AOZ13058DI

ECPower™ 55V 20mΩ Smart Protection Switch With Ideal Diode Reverse Current Blocking

General Description

The AOZ13058DI is a protection switch intended for applications that require reverse current protection. The input operating voltage range is between 3.3V and 55V, and both VIN and VOUT terminals are rated at 60V Absolute Maximum. The power switch is capable for 20A surge current for 10ms. AOZ13058DI provides under-voltage lockout, over-voltage, and over-temperature protection. The FLTB pin flags thermal shutdown and over-voltage faults.

AOZ13058DI is the ideal solution for multi-port Type-C PD (Power Delivery) EPR (Extended Power Range) application. The Ideal Diode True Reverse Current Blocking (IDTRCB) feature prevents VIN to rise due to reverse current flow from VOUT under all conditions.

An internal soft start circuit controls inrush current due to highly capacitive loads and the slew rate can be adjusted using an external capacitor. The integrated back-to-back MOSFET offers the industry's lowest ON-resistance and highest SOA (Safe Operating Area) to safely handle high current and a wide range of output capacitances on VOUT.

The AOZ13058DI is available in a thermally enhanced 5.2mm x 4mm DFN-20L package which can operate over -40°C to +125°C junction temperature range.

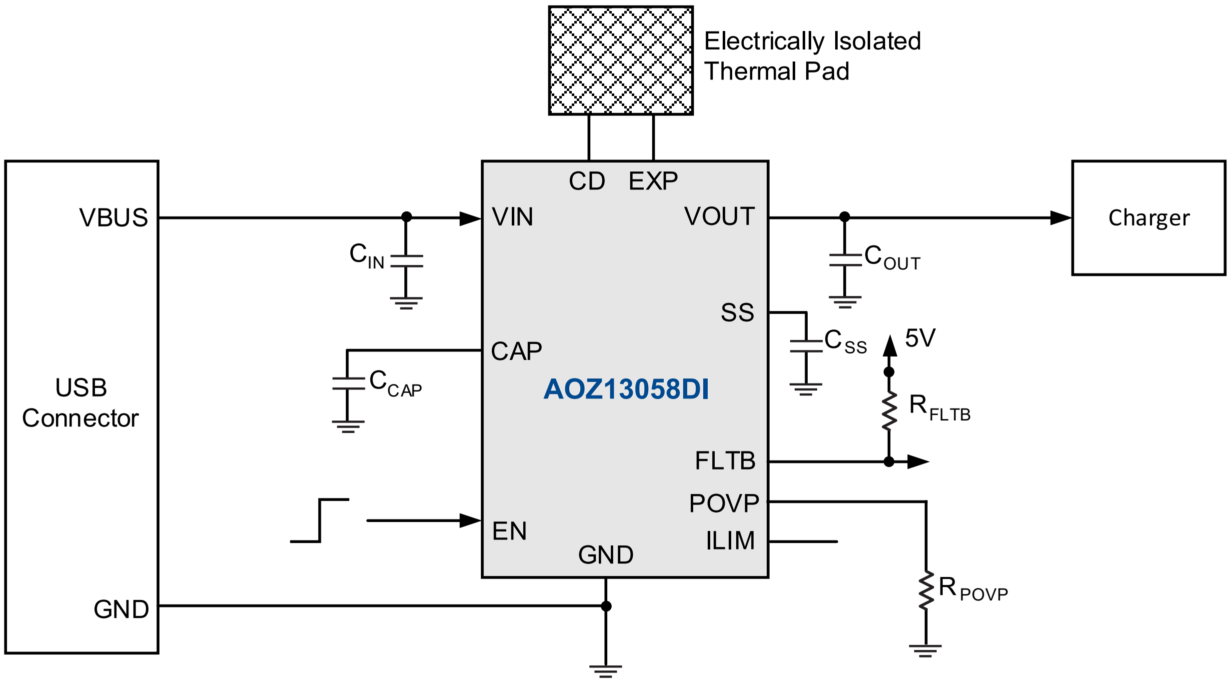
Features

- 7A continuous current
- 20A peak current for 10ms @ 2% duty cycle
- 20mΩ typical ON-resistance
- 3.3V to 55V operating input voltage
- VIN and VOUT are rated 60V Abs max
- Integrated positive and negative transient voltage suppression at VIN
- Ideal Diode True Reverse Current Blocking (IDTRCB)
- Programmable soft start
- VIN Under-voltage Lockout (UVLO)
- VIN Over-voltage Lockout (OVLO)
- Thermal shutdown protection
- Start-up short circuit protection
- IEC61000-4-2: ±8kV contact, ±15kV contact
- IEC61000-4-5: 20A (8/20µs) on VIN and VOUT
- Thermally enhanced DFN5.2x4-20L package

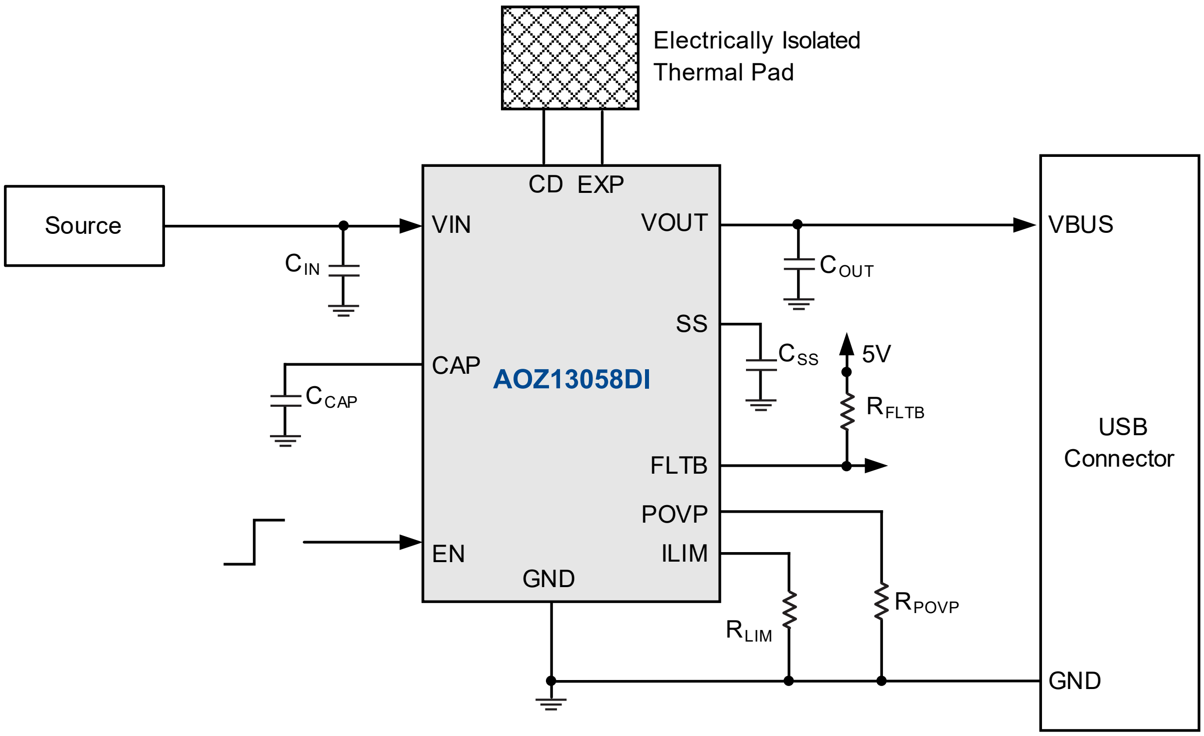
Applications

- Thunderbolt/USB Type-C PD EPR power switch
- Notebooks computer barrel jack
- Docking stations/dongles
- Power ORing applications

Typical Applications

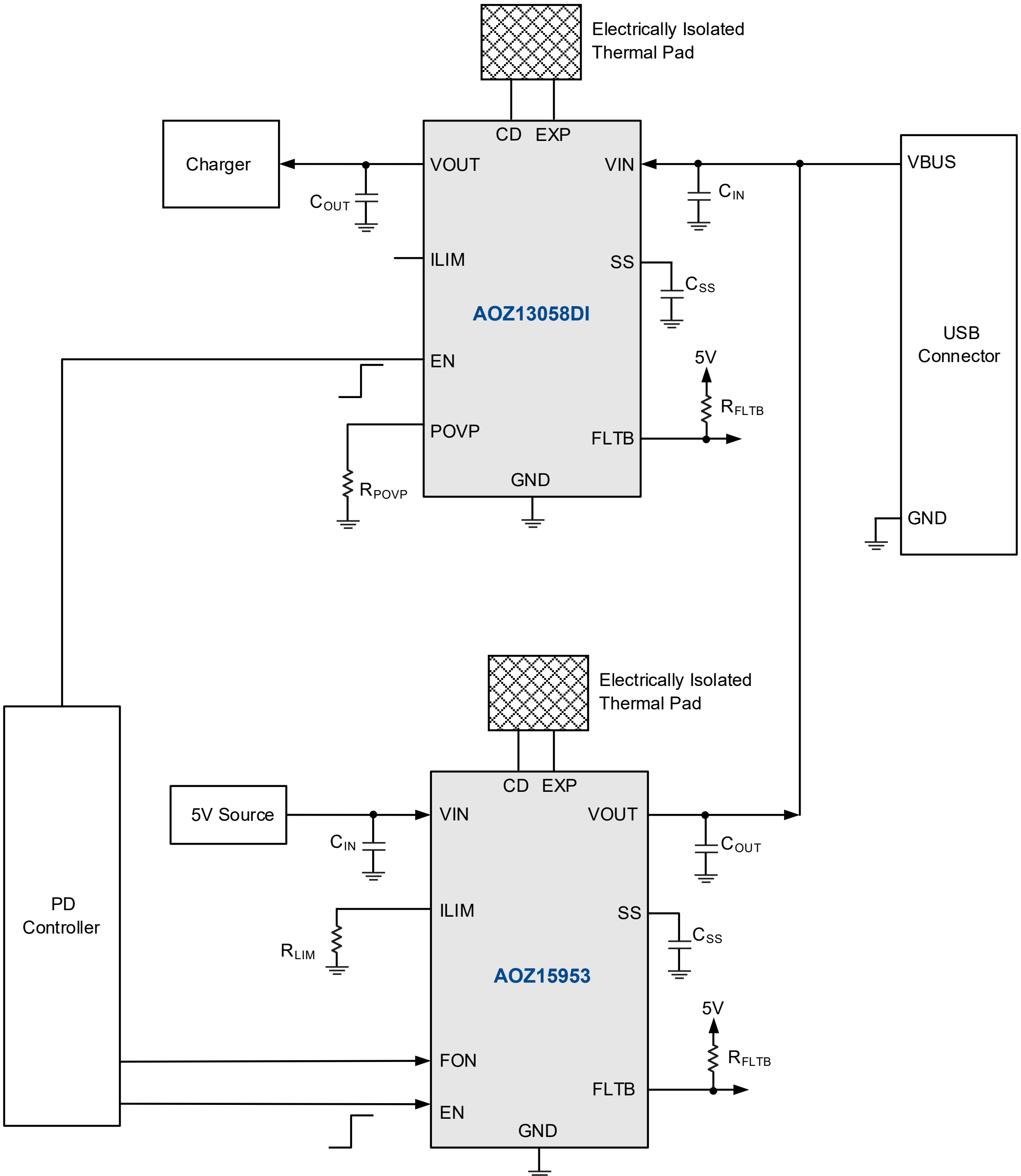


Current Sinking Application



Current Sourcing Application

Dual Port Typical Application



USB PD EPR Application

Ordering Information

Part Number	Recovery	Junction Temperature Range	Package	Environmental
AOZ13058DI-01	Auto-restart	-40°C to +125°C	DFN5.2x4-20L	RoHS
AOZ13058DI-02	Latch-off	-40°C to +125°C	DFN5.2x4-20L	RoHS

AOS products are offered in packages with Pb-free plating and compliant to RoHS standards.
Please visit https://aosmd.com/sites/default/files/media/AOSGreenPolicy.pdf for additional information.

