2.0A Low Loss Power Switch With Flag

❖ GENERAL DESCRIPTION

AX8713/AX8723 is a low voltage, single NMOSFET high-side power switch, optimized for self-powered and bus-powered Universal serial bus (USB) application. AX8713/AX8723 equipped with a charge pump circuitry to drive the internal NMOSFET switch, the switch's low Rds(on) 70mΩ, meets USB voltage droop requirement and a flag output is available to indicate fault conditions to the local USB controller.

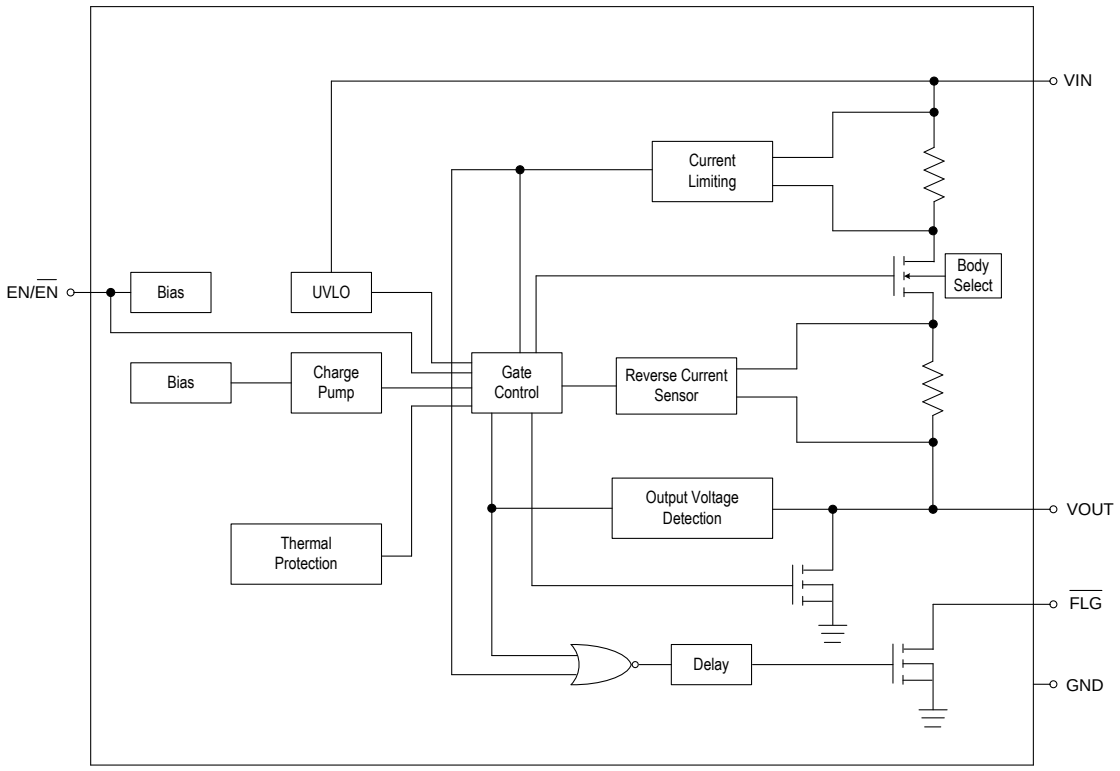
Additional features include soft-start to limit the inrush current during plug-in, thermal shutdown to prevent catastrophic switch failure from high-current loads, under voltage lockout (UVLO) to ensure that the device remains off unless there is a valid input voltage present. The maximum current is limited to typically 3.0A in dual ports in accordance with the USB power requirement. The low quiescent current as 35uA makes this device ideal for portable battery operated equipment.

AX8713/AX8723 is available in SOT-23-5L, SOP-8L and MSOP-8L packages requiring minimum board space and few peripheral components.

❖ FEATURES

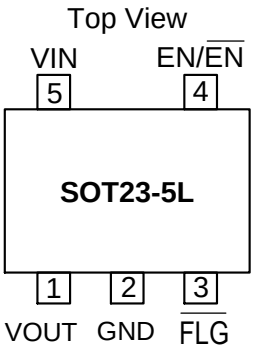
- Wide Input Voltage Range: 2.5V to 5.5V
- Compliant to USB Specifications
- AX8713/AX8723 Enable Active Low/High
- Typical Rdson
  70mΩ (SOT-23-5L)
- Typical 2.1V under voltage lockout
  Output can be forced higher than input (Off-state)
- Low supply current
  Less than 1uA at the off state
  35uA at switch on state
- Guaranteed 2A continuous load current
- Open Drain Fault Flag Output
- Hot Plug-In Application(Soft start)
- Current Limiting Protection
- Thermal Shutdown Protection
- Reverse Current Flow Blocking (no body diode)
- RoHS and Halogen free compliance
- UL Approved-E353665
- TuV EN60950-1 Certification
- CB IEC60950-1 Certification

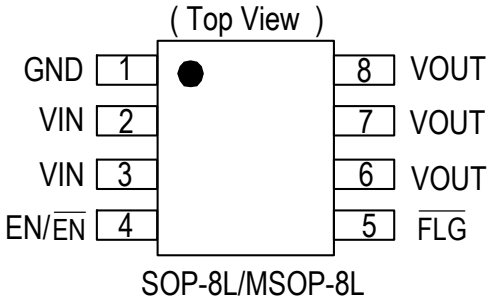
❖ BLOCK DIAGRAM



❖ PIN ASSIGNMENT

The pin assignment is given by:





Name	Pin No. SOT-23-5L	Pin No. SOP-8 /MSOP-8	Description
VOUT	1	6,7,8	Output Voltage.
GND	2	1	Ground.
FLG	3	5	Fault FLAG Output.
EN/EN	4	4	Chip Enable (Active High/Low).
VIN	5	2,3	Power Input Voltage.

