

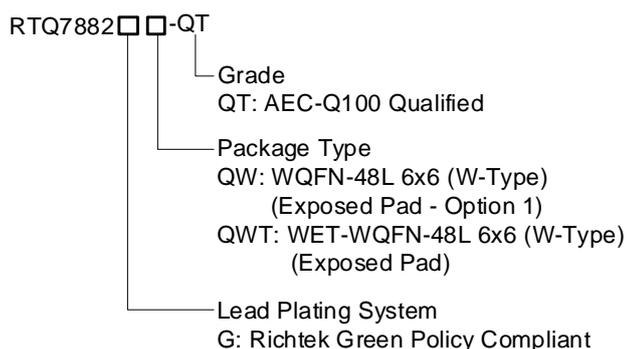
# USB Type-C PD and PWM Buck-Boost Controller with AnyPower<sup>™</sup> and PD Safe<sup>®</sup> Features

## General Description

The RTQ7882-QT is a USB Type-C Power Delivery (USBC PD) and PWM buck-boost controller with highly integrated functions and flexibility for USB PD provider applications. The IC has an embedded ARM Cortex<sup>™</sup>-M0 MCU, which handles various functions of communication protocol, smart control of the PWM converter, firmware-based protections, and customized functions. The IC features hardware-based protections, such as inductor peak current limit, VBUS overvoltage protection (VBUS OVP), VIN undervoltage protection (VIN UVP), VIN overvoltage protection (VIN OVP), VO undervoltage protection (VO UVP), and VCONN current-limit protection, so that the protections have faster responses and can still function even when the MCU is not activated. The RTQ7882-QT can offer an excellent USB PD solution for a USB-PD Provider application with few external components and simple PCB layout.

The recommended junction temperature range is -40°C to 125°C, and the ambient temperature range is -40°C to 105°C.

## Ordering Information



Note:

Richtek products are Richtek Green Policy compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.

## Applications

- Automotive USB Type-C Power Delivery Charger

## Features

- Support USB Type-C Power Delivery (PD) Provider
- AEC-Q100 Grade 2 Qualified
- Operating Ambient Temperature: -40°C to 105°C
- Type-C, USB PD and Communication Protocols
  - ▶ Compliant with USB PD 3.1 Specification, USB Type-C Cable and Connector Specification 2.1
  - ▶ VCONN Output 100mW
  - ▶ Support Other Proprietary Communication Protocols through Internal MCU, DP, and DM Pins
- Integrated PWM Buck-Boost Controller
  - ▶ Wide Input Voltage Range: 4.5V to 30V
  - ▶ Wide Output Voltage Range: 3.3V to 21V
  - ▶ Peak-Current Mode PWM Operation
  - ▶ Internal Compensation for CV, and CC
  - ▶ Programmable PWM Switching Frequency (200kHz to 600kHz)
  - ▶ Pulse-Skipping Mode for Light-Load Efficiency; Selectable Forced CCM Operation
- AnyPower<sup>™</sup> for Constant Voltage Output and Constant Current Output
- PD Safe<sup>®</sup>
  - ▶ Adjustable Converter Input Overcurrent Limit (INOC)
  - ▶ Fast Response VIN OVP/UVP Detection
  - ▶ Programmable VBUS OVP and VO UVP
  - ▶ Fast Response OVP for CC1/2 and D+/D-
  - ▶ Adjustable External OTP/Internal OTP
  - ▶ CC1/2 Output Current Limit
  - ▶ CC1/2, D+/D- 25V Tolerant
- Cable Voltage Drop Compensation for VBUS
- Switching Frequency Synchronization for Better EMI
- Adjustable Gate Drive Current for Better EMI
- Firmware-based Functions
  - ▶ VIN De-Rating and Power Sharing
- Master and Slave I<sup>2</sup>C Interfaces, LED Drivers, GPIOs
- EN Control for Power Saving

- Built-In Output Bleeders for Quick VBUS Discharge
- Built-In Charge Pump for Driving Cost-Effective N-MOSFETs
- Built-In Internal LDO
- Online Firmware Update via Slave I<sup>2</sup>C Interface or CC1/2 Interface
- Available in WQFN-48L or WET-WQFN-48L 6x6 Package
- USB PD PD3.1/PPS Certification Passed (TID 8011)
- Junction Temperature Range: -40°C to 125°C
- Ambient Temperature Range: -40°C to 105°C

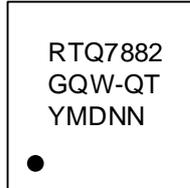
## Marking Information

RTQ7882GQWT-QT



RTQ7882GQWT-QT: Product Code  
YMDNN: Date Code

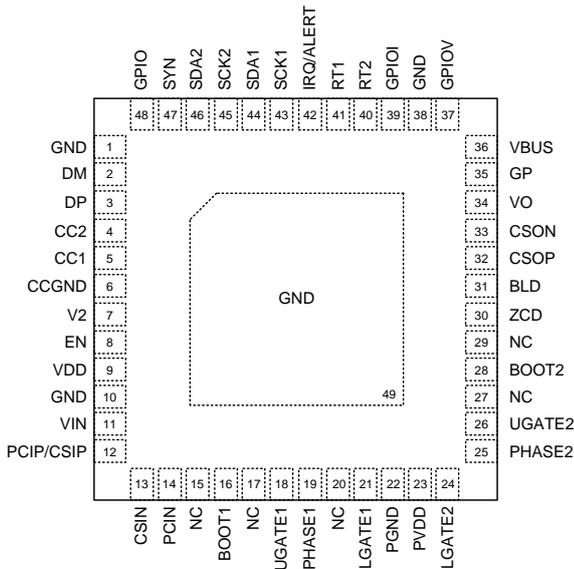
RTQ7882GQW-QT



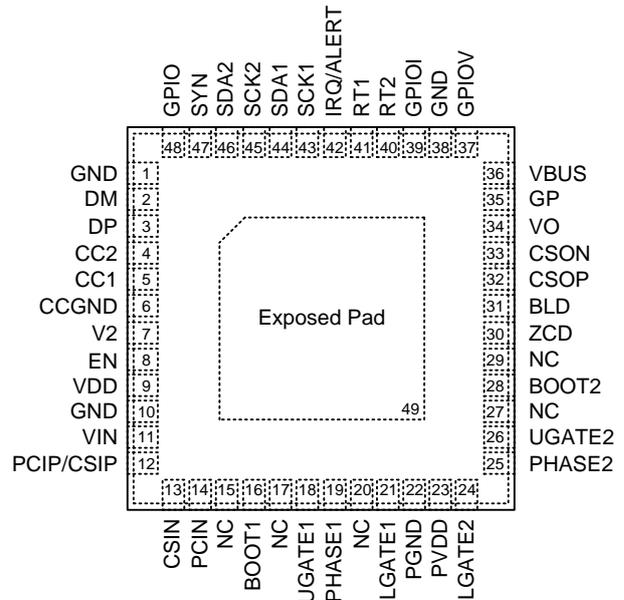
RTQ7882GQW-QT: Product Code  
YMDNN: Date Code

## Pin Configuration

(TOP VIEW)

