

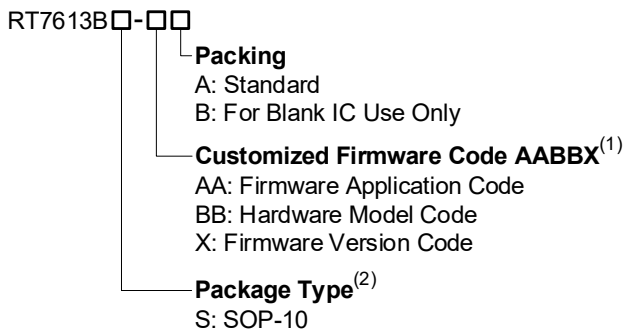
Low Quiescent Current USB Type-C PD Controller with Internal Compensation and Built-In Blocking N-MOSFET

1 General Description

The RT7613B is a low quiescent current USB Type-C Power Delivery (PD) controller that is primarily used on the secondary side for offline AC-DC power converters. Through its high integration of control regulators and a built-in blocking N-MOSFET, compact designs are easily implemented. An embedded MCU and a Bi-phase Mark Coding (BMC) transmitter are incorporated to handle the PD protocol. The built-in feedback compensation not only reduces external components, but also enhances transient response. Furthermore, digital-to-analog (DAC) and analog-to-digital (ADC) converters are integrated to achieve high-precision control in various applications.

The RT7613B is available in a SOP-10 package. The recommended junction temperature range is -40°C to 125°C , and the ambient temperature range is -40°C to 105°C .

2 Ordering Information



Note 1.

- Marked with ⁽¹⁾ indicates if the firmware code is empty, this field will be removed.
- Marked with ⁽²⁾ indicates compatible with the current requirements of IPC/JEDEC J-STD-020.

3 Features

- Protocol Support**
 - USB PD3.2 SPR PPS and AVS
- High Integration**
 - Wide Operating Voltage Range from 4V to 21V
 - Built-In Shunt Regulator for Constant Voltage and Constant Current Regulation
 - Built-In Blocking N-MOSFET
 - Built-In Quick Discharge in VDD and VBUS
 - Built-In VCONN Power and Switches
 - Programmable Cable Compensation
 - Power-Saving Standby Mode
 - Embedded MCU with 16kB OTP-ROM
 - Embedded BMC Transmitter
- Protection**
 - VDD Adaptive Overvoltage Protection (OVP)
 - VDD Adaptive Undervoltage Protection (UVP)
 - CC1/CC2 Overvoltage Protection (IO OVP)
 - Overcurrent Protection (OCP)
 - Over-Temperature Protection (OTP)

4 Applications

- USB Type-C PD Controller in Source Application for Chargers/Adapters of Smartphones, Tablets, Notebooks, and Other Electronics

5 Marking Information

RT7613BS-AABBX

RT7613BS
YMDANAABBX

RT7613BS: Product Code

YMDAN: Date Code

AABBX: Customized Firmware Code

6 Simplified Application Circuit

6.1 RT7613B Simplified Circuit for Source Application

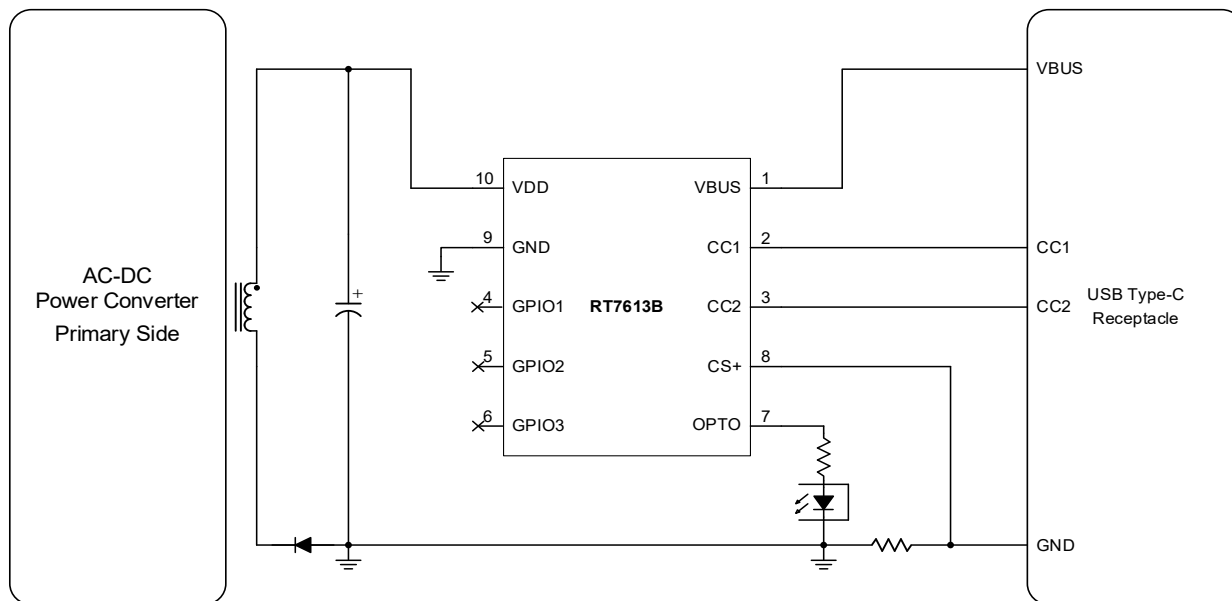
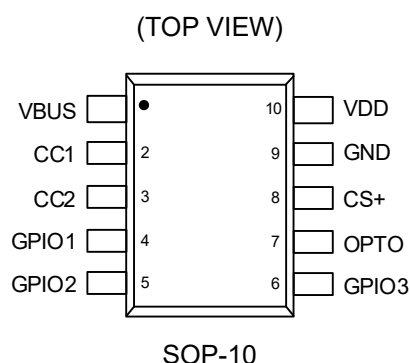


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7 Pin Configuration



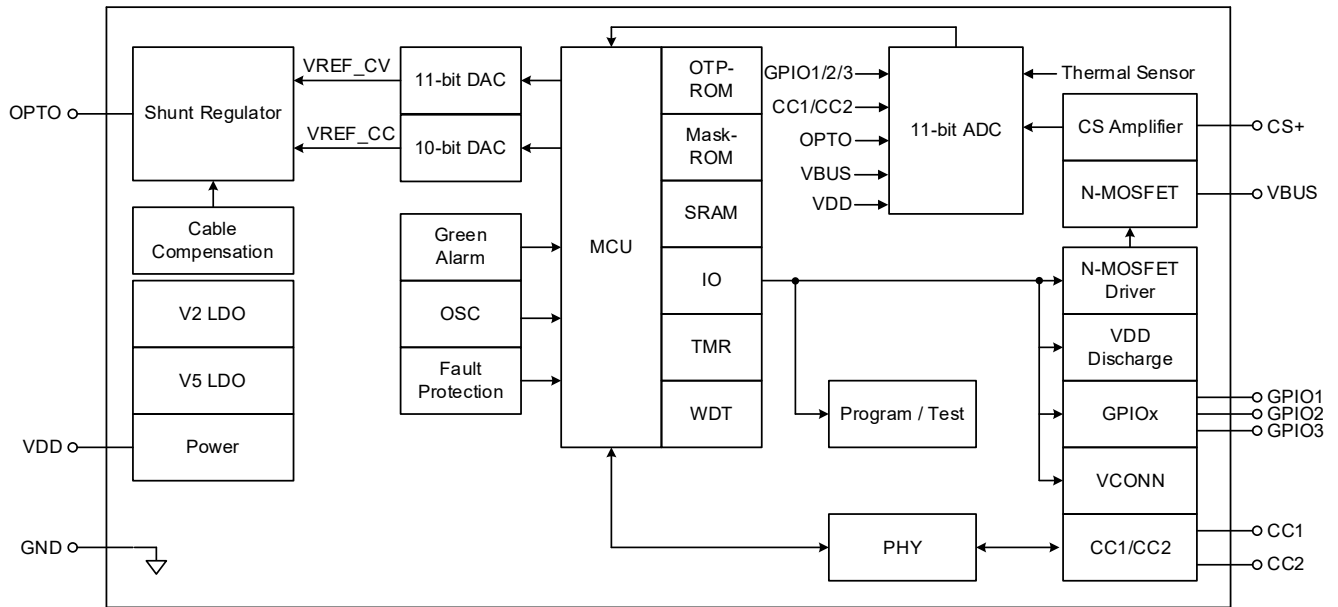
8 Functional Pin Description

Pin No.	Pin Name	I/O	Pin Function
1	VBUS	PWR A/D IO	Source terminal of blocking N-MOSFET. The VBUS bleeder connection node provides another path to discharge the VBUS capacitor. Can be configured as an ADC input.
2	CC1	A/D IO	Type-C connector Configuration Channel (CC) 1. Can be configured as an ADC input.
3	CC2	A/D IO	Type-C connector Configuration Channel (CC) 2. Can be configured as an ADC input.
4	GPIO1	A/D IO	General purpose input/output and open drain output. Current source for over-temperature protection. PWM control for LED on/off control. Can be configured as an ADC input.
5	GPIO2	A/D IO	General purpose input/output and open drain output. Current source for over-temperature protection. Can be configured as an ADC input.
6	GPIO3	A/D IO	General purpose input/output and open drain output. PWM control for LED on/off control. Can be configured as an ADC input.
7	OPTO	AO	Current source output for an optocoupler connection.
8	CS+	AI	Positive input of a current-sense amplifier for output current sensing.
9	GND	GND	Ground.
10	VDD	PWR	Supply input voltage.

8.1 IO Type Definition

- PWR: Power Pin
- GND: Ground Pin
- A I: Analog Input Pin
- A O: Analog Output Pin
- A/D IO: Analog/Digital Input/Output Pin

9 Functional Block Diagram



10 Absolute Maximum Ratings

(Note 2)

- VDD, VBUS, CC1, CC2, GPIO1 to GND -----0.3V to 28V
- OPTO, CS+, GPIO2, GPIO3 to GND -----0.3V to 6.5V
- Power Dissipation, P_D @ $T_A = 25^\circ\text{C}$
SOP-10-----0.61W
- Package Thermal Resistance (Note 3)
SOP-10, θ_{JA} -----164.49°C/W
SOP-10, θ_{JC} -----46.3°C/W
- Junction Temperature-----150°C
- Lead Temperature (Soldering, 10sec.) -----260°C
- Storage Temperature Range-----65°C to 150°C
- ESD Susceptibility (Note 4)
HBM (Human Body Model)-----2kV

Note 2. 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 3. θ_{JA} is simulated under natural convection (still air) at $T_A = 25^\circ\text{C}$ with the component mounted on a low effective-thermal-conductivity single-layer test board on a JEDEC 51-3 thermal measurement standard. θ_{JC} is simulated at the bottom of the package.

Note 4. Devices are ESD sensitive. Handling precautions are recommended.

11 Recommended Operating Conditions

(Note 5)

- Supply Input Voltage, V_{DD} -----4V to 21V
- Supply Input Current, I_{DD} (Based on $T_J < 125^\circ\text{C}$) -----0A to 5A
- Junction Temperature Range-----40°C to 125°C
- Ambient Temperature Range -----40°C to 105°C

Note 5. The device is not guaranteed to function outside its operating conditions.

12 Electrical Characteristics

(T_A = 25°C, unless otherwise specified.)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
IDD Section						
VDD Start-Up Current	IDD_STA	VDD = 2.5V	--	0.2	0.3	mA
VDD Normal Mode Current	IDD_NOR	Excluding the sourcing capabilities of the CC1/CC2/GPIO/OPTO pins	--	2.35	5	mA
VDD Idle Mode Current	IDD_IDLE	Excluding the sourcing capabilities of the CC1/CC2/GPIO/OPTO pins	--	0.47	0.61	mA
VDD Green Mode Current	IDD_GREEN	Excluding the sourcing capabilities of the CC1/CC2/GPIO/OPTO pins	--	0.35	0.45	mA
VDD Section						
VDD Turn-On Threshold Voltage	VDD_ON		2.9	3.05	3.2	V
VDD Turn-Off Threshold Voltage	VDD_OFF		2.7	2.85	3.1	V
VDD Sink Current for Output Voltage Discharge	IVDD_DSCHG		21	30	39	mA
			42	60	78	
			63	90	117	
			84	120	156	
			105	150	195	
			126	180	234	
VDD Resistor Divider for Voltage Feedback	RVDD_FB	RFB = RFB1 + RFB2 RFB1: VDD to VFB RFB2: VFB to GND (Note 6)	588	840	1092	kΩ
VDD Resistor Divider Scaling Factor for Voltage Feedback	KVDD_FB		9.9	10	10.1	V/V
VDD Threshold Voltage for Maximum Overvoltage Protection	VVDD_MOVP		23	24	25	V
VDD Maximum Overvoltage Protection Deglitch Time	tvDD_MOVP	(Note 6)	25	30	35	μs
VDD Threshold Voltage for Adaptive Overvoltage Protection	VVOUT_OVP	110% (min) to 160% (max), adjustable in 2.5% steps	104.50	110.00	115.50	%
			152.00	160.00	168.00	
VDD Threshold Voltage for Adaptive Overvoltage Protection	tD_VDD_OVP	11.5μs (min) to 53.5μs (max), adjustable in 3μs steps (Note 6)	9.66	11.50	13.34	μs
			44.94	53.50	62.06	
VDD Threshold Voltage for Adaptive Undervoltage Protection	VDD_UV_WK	52.5% (min) to 90% (max), adjustable in 2.5% steps	85.50	90.00	94.50	%
			49.88	52.50	55.13	
VDD Adaptive Undervoltage Protection Deglitch Time	tD_VDD_UV	11.5μs (min) to 53.5μs (max), adjustable in 3μs steps (Note 6)	9.66	11.50	13.34	μs
			44.94	53.50	62.06	
Oscillator Frequency for MCU	fOSC_MCU		10.26	10.80	11.34	MHz

