Programmable Current Limit Switches

Features

- Wide input voltage range from 2.7V to 6.5V
- Maximum input voltage is 24V
- Integrated low R_{dson} switch: 50mΩ
- Programmable current limit from 250mA to 3A
  - 3A with 7% Accuracy
  - 250mA with 30% Accuracy
- 7.5V input overvoltage shutoff
- 150ns overvoltage lockout response
- 5.4V overvoltage clamp
- Built-in soft start
- Thermal shutdown protection
- Fault output
- Enable interface pin
- DFN 2mmx2mm-6L
- Certificated by CB
  IEC62368-1: 2018, file no. BE-41997
- Certificated by UL
  UL62368-1: 2014, file no. E532659

Applications

- White goods, Appliances
- Set-top boxes, DVD and Gaming consoles
- HDD and SSD drives
- Adapter power devices
- Smart meters, Gas analyzers
- Smart load switches/USB switches

General Description

AW35019 is a smart e-Fuse with robust overcurrent and overvoltage protection. The wide operating voltage allows control of many popular DC buses.

AW35019 uses N-channel MOSFET as power switch, and allows the user to program the current-limit threshold between 250mA to 3A with an external resistor when the load exceeds the current-limit threshold.

AW35019 can withstand 24V DC voltage. In the events that an incorrect voltage is IN, the output clamps to 5.4V to protect the load. If the voltage at IN exceeds 7.5V, the device disconnects the load to prevent damage to the device and/or load.

Additional features include enable, under-voltage, over-temperature, output discharge and fault flag output are provided to monitor system status.

Typical Application Circuit

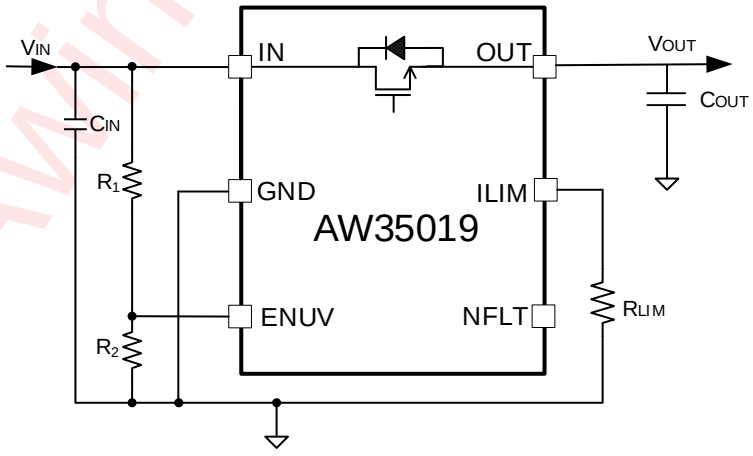


Figure 1 Typical application circuit

Pin Configuration And Top Mark

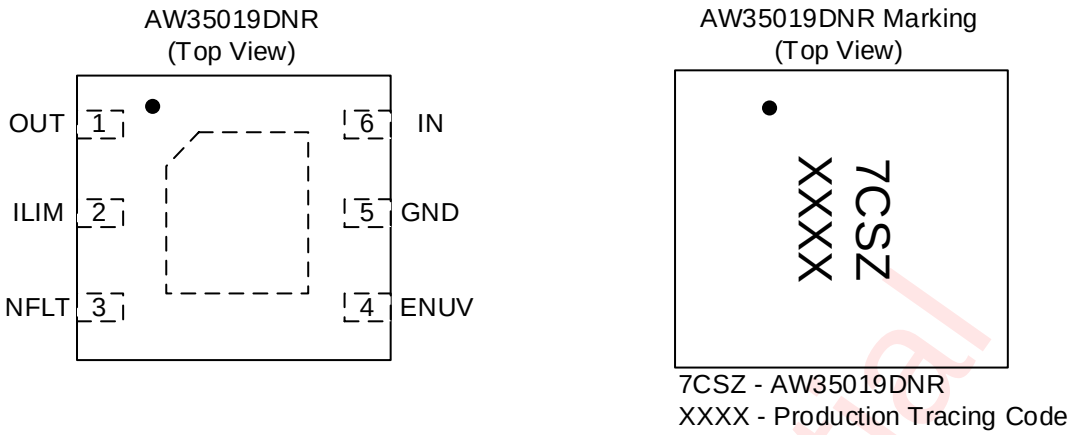


Figure 2 Pin Configuration

Pin Definition

Pin	Name	Description
1	OUT	Power output.
2	ILIM	A resistor from this pin to GND. Setting threshold of limit current.
3	NFLT	Active-low open-drain output, connect a pull up resistor to high. Asserted low during over voltage, UVLO, short circuit, over temperature, fast-trip and current limit.
4	ENUV	Logic-level control input. When this pin is driven high, the power switch is enabled. When this pin is driven low, the power switch turns off. This pin can set the programmable threshold of UVLO.
5	GND	Ground.
6	IN	Power input, supply voltage of the device.

Functional Block Diagram

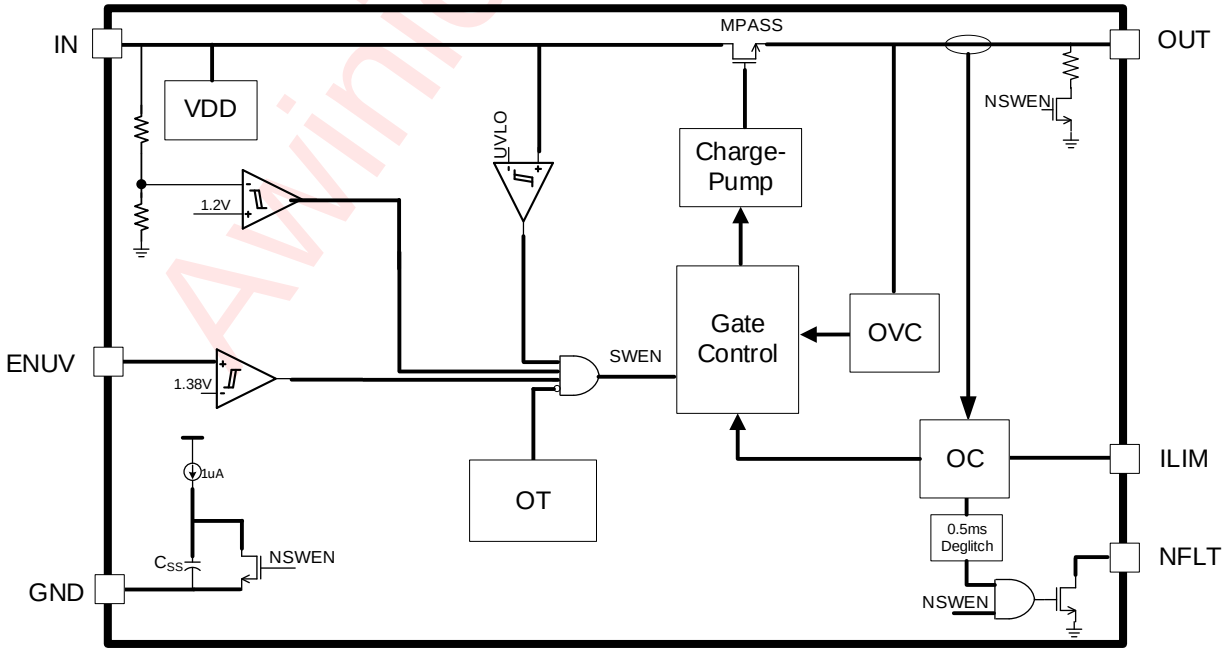


Figure 3 Functional Block Diagram

Typical Application Circuits

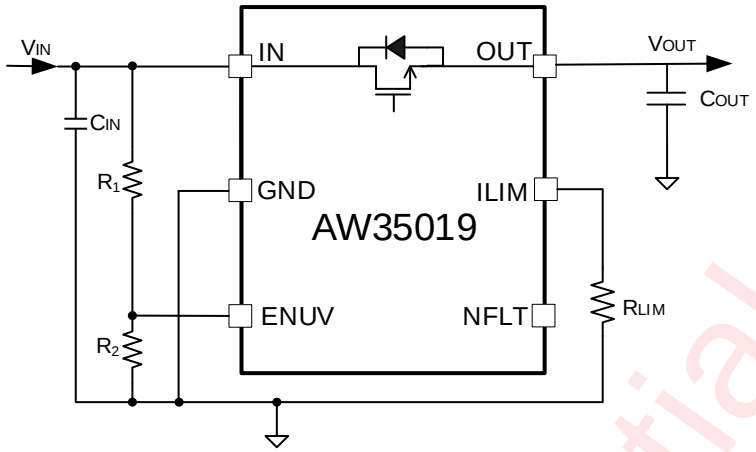


Figure 4 Application circuit

Notice for Typical Application Circuits:

1. Place C_{IN} as close as possible to IN.
2. Place C_{OUT} as close as possible to OUT.
3. Place R_{LIM} as close as ILIM.
4. If NFLT is not used, it can be left floating.
5. IN, OUT support 3A current, the connection lines should be as wide as possible.

