Back to Back OVP with Adjustable Current Limit

General Description

The ET2195 is a slew-rate controlled, low $R_{DS(ON)}$ Over voltage protection device. It is used in between a power source and a load to protect and isolate power source against unwanted abnormal voltage and current condition. Especially, in the OTG mode of smartphone, the ET2195 could be placed between OTG boost regulator and USB port. The ET2195 can protect boost regulator in smartphone from the USB fault conditions like over-voltage or over-current condition.

In order to be used at high voltage application (9V or above), the ET2195 apply a high voltage device power FET switch and a maximum input voltage is 13.5V. Its over voltage protection level is set to 5.8V in ET2195, 11.5V in ET2195H, 14.2V in ET2195K. To prevent excessive input voltage or battery droop resulting from a large inrush current, the ET2195 also implements several protection functions, such as output over voltage and input under-voltage protection, over-current protection with FLAG and over-temperature protection. ET2195 is available in a WLCSP9 package.

Features

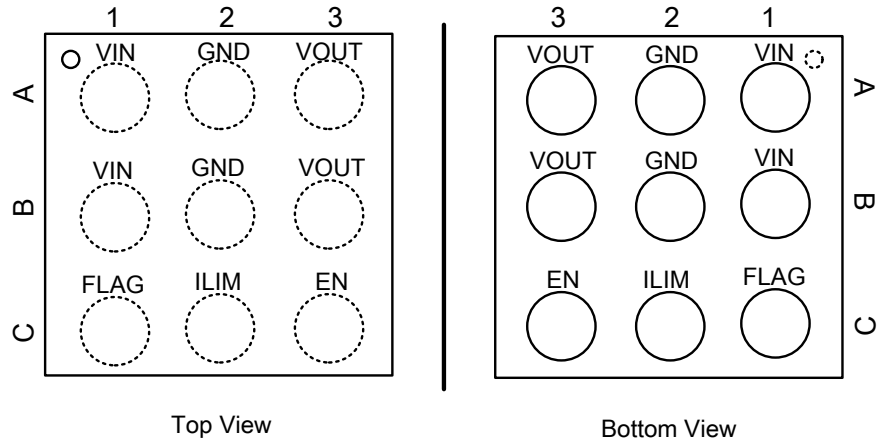
- Wide Voltage Operation: 2.5V to 13.5V
- 28V Absolute Maximum Voltage Rating of VOUT
- Adjustable Current Limit with external resistor
- Integrated Power FET switch with 60mΩ $R_{DS(ON)}$ @ 5V/1A
- Built in Soft Start to prevent inrush current
- Over Temperature Protection (OTP)
- Over Voltage Protection (OVP) is 5.8V(ET2195)/11.5V(ET2195H) /14.2V(ET2195K) Typical
- Adjust Over Current Protection
- Reverse Current Protection
- Compliance to IEC61000-4-2 on VOUT
  -- Contact discharge: ±8kV
  -- Air Gap discharge: ±15kV
- Part No. and Package

Part No.	Package	MSL
ET2195/H/K	WLCSP9 (1.22mm × 1.22mm, 0.4mm pitch)	1

Application

- Smartphones, Tablet PC, Note PC
- HDD, Storage, and Solid State Memory Devics
- Portable Media Devices, Laptop & MID
- SLR Digital Cameras
- Mobile IoT Devices