Pin Configuration

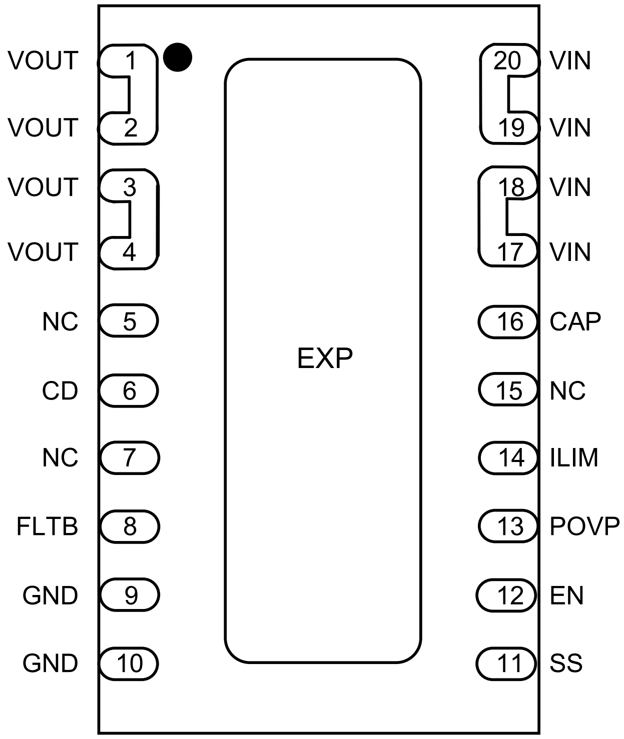


Figure 1. DFN5.2x4-20L (Top Transparent View)

Pin Description

Pin Number	Pin Name	Pin Function
1, 2, 3, 4	VOUT	Output pins. Connect to internal load.
5	NC	No connect.
6	CD	Common drain node for the power switches and it must be electrically connected to Exposed Pad (EXP).
7	NC	No connect.
8	FLTB	Fault indicator, open-drain output. Pull low after a fault condition is detected.
9, 10	GND	Ground.
11	SS	Soft start pin. Connect a capacitor C_{SS} from SS to GND to set the soft start time.
12	EN	Enable Active High.
13	POVP	Over-voltage Protection Setting. Connect a resistor or direct DC voltage to determine the OVP threshold.
14	ILIM	Current limit set pin. Connect a 1% resistor RLIM between ILIM and GND to set the current limit threshold. Leave this floating/short to GND to disable the current limit function.
15	NC	No connect.
16	CAP	Connect a 10nF capacitor to GND.
17, 18, 19, 20	VIN	Connect to adapter or power input. Place a 10 µF capacitor from VIN to GND.
EXP	EXP	Exposed Thermal Pad. It is the common drain node for the power switches and it must be electrically isolated. Solder to a metal surface directly underneath the EXP and connect to floating copper thermal pads on multiple PCB layers through many VIAs. For best thermal performance, make the floating copper pads as large as possible.

Absolute Maximum Ratings

Exceeding the Absolute Maximum ratings may damage the device.

Parameter	Rating
VIN, VOUT to GND	-0.3V to +60V
VIN to GND (during IEC6100-4-5 surge event)	-5V to +66V
EN, FLTB to GND	-0.3V to +6V
SS POVP ILIM to GND	0V to +3.5V
CAP to VIN	-0.3V to +6V
CD=EXP to the greater of VIN or VOUT	-0.3V
CD=EXP to GND	60V
Junction Temperature (T_J)	+150°C
Storage Temperature (T_S)	-65°C to +150°C
ESD Rating CDM All Pins	±1kV

Recommended Operating Conditions

The device is not guaranteed to operate beyond the Maximum Recommended Operating Conditions.

Parameter	Rating
Supply Voltage VIN to GND	3.3V to 55V
VOUT to GND	0V to 55V
EN, FLTB to GND	0V to 5.5V
SS POVP ILIM to GND	0V to 3V
CAP to VIN	-0.3 V to +5.5 V
CD=EXP to the greater of VIN or VOUT	-0.3V
CD=EXP to GND	55V
DC Fully On Switch Current (I_{SW})	0A to 7A
Peak Switch Current (I_{SW}) for 10 ms @ 2% Duty Cycle	20A
Minimum output capacitance	1µF
Junction Temperature (T_J)	-40°C to +125°C

Electrical Characteristics

T_A = 25°C, VIN = 48V, EN = 5V, C_{IN} = 10µF, C_{OUT} = 10µF, C_{SS} = 5.6nF, C_{CAP} = 10nF, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
General						
V_{VIN}	Input Supply Voltage		3.3		55	V
V_{IN_TVS}	Transient Clamp Voltage[1]	I_{PP} = 20A		65		V
V_{RWM}	Reverse Stand-off Voltage			56		V
V_{UVLO}	Under-voltage Lockout Threshold	VIN rising	2.35		2.65	V
V_{UVLO_HYS}	Under-voltage Lockout Hysteresis			150		mV
I_{VIN_ON}	Input Quiescent Current	I_{OUT} = 0		890		µA
I_{VIN_OFF}	Input Shutdown Current	I_{OUT} = 0, EN = 0V		100		µA
I_{VOUT_OFF}	Output Leakage Current	VOUT = 48V, VIN = 0V, EN = 0V			100	µA
R_{ON_48V}	Switch ON-resistance[2]	I_{OUT} = 1A		20		mΩ
R_{ON_5V}		VIN = 5V, I_{OUT} = 1A		20		mΩ
V_{EN_H}	EN Input High Threshold	EN rising			1.4	V
V_{EN_L}	EN Input Low Threshold	EN falling	0.4			V
I_{EN}	EN Bias Current	V_{EN} = 1.8V			1.5	µA
V_{FLTB_LO}	FLTB Pin Pull-down Voltage	FLTB sinking 3mA			0.3	V

Electrical Characteristics

T_A = 25°C, VIN = 48V, EN = 5V, C_{IN} = 10µF, C_{OUT} = 10µF, C_{SS} = 5.6nF, C_{CAP} = 10nF, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Input Over-voltage Protection						
V_{OVP}	Over-voltage Protection Threshold	POVP > 1.3V	56	58	60	V
		0.85V < POVP < 1.1V	41.7	43.5	45.3	V
		0.50V < POVP < 0.75V	32.3	34	35.7	V
		POVP < 0.4V	23.0	24	25.0	V
t_{OVP_DELAY}	OVP Delay Time			1		µs
I_{OVP}	Source Current	0 < POVP < 2V		5		µA
V_{OVP_HYS}	Over-voltage Protection Hysteresis (-01) (Percentage of Vovp)	POVP > 1.3V		4		%
		0.85V < POVP < 1.1V		4		%
		0.50V < POVP < 0.75V		4		%
		POVP < 0.4V		4		%
True Reverse Current Blocking (TRCB)						
V_{IDRCB}	Ideal Diode TRCB Regulation Voltage	VIN – VOUT		20		mV
V_{FRCB}	Fast TRCB Threshold	VOUT - VIN		50		mV
V_{FRCB_HYS}	Fast TRCB Hysteresis	VOUT - VIN		35		mV
$t_{TRCB\_DEGLITCH}$	TRCB Deglitch Time			2		µs
Over Current Protection (OCP)						
ILIM	Current Limit Threshold Ta = -40°C to 85°C	RLIM = 4.53kΩ	7.90	9.30	10.70	A
		RLIM = 4.53kΩ for Vin from 3.3 to 55V	7.02	9.30	11.70	A
		RLIM = 7.15kΩ	4.80	5.90	7.00	A
		RLIM = 7.15kΩ for Vin from 3.3 to 55V	4.40	5.90	7.40	A
		RLIM = 10.2kΩ	2.90	3.90	4.90	A
		RLIM = 10.2kΩ for Vin from 3.3 to 55V	2.75	3.90	5.00	A
		RLIM = open/short		DSBL		A
t_{OCP_HOLD}	Over-Current Duration before Switch Off	From $I_{OUT} \geq I_{LIM}$ to Switch Off		180		µs
t_{OCP_FLTB}	Over-Current Flag Delay	From $I_{OUT} \geq I_{LIM}$ to FLTB = Low		90		µs
Dynamic Timing Characteristics						
t_{CHECK}	Check Time before Start-up	From FTLB rising edge to VOUT reaching 10% of VIN		1		ms
t_{D_ON}	Turn-on Delay Time	From EN rising edge to VOUT reaching 10% of VIN		8		ms
t_{ON}	Turn-on Rise Time	VOUT from 10% to 90% of VIN		1.6		ms
t_{RST}	Auto-retry Time (-01)	During OVP; SCP (steady state); OCP; TSD; event		64		ms
$t_{SCP\_RST\_01}$	SCP Restart Time (-01)	During soft start		64		ms
$t_{SCP\_RST\_02}$	SCP Restart Time (-02)	During soft start		4		ms
N_{retry}	Auto-retry Time (-02)(1)	During SCP during soft start; TSD; OCP		15		times

Electrical Characteristics

T_A = 25°C, VIN = 48V, EN = 5V, C_{IN} = 10µF, C_{OUT} = 10µF, C_{SS} = 5.6nF, C_{CAP} = 10nF, unless otherwise specified.

