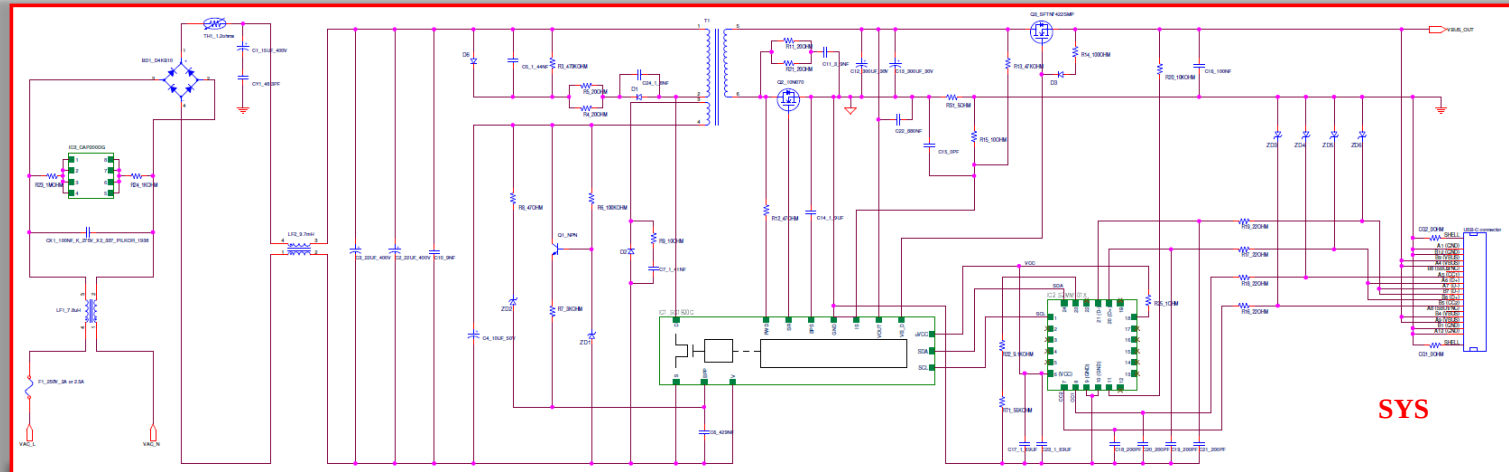


Samsung Electronics Co., Ltd., Users Guide for Samsung EP-TA865 at p. 71.

These are typical examples of Samsung generally instructing users of its power converters to couple them to loads.

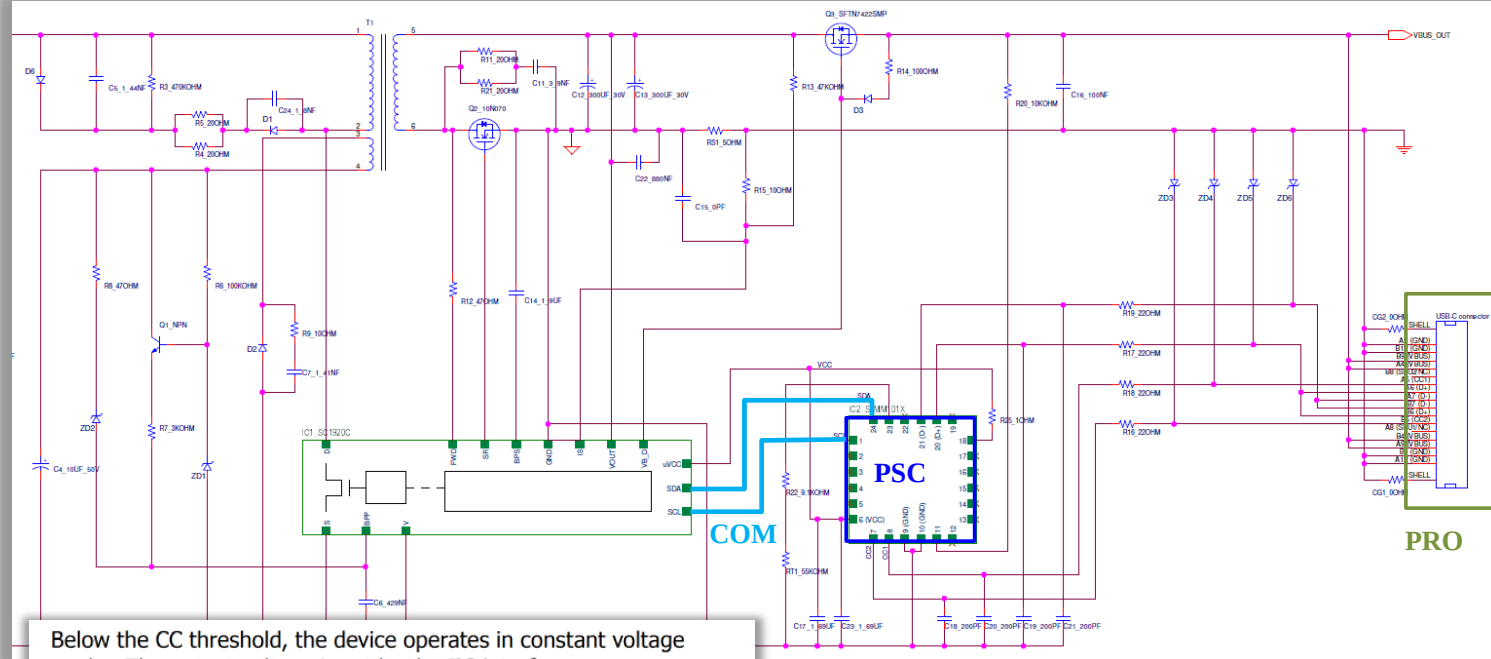
Claim 6

A (SYS) power system, comprising:



Claim 6

a **(PSC) power system controller** configured to provide a **(COM) signal** characterizing a **(PREQ) power requirement** of a **(PRO) processor system**; and



Below the CC threshold, the device operates in constant voltage mode. The output voltage is set by the I²C interface.

In this design, (U2) is the USB PD controller. It gets its supply from the μ VCC pin of the InnoSwitch3-Pro IC. Output voltage requests are sent by the IC (U2) to InnoSwitch3-Pro through the I²C communication lines (SDA and SCL) when sink requests for the same. The μ VCC pin needs a decoupling capacitor C14.

PREQ

USB PD protocol is communicated over either CC1 or CC2 line depending on the orientation in which the Type-C plug is connected.

Source(s): [2]

InnoSwitch3-Pro Functional Description

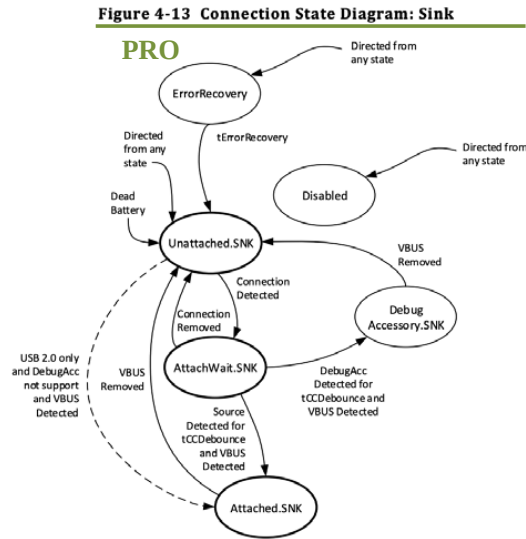
The InnoSwitch3-Pro combines a high-voltage power MOSFET switch, along with both primary-side and secondary-side controllers in one device.

The architecture incorporates a novel inductive coupling feedback scheme using the package lead frame and bond wires to provide a safe, reliable, and low-cost means to communicate accurate direct sensing of the output voltage and output current on the secondary IC to the primary IC.

Claim 6

a (PSC) power system controller configured to provide a (COM) signal characterizing a (PREQ) power requirement of a (PRO) processor system; and

Figure 4-13 illustrates a connection state diagram for a simple Sink (Device/Hub UFP).