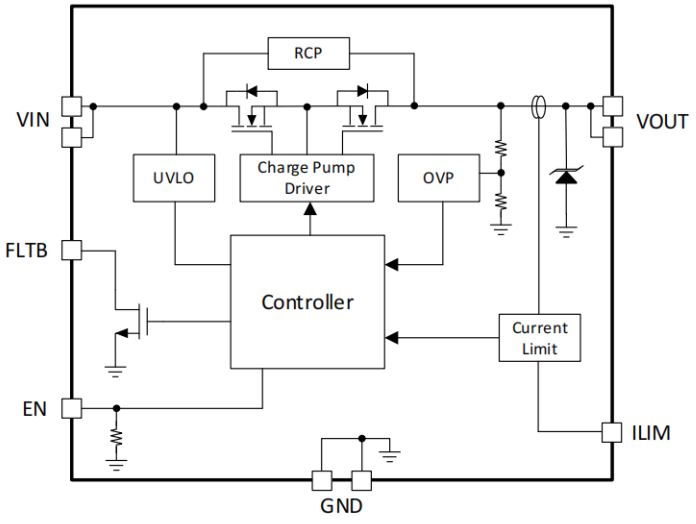
Pin Configuration



Pin Function

Pin	Name	Description
A3, B3	VOUT	Output of the load switch.
A1, B1	VIN	Input of the load switch.
A2, B2	GND	Ground.
C3	EN	Active HIGH-GPIO compatible Enable input. EN high to turn on the load switch.
C1	FLAG	Over-Current limit fault flag pin. Open-drain output, active low signal. Pull up with a resistor.
C2	ILIM	Current limit set pin. Connect a resistor between this pin and ground to program the desired current limit point.

Block Diagram



Detailed Description

Enable

The ET2195 is powered from VIN. Once VIN voltage is higher than VIN_UVLO and EN voltage is asserted high, internal switch is fully turned on after soft-startup which is shown in Figure 1. Even though EN is high before supplying VIN, switch-on delay time is counted after VIN is higher than VIN_UVLO. If VIN is dropped below than VIN_UVLO or EN is asserted low during operation, switch is turned off without delay time.

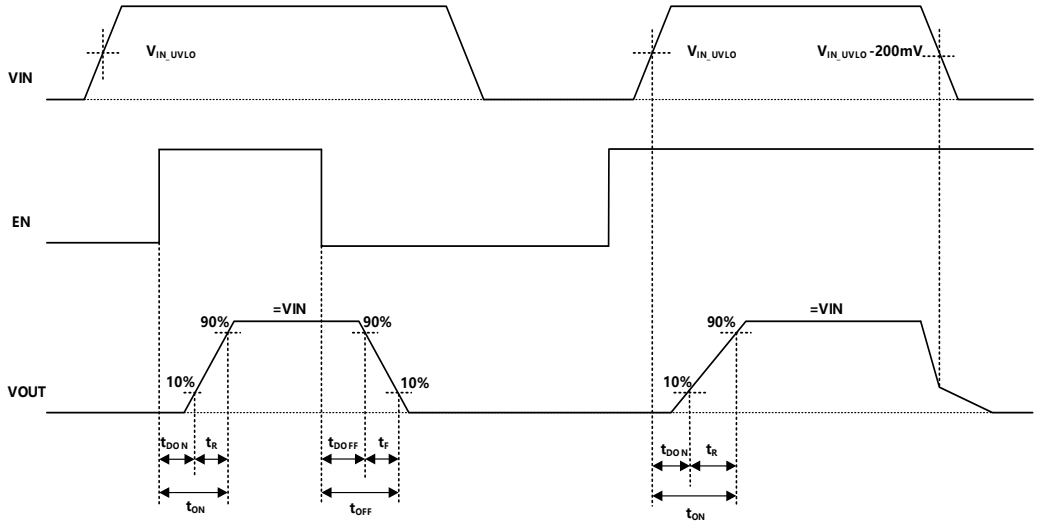


Figure 1. Enable/Disable Timing Diagram

Over Voltage Protection

The power FET is immediately turned off whenever VOUT voltage is higher than VOVP_TH. The OVP threshold, VOVP_TH is internally fixed to 5.8V/11.5V/14.2V. Figure 2 shows the Over voltage protection timing diagram.

