RICHTEK®

RT1988

53V/8A Ideal Diode Protection Switch

1 General Description

The RT1988 provides an ideal diode reverse current blocking function with low forward voltage and an enable input for disconnection. The 3.4V to 53V input operating range and 8A continuous current rating make the RT1988 well suited for multi-port USB-C sink current applications. In addition, this part includes a 60V Absolute Maximum Rating (AMR), a 20A peak current rating (up to 10ms), undervoltage-lockout, overvoltage protection, and over-temperature protection.

An adjustable soft-start circuit sets the output voltage slew rate and manages inrush current into high capacitance loads. Short-circuit protection is provided during this period, while the integrated MOSFET provides a low forward voltage drop and high Safe Operating Area (SOA).

The RT1988 is available in a VDFN-20TL 5.2x4 package and can operate over –40°C to 125°C junction temperature.

2 Features

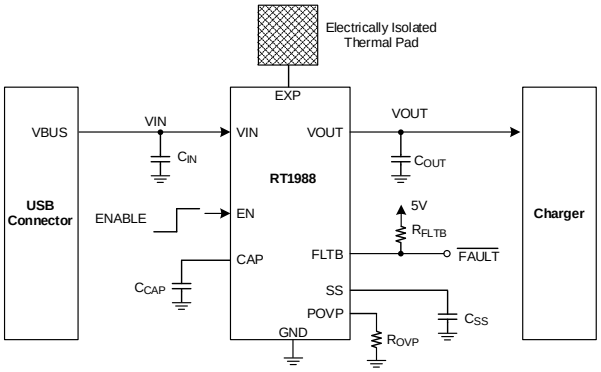
- **8A Continuous/20A Peak Current Capability**
- **Input Supply Voltage: 3.4V to 53V**
- **20mΩ (Typical) R_{ON}**
- **Analog Ideal Diode Gate Control**
  - **Blocks Reverse Current**
  - **Avoids Switch Chatter**
  - **Enables Fast Power Swap**
- **Programmable Soft-Start**
- **Programmable Overvoltage Protection**
- **Over-Temperature Protection**
- **Start-Up Short-Circuit Protection**
- **Compliance with IEC61000-4-2 and IEC61000-4-5 Standards**

3 Applications

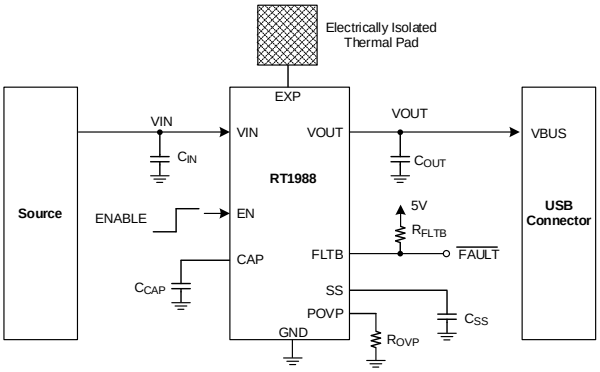
- USB-C/Thunderbolt Sink Power Delivery
- Notebooks Computer Barrel Jack
- Docking Stations
- Power ORing Applications

4 Simplified Application Circuit

Current Sinking Application



Current Sourcing Application



5 Ordering Information

RT1988 □ - □

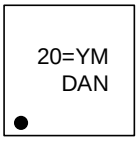
Packing
B: Customized Tape and Reel Size

Package Type(1)
N: VDFN-20TL 5.2x4 (V-Type)

Note 1.

Richtek products are Richtek Green Policy compliant and marked with (1) indicates compatible with the current requirements of IPC/JEDEC J-STD-020.

6 Marking Information



20=: Product Code
YMDAN: Date Code

Ideal Diode Protection Switch Selection Table

Part Number	Input Supply Voltage	Continuous Current Capability	OVP Threshold	Package
RT1985	3.4V to 23V	8A	Fixed	VDFN-12TL 3x3
RT1986	3.4V to 23V	5.5A	Fixed	VDFN-12TL 3x3
RT1987	3.4V to 32V	8A	Programmable	VDFN-12T1L 3x3
RT1988	3.4V to 53V	8A	Programmable	VDFN-20TL 5.2x4

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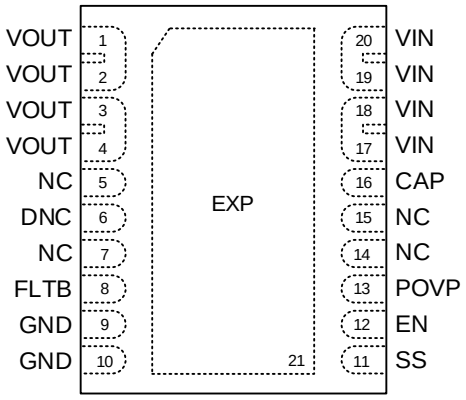
7 Pin Configuration

(TOP VIEW)