**4.5.2.2.5 Attached.SNK State**

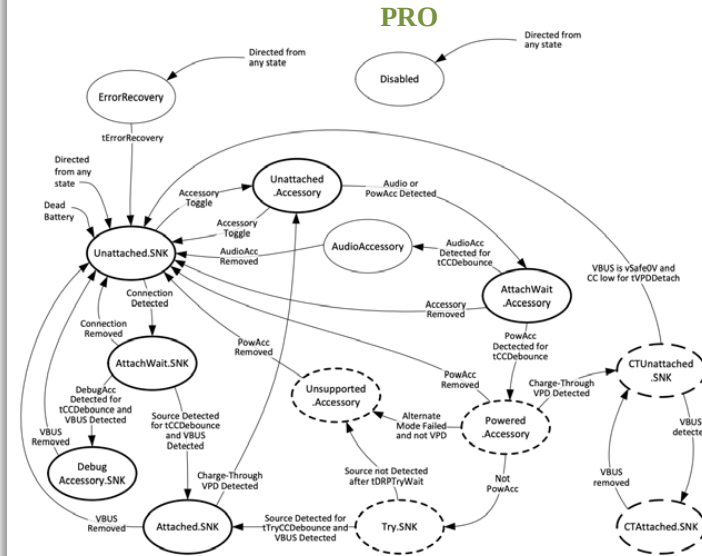
This state appears in Figure 4-13, Figure 4-14, Figure 4-15, Figure 4-16, Figure 4-17 and Figure 4-18.

When in the Attached.SNK state, the port is attached and operating as a Sink. When the port initially enters this state it is also operating as a UFP. The power and data roles can be changed using USB PD commands. **PREQ**

A port that entered this state directly from Unattached.SNK due to detecting VBUS shall not determine orientation or availability of higher than Default USB Power and shall not use USB PD.

Source(s): [1]

Figure 4-14 illustrates a connection state diagram for a Sink that supports Accessory Modes.

Figure 4-14 Connection State Diagram: Sink with Accessory Support**4.5.2.2.5.1 Attached.SNK Requirements**

If the port needs to determine the orientation of the connector, it shall do so only upon entry to this state by detecting which of the CC1 or CC2 pins is connected through the cable (i.e., the CC pin that is in the SNK.Rp state).

If the port supports signaling on SuperSpeed USB pairs, it shall functionally connect the SuperSpeed USB pairs and maintain the connection during and after a USB PD PR_Swap.

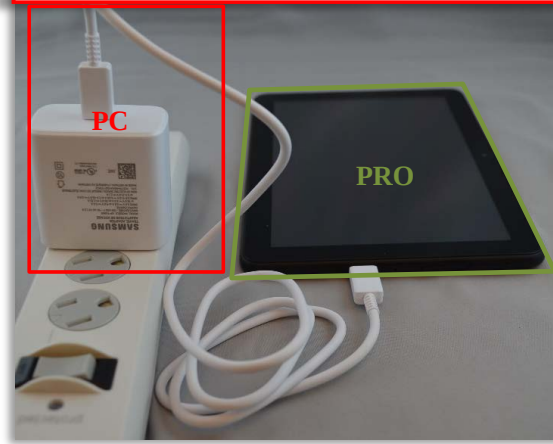
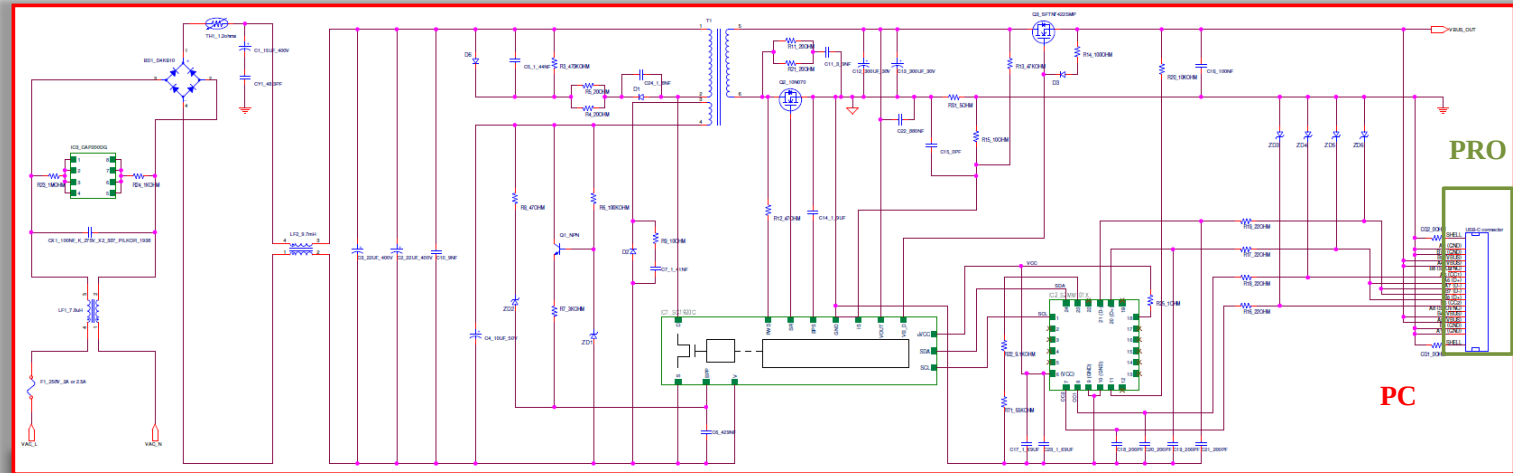
If the port has entered the Attached.SNK state from the AttachWait.SNK or TryWait.SNK states, only one the CC1 or CC2 pins will be in the SNK.Rp state. The port shall continue to terminate this CC pin to ground through Rd.

If the port has entered the Attached.SNK state from the Attached.SRC state following a USB PD PR_Swap, the port shall terminate the connected CC pin to ground through Rd.

The port shall meet the Sink Power Sub-State requirements specified in Section 4.5.2.2.22.

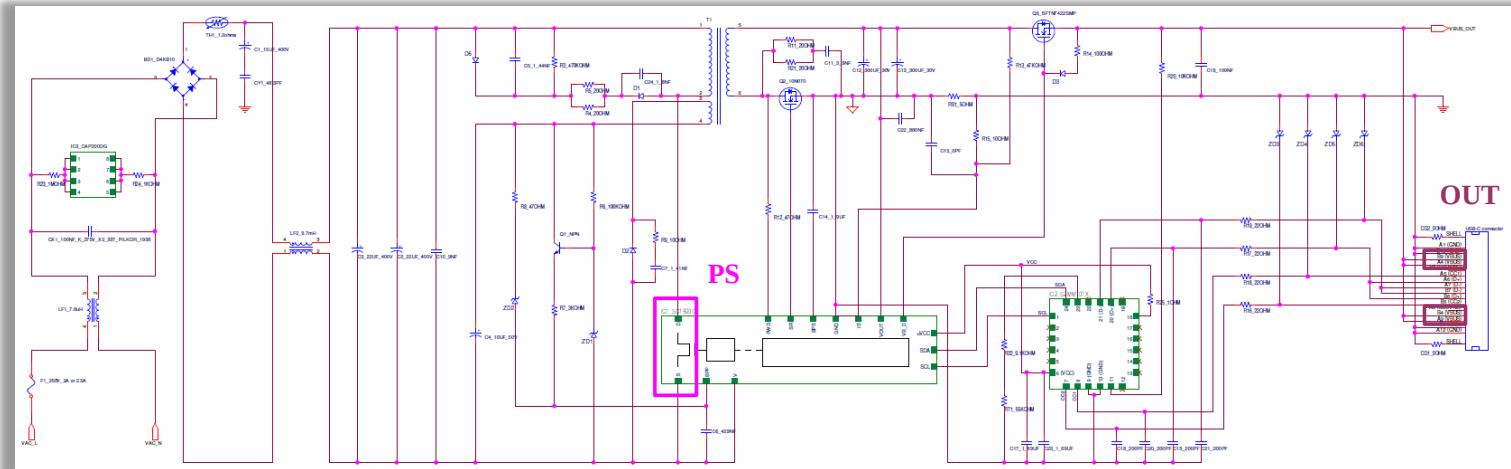
Claim 6

a (PC) power converter coupled to said (PRO) processor system, comprising:



Claim 6

a **(PS) power switch** configured to conduct for a **(DC) duty cycle** to provide an **(OC) output characteristic** at an **(OUT) output** thereof, and



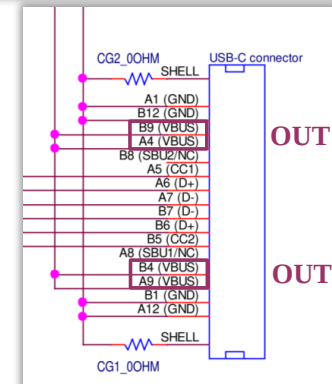
4.5 Configuration Channel (CC)

4.5.1 Architectural Overview

For the USB Type-C solution, two pins on the connector, CC1 and CC2, are used to establish and manage the Source-to-Sink connection. When the device is connected through a hub, the connection between a Sink (UFP) on the hub and the Source (host port) and the connection between the Sink (device port) and a Source (DFP on the hub), are treated as separate connections. Functionally, the configuration channel is used to serve the following purposes.