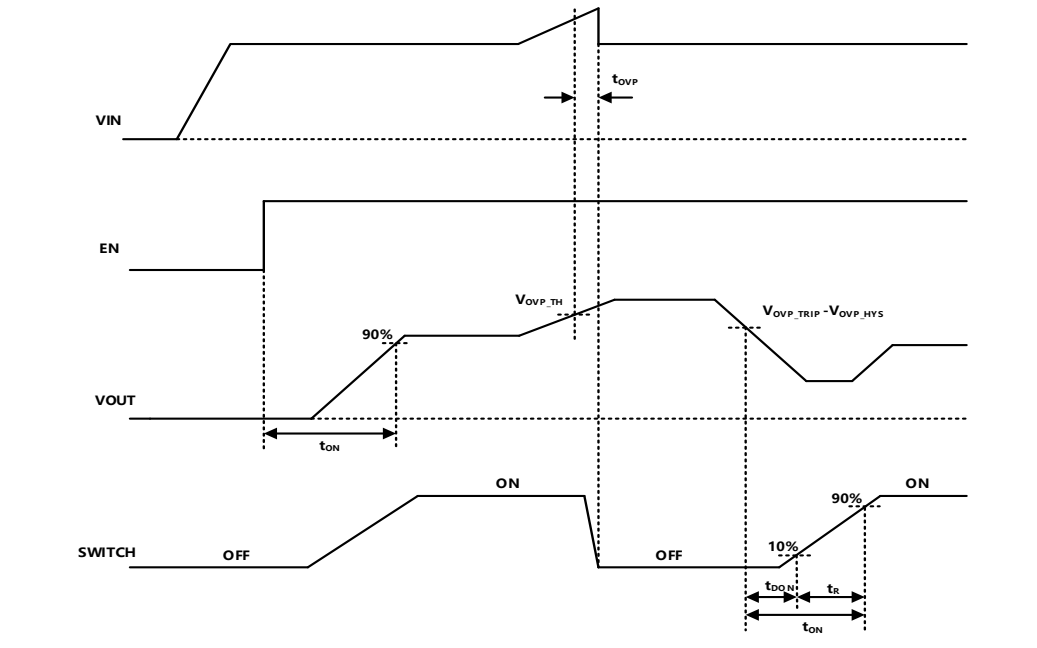


Figure 2. ET2195 OVP Timing Diagram

Over Current Protection

The current limit ensures that the current through the switch does not exceed the maximum set value, while not limiting the minimum value. Current limit level could be adjusted through the selection of resistor connected to the ILIM pin. The device operates as a constant current source when current is higher than the maximum current limit. During limited current operation, internal switch power loss is increase and the device should be protected by over temperature protection.

Table 1. Current Limit Setting with RLIM

R_{LIM} (Ω)[1]	Current Limit (mA)			R_{LIM} (Ω)[1]	Current Limit (mA)		
	Min	Typ	Max		Min	Typ	Max
345	2700	3000	3300	1300	720	800	880
415	2250	2500	2750	1500	630	700	770
460	2025	2250	2475	1750	540	600	660
520	1800	2000	2200	2100	450	500	550
600	1570	1750	1920	2300	405	450	495
700	1350	1500	1650	2600	360	400	440
850	1125	1250	1375	3000	315	350	385
1040	900	1000	1100	3500	270	300	330
1150	810	900	990	4200	220	250	280

Note1: Table values based on 1% tolerance resistor.

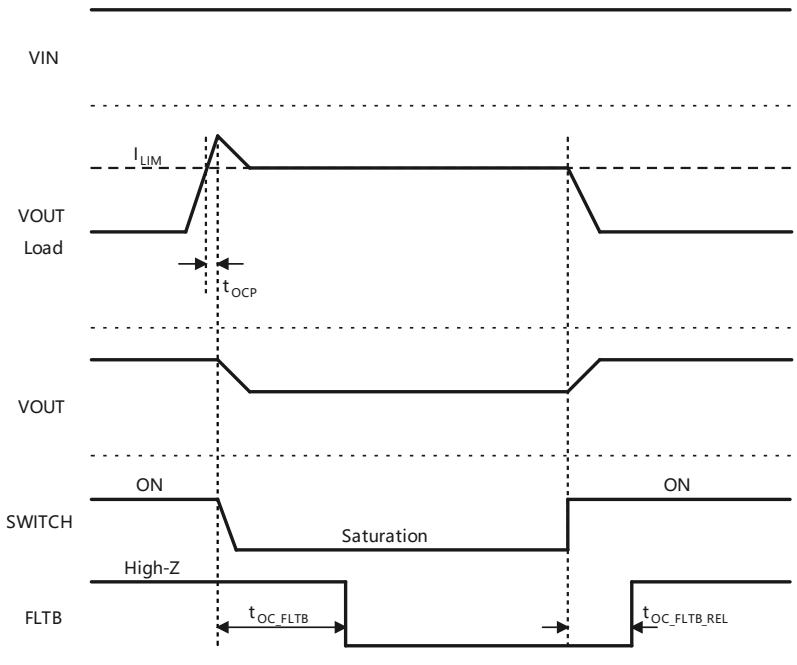


Figure 3. ET2195 OCP Timing Diagram

Reverse Current Protection (RCP)