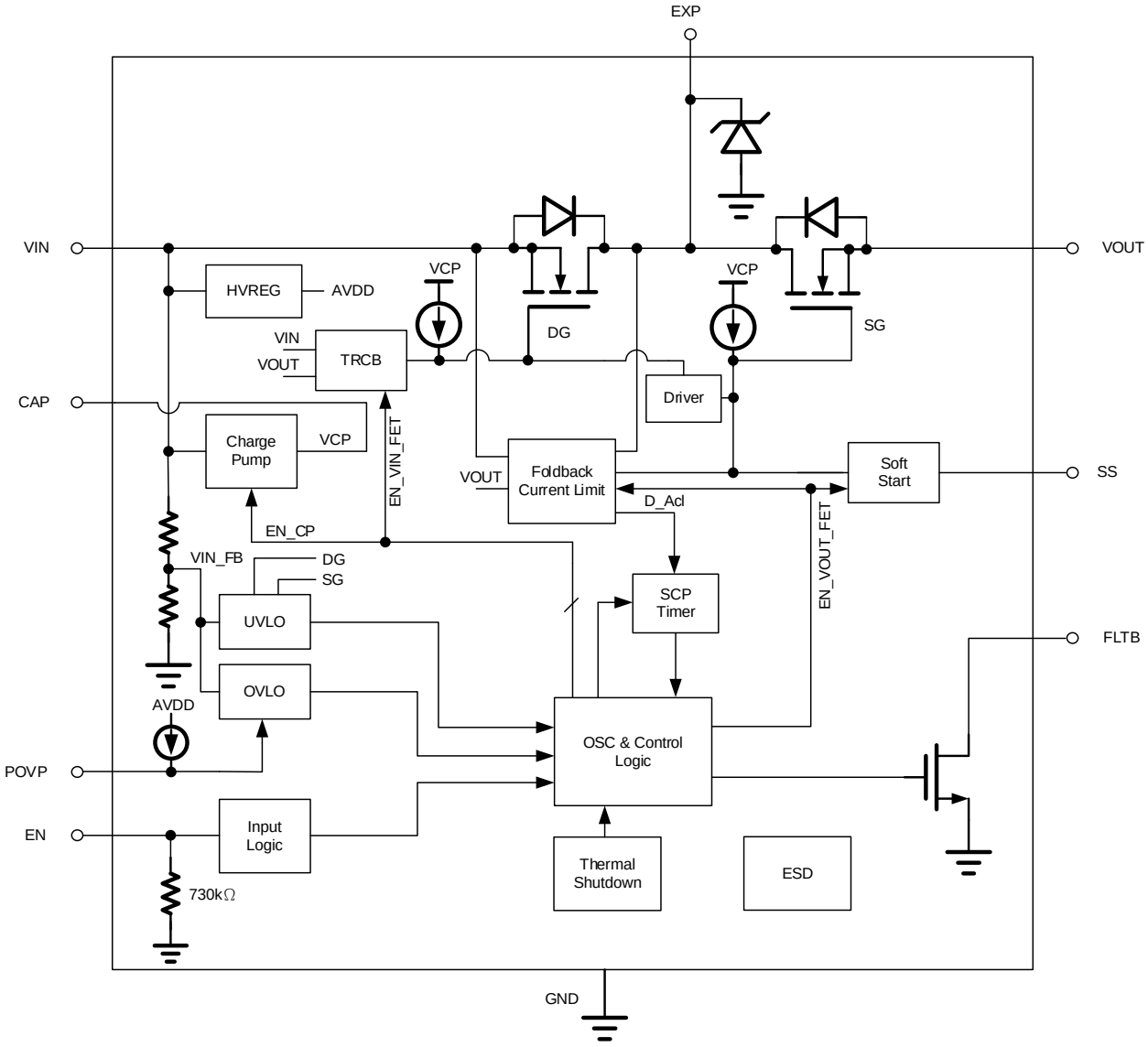


VDFN-20TL 5.2x4

8 Functional Pin Description

Pin No.	Pin Name	Pin Function
1, 2, 3, 4	VOUT	Output voltage. Connect to the load.
5, 7, 14, 15	NC	No Connect.
6	DNC	Do Not Connect. Internally connected to the Exposed Pad (EXP).
8	FLTB	Open-drain fault indicator. Connect a pull-up resistor to a low-voltage supply. This pin pulls low if a fault condition is detected.
9, 10	GND	Ground.
11	SS	Soft-start input. Connect a capacitor, Css, from SS to GND to set the soft-start time.
12	EN	Enable active high. Pull high to enable the ideal diode function. Pull low to disconnect VIN from VOUT.
13	POVP	Programmable Overvoltage Protection threshold setting. Connect a resistor between this pin and GND to set the OVP threshold. Do not apply a direct DC voltage to this pin.
16	CAP	Connect a 1nF capacitor to GND.
17, 18, 19, 20	VIN	Input voltage. Connect to a power input and bypass with a 10μF capacitor to GND.
21 (Exposed Pad)	EXP	Exposed pad. The exposed pad is electrically connected to the common-drain node of the internal power MOSFET and must be electrically isolated. For improved thermal performance, this pad should be soldered to a large electrically isolated pad and tied to as much copper (electrically isolated) as possible using many vias.

9 Functional Block Diagram



10 Absolute Maximum Ratings

(Note 2)

- VIN, VOUT to GND

  DC ---------- –0.3V to +56V

  <800μs ---------- +60V
- EN, SS, FLTB, POVP to GND ---------- –0.3V to +6V
- CAP to VIN ---------- –0.3V to +10V
- Power Dissipation, P_D @ T_A = 25°C

  VDFN-20TL 5.2x4 ---------- 3.08W
- Package Thermal Resistance (Note 3)

  VDFN-20TL 5.2x4, θ_{JA} ---------- 32.43°C/W

  VDFN-20TL 5.2x4, θ_{JC} ---------- 0.28°C/W
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Junction Temperature ---------- 150°C
- Storage Temperature Range ---------- –65°C to 150°C

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 measured under natural convection (still air) at T_A = 25°C with the component mounted on a high effective-thermal-conductivity four-layer test board on a JEDEC 51-7 thermal measurement standard. θ_{JC} is measured at the exposed pad of the package.

11 ESD Ratings

(Note 4)

- HBM (Human Body Model) All Pins ---------- ±2kV
- IEC 61000-4-2 at VIN and VOUT ---------- ±8kV
- IEC 61000-4-5 at VIN no CAP ---------- 20A (8/20μs)

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

12 Recommended Operating Conditions

(Note 5)

- Supply Input Voltage, VIN ---------- 3.4V to 53V
- EN, FLTB ---------- 0V to 5.5V
- CAP ---------- 0V to 65V
- SS, POVP ---------- 0V to 3V
- IVIN, IVOUT ---------- 0A to 8A
- Peak IVIN, IVOUT for 10ms at 2% Duty Cycle ---------- 20A
- Junction Temperature Range ---------- –40°C to 125°C

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

13 Electrical Characteristics

(V_{IN} = 48V, V_{EN} = 5V, C_{IN} = 10µF, C_{OUT} = 10µF, C_{SS} = 5.6nF, T_A = T_J = 25°C, unless otherwise noted.)

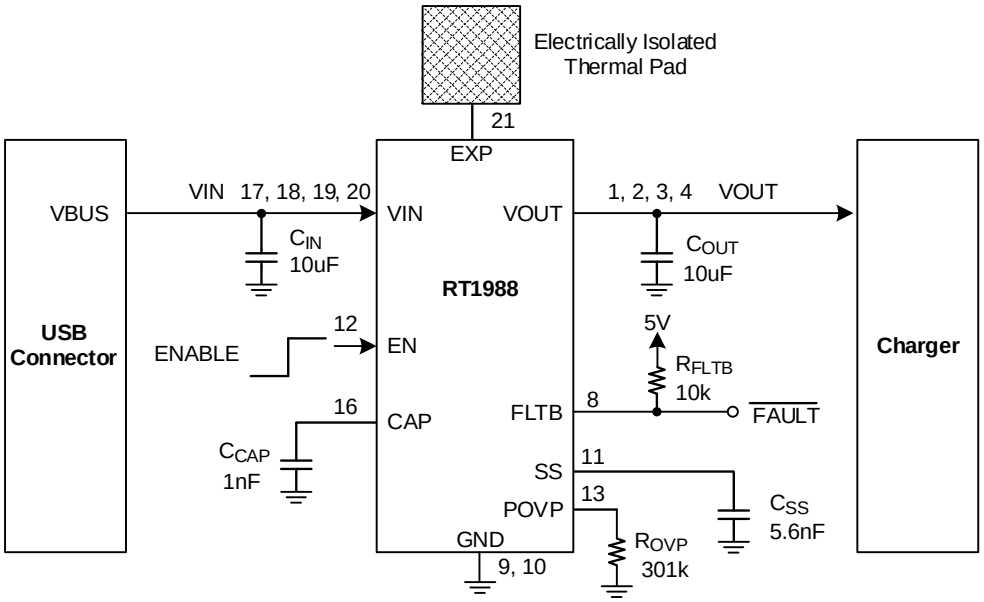
Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
General						
Input Voltage Range	V_{IN}		3.4	--	53	V
Transient Clamp Voltage	V_{IN_TVS}		--	60	--	V
Input Undervoltage-Lockout	V_{IN_UVLO}	VIN rising	2.9	--	3.35	V
UVLO Hysteresis	V_{UVLO_HYS}		--	250	--	mV
Input Quiescent Current	I_Q	I_{OUT} = 0A, V_{IN} = 48V	--	550	800	µA
Input Shutdown Current	I_{SHDN}	I_{OUT} = 0A, V_{IN} = 48V, EN = 0V	--	--	120	µA
Output Leakage Current	I_{OUT_LK}	V_{OUT} = 48V, V_{IN} = 0V, EN = 0V	--	--	100	µA
Switch On Resistance	R_{ON_48V}	V_{IN} = 48V, I_{OUT} = 1A (Note 6)	--	20	--	mΩ
	R_{ON_5V}	V_{IN} = 5V, I_{OUT} = 1A (Note 6)	--	22	--	
Enable Input Rising Threshold	V_{EN_R}	EN rising	--	--	1.4	V
Enable Input Falling Threshold	V_{EN_F}	EN falling	0.4	--	--	V
Enable Input Pull-Down Resistance	R_{EN_PD}	EN rising	475	730	985	kΩ
FLTB Pull-Down Voltage	V_{FLTB_PD}	I_{FLTB} = –3mA	--	--	0.3	V
Input Overvoltage Protection						
Overvoltage Protection Threshold	V_{OVP_R}	POVP > 1.3V (ROVP > 260kΩ), V_{IN} rising	56	58	60	V
		0.85V < POVP < 1.1V (170kΩ < ROVP < 220kΩ), V_{IN} rising	41.7	43.5	45.3	
		POVP < 0.6V (ROVP < 120kΩ), V_{IN} rising	32.3	34	35.7	
POVP Current	I_{POVP}		--	5	--	µA
Overvoltage Protection Blanking Time	t_{BLK_OVP}		--	512	--	µs
Ideal Diode (Reverse Current Blocking)						
Ideal Diode Forward Regulation Voltage	V_{FWD}	V_{IN} – V_{OUT}, I_{OUT} < 1A	--	35	--	mV
Fast Reverse Current Threshold	V_{FRC}	V_{IN} - V_{OUT} fast turn off	--	–50	--	mV
Fast Reverse Current Delay Time	t_{FRC}		--	0.6	--	µs
Dynamic Timing Characteristics						
Turn-On Delay Time	t_{D_ON}	From EN rising edge to VOUT reaching 10% of VIN	--	8	--	ms
Turn-On Rise Time	t_{ON}	VOUT from 10% to 90%	--	2	--	ms
Short-Circuit Protection Restart Time	t_{SCP_RST}	During soft-start.	--	64	--	ms