- Detect attach of USB ports, e.g. a Source to a Sink
- Resolve cable orientation and twist connections to establish USB data bus routing
- Establish data roles between two attached ports
- Discover and configure Vbus: USB Type-C Current modes or USB Power Delivery

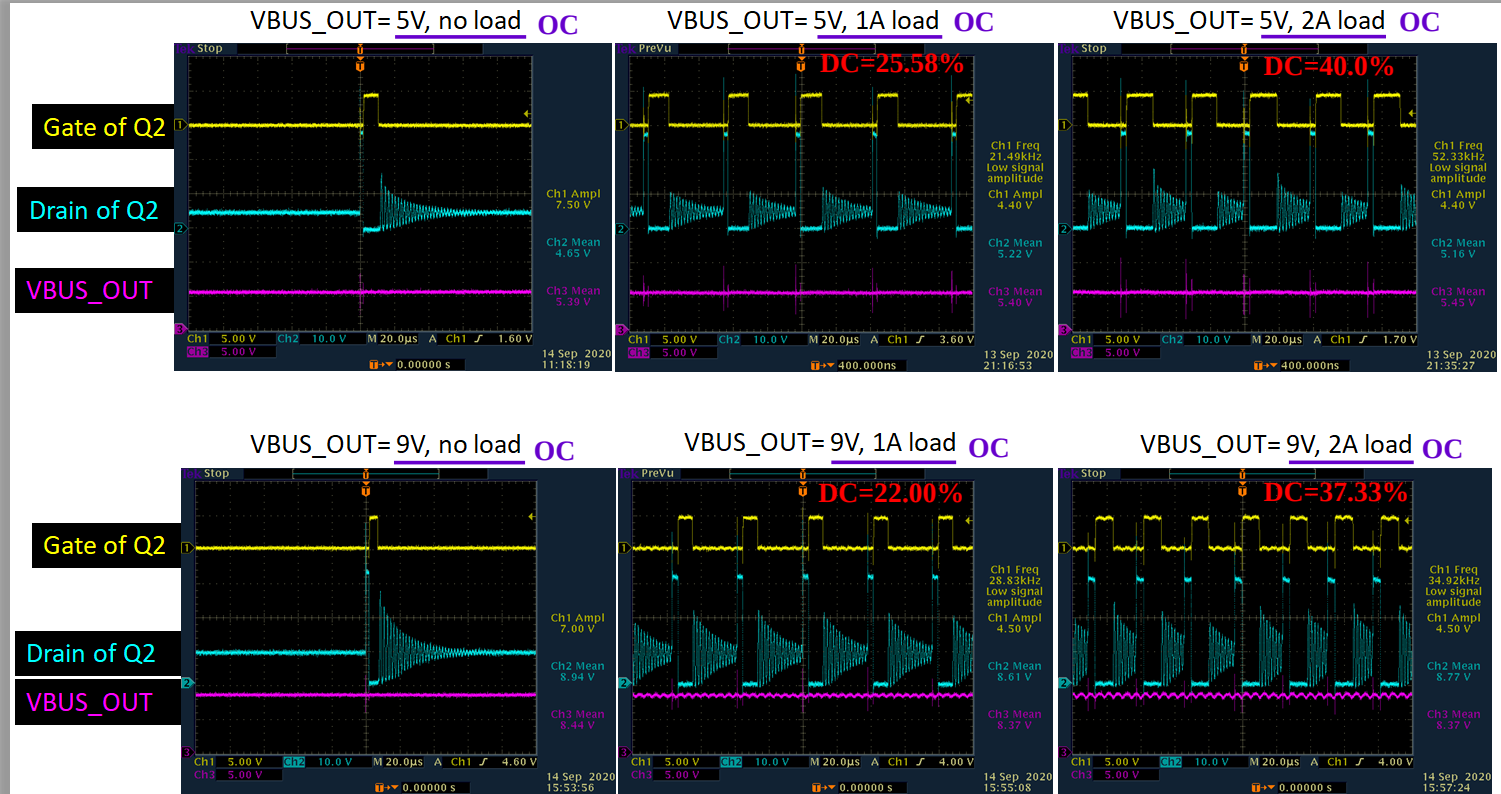
OC



Source(s): [1]

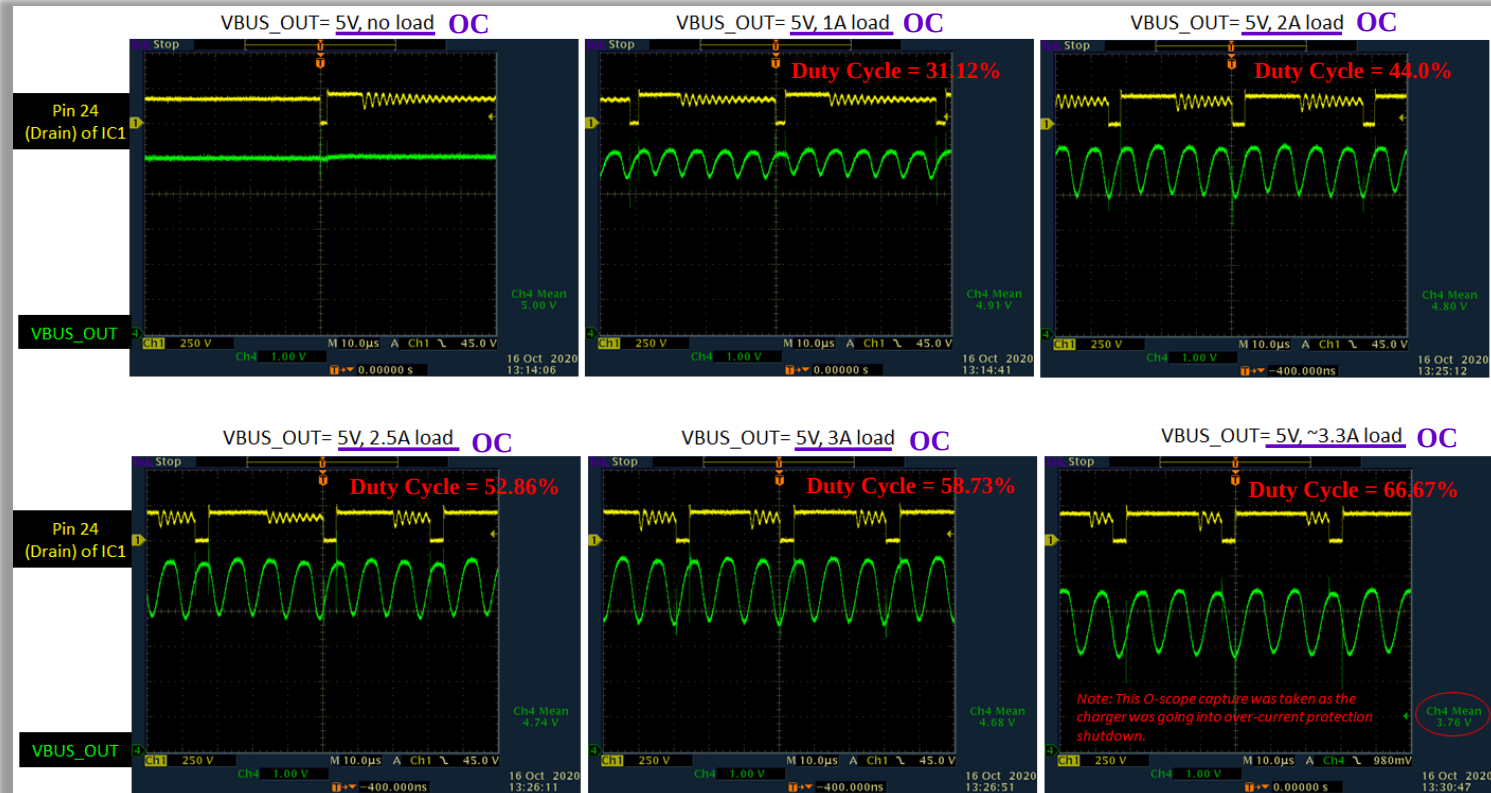
Claim 6

a (PS) power switch configured to conduct for a (DC) duty cycle to provide an (OC) output characteristic at an (OUT) output thereof, and