Ordering Information

Part Number	Temperature	Package	Marking	Moisture Sensitivity Level	Environmental Information	Delivery Form
AW35019DNR	-40℃ ~ 85℃	DFN 2mm×2mm-6L	**7CSZ**	MSL1	ROHS+HF	3000 units/ Tape and Reel

Absolute Maximum Ratings (NOTE 1)

Symbol	Parameter	Condition	Min.	Max.	Unit
V_{IN}	Power voltage		-0.3	28	V
V_{OUT}	OUT voltage		-0.3	28	V
V_{ENUV}	ENUV input voltage		-0.3	28	V
V_{NFLT}	NFLT output voltage		-0.3	28	V
V_{ILIM}	ILIM voltage		-0.3	6	V
T_{JMAX}	Maximum operating junction temperature			140	°C
T_{STG}	Storage temperature		-65	150	°C
T_{LEAD}	Soldering temperature	At leads, 10 seconds		260	°C

NOTE1: Conditions out of those ranges listed in "absolute maximum ratings" may cause permanent damages to the device. In spite of the limits above, functional operation conditions of the device should within the ranges listed in "recommended operating conditions". Exposure to absolute-maximum-rated conditions for prolonged periods may affect device reliability.

Thermal Information

Symbol	Parameter	Condition	Value	Unit
$R_{\theta JA}$	Thermal resistance from junction to ambient (NOTE 1)	In free air	78	°C/W

NOTE1: Thermal resistance from junction to ambient is highly dependent on PCB layout.

ESD And Latch-Up Ratings

Symbol	Parameter	Condition	Value	Unit
V_{ESD}	Human body model	ESDA/JEDEC JS-001-2017	±2	kV
	Charged device model	ESDA/JEDEC JS-002-2018	±1.5	kV
$I_{Latch-up}$	Latch up	JESD78E	±200	mA

Recommended Operating Conditions

Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{IN}	Power voltage	2.7		6.5	V
V_{ENUV}	ENUV input voltage	0		6.5	V
V_{NFLT}	NFLT output voltage	0		5.5	V
V_{ILIM}	ILIM voltage	0		5.5	V
I_{OUT}	Current limit	0.25		3	A
T_A	Ambient temperature	-40		85	°C

Electrical Characteristics

T_A = -40°C to 85°C, V_{IN} = 5V, V_{ENUV}=2V, R_{ILIM}=100kΩ, C_{IN} = 0.1μF, C_{OUT} =1μF, unless otherwise noted.

Symbol	Description	Test Conditions	Min.	Typ.	Max.	Unit
Power supply and internal UVLO						
V_{UVLO}	Power under voltage lockout	V_{IN} rising	2.45	2.55	2.65	V
V_{UVLO_HYS}	Power under voltage lockout hysteresis			100		mV
I_{Q_OFF}	Supply current, disable	V_{ENUV}=0V, V_{IN}=5V		0.4	1	μA
I_{Q_ON}	Supply current, enable	V_{ENUV}=2V, V_{IN}=5V		180	300	μA
Input over-voltage protection						
V_{IN_OVLO}	OVP trip level	V_{IN} rising	7	7.5	8	V
		Hysteresis		0.12		V
Enable and under voltage lockout input (ENUV)						
V_{ENR}	ENUV threshold voltage, rising		1.33	1.38	1.46	V
V_{ENF}	ENUV threshold voltage, falling		1.27	1.33	1.39	V
I_{EN}	EN input leakage current	0V≤V_{ENUV}≤5V		0	0.5	μA
Discharge						
R_{DCHG}	OUT discharge resistance	V_{OUT}=5V, V_{ENUV}=0V		600		Ω
Power MOSFET switch						
R_{ON}	Switch on resistance	I_{OUT}=0.1A	30	50	70	mΩ
Current limit programming (I_{LIM})						
I_{ILIM}	Current limit	R_{ILIM}=50kΩ, T_A=25°C	1.86	2.00	2.14	A
		R_{ILIM}=200kΩ, T_A=25°C	0.44	0.50	0.56	A
		R_{ILIM}=300kΩ, T_A=25°C	0.28	0.33	0.38	A
$I_{FAST-TRIP}$	Fast-trip comparator threshold	R_{ILIM} in kΩ			2xI_{LIM}	A
Voltage Clamp OUT						
V_{OVC}	OUT clamp voltage threshold	C_{OUT} =1μF, R_L=100Ω, V_{IN}=6.5V	5.25	5.4	5.55	V

Electrical Characteristics（continued）

T_A = -40°C to 85°C unless otherwise noted. Typical values are guaranteed for V_{IN} =5V, C_{IN} = 0.1μF, C_{OUT} =1μF, V_{ENUV}=2V, R_{ILIM}=100kΩ, unless otherwise noted.

Symbol	Description	Test Conditions	Min.	Typ.	Max.	Unit
Fault flag (NFLT): active low						
R_{NFLT}	NFLT pull down resistance	V_{ENUV}=0V, I_{NFLT}=100mA	19	27	35	Ω
I_{NFLT}	NFLT input leakage current	Device not in fault condition, V_{NFLT}=0V, 5V		0	0.5	μA
Thermal shutdown						
T_{SDN}	Thermal shutdown threshold	Temperature rising		140		°C
T_{SDN_HYS}	Hysteresis	Temperature falling		20		°C
Enable and under voltage lockout input						
t_{OFF_DLY}	Turn off delay	ENUV=0 to V_{OUT} falling		3		μs
t_{ON_DLY}	Turn on delay	ENUV=1 to V_{OUT}=0.5V		170		μs
t_r	OUT voltage rise time	V_{OUT} = 0.5V to V_{OUT} = 4.5V, with C_{OUT} = 1μF, R_L = 100 Ω		280		μs
t_f	OUT voltage fall time	V_{OUT} = 4.5V to V_{OUT} = 0.5V, with C_{OUT} = 1μF, R_L = 100 Ω		280		μs
Over voltage protection input						
t_{OVP_DLY}	Turn off delay for OVLO	C_{OUT}=1μF, R_L=100Ω, V_{IN}>V_{IN_OVLO} to V_{OUT} stop rising, V_{IN} initial 5V, 20V surge test, T_A=25°C		150		ns
SOFT-START: OUTPUT RAMP CONTROL (SS)						
t_{SS}	Output Ramp Time	ENUV↑ to V_{OUT} = 4.5V, with C_{OUT} = 1μF		450		μs
Current limit programming (I_{LIM})						
$t_{FAST\text{-}TRIP\_DLY}$	Fast trip comparator delay	I_{OUT}>$I_{FAST\text{-}TRIP}$		1		μs
Thermal shutdown (TSD)						
t_{TSD_DLY}	Retry delay after thermal shutdown recovery	V_{IN}=5V		130		ms
Fault flag (NFLT): active low						