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
DAC/ADC Section						
Maximum DAC Output Voltage for Constant Voltage Regulator	VDAC_CV_MAX		2.178	2.2	2.222	V
Minimum DAC Output Voltage for Constant Voltage Regulator	VDAC_CV_MIN		--	0.15	--	V
Maximum DAC Output Voltage for Constant Current Regulator	VDAC_CC_MAX		0.147	1.5	1.53	V
Minimum DAC Output Voltage for Constant Current Regulator	VDAC_CC_MIN		--	0	--	V
ADC Input Voltage	VADC		2.178	2.2	2.222	V
Current-Sense Amplifier Section						
Current-Sense Amplifier Gain	KCS		29.2	30	30.8	V/V
Current-Sense Amplifier Output Offset Voltage	VCS_OFFSET		0.36	0.4	0.44	V
Cable Compensation Resistance	RCABLE	(Note 6)	39	50	61	mΩ
			63	75	87	
			90	100	110	
			105	125	145	
			130	150	170	
Current-Sense Amplifier Input Threshold Voltage for Current Wake-Up	VCS_WK		0.51	0.55	0.59	V
			0.7117	0.75	0.7883	
			0.7508	0.7875	0.8242	
			0.7775	0.8125	0.8475	
			0.8042	0.8375	0.8708	
			0.8683	0.9	0.9317	
			0.8825	0.9125	0.9425	
			0.9217	0.95	0.9783	
			0.9483	0.975	1.0017	
			0.975	1	1.025	
			1.0142	1.0375	1.0608	
			1.0533	1.075	1.0967	
			1.08	1.1	1.12	
			1.1317	1.15	1.1683	
			1.1833	1.2	1.2167	
1.235	1.25	1.265				
OPTO Section						
OPTO Output Low Resistance	ROPTO_OL		--	5	200	Ω
OPTO Pull-Down Resistance	ROPTO_PD		42	60	78	kΩ

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Maximum OPTO Output Clamping Voltage	VOPTO_MAX_C LAMP	VDD = 5V, ISRC_OPTO = 1mA	2.1	2.4	2.7	V
Maximum OPTO Source Current	LOPTO_MAX	100Ω resistor connected in series	2	--	50	mA
Internal Compensation Section						
Rz for Zero Point	Rz		6.5	10	13.5	kΩ
			19.5	30	40.5	
			32.5	50	67.5	
			52	80	108	
			70	100	130	
			112	160	208	
			161	230	299	
			217	310	403	
CZ for Zero Point	Cz	(Note 6)	8.31	--	1064	nF
Overshoot Clamping Threshold	VVOUT_OVC		104.5	110	115.5	%
Undershoot Clamping Trigger Threshold	VVOUT_UVC_T R		85.5	90	94.5	%
			87.8	92.5	97.2	
Undershoot Clamping Release Threshold	VVOUT_UVC_R E		90.3	95	99.8	%
			92.6	97.5	102.4	
Overshoot and Undershoot Clamping Deglitch Time	tD_OVUV_CLAMP P	(Note 6)	--	10	--	μs
			--	20	--	
Deglitch Time for Disabling Undershoot Clamping in CC Mode	tDIS_UVCC_CLAMP P	(Note 6)	--	10	--	μs
			--	20	--	
CC1 and CC2 Section						
CC1/CC2 Source Current	ICC_SRC	VDD > 3V	18	20	22	μA
			72	80	88	
			169	180	191	
			304	330	356	
CC1/CC2 Source Current Clamping Voltage	VCC_CLP	VDD > 5V	4	4.5	5	V
			2.9	3.25	3.6	
CC1/CC2 Source Current for Rust Detection	ICC_RUST		0.5	1	1.5	μA
CC1/CC2 Input High Threshold Voltage	VCC_IH		2.5	2.6	2.7	V
			1.5	1.6	1.7	
			1.9	2	2.1	
			0.9	1	1.1	
CC1/CC2 Threshold Voltage for Overvoltage Protection	VCC_OVP		5.75	6	6.25	V
CC1/CC2 Overvoltage Protection Deglitch Time	tCC_OVP	(Note 6)	--	0.1	--	ms

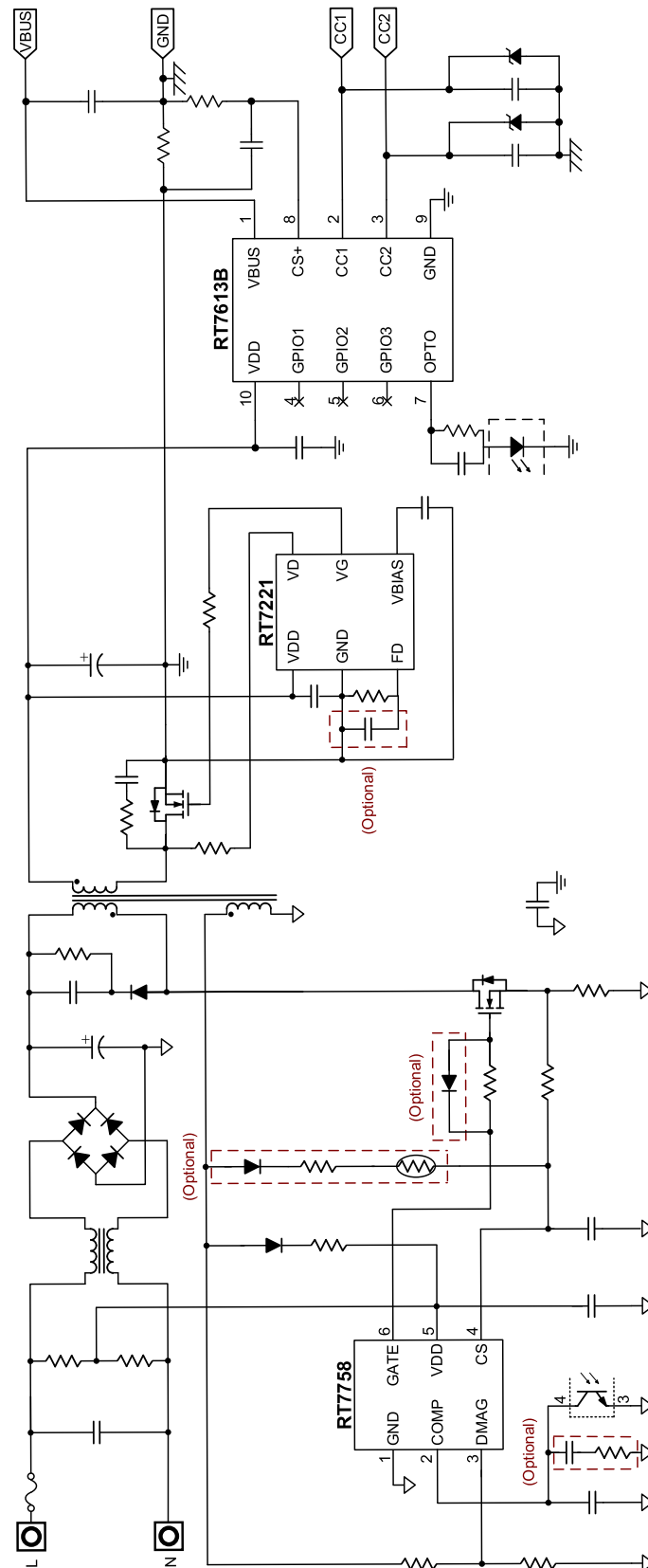
Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
VCONN Section						
VCONN Voltage	V _{VCONN}	V _{DD} = 5V, I _{LOAD} = 0mA	4.6	4.8	5	V
		V _{DD} = 5V, I _{LOAD} = 33mA	3.8	--	--	
VCONN Short-Circuit Current	I _{VCONN_SC}		45	70	95	mA
PD PHY Section						
BMC Transmitter Output High Voltage	V _{OH_BMC}		1.05	1.125	1.2	V
BMC Transmitter Output Low Voltage	V _{OL_BMC}		0	0.0375	0.075	V
BMC Transmitter Output On-Resistance	R _{ON_BMC}		15	35	55	Ω
BMC Transmitter Output Voltage Rise Time	t _{R_BMC}	(Note 6)	300	--	700	ns
BMC Transmitter Output Voltage Fall Time	t _{F_BMC}	(Note 6)	300	--	700	ns
GPIO1 Section						
GPIO1 Source Current	I _{GPIO1_BIAS}	V _{DD} > 3V	18	20	22	μA
			95	100	105	
GPIO1 Source Current Clamping Voltage	V _{GPIO1_CLP}	V _{DD} = 5V, I _{GP1_BIAS} = 95μA	2.7	4	5	V
GPIO1 Clamping Voltage for OTP	V _{GPIO1_CLP_OTP}		1	1.2	1.4	V
			1.3	1.5	1.7	
			1.6	1.8	2	
			1.9	2.1	2.3	
GPIO1 Source Voltage	V _{GPIO1_SRC}	V _{DD} = 5V, I _{LOAD} = 1.1mA	3.86	4.12	4.38	V
GPIO1 Pull-Up Resistance	R _{GPIO1_PU}		0.56	0.8	1.04	kΩ
GPIO1 PWM Duty for LED Control	D _{GPIO1_LED_DUTY}	(Note 6)	2	5	8	%
			7	10	13	
			17	20	23	
			37	40	43	
GPIO1 PWM Frequency for LED Control	f _{GPIO1_LED_FREQ}	(Note 6)	80	100	120	Hz
			400	500	600	
			800	1000	1200	
			1600	2000	2400	
GPIO1 Pull-Down Voltage	V _{GPIO1_PD}	I _{LOAD} = 3mA	--	--	0.2	V
GPIO1 Input High Threshold Voltage for OTP Wake-up	V _{GPIO1_OTP_IH}		0.9	1	1.1	V
			1.9	2	2.1	
GPIO1 Input Low Threshold Voltage for OTP Wake-up	V _{GPIO1_OTP_IL}		0.885	0.98	1.075	V
			1.88	1.98	2.08	

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
GPIO2 Section						
GPIO2 Source Current	IGPIO2_BIAS	VDD > 3V	70	100	130	μA
			850	1100	1350	
GPIO2 Source Current Clamping Voltage	VGPIO2_CLP	VDD = 5V, IGP1_BIAS = 850μA	3.2	3.6	4.4	V
GPIO2 Source Voltage	VGPIO2_SRC	VDD = 5V, ILOAD = 1mA	3.7	4	4.3	V
GPIO2 Pull-Up Resistance	RGPIO2_PU		0.7	1	1.3	kΩ
GPIO2 Comparator Input High Voltage	VGPIO2_IH		--	0.9	--	V
GPIO2 Comparator Input Low Voltage	VGPIO2_IL		--	VGPIO2_IH – 0.23	--	V
GPIO2 Pull-Down Voltage	VGPIO2_PD		--	--	0.2	V
GPIO3 Section						
GPIO3 Source Voltage	VGPIO3_SRC	VDD = 5V, ILOAD = 1.1mA	3.57	3.9	4.23	V
GPIO3 Pull-Up Resistance	RGPIO3_PU		0.7	1	1.3	kΩ
GPIO3 PWM Duty for LED Control	DGPIO3_ED_DUTY	(Note 6)	2	5	8	%
			7	10	13	
			17	20	23	
			37	40	43	
GPIO3 PWM Frequency for LED Control	fGPIO3_LED_FREQ	(Note 6)	80	100	120	Hz
			400	500	600	
			800	1000	1200	
			1600	2000	2400	
GPIO3 Input High Threshold Voltage	VGPIO3_IH		0.6	0.9	1.2	V
GPIO3 Input Low Threshold Voltage	VGPIO3_IL		--	VIH_RT – 0.23	--	V
GPIO3 Pull-Down Voltage	VGPIO3_PD		--	--	0.2	V
VBUS Section						
VBUS Pull-Down Impedance	RVBUS_PD		126	180	234	Ω
Drain-Source Current Threshold for Limited Power Source Protection	IDS_LPS	TA = 25°C	2	2.5	3	A
		TA = –40°C to 125°C (Note 6)	0.5	2.5	5	
VDD Pin to VBUS Pin Turn-On Resistance	RON	VGS = 8.5V, IDS = 1A@25°C	6.6	8.8	12.8	mΩ
		VGS = 8.5V, IDS = 1A @–40°C to 125 °C (Note 6)	6.0	--	14.0	
Accuracy Section						
Internal Thermal Sensor Error	ETS	25°C to 105°C (Note 6)	–7	--	7	°C