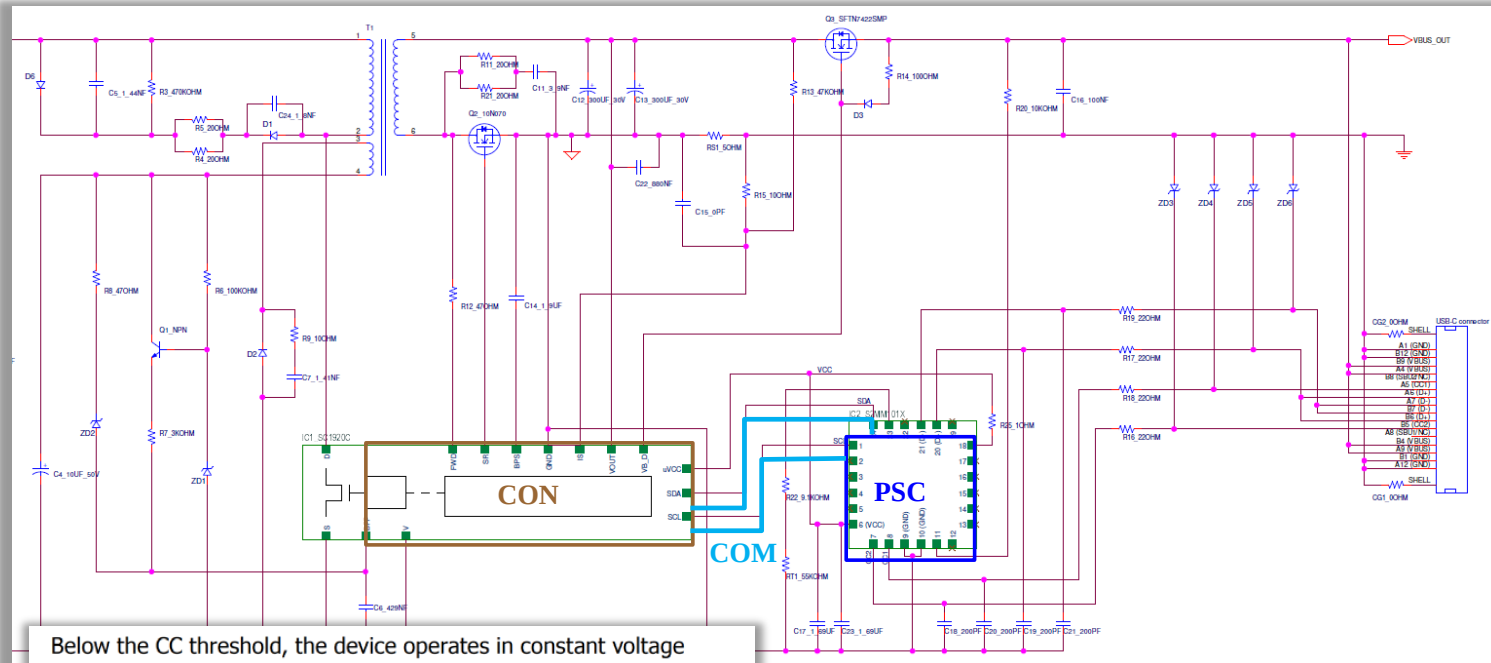
Claim 6

a (PS) power switch configured to conduct for a (DC) duty cycle to provide an (OC) output characteristic at an (OUT) output thereof, and



Claim 6

a **(CON) power converter controller** configured to receive a **(COM) signal** from said **(PSC) power system controller** to control an **(IOC) internal operating characteristic** of said **(PC) power converter** as a function of said **(COM) signal**.



Below the CC threshold, the device operates in constant voltage mode. The output voltage is set by the I²C interface.

In this design, (U2) is the USB PD controller. It gets its supply from the μ VCC pin of the InnoSwitch3-Pro IC. Output voltage requests are sent by the IC (U2) to InnoSwitch3-Pro through the I²C communication lines (SDA and SCL) when sink requests for the same. The μ VCC pin needs a decoupling capacitor C14.

USB PD protocol is communicated over either CC1 or CC2 line depending on the orientation in which the Type-C plug is connected.

Source(s): [2]

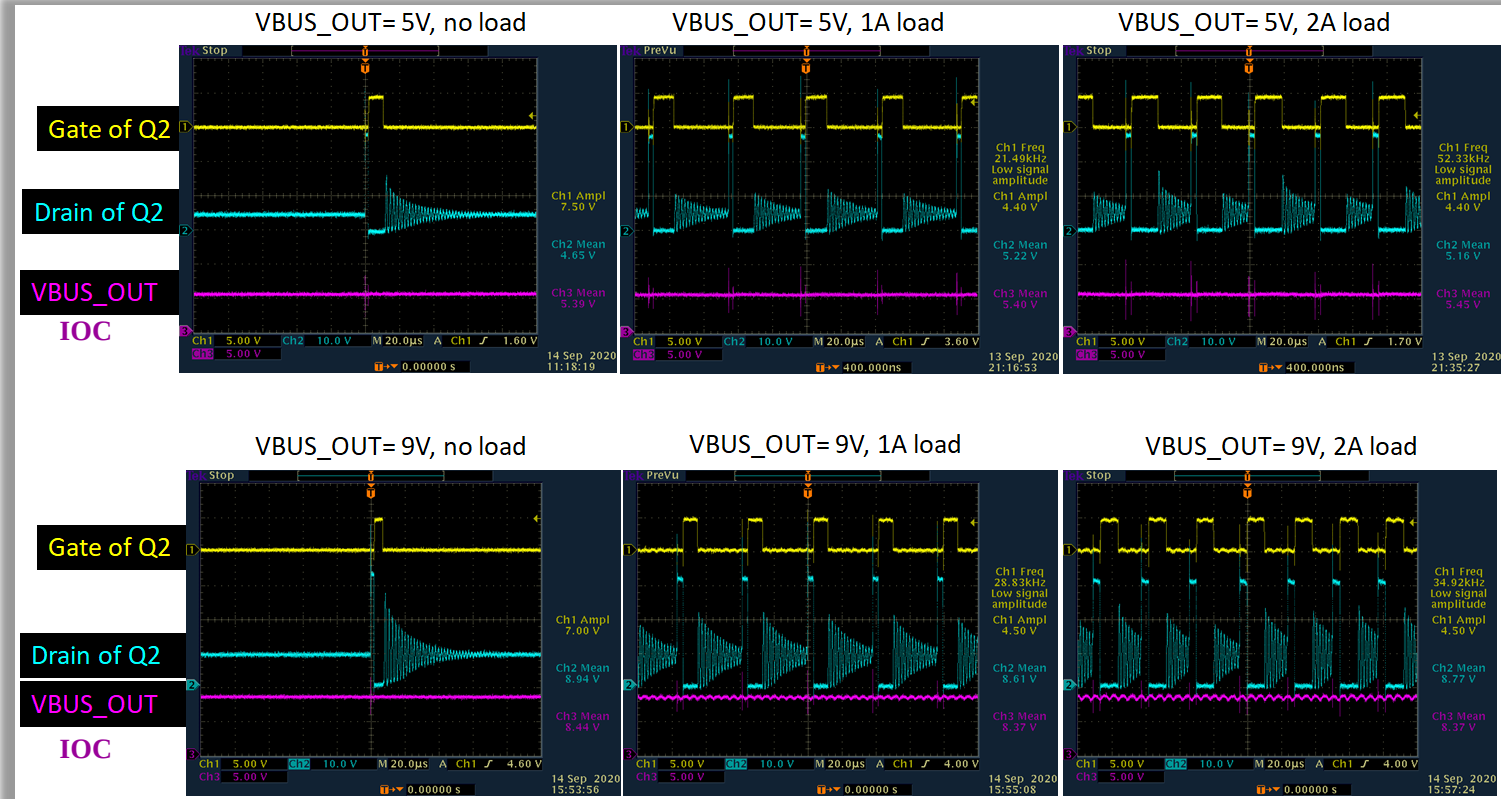
InnoSwitch3-Pro Functional Description

The InnoSwitch3-Pro combines a high-voltage power MOSFET switch, along with both primary-side and secondary-side controllers in one device.

The architecture incorporates a novel inductive coupling feedback scheme using the package lead frame and bond wires to provide a safe, reliable, and low-cost means to communicate accurate direct sensing of the output voltage and output current on the secondary IC to the primary IC.