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Over-Temperature Protection						
Over-Temperature Protection Threshold	T_{OTP}	Non-latch off	--	150	--	°C
Start-Up Short-Circuit Protection						
Short-Circuit Protection Current Limit	I_{SCP}	V_{IN} = 48V, V_{OUT} = 0V, during start-up.	--	2	--	A
		V_{IN} = 48V, V_{OUT} = 20V, during start-up.	--	10.5	--	
		V_{IN} = 48V, V_{OUT} = 47V, during start-up.	--	15	--	
Short-Circuit Protection Timeout	t_{SCP}		--	256	--	μs

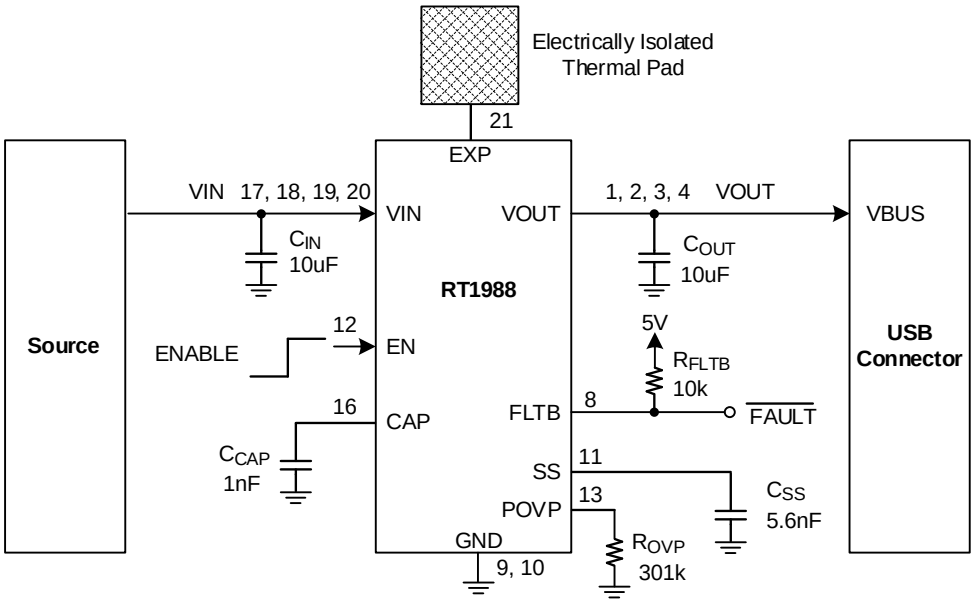
Note 6. R_{ON} is tested at 1A in test mode to bypass ideal diode regulation.

14 Typical Application Circuit

14.1 Current Sinking Application



14.2 Current Sourcing Application



15 Timing Diagram

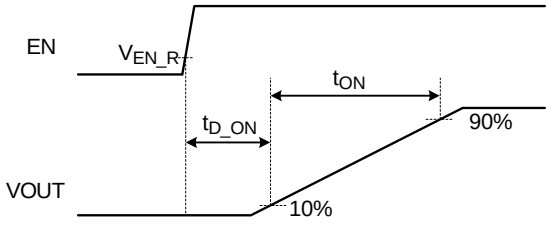


Figure 1. Turn-On Delay Time and Turn-On Rise Time

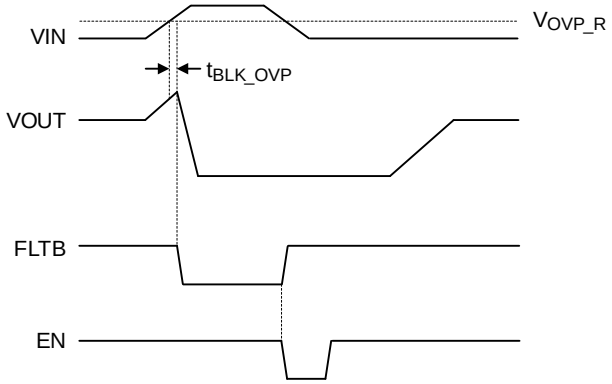
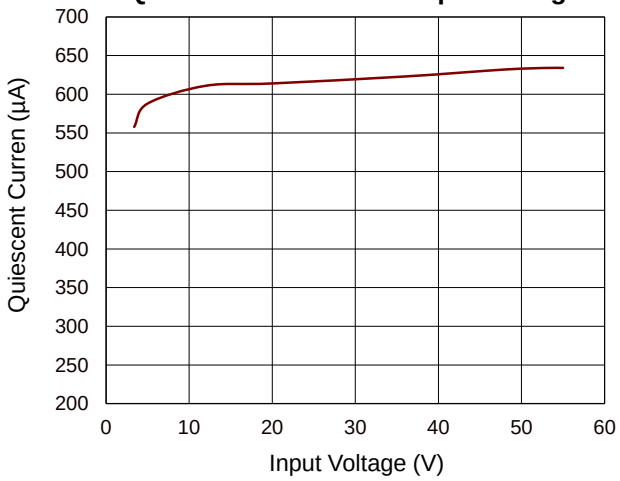