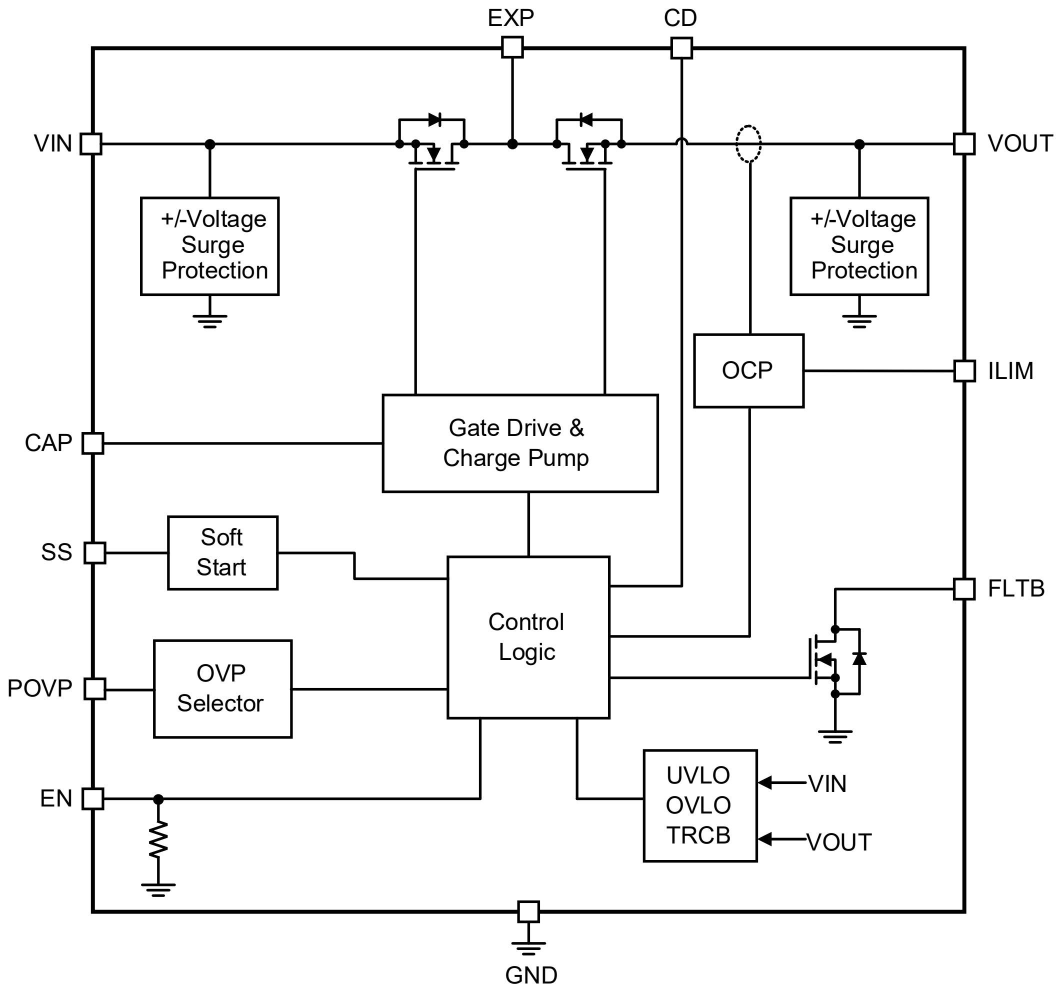
Symbol	Parameter	Conditions	Min	Typ	Max	Units
Thermal Shutdown Protection						
T_{SD}	Thermal Shutdown Threshold	Temperature rising.		140		°C
T_{SD_HYS}	Thermal Shutdown Hysteresis (-01)			20		°C
Short Circuit Protection						
I_{SCP_TH}	Current Limit Threshold for Short Circuit Protection		25			A
t_{SCP_DLY}	Short Circuit Protection delay time	After start-up		2		µs
$t_{SOA\_TIMEOUT}$	Current Limit hold off time for Short Circuit Protection	During start-up		256		µs

Thermal Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Units
$R\Theta_{JC}$	Thermal Resistance from junction to case(3)			2.9		°C/W
$R\Theta_{JA}$	Thermal Resistance from junction to ambient(3)			33.5		°C/W

Notes:
1. Guaranteed by design.
2. R_{ON} is tested at 1A in test mode to bypass ideal diode regulation.
3. Thermal resistance measured on AOS 4-layer EVB.

Functional Block Diagram



Timing Diagrams

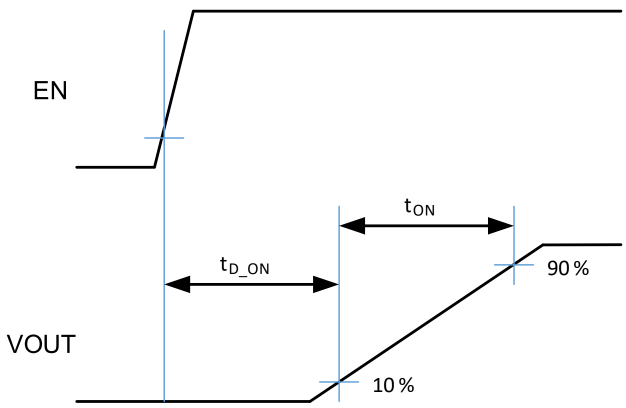


Figure 2. Turn-on Delay and Turn-on Time

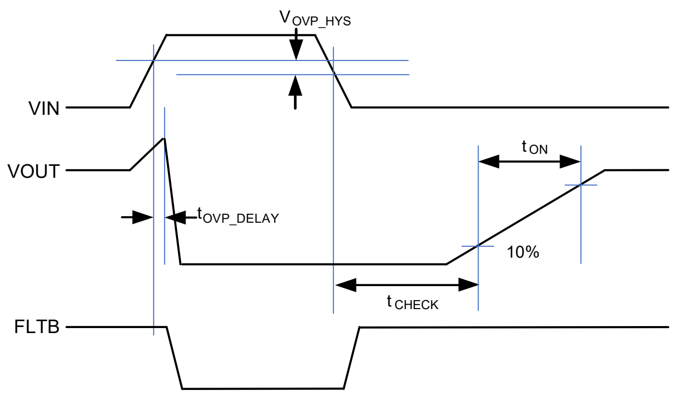


Figure 3. Over-voltage Protection (-01)

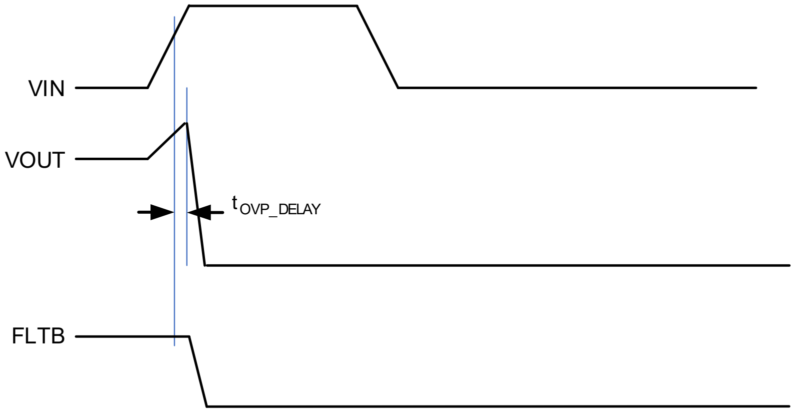


Figure 4. Over-voltage Protection (-02)

Timing Diagrams

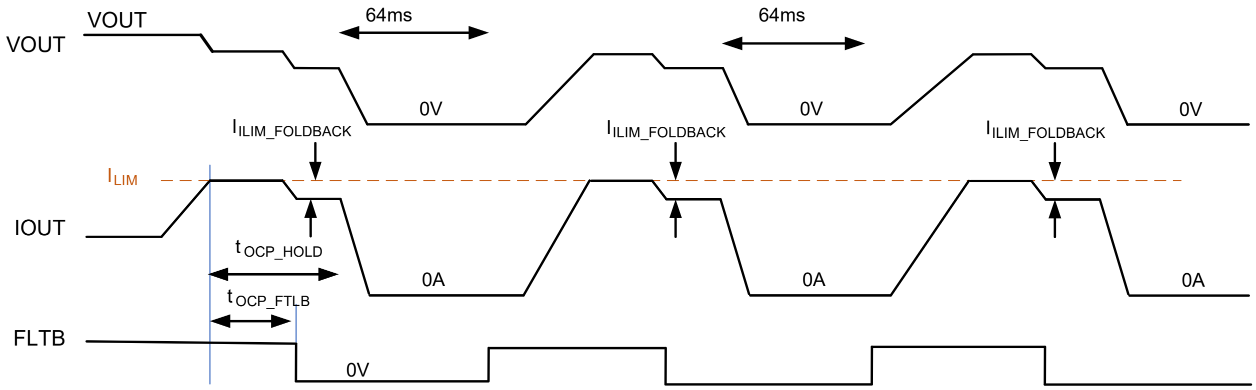


Figure 5. Over-current Protection (-01)

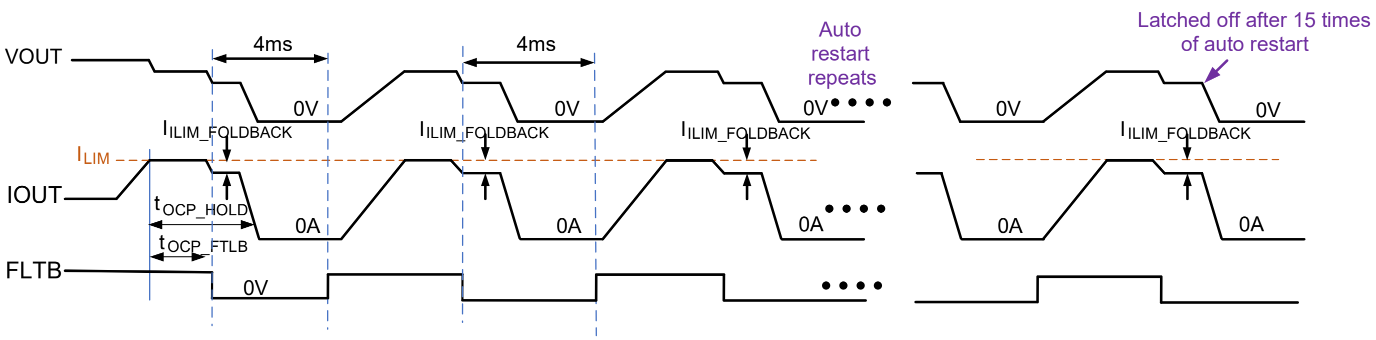


Figure 6. Over-current Protection (-02)