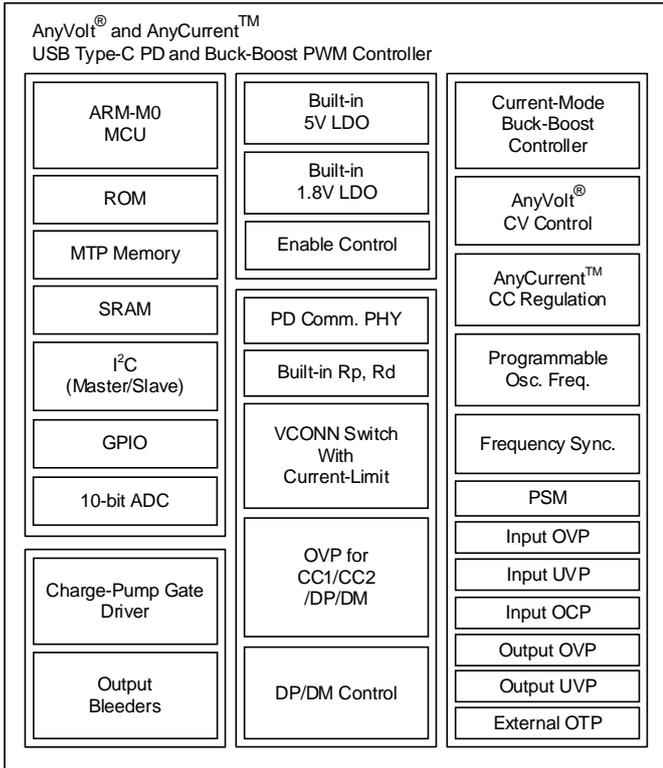


WQFN-48L 6x6

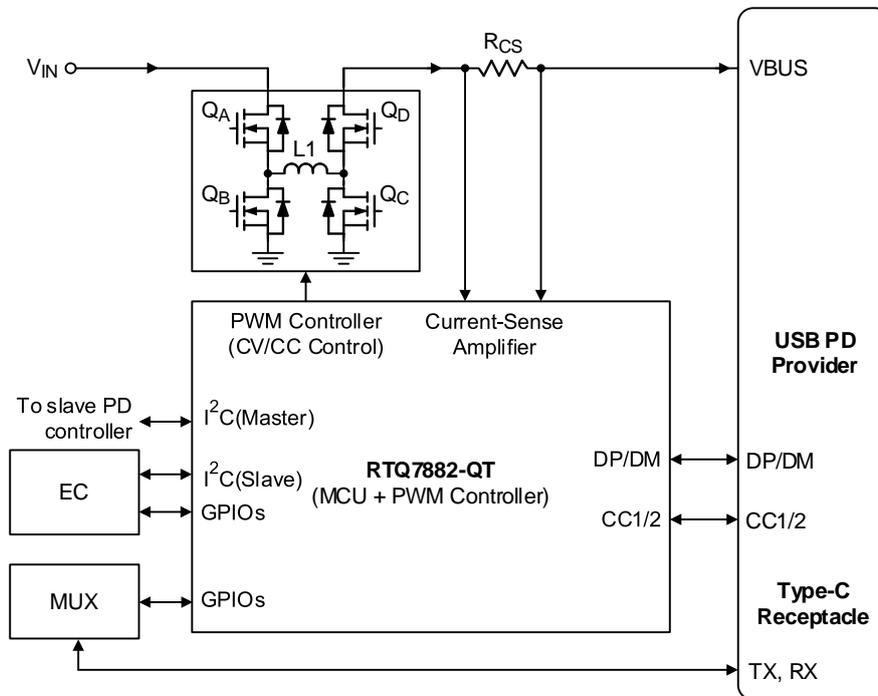


WET-WQFN-48L 6x6

**Simplified Functional Block Diagram**



**Simplified Application Circuit**

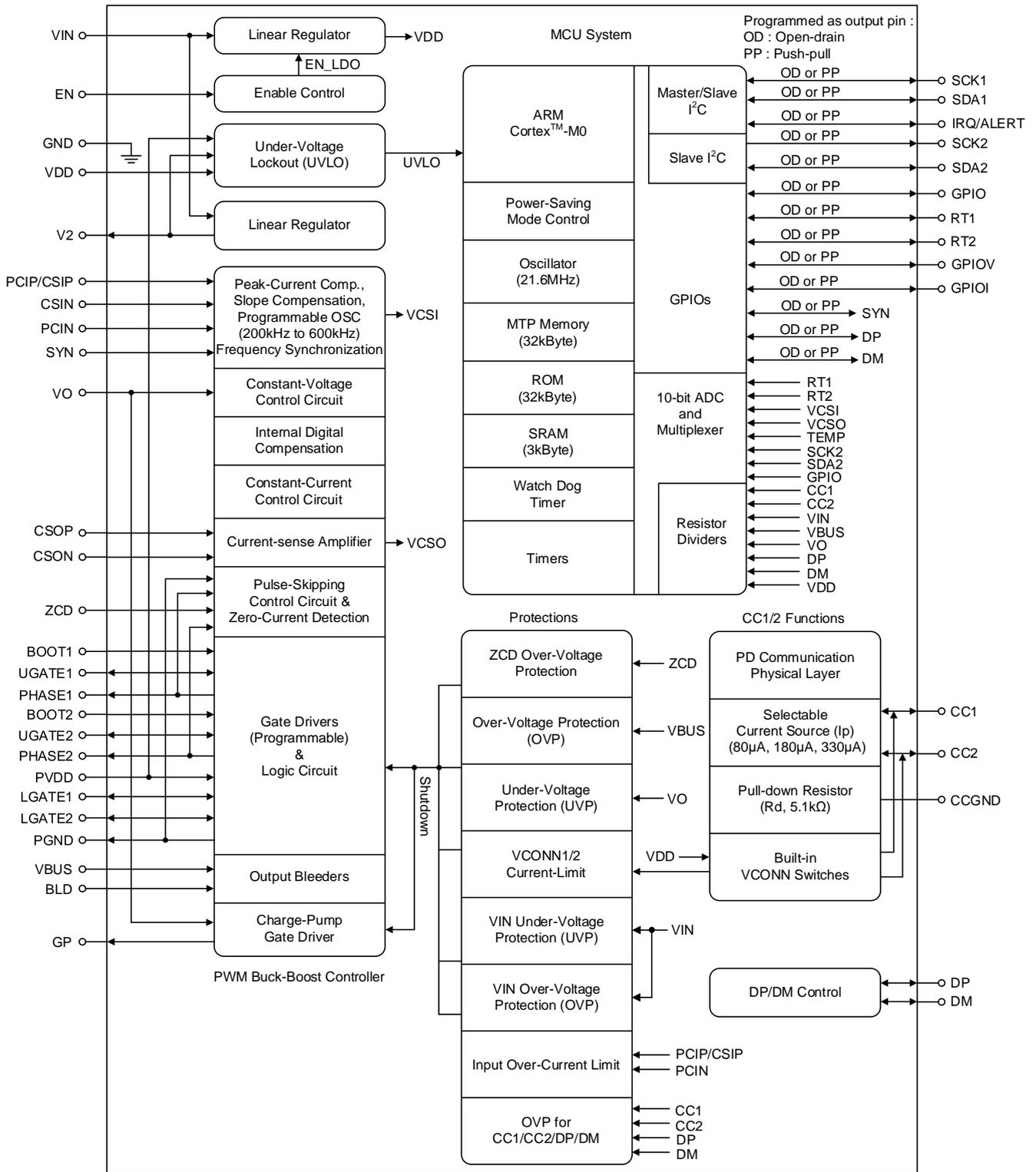


## Functional Pin Description

Pin No.	Pin Name	Pin Function
1, 10, 38	GND	Analog ground.
2	DM	Input/Output pin of built-in DPDM interface for BC1.2 and proprietary protocols. Connect this pin to D- pin of a USB connector. This pin can be set as an open-drain or push-pull GPIO pin.
3	DP	Input/Output pin of built-in DPDM interface for BC1.2 and proprietary protocols. Connect this pin to D+ pin of a USB connector. This pin can be set as an open-drain or push-pull GPIO pin.
4	CC2	Type-C connector Configuration Channel (CC) 2. Generally, this input/output pin is connected to USB Type-C connector CC2 terminal.
5	CC1	Type-C connector Configuration Channel (CC) 1. Generally, this input/output pin is connected to USB Type-C connector CC1 terminal.
6	CCGND	Analog ground.
7	V2	Internal 1.8V linear regulator output to supply power for internal circuitry. An MLCC (1 $\mu$ F typ. or greater) must be connected from this pin to ground.
8	EN	Enable control input with internal pull high source. Keep floating for normal operation. A logic-low voltage to disable the IC for power saving.
9	VDD	Output pin of the VIN-to-VDD linear regulator. An external MLCC (at least 4.7 $\mu$ F, 0805/X5R/25V) and a 5.6V zener diode (tolerance 5.6V $\pm$ 2%) must be connected from this pin to GND pin.
11	VIN	Input voltage to the converter and the IC. An aluminum hybrid polymer capacitor (at least 68 $\mu$ F) must be connected from converter VIN to ground.
12	PCIP/CSIP	Positive peak-current signal input pin and positive average-current signal input pin.
13	CSIN	Negative average-current signal input pin.
14	PCIN	Negative peak-current signal input pin.
15, 17, 20, 27, 29	NC	No internal connection.
16	BOOT1	Bootstrap capacitor connection node. Connect a 0.1 $\mu$ F ceramic capacitor from this pin and the PHASE1 pin to power the internal 1 <sup>st</sup> high-side gate driver.
18	UGATE1	1 <sup>st</sup> High-side gate driver output.
19	PHASE1	Negative power-rail pin of the 1 <sup>st</sup> high-side gate driver.
21	LGATE1	1 <sup>st</sup> Low-side gate driver output.
22	PGND	Ground of the low-side gate drivers and one input pin of zero-current detection at the MOSFET controlled by LGATE1. Connect this pin to the source of the MOSFET.
23	PVDD	Bias voltage (5V typ.) supply for the low-side gate drivers. It is recommended to connect an external MLCC (1 $\mu$ F) from this pin to PGND pin.
24	LGATE2	2 <sup>nd</sup> Low-side gate driver output.
25	PHASE2	Negative power-rail pin of the 2 <sup>nd</sup> high-side gate driver.
26	UGATE2	2 <sup>nd</sup> High-side gate driver output.
28	BOOT2	Bootstrap capacitor connection node. Connect a 0.1 $\mu$ F ceramic capacitor from this pin and the PHASE2 pin to power the internal 2 <sup>nd</sup> high-side gate driver.

Pin No.	Pin Name	Pin Function
30	ZCD	One input pin of zero-current detection (at the MOSFET controlled by UGATE2) and Output overvoltage protection input pin.
31	BLD	Bleeder connection node. An output bleeder, comprising a pull-low NMOS, is built in to provide another path to discharge the output capacitor of the PWM converter. Connect this pin to the converter output through an external resistor.
32	CSOP	Positive input of a current-sense amplifier to sense the output current for constant current regulation and also through an ADC to the MCU. Connect this pin to the positive terminal of output current-sense resistor via an RC filter.
33	CSOIN	Negative input of a current-sense amplifier for output constant-current regulation and output current detection. Connect this pin to the negative terminal of output current-sense resistor via an RC filter.
34	VO	Input of feedback voltage from converter output. The voltage is monitored for output undervoltage protection.
35	GP	Charge-pump gate driver output. It drives N-channel power MOSFET(s) to turn on/off the output power path.
36	VBUS	USB-C VBUS voltage input. The voltage at this pin is monitored for USB-C VBUS overvoltage protection with an 8-bit programmable threshold voltage.
37	GPIOV	General-purpose input/output.
39	GPIOI	General-purpose input/output.
40	RT2	Open-drain/push-pull GPIO, analog input or external over-temperature protection (EOTP) input pin. Connect an NTC from this pin to GND pin for the EOTP.
41	RT1	Open-drain/push-pull GPIO, analog input or external over-temperature protection (EOTP) input pin. Connect an NTC from this pin to GND pin for the EOTP.
42	IRQ/ALERT	Interrupt input/output pin. The RTQ7882-QT can do emergency control when it receives a low-level signal via this pin; an external MCU can check the slave I <sup>2</sup> C registers to do emergency control when it receives a low-level signal via this pin. This pin can be set as an open-drain or push-pull GPIO pin.
43	SCK1	Open-drain clock signal input/output pin of the Slave/Master I <sup>2</sup> C interface. This pin can be set as an open-drain or push-pull GPIO pin.
44	SDA1	Open-drain data signal input/output pin of the Slave/Master I <sup>2</sup> C interface. This pin can be set as an open-drain or push-pull GPIO pin.
45	SCK2	Open-drain clock signal input/output pin of the Slave I <sup>2</sup> C interface. This pin can be set as an open-drain or push-pull GPIO pin.
46	SDA2	Open-drain data signal input/output pin of the Slave I <sup>2</sup> C interface. This pin can be set as an open-drain or push-pull GPIO pin.
47	SYN	Switching frequency synchronization in two port application.
48	GPIO	General-purpose input/output.
49 (Exposed Pad)	GND	Ground. The exposed pad must be soldered to a large PCB and connected to GND for maximum power dissipation.

Functional Block Diagram



## Operation

The RTQ7882-QT is a versatile USB Type-C Power Delivery (USB-C PD) and PWM Buck-Boost controller designed especially for applications as Providers. It is a highly integrated solution, comprising four main functional blocks: MCU System, PWM Buck-Boost Controller, Protections and CC1/2 Functions as depicted in the “Functional Block Diagram”.

The MCU System embeds an ARM Cortex™-M0 MCU, a multi-time programming (MTP) memory, a ROM, an SRAM, a 10-bit ADC (analog to digital converter), two I<sup>2</sup>C interfaces (slave and master) and GPIO (general purpose input or output) pins. The MCU System is programmed to perform power controls, customized functions, as a policy engine and a device policy manager. This MCU reports the operating status of PD operation, such as present input/output voltage, output current and external temperature to an EC (embedded controller) or AP (application processor) and receives commands from the EC/AP, as a system policy manager, via the slave I<sup>2</sup>C interface. The GPIO pins can be used to control high-speed multiplexers or other customized functions.

The “PWM Buck-Boost controller” consists of an AnyVolt® constant-voltage (CV) control circuit (9.93mV/step, typ.), an AnyCurrent™ constant-current (CC) control circuit, an output current-sense amplifier (7.8mA to 12.5mA/step, depending on the current-sense resistor), built-in gate drivers, one charge-pump gate driver and output bleeders (at BLD and VBUS pins). Generally, either the CV or the CC control circuit regulates the output voltage or current through peak-current mode PWM operation. Diode emulation function and pulse-skipping mode (PSM) are built in to improve power efficiency at light loads. The output current-sense amplifier (OCS-AMP) allows current-sense resistors as low as 5mΩ to 15mΩ for reducing power loss. Moreover the charge-pump driver adopts N-channel MOSFETs for on/off control of output power-path, instead of P-channel MOSFETs having higher cost. In operation the output bleeders at BLD and VBUS pins can be turned on to discharge output voltage (VBUS) during the VBUS negative transition, in the hard reset process, or after the removal of the USB-C connector.

The PD Safe® power delivery operation consists of overvoltage protection (OVP) at the VBUS pin, undervoltage protection at the VO pin, output CC regulation and VCONN1/2 output current-limit function. With the PD Safe® feature, trip levels of the OVP and UVP can be set dynamically for each output voltage target. The CC regulation level is also adaptively programmed according to the current level in full load.

The “CC1/2 Functions” block consists of the physical layer, three selectable levels of the pull-up current sources I<sub>p</sub> (instead of resistors R<sub>p</sub>), a controllable pull-down resistor R<sub>d</sub> and programmable VCONN power-path switches.

### Undervoltage Lockout (UVLO)

The RTQ7882-QT UVLO function continuously monitors bias voltages at the VDD and V2 pins. When both of the supply voltages (VDD and V<sub>v2</sub>) rise above the respective rising UVLO thresholds, the internal UVLO signals will go low to activate the MCU. In addition, the IC also monitors the bias voltage at the PVDD pin for UVLO function. Only when all of the UVLO signals go low, or the PWM Buck-Boost controller will not be activated; meanwhile the MCU or PWM controllers will be kept in the “Undervoltage Lockout” state to prevent any undesirable operation.

### Pulse-Skipping Mode (PSM) with Diode Emulation

When a switch-mode converter operates in light load condition, most power loss is caused by switching losses. To reduce switching loss in light load condition, the switching frequency needs to be reduced by entering the pulse-skipping mode (PSM) and the discontinuous conduction mode (DCM). In this operation, an internal compensation voltage V<sub>COMP</sub> is compared by a PSM comparator, which has a programmable PSM threshold.

When the internal compensation voltage V<sub>COMP</sub> is above the PSM threshold, the converter works in normal fixed-frequency PWM mode. As long as the V<sub>COMP</sub> drops below the PSM threshold, the converter will enter the pulse-skipping mode to reduce switching frequency and thus diminish switching losses. The PSM threshold also defines the minimum inductor peak

current in PSM operation. Setting a larger PSM threshold will give a higher minimum peak current which in turn gives a lower switching frequency at light load for better light load efficiency at the cost of increased output voltage ripple. Conversely, a lower PSM threshold gives lower peak current and lower PSM ripple at the cost of worse light load efficiency.

A Diode Emulation Mode (DEM) is also a necessary function to avoid delivering energy from converter output to converter input during dynamic output voltage control. The DEM function is equipped with two zero-current detection (ZCD) circuits for the low-side and high-side MOSFETs respectively controlled by the LGATE1 and UGATE2 pins: The Source-to-Drain voltage ( $V_{SDB}$ , detected via PGND and PHASE1 pins) of the low-side MOSFET is compared with a zero-current threshold ( $V_{TH\_ZCDB}$ ). When the  $V_{SDB}$  drops below the  $V_{TH\_ZCDB}$  voltage, the RTQ7882-QT turns off the low-side MOSFET thereby avoiding reverse inductor current. In DEM operation, the behavior of the low-side MOSFET resembles a diode. The second ZCD circuit compares the Source-to-Drain voltage ( $V_{SDD}$ , detected via PHASE2 and ZCD pins) of the high-side MOSFET with a zero-current threshold ( $V_{TH\_ZCDD}$ ) to achieve the DEM function.

### Cable Voltage Drop Compensation (CDC)

In a power delivery system with both a Provider and a Consumer, the Provider with the RTQ7882-QT AnyVolt® feature can slightly adjust its CV output voltage to compensate voltage drop across the USB cable. A PD controller of the Consumer can request higher VBUS voltage from the Provider through PD communication to achieve an accurate application voltage.

There is another method to implement the CDC function without PD communication. The RTQ7882-QT can use the ADC to detect the output current-sense voltage ( $V_{CSO}$ ) between CSOP and CSON pins and adaptively add a proper output voltage offset ( $V_{CDC}$ ) to compensate the cable voltage drop. The output voltage offset ( $V_{CDC}$ ) is gradually added by adjusting the CV regulated output voltage ( $V_{REG\_VO}$ ) and is approximately proportional to the converter output current ( $I_{OUT}$ ).  $V_{CDC}$  is approximately determined by

the following equation:

$$V_{CDC} = I_{OUT} \times R_{CABLE}$$

where:

$R_{CABLE}$  is a preset value of parasitic resistance of USB cable.

### VBUS Overvoltage Protection (VBUS OVP)

In Figure 1, the VBUS OVP function is a hardware-based protection which monitors the voltage at the VBUS pin via a built-in resistor-divider. When the VBUS voltage exceeds its OVP threshold, the output of the OVP comparator goes high and starts the debounce time counting. At the end of the debounce time counting, the signal VBUS OVP goes high to turn off the PWM controller. The OVP trip voltage is programmable from 3.3V to 24V (8-bit, 100mV/step typ.) and its debounce time is also selectable to meet various application requirements.