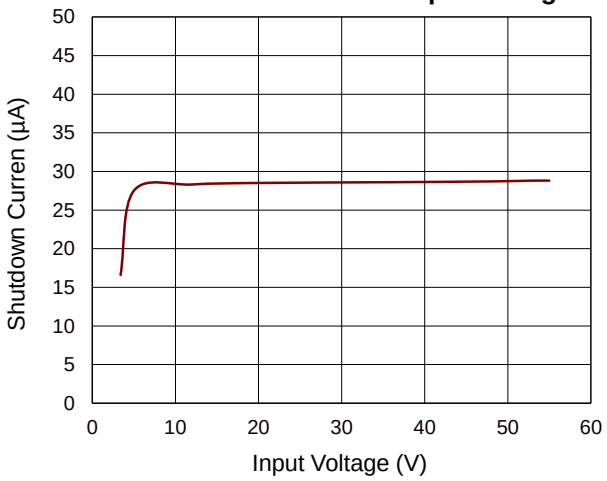
Figure 2. Overvoltage Protection

16 Typical Operating Characteristics

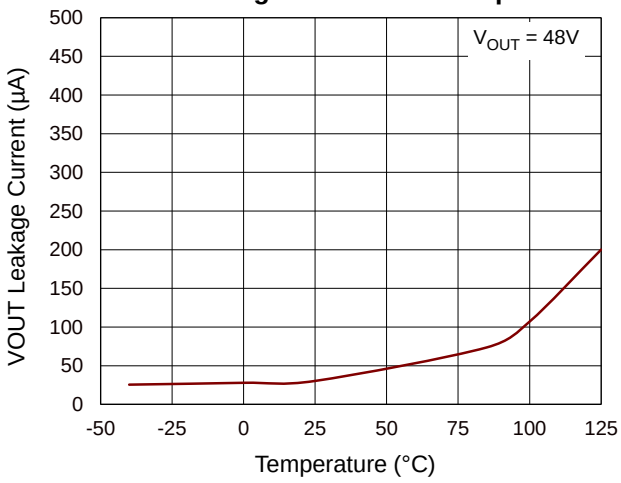
Quiescent Current vs. Input Voltage



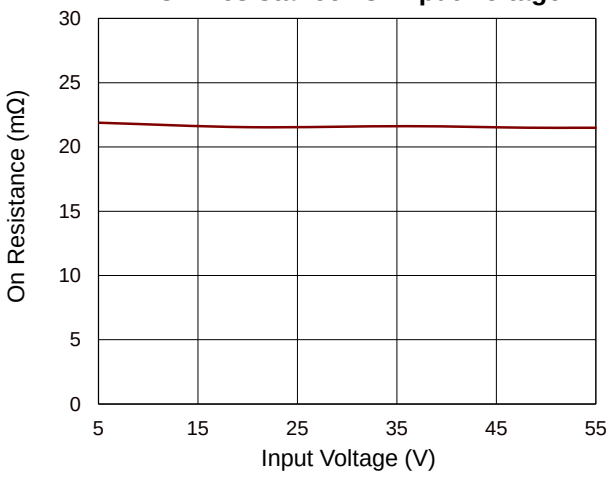
Shutdown Current vs. Input Voltage



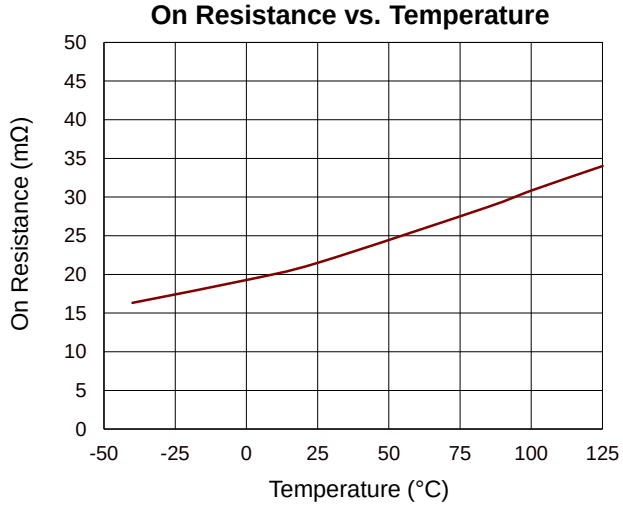
VOUT Leakage Current vs. Temperature



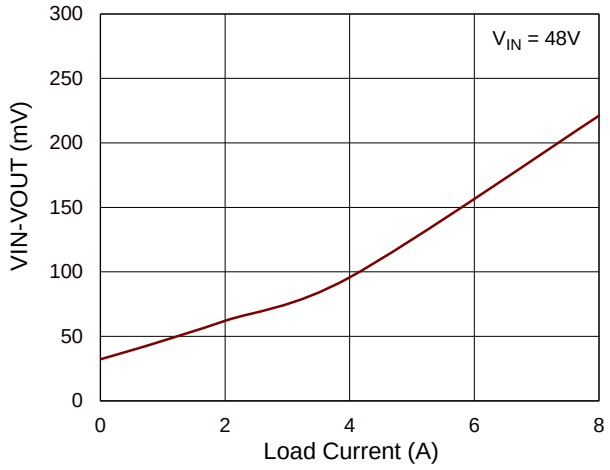
On Resistance vs. Input Voltage



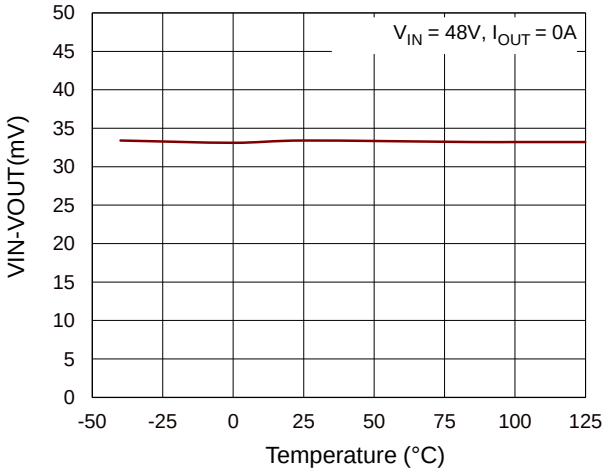
On Resistance vs. Temperature



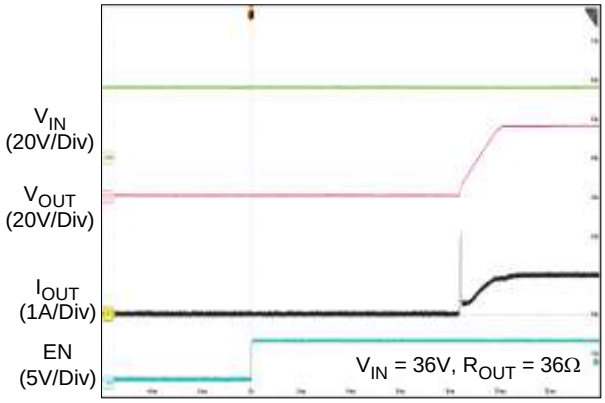
Ideal Diode Regulation Voltage vs. Load Current



Ideal Diode Regulation Voltage vs. Temperature

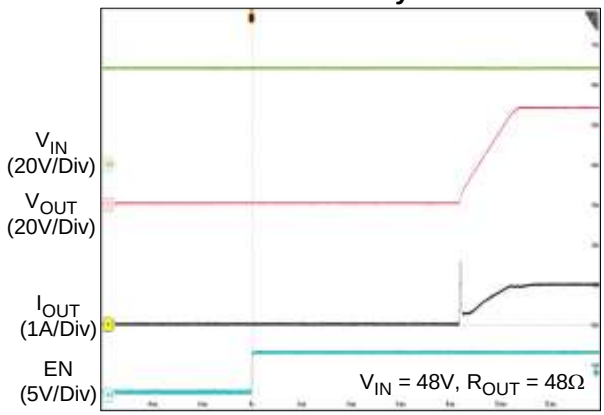


Turn-On Delay Time



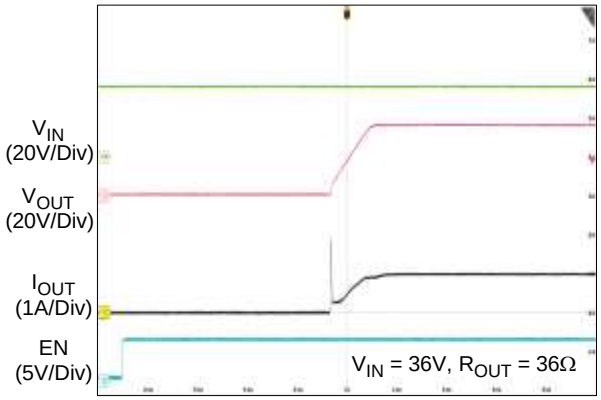
Time (2ms/Div)

Turn-On Delay Time



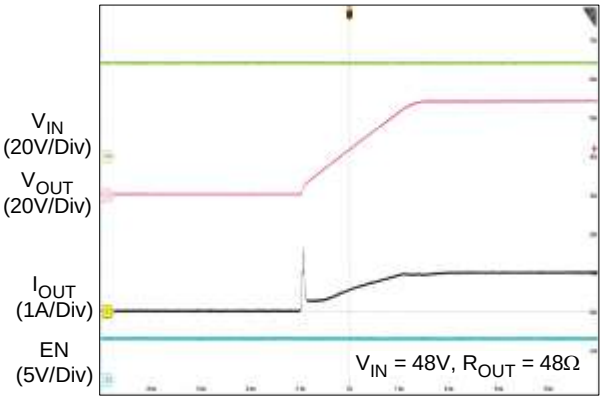
Time (2ms/Div)

Turn-On Rise Time



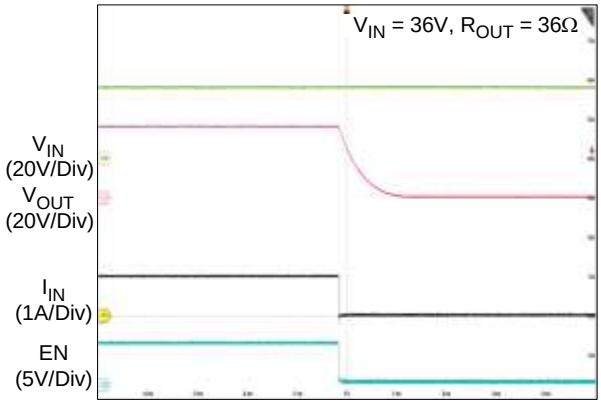
Time (2ms/Div)