t_{NFLT}	NFLT assertion due to overcurrent condition			0.5		ms

Timing Diagram

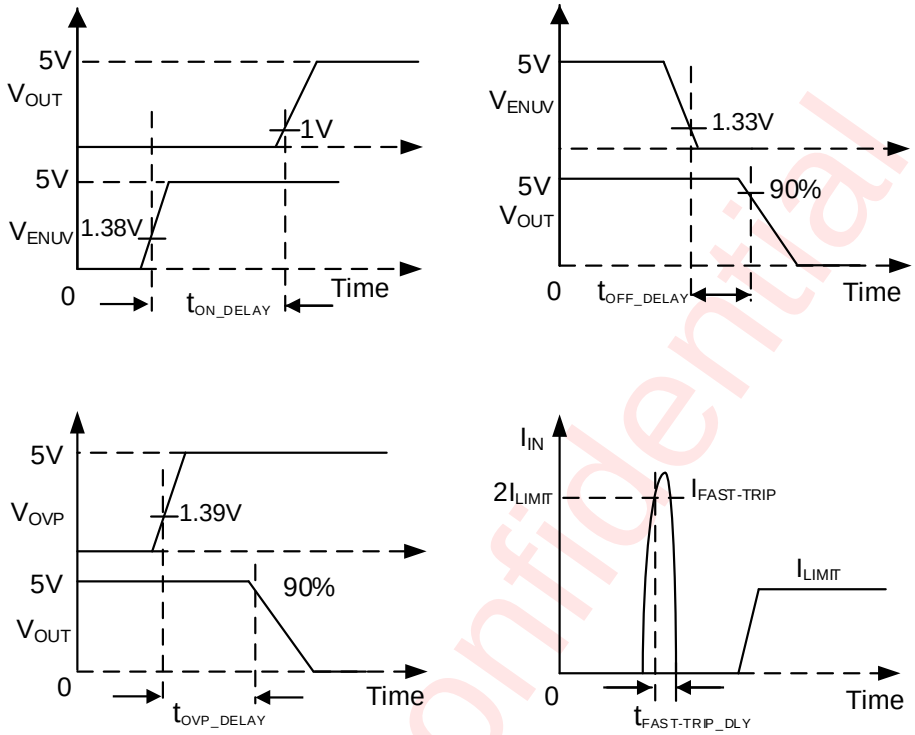


Figure 5 Timing Diagram

Typical Characteristics

Ambient temperature is 25°C, V_{IN}=2.7V to 6.5V, C_{IN} = 0.1μF, C_{OUT} =1μF, V_{ENUV}=2V, R_{ILIM}=100kΩ, unless otherwise noted.