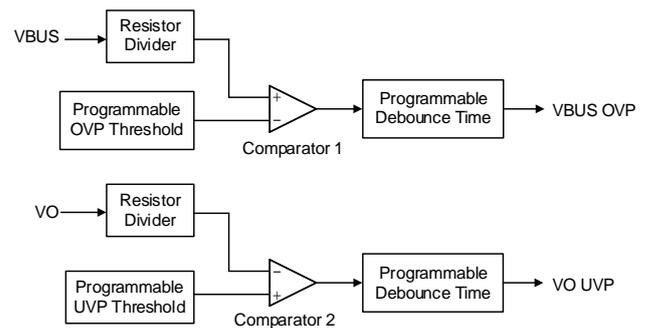


Figure 1. Functional diagram of VBUS OVP and VO UVP

### VO Undervoltage Protection (VO UVP)

In Figure 1, the VO UVP function is a hardware-based protection which monitors the voltage at the VO pin via a built-in resistor-divider. When the VO voltage falls below its UVP threshold, the output of the UVP comparator goes high and starts the debounce time counting. At end of the debounce time, the signal VO UVP goes high to turn off PWM controller. The UVP trip voltage is programmable from 3V to 20V (8-bit, 100mV/step typ.) and its debounce time is also selectable to avoid false triggering and to meet various application requirements.

**AnyCurrent™ Constant-Current (CC) Regulation**

It is noted that a robust system is very important in USB PD operations, the AnyCurrent™ CC regulation allows setting the most suitable CC level for a negotiated PD system.

The RTQ7882-QT integrates a current-sense amplifier to sense output current for CC regulation and also through an ADC to the MCU for the output current to be recorded. The amplifier accurately sense the current-sense voltage (i.e.,  $V_{CS} = \text{output current} \times \text{current-sense resistor}$ ) between the CSOP and CSON pins. The recommended current-sense voltage range for CC regulation is from 5mV to 35mV which is programmed by an internal 10-bit DAC (digital-to-analog converter) with 0.0625mV/step resolution.

**Power-Path Gate Driver for Driving N-Channel MOSFETs**

The RTQ7882-QT integrates a power-path gate driver to control external output blocking MOSFETs between the output of the PWM converter and the USB-C VBUS terminal. A built-in charge pump is included to supply the gate driver to turn on the external N-channel power MOSFETs, which allow power systems to be more cost-effective, compared to the counterpart, P-channel power MOSFETs.

**Online Firmware Update via Slave I<sup>2</sup>C or CC1/CC2 Interface**

The embedded MTP memory allows the RTQ7882-QT's firmware to be updated by an EC (Embedded Controller) or AP (Application Processor) through the I<sup>2</sup>C slave interface. The RTQ7882-QT provides some firmware-programmable design features, which greatly eases the design efforts during product development stage. End users are also allowed to update the firmware through CC1/CC2.

## Absolute Maximum Ratings (Note 1)

• V2 to GND	-----	-0.3V to 2.5V
• VDD, PVDD to GND	-----	-0.3V to 6.5V
• GPIOV, GPIOI to GND	-----	-0.3V to 6.5V
• VBUS, CSOP, CSON, VO, BLD, ZCD to GND	-----	-0.3V to 25V
• CSOP to CSON Voltage (VCSOP-CSON)	-----	-5V to 5V
• GP to GND	-----	-0.3V to 33V
• VIN, PCIN, PCIP/CSIP, CSIN to GND (DC)	-----	-0.3V to 32V
(< 0.4s)	-----	-0.3V to 36V
• ZCD to CSOP (VZCD-CSOP) and ZCD to CSON Voltage (VZCD-CSON)	-----	-0.3V to 6.5V
• PCIP/CSIP to CSIN Voltage (VPCIP/CSIP-CSIN)	-----	-5V to 5V
• VIN to PCIP/CSIP (VVIN-PCIP/CSIP) and VIN to PCIN Voltage (VVIN-PCIN) and VIN to CSIN Voltage (VVIN-CSIN)	-----	-0.3V to 6.5V
• PCIP/CSIP to PCIN Voltage (VPCIP/CSIP-PCIN)	-----	-5V to 5V
• EN to GND	-----	-0.3V to 6.5V
• I <sup>2</sup> C Pins (SCK1, SDA1, IRQ/ALERT, SCK2, SDA2) to GND	-----	-0.3V to 6.5V
• GPIO Pins (SYN, GPIO, RT1, RT2) to GND	-----	-0.3V to 6.5V
• DP, DM to GND	-----	-0.3V to 25V
• CC1, CC2 to GND	-----	-0.3V to 25V
• BOOT1/2 to PHASE1/2 (VBOOT-PHASE)	-----	-0.3V to 6.5V
• UGATE1/2 to PHASE1/2	-----	-0.3V to VBOOT-PHASE + 0.3V
• PHASE1 to GND (DC)	-----	-0.3V to 30V
(< 20ns)	-----	-5V to 36V
• PHASE2 to GND (DC)	-----	-0.3V to 25V
(< 20ns)	-----	-5V to 30V
• LGATE1/2 to PGND	-----	-0.3V to VPVDD + 0.3V
• PGND, CCGND to GND	-----	-0.3V to 0.3V
• Power Dissipation, P <sub>D</sub> @ T <sub>A</sub> = 25°C		
WQFN-48L 6x6	-----	3.73W
WET-WQFN-48L 6x6	-----	3.67W
• Package Thermal Resistance (Note 2)		
WQFN-48L 6x6, θ <sub>JA</sub>	-----	26.8°C/W
WQFN-48L 6x6, θ <sub>JC</sub>	-----	1.3°C/W
WET-WQFN-48L 6x6, θ <sub>JA</sub>	-----	27.2°C/W
WET-WQFN-48L 6x6, θ <sub>JC</sub>	-----	3.5°C/W
• Lead Temperature (Soldering, 10 sec.)	-----	260°C
• Junction Temperature	-----	150°C
• Storage Temperature Range	-----	-65°C to 150°C
• ESD Susceptibility (Note 3)		
HBM (Human Body Model)	-----	2kV

**Recommended Operating Conditions** (Note 4)

- PWM Converter Input Voltage,  $V_{IN}$  ----- 4.5V to 30V
- PWM Converter Output Voltage,  $V_{OUT}$  ----- 3V to 22V
- VDD Output Voltage/PVDD Supply Voltage ----- 4.5V to 5.5V
- Junction Temperature Range -----  $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$
- Ambient Temperature Range -----  $-40^{\circ}\text{C}$  to  $105^{\circ}\text{C}$
- Minimum MTP Memory Write/Erase Cycles ----- 100cycles at  $25^{\circ}\text{C}$

**Electrical Characteristics**

( $V_{DD} = V_{PVDD} = V_{VCONN} = 5\text{V}$ ,  $T_A = T_J = -40^{\circ}\text{C}$  to  $105^{\circ}\text{C}$ , unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
<b>VDD and V2 Linear Regulators (VDD LDO and V2 LDO), Undervoltage Lockout (UVLO) and Enable Control</b>						
VDD Output Voltage (5.0V Normal/4.3V DGM)	VREG_VDD	In normal mode, $V_{IN} = 12\text{V}$ , $I_o = 0\text{mA}$ , $C_{VDD} = 4.7\mu\text{F}$	4.7	5	5.3	V
		In deep-green mode, $V_{IN} = 12\text{V}$ , $I_o = 0\text{mA}$ , $C_{VDD} = 4.7\mu\text{F}$	3.9	4.2	4.5	
VDD Load Regulation Drop Voltage (5.0V Normal)	VDROP_VDD12	$V_{IN} = 12\text{V}$ , $I_o = 100\text{mA}$ , $C_{VDD} = 4.7\mu\text{F}$	--	0.3	--	V
	VDROP_VDD5	$V_{IN} = 5\text{V}$ , $I_o = 100\text{mA}$ , $C_{VDD} = 4.7\mu\text{F}$	--	0.3	--	V
VDD Short Current	ISC_VDD	$V_{IN} = 12\text{V}$ , $V_{DD} = 3\text{V}$ short to GND	--	150	--	mA
VIN Normal Operating Current	IOP_VIN	$V_{IN} = 12\text{V}$ , PWM = MCU = on, digital output pins = open	--	10	--	mA
VIN Operating Current in Deep Green-Mode (DGM)	IDGM_VIN	$V_{IN} = 12\text{V}$ , PWM = off, MCU = off, no load current, CC1/CC2 RX detection	--	0.5	--	mA
VIN Operating Current in Deep Green-Mode (DGM_LQ)	IDGM_LQ_VIN	$V_{IN} = 12\text{V}$ , PWM = MCU = off, CC1/CC2 falling detection only	--	120	--	$\mu\text{A}$
VIN Operation Current in EN Reset-Mode	IRST_VIN	$V_{IN} = 12\text{V}$ , EN = 0, PWM = MCU = off, digital output pins = open, VDD off	--	10	50	$\mu\text{A}$
V2 Output Voltage	VREGV2	In normal mode $I_{V2} = 20\text{mA}$ load, $C_{V2} = 1\mu\text{F}$	1.62	1.8	1.98	V
V2 Short-Circuit Current	ISC_V2	$V_{IN} = 12\text{V}$ , $V_{DD} = 5\text{V}$ V2 short to GND	--	50	--	mA
VDD POR Voltage Threshold		VDD rising	3.8	4	4.2	V
VDD UVLO Voltage Hysteresis		VDD falling	--	0.225	--	V
PVDD POR Threshold		VPVDD rising	3.8	4	4.2	V
PVDD UVLO Hysteresis		VPVDD falling	--	0.2	--	V
PVDD Input Current in PWM Shut Down		$V_{IN} = 12\text{V}$ , $V_{DD} = 5\text{V}$ , $V_{PVDD} = 5\text{V}$ , $PVDD\_EN = \text{off}$ , PWM = off	--	--	3	$\mu\text{A}$

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
EN Internal Pull-High Voltage		$V_{IN} = 12V, V_{DD} = 5V, EN$ open	3	--	5	V
EN Internal Pull-High Resistor		$V_{IN} = 12V, V_{DD} = 5V, EN = 0$	--	1200	--	k $\Omega$
EN Threshold Voltage	$V_{IH\_EN}$	$V_{IN} = 12V, V_{DD} = 5V$	1.5	--	$V_{DD}$	V
	$V_{IL\_EN}$	$V_{IN} = 12V, V_{DD} = 5V$	0	--	0.4	
<b>PWM Controller – Programmable Oscillator</b>						
PWM Frequency Range	$f_{PWM}$	Programmable	200	--	600	kHz
PWM Frequency Accuracy		$f_{PWM} = 300kHz/400kHz$	-10	--	10	%
<b>MCU Section</b>						
MCU Clock Frequency	$f_{MCU}$		19.4	21.6	23.8	MHz
OSC 80K Frequency in Deep Green-Mode	$f_{80K}$		--	80	--	kHz
<b>PWM Controller – Constant-Voltage (CV) Control Loop</b>						
CV Regulated Voltage Range at VO Pin	$V_{REG\_VO}$	Programmable (11-bit), 9.93mV/step	3	--	22	V
CV Regulated Voltage Accuracy at VO Pin (CVDAC_11bit)		$V_{OUT} = 3.3V/5V/9V$	-120	--	120	mV
CV Regulated Voltage Accuracy at VO Pin (CVDAC_11bit)		$V_{OUT} = 12V/15V/20V$	-200	--	200	mV
<b>PWM Controller – Constant-Current (CC) Control Loop and Output</b>						
CSON and CSOP Operating Voltage Range			3	--	22	V
CC Regulated Voltage Range between CSOP and CSON Pins (CCDAC_10bit)	$V_{REF\_CC}$	CSA $gain = 40$ , programmable (10-bit), 0.0625mV/step (typ.), $V_{CSON}$ and $V_{CSOP} > 3V$	5	--	35	mV
CC Regulated Voltage Accuracy between CSOP and CSON Pins		CSA $gain = 40$ , nominal $V_{REF\_CC} = 5mV/15mV/25mV$	-1	--	1	mV
CSOP/CSON Input Current		PWM bias = on	--	--	50	$\mu A$
		PWM bias = off	--	--	1	
CSA Detection Voltage Range between CSIP and CSIN Pins		CSA $gain = 40$	5	--	35	mV
CSIP/CSIN Input Current in VinCSA		PWM bias = on	--	--	50	$\mu A$
		PWM bias = off	--	--	1	
<b>PWM Controller – Input Current Comparison, Slope Compensation</b>						
Maximum Input Overcurrent (INOC) Voltage Threshold Range	$V_{TH\_CSMAX}$	Programmable	30	--	150	mV