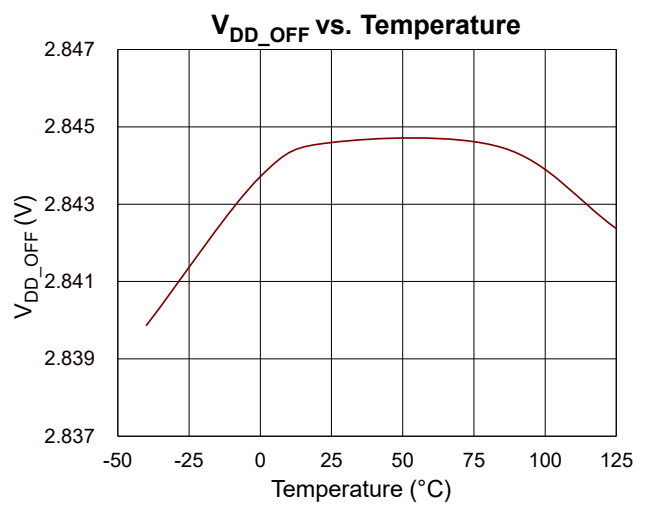
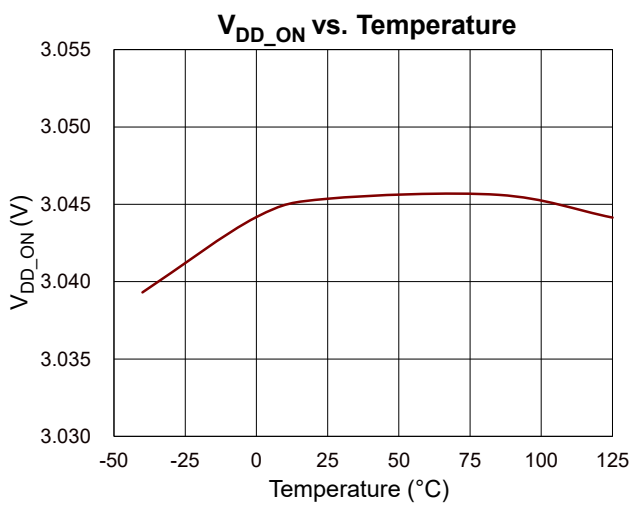
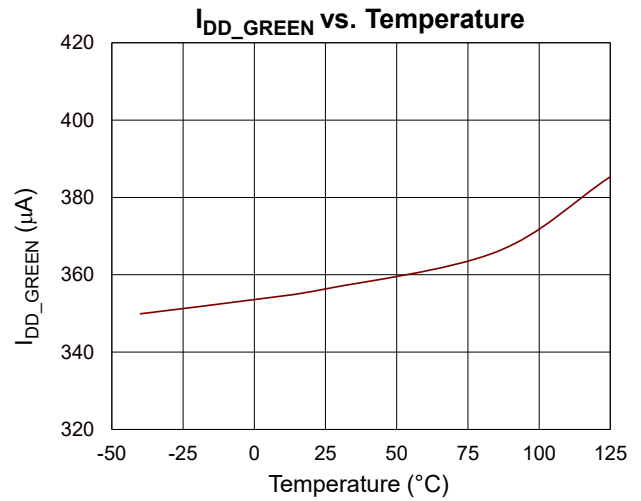
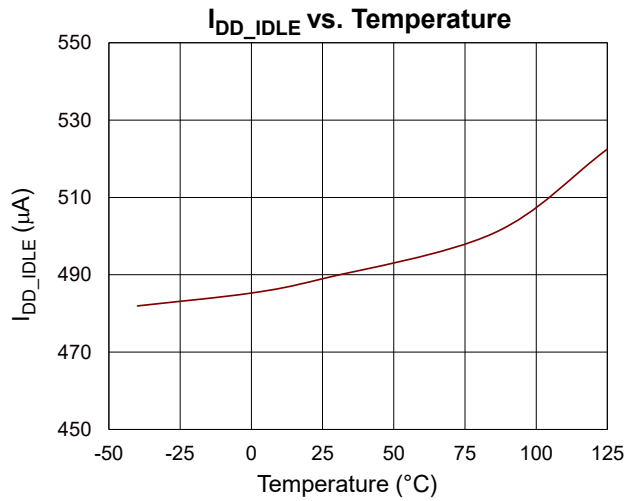
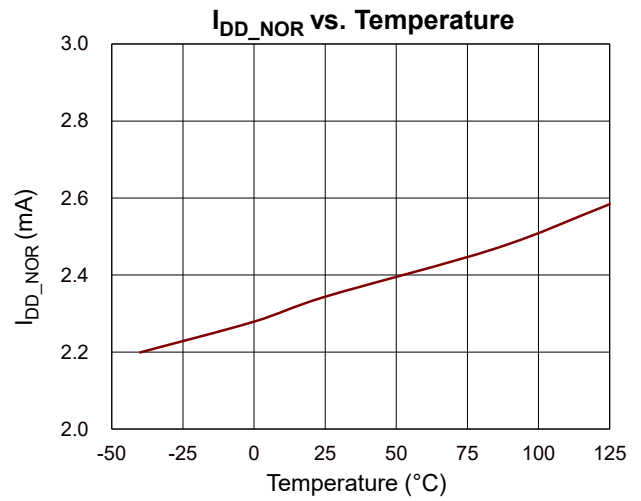
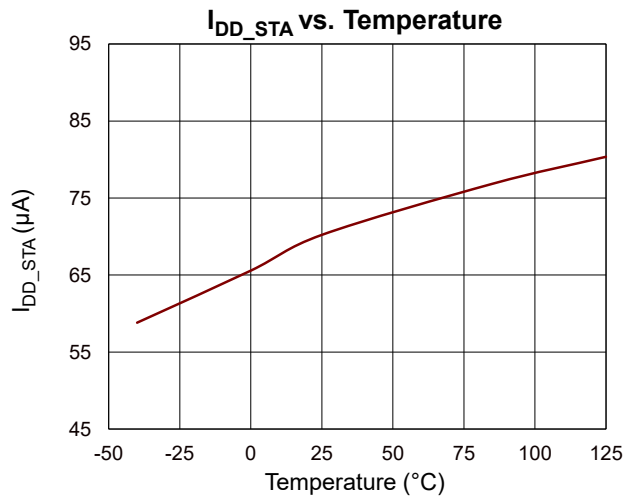
Note 6. Guaranteed by design.

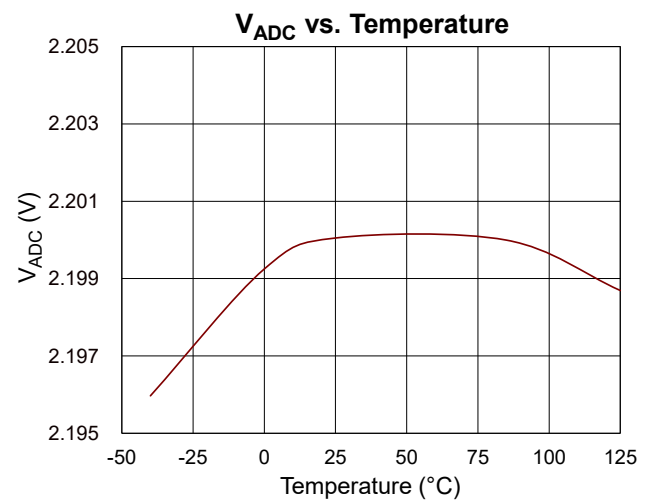
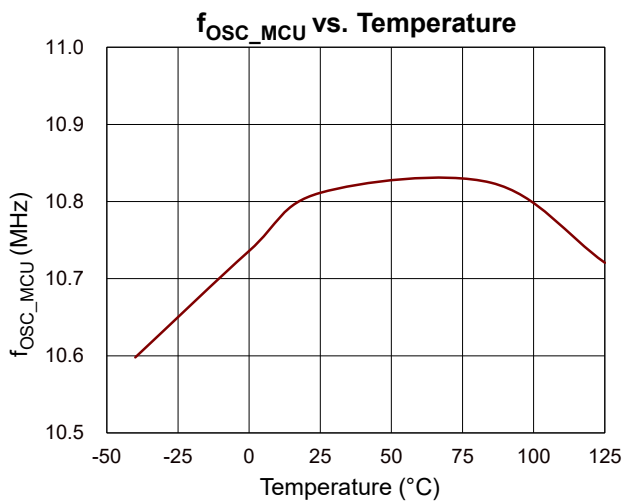
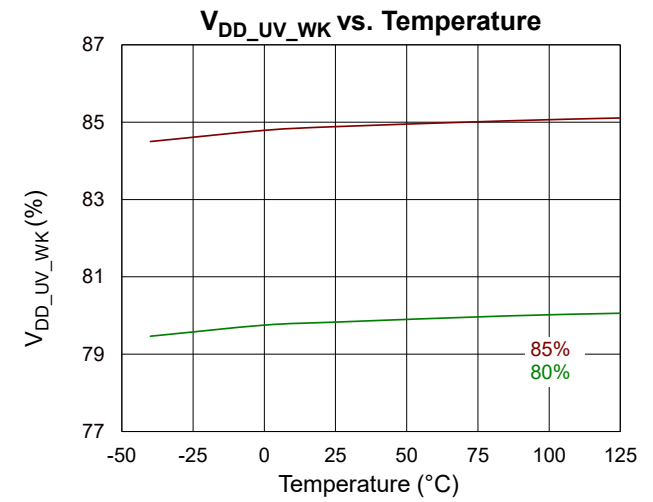
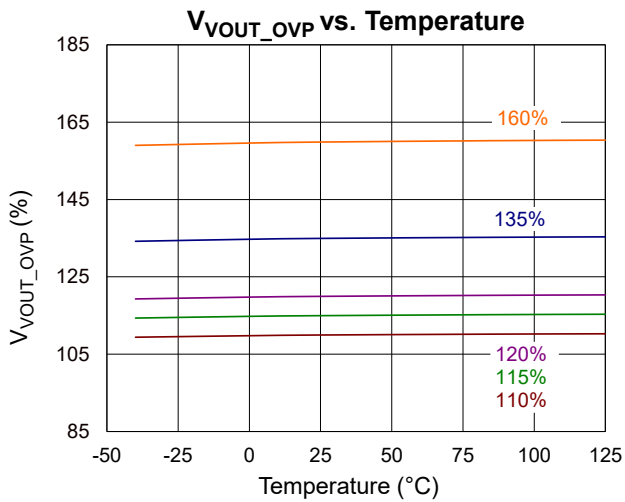
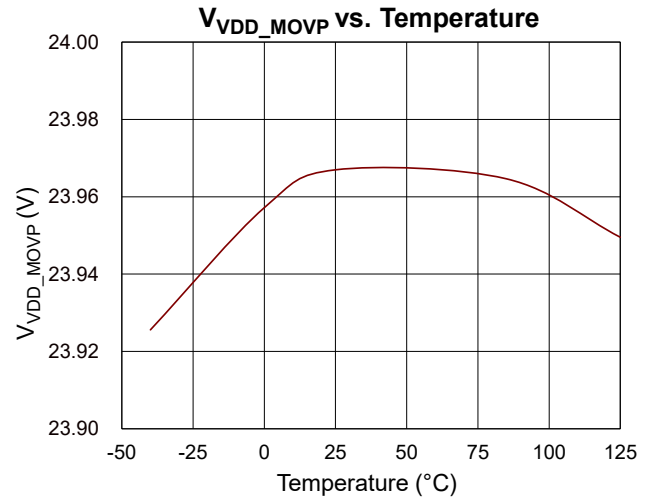
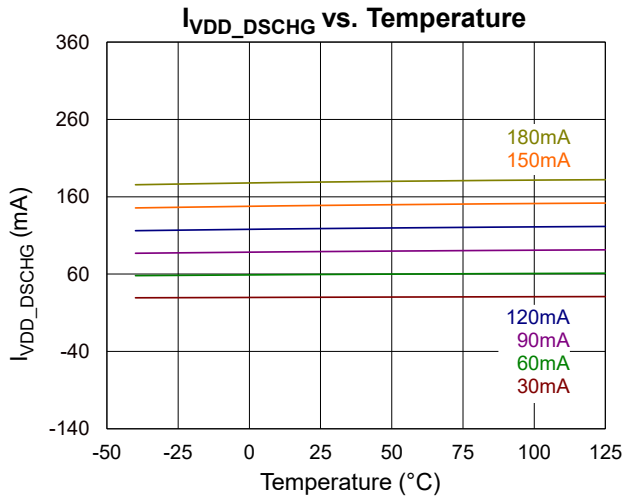
13 Typical Application Circuit