Turn-On Rise Time



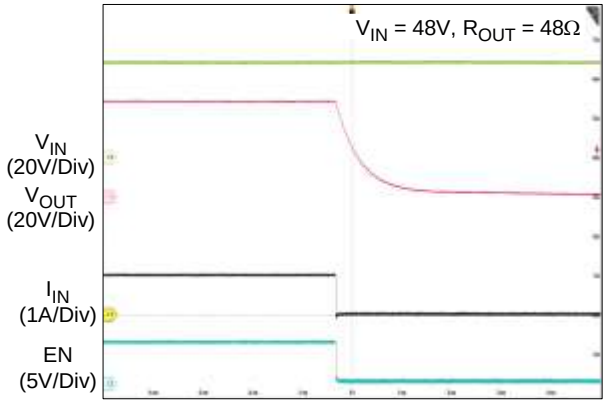
Time (1ms/Div)

Power Off



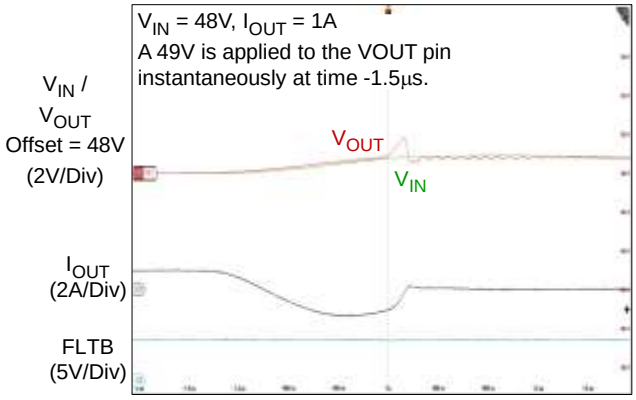
Time (1ms/Div)

Power Off



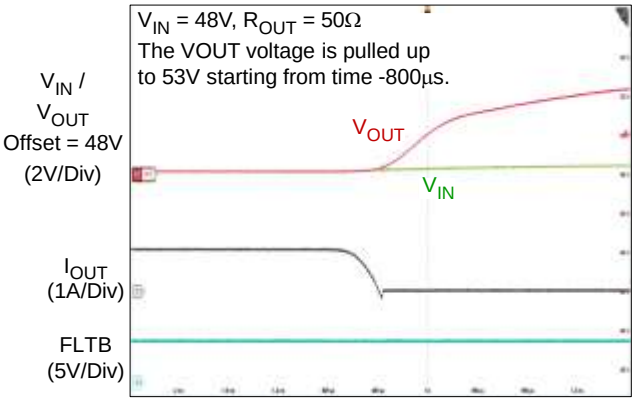
Time (1ms/Div)

Fast Reverse Current Blocking



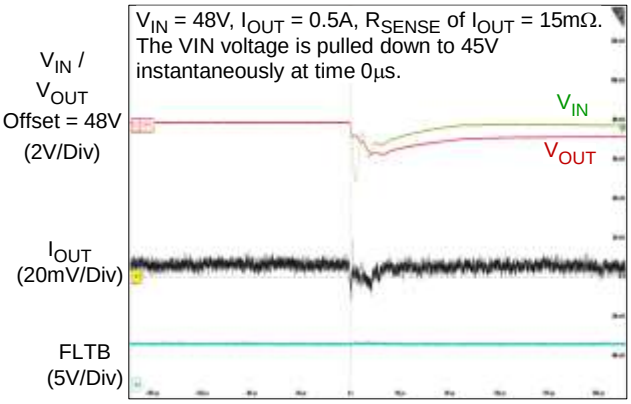
Time (400ns/Div)

Ideal Diode True Reverse Current Blocking



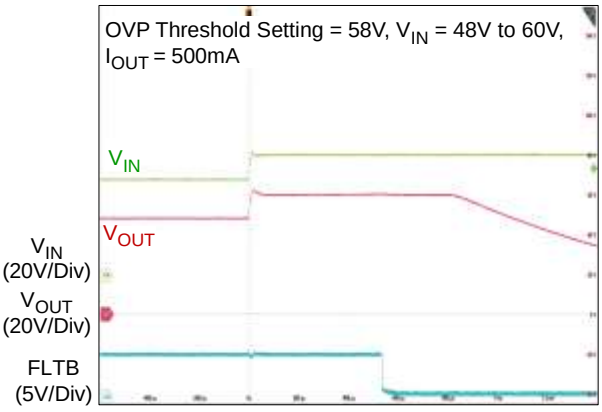
Time (400μs/Div)

Recovery of Ideal Diode True Reverse Current Blocking



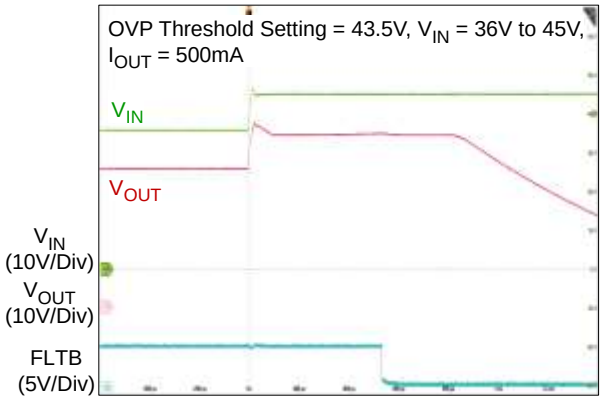
Time (40μs/Div)

Overvoltage Protection



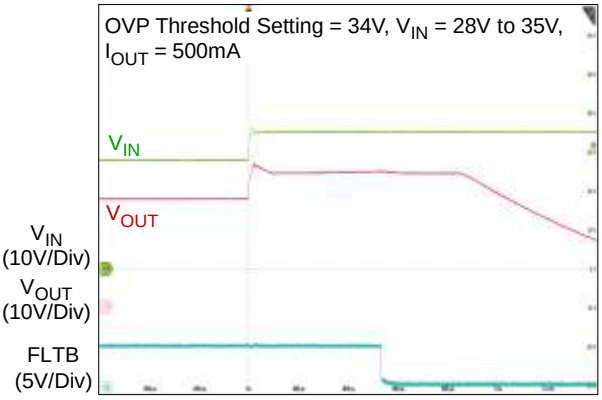
Time (200μs/Div)

Overvoltage Protection

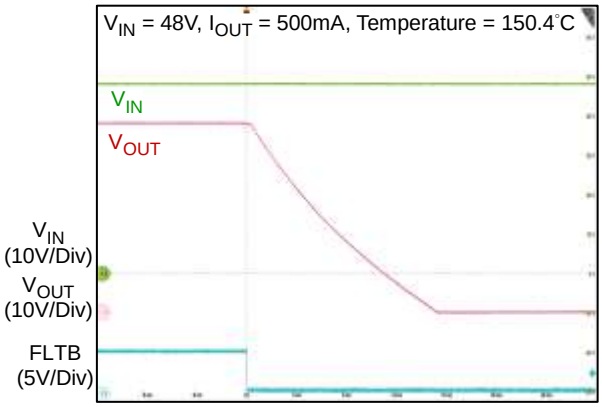


Time (200μs/Div)