The ET2195 integrates RCP circuitry by measuring voltage difference between VIN and VOUT, to prevent any reverse drive from VOUT to system.

If VOUT voltage is higher than VIN voltage, this condition is detected as a reverse current condition and the power FET is turned off after response time of tRCP. Even if VIN is higher than VIN_UVLO and EN is applied to high, power FET is kept in OFF state if RCP condition is not released, see Figure 4 showing.

During the normal soft-start operation of ET2195, VOUT voltage may overshoot above VIN voltage at certain load condition. To prevent an abnormal RCP triggering during this period, RCP is disabled during soft startup.

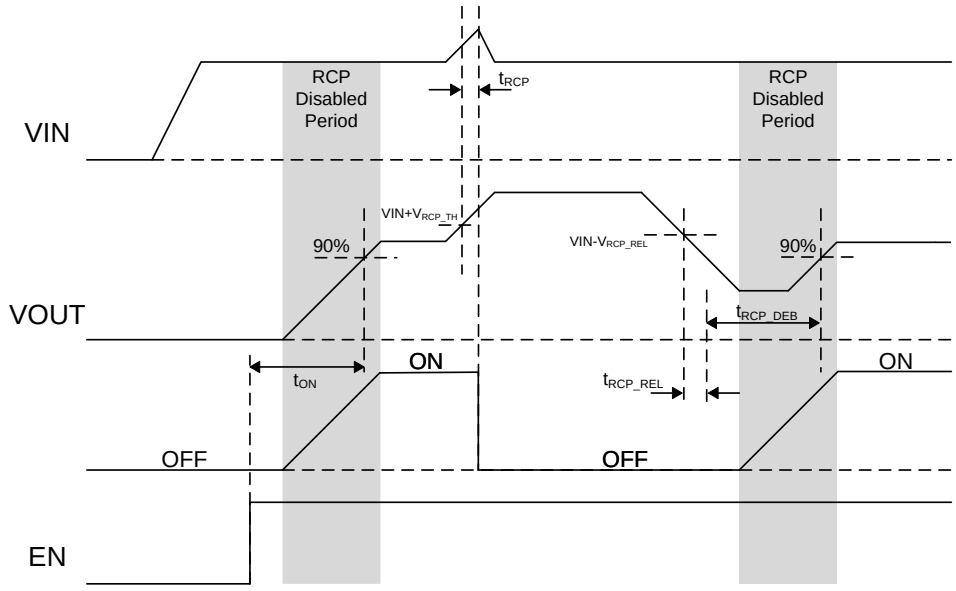


Figure 4. ET2195 RCP Timing Diagram

Fault Signal (FLAG)

The FLAG pin is open drain output and external pull-up resistor is required. When the current from VIN to VOUT exceeds ILIM threshold, FLAG is pulled down to GND. It is returned to high impedance when the current falls below ILIM threshold.

FLAG signal is not driven from over temperature protection or over voltage protection.

Input Capacitor

The input capacitor C_{IN} protects the power supply from current transients generated by the load attached to the ET2195. C_{IN} should be located as close to the device VIN pin as practically possible. A high-value capacitor on C_{IN} can be used to reduce the voltage drop in high-current applications.

Output Capacitor

An output capacitor should be placed between the V_{OUT} and GND pins. This capacitor prevents parasitic board inductance from forcing V_{OUT} below GND when the switch is on. This capacitor also prevents reverse inrush current from creating a voltage spike that could damage the device in the case of a V_{OUT} short.