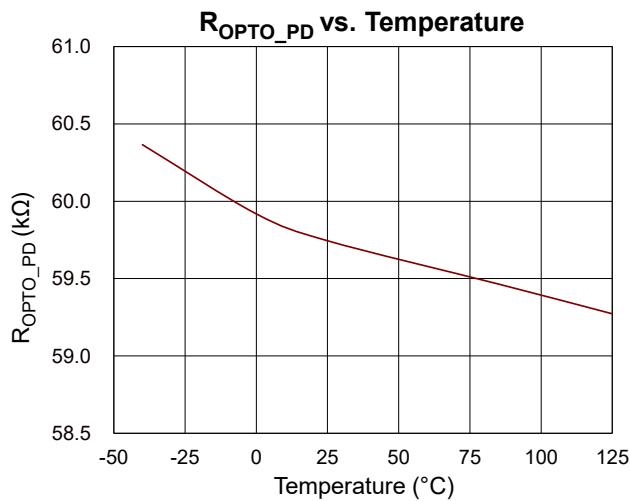
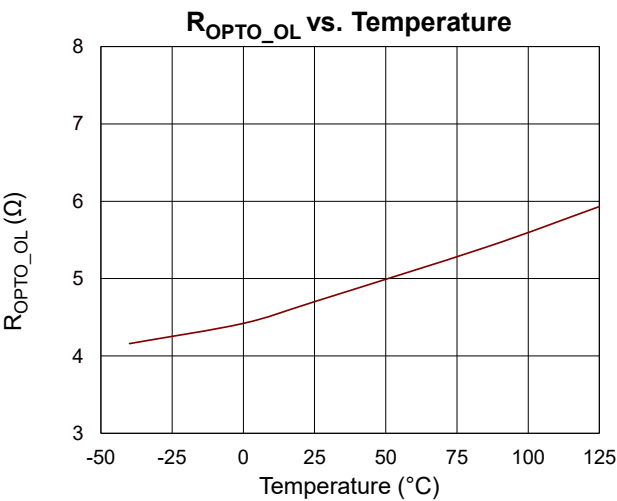
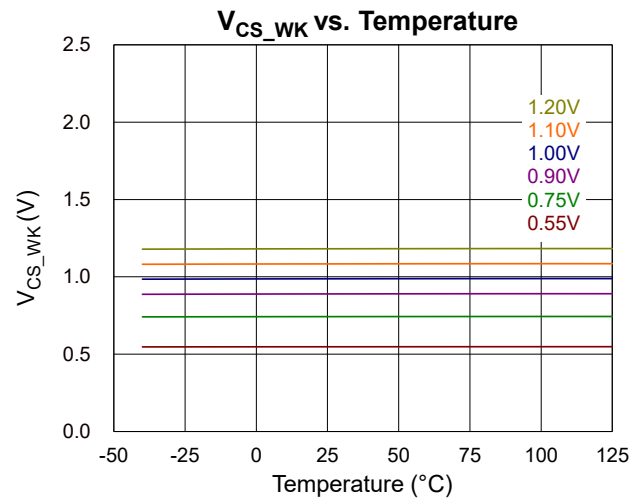
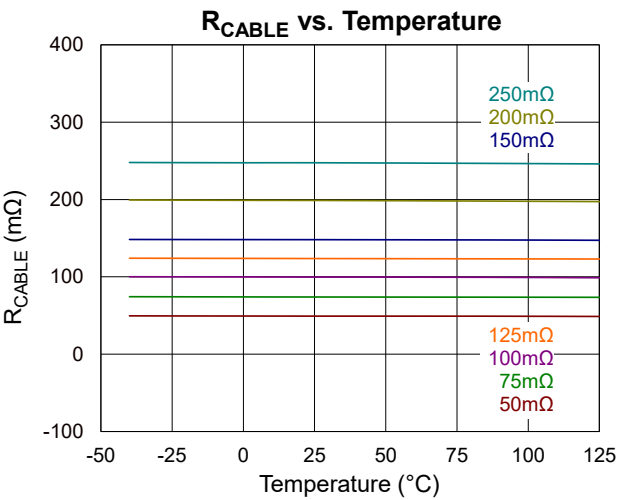
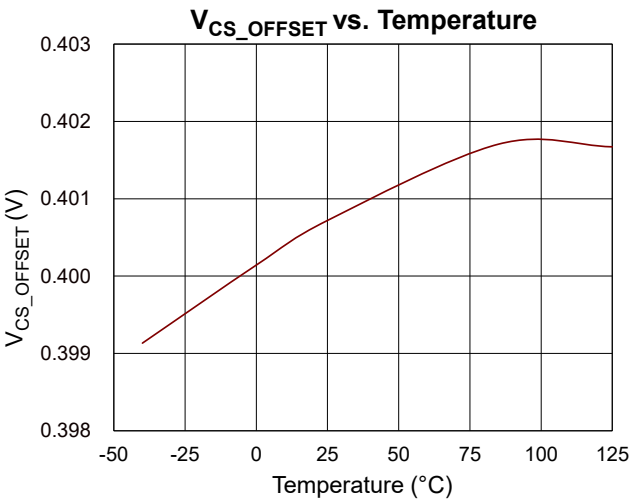
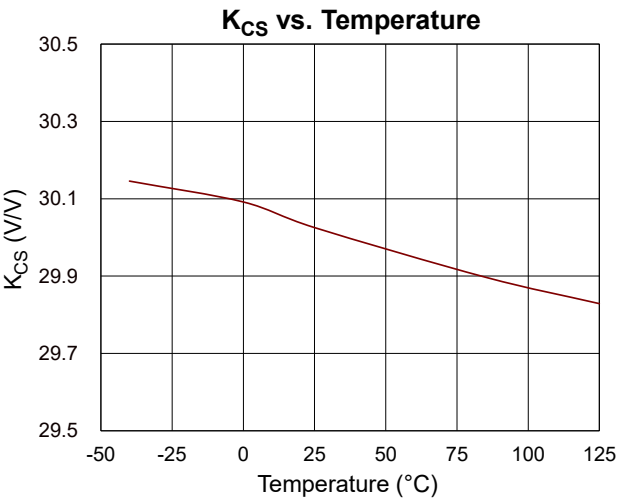
13.1 The RT7613B Typical Application Circuit for Source Side

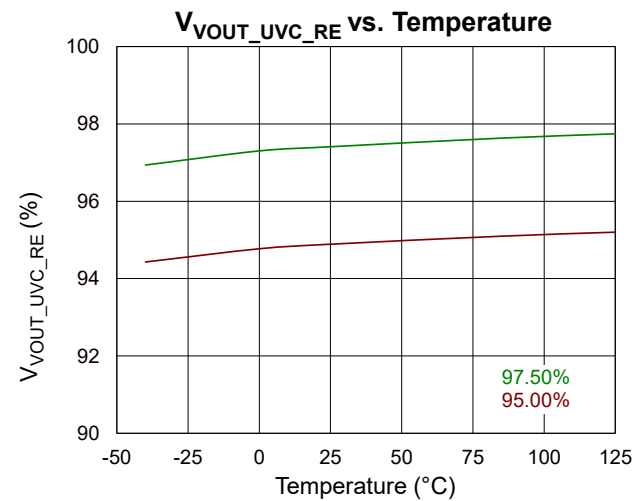
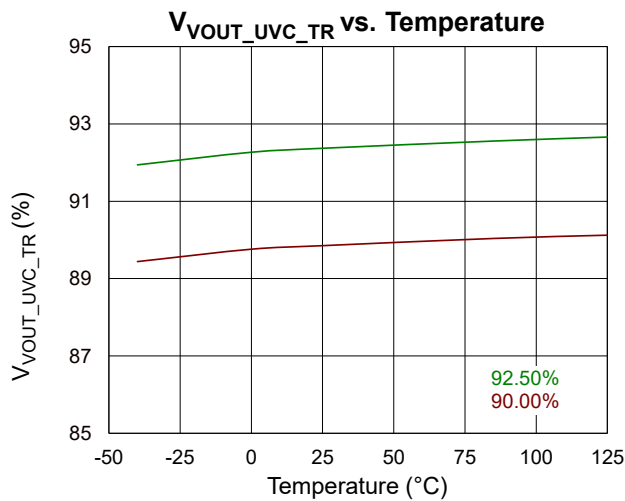
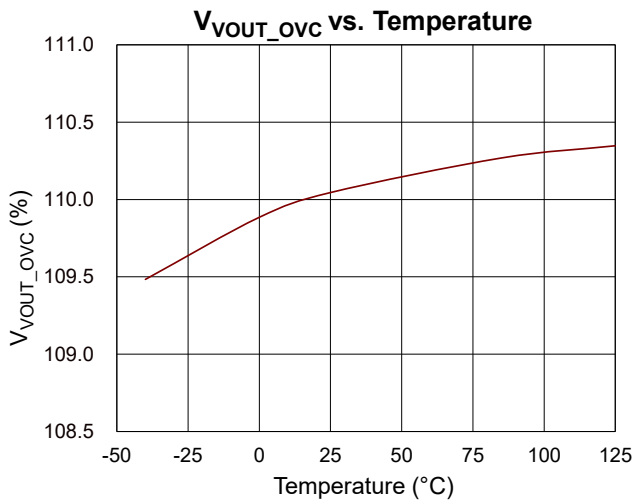
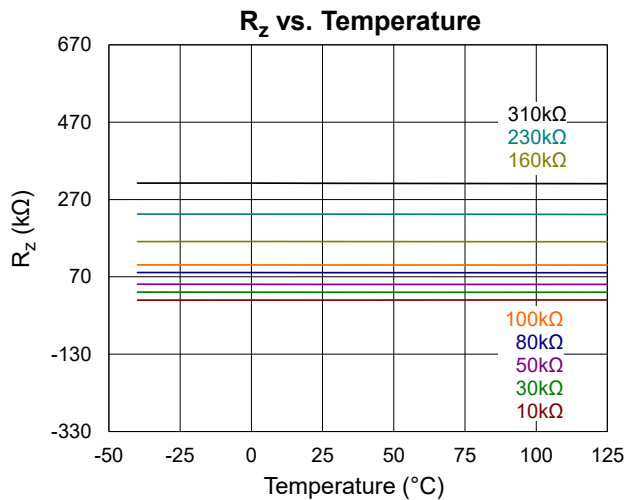
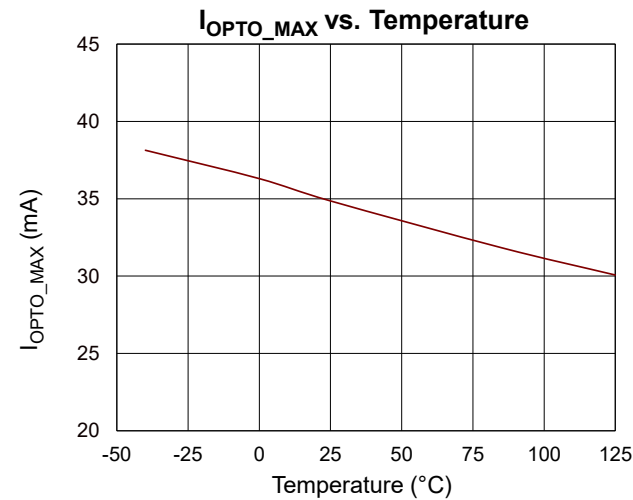
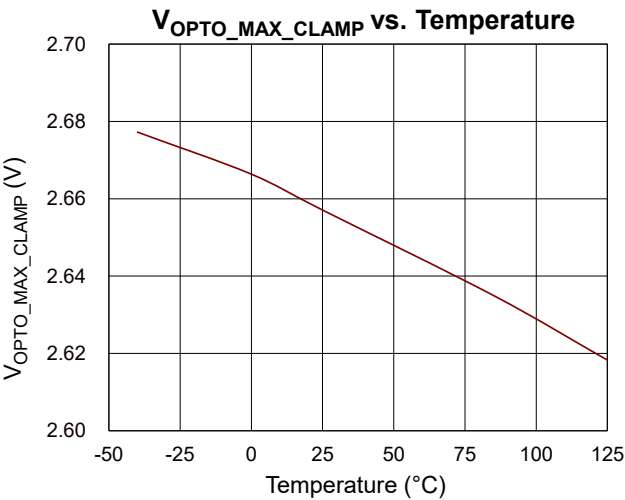