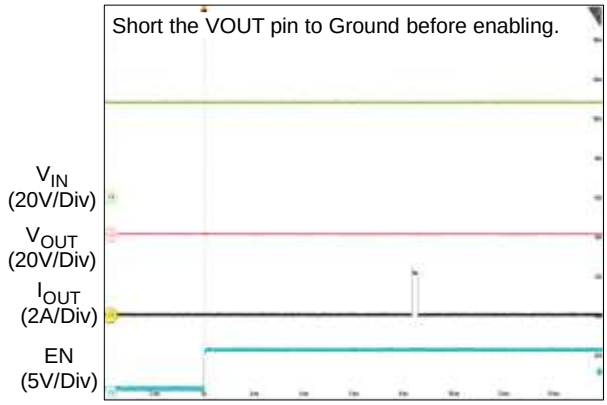
Overvoltage Protection



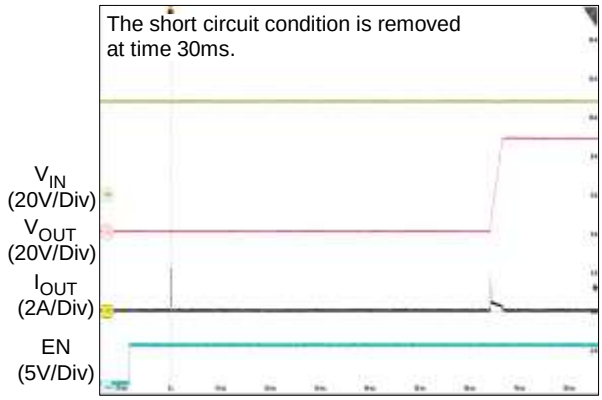
Over-Temperature Protection



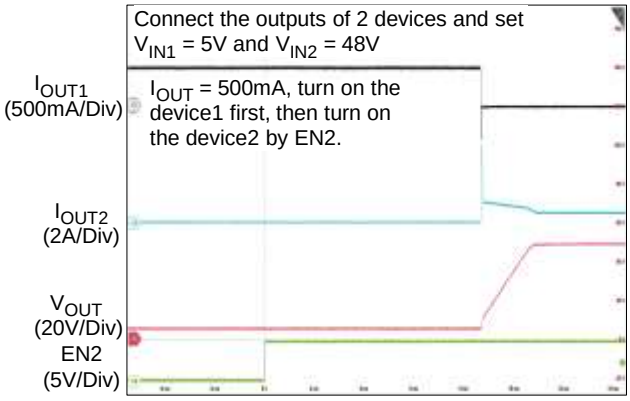
Start-Up Short-Circuit Protection



Start-Up Short-Circuit Protection Restart Time



Dual Port with Same Output



17 Operation

The RT1988 is a high-side protection device which is particularly well suited for USB-C sink applications. Its ideal diode functionality and back-to-back integrated 20mΩ MOSFETs provide reverse current blocking and diode-OR power source sharing while programmable soft-start, overvoltage, over-temperature, and short-circuit protection features protect the system from faults. The 3.4V to 53V operating range aligns with USB-C voltage levels as well as other common power supplies. Unlike single MOSFET devices, the RT1988 completely isolates VIN and VOUT when disabled using the EN input.

17.1 Enable (EN and UVLO)

The active high EN pin provides on/off control for the power path while the input undervoltage-lockout (UVLO) circuit monitors the input voltage (VIN). When VIN > V_{IN_UVLO} (typically 3.175V), driving EN above V_{EN_R} (1.4V max) turns on the power path. The timing diagram is shown in Figure 1. Assuming no other faults – such as OVP or OTP – VOUT will start to ramp after t_{D_ON} (typically 8ms). VOUT ramps up to VIN with a 10% to 90% rise time of approximately t_{ON} as set by C_{SS}. See the Soft-Start Slew Rate Control section for more information.

Driving EN below V_{EN_F} (0.4Vmin) disables the power path and puts the RT1988 in a low quiescent current state, drawing just I_{SHDN} (120μA maximum). A low input voltage (VIN < V_{IN_UVLO} – V_{UVLO_HYS}, typically 2.925V) also disables the power path.

17.2 Power Delivery and Soft-Start

When an input voltage is first applied to the RT1988, the voltage at VOUT ramps up linearly with a slope determined by the SS pin capacitance. During this time, which is typically a few milliseconds, the RT1988 has high internal MOSFET stress with a power dissipation equal to (VIN – VOUT) x IOUT, where IOUT is the sum of the system load current and the current required to charge the output capacitance. The internal power dissipation is calculated as follows:

$$\text{Power} = (\text{VIN} - \text{VOUT}) \times \text{IOUT} = (\text{VIN} - \text{VOUT}) \times \left(\text{ISYS} + \frac{\text{dVOUT}}{\text{dt}} \times C_{OUT}\right)$$

where ISYS is the system load current and C_{OUT} is the output capacitance. The internal MOSFET ability to survive this high-power scenario depends on the MOSFET's safe operating area (SOA), as illustrated in Figure 4, and the thermal performance of the package – with a soft-start time of just a few milliseconds, the thermal performance of the PCB does not play a significant role.

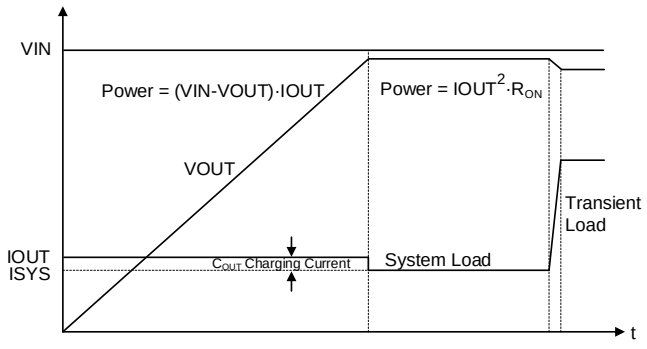


Figure 3. Soft-Start Power Dissipation

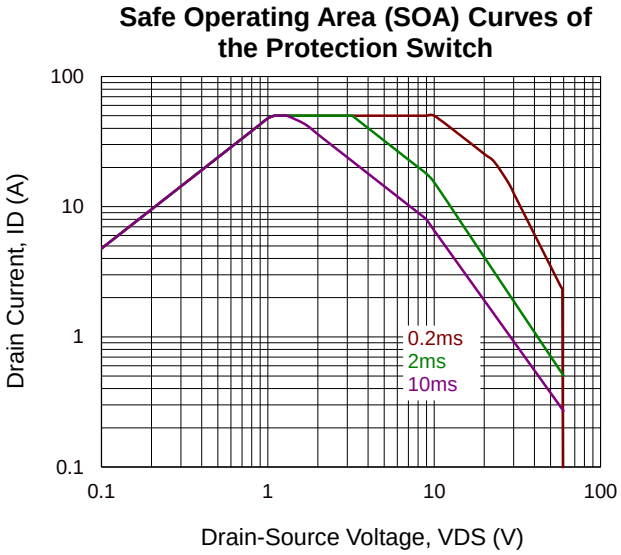


Figure 4. Safe Operating Area (SOA) Curves of the Protection Switch

When the soft-start ramp is complete, the internal power device switches completely on (provided ISYS x R_{ON} > V_{FWD}) and acts like a resistor with resistance R_{ON}. Because of the low differential voltage between VIN and VOUT, the power dissipation during this mode is considerably lower than during soft-start. Careful PCB layout consideration of thermal performance, combined with the low on-resistance of the internal power device, will ensure maximum system efficiency and minimal heat generation.

17.3 Soft-Start Slew Rate Control

When the RT1988 is first enabled, the soft-start function limits the rate of rise on the internal gate of the power device to control the VOUT ramp and limit inrush current. An external capacitor, C_{SS}, on the SS pin programs the 10% to 90% ramp time, t_{ON}, as follows:

t_{ON} = 7.44 x C_{SS} x V_{IN}

With C_{SS} in nF and t_{ON} in μs. To calculate C_{SS}:

$$C_{SS} = 0.134 \times \frac{t_{ON}}{V_{IN}}$$

17.4 Fault Protection

The RT1988 provides protection against reverse current (TRCB), overvoltage (OVP), overtemperature (OTP), and short-circuit (OCP) faults. When the device is first enabled, if any of the following conditions exist, the internal power MOSFET will not turn on:

1. VIN – VOUT < V_{FRC} (typically -50mV)
2. VIN > V_{OVP_R} (58V when POVP > 1.3V; 43.5V when 0.85V < POVP < 1.1V; 34V when POVP < 0.6V)
3. T_{DIE} > T_{OTP} (typically 150°C)

In addition, for conditions #2 (OVP) and #3 (OTP), the FLTB pin will be pulled low to indicate the fault status of the device. Note that a TRCB condition prevents the power device from turning on but does not result in a fault indication. The RT1988 continuously monitors these conditions to determine when to allow the power path to be enabled. See Table 1 for more information.