Figure 6 UVLO Threshold Voltage vs. Temperature

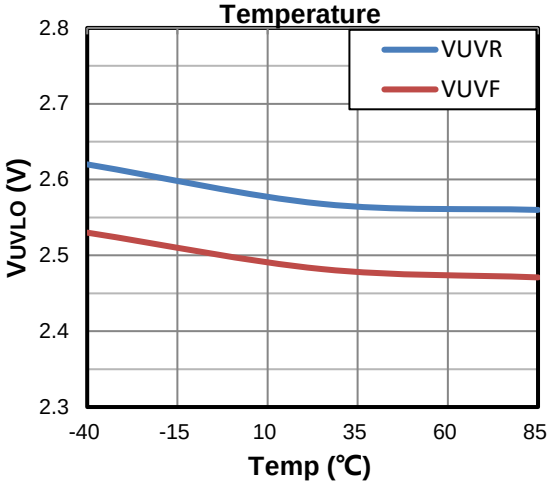


Figure 7 Supply Current vs. VIN at Operation

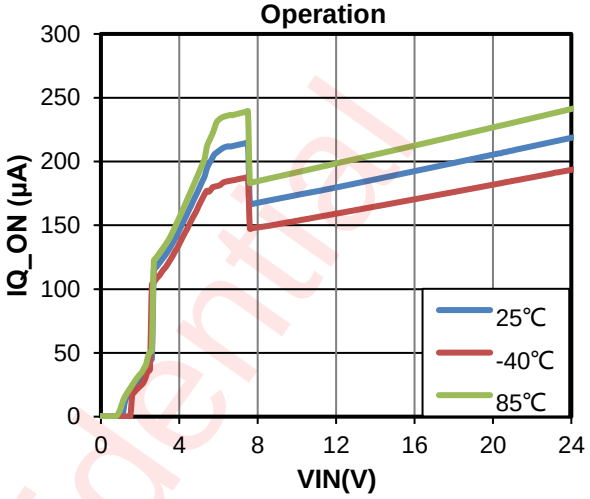


Figure 8 Supply Current vs. VIN at Shutdown

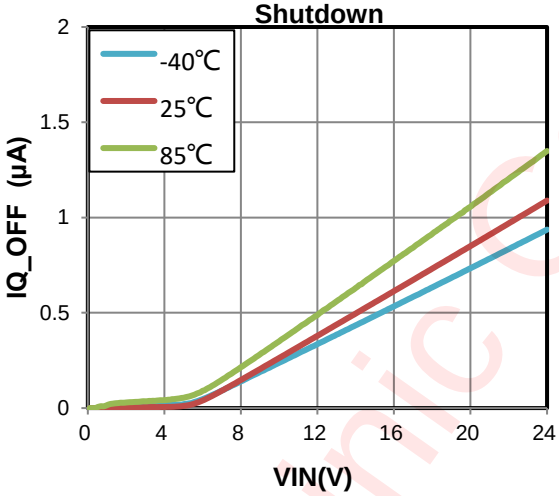


Figure 9 ENUV Threshold Voltage vs. Temperature

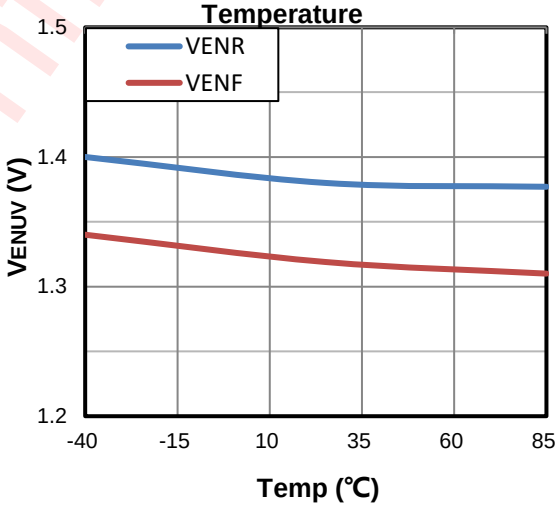


Figure 10 OVLO Threshold Voltage vs. Temperature

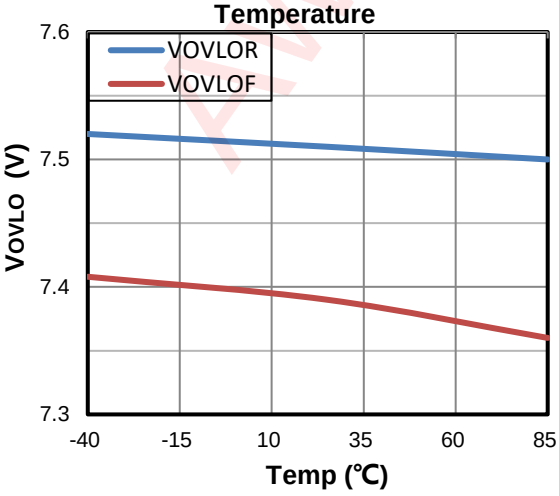


Figure 11 Output Clamp Voltage vs. Temperature

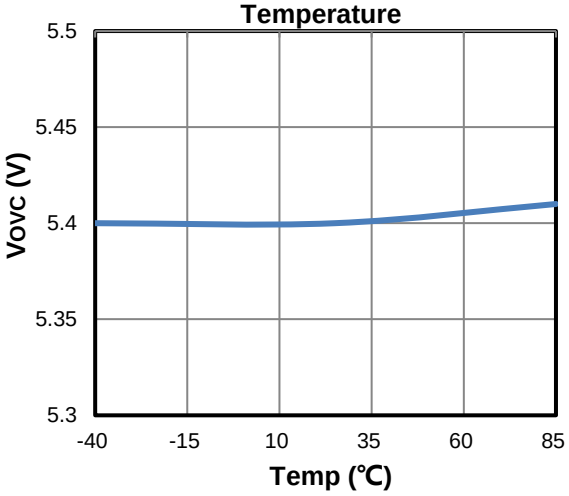


Figure 12 Output Ramp Time vs. Temperature

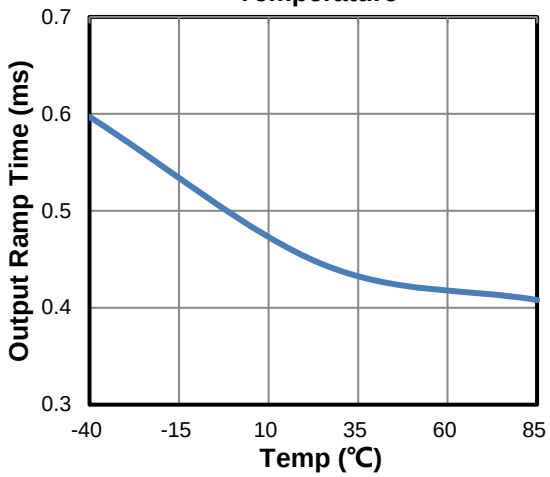


Figure 13 Current Limit vs. Temperature

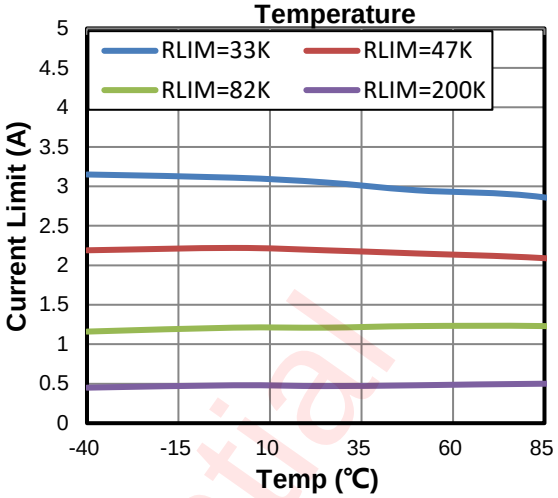


Figure 14 RDSON vs. Temperature

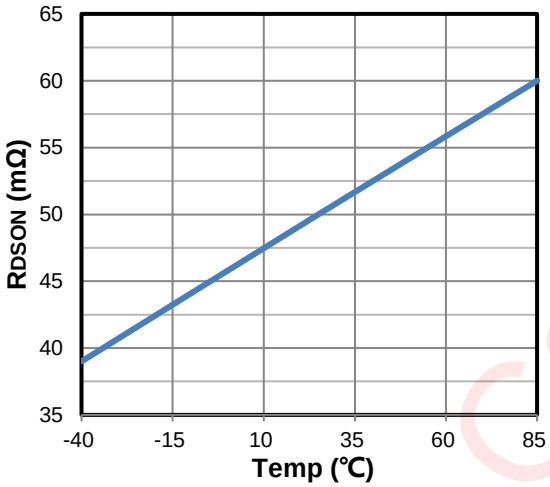


Figure 15 Current Limit vs. Current Limit Resistor

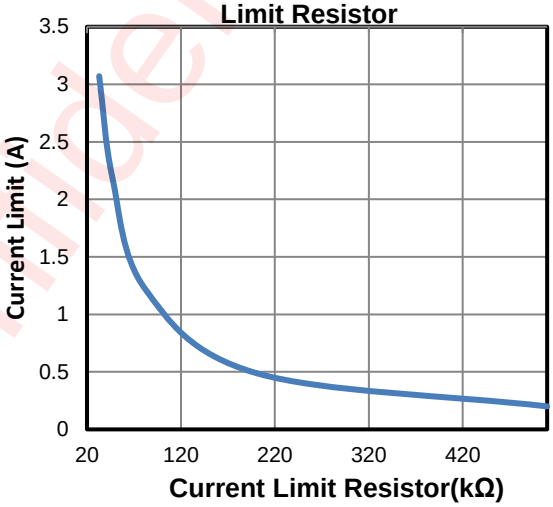


Figure 16 ENUV Turn-On Delay: ENUV↑to Output Ramp↑

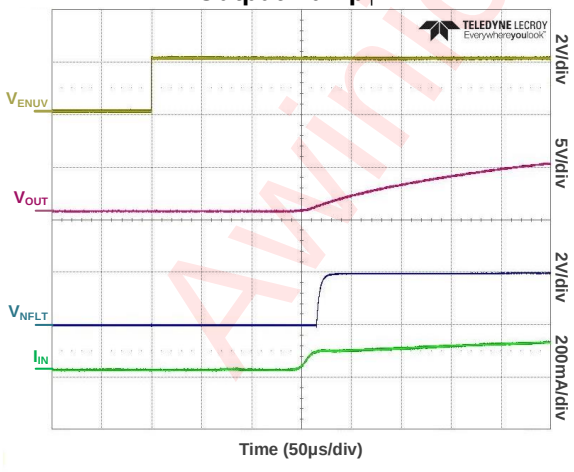


Figure 17 ENUV Turn-Off Delay: ENUV↓ to Fault↓

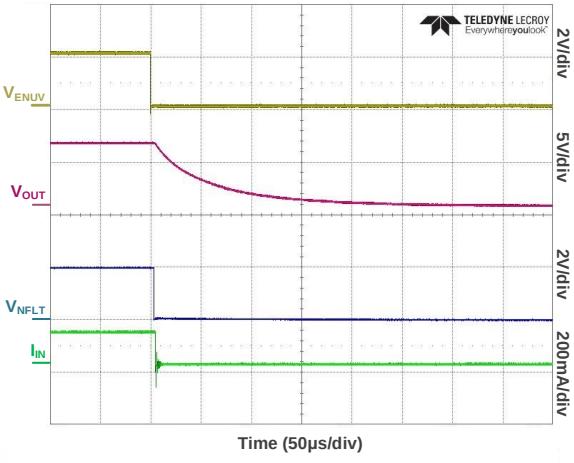


Figure 18 Discharge resistance vs. VOUT

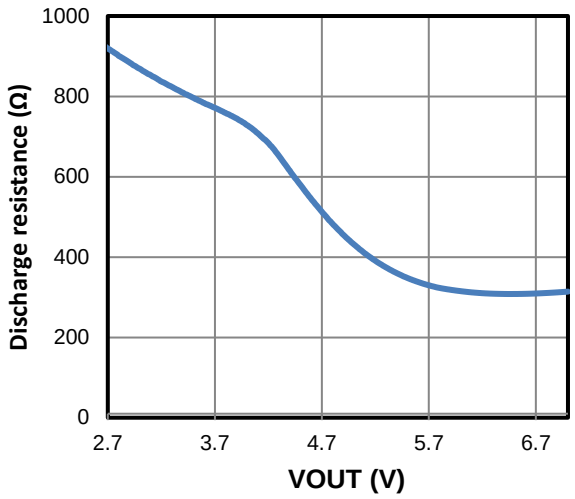


Figure 19 R_{DSON} vs. I_{LOAD}

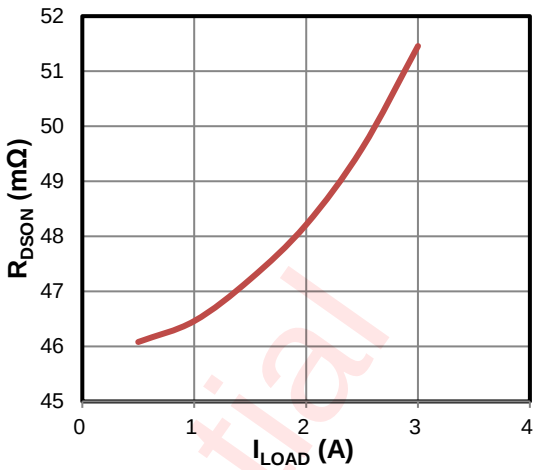


Figure 20 VIN Step 5 V to 8 V with 4.7 μF // 100 Ω

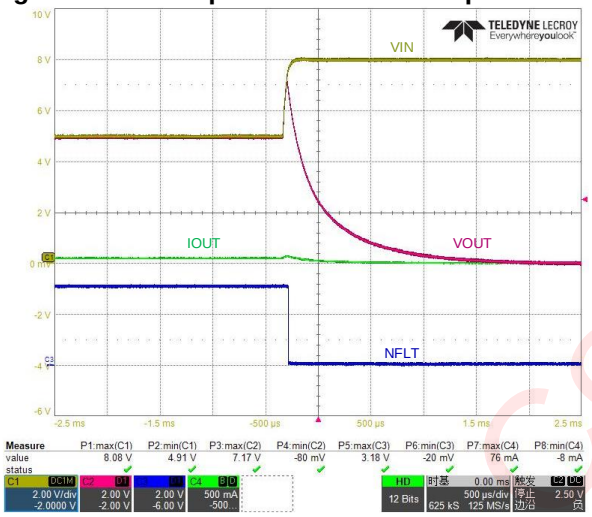


Figure 21 5-V to 10-V OVLO Response Time

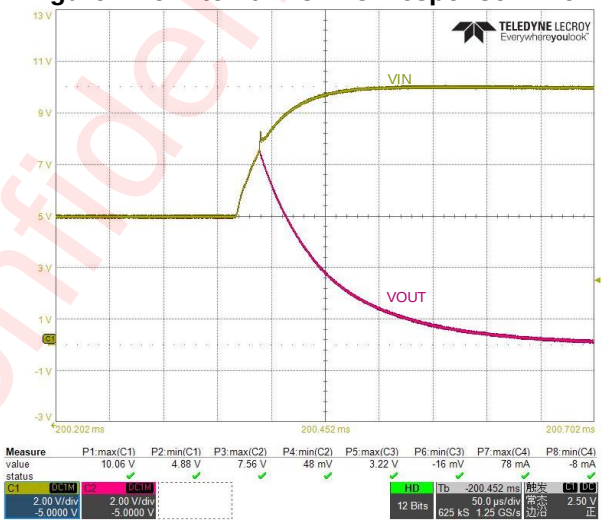


Figure 22 Power On

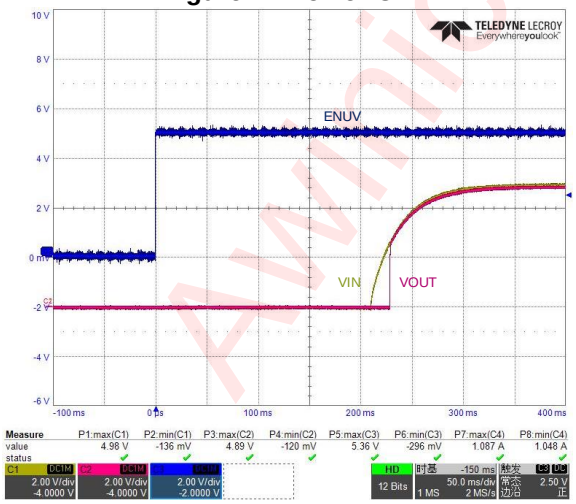


Figure 23 Power Off

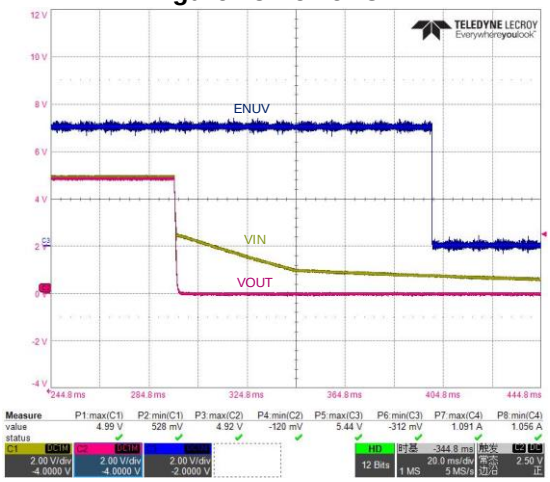


Figure 24 2.5 Ω to Output Short Transient Response

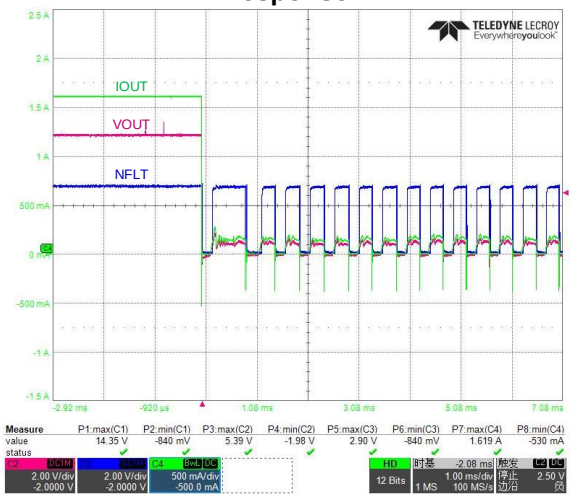


Figure 25 Output Short to 2.5-Ω Load Recovery Response

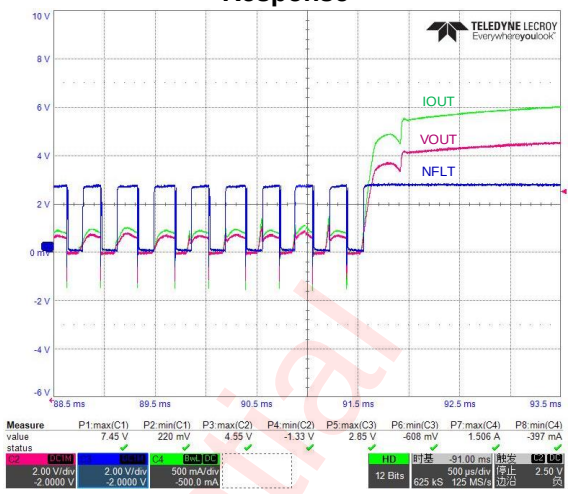


Figure 26 No Load to Output Short Transient Response

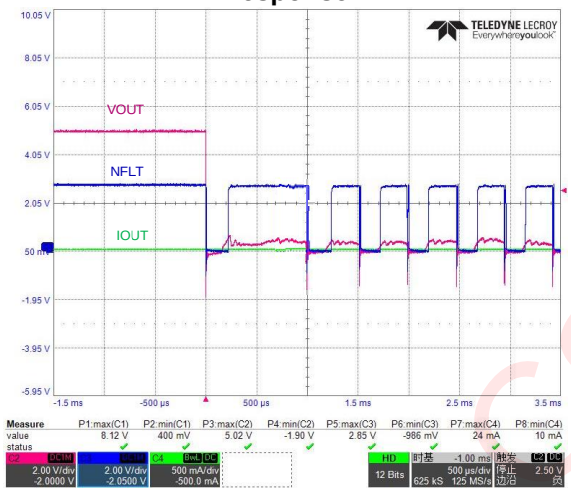


Figure 27 Output Short to No Load Recovery Response

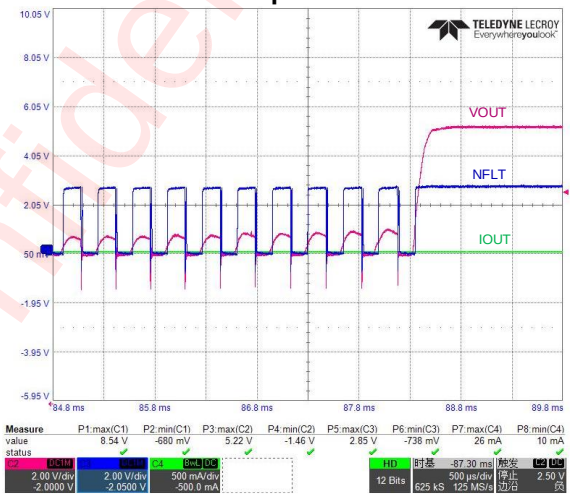


Figure 28 Pulse overvoltage with 100Ω