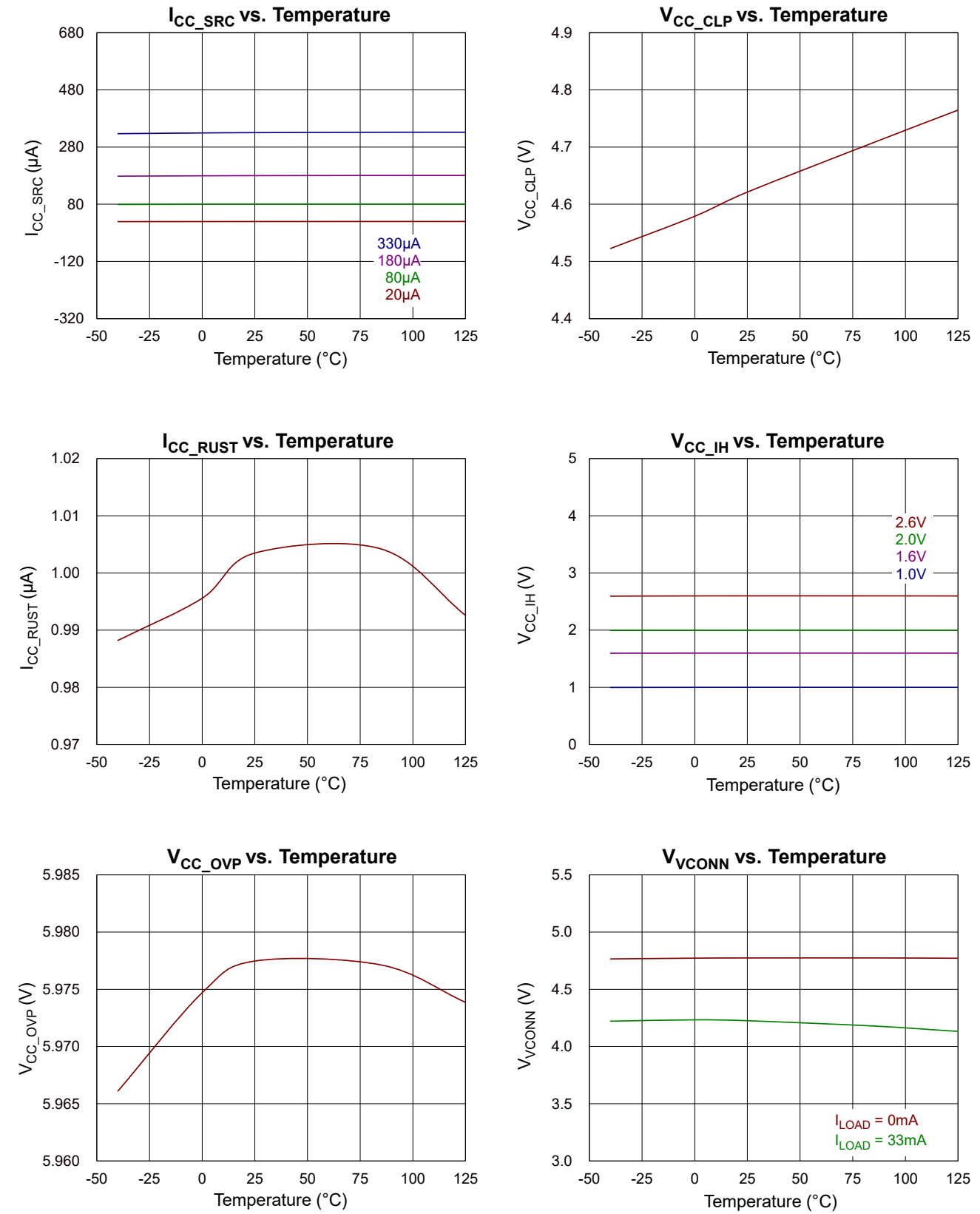
14 Typical Operating Characteristics

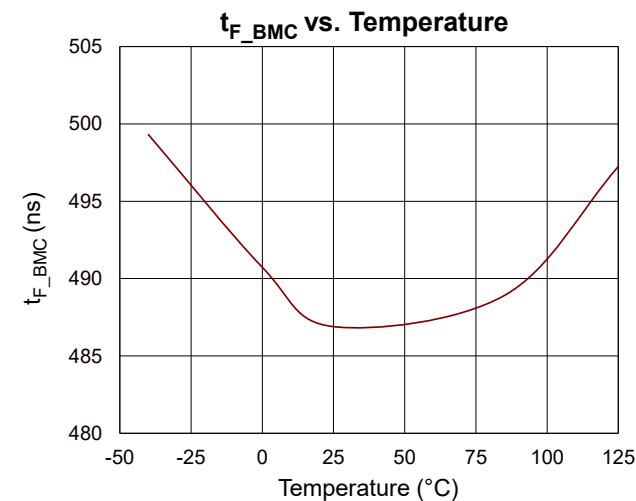
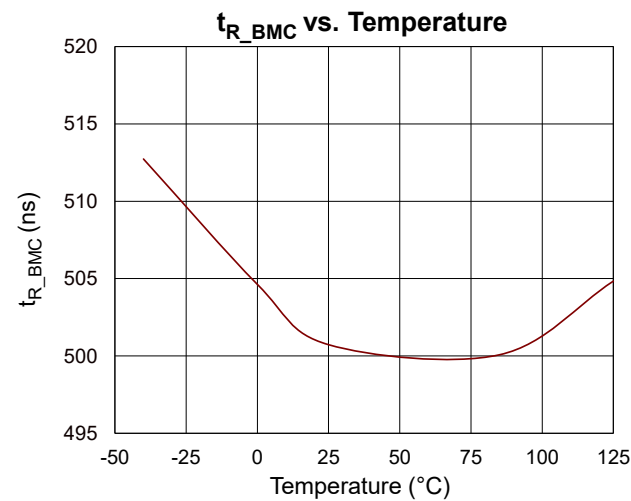
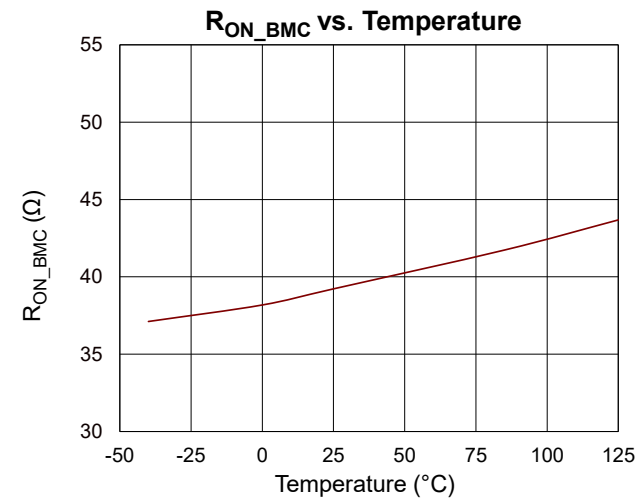
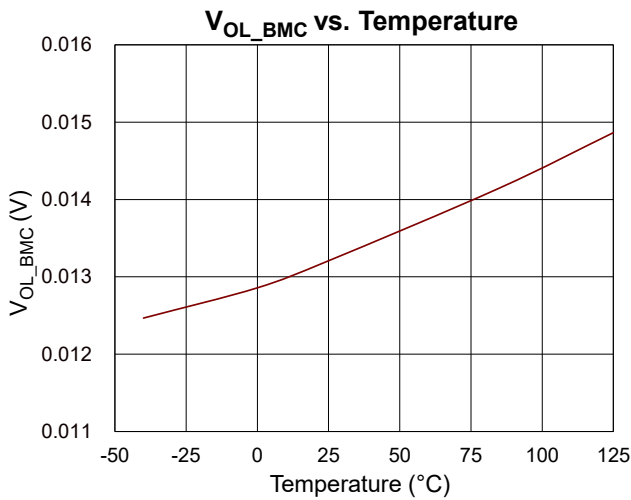
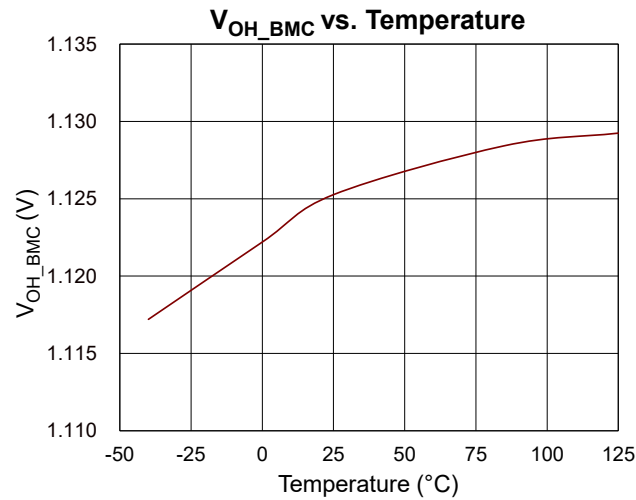
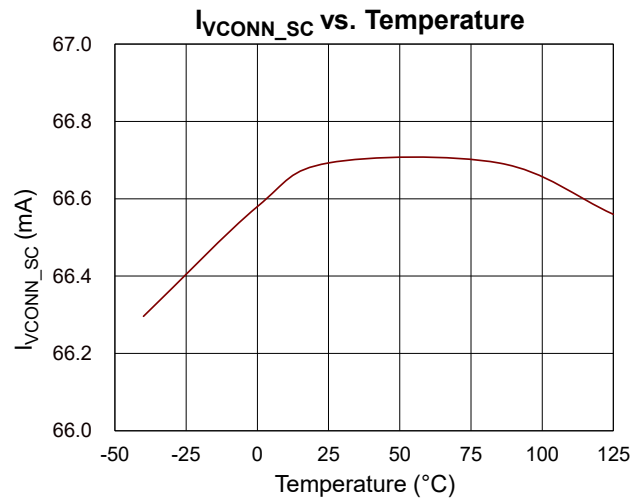


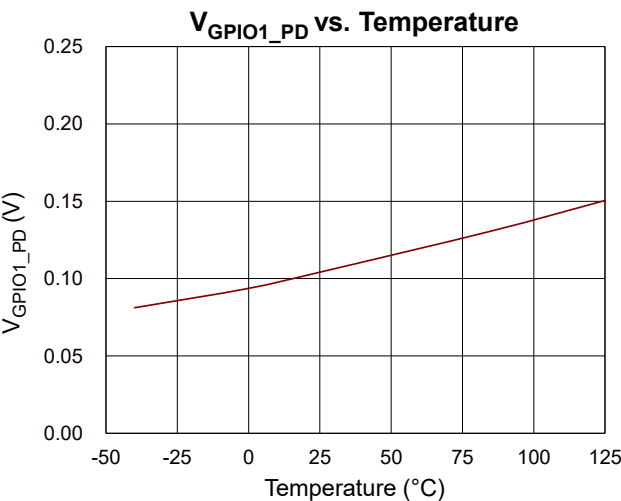
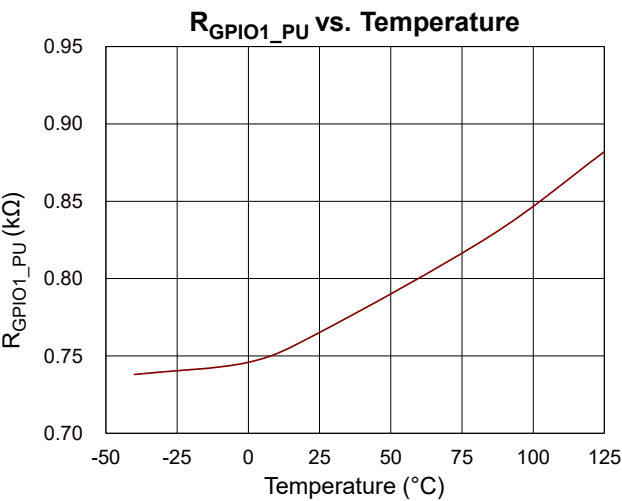
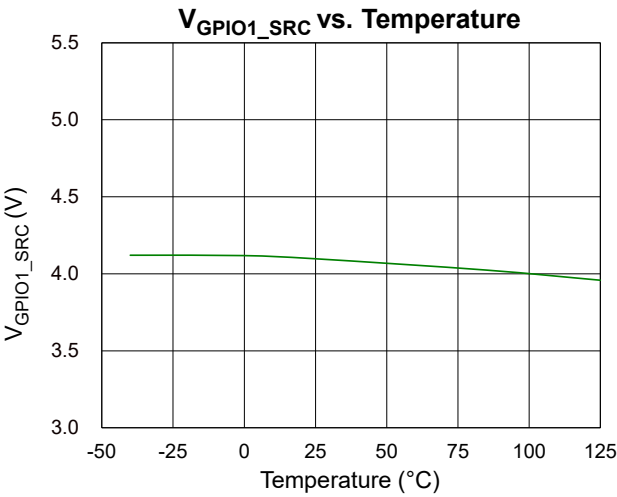
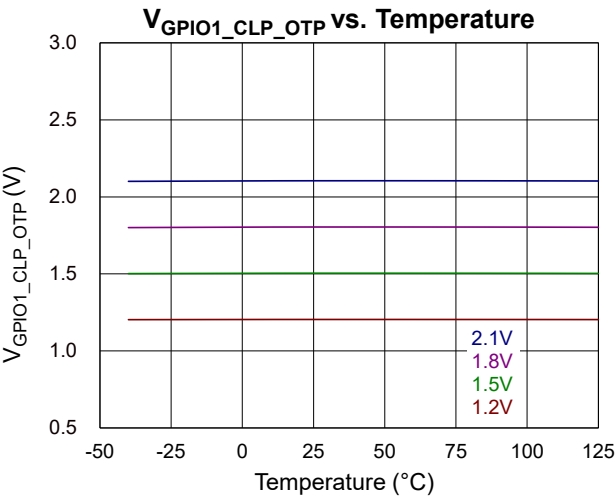
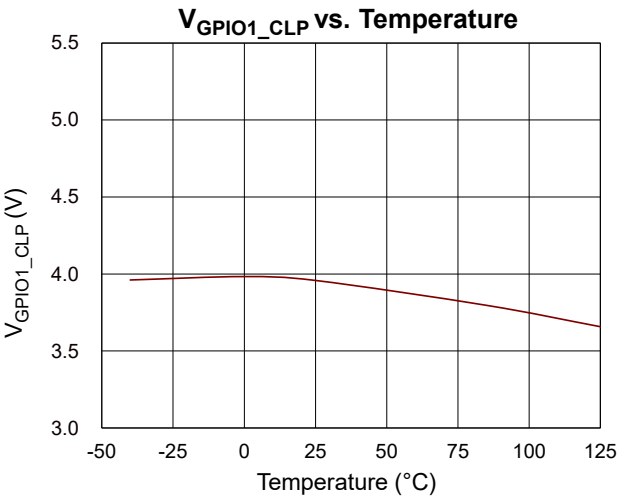
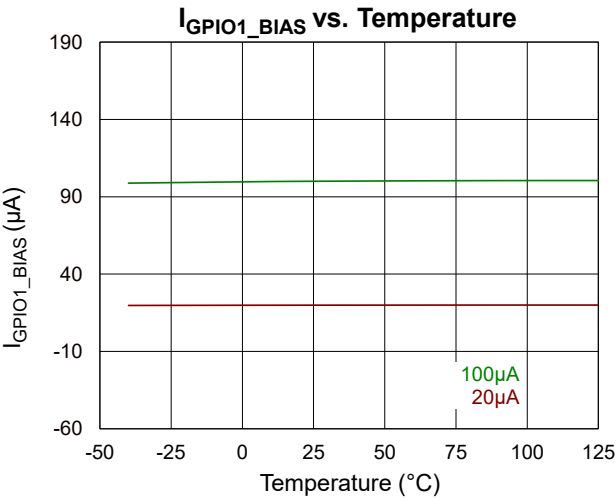