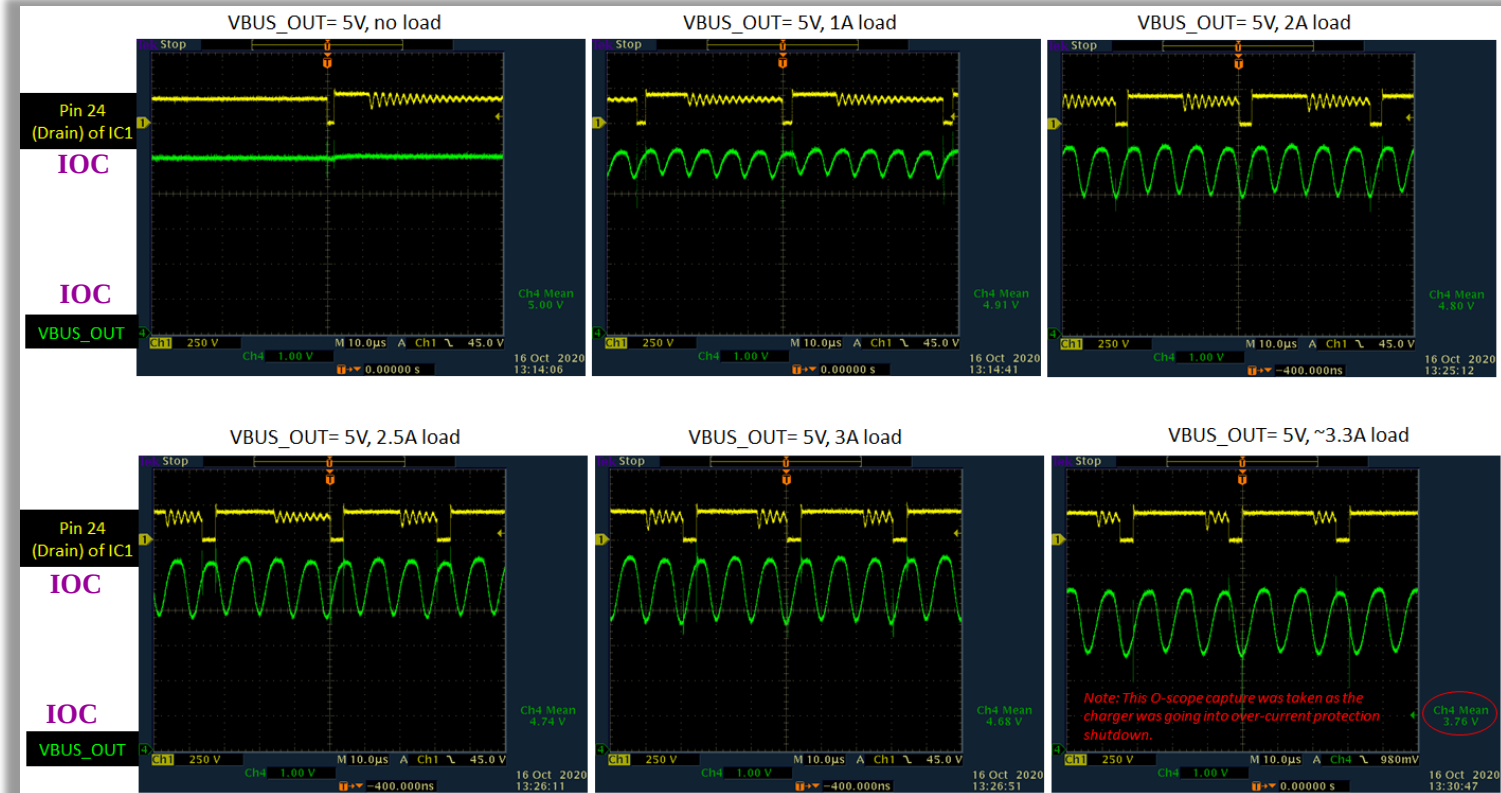
Claim 6

a **(CON) power converter controller** configured to receive a **(COM) signal** from said **(PSC) power system controller** to control an **(IOC) internal operating characteristic** of said **(PC) power converter** as a function of said **(COM) signal**.



Claim 6

a **(CON) power converter controller** configured to receive a **(COM) signal** from said **(PSC) power system controller** to control an **(IOC) internal operating characteristic** of said **(PC) power converter** as a function of said **(COM) signal**.



Ch1 -Duty 17.13 %
Low resolution
Ch2 Mean 1.36 V

Ch3 Mean 3.13mV
Ch4 Mean 4.97 V

Ch1 250 V Ch2 2.00 V M1.00ms A Ch2 320mV
Ch3 2.00 V Ch4 5.00 V 4.000000ms

13 Oct 2020 16:29:48

CON

In this design, (U2) is the USB PD controller. It gets its supply from the μ VCC pin of the InnoSwitch3-Pro IC. Output voltage requests are sent by the IC (U2) to InnoSwitch3-Pro through the I²C communication lines (SDA and SCL) when sink requests for the same. The μ VCC pin needs a decoupling capacitor C14.

COM

Pin 24 (Drain)
of IC1

IOC

CC1

CC2

VBUS_OUT

lek Stop

Ch1 - Duty 14.49 %

Ch2 Mean 1.61 V

Ch3 Mean 26.4mV

Ch4 Mean 7.66 V

Ch1 250 V Ch2 2.00 V M 20.0ms A Ch2 320mV

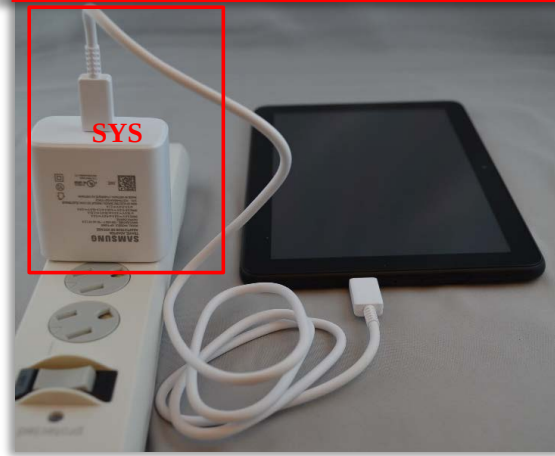
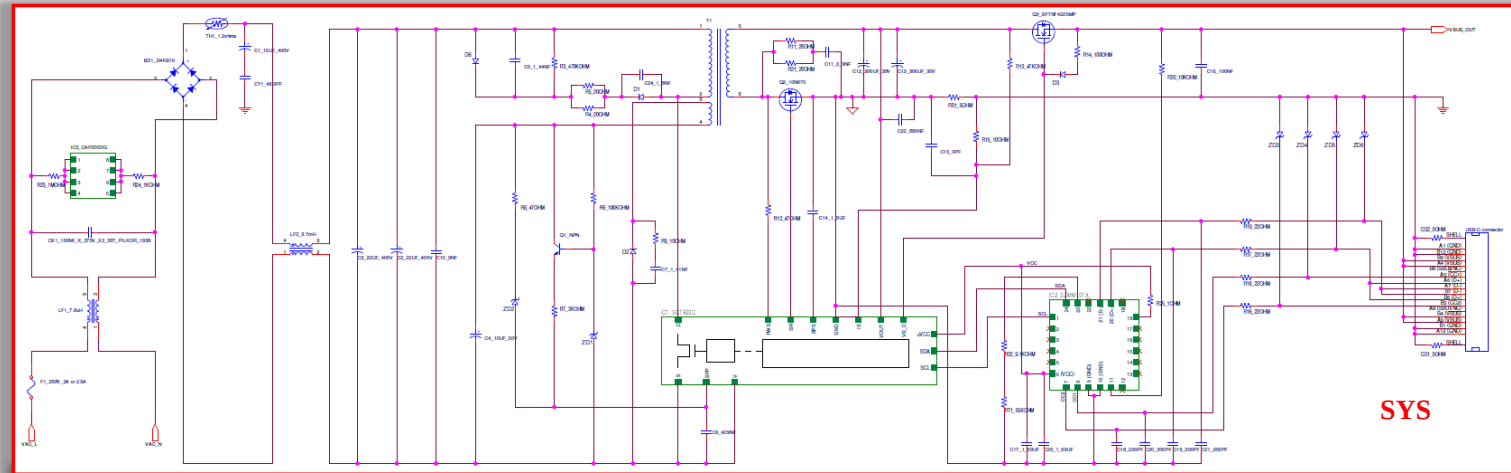
Ch3 2.00 V Ch4 5.00 V