Timing Diagrams

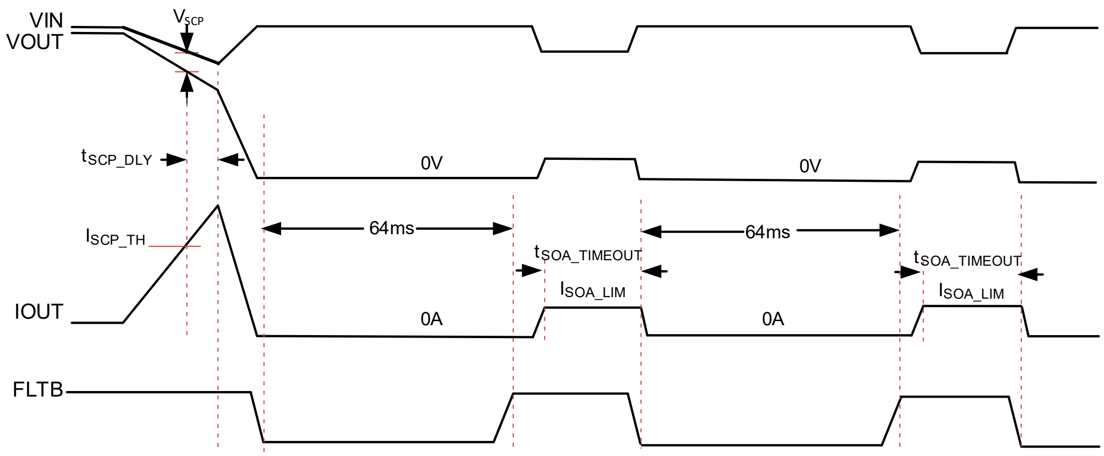


Figure 7. Short Circuit Protection (-01) Short After Start-up

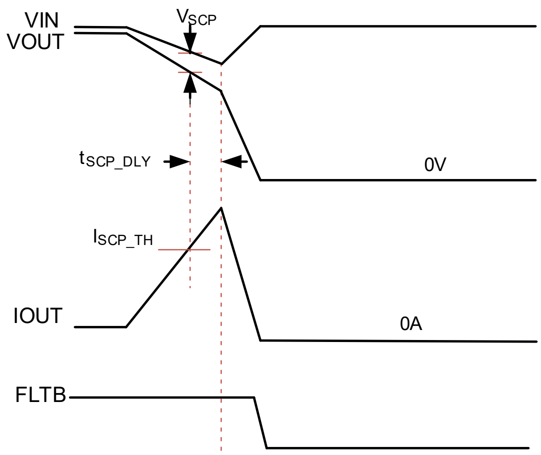


Figure 8. Short Circuit Protection (-02) Short After Start-up

Timing Diagrams

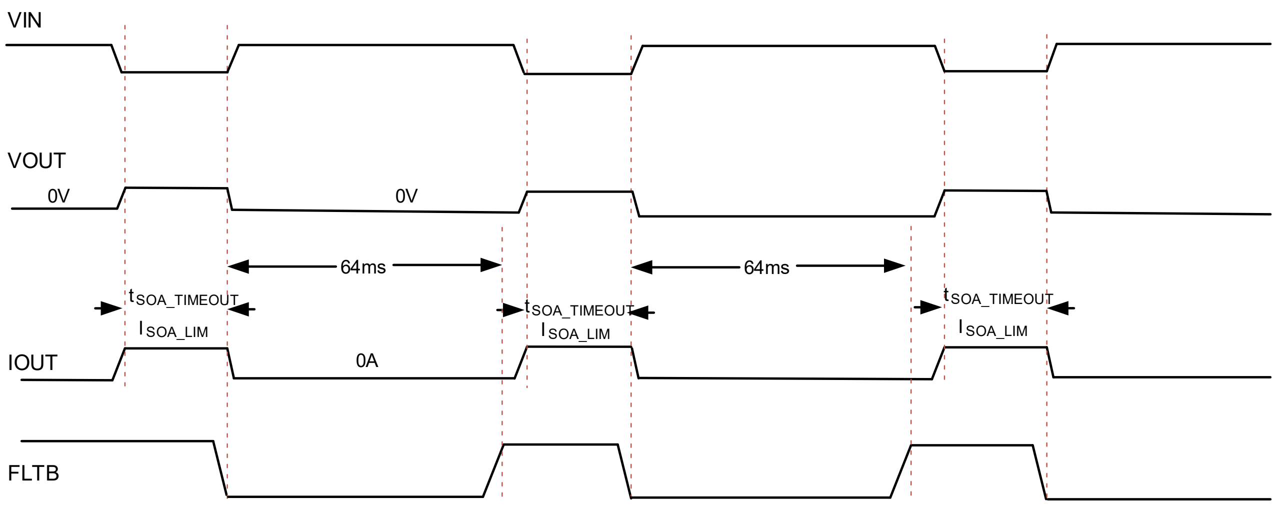


Figure 9. Short Circuit Protection (-01) Short Before Start-up

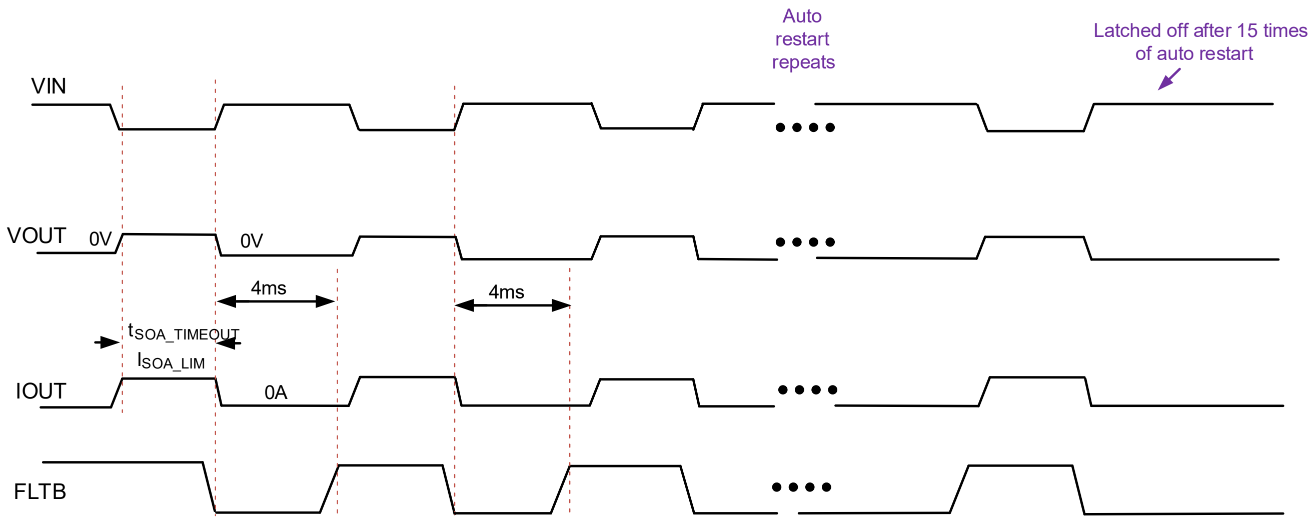


Figure 10. Short Circuit Protection (-02) Short Before Start-up

Timing Diagrams

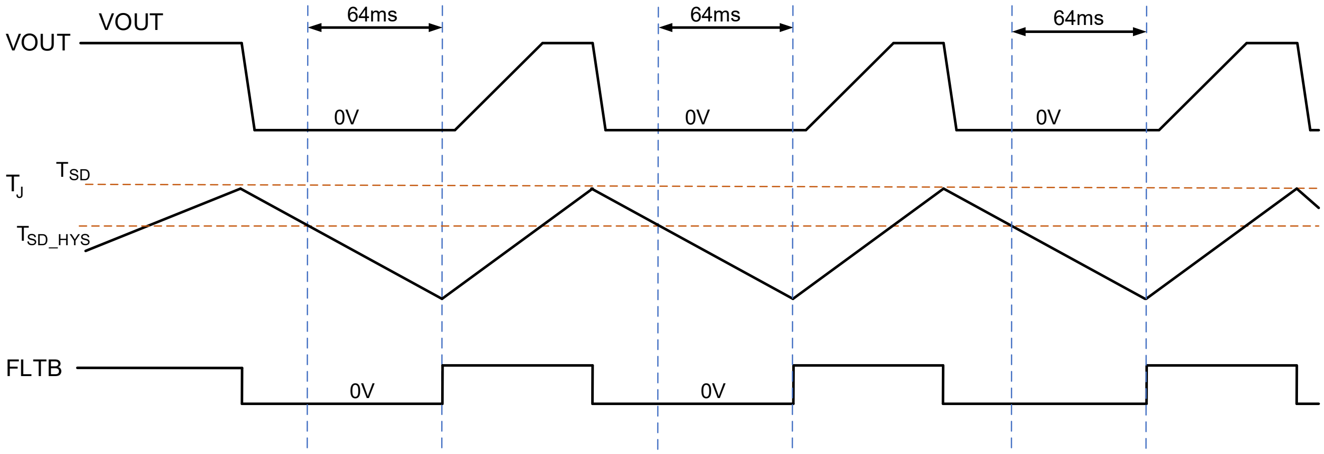


Figure 11. Thermal Shutdown (-01)

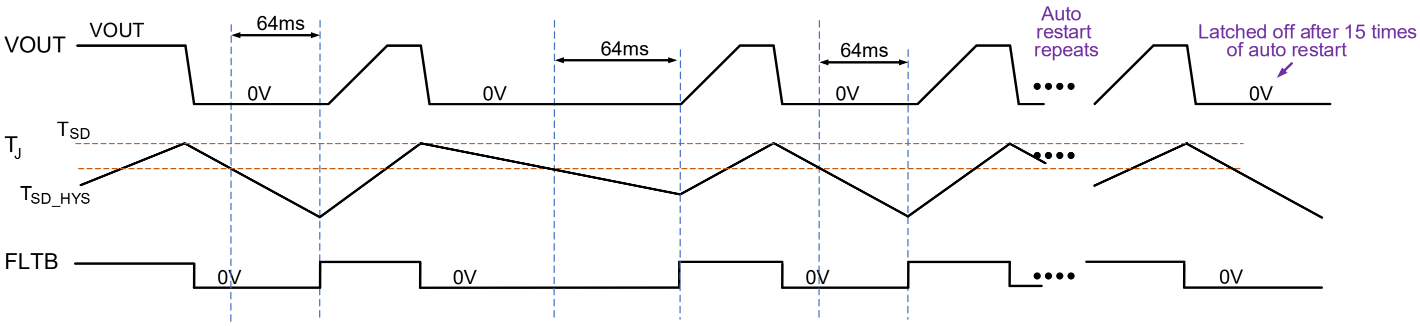


Figure 12. Thermal Shutdown (-02)

Typical Characteristics

T_A = 25 °C, unless otherwise specified.