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Maximum Input Overcurrent (INOC) Voltage Threshold Accuracy		$V_{TH\_CSMAX} = 30mV, 120mV$	-10	--	10	mV
Voltage Rate Range of Slope Compensation		Programmable	0	--	80	mV/ $\mu$ s
PCIP/CSIP Input Current in INOC		In PSM, $V_{CSIP} = 24V$	--	--	50	$\mu$ A
		PWM bias = off, $V_{CSIP} = 24V$	--	--	3	
PCIN Input Current		In PSM, $V_{CSIN} = 24V$	--	--	30	$\mu$ A
		PWM bias = off, $V_{CSIN} = 24V$	--	--	3	
<b>PWM Controller – Zero-Current Detection (ZCD)</b>						
MOS-D ZCD Voltage Threshold between PHASE2 and ZCD Pins	$V_{TH\_ZCDD}$	To compare the PHASE2-to-ZCD voltage	--	4	--	mV
MOS-B ZCD Voltage Threshold between PGND and PHASE1 Pins	$V_{TH\_ZCDB}$	To compare the PGND-to-PHASE1 voltage	--	4	--	mV
ZCD Input Current		In PSM, $V_{ZCD} = 20V$	--	--	300	$\mu$ A
		PWM bias = off, $V_{ZCD} = 20V$	--	--	90	
<b>PWM Controller – Gate Drivers</b>						
UGATE1/2 Pull-High Resistance		Programmable, $V_{BOOT1/2-PHASE1/2} = 5V$ , $V_{BOOT1/2-UGATE1/2} = 0.1V$	--	1.7	--	$\Omega$
			--	5	--	
			--	10	--	
			--	20	--	
UGATE1/2 Pull-Low Resistance		$V_{UGATE1/2} - V_{PHASE1/2} = 0.1V$	--	0.8	--	$\Omega$
LGATE1/2 Pull-High Resistance		Programmable, $V_{PVDD} - V_{LGATE1/2} = 0.1V$	--	1.7	--	$\Omega$
			--	5	--	
			--	10	--	
			--	20	--	
LGATE1/2 Pull-Low Resistance		$V_{LGATE1/2} = 0.1V$	--	0.8	--	$\Omega$
Dead-Time at LGATE1/2 Falling Edge			--	40	--	ns
Dead-Time after UGATE1/2 Falling Edge			--	40	--	ns
<b>System Protections – Overvoltage, Undervoltage, and Overcurrent Protections (OVP, UVP, and OCP)</b>						
VIN UVP Voltage Threshold Range	$V_{TH\_VINUV}$	Programmable, (8-bit), 125mV/step (typ.)	4	--	27	V
VIN UVP Voltage Threshold Accuracy		Setting of $V_{TH\_VINUV} = 5V/10V/15V$	-5	--	5	%
VIN OVP Voltage Threshold Range	$V_{TH\_VINO}$	Programmable, (8-bit), 125mV/step (typ.)	4	--	30	V

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
VIN OVP Voltage Threshold Accuracy		Setting of $V_{TH\_VINOVP} = 19V/26V$	-5	--	5	%
VBUS OVP Voltage Threshold Range	$V_{TH\_VBUSOV}$	Programmable, (8-bit), 100mV/step (typ.)	3.3	--	24	V
VBUS OVP Voltage Threshold Accuracy		Setting of $V_{TH\_VBUSOV} = 12V/20V$	-5	--	5	%
VBUS OVP Voltage Threshold Accuracy		Setting of $V_{TH\_VBUSOV} = 3.3V/ 5V$	-0.3	--	0.3	V
ZCD Pin OVP Voltage Threshold (VO Pin Open, OVP)	$V_{TH\_ZCDOV}$		-7	125	7	%
VO UVP Voltage Threshold Range	$V_{TH\_VOUV}$	Programmable, (8-bit), 100mV/step (typ.)	3	--	20	V
VO UVP Voltage Threshold Accuracy		Setting of $V_{TH\_VOUV} = 5V/12V/20V$	-5	--	5	%
VO UVP Voltage Threshold Accuracy		Setting of $V_{TH\_VOUV} = 3V$	-0.2	--	0.2	V
<b>USB PD Controller – CC1/2 Voltage Detections, BMC Transmitter/Receiver and VCONN Switches</b>						
CC1/2 Pull-Up Current Source – 1	Ip1	For default USB power	64	80	96	$\mu A$
CC1/2 Pull-Up Current Source – 2	Ip2	For 1.5A and 5V	165.6	180	194.4	$\mu A$
CC1/2 Pull-Up Current Source – 3	Ip3	For 3A and 5V	303.6	330	356.4	$\mu A$
CC1/2 Open-Loop Clamping Voltage for pull-up Source	$V_{CC\_CLAMP}$	$V_{DD} = 5V @$ pull-up Current 330 $\mu A$	2.9	3.25	--	V
CC1/2 Pull-Down Resistor	Rd	$V_{DD} = 5V @$ pull-up 56k $\Omega$	4.6	5.1	5.6	k $\Omega$
Transmitter High-Level Output Voltage Range			1.05	1.125	1.2	V
Transmitter Low-Level Output Voltage Range			0	--	75	mV
Rising Time of the Transmitter Output Voltage		From 10% to 90%, CL=200pF to 600pF	300	--	--	ns
Falling Time of the Transmitter Output Voltage		From 90% to 10%, CL= 200pF to 600pF	300	--	--	ns
Receiver High-Level Input Voltage Range			--	0.8	--	V
			--	0.7	--	
			--	0.6	--	
			--	0.5	--	
Receiver Low-Level Input Voltage Range			--	0.5	--	V
			--	0.4	--	
			--	0.3	--	

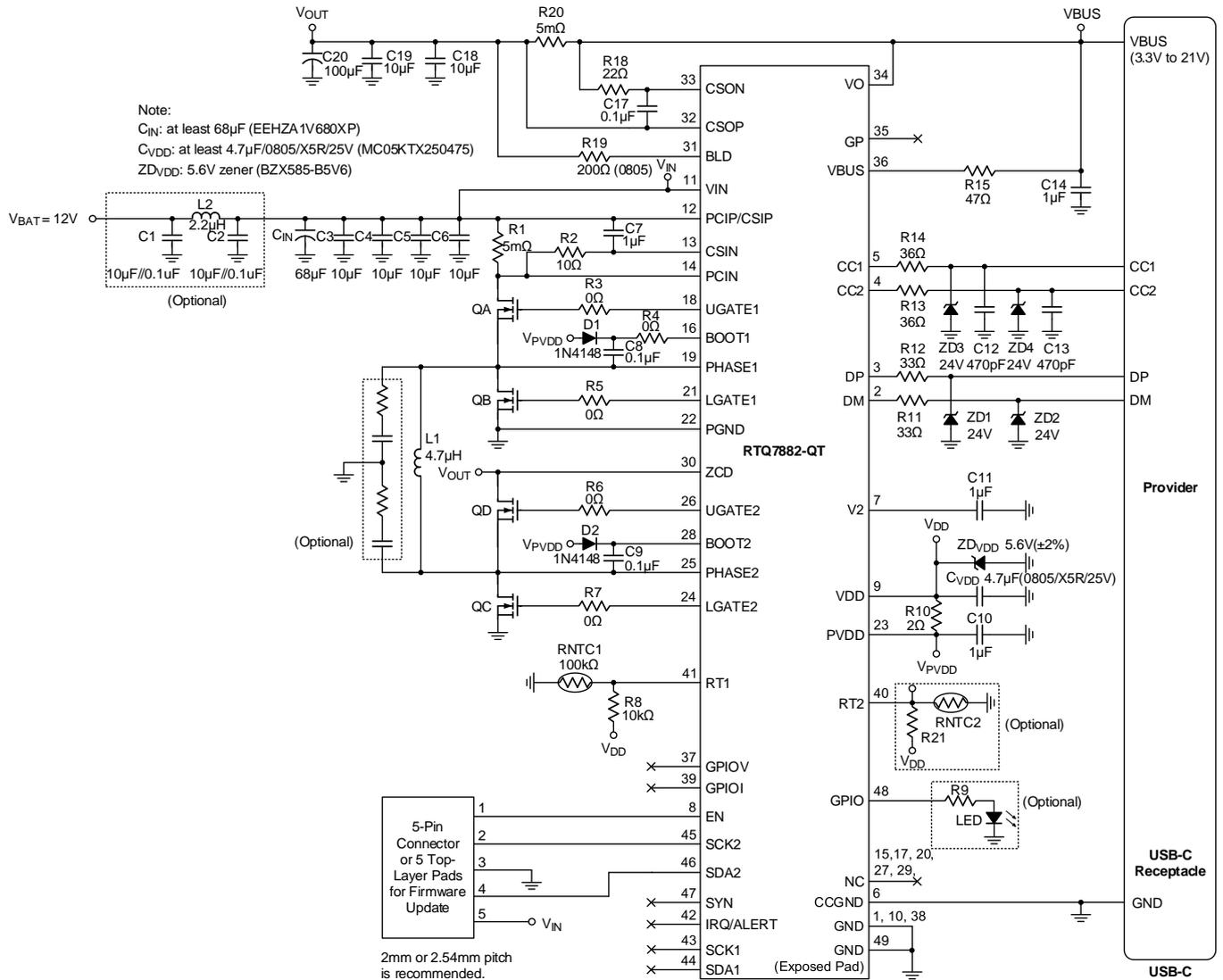
Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
			--	0.2	--	
VCONN On-Resistance of VDD-to-CC1/2 MOSFET		VDD = 5V, output current = 20mA	--	10	15	Ω
VCONN Output Voltage Drop VDD-to-CC1/2 MOSFET		VDD = 5V, output current = 20mA	--	0.2	0.3	V
VCONN Current-Limit Threshold		CC1/CC2 = GND	--	50	--	mA
CC1/CC2 Short to VBUS Protection			5.7	6	6.3	V
<b>DPDM Interfaces in Source Role Operation</b>						
On-Resistance of DP-to-DM MOSFET			--	--	40	Ω
DP/DM High-Level Output Voltage	VOH_DPDM	Sourcing current = 2mA	--	3.3	--	V
			--	1.8	--	
DP/DM Low-Level Output Voltage	VOL_DPDM	Sinking current = 2mA	--	--	0.3	V
DP/DM Voltage Falling Threshold for Plug-Out Detection	VREF1_DPDM		--	0.3	--	V
			--	0.4	--	
			--	0.5	--	
			--	0.6	--	
Input Voltage Offset Selection VREF2H_DPDM, VREF2L_DPDM	VIN_LEV		--	0	--	V
			--	0.4	--	
RX Upper Input Voltage Threshold	VREF2H_DPDM	VIN_LEV = 0V	--	0.8	--	V
			--	1.3	--	
			--	1.9	--	
			--	2.05	--	
		VIN_LEV = 0.4V	--	1.2	--	
			--	1.7	--	
			--	2.3	--	
			--	2.45	--	
RX Lower Input Voltage Threshold	VREF2L_DPDM	VIN_LEV = 0V	--	0.6	--	V
			--	1.1	--	
			--	1.8	--	
			--	1.95	--	
		VIN_LEV = 0.4V	--	1	--	
			--	1.5	--	
			--	2.2	--	
			--	2.35	--	

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
DP/DM Internal Pull-Low Resistance	RDWN_DPDM		16	20	24	kΩ
DP/DM Output Voltage for Divider Mode			1.13	1.2	1.27	V
			1.88	2	2.12	
			2.57	2.7	2.84	
			3.14	3.3	3.47	
Output Resistance DP/DM for Divider Mode 2.0/2.7/3.3			--	30	--	kΩ
Output Resistance DP/DM for Divider Mode 1.2			--	100	--	kΩ
DP/DM Output Voltage-1 for SRC	VSRC1_DPDM		--	0.6	--	V
DP/DM Output Voltage-2 for SRC	VSRC2_DPDM		--	3.3	--	V
DP/DM Short to VBUS Protection			5.415	5.7	5.985	V
<b>Charge-Pump Gate Drivers and Bleeders</b>						
GP On-Resistance of Pull-Low MOSFET		Pull-low NMOS is on, sinking I <sub>GP</sub> = 10mA, V <sub>DD</sub> = 5V	--	--	200	Ω
Maximum GP Voltage		V <sub>VO</sub> = 20V, R <sub>GP-to-GND</sub> = 667kΩ	V <sub>VO</sub> + 4V	V <sub>VO</sub> + 4.5V	V <sub>VO</sub> + 10V	V
BLD On-Resistance of Pull-Low MOSFET		Pull-low NMOS is on, sinking I <sub>BLD</sub> = 10mA, V <sub>DD</sub> = 5V	--	20	40	Ω
BLD Leakage Current		V <sub>BLD</sub> = 20V, pull-low NMOS is off V <sub>DD</sub> = 5V	--	--	1	μA
VBUS Bleeder Resistor		Pull-low NMOS is on V <sub>DD</sub> = 5.0V & V <sub>BUS</sub> = 23V	--	1.2	--	kΩ
<b>Digital Input and Output – I<sup>2</sup>C Pins (IRQ/ALERT, SCK1, SDA1, SCK2 and SDA2) and GPIO Pins (IRQ/ALERT, SCK1, SDA1, SCK2, SDA2, GPIOV, GPIOI, SYN, GPIO, RT1 and RT2)</b>						
I <sup>2</sup> C/GPIO High-Level Input Voltage Range	V <sub>IH</sub>	For the pins configured as input pins	1.5	--	--	V
I <sup>2</sup> C/GPIO Low-Level Input Voltage Range	V <sub>IL</sub>	For the pins configured as input pins	--	--	0.4	V
I <sup>2</sup> C/GPIO High-Level Output Voltage	V <sub>OH</sub>	Sourcing current = 2mA, for the pins configured as push-pull output pins	V <sub>DD</sub> - 1.5V	V <sub>DD</sub> - 0.8V	--	V
I <sup>2</sup> C/GPIO Low-Level Output Voltage	V <sub>OL</sub>	Sinking current = 2mA	--	--	0.3	V
I <sup>2</sup> C/GPIO Leakage Current		Pin input voltage = 5V	--	--	1	μA
RT1/2 Current Source		V <sub>RT1/2</sub> < 2.7V	92	100	108	μA

- Note 1.** Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions may affect device reliability.
- Note 2.**  $\theta_{JA}$  is measured under natural convection (still air) at  $T_A = 25^\circ\text{C}$  with the component mounted on a high effective-thermal-conductivity four-layer test board on a JEDEC 51-7 thermal measurement standard.  $\theta_{JC}$  is measured at the exposed pad of the package.
- Note 3.** Devices are ESD sensitive. Handling precautions are recommended.
- Note 4.** The device is not guaranteed to function outside its operating conditions.