13 Oct 202 16:28:02

14

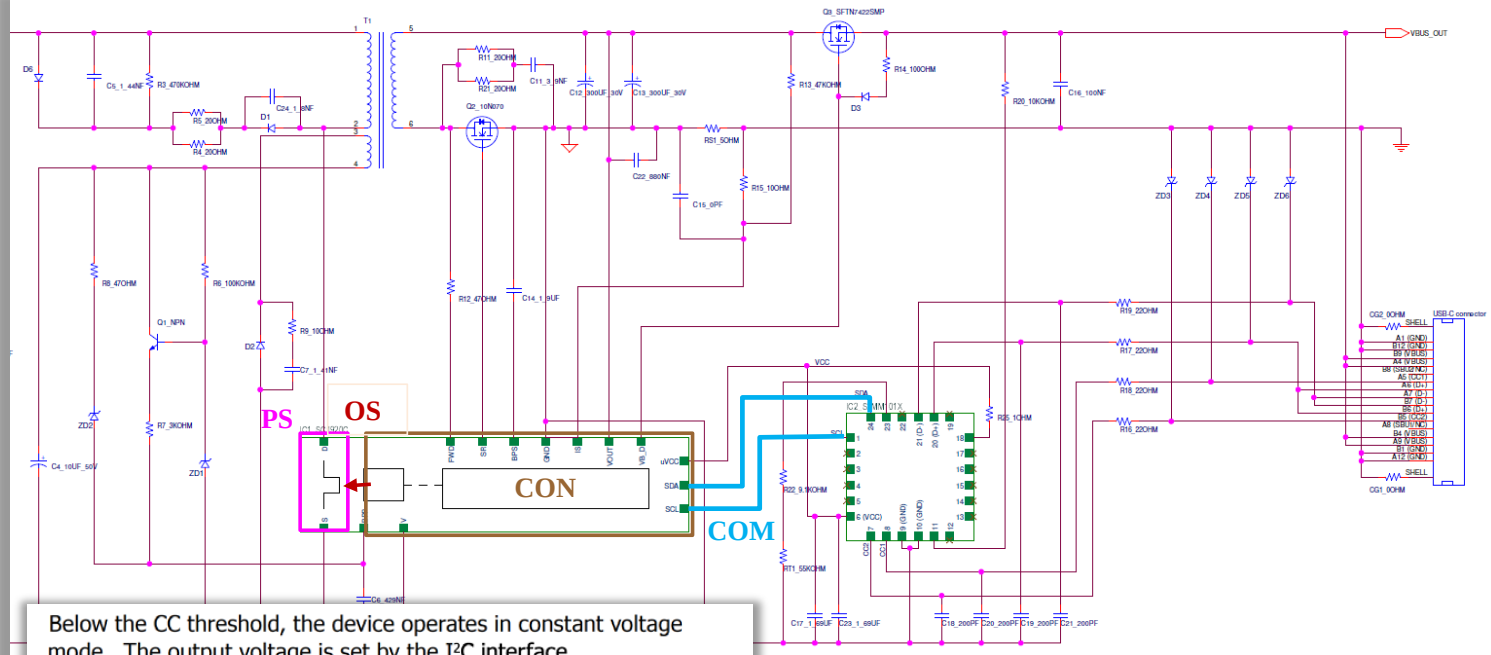
Claim 7

The **(SYS) power system** as recited in claim 6 wherein



Claim 7

said **(CON) power converter controller** is further configured to provide another **(OS) signal** to control said **(DC) duty cycle** of said **(PS) power switch** as a function of said **(OC) output characteristic** and in accordance with said **(COM) signal**.



Below the CC threshold, the device operates in constant voltage mode. The output voltage is set by the I²C interface.

In this design, (U2) is the USB PD controller. It gets its supply from the μ VCC pin of the InnoSwitch3-Pro IC. Output voltage requests are sent by the IC (U2) to InnoSwitch3-Pro through the I²C communication lines (SDA and SCL) when sink requests for the same. The μ VCC pin needs a decoupling capacitor C14.

USB PD protocol is communicated over either CC1 or CC2 line depending on the orientation in which the Type-C plug is connected.

Source(s): [2]

InnoSwitch3-Pro Functional Description

The InnoSwitch3-Pro combines a high-voltage power MOSFET switch, along with both primary-side and secondary-side controllers in one device.

The architecture incorporates a novel inductive coupling feedback scheme using the package lead frame and bond wires to provide a safe, reliable, and low-cost means to communicate accurate direct sensing of the output voltage and output current on the secondary IC to the primary IC.

Claim 7

said (CON) **power converter controller** is further configured to provide another (OS) **signal** to control said (DC) **duty cycle** of said (PS) **power switch** as a function of said (OC) **output characteristic** and in accordance with said (COM) **signal**.

Switching Frequency (F_{sw})

It is a unique feature in InnoSwitch3-Pro ICs that a designer can set the switching frequency at full load between 25 kHz to 95 kHz depending on the design specification. To have lower device temperature, the switching frequency can be set to around 60 kHz. To have smaller size transformer, the switching frequency needs to be set to a value closer to a maximum of 95 kHz. When setting the full load switching frequency, it is important to consider primary inductance and peak current tolerances to ensure that average switching frequency does not exceed 110 kHz which may trigger auto-restart due to overload protection. The following table provides a guide for frequency selection based on the device size. This represents the best compromise between the overall device losses (conduction and switching losses) based on size of the internal high-voltage MOSFET.

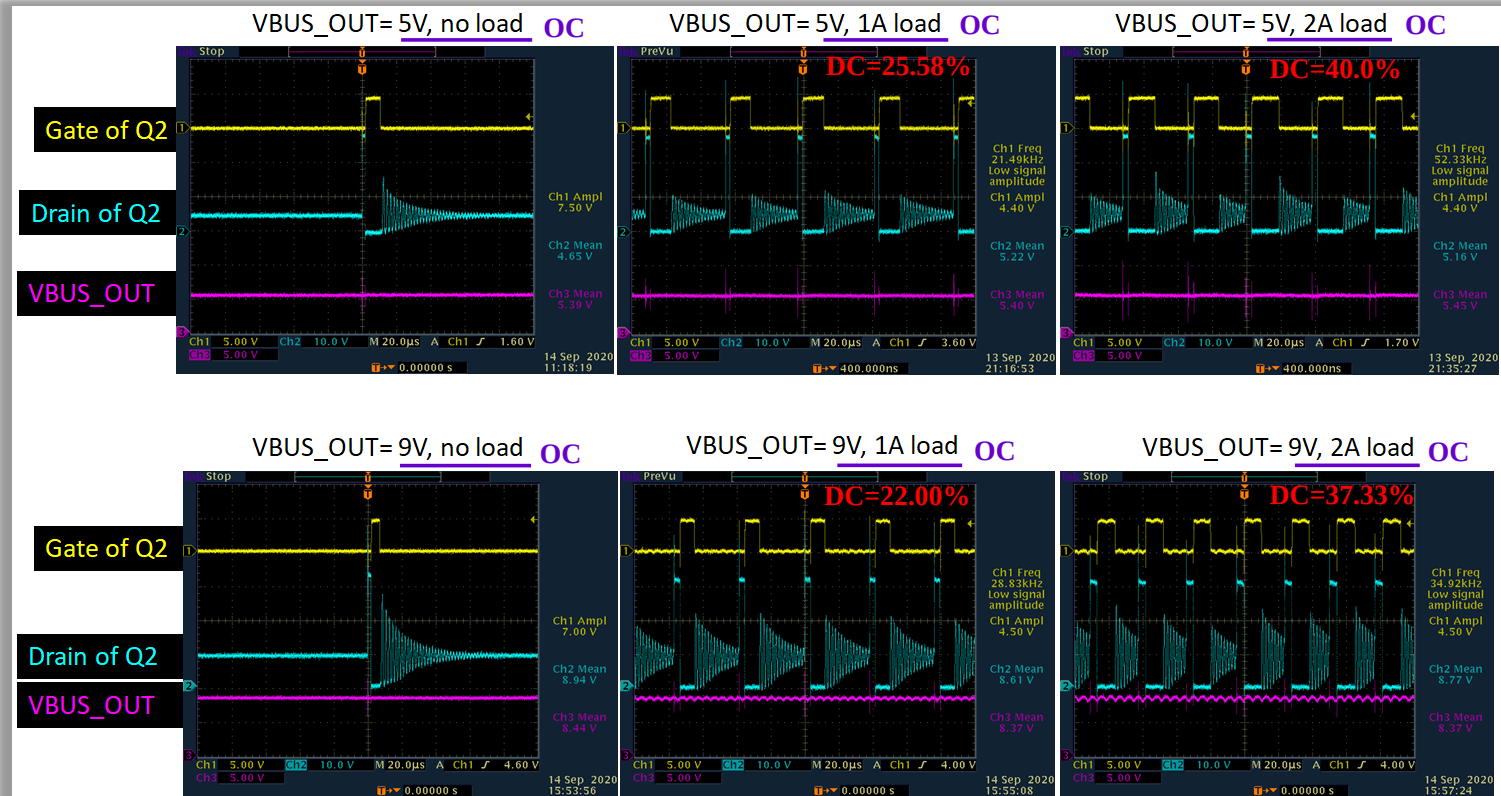
The architecture incorporates a novel inductive coupling feedback scheme using the package lead frame and bond wires to provide a safe, reliable, and low-cost means to communicate accurate direct sensing of the output voltage and output current on the secondary IC to the primary IC.