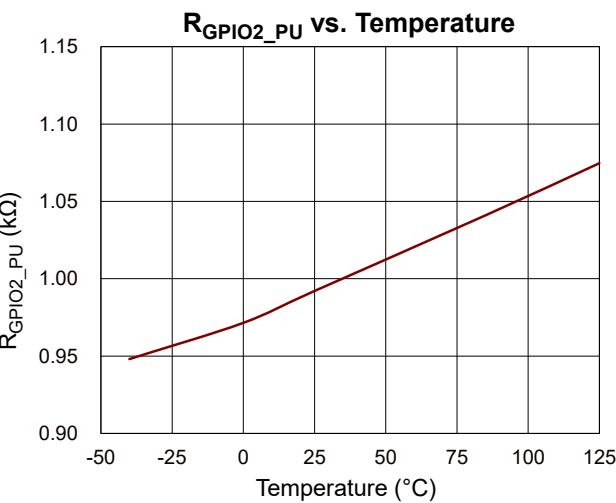
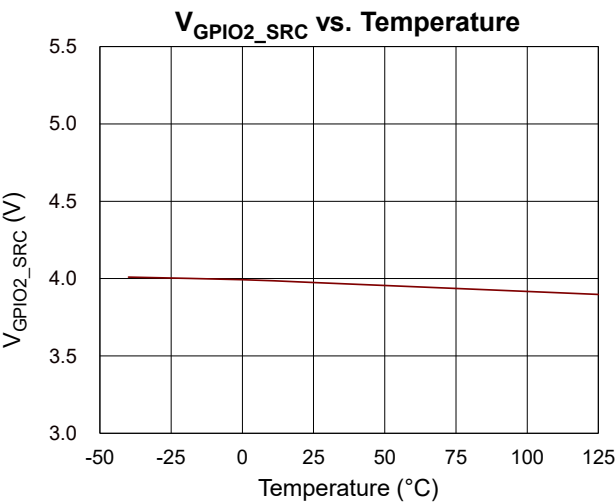
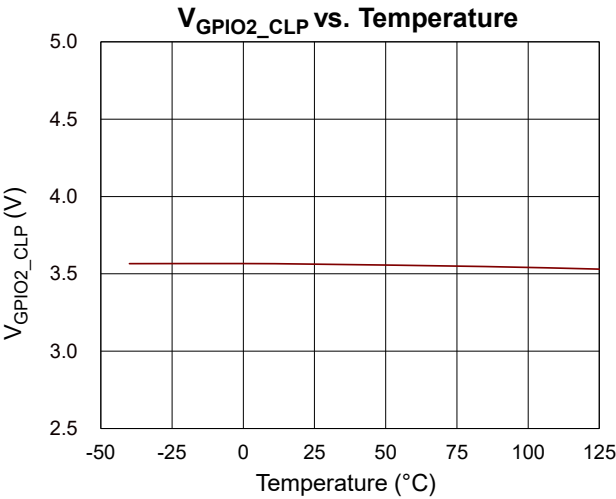
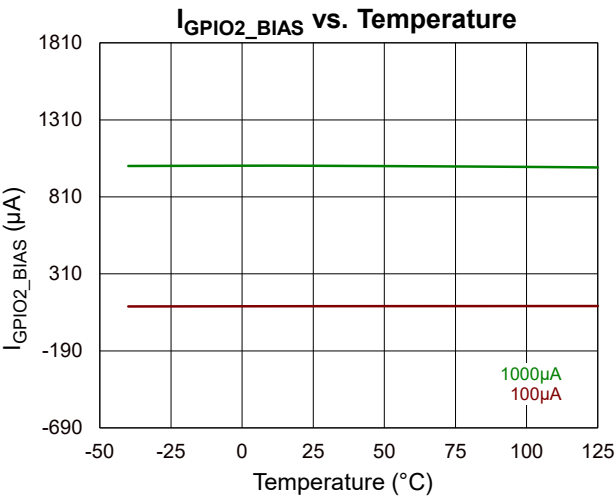
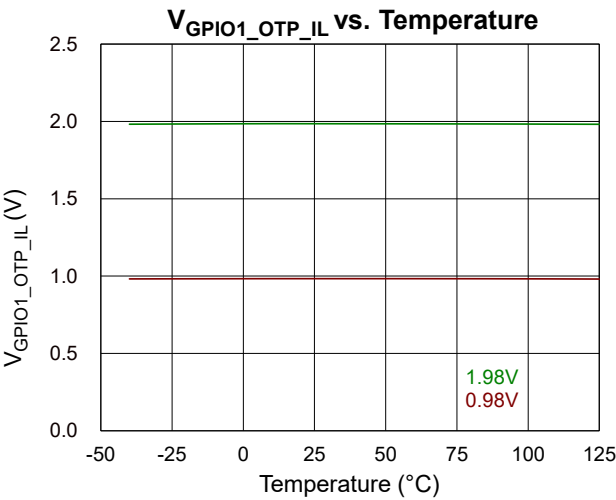
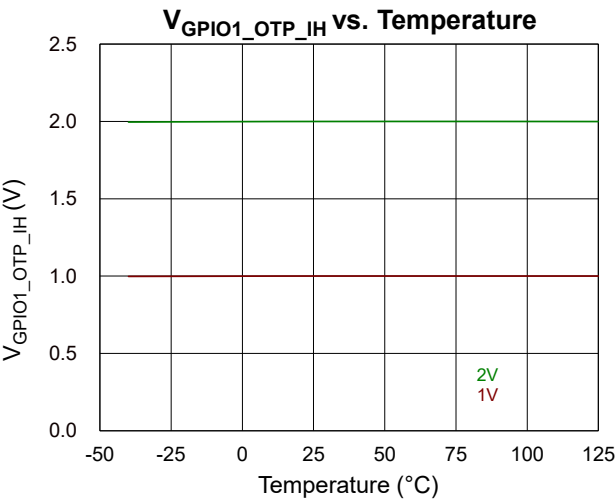


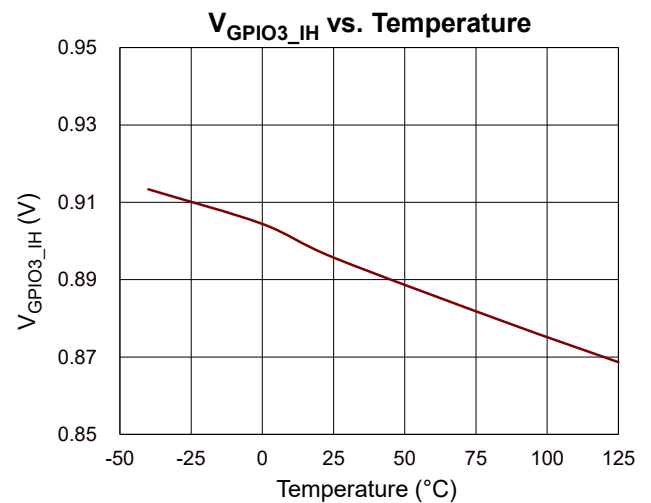
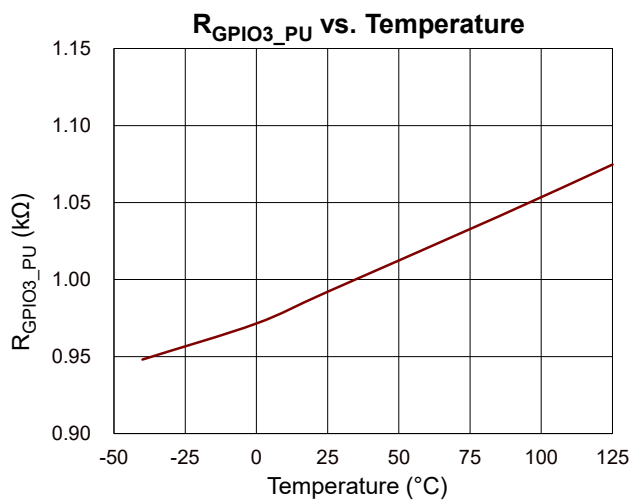
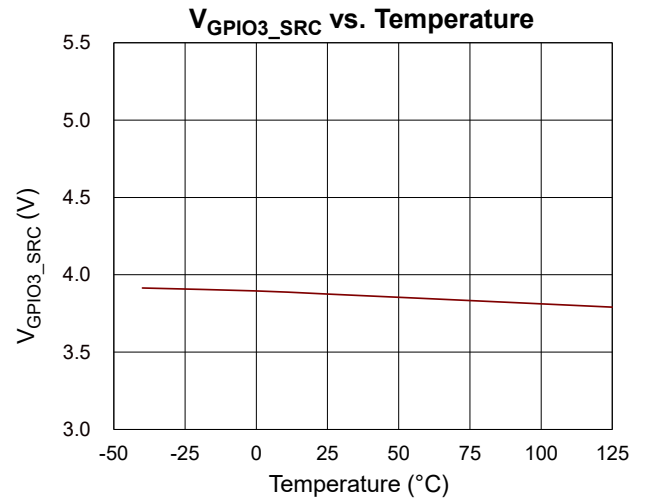
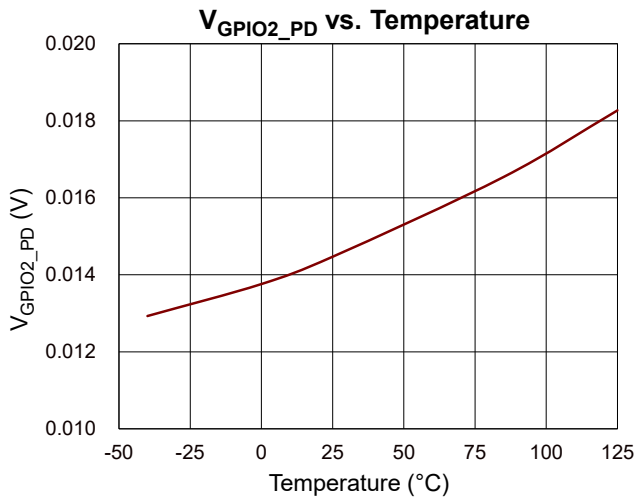
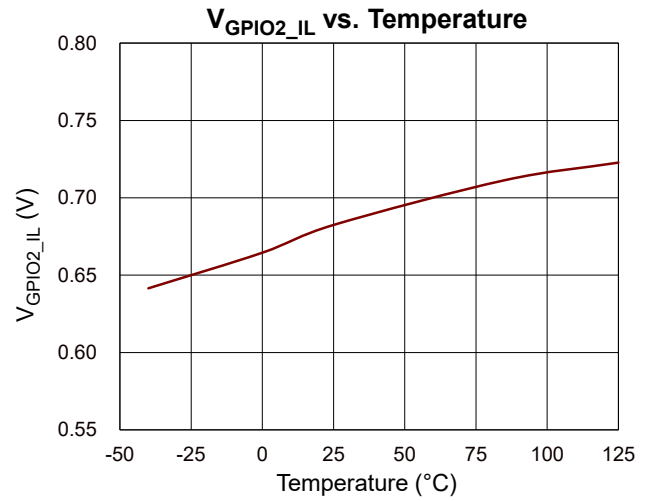
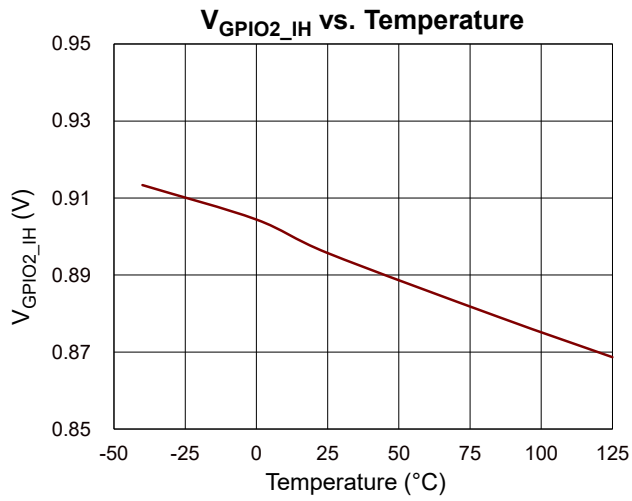


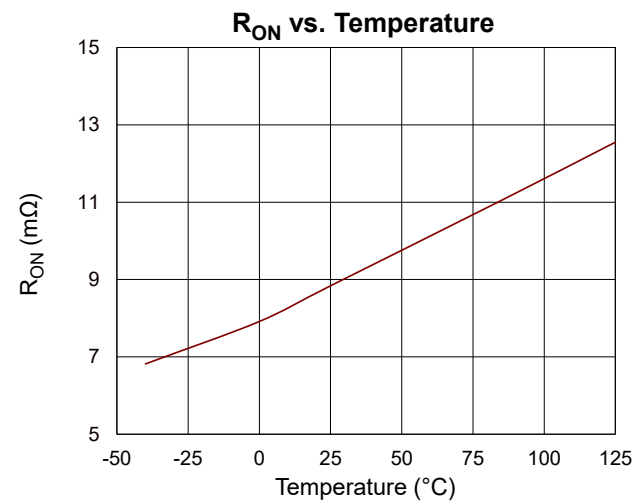
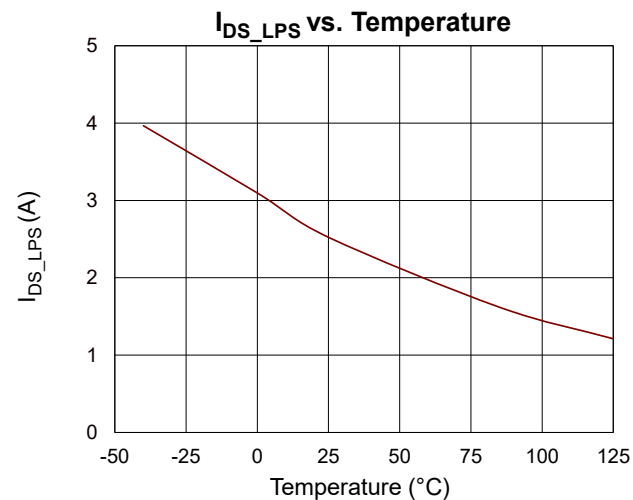
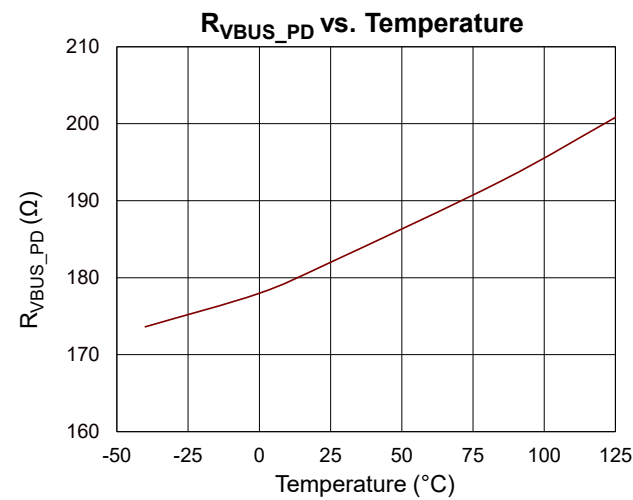
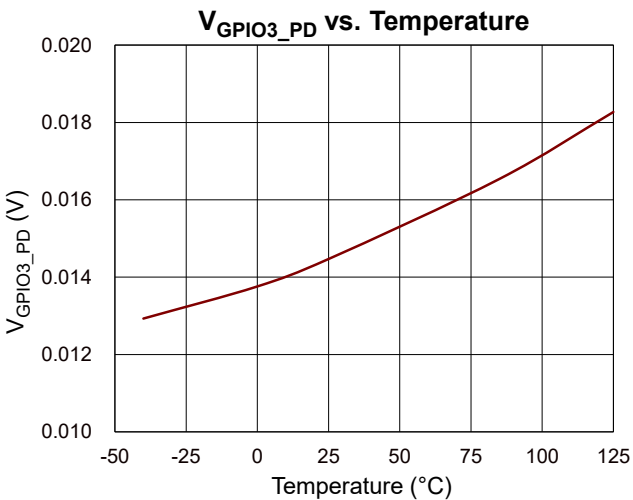
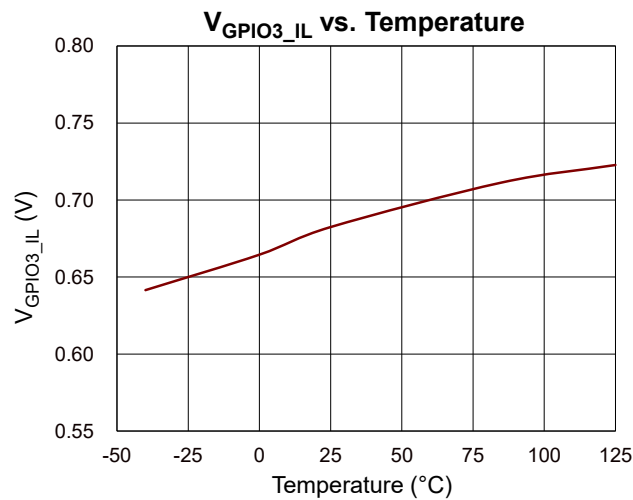












15 Operation

The RT7613B is a highly integrated programmable secondary-side PD controller, providing various functions and comprehensive protection for offline AC-DC converters.