## Typical Application Circuit

### RTQ7882-QT Typical Application Circuit



RTQ7882-QT Typical Application Circuit with VBUS Blocking MOSFET

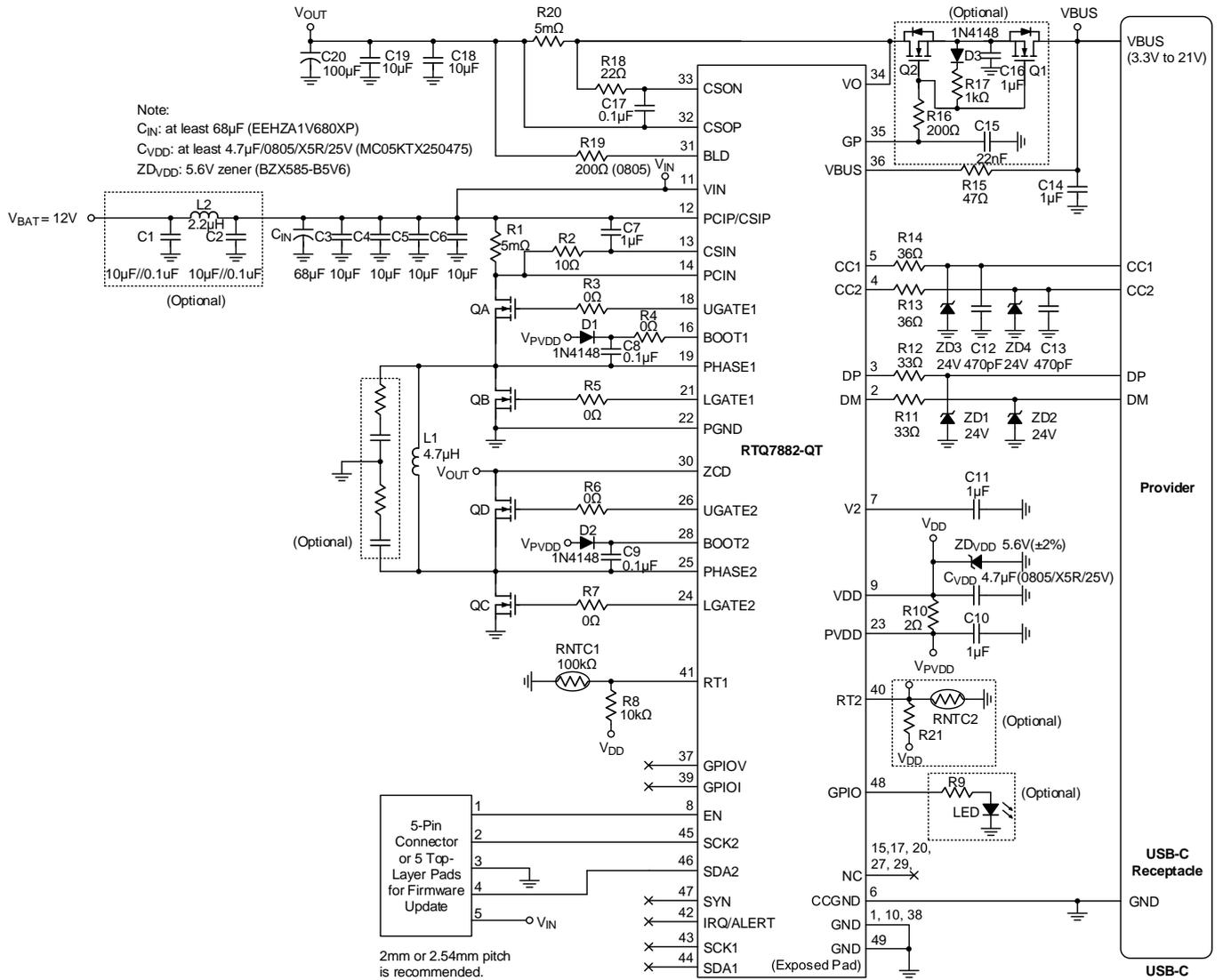
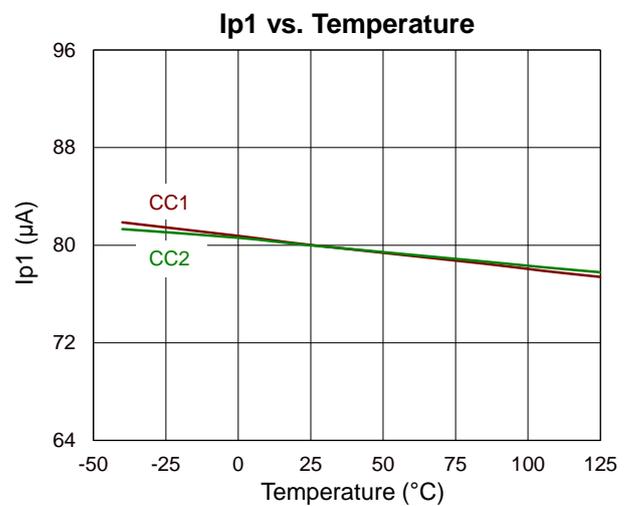
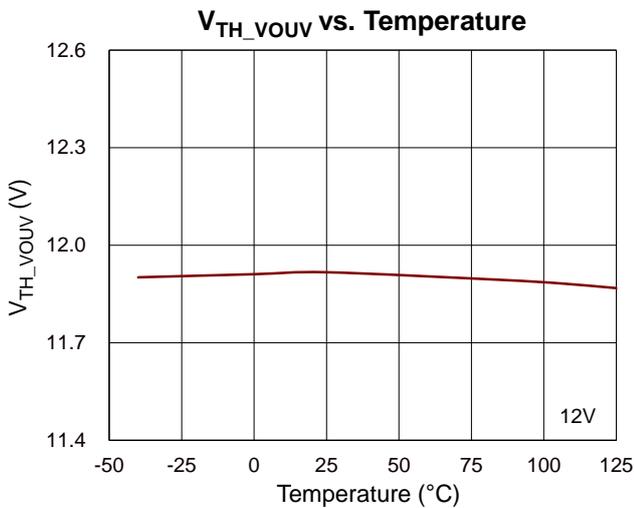
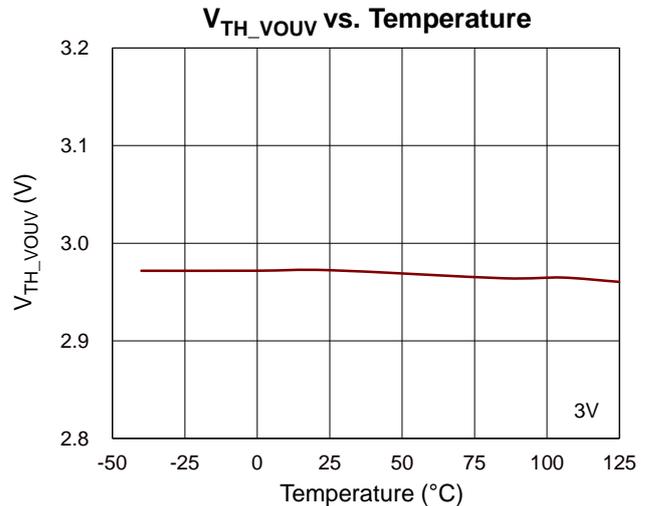
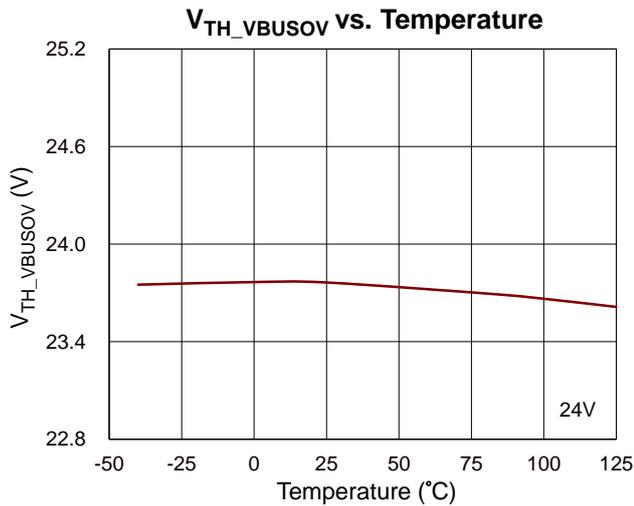
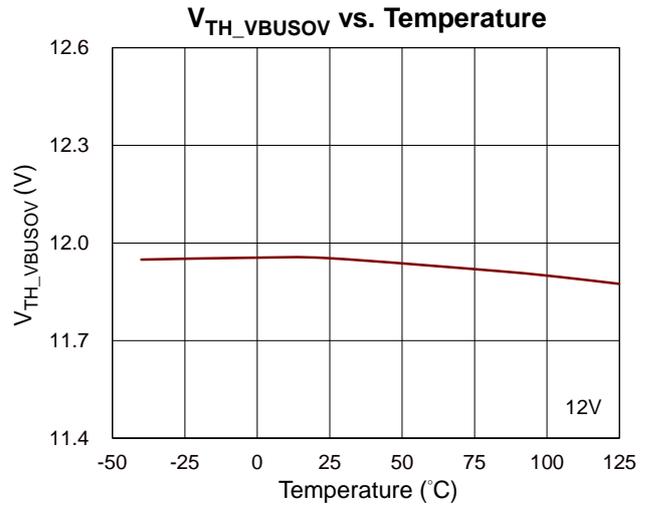
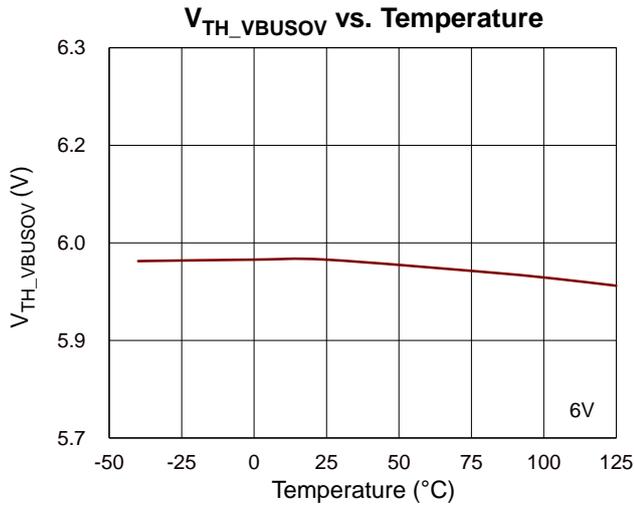
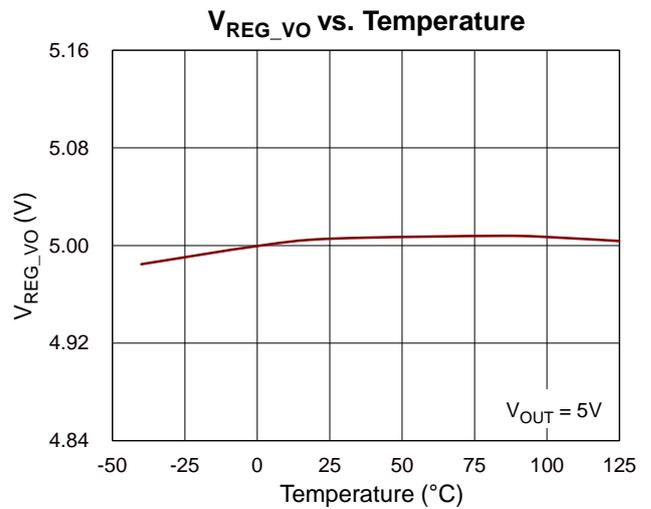
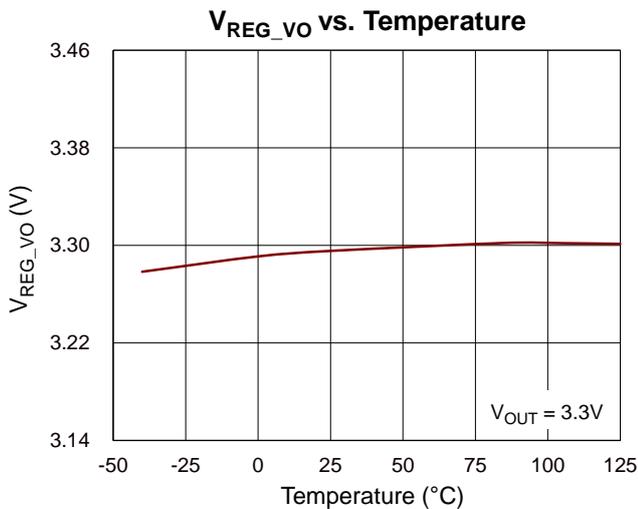
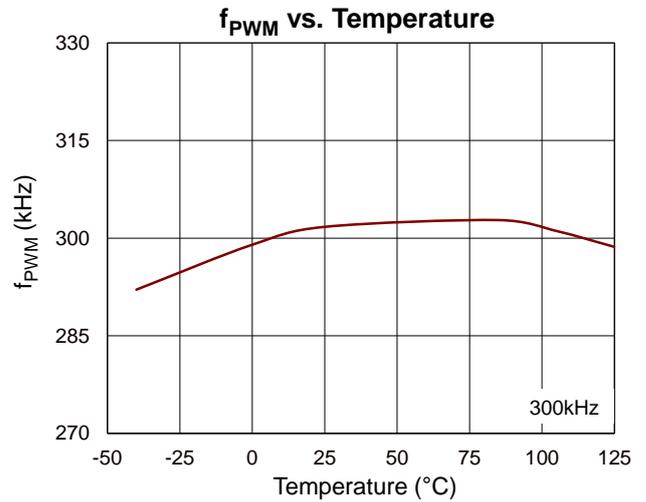
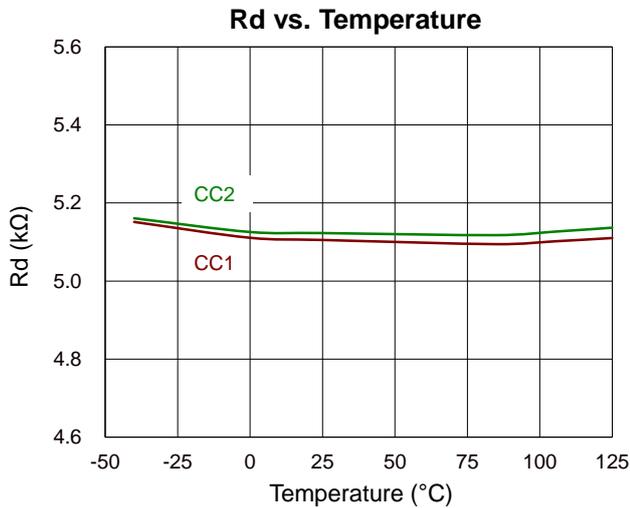
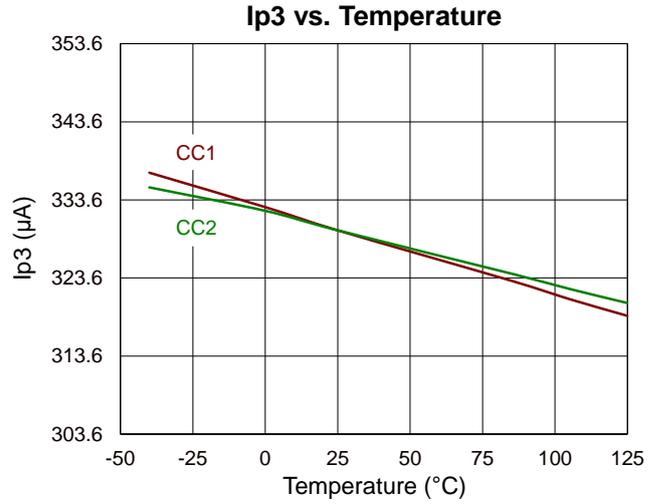
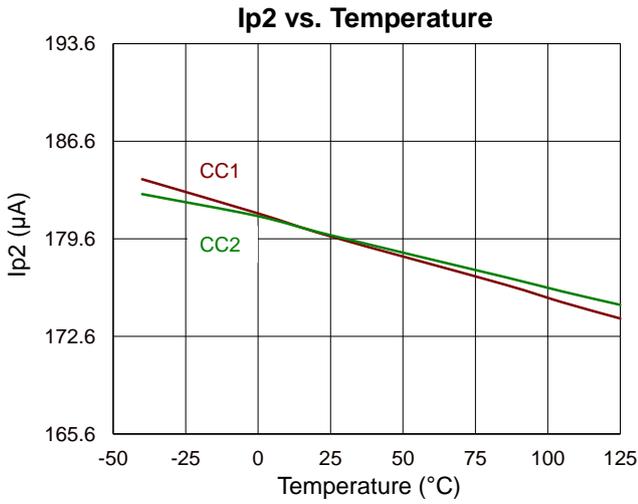