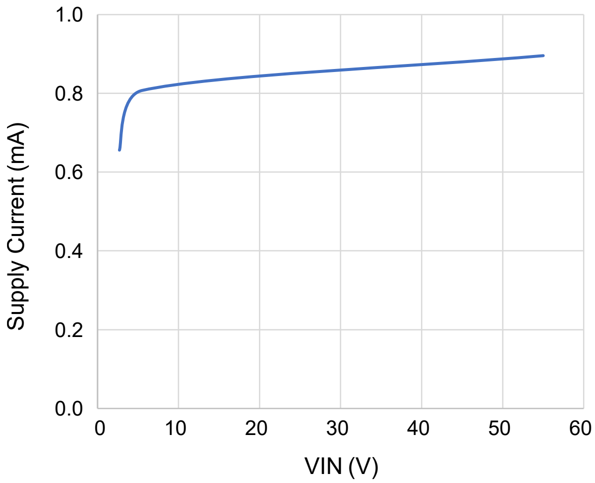


Figure 13. Quiescent Current vs. VIN

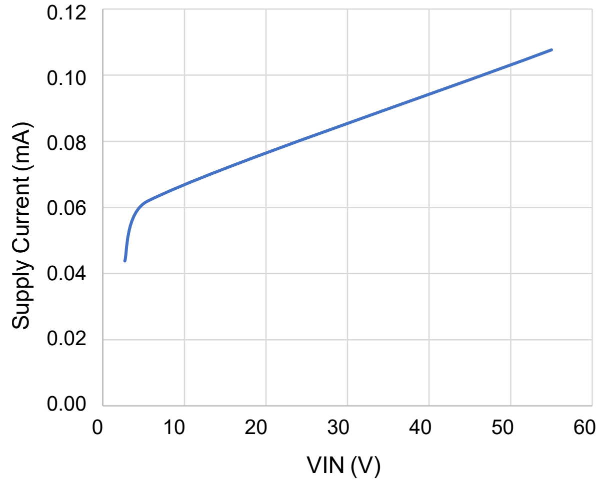


Figure 14. Shutdown Current vs. VIN

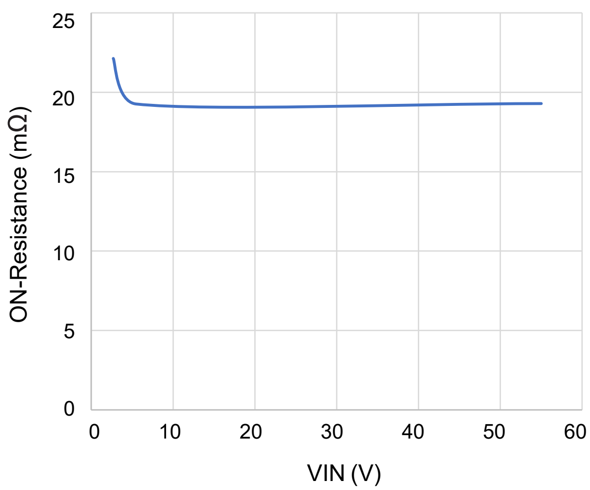


Figure 15. ON-resistance vs. VIN

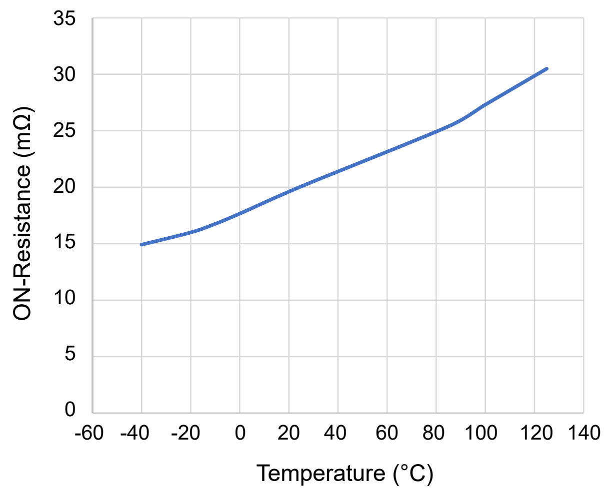


Figure 16. ON-resistance vs. Temperature

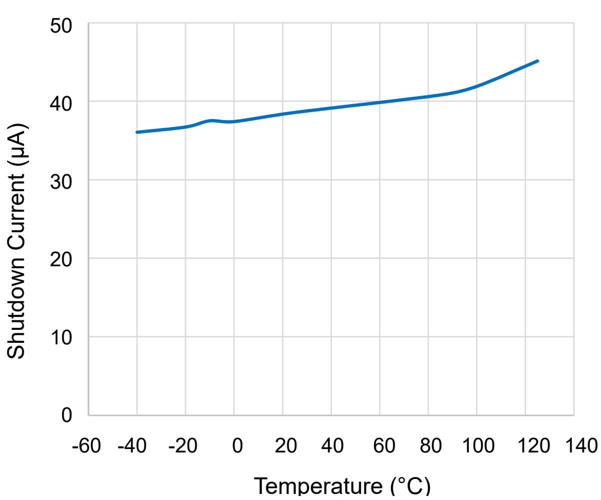


Figure 17. Output Leakage Current vs. Temperature

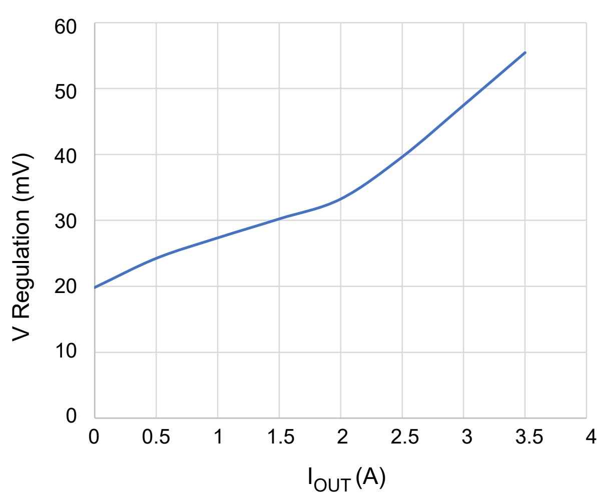
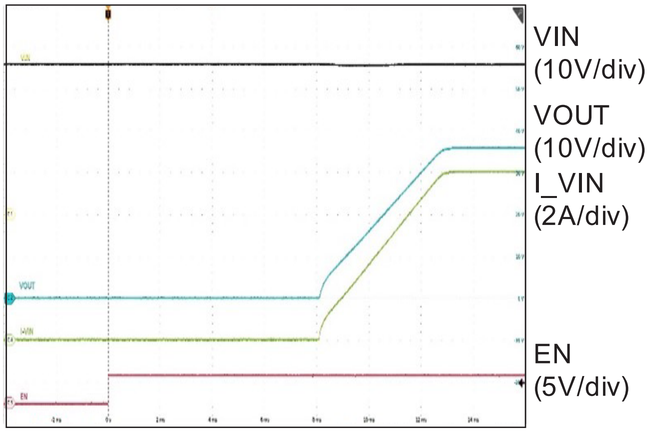


Figure 18. Ideal Diode Regulation Voltage vs. I_{OUT}

Typical Characteristics

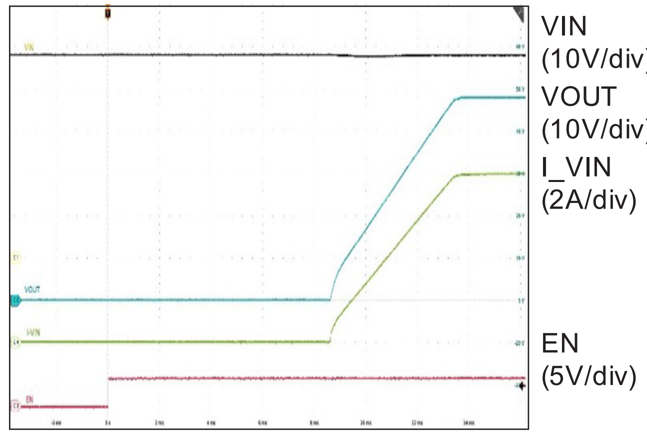
T_A = 25°C, VIN = 48V, EN = 5V, C_{CAP} = 10nF, C_{IN} = 10µF, C_{OUT} = 10µF, C_{SS} = 15nF, unless otherwise specified.

Soft Start Delay Time
(VIN = 36V, R_{OUT} = 4.5Ω)



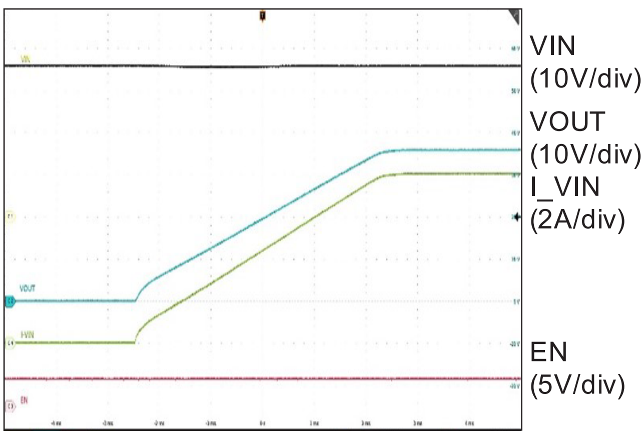
2ms/div

Soft Start Delay Time
(VIN = 48V, R_{OUT} = 6Ω)



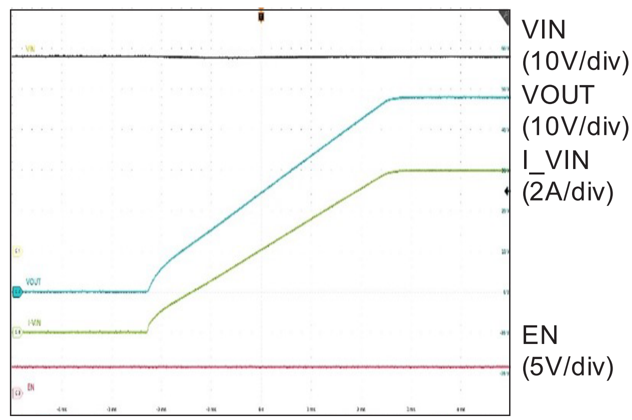
2ms/div

Soft Start Ramp
(VIN = 36V, R_{OUT} = 4.5Ω)



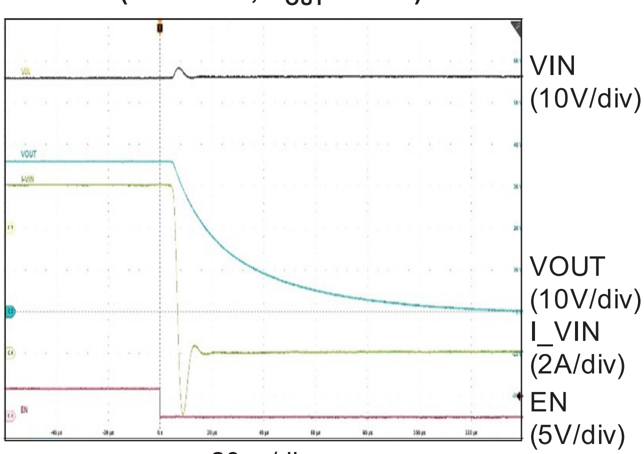
1ms/div

Soft Start Ramp
(VIN = 48V, R_{OUT} = 6Ω)



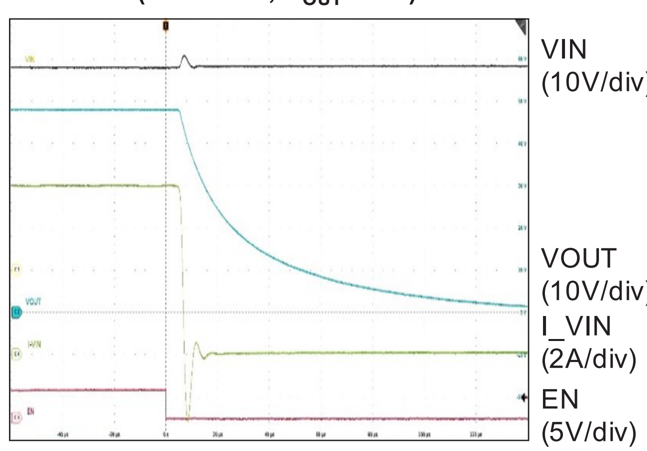
1ms/div

Shut Down
(VIN = 36V, R_{OUT} = 4.5Ω)