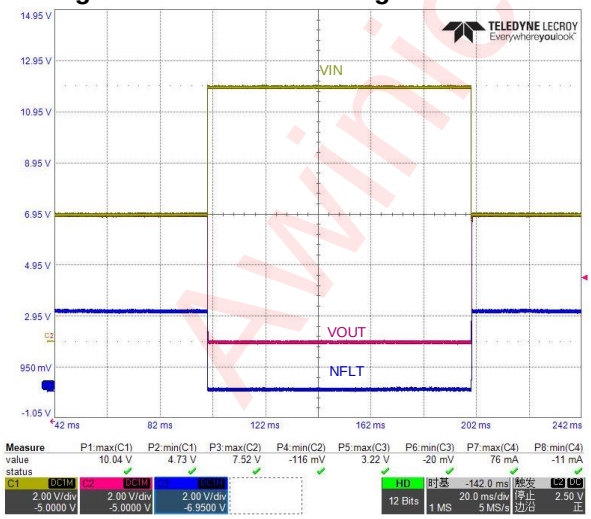
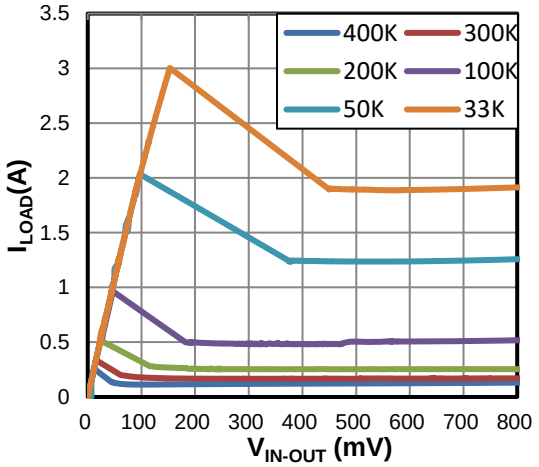


Figure 29 I_{LOAD} vs. V_{IN-OUT}



Detailed Functional Description

The AW35019 is a smart e-Fuse with enhanced built-in protection circuitry. It provides robust protection for all systems and applications powered from 2.7V to 6.5V. V_{IN} can withstand up to 24 V. Within 0 V to 24 V range, it can be divided to four modes as shown in Figure 30.

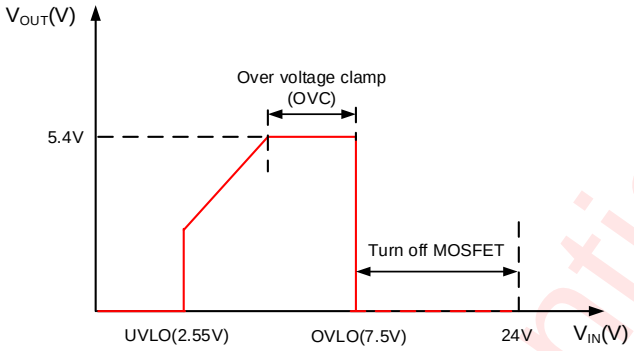


Figure 30 Output vs Input voltage

For hot-plug-in boards, the device provides in-rush current control and programmable output ramp rate. AW35019 integrate over-current and short-circuit protections. The precision over-current limit helps to minimize over design of the input power supply, while the fast response short-circuit protection immediately isolates the load from input when a short circuit is detected. The device allows the user to program the over-current limit threshold between 0.25A and 3A via an external resistor. The device provides precision monitoring of voltage bus for brown-out and over-voltage conditions of voltage bus for brown-out and over-voltage conditions and asserts fault for downstream system. AW35019 is designed to protect systems such as White Goods, STBs, DTVs, Smart Meters and Gas Analyzers.

The additional features include:

Over-temperature protection to safely shutdown in the event of an over-current event.

Fault reporting for brown-out and over voltage, UVLO, short circuit, over temperature, fast-trip and current limit.

Fault recover condition is following:

Protection	V_{IN}-V_{OUT} Switch	Response condition	Recover condition
UVLO	Off	V_{IN}<UVLO	V_{IN}>UVLO
Over voltage	Off	V_{IN}>OVLO	V_{IN}<OVLO
Short circuit	Off	V_{OUT}<2V	V_{OUT}>2V, 130ms Retry after short to GND
Fast-trip	Off	I_{OUT}>2*I_{LIM}	I_{OUT}<2*I_{LIM}
Current limit	On	I_{OUT}>I_{LIM}	I_{OUT}<50%*I_{LIM}