Under-Voltage Lockout (UVLO)

The under-voltage lockout turns the switch off if the input voltage drops below the lockout threshold. With the EN pin active, the input voltage rising above the UVLO threshold releases the lockout and enables the switch.

Thermal Shutdown

The thermal shutdown protects the die from internally or externally generated excessive temperature. During an over-temperature condition, the switch is turned off. The switch automatically turns on again if the temperature of the die drops below the threshold temperature.

Board Layout

For best performance, all traces should be as short as possible. To be most effective, the input and output capacitors should be placed close to the device to minimize the effect that parasitic trace inductance may have on normal and short-circuit operation. Using wide traces for VIN, VOUT, GND helps minimize parasitic electrical effects along with minimizing the case-to-ambient thermal impedance.

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameters			Min	Max	Unit
V_{IN}	VIN pin voltage			-0.3	16	V
V_{OUT}	VOUT pin voltage			-0.3	28	V
V_{EN}	EN pin voltage			-0.3	6.5	V
V_{ILIM}	ILIM pin voltage			-0.3	6.5	V
V_{FLAG}	FLAG pin voltage			-0.3	6.5	V
T_J	Operating Junction Temperature			-40	+150	°C
T_L	Lead soldering temperature				+260	°C
T_{STG}	Storage Temperature			-65	+150	°C
I_{SW}	Maximum Continuous Switch Current				3.0	A
P_D	Total Power Dissipation at T_A=25°C				1.0	W
θ_{JA}	Thermal Resistance, Junction-to-Ambient (1 inch Square Pad of 2 oz. Copper)				100	°C/W
V_{ESD}	Electrostatic Discharge Capability	Human Body Model, JESD22-A114	VOUT Pin	±2.0		kV
			All other pins	±2.0		
		Charged Device Model, JESD22-C101		±1.5		
	IEC61000-4-2 System Level	Air Discharge (V_{OUT} to GND)		±15.0		
		Contact Discharge (V_{OUT} to GND)		±8.0		

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. ET2195 does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameters	Min	Max	Unit
V_{IN}	Supply Voltage	2.5	13.5	V
T_A	Ambient Operating Temperature	-40	85	°C

Electrical Characteristics

Minimum and maximum values are at V_{IN}=2.4V ~ 13.5V, T_A=-40°C~+85°C, unless otherwise noted. Typical values are at T_A=25°C, V_{IN} =5.0V. C_{IN}=1μF, C_{OUT}=4.7μF, R_{LIM} = 415Ω.

Symbol	Parameter	Test Conditions	Temp	Min	Typ	Max	Unit
Power Supplies							
V_{IN_UVLO}	VIN Under Voltage Lockout	Rising, 200mV hysteresis	25°C		2.4		V
I_{IN_SD}	Shutdown Current	V_{IN} = 5V, EN = Low			2.8	12	μA
I_{IN_Q}	Quiescent Current	V_{IN} = 5V, EN = HIGH I_{OUT} = no load			35	70	μA
Digital Inputs							
V_{EN_IH}	Input High Voltage	EN pin	Full	0.9			V
V_{EN_IL}	Input Low Voltage	EN pin	Full			0.35	V
R_{EN_PD}	Pull Down Resistor	EN pin	+25°C		14		MΩ
Over Voltage Protection							
V_{OVP_TH}	ET2195	OVP Rising Threshold		5.5	5.8	6	V
		OVP Falling Threshold			5.5		V
	ET2195H	OVP Rising Threshold		11.0	11.5	12.0	V
		OVP Falling Threshold			11.0		V
	ET2195K	OVP Rising Threshold		13.5	14.2	14.9	V
		OVP Falling Threshold			13.4		V
T_{OVP}	OVP Response Time[(2)]	I_{OUT} = 0.5A, C_L = 4.7μF	+25°C		30		ns
Over Current Protection							
I_{LIM}	Current Limit	V_{IN} = 5V, R_{LIM} = 1000Ω		0.88	1.04	1.2	A
t_{OCP}	Over Current Response Time	I_{OUT} > I_{LIM}			7		μs
t_{SCP}	Short Current Protection Response Time	I_{OUT} > I_{LIM}, V_{OUT} < 2V			6		μs