20µs/div

Shut Down
(VIN = 48V, R_{OUT} = 6Ω)

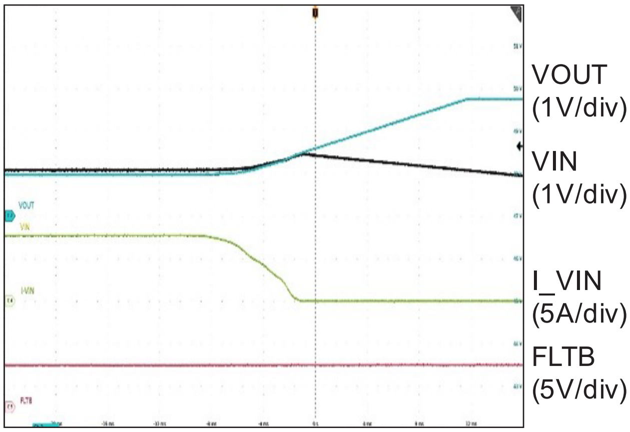


20µs/div

Typical Characteristics

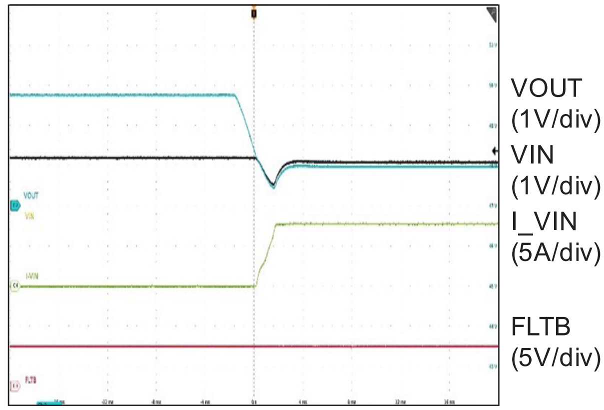
T_A = 25°C, VIN = 48V, EN = 5V, C_{CAP} = 10nF, C_{IN} = 10μF, C_{OUT} = 10μF, C_{SS} = 15nF, unless otherwise specified.

Ideal Diode True Reverse Current Blocking (VIN = 48V, R_{OUT} = 6Ω)



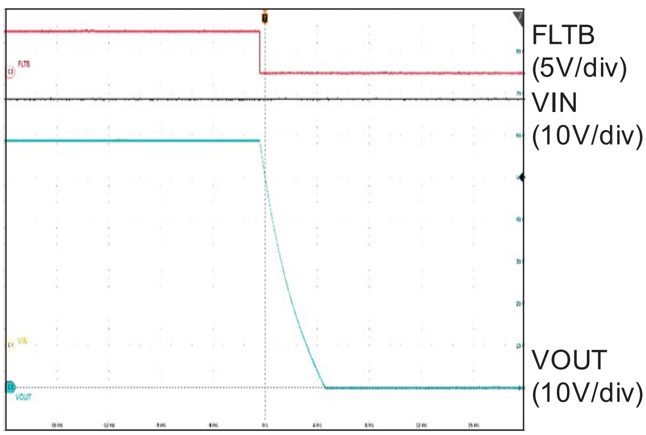
4ms/div

Recovery of Ideal Diode True Reverse Current Blocking (VIN = 48V, R_{OUT} = 6Ω)



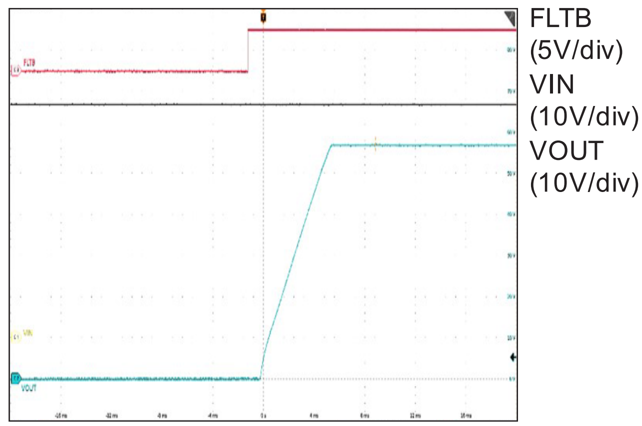
4ms/div

Over-voltage Protection (R_{OVP} = 300k)



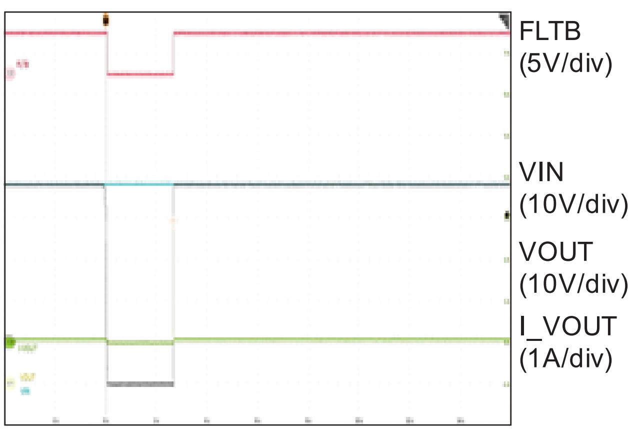
4ms/div

Over-voltage Protection (R_{OVP} = 300k)



4ms/div

Thermal Shutdown (-01)



2s/div

Detailed Description

The AOZ13058DI is a high side protection switch with programmable soft start, programmable over-voltage, over-temperature, and reverse current protections. It is capable of operating from 3.3V to 55V.

The internal power switch consists of back-to-back connected MOSFET. When the switch is enabled, the overall resistance between VIN and VOUT is only 20mΩ, minimizing power loss and heat generation. The back-to-back configuration of MOSFET completely isolates VIN and VOUT when the switch is turned off, preventing leakage between the two pins.

Power Delivery Capability

During start-up, the voltage at VOUT linearly ramps up to the VIN voltage over a period of time set by the soft start time. This ramp time is referred to as the soft start time and is typically in milliseconds. Figure 19 illustrates the soft start condition and power dissipation.

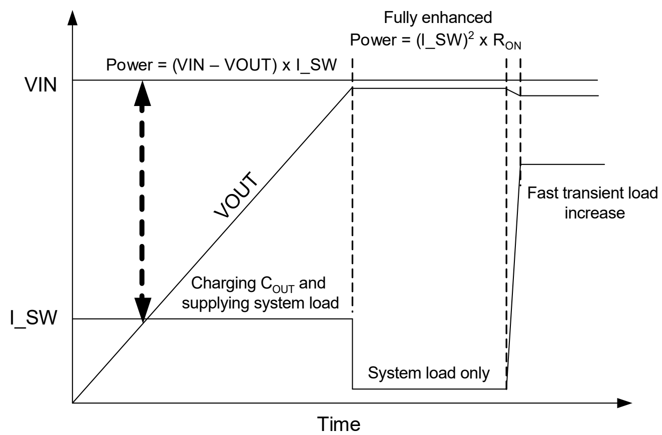


Figure 19. Soft Start Power Dissipation

During this soft start time, there will be a large voltage across the power switch. Also, there will be current I_SW through the switch to charge the output capacitance. In addition, there may be load current to the downstream system as well. This total current is calculated as:

$$I_{SW} = C_{OUT}\left(\frac{dVOUT}{dt}\right) + I_{SYS}$$

In the soft start condition, the switch is operating in the linear mode, and power dissipation is high. The ability to handle this power is largely a function of the power MOSFET linear mode SOA and good package thermal performance $R\Theta_{JC}$ (Junction-to-Case) as the soft start ramp time is in milliseconds. $R\Theta_{JA}$ (Junction-to-Ambient), which is more a function of PCB thermal performance, doesn't play a role.

With a high-reliability MOSFET as the power switch and superior packaging technology, the AOZ13058DI is capable of dissipating this power. The power dissipated is:

Power Dissipation = I_SW × (VIN - VOUT)

To calculate the average power dissipation during the soft start period: ½ of the input voltage should be used as the output voltage that will ramp towards the input voltage, as shown in Figure 21.

For example, if the output capacitance C_{OUT} is 10μF, the input voltage VIN is 20V, the soft start time is 2ms, and there is an additional 1A of system current (I_SYS), then the average power being dissipated by the part is:

$$I_{SW} = 10\mu F\left(\frac{20V}{2ms}\right) + 1A = 1.1A$$

$$\text{Average Power Dissipation} = 1.1A \times \frac{20V}{2} = 11W$$

Referring to the SOA curve in Figure 20, the maximum power allowed for 2ms 100W (5A x 20V or 10Ax 10V). The AOZ13058DI power switch is robust enough to drive a large output capacitance with load in reasonable soft start time.

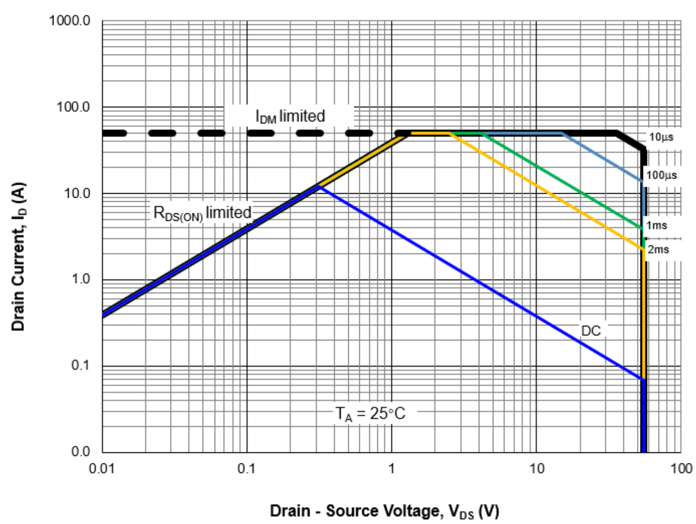


Figure 20. Safe Operating Area (SOA) Curves for Power Switch

After soft start is completed, the power switch is fully on, and it is at its lowest resistance. The power switch acts as a resistor. Under this condition, the power dissipation is much lower than the soft start period. However, as this is a continuous current, a low ON-resistance is required to minimize power dissipation. Attention must be paid to the board layout so that losses dissipated in the switch are dissipated to the PCB and hence the ambient.

With a low ON-resistance of 20mΩ, the AOZ13058DI provides the most efficient power delivery without much resistive power dissipation.

While Type C Extended Power Range (EPR) power delivery is limited to 48V @ 5A or a 240W, many high-end laptops require peak currents far in excess of the 5A. While the thermal design current (TDC) for a CPU may be low, peak current (ICCmax in the case of Intel and EDP in the case of AMD) of many systems is often 2 x thermal design current. These events are typical of short duration (< 2ms) and low duty cycle, but they are important for system performance as a CPU/GPU capable of operating at several GHz can boost its compute power in those 2ms peak current events. The AOZ13058DI can handle such short, high current, transient pulses without any reliability degradation, thus enhancing the performance of high-end systems when plugged into the Type C adaptor. The shorter the pulse and the lower the duty cycle, the higher the pulse current that the part can sustain. The part has enough time to dissipate the heat generated from the pulse current with longer off-time. For example, AOZ13058DI can maintain 20A for 10ms with a duty cycle of 2%.