15.1 Power Structure

Two internally regulated voltages, V5 and V2, are derived from the VDD supply. V5 powers the internal circuitry, while V2 supplies the internal microprocessor (MCU).

15.2 Hardware Cable Compensation

A compensation current proportional to the load current is applied to the RFB1 to compensate for the voltage drop across the cable resistance. The user can select the compensation setting (RCABLE) according to the actual cable resistance. For example, if the cable resistance is 100 mΩ, it is recommended to select the 100 mΩ setting.

15.3 Constant Voltage (CV) Loop

As shown in [Figure 1](#), the RT7613B integrates two transconductance amplifiers, which are connected to the feedback compensation to regulate the output voltage and current, respectively. The output voltage is calculated as below:

$$V_{OUT} = K_{FB} \times V_{REF_CV}$$

where

$$K_{FB} = (R_{FB1} + R_{FB2}) / R_{FB2} = 10$$

Therefore, VOUT is determined by VREF_CV, the analog output from the DAC, which is controlled by the MCU.

15.4 Constant Current (CC) Loop

As shown in [Figure 1](#), the RT7613B integrates a virtually zero input offset current-sense amplifier with differential-mode inputs to minimize noise interference. The sensed signal, Io_signal, is fed into an 11-bit ADC to be monitored and processed by the MCU. The reference voltage of the CC loop is determined by VREF_CC (from the DAC), which is programmed according to the charger requirements.

The constant voltage and constant current compensation loops are both connected to the feedback compensation. The OPTO driver sources current through an external resistor ROPTO and an optocoupler that isolates the secondary side from the primary side and then feeds back the compensation signal to the primary side. Note that for better linearity of the loop compensation range, ROPTO should be designed to cover operation at the minimum output voltage.

$$\frac{V_{OPTO_MAX} - V_F}{R_{OPTO}} \times CTR \geq I_{COMP_MAX}$$

where

CTR: Current transfer ratio of the optocoupler;

VF: Forward voltage of the optocoupler;

ROPTO: External series resistor for the OPTO pin;

VOPTO_MAX: The maximum OPTO voltage for the OPTO driver to source 1mA;

ICOMP_MAX: The maximum COMP sourcing current of a traditional PWM controller in the primary side. It is a current sourced from an internal bias through a built-in pull-high resistor connected to the COMP pin in the PWM controller.

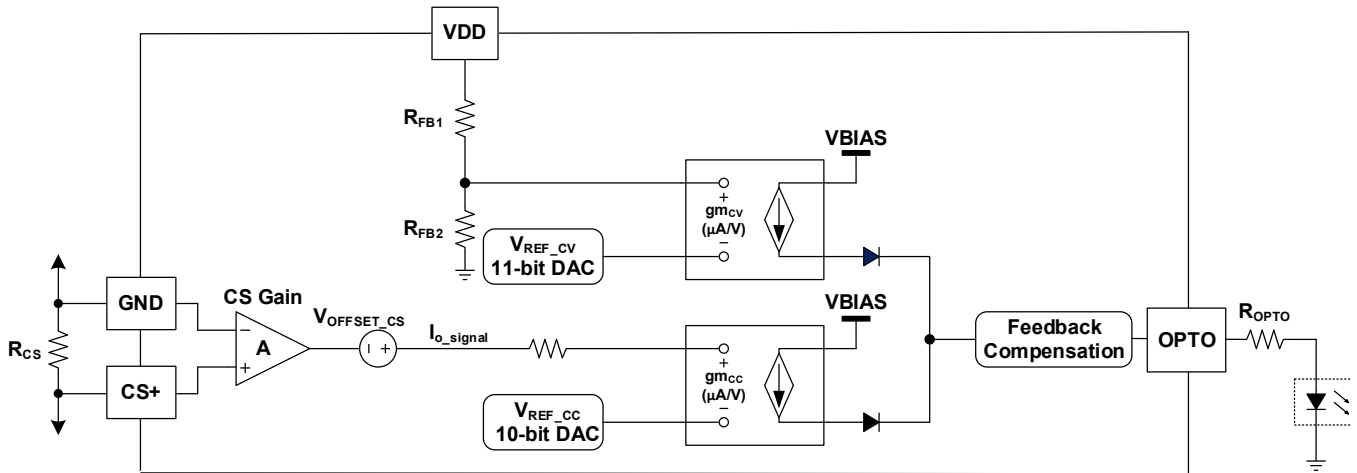


Figure 1. CV and CC Loops

15.5 Internal Feedback Compensation

The RT7613B integrates a built-in feedback compensator to optimize loop stability and transient response across different applications, while also reducing the number of external components. In offline flyback converters, a Type-II compensator is commonly used for loop compensation. This compensator includes an integrator (a pole at the origin), a low-frequency zero, and a high-frequency pole. The design objective is to place the compensator's low-frequency zero to offset the system's low-frequency pole, and to place the compensator's high-frequency pole to cancel out the ESR zero of the output capacitor. With proper compensation, the system can achieve improved phase margin, resulting in better stability. In addition, selecting an appropriate mid-band gain helps achieve better transient response and further enhances overall system stability. The RT7613B provides a simple and flexible way to implement this compensation: the compensator R_z , C_z , and the mid-band gain can be programmed to match different output conditions, making it easier to achieve a stable design.

15.6 N-MOSFET Driver

The charge pump drives the integrated blocking N-MOSFET. The soft-start function is to prevent voltage drop during startup conditions with capacitive loads.

15.7 VDD Pin Discharger for Output Capacitor

The VDD pin provides discharge current control, acting as a bleeder to discharge the output capacitor when a device is detached or when a lower output voltage is requested, such as reducing VOUT from 20V to 5V. The I_{VDD_DISCHG} capability should consider both the operating voltage and output capacitance. The discharge current is programmable via the internal register based on power dissipation.

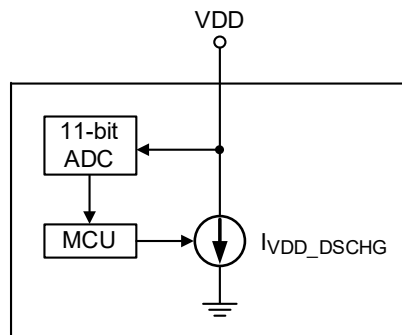


Figure 2. Discharge Current Control of the VDD Pin

15.8 VBUS Pin Discharger for Vsafe0V

The VBUS pin uses an open-drain driver to discharge the VBUS capacitor when a device is detached. The pin voltage is continuously monitored by the ADC, enabling the IC to determine compliance with the Vsafe0V specification.

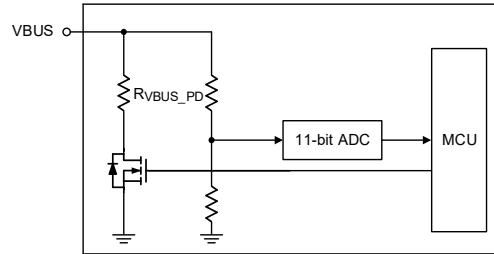


Figure 3. Discharge Current Control of the VBUS Pin

15.9 GPIO Pins Functional Description

The GPIO pins support multiple functions, including general-purpose input and open-drain output. They can also be configured as current or voltage sources and serve as ADC inputs for voltage monitoring. A hardware comparator enables voltage change detection and allows the device to wake up from power-saving mode.

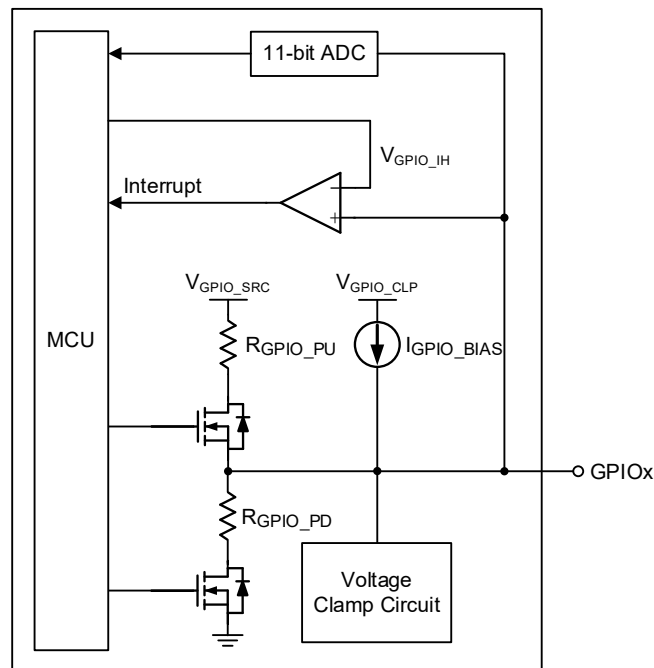


Figure 4. Internal Circuit Diagram of the GPIO Pins

15.10 CC Pin Attach/Detach Detection

The CC pin supports attach/detach detection and current advertisement in accordance with the USB Type-C specification. Hardware comparators detect attach and detach events by instantly responding to voltage changes on the CC pin, allowing the system to quickly identify cable insertion or removal.

15.11 PD PHY

The USB PD PHY implements a BMC transceiver for communication over the CC channel. It supports packet encoding and decoding, CRC generation and checking, SOP/EOP detection, and clock recovery, ensuring robust and reliable data exchange between the protocol layer and the CC line.

15.12 VCONN

The device integrates a VCONN switch to supply power (up to 100mW) to active or electronically marked (e-marked) cables through the unused CC pin. The VCONN path features overcurrent protection to ensure safe operation.

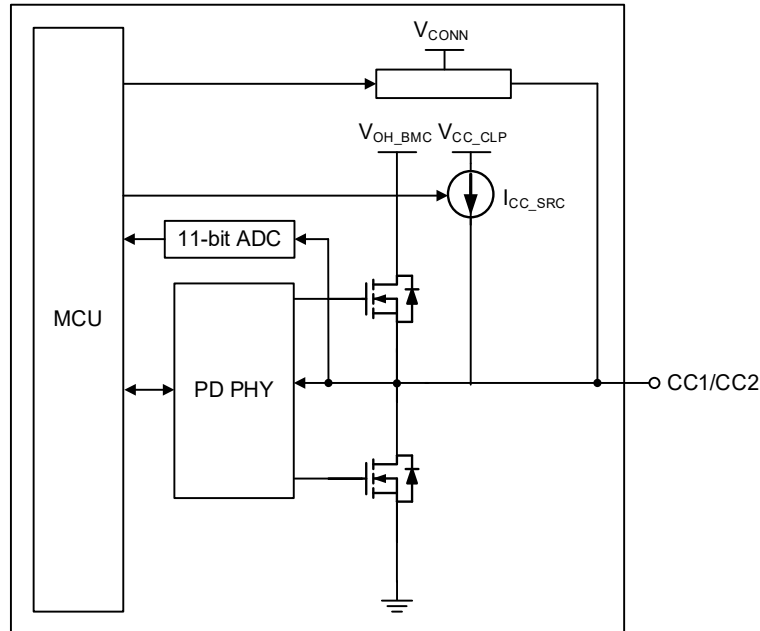


Figure 5. Internal Circuit Diagram of the CC1 and CC2 Pins

15.13 Temperature Sensing (Internal)

A built-in temperature sensor supports temperature reporting and provides over-temperature protection (OTP).

15.14 Temperature Sensing (External)

The current source of the CC1, CC2, and GPIO pins can source current to a thermistor, enabling the ADC to measure the resulting voltage. Temperature is calculated by converting this value according to the thermistor's characteristic table, supporting temperature reporting and over-temperature protection (OTP).

16 Application Information

(Note 7)

16.1 VDD Adaptive Overvoltage Protection

A fast turn-off blocking N-MOSFET provides VOUT overvoltage protection. When the internal voltage related to VDD exceeds the programmable threshold (V_{VDD_OVP}), the blocking N-MOSFET is immediately turned off, and a fault flag is sent to the embedded MCU for customized protection actions. This mechanism safeguards against malfunctions such as optocoupler aging in the feedback loop.

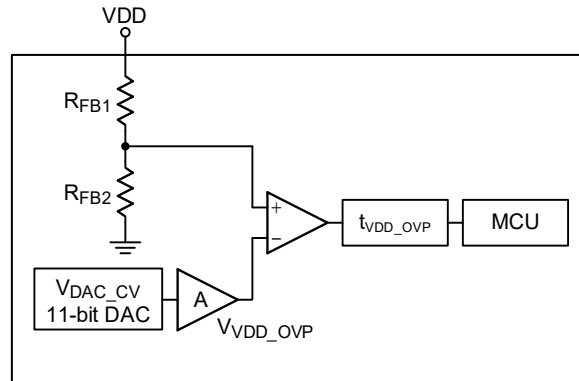


Figure 6. OVP Functional Diagram

16.2 VDD Adaptive Undervoltage Protection

A fast turn-off blocking N-MOSFET provides VOUT undervoltage protection. When the internal voltage related to VDD drops below the programmable threshold (V_{VDD_UVP}), the blocking N-MOSFET is immediately turned off, and a fault flag is sent to the embedded MCU for customized protection actions. This mechanism safeguards against feedback failure and output short-circuit events.