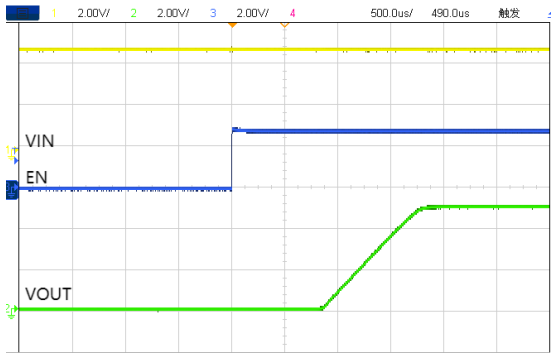
Electrical Characteristics(Continued)

Minimum and maximum values are at V_{IN}=2.4V ~ 13.5V, T_A=-40°C~+85°C, unless otherwise noted. Typical values are at T_A=25°C, V_{IN} =5.0V. C_{IN}=1μF, C_{OUT}=4.7μF, R_{LIM} = 415Ω.

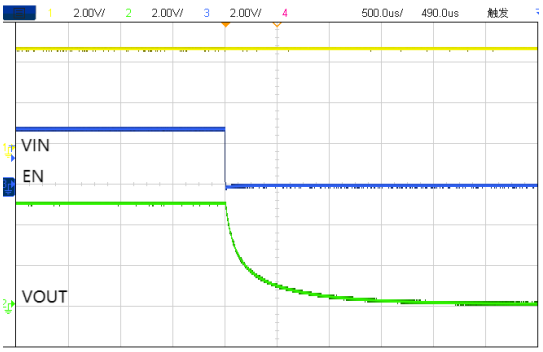
Symbol	Parameter	Test Conditions	Temp	Min	Typ	Max	Unit
t_{OC_FLTB}	Over Current Flag Response Time	Time from Over-current Detection to Pulling FLAG Down			8		ms
$t_{OC\_FLTB\_REL}$	Over Current Flag Release Time				3		ms
V_{RCP_TH}	Reverse Current Protection Threshold	VOUT - VIN, Rising			50		mV
V_{RCB_REL}	Reverse Current Protection Release Threshold	VIN - VOUT, Falling			50		mV
t_{RCP}	RCP Response Time				10		μs
t_{RCP_REL}	RCP Release Time(2)				1		μs
t_{RCP_DEB}	RCP Debounce Time				1.5		ms
I_{RCP_Q}	Reverse Current of VOUT	V_{IN} = GND, V_{OUT} = 5V				2	μA
Dynamic Characteristics							
t_{DON}	Turn-On Delay	V_{IN} = 5V, R_L = 100Ω , R_{LIM}= 2040Ω	25°C		0.7		ms
t_R	VOUT Rise Time				0.7		ms
t_{ON}	Turn-On Time				1.4		ms
t_{DOFF}	Turn-Off Delay				10		μs
t_F	VOUT Falling Time				220		μs
t_{OFF}	Turn-Off Time				230		μs
Load Switch Section							
R_{ON}	On Resistance	V_{IN} = 5V, I_{OUT} = 1A	Full		60		mΩ
		V_{IN} = 3.7V, I_{OUT} = 1A	Full		65		mΩ
Thermal Protection							
T_{SHDN}	Thermal Shutdown(2)		-		150		°C
T_{HYS}	Thermal Hysteresis(2)		-		20		°C

Note2: This parameter is guaranteed by design and characterization.