Table 1. Fault Response to Protection Features

Protection	Fault Response	FLTB Status
Reverse Current (TRCB)	Auto-restart without soft-start at fault removal	High Impedance
Overvoltage Protection (OVP)	Auto-restart with soft-start at fault removal	Low
Over-Temperature Protection (OTP)	Auto-restart with soft-start at fault removal	Low
Start-Up Short-circuit Protection (SCP)	Auto-restart after t_{SCP_RST} (typically 64 ms)	Low

17.5 Start-Up Short-Circuit Protection (SCP)

During the soft-start ramp (t_{ON}), the RT1988 monitors for short-circuit faults. If the output current, IOUT, exceeds I_{SCP} during the soft-start ramp, the internal MOSFET will turn off. To maximize the power handling capability of the internal MOSFET within SOA, I_{SCP} varies with VIN – VOUT. When the output voltage begins to start up, the initial value of the current limit is 2A. As the output voltage rises above 3V, the current limit starts to increase, with its value inversely proportional to VIN-VOUT, as shown in Figure 5. A fixed timer is set to disable the power path if in-rush current is continuously clamped by the short-circuit current limit for 256μs. The timer resets if the in-rush current drops below the current limit. In the case of an output short-circuit, the RT1988 will disable the power path by turning off the internal MOSFET when the 256μs timer elapses. After t_{SCP_RST} (typically 64ms), the auto-retry mode will enable the power path and try to start up again. Both the SCP current limit and shutdown functions are disabled after t_{ON} (when the soft-start completes and the internal MOSFET is fully enhanced). Large output capacitors may require a longer soft-start time.

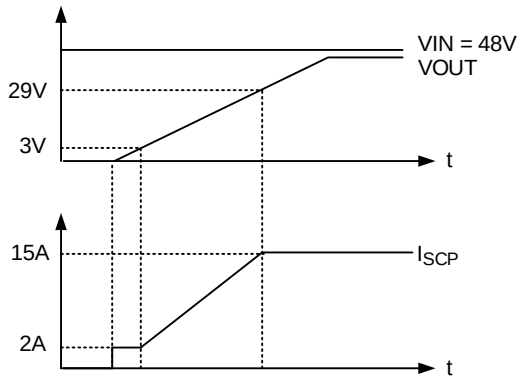


Figure 5. Short-Circuit Protection

17.6 Ideal Diode True Reverse Current Blocking (TRCB)

When the power path is enabled, the ideal diode control circuitry attempts to regulate $V_{IN} – V_{OUT} = V_{FWD}$ (typically 35 mV). Provided that $I_{OUT} \times R_{ON} < V_{FWD}$, the drive circuitry servos the internal gate drive to maintain this differential voltage. If the load current increases such that $I_{OUT} \times R_{ON} > V_{FWD}$, then the internal MOSFET is fully enhanced, and the VIN to VOUT voltage is determined by the load current and R_{ON}. If VIN decreases (or VOUT increases) such that VIN – VOUT falls to less than V_{FWD}, the ideal diode gate drive will force the internal MOSFET off. The ideal diode control circuitry is designed to accommodate relatively slow changes in load conditions. In the case of a fast transient, the RT1988 includes a fast reverse current comparator that trips within t_{FRC} (typically about 0.6μs) if VIN – VOUT falls below V_{FRC} (typically –50mV).

17.7 Overvoltage Protection (OVP)

The OVP circuit monitors the input voltage (VIN) for an overvoltage event to protect downstream loads. The OVP threshold can be set by connecting a resistor between the POVP pin and GND. When EN goes high and prior to the soft-start process, the POVP threshold setting will be latched. The POVP threshold remains unaffected by any subsequent changes. See Table 2 for the POVP threshold setting.

When RT1988 detects an overvoltage event, the resulting behavior depends on the current state of the power path. If the power path is on, the internal power device will be switched off after the OVP blanking time (t_{BLK_OVP} – typically 512μs). If the power path is off, OVP will prevent the internal power device from being turned on. In both cases the FLTB pin is pulled low indicating a fault condition. The RT1988 can be re-enabled by toggling the EN pin or when VIN falls below the OVP falling threshold (typically 1V lower than the OVP rising threshold).

Table 2. Overvoltage Protection Threshold Setting

POVP Voltage	OVP Threshold (Typical)
POVP > 1.3V	58V
0.85V < POVP < 1.1V	43.5V
POVP < 0.6V	34V

17.8 Overtemperature Protection (OTP)

If the RT1988 die temperature reaches 150°C, the power path is disabled. The RT1988 can be re-enabled by toggling the EN pin or when the temperature falls below the OTP falling threshold (typically 110°C).

18 Application Information

(Note 7)

18.1 Input Capacitor Selection

A quality input capacitor provides a low impedance at high frequency to reduce input voltage transients, supply fast load transients, and reduce high frequency noise. A 10μF ceramic input capacitor is recommended and should be placed as close to the VIN and GND pins as possible.

18.2 Output Capacitor Selection

While the RT1988 does not require a specific amount of output capacitance, the user should choose enough low ESR output capacitance to minimize high frequency output voltage transients due to dynamic loads.

18.3 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 VDFN-20TL 5.2x4 package, the thermal resistance, θ_{JA}, is 32.43°C/W on a standard JEDEC 51-7 high effective-thermal-conductivity four-layer test board. The maximum power dissipation at T_A = 25°C can be calculated as below:

$P_{D(MAX)}$ = (125°C – 25°C)/(32.43°C/W) = 3.08W for a VDFN-20TL 5.2x4 package.

The maximum power dissipation depends on the operating ambient temperature for the fixed $T_{J(MAX)}$ and the thermal resistance, θ_{JA}. The derating curve in Figure 6 allows the designer to see the effect of rising ambient temperature on the maximum power dissipation.

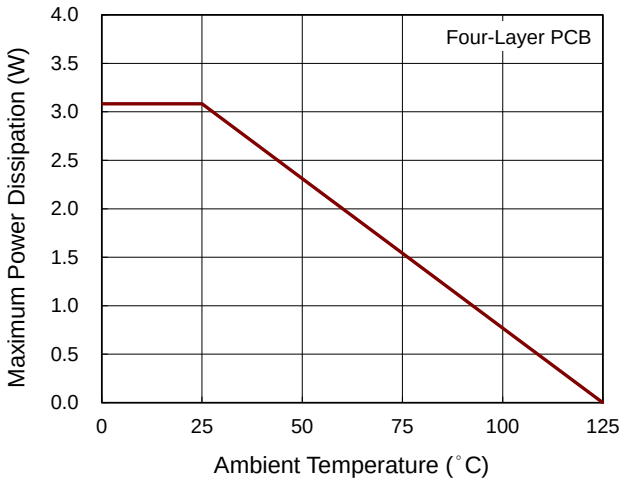
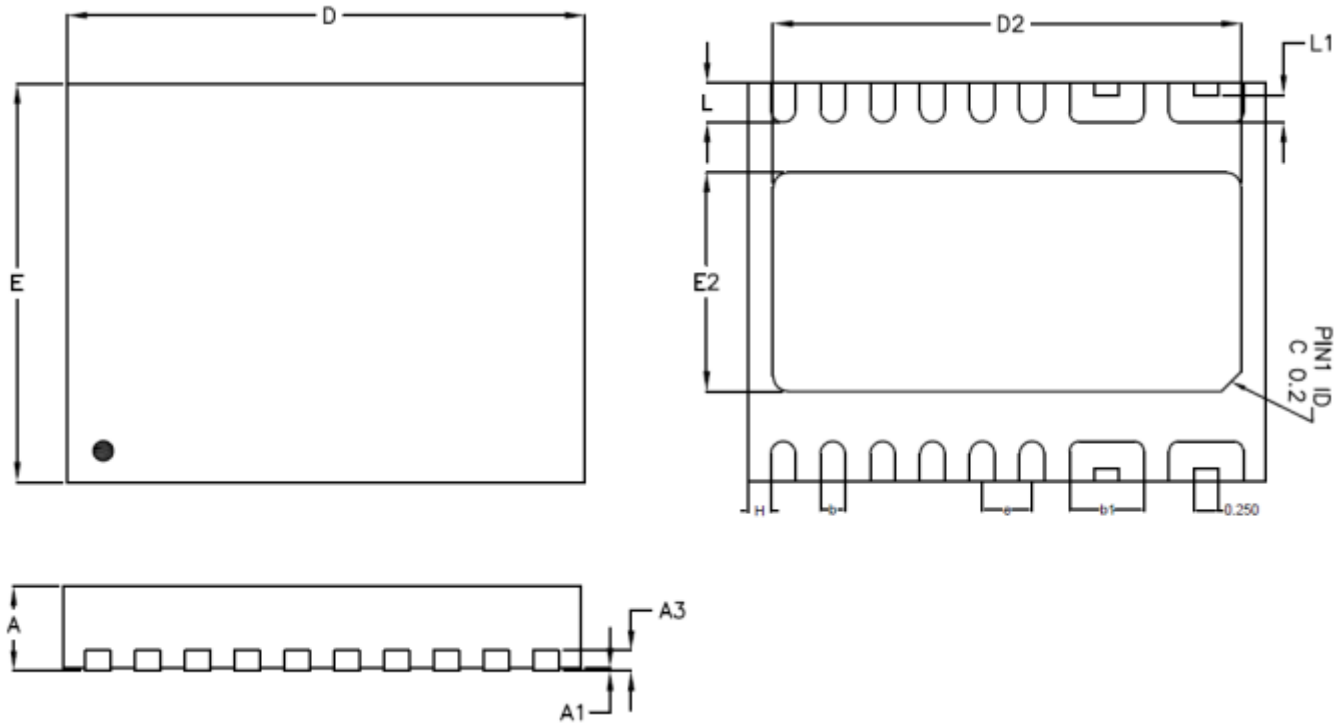


Figure 6. Derating Curve of Maximum Power Dissipation

Note 7. The information provided in this section is for reference only. The customer is solely responsible for the designing, validating, and testing your product incorporating Richtek's product and ensure such product meets applicable standards and any safety, security, or other requirements.