OTP	Off	Temperature>140℃	130ms retry delay after thermal shutdown recovery

Enable

ENUV enables the control circuits, and power switch when V_{ENUV}>1.38V. It turns off power switch when V_{ENUV}<1.33V. When V_{ENUV} is low, it will reset AW35019 that have latched off due to a fault condition.

Over-voltage protection

AW35019 has internal over-voltage protection, and its threshold voltage is 7.5V. When over voltage event happens, power switch is turned off to protect downstream load.

Over-load and short-circuit protection

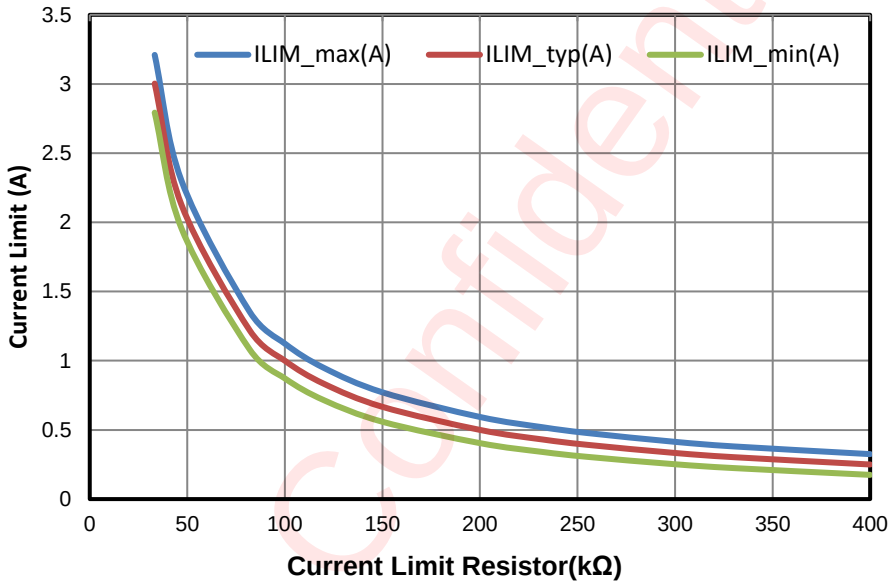
Load current is monitored by sensing voltage across an internal sense resistor. Current limit threshold is

programmed by connecting external resistor R_{ILIM} to GND.

$$ILIM\_typ(A) = \frac{100000V}{R_{LIM}\Omega}$$

When over load happens, current is limited to the current limit threshold, and current limit decrease as VIN-VOUT increase until I_{LIM_ST}. I_{LIM_ST} is start-up current limit value when VOUT=0V, I_{LIM_ST} is about 50%*ILIM.
Method of measuring the current limit threshold: 2.7V ≤ VIN ≤ 5.15V, increase the load current, when load current is limited to a value, the value is current limit threshold.
But when a transient short-circuit event happens, the current through the device increases very rapidly. Current limit amplifier cannot respond quickly. So a fast-trip comparator is also integrated to shut down power switch within 1μs. The fast-trip threshold current is $2xI_{LIMT}$. Fast-trip comparator shuts down power switch for only a few microseconds, then the device attempts to soft start power switch.
The tolerance of the current limit threshold when selecting a value for R_{ILIM} is following:

Figure 31 Current Limit vs. Current Limit Resistor



Output-voltage clamp (OVC)

When 5.4V<VIN<7.5V, the output-voltage clamp (OVC) circuit clamps the output voltage to 5.4V. Within this VIN range, the over-current protection remains active, but current limit is I_{LIM_ST}.