The primary controller on InnoSwitch3-Pro is a Quasi-Resonant (QR) flyback controller that has the ability to operate in continuous conduction mode (CCM). The controller uses both variable frequency and variable current control schemes. The primary controller consists of a frequency jitter oscillator; a receiver circuit magnetically coupled to the secondary controller, a current limit controller, 5 V regulator on the PRIMARY BYPASS pin, audible noise reduction engine for light load operation, bypass overvoltage detection circuit, a lossless input line sensing circuit, current limit selection circuitry, over-temperature protection, leading edge blanking, secondary output diode/SR FET short protection circuit and a 650 V / 725 V power MOSFET.

Source(s): [2]

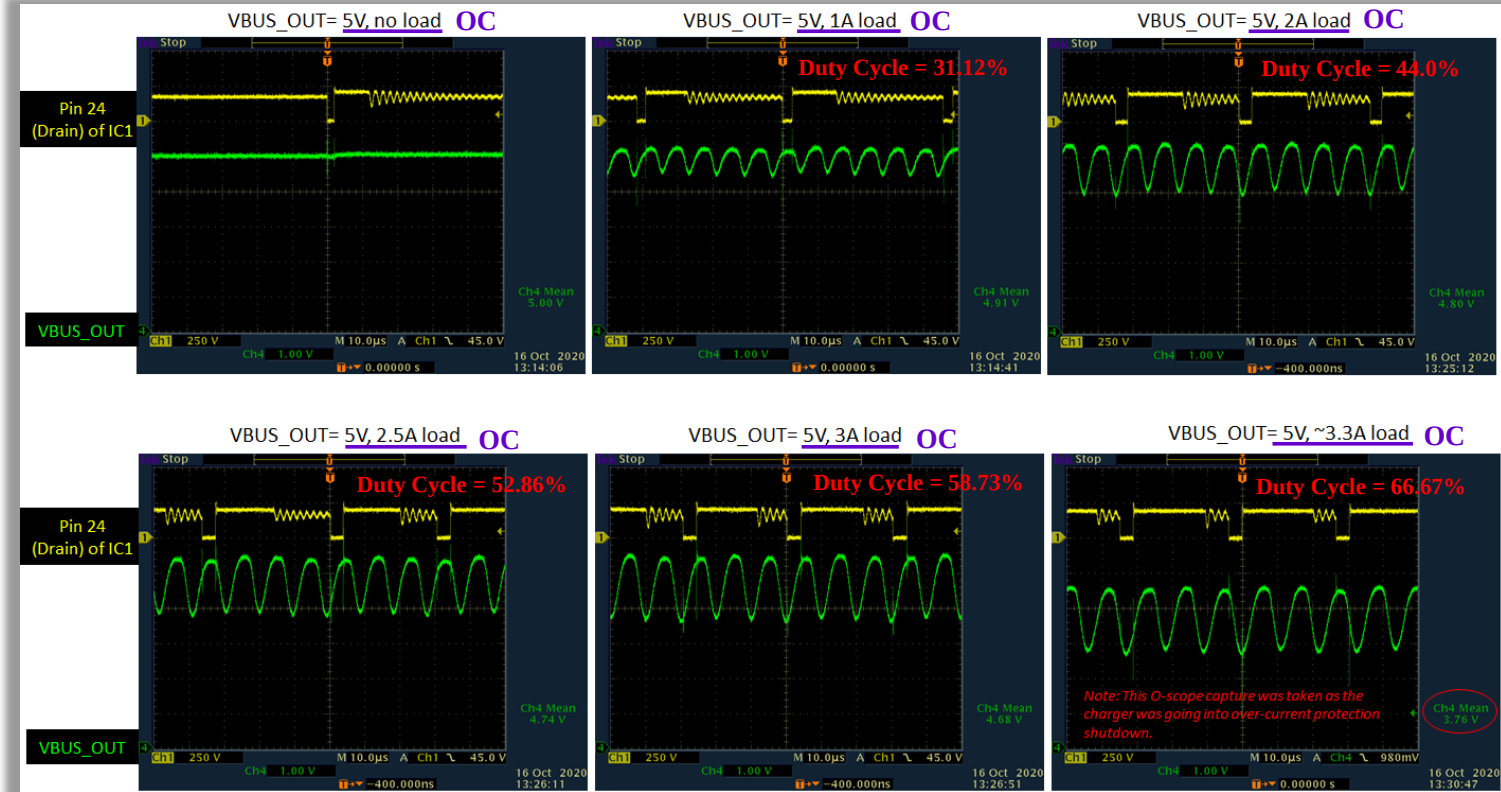
Claim 7

said (CON) power converter controller is further configured to provide another (OS) signal to control said (DC) duty cycle of said (PS) power switch as a function of said (OC) output characteristic and in accordance with said (COM) signal.



Claim 7

said (CON) power converter controller is further configured to provide another (OS) signal to control said (DC) duty cycle of said (PS) power switch as a function of said (OC) output characteristic and in accordance with said (COM) signal.



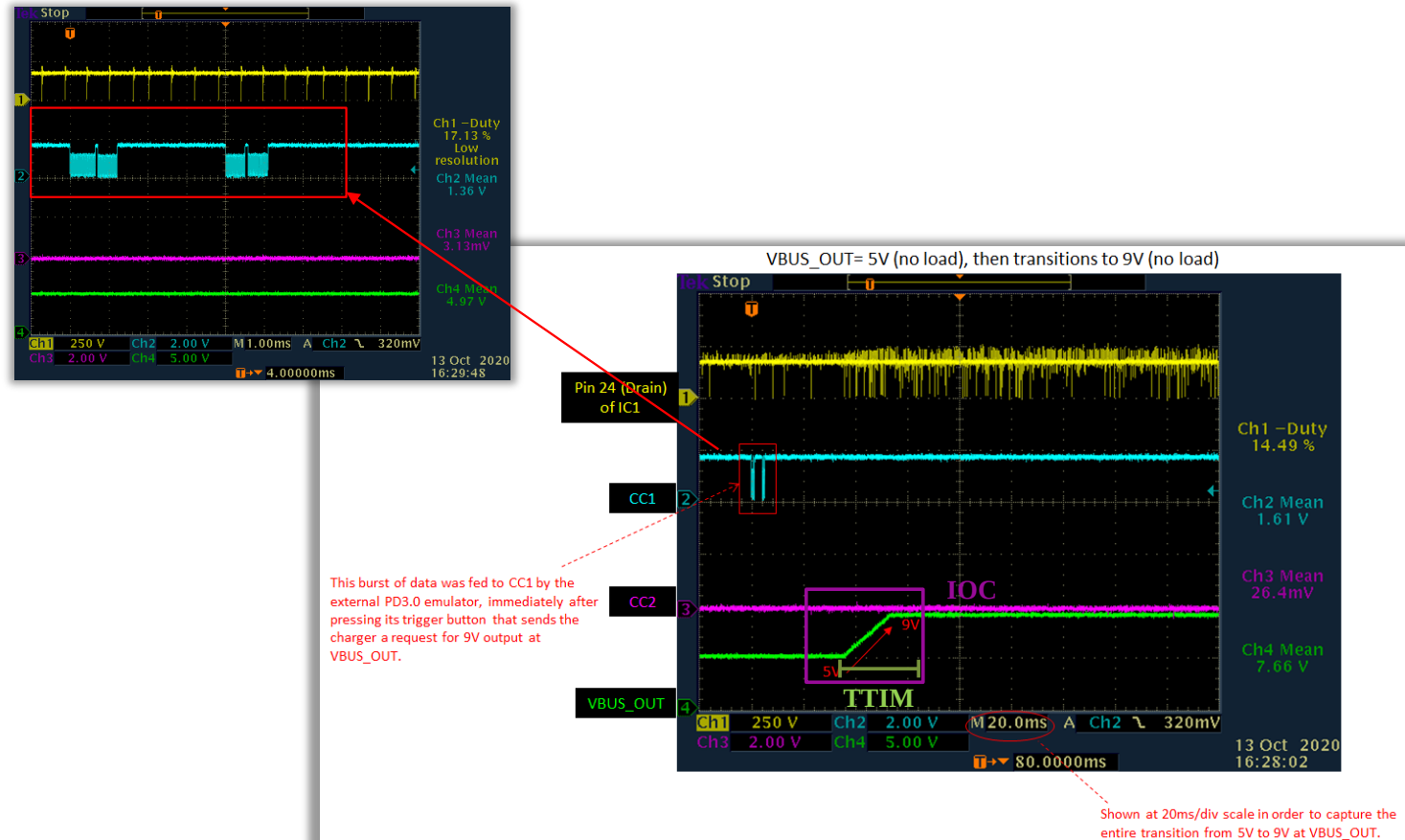
Source(s): [2]

Command Register Address	Default		Recommended for Speed Up	
	MSB	LSB	MSB	LSB
0x32	0x28	0x1E	0x14	0x0A
0x34	0x08	0xC8	0x0F	0x84

Using values other than the default or recommended settings about could lead to oscillatory behavior.