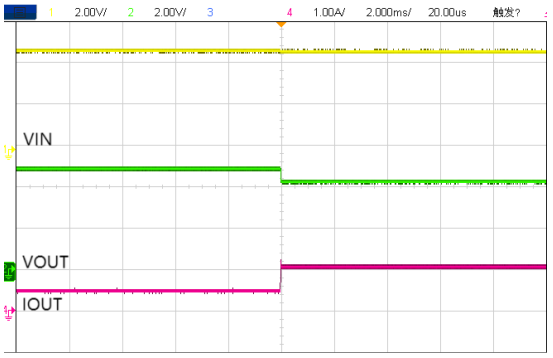
Typical Performance Characteristics



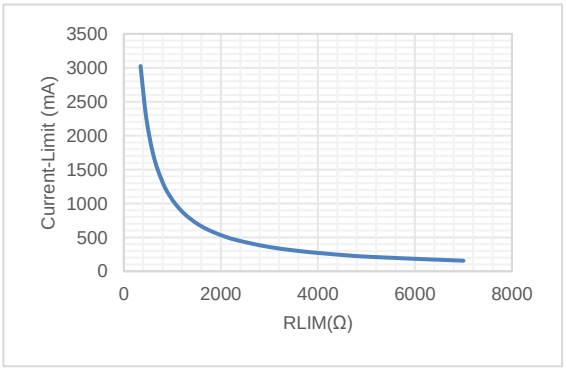
Turn on delay



Turn off delay

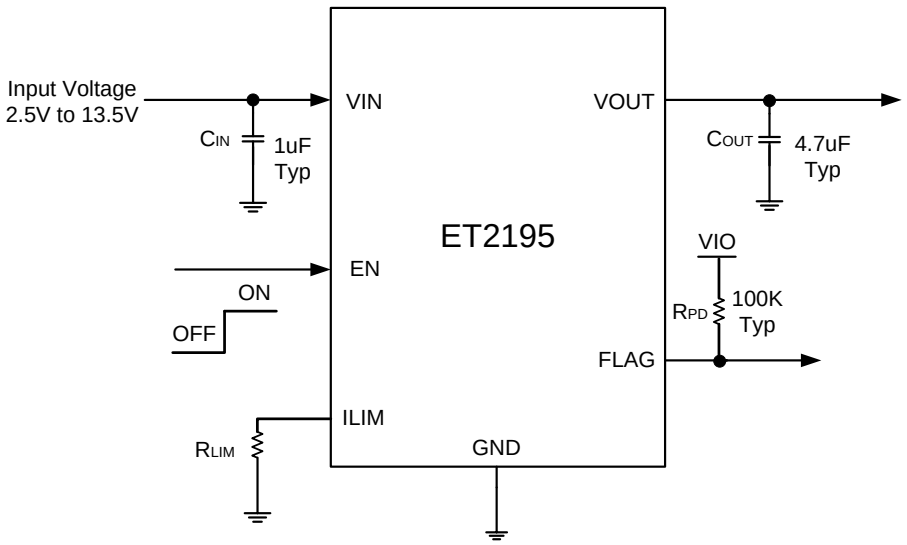


R_{LIM}=1KΩ Current limit – Load 10Ω to 4Ω



ILIM vs RILIM

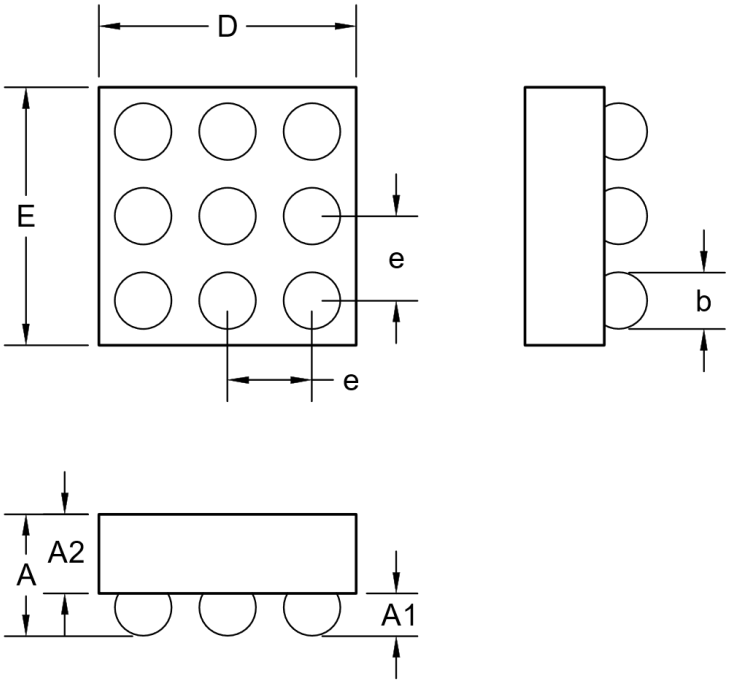
Application Circuits



Note*: This application circuit is for reference, recommended minimum value of C_{IN} is 1uF，and C_{OUT} is 4.7uF.