NFLT Fault Report

NFLT pin is asserted low during over-voltage, under-voltage, thermal shut down, over load and current limit. It is de-asserted after the fault condition is removed and then recover normal operation. It's recommended to be pulled up by 100kΩ pull-up resistor to input. During normal operation, NFLT is pulled up to logic high by pull-up resistor, when fault event happens, NFLT will output logic low.

Thermal shutdown

When the junction temperature rises to approximately 140°C, thermal shutdown (TSD) protection turns off the load switch for cooling the device until the junction temperature falls to approximately 120°C.

Output discharge

A discharge resistor with 600Ω is connected to the OUT terminal when power switch is turned off. The discharge resistor dissipates stored charge and leakage current on OUT. The pull-down capability decreases as V_{IN} decreases.

PCB Layout Consideration

To obtain the optimal performance of AW35019, PCB layout should be considered carefully. Here are some guidelines:

1. Place C_{IN} as close as possible to IN.
2. Place C_{OUT} as close as possible to OUT.
3. Place R_{LIM} as close as ILIM.
4. IN, OUT support 3A current, the connection lines should be as wide as possible.
5. Connect the IN and OUT pads to a large IN and OUT plane respectively to achieve better thermal performance.

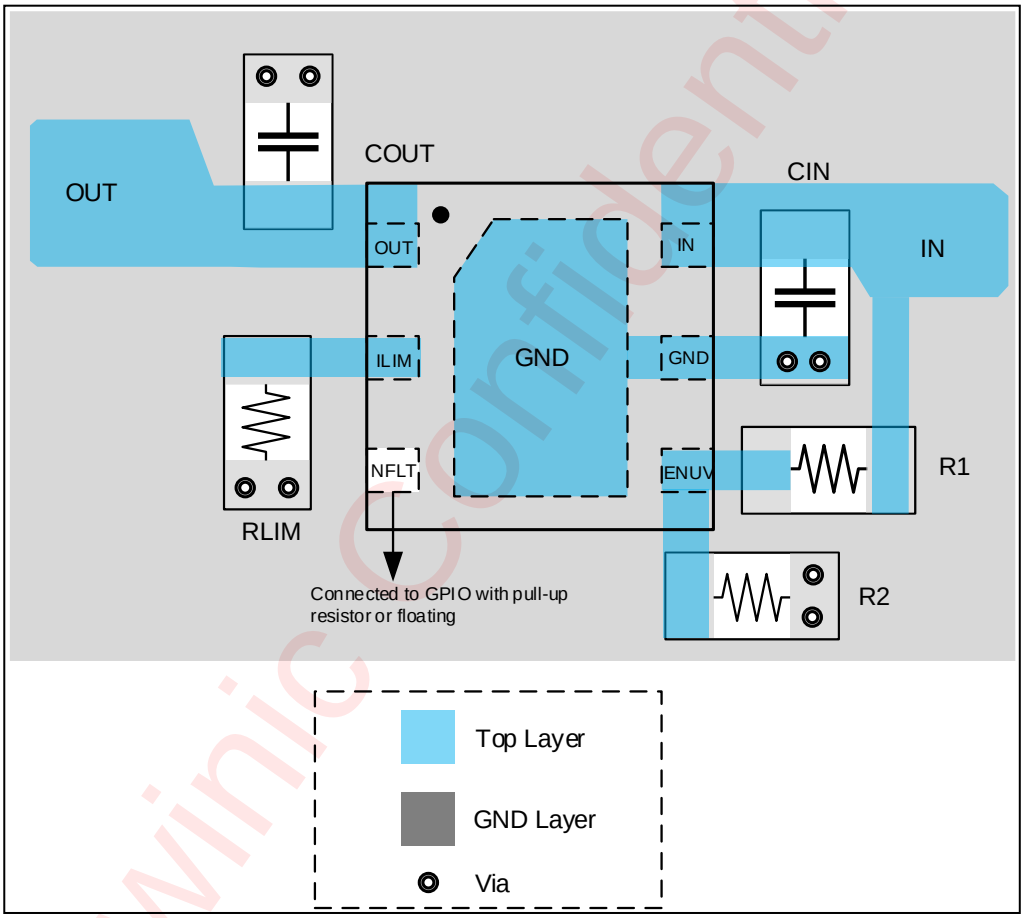
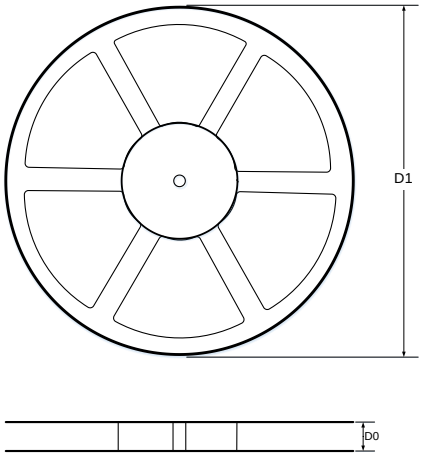


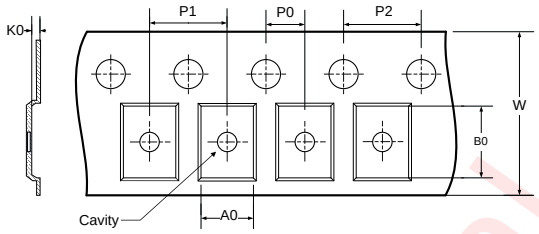
Figure 32 External Components Placements and PCB Layout Example

Tape And Reel Information

REEL DIMENSIONS

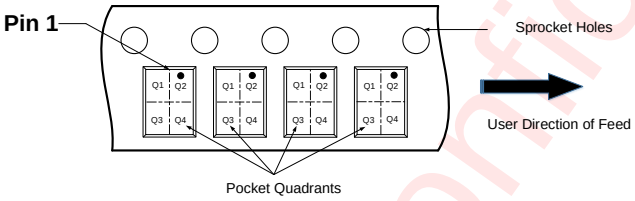


TAPE DIMENSIONS



A0：Dimension designed to accommodate the component width
B0：Dimension designed to accommodate the component length
K0：Dimension designed to accommodate the component thickness
W：Overall width of the carrier tape
P0：Pitch between successive cavity centers and sprocket hole
P1：Pitch between successive cavity centers
P2：Pitch between sprocket hole
D1：Reel Diameter
D0：Reel Width

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



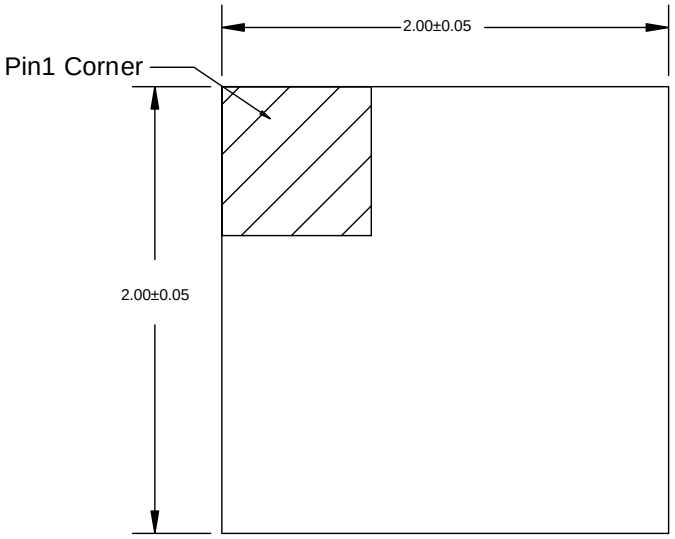
Note：The above picture is for reference only. Please refer to the value in the table below for the actual size