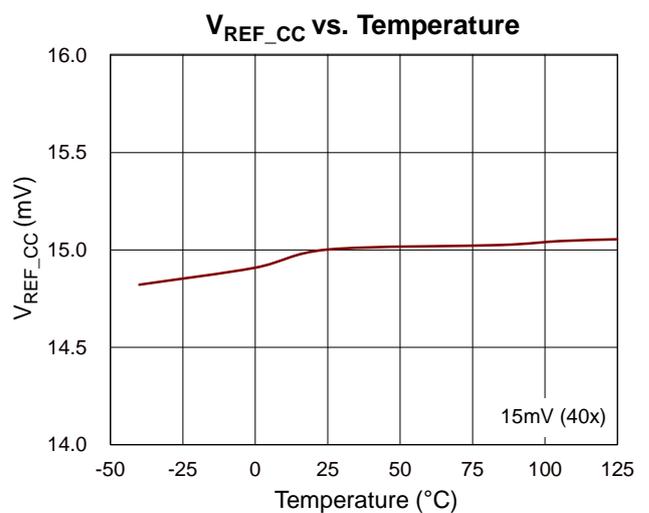
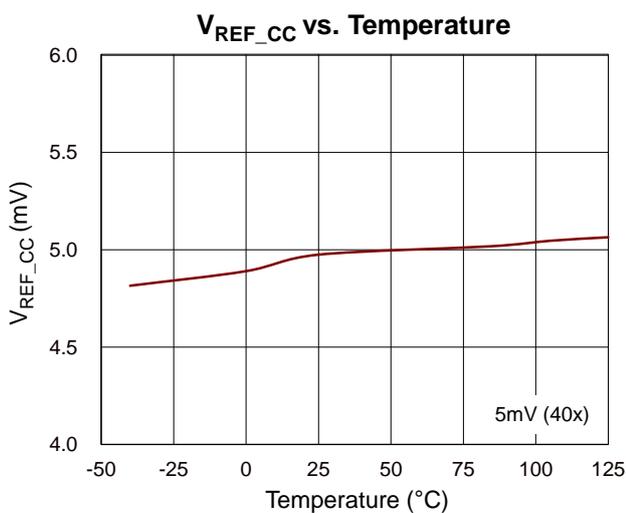
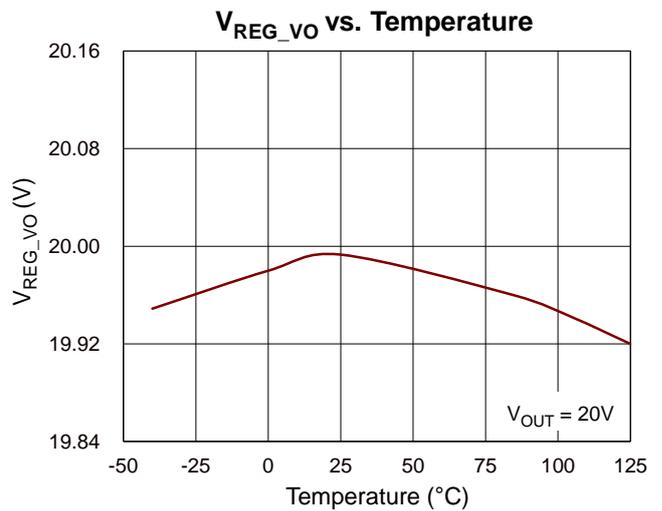
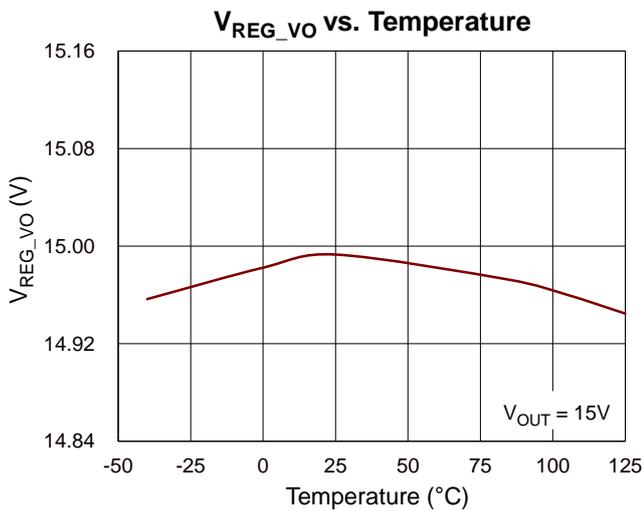
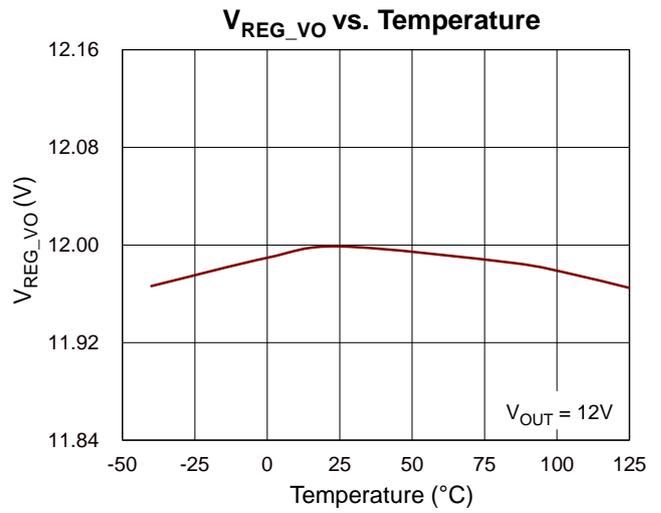
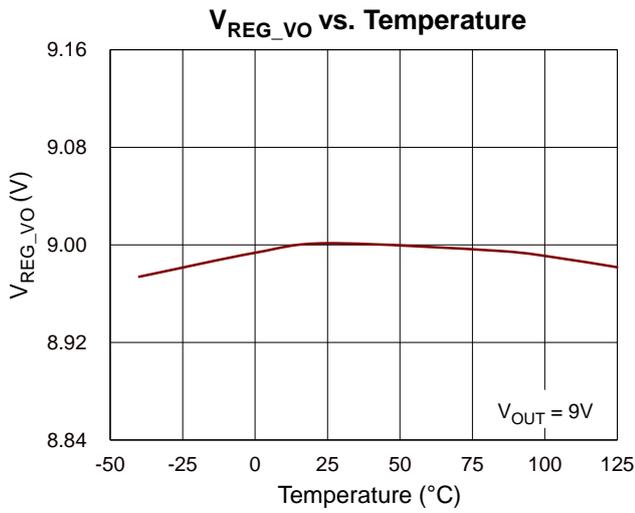
Table 1.

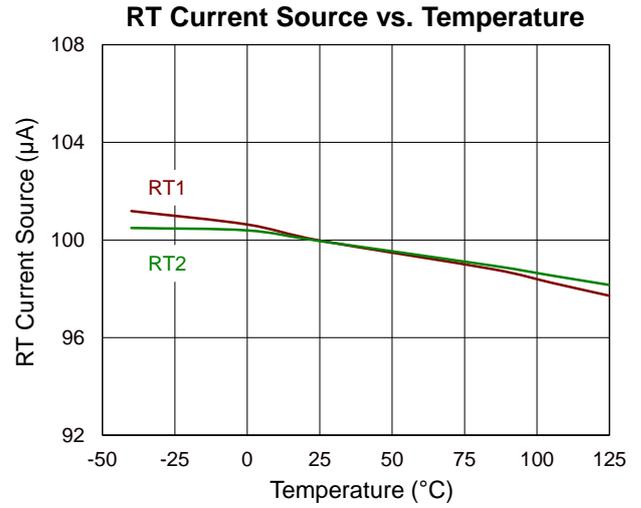
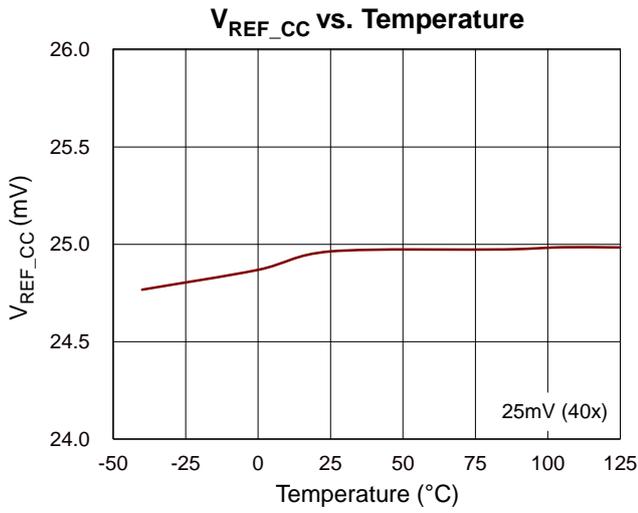
VBUS Blocking MOSFET		Note
Q1	Q2	
Y	Y	The safe VBUS protection circuit.
N	Y	Prevent current from V <sub>IN</sub> to VBUS.
Y	N	Prevent current from VBUS to V <sub>IN</sub> .
N	N	VBUS does not have any protection circuit.

## Typical Operating Characteristics









## Application Information

*Richtek's component specification does not include the following information in the Application Information section. Thereby no warranty is given regarding its validity and accuracy. Customers should take responsibility to verify their own designs and reserve suitable design margin to ensure the functional suitability of their components and systems.*

### Calculating Output Discharge Time

Figure 2 shows the functional block diagram of two built-in output bleeders at VBUS and BLD pins. The VBUS bleeder consists of an internal resistor (1.2kΩ typ.) and a pull-low MOSFET (QBLD2) for discharging the capacitors at VBUS side; the BLD bleeder consists of an external resistor (RBLD\_EXT) and a pull-low MOSFET (QBLD1) for discharging the capacitors at the output of the PWM converter. If the blocking MOSFETs (Q1A and Q1B) are on during discharging, the BLD bleeder with larger current capability dominates the discharge time. If the blocking MOSFETs are off, the discharge time (tDIS\_CVBUS) of the capacitor connected to the VBUS pin is determined by the following equation:

$$t_{DIS\_CVBUS} = R_{BLD\_INT} \times C_{VBUS} \times \ln\left(\frac{V_{BUS\_INI}}{V_{BUS\_FINAL}}\right)$$

where:

- ▶ RBLD\_INT is total internal resistance during on-state of the internal MOSFET QBLD2.
- ▶ CVBUS is the total capacitance, coupled to the VBUS pin.
- ▶ VBUS\_INI is the initial bus voltage before the discharging.
- ▶ VBUS\_FINAL is the final bus voltage at end of the discharging.