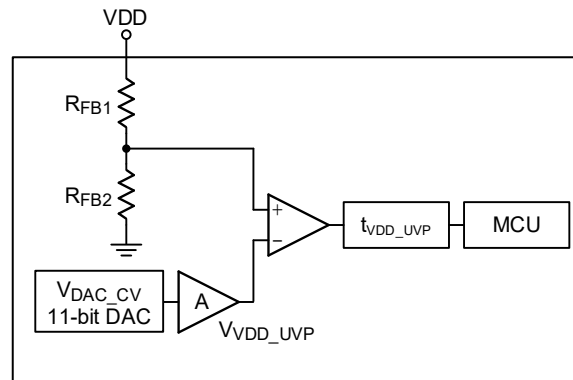


Figure 7. UVP Functional Diagram

16.3 Limited Power Source Protection

Limited Power Source (LPS) protection is implemented by monitoring both the drain-source voltage across the blocking MOSFET and the voltage across the current-sense resistor. If the drain-source voltage exceeds the threshold corresponding to I_{DS_LPS} while the current-sense voltage remains below the firmware-defined value, a mismatch between the actual blocking MOSFET current and the current-sense reading is detected. Consequently, an LPS protection is triggered to ensure system safety.

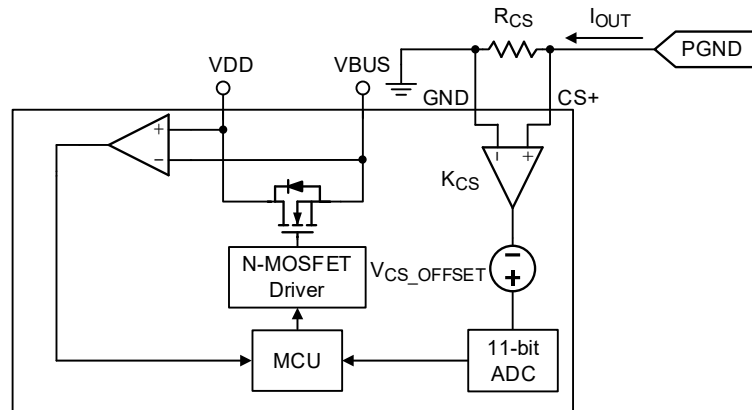


Figure 8. LPS Functional Diagram

16.4 Programmable Overcurrent Protection

Programmable Overcurrent Protection (OCP) is achieved by amplifying the voltage across the current-sense resistor, adding an offset voltage, and converting the result with the ADC for current calculation. When the measured current exceeds the user-defined protection threshold, OCP is triggered to prevent damage and ensure system reliability.

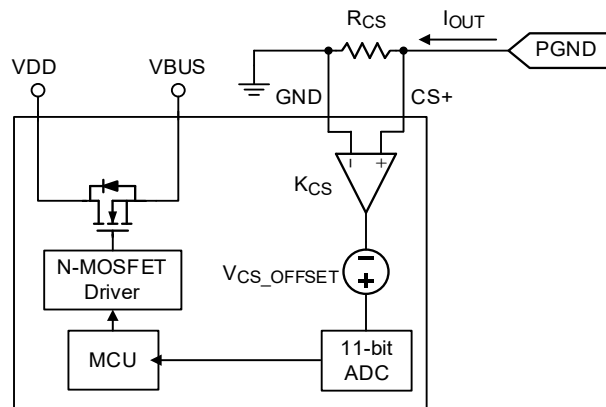


Figure 9. OCP Functional Diagram

16.5 Programmable External and Internal Over-Temperature Protection

Programmable external and internal over-temperature protection (OTP) is provided through real-time monitoring by an internal temperature sensor and by sourcing current to a thermistor via CC1, CC2, and the GPIO pins for external sensing. The MCU calculates the temperature from the ADC reading, and OTP is triggered when the measured value exceeds the set threshold.

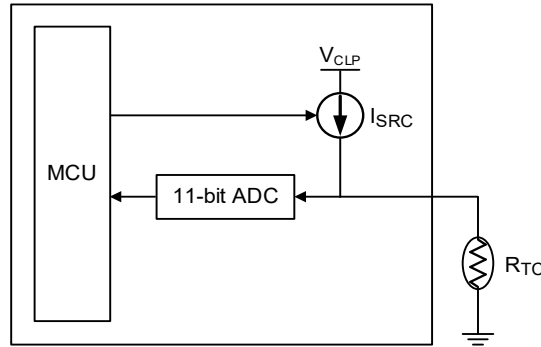


Figure 10. External OTP Functional Diagram

16.6 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 θ_{JA} is the junction-to-ambient thermal resistance.

For continuous operation, the maximum operating junction temperature indicated under Recommended Operating Conditions is 125°C. The junction-to-ambient thermal resistance, θ_{JA} , is highly package-dependent. For a SOP-10 package, the thermal resistance, θ_{JA} , is 164.49°C/W on a standard JEDEC 51-3 low effective-thermal-conductivity single-layer test board. The maximum power dissipation at $T_A = 25^\circ\text{C}$ can be calculated as follows:

$$P_{D(MAX)} = (125^\circ\text{C} - 25^\circ\text{C}) / (164.49^\circ\text{C/W}) = 0.61\text{W for a SOP-10 package.}$$

The maximum power dissipation depends on the operating ambient temperature for a given $T_{J(MAX)}$ and the thermal resistance, θ_{JA} . The derating curve in [Figure 11](#) allows the user to see the effect of rising ambient temperature on the maximum power dissipation.

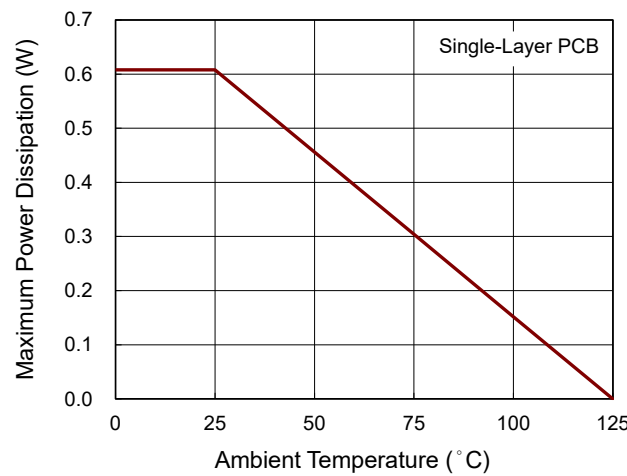
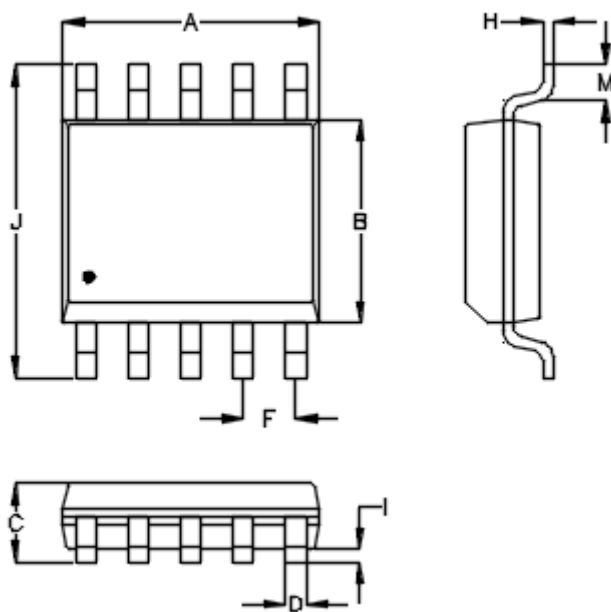


Figure 11. Derating Curve of Maximum Power Dissipation

Note 7. The information provided in this section is for reference only. The customer is solely responsible for designing, validating, and testing any applications incorporating Richtek’s product(s). The customer is also responsible for applicable standards and any safety, security, or other requirements.

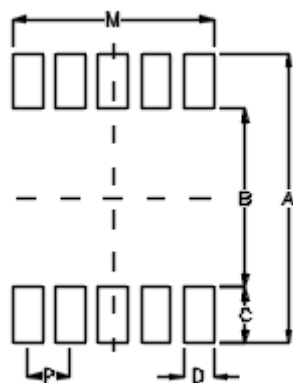
17 Outline Dimension



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	4.800	5.000	0.189	0.197
B	3.800	4.000	0.150	0.157
C	1.300	1.750	0.051	0.069
D	0.300	0.500	0.012	0.020
F	1.000		0.039	
H	0.100	0.250	0.004	0.010
I	0.050	0.250	0.002	0.010
J	5.800	6.200	0.228	0.244
M	0.400	1.270	0.016	0.050

SOP-10 Package

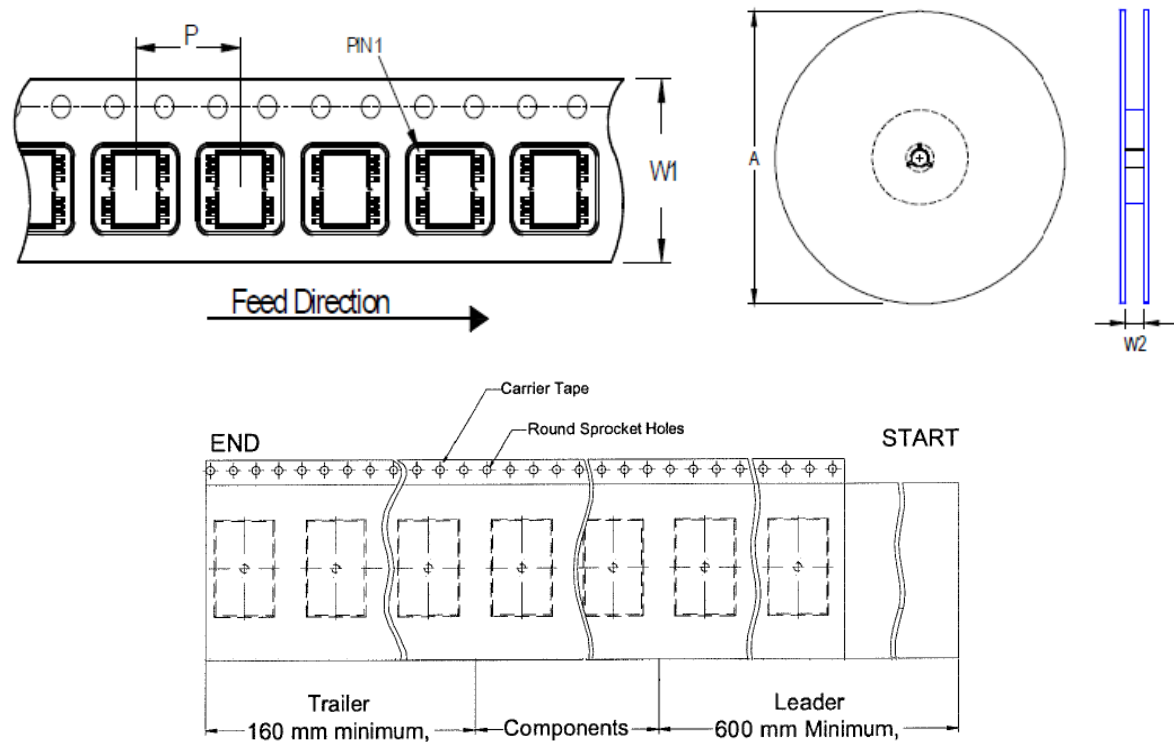
18 Footprint Information



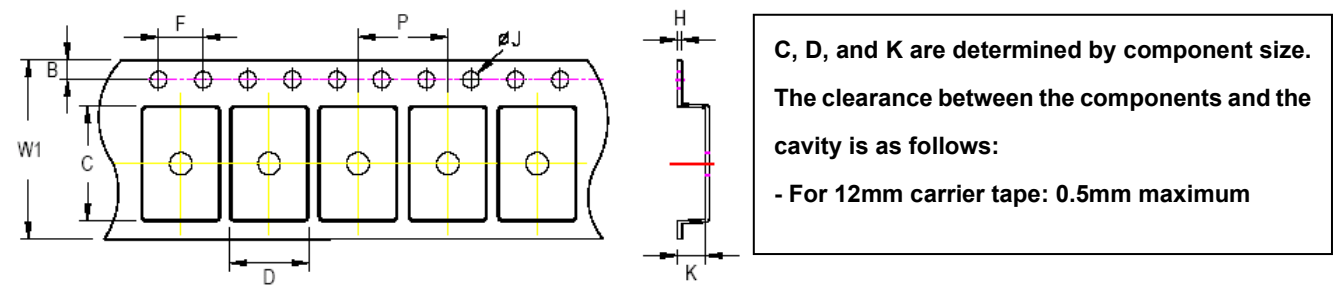
Package	Number of Pin	Footprint Dimension (mm)						Tolerance
		P	A	B	C	D	M	
SOP-10	10	1.00	6.80	4.20	1.30	0.70	4.70	±0.10

19 Packing Information

19.1 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)				
SOP-10	12	8	330	13	2,500	160	600	12.4/14.4



Tape Size	W1	P		B		F		ØJ		K		H
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Max
12mm	12.3mm	7.9mm	8.1mm	1.65mm	1.85mm	3.9mm	4.1mm	1.5mm	1.6mm	1.9mm	2.2mm	0.6mm

19.2 Tape and Reel Packing

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

Container Package	Reel		Box			Carton		
	Size	Units	Item	Reels	Units	Item	Boxes	Units
SOP-10	13"	2,500	Box G	1	2,500	Carton A	6	15,000

19.3 Packing Material Anti-ESD Property

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

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20 Datasheet Revision History

Version	Date	Description
00	2026/9/17	First Edition