Enable

The active high EN pin is the ON/OFF control for the power switch. The device is enabled when the EN pin is high and device is not in UVLO state. The EN pin must be driven to a logic high (> V_{EN_H}) or logic low (< V_{EN_L}) state to guarantee operation. AOZ13058DI draws about 100μA supply current when it is disabled.

Input Under-voltage Lockout (UVLO)

The internal control circuit is powered from VIN. The under-voltage lockout (UVLO) circuit monitors the voltage at the input pin (VIN) and only allows the power switches to turn on when it is higher than 2.65V (V_{UVLO}).

Over-voltage Protection (OVP)

The OVP threshold can be programmed by either using an external resistor from POVP pin to GND or applying a DC voltage to POVP pin. When EN > 1.4V POVP will be pulled up internally by a 5μA current source and just before the soft start begins, the threshold setting at POVP will be latched and any subsequent changes will not affect the OVP threshold. The POVP voltage setting is listed in Table 1.

Table 1. Over-voltage Protection Threshold Setting

ROVP Resistor Value (1%)	POVP Voltage	OVP Threshold (Typ)
<71.5k	POVP < 0.4V	24 V
124k	0.5V< POVP < 0.75V	34V
196k	0.85V < POVP < 1.1V	43.5V
>294k	POVP > 1.3V	58V

In case the voltage exceeds the OVP threshold, over-voltage protection is activated:

1. If the power switch is on, it will be turned off after OVP delay time (t_{OVP_DELAY}) to isolate VOUT from VIN;
2. OVP will prevent power switch to be turned on if it is in off state;

In either case, FLTB pin is pulled low to report the fault condition.

Ideal Diode True Reverse Current Blocking (IDTRCB)

When the device is ON with no load or under light load conditions, it regulates VOUT to be 20mV below VIN. As the load current is increasing or decreasing, the device adjusts the gate drive to maintain the 35mV drop from VIN to VOUT. As the load current continues to increase the device increases the gate drive until the gate is fully turned on and VIN to VOUT drop is determined by IR drop through the MOSFET. If for any reason VOUT increases such that VIN to VOUT drop to less than 20mV, the gate driver forces the switch to turn off.

Programmable Current Limit and Over-Current Protection (OCP)

The AOZ13058DI has current limit that ensures the current passing through the switch does not exceed the current limit threshold set by the external resistor R_{LIM}.

The current limit threshold can be estimated using the equation below for the range from 1A to 9.5A:

$$\text{Current Limit} = 42.126 / R_{LIM}$$

For example, for 8A current limit, a 5.23kΩ R_{LIM} should be selected. 1% resistor is recommended for R_{LIM}.

Table 2. R_{LIM} Resistor Value vs. Current Limit Threshold

Typical Current Limit (A)	Resistor Value ±1% (kΩ)
8.0	5.23
5	8.45
3.5	12.0
2.5	16.9
1.0	42.2

AOZ13058DI continuously limits the output current when output is overloaded. Under current-limiting condition, FLTB is pulled low after delay (t_{OCP_FLTB}). Severe overload causes power dissipation and die temperature to increase and may trigger thermal shutdown.

In the AOZ13058DI-02 version, the TSD due to OCP event will latch-off the power switch after failing to retry 15 times. The power switch can only be turned on again by either toggling the EN pin or recycling the input supply.

Thermal Shutdown Protection (TSD)

Thermal shutdown protects device from excessive temperature. When the die temperature reaches 140°C, the power switch is turned off. There is a 20°C hysteresis for the AOZ13058DI-01 only. The power switch is allowed to turn on again if the die temperature drops below approximately 120°C.

AOZ13058DI-01 (Auto-restart version): Once TSD is removed, the power switch will be turned on again with soft start.

AOZ13058DI-02 (Latch-off version): The device will latch-off and can only turn on by either toggling the EN pin or cycling the input power supply.

Soft Start Slew Rate Control

When EN pin is asserted high, the slew rate control applies voltage on the gate of the power switch in a manner such that the output voltage is ramped up linearly until VOUT reaches VIN voltage level. The output ramps up time (t_{ON}) is programmable by an external soft start capacitor (C_{SS}). The following formula provides the estimated 10% to 90% ramp up time.

where C_{SS} is in nF and t_{ON} is in ms.

$$t_{ON} = \frac{C_{SS}}{3.5}$$

System Start-up

The device is enabled when EN ≥ 1.4V and VIN is higher than UVLO threshold (V_{UVLO}). The device will check if any fault condition exists. If no fault exists, the power switch is turned on and VOUT is then ramped up after enable delay (t_{D_ON}), controlled by the soft start time (t_{ON}) until VOUT reaches VIN voltage level. Soft start time can be programmed externally through SS input with a capacitor C_{SS} to control in-rush current.

In-rush Current Limit and SCP During Start-up

AOZ13058DI has current limit and short circuit protection function at start-up, which is so-called SOA current management. During start-up, the current limit is a function of the voltage drop from VIN to VOUT. The current limit will increase if the (VIN – VOUT) voltage decreases. With this current limit control, the inrush current can be effectively clamped to reduce the initial current spikes. At initial start-up, the internal power switch close to VIN and is susceptible to large power loss. To ensure the internal FET working in Safe Operation Area (SOA), a fixed timer is set to shut down the power switch if the inrush current is clamped by current limit ramp for about 256μs continuously. This timer will be reset once the inrush current drops below the current limit. For short circuit event, the part will shut down after this 256μs timer is finished. In case of large output capacitors, the soft start time needs to increase to avoid the large inrush current from triggering the current limit for 256μs. SOA current management is disabled after the switch is fully turned on.

AOZ13058DI-01 (Auto-restart version): The power switch is turned off under the short circuit condition at start-up. The device will try to restart indefinitely for every 64ms($t_{SCP\_REC\_01}$) until it is disabled.

AOZ13058DI-02 (Latch-off version): The power switch is turned off under the short circuit condition at start-up. The device will try to start up for 15 times with an interval of 4ms($t_{SCP\_REC\_02}$). If short circuit condition still exists after these 15 times retry, the device will be latched-off.

SCP After Soft Start

AOZ13058DI enables output short circuit protection function once soft-start finishes. The short circuit current level is 25A (Minimum) independent of input voltage. This minimum short circuit current guarantees the device can provide 20A peak current without trigging the protection. The response time is within 2us with fast turn off to protect the system.

AOZ13058DI-01 (Auto-restart version): The power switch is turned off under the short circuit condition after start-up. The device will try to restart indefinitely for every 64ms ($t_{SCP\_REC\_01}$) until it is disabled or short is removed.

AOZ13058DI-02 (Latch-off version): The power switch is turned off under the short circuit condition after start-up. The latch can only be removed by cycling Vin or Enable.

Fault Protection

The AOZ13058DI offers multiple protection against the following fault conditions: VIN over-voltage (OVLO); reverse current blocking when VOUT > VIN; and over-temperature.

When the device is first enabled, the power switch is off and fault conditions are checked. If any of these conditions exist:

1. VIN is higher than the OVP threshold (V_{OVLO}).
2. Die temperature is higher than thermal shutdown threshold (T_{SD}).
3. VOUT is higher than VIN.

The power switch will not be turned on and FLTB pin will be pulled low for OVP and TSD conditions to indicate fault status of the device.

The power switch will be turned on once TRCB condition no longer exists. The device will continuously monitor these fault conditions. In addition, the short circuit condition is being monitored during the soft start. See previous section on SCP at start up for more details. Table 3 and 4 summarize the fault response and FLTB flag status to all protection functions for AOZ13058DI-01 and AOZ13058DI-02, respectively.

Table 3. AOZ13058DI-01 Fault flag Response to All Protection Functions

Protection	Fault Response	FLTB Status
IDTRCB	Auto-restart without soft start at fault removal	High Impedance
SCP during start-up	Auto-restart after 64ms	Low
SCP after start-up	Auto-restart after 64ms	Low
OCP	Auto-restart after 64ms	Low
TSD	Auto-restart with soft start at fault removal	Low
OVP	Auto-restart with soft start at fault removal	Low

Table 4. AOZ13058DI-02 Fault Flag Response to All Protection Functions

Protection	Fault Response	FLTB Status
IDTRCB	Auto-restart without soft start at fault removal	High Impedance
SCP during start-up	15 times retry then latch-off	Low
SCP after start-up	Latch-off	Low
OCP	15 times retry then latch-off	Low
TSD	15 times auto-restart with soft start at fault removal then latch-off	Low
OVP	Latch-off	Low

Input Capacitor Selection

The input capacitor prevents large voltage transients from appearing at the input, and provides the instantaneous current needed each time the switch turns on to charge output capacitors and to limit input voltage drop. It is also to prevent high-frequency noise on the power line from passing through to the output. The input capacitor should be located as close to the pin as possible. A 10µF ceramic capacitor is recommended. The USB specification limits the capacitance on VBUS to a maximum of 10µF. Use this maximum value for noise immunity due to the system and cable plug/unplug transients.

Power Dissipation Calculation

The following equation can be used to estimate the power dissipation for normal load condition:

$$\text{Power Dissipated} = RON \times (I_{OUT})^2$$

Soft Start and Output Capacitor Selection Guideline

The output capacitor has to supply enough current for a large peak current load that it may encounter during system transient. This bulk capacitance must be large enough to supply fast transient load in order to prevent the output from dropping.

The external soft start capacitor (C_{SS}) to determine soft start time (t_{ON}) should be selected properly with output capacitor and system resistive load current conditions in the application.

AOZ13058 has maximum current limit 25A during soft start period, which contains DC and AC current. DC current is input voltage dependent and AC current is output voltage dependent, which is equivalent to about 2.5Ω resistive load. The DC current is in charge of output capacitive load while the AC current is in charge of resistive load.

For 20V input voltage case, the AC current is about 8A (20V÷2.5Ω) and DC current is about 17A, 25A in total. With the output voltage ramping up, the current limit increases linearly to 25A while output voltage reaches 20V. Figure 21 shows the relationship between current limit and output voltage during a successful soft start period.

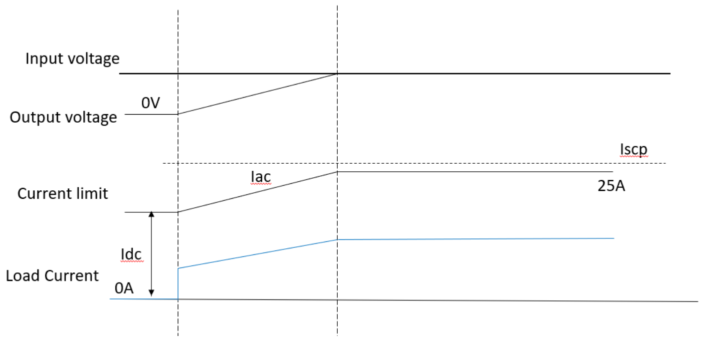


Figure 21. Successful Soft Start

There is a 256μs timer (Tsoa) during the soft start period. Once the current hits the current limit for 256μs for some reason, the device will shut down to protect the switch itself and system. Figure 22 shows how the current limit works during soft start period.