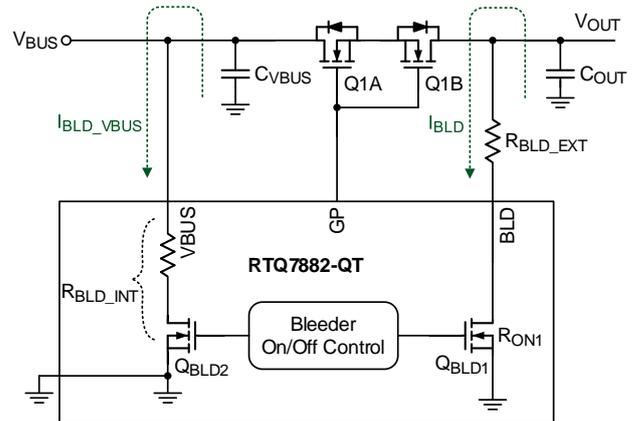


Figure 2. Functional Diagram of the Output Bleeders

Similar to the operation of the VBUS bleeder, the discharge time (tDIS\_COUT) of the capacitor connected to the output of the PWM converter is determined by the following equation:

$$t_{DIS\_COUT} = (R_{BLD\_EXT} + R_{ON1}) \times C_{OUT} \times \ln\left(\frac{V_{OUT\_INI}}{V_{OUT\_FINAL}}\right)$$

where:

- ▶ RBLD\_EXT is resistance of the external resistor.
- ▶ RON1 is on-resistance of the internal MOSFET QBLD1.
- ▶ COUT is the total capacitance connected to the output of the PWM converter.
- ▶ VOUT\_INI is the initial voltage of the PWM converter output before discharging.
- ▶ VOUT\_FINAL is the final voltage of the PWM converter output at end of discharging.

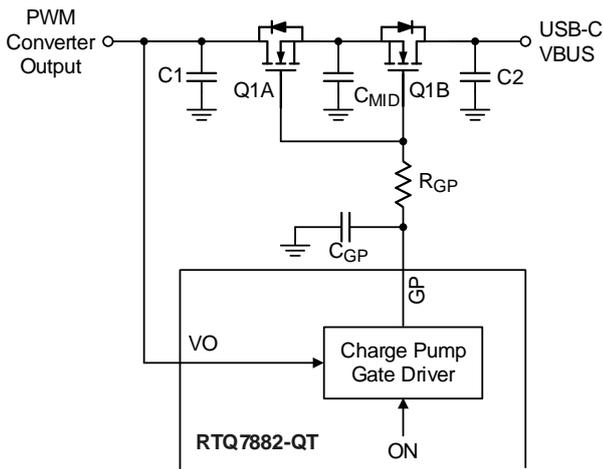


Figure 3. Functional Diagram of the Power-Path Control

### Using Charge-Pump Gate Driver for Power-Path On/Off Control

Figure 3 shows the application schematic of a power-path on/off control. In this schematic, two N-channel MOSFETs of low on-resistance driven by a built-in gate driver, supplied by the charge pump, are employed to turn on or off the power-path between the PWM converter output and the USB-C VBUS terminal. If the internal control signal “ON” goes high, the GP voltage ( $V_{GP}$ ) will be pulled high to turn on the power MOSFETs (Q1A and Q1B) and connect the power-path. If “ON” goes low,  $V_{GP}$  will be pulled low by a built-in MOSFET to disconnect the power-path.

Power input (VO) is needed for the charge pump, and the VO pin must be connected the PWM converter output to ensure the power MOSFETs can be turned on successfully.

An optional MLCC capacitor ( $C_{GP}$ ) can be used to reduce the  $V_{GP}$  rising rate and surge current in the power-path as the power MOSFETs being switched on. When the power MOSFETs being switched off, the parasitic inductor and capacitors, C1 or C2, on the power path may cause voltage ringing at the drain of the Q1A or Q1B. An optional gate resistor ( $R_{GP}$ ) can be added to reduce the falling rate of the power-path current and prevent voltage spikes. A  $1\mu\text{F}$  MLCC capacitor ( $C_{MID}$ ) between the source terminals to ground is necessary in order to prevent oscillation due to such dual-MOSFET connection.

### Thermal Considerations

The junction temperature should never exceed the absolute maximum junction temperature  $T_{J(MAX)}$ , listed under Absolute Maximum Ratings, to avoid permanent damage to the device. The maximum allowable power dissipation depends on the thermal resistance of the IC package, the PCB layout, the rate of surrounding airflow, and the difference between the junction and ambient temperatures. The maximum power dissipation can be calculated using the following formula:

$$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$$

where  $T_{J(MAX)}$  is the maximum junction temperature,  $T_A$  is the ambient temperature, and  $\theta_{JA}$  is the junction-to-ambient thermal resistance.

For continuous operation, the maximum operating junction temperature indicated under Recommended Operating Conditions is  $125^\circ\text{C}$ . The junction-to-ambient thermal resistance,  $\theta_{JA}$ , is highly package dependent. For a WQFN-48L 6x6 package, the thermal resistance,  $\theta_{JA}$ , is  $26.8^\circ\text{C/W}$  on a standard JEDEC 51-7 high effective-thermal-conductivity four-layer test board. For a WET-WQFN-48L 6x6 package, the thermal resistance,  $\theta_{JA}$ , is  $27.2^\circ\text{C/W}$  on a standard JEDEC 51-7 high effective-thermal-conductivity four-layer test board. The maximum power dissipation at  $T_A = 25^\circ\text{C}$  can be calculated as below:

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / (26.8^\circ\text{C/W}) = 3.73\text{W for a WQFN-48L 6x6 package.}$$

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / (27.2^\circ\text{C/W}) = 3.67\text{W for a WET-WQFN-48L 6x6 package.}$$

The maximum power dissipation depends on the operating ambient temperature for the fixed  $T_{J(MAX)}$  and the thermal resistance,  $\theta_{JA}$ . The derating curves in Figure 4 allow the designer to see the effect of rising ambient temperature on the maximum power dissipation.

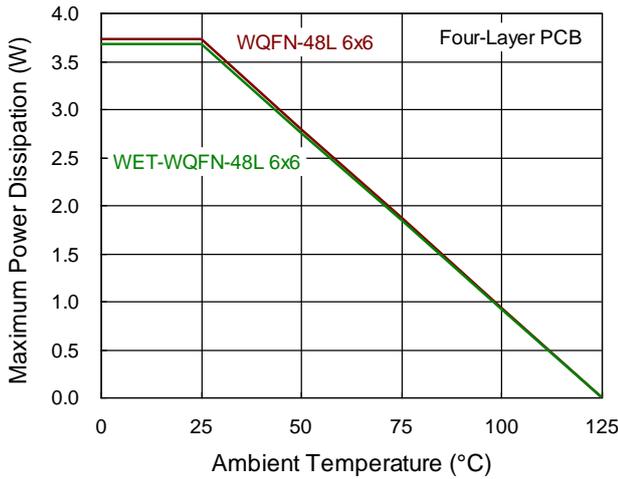


Figure 4. Derating Curve of Maximum Power Dissipation

### Layout Considerations

- ▶ Connect the IC GND pin and the exposed pad to a ground plane (IC-ground), and then connect the IC-ground to the USB GND terminals via a low-impedance path. The exposed pad is also used to dissipate the heat into PCB.
- ▶ Connect the decoupling MLCCs near the pins of VDD, V2, PVDD and VBUS. Connect the MLCCs to the pins and IC-ground via low impedance paths.
- ▶ Connect the decoupling MLCC from the BOOT1/2 pin to the PHASE1/2 pin via a short and low-impedance path.
- ▶ Connect the PGND and PHASE1 pins respectively to the Source and the Drain of low-side power MOSFET (controlled by LGATE1) via dedicated and low-impedance paths.
- ▶ Connect the PHASE2 and ZCD pins respectively to the Source and the Drain of high-side power MOSFET (controlled by UGATE2) via a dedicated and low-impedance paths.

- ▶ Connect the capacitor (between the CSOP and CSON pins) close to these pins. The paths of CSOP and CSON must be directly connected to the terminals of current-sense resistor ( $R_{CSO}$ ) using Kelvin connections as shown in the layout shown in Figure 5.

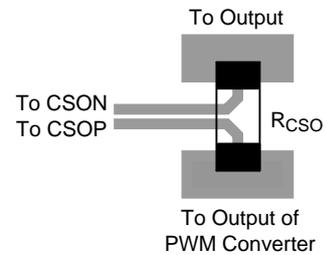


Figure 5. Kelvin Connections for the  $R_{CSO}$

- ▶ Figure 6 is a recommended placement of the PWM Buck-Boost power-stage. Two critical loops “from  $C_{IN1} \rightarrow R_{CSI} \rightarrow Q_A \rightarrow Q_B$  to  $C_{IN1}$ ” and “from  $C_{O1} \rightarrow Q_D \rightarrow Q_C$  to  $C_{O1}$ ” must be as short as possible to minimize the switching noise at PCIP/CSIP, PCIN, PHASE1, PHASE2 and ZCD pins. The shorter paths also help to reduce radiated EMI. It is necessary to use an MLCC (10 $\mu$ F/50V, X5R/X7R) for the input capacitor ( $C_{IN1}$ ) and output capacitor ( $C_{O1}$ ). For reducing the input and output voltage ripples during heavy load operation, it is recommended to add more MLCCs or solid input and output capacitors. Moreover, to improve heat dissipation, one needs to increase the PCB areas for Drains of high-side and low-side MOSFETs.

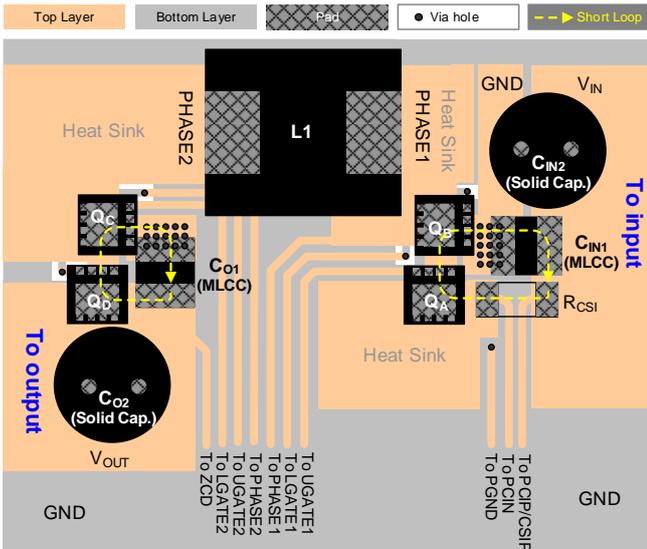


Figure 6. Recommended PCB Layout of the Power Stage

- ▶ To prevent the switching noises, separate the following signals from the switching nodes and the switching-current paths connected with PHASE pin:
  - Input and output current-sense signals
  - CC1 and CC2 signals
  - CV-loop feedback signal
- ▶ For improving ESD immunity, connect MLCCs close to the GND and VBUS terminals of the USB Type-C connector. Connect the capacitors to the USB VBUS and GND terminals through the low-impedance paths.

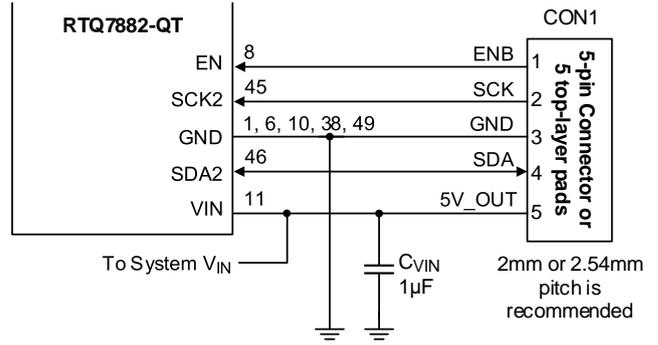


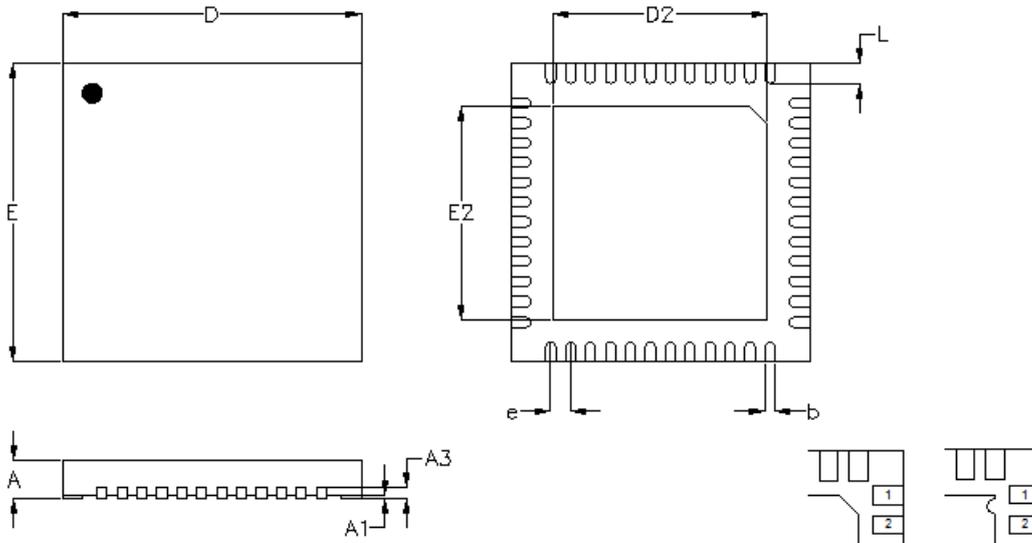
Figure 7. Connections for Manual Firmware Updates

### Manual Firmware Update

During product development stage, users might need to download or update the RTQ7882-QT firmware. This can be done by adding a 5-pin connector (CON1) or five test pads on PCBs for updating the RTQ7882-QT firmware manually as shown in Figure 7. This connector is then connected to a “Firmware update fixture” by a 5-pin cable. The fixture is also connected to a PC via a Micro USB cable and acts as a bridge between the RTQ7882-QT and the PC. With this setup, users can download firmware to the RTQ7882-QT by using the RTQ7882-QT graphic user interface (GUI) installed in the PC. During the firmware update process, the fixture can supply current (up to 40mA) to the RTQ7882-QT and the system  $V_{IN}$  via the 5V\_OUT pin of the 5-pin cable.