DIMENSIONS AND PIN1 ORIENTATION

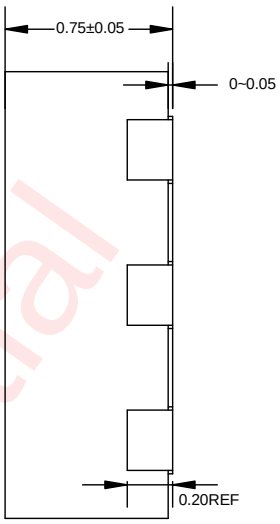
D1 (mm)	D0 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
178.00	8.40	2.25	2.25	0.95	2.00	4.00	4.00	8.00	Q2

All dimensions are nominal

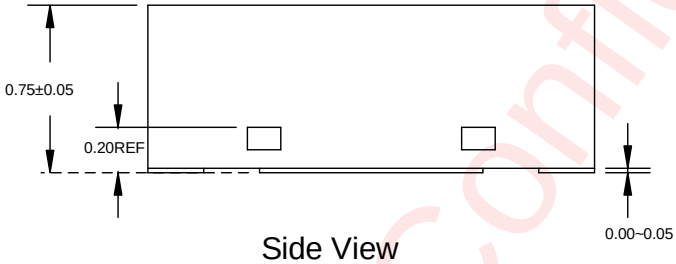
Package Description



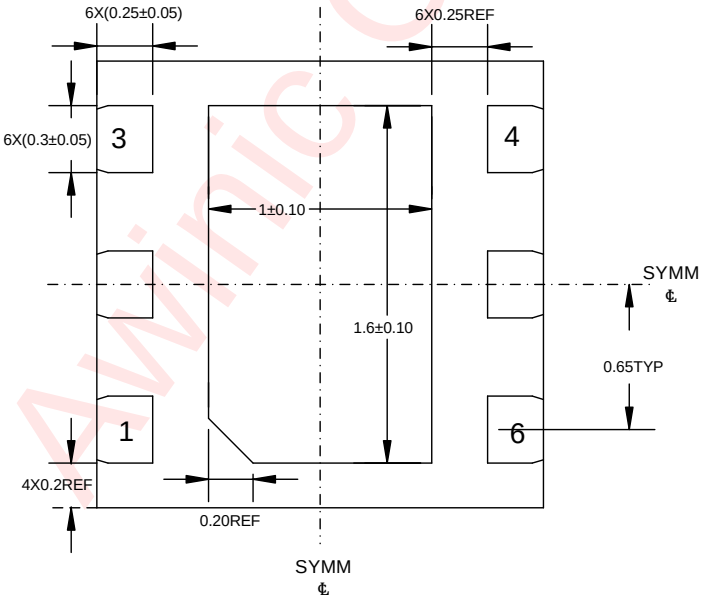
Top View



Side View



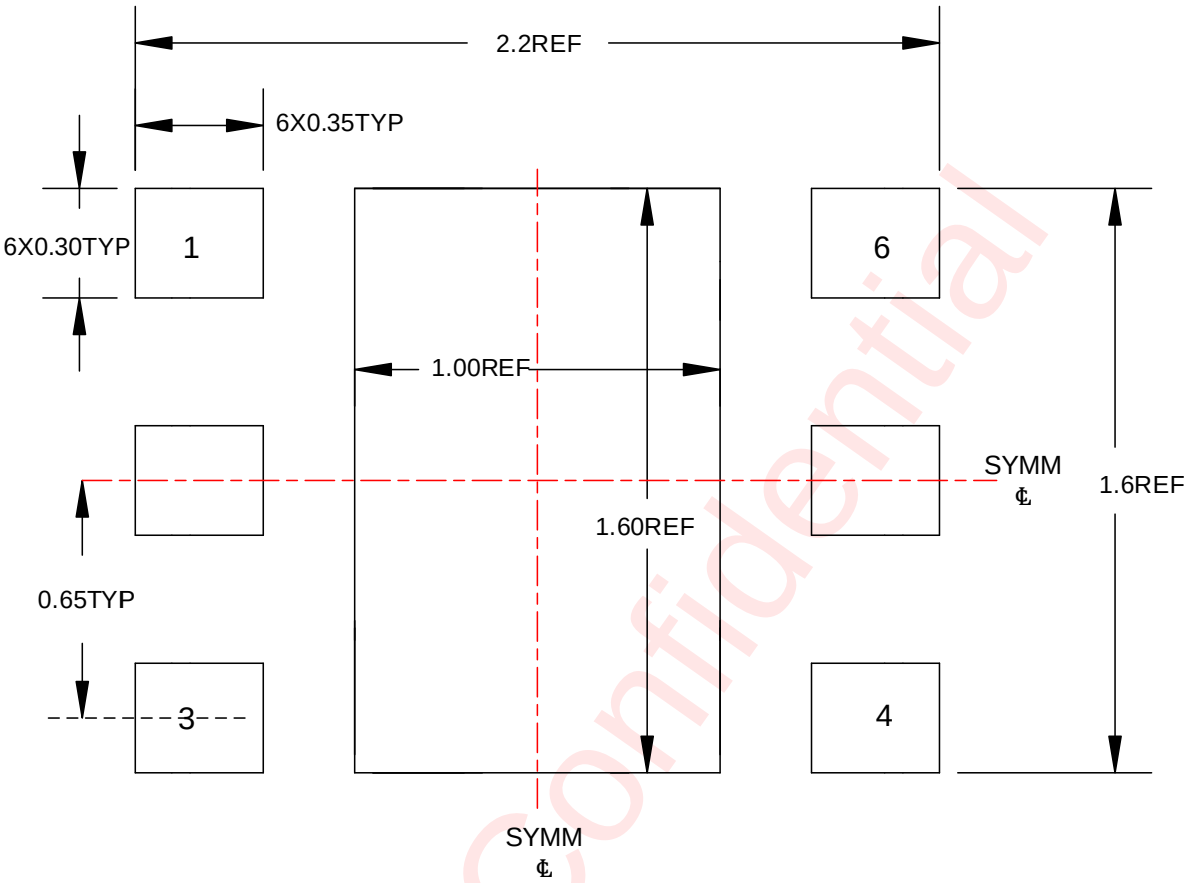
Side View

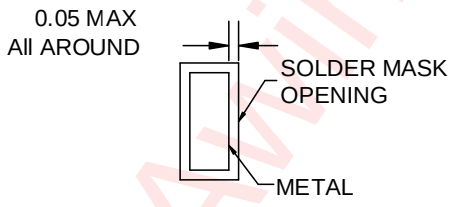


Bottom View

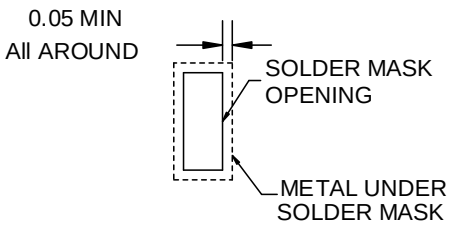
Unit：mm

Land Pattern Data





NON SOLDER MASK DEFINED



SOLDER MASK DEFINED

Unit: mm

Reversion History

Version	Date	Change Record
V1.0	January 2021	First version.
V1.1	February 2022	1. Modify NFLT description on page 2 2. Add ILIM up limit and down limit on page 6 3. Add VOVC up limit and down limit on page 7 4. Modify figure7, figure13, figure15 5. Update description on page 11 6. Delete Css 7. Delete Vovp
V1.2	July 2022	1. I_{LIM_ST} update description 2. Update accuracy of I_{LIMIT} 3. Update IQ
V1.3	September 2022	1. Update spec of V_{OVC} 2. Add CB/UL certificates number 3. Update I_{LIMT} spec, and I_{LIMT} error formula and curve 4. Add curve of V_{OUT} vs V_{IN} 5. Add fault recover condition diagram 6. t_{NFLT} update from 1ms to 0.5ms 7. Add application curves
V1.4	March 2023	1. Modify figure19,29 2. Update CB/UL certificates number 3. Update accuracy of I_{LIMIT} 4. Update description on page 13 5. Delete I_{LIMT} formula
V1.5	April 2023	1. Add CB/UL certificates file number
V1.6	May 2024	1. Add t_r, t_f, and t_{SS} parameters on page 6 2. Update IQ 3. Modify figure 7/16/17 and title of figure 22/23

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