Package Dimension

WLCSP9

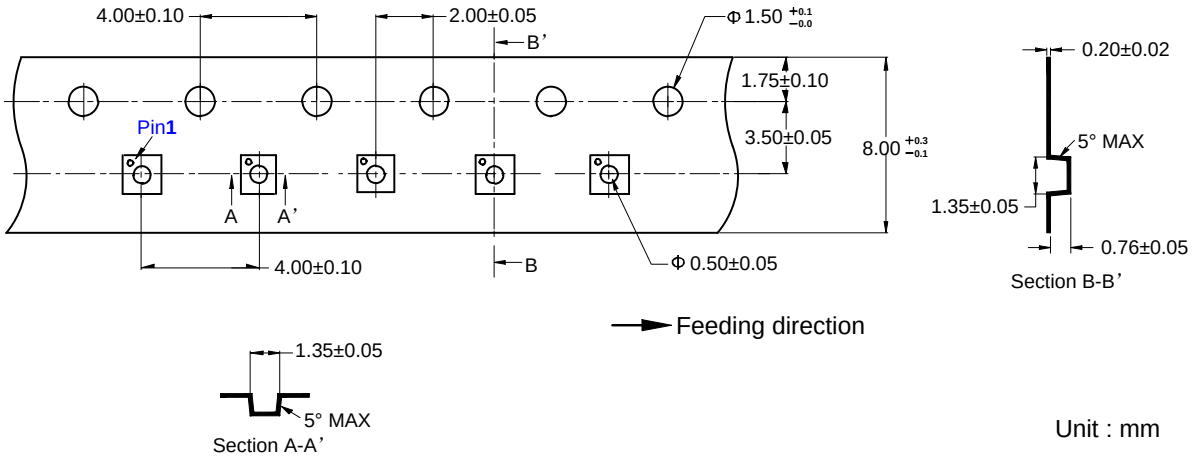


COMMON DIMENSIONS

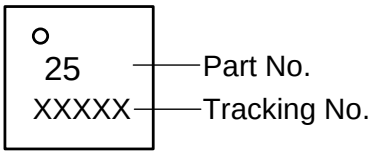
SYMBOL	MIN	NOM	MAX
A	0.54	0.57	0.60
A1	0.18	0.20	0.22
A2	0.36	0.37	0.38
b	0.24	0.27	0.30
D	1.19	1.22	1.25
E	1.19	1.22	1.25
e	0.40BSC		

Unit: mm

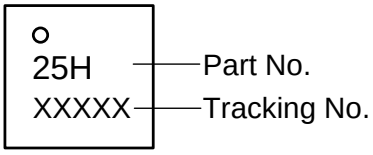
Tape Information



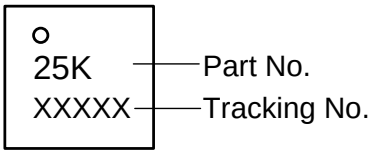
ET2195/M/H Marking



Part NO. ET2195-25



Part NO. ET2195H-25H



Part NO. ET2195K-25K

Revision History and Checking Table

Version	Date	Revision Item	Modifier	Function & Spec Checking	Package & Tape Checking
0.0	2023-4-25	Preliminary Version	Guoy Shibo	guoy	guoy
0.1	2024-2-19	Update EC table	Wuhesong	guoy	guoy
1.0	2024-4-8	Officially Version	Zoucm	Guoy	Shibo
1.1	2024-8-8	Update EC table	Wuhesong	Guoy	Shibo
1.2	2024-9-6	Update EC table and Figure	Zoucm	Guoy	Shibo
1.3	2024-12-31	Update EC table	Zoucm	Guoy	Shibo