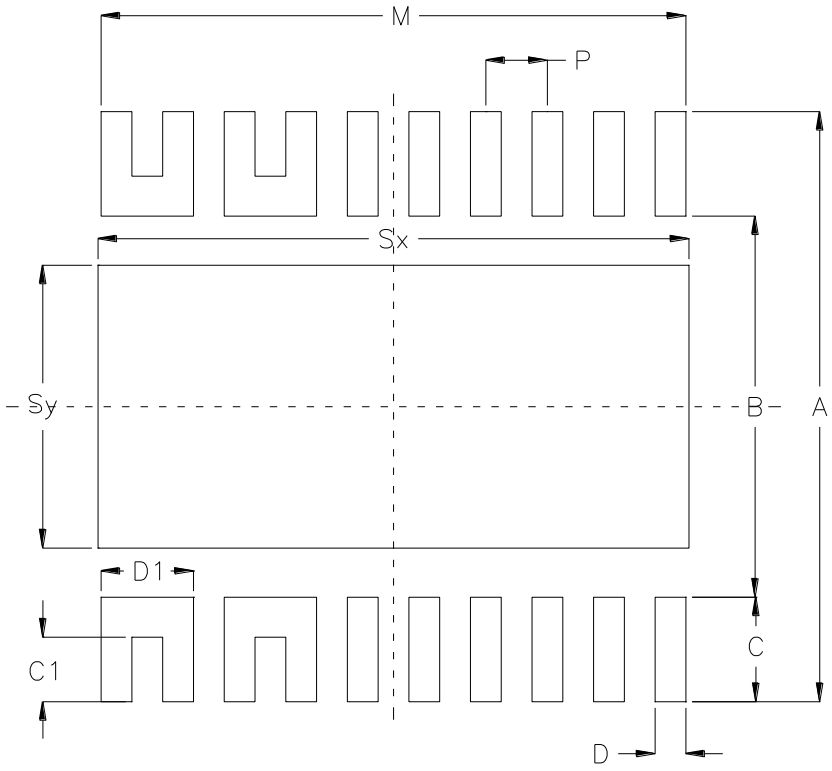
19 Outline Dimension



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.800	1.000	0.031	0.039
A1	0.000	0.050	0.000	0.002
A3	0.175	0.250	0.007	0.010
b	0.200	0.300	0.008	0.012
b1	0.700	0.800	0.028	0.031
D	5.150	5.250	0.203	0.207
D2	4.650	4.750	0.183	0.187
E	3.950	4.050	0.156	0.159
E2	2.150	2.250	0.085	0.089
e	0.500		0.020	
L	0.350	0.450	0.014	0.018
L1	0.225	0.325	0.009	0.013
H	0.225		0.009	

V-Type 20TL DFN 5.2x4 Package

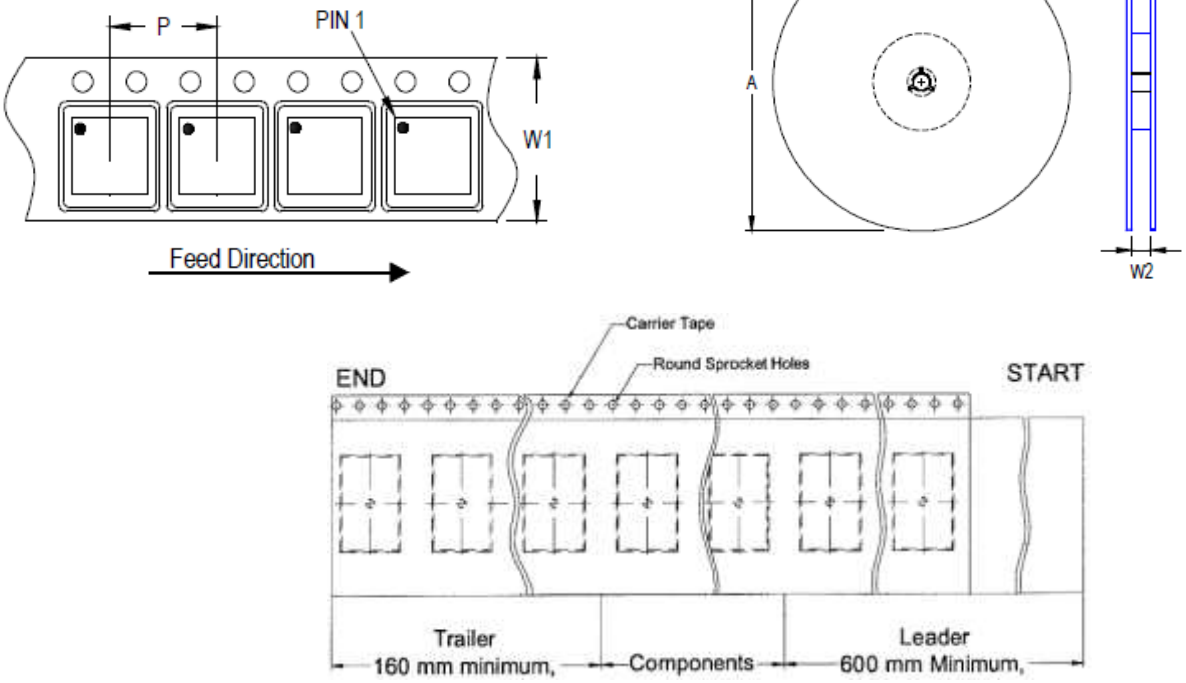
20 Footprint Information



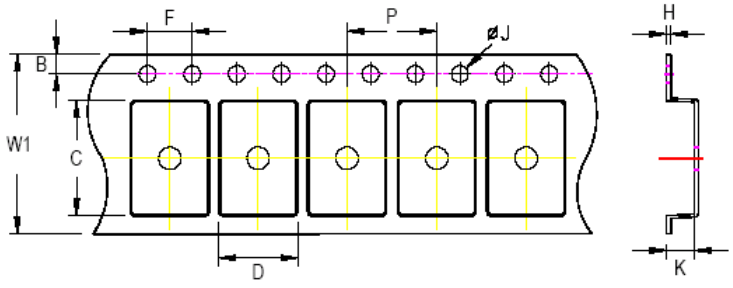
Package	Number of Pins	Footprint Dimension (mm)										Tolerance
		P	A	B	C	C1	D	D1	Sx	Sy	M	
V/W/U/XDFN5.2x4-20T	20	0.500	4.800	3.100	0.850	0.525	0.250	0.750	4.800	2.300	4.750	±0.05

21 Packing Information

21.1 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)				
(V, W) QFN/DFN 5.2x4	12	8	330	13	2,500	160	600	12.4/14.4



C, D, and K are determined by component size. The clearance between the components and the cavity is as follows:

- For 12mm carrier tape: 0.5mm max.

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	1.0mm	1.3mm	0.6mm

21.2 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
(V, W) QFN and DFN 5.2x4	13”	2,500	Box G	1	2,500	Carton A	6	15,000

21.3 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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22 Datasheet Revision History

Version	Date	Description
00	2025/8/14	First Edition