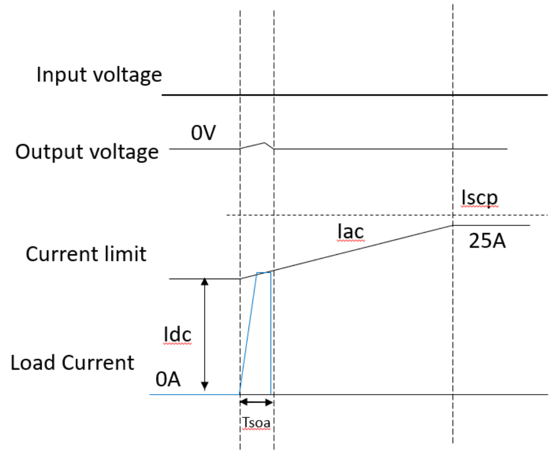
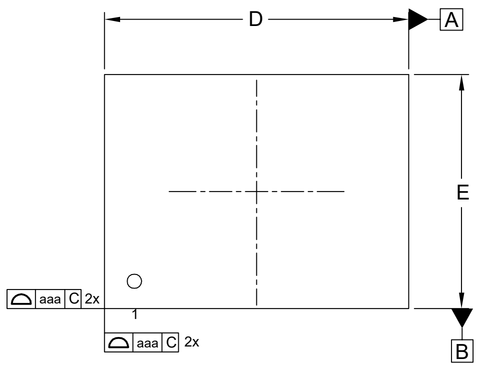


Figure 22. Unsuccessful Soft Start Due to Current Limit

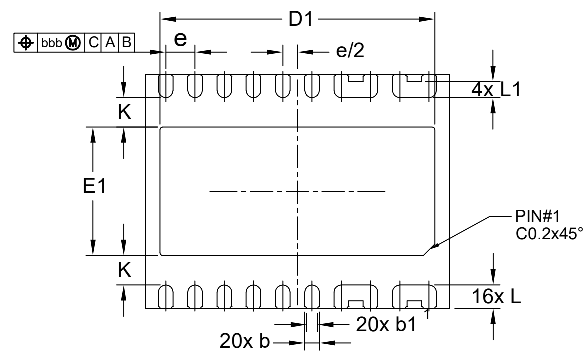
Generally speaking, the DC current is large enough to make the soft start successful during normal condition. With 3ms soft start time, the calculated output capacitance can reach more than 1500μF.

For start-up with load in Type C port application, it is recommended to start-up at 5V input and then Type C PD controller programs the input to higher voltage after start-up. This is to ensure no start-up issue and no issue with FET SOA with large output capacitors.

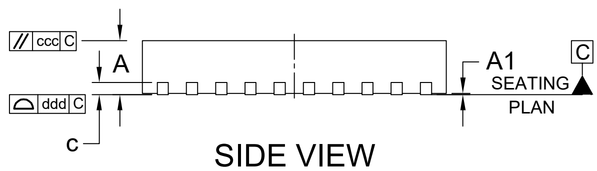
Package Dimensions, DFN5.2x4-20L



TOP VIEW

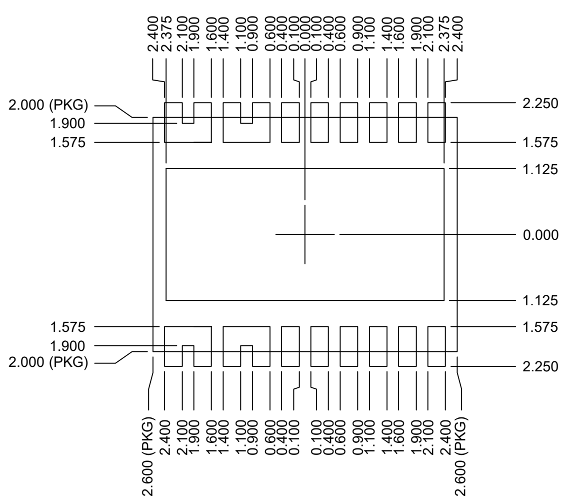


BOTTOM VIEW



SIDE VIEW

RECOMMENDED LAND PATTERN



SYMBOL	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHS		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.800	0.900	1.000	0.031	0.035	0.039
A1	0.000	0.020	0.050	0.000	0.001	0.002
b	0.200	0.250	0.300	0.008	0.010	0.012
b1	0.190 REF.			0.007 REF.		
c	0.203 REF.			0.008 REF.		
D	5.100	5.200	5.300	0.201	0.205	0.209
D1	4.600	4.700	4.800	0.181	0.185	0.189
E	3.900	4.000	4.100	0.154	0.157	0.161
E1	2.100	2.200	2.300	0.083	0.087	0.091
e	0.500 BSC			0.020 BSC		
L	0.300	0.400	0.500	0.012	0.016	0.020
L1	0.225	0.275	0.325	0.009	0.011	0.013
K	0.500 REF.			0.020REF.		
aaa	0.150			0.006		
bbb	0.100			0.004		
ccc	0.100			0.004		
ccc	0.080			0.003		

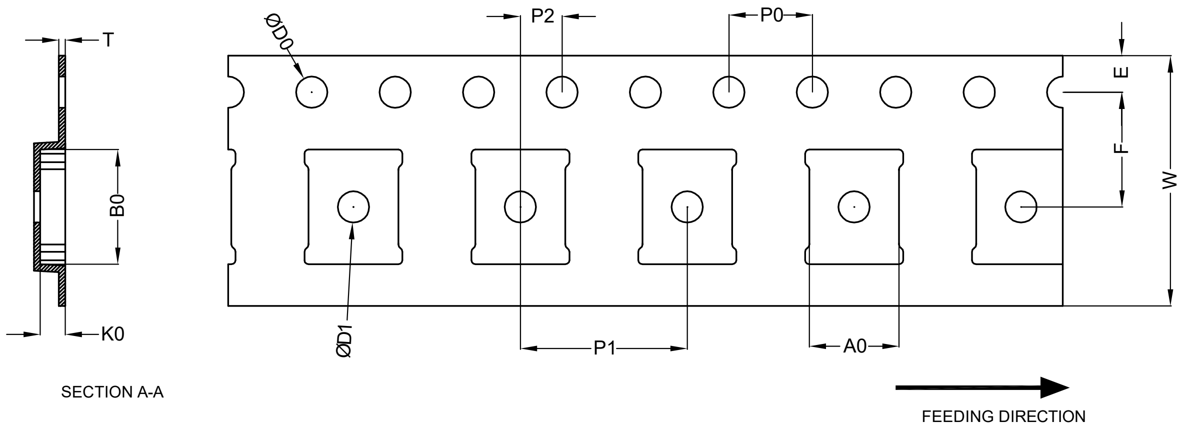
UNIT: mm

NOTE:

1. CONTROLLING DIMENSION IS MILLIMETER. CONVERTED INCH DIMENSIONS ARE NOT NECESSARILY EXACT.

Dimensions, DFN5.2x4-20L

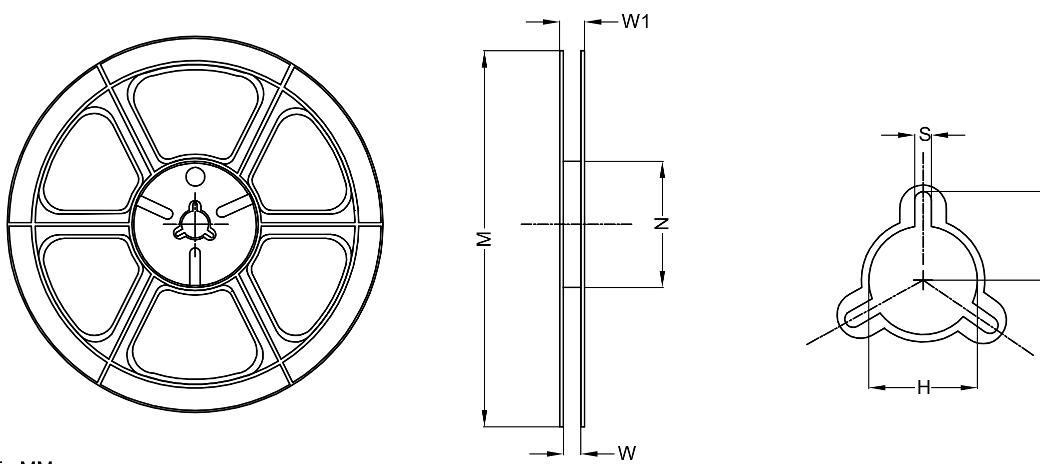
Carrier Tape



UNIT: MM

PACKAGE	A0	B0	K0	D0	D1	W	E	F	P0	P1	P2	T
DFN5.2x4	4.30 ±0.10	5.50 ±0.10	1.20 ±0.10	Ø1.50 +0.10 -0.00	Ø1.50 +0.20 -0.00	12.00 +0.30 -0.10	1.75 ±0.10	5.50 ±0.05	4.00 ±0.10	8.00 ±0.10	2.00 ±0.05	0.30 ±0.03

Reel

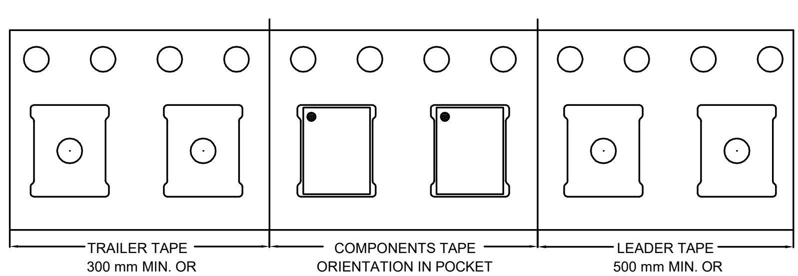


UNIT: MM

TAPE SIZE	REEL SIZE	M	N	W	W1	H	K	S
12 mm	Ø330	Ø330 ±2.0	Ø101.6 ±2.0	12.4 +2.0 -0.0	15.0 +3.0 -0.2	Ø13.2 +0.3 -0.2	10.6	2.00 ±0.50

Tape

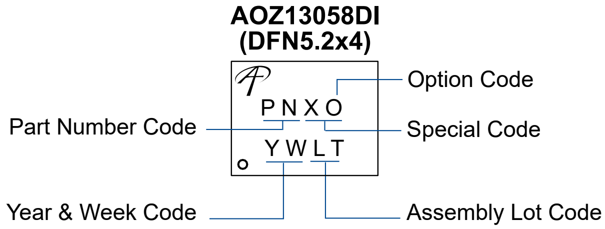
Leader / Trailer
& Orientation



Unit Per Reel:
3000pcs

All Dimensions Comply with EAI-481

Part Marking



Part Number	Description	Code
AOZ13058DI-01	Green Product	AA01
AOZ13058DI-02	Green Product	AA02