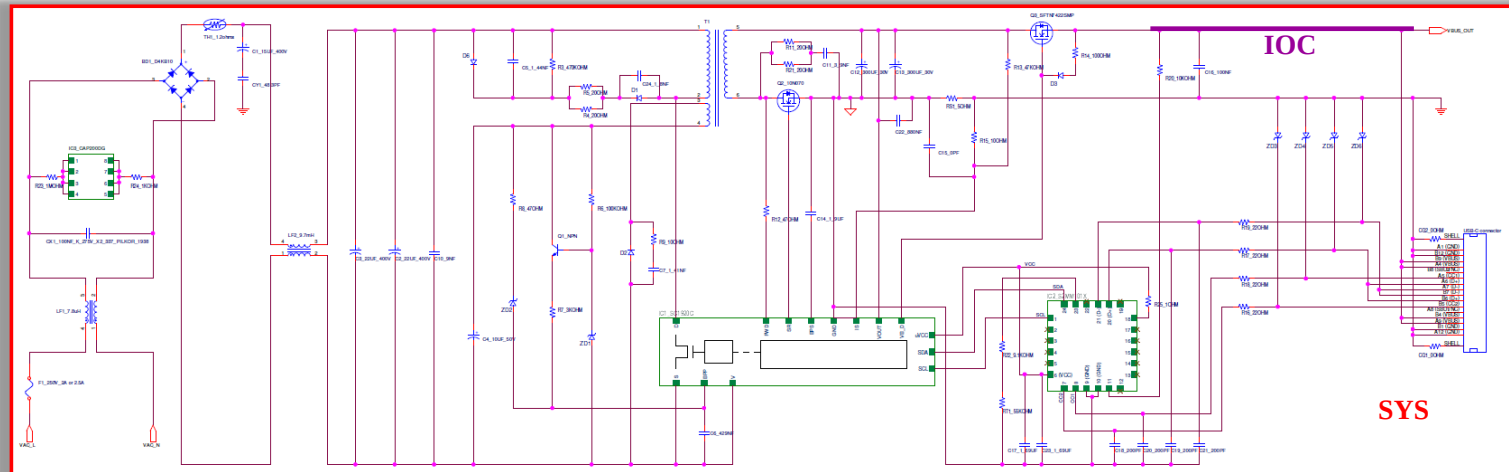
Claim 8

The (SYS) power system as recited in claim 6 wherein said (CON) power converter controller is configured to adjust said (IOC) internal operating characteristic over a (TTIM) period of time.



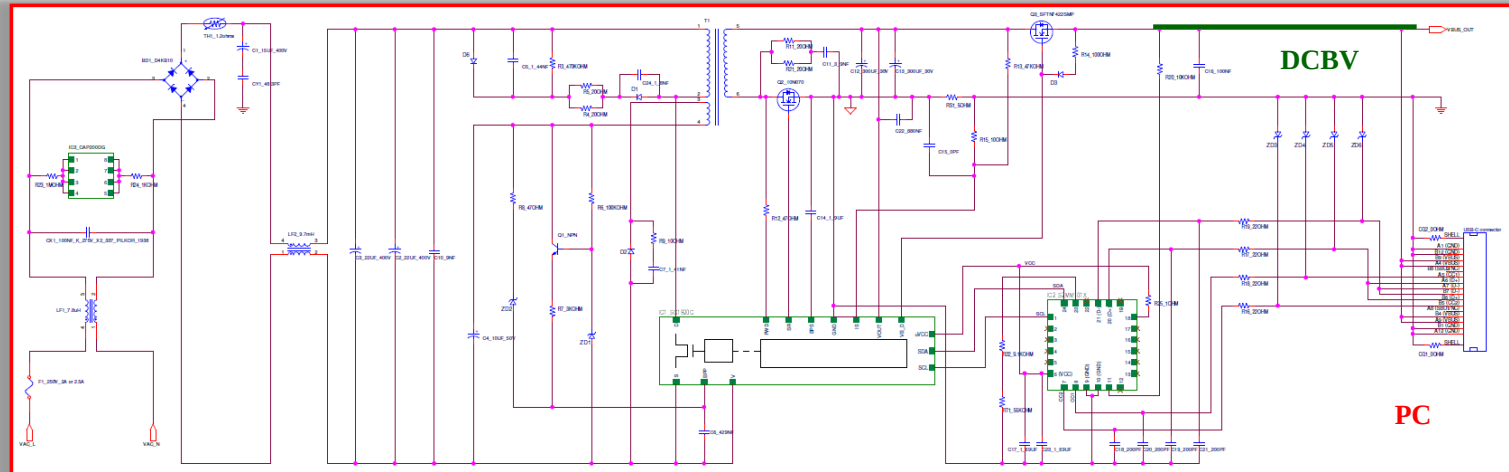
Claim 10

The **(SYS) power system** as recited in claim 6 wherein said **(IOC) internal operating characteristic** is selected from the group consisting of:



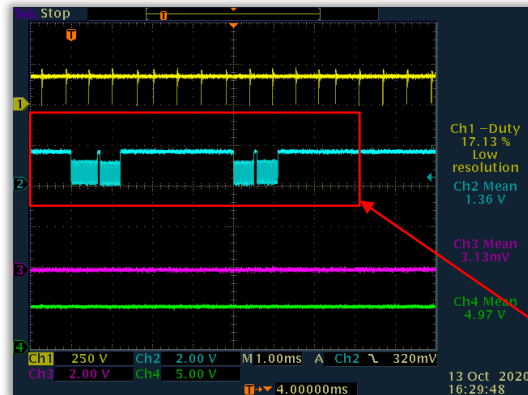
Claim 10

a gate drive voltage level of said **(PS) power switch** of said **(PC) power converter**, a switching frequency of said **(PC) power converter**, and an **(DCBV) internal direct current bus voltage** of said **(PC) power converter**.

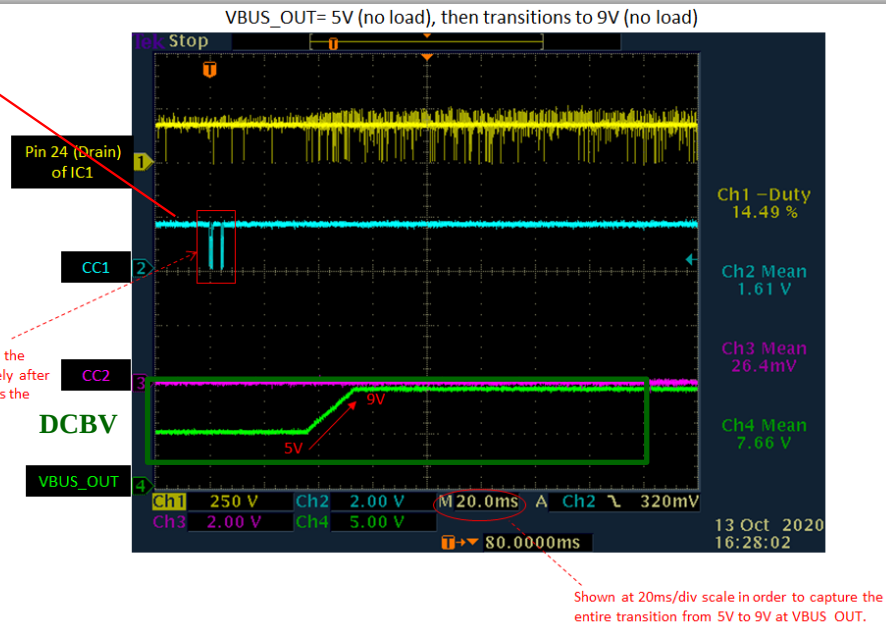


Claim 10

a gate drive voltage level of said **(PS) power switch** of said **(PC) power converter**, a switching frequency of said **(PC) power converter**, and an **(DCBV) internal direct current bus voltage** of said **(PC) power converter**.



This burst of data was fed to CC1 by the external PD3.0 emulator, immediately after pressing its trigger button that sends the charger a request for 9V output at VBUS_OUT.



Sources and citations

1. Universal Serial Bus Type-C Cable and Connector Specification, Release 2.0, August 2019;
2. Power Integrations InnoSwitch3-Pro Family, Rev. E 08/18;

Note: The citations may pertain to only specific document excerpts and not the schematics or other data.