If the power from the fixture is enough to power the RTQ7882-QT and the system  $V_{IN}$ , it is not necessary to use the auxiliary input voltage for the system  $V_{IN}$ . On the other hand, if the system  $V_{IN}$  consumes more current than the fixture capability, one needs to use an auxiliary input voltage.

## Outline Dimension



**DETAIL A**

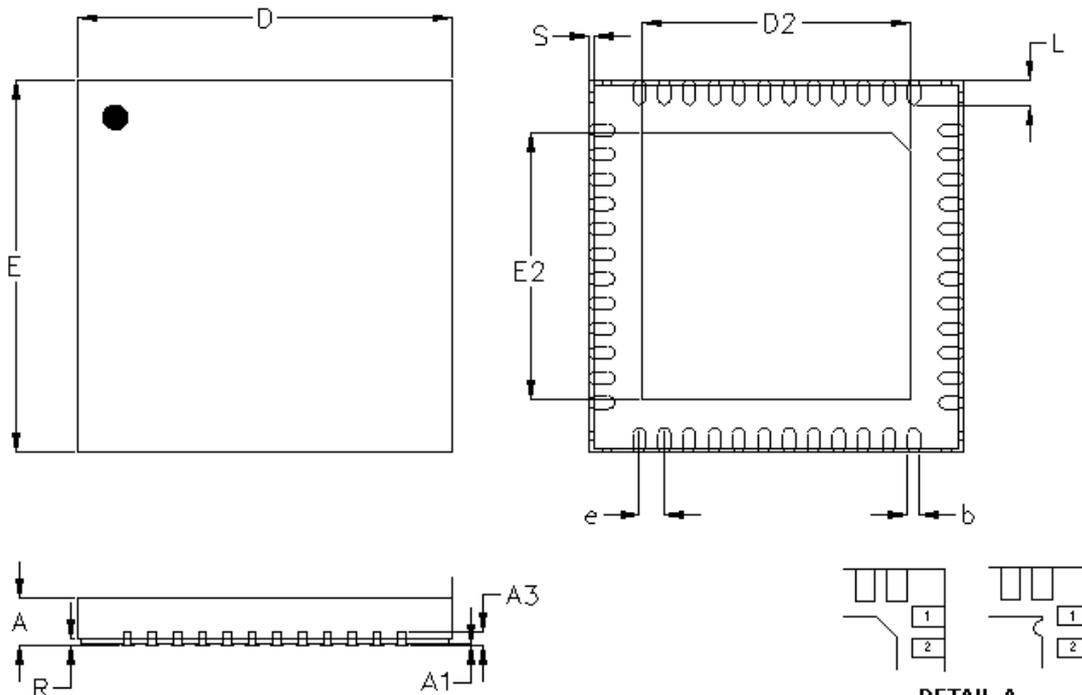
Pin #1 ID and Tie Bar Mark Options

Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Dimensions In Millimeters		Dimensions In Inches		
	Min	Max	Min	Max	
A	0.700	0.800	0.028	0.031	
A1	0.000	0.050	0.000	0.002	
A3	0.175	0.250	0.007	0.010	
b	0.150	0.250	0.006	0.010	
D	5.950	6.050	0.234	0.238	
D2	Option 1	4.250	4.350	0.167	0.171
	Option 2	4.350	4.450	0.171	0.175
	Option 3	4.650	4.750	0.183	0.187
	Option 4	4.450	4.550	0.175	0.179
E	5.950	6.050	0.234	0.238	
E2	Option 1	4.250	4.350	0.167	0.171
	Option 2	4.350	4.450	0.171	0.175
	Option 3	4.650	4.750	0.183	0.187
	Option 4	4.450	4.550	0.175	0.179
e	0.400		0.016		
L	0.350	0.450	0.014	0.018	

### W-Type 48L QFN 6x6 Package

Note: The package of RTQ7882-QT uses Option 1.



**DETAIL A**

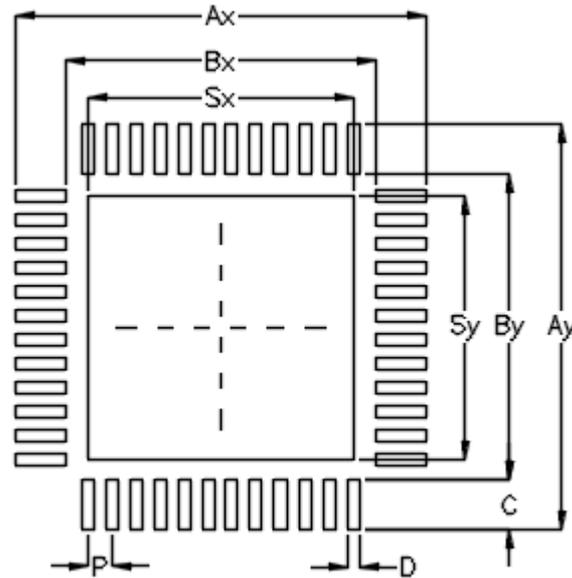
Pin #1 ID and Tie Bar Mark Options

Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.175	0.250	0.007	0.010
b	0.150	0.250	0.006	0.010
D	5.950	6.050	0.234	0.238
D2	4.250	4.350	0.167	0.171
E	5.950	6.050	0.234	0.238
E2	4.250	4.350	0.167	0.171
e	0.400		0.016	
L	0.350	0.450	0.014	0.018
R	0.050	0.150	0.002	0.006
S	0.001	0.090	0.000	0.004

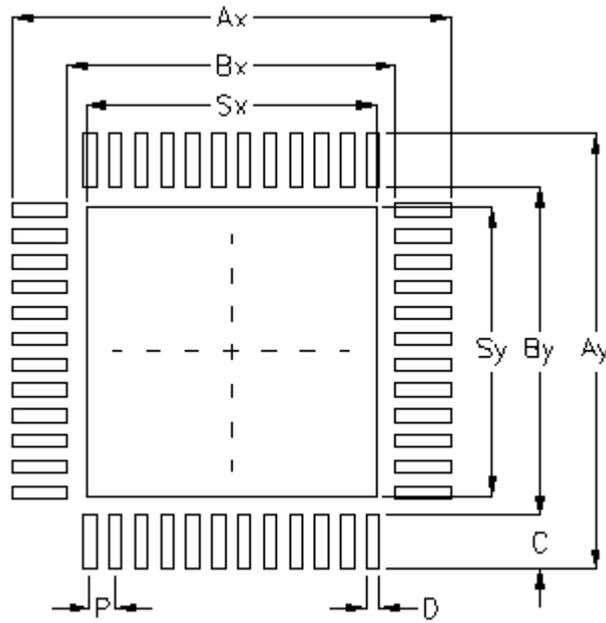
**WET W-Type 48L QFN 6x6 Package**

## Footprint Information



Package		Number of Pin	Footprint Dimension (mm)								Tolerance	
			P	Ax	Ay	Bx	By	C	D	Sx		
V/W/U/XQFN6x6-48	Option1	48	0.40	6.80	6.80	5.10	5.10	0.85	0.20	4.40	4.40	±0.05
	Option2									4.50	4.50	
	Option3									4.70	4.70	
	Option4									4.60	4.60	

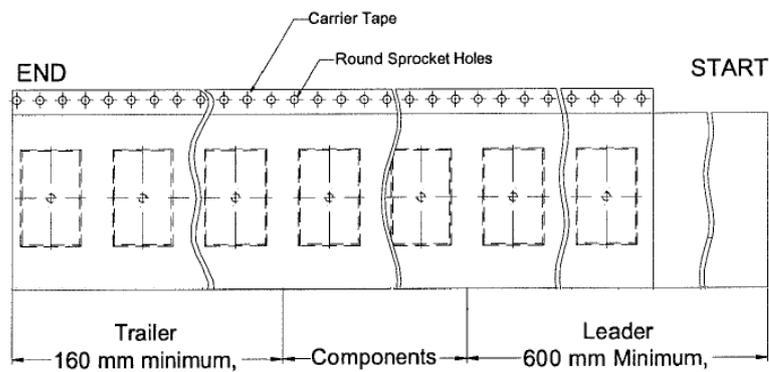
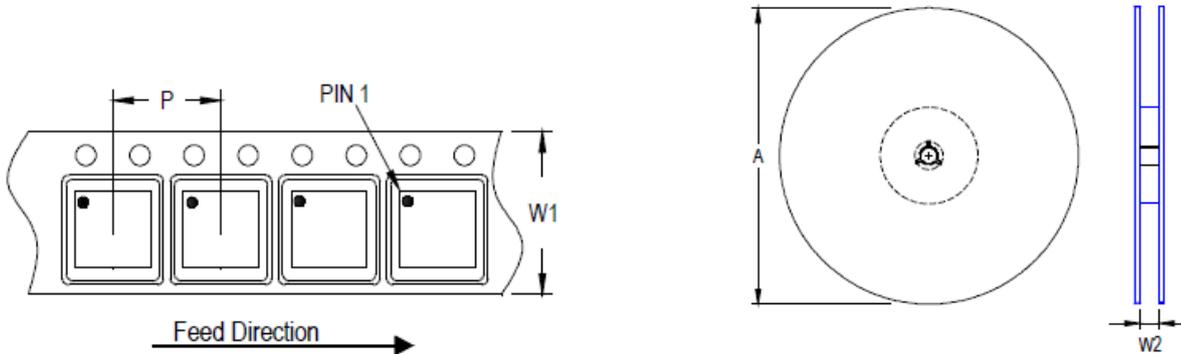
Note: The package of RTQ7882-QT uses Option 1.



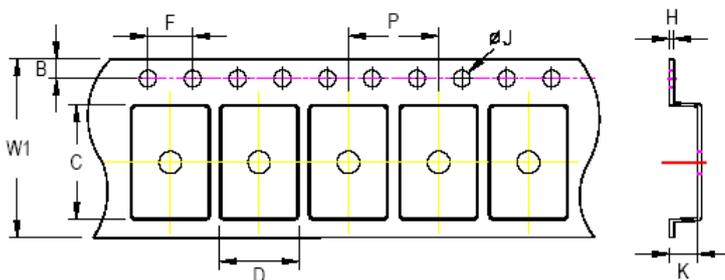
Package	Number of Pin	Footprint Dimension (mm)									Tolerance
		P	Ax	Ay	Bx	By	C	D	Sx	Sy	
WET-V/W/U/XQFN6x6-48	48	0.40	6.80	6.80	5.10	5.10	0.85	0.20	4.40	4.40	±0.05

## Packing Information

### Tape and Reel Data



Package Type	Tape Size (W1) (mm)	Pocket Pitch (P) (mm)	Reel Size (A)		Units per Reel	Trailer (mm)	Leader (mm)	Reel Width (W2) Min./Max. (mm)
			(mm)	(in)				
QFN/DFN 6x6	16	12	330	13	2,500	160	600	16.4/18.4



**C, D, and K are determined by component size.**  
**The clearance between the components and the cavity is as follows:**  
**- For 16mm carrier tape: 1.0mm max.**

Tape Size	W1		P		B		F		ØJ		H
	Max.	Min.	Max.	Min.	Min.	Max.	Min.	Max.	Min.	Max.	Max.
16mm	16.3mm	11.9mm	12.1mm	1.65mm	1.85mm	3.9mm	4.1mm	1.5mm	1.6mm	0.6mm	

**Tape and Reel Packing**

Step	Photo/Description	Step	Photo/Description
1	 <p>Reel 13"</p>	4	 <p>1 reel per inner box <b>Box G</b></p>
2	 <p>HIC &amp; Desiccant (2 Unit) inside</p>	5	 <p>6 inner boxes per outer box</p>
3	 <p>Caution label is on backside of Al bag</p>	6	 <p>Outer box <b>Carton A</b></p>

Package \ Container	Reel		Box			Carton		
	Size	Units	Item	Reels	Units	Item	Boxes	Units
QFN and DFN 6x6	13"	2,500	Box G	1	2,500	Carton A	6	15,000

## Packing Material Anti-ESD Property

Surface Resistance	Aluminum Bag	Reel	Cover tape	Carrier tape	Tube	Protection Band
$\Omega/\text{cm}^2$	$10^4$ to $10^{11}$					

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**Datasheet Revision History**

Version	Date	Description	Item
00	2023/6/19	Final	Ordering Information P1 Functional Pin Description on P4 Application Information on P23 Outline Dimension on P27 Footprint Information on P29
01	2024/3/13	Modify	General Description on P1 Features on P1, 2 Simplified Application Circuit on P3 Functional Pin Description on P4 Operation on P7 Electrical Characteristics on P11, 12 Typical Application Circuit on P18, 19 Application Information on P25, 26