❖ ORDER/MARKING INFORMATION

Order Information	Top Marking (SOT-23-5L)
AX87XX XX X Enable Active: Enable Low: 13, Enable High: 23 Package Type: S: SOP-8L, B: SOT-23-5L, U8: MSOP-8L Packing: Blank: Tube/Bag, A : Taping	XXYWX → ID code: internal WW: 01~26(A~Z), 27~52(a~z) Year: A= 2010, 1= 2011 ⋮ 9= 2019 A7: AX8713 A8: AX8723
Top Marking (SOP-8L/MSOP-8L)	**Top Marking (SOP-8L/MSOP-8L)**
Logo ← AX8713 → Part number YYWWX → ID code:internal WW:01~52 Year: 10=2010, 11=2011 ⋮ 19=2019	Logo ← AX8723 → Part number YYWWX → ID code:internal WW:01~52 Year: 10=2010, 11=2011 ⋮ 19=2019

❖ ABSOLUTE MAXIMUM RATINGS

Characteristics		Symbol	Rating	Unit
Supply Input Voltage		V_{IN}	6.5	V
EN Input Voltages			-0.3 to 6.5	V
FLAG Voltage			6.5	V
Package Power Dissipation		P_D	PD=(TJ-TA) / θJA	W
Operating Temperature Range			-40 to 85	°C
Junction Temperature		T_J	-40~125	°C
Storage Temperature Range		T_S	-65 to +150	°C
ESD Rating (Note)	HBM (Human Body Mode)		2	kV
	MM (Machine Mode)		200	V
Thermal Resistance from Junction to ambient	SOP-8L	θ_{JA}	160	°C/W
	SOT-23-5L		250	
	MSOP-8L		160	
Thermal Resistance from Junction to case	SOP-8L	θ_{JC}	60	°C/W
	SOT-23-5L		130	
	MSOP-8L		55	

Note: Absolute Maximum Ratings are the values beyond which the life of the device may be impaired.

❖ ELECTRICAL CHARACTERISTICS

(V_{IN}=5V, C_{IN}=1uF, C_{OUT}=10uF per channel, T_A = 25°C, unless otherwise specified)

Characteristics		Symbol	Conditions		Min	Typ	Max	Units
Input Voltage Range		V_{IN}			2.5	-	5.5	V
Under Voltage Lockout		V_{UVLO}	V_{IN} Increase		1.7	2.1	2.4	V
Under Voltage Hysteresis			V_{IN} Decrease		-	100	-	mV
Input Leakage Current		I_{LEAK}	Disabled, OUT grounded			0.1	1	μA
Output Leakage Current			Disabled, R_{LOAD}=0Ω		-	0.5	1	μA
Reverse Leakage Current		I_{REV}	Disabled, V_{IN}= 0V, V_{OUT}= 5V, I_{REV} at V_{IN}			0.1	1	μA
Switch On Resistance		R_{DSON}	V_{IN}=3.3V, I_{OUT}=0.5A		-	60	75	mΩ
			V_{IN}=5.0V, I_{OUT}=0.5A		-	60	75	
Supply Current		I_Q	Switch On, V_{OUT} = OPEN		-	35	55	μA
		I_{SHDN}	Switch Off, V_{OUT} = OPEN		-	0.1	1	
EN Threshold	AX8723	V_{IL}	Low Voltage		-	-	0.7	V
		V_{IH}	High Voltage		1.3	-	-	V
$\overline{EN}$ Threshold	AX8713	V_{IH}	High Voltage		-	-	0.7	V
		V_{IL}	Low Voltage		1.3	-	-	V
EN/$\overline{EN}$ Input Current		I_{SINK}	VEN/$\overline{EN}$ From 0V to 5V		-	0.01		μA
Current Limit		I_{LIMIT}	V_{IN}= 5V, V_{OUT}= 4.5V	-40°C ≤ T_A ≤85°C	2.2	3.0	3.8	A
Short Circuit Fold back Current Hysteresis		I_{SHORT}	V_{OUT}=0V, Measured prior to the thermal shutdown		-	1.2	-	A
Output Turn-on Rise Time		T_R	V_{IN}=3.3V, C_L=1μF, R_{load}=3Ω, V_{OUT} Rise From 10% to 90%		-	1.6	-	ms
			V_{IN}=5.0V, C_L=1μF, R_{load}=5Ω, V_{OUT} Rise From 10% to 90%		-	3.0	-	ms
Output Turn-on Delay Time		$T_{D(ON)}$	C_L=1μF, R_{load}=10Ω, EN 10% ($\overline{EN}$ 90%) to V_{OUT} 10%		-	50	-	us
Output Turn-off Fall Time		T_F	C_L=1μF, R_{load}=10Ω, V_{OUT} Fall From 90% to 10%		-	20	-	us
Output Turn-off Delay Time		$T_{D(OFF)}$	C_L=1μF, R_{load}=10Ω, EN 90% ($\overline{EN}$ 10%) to V_{OUT} 90%		-	10	-	us
Reverse Current Limit		I_{RLIMIT}	V_{IN}= 5V, V_{OUT}= 5.5V -40°C ≤ TA ≤85°C			500		mA
Reverse Over Voltage Protect		V_{ROVP}	V_{OUT} - V_{IN}			150		mV
Reverse Protect Delay Time		T_{PD}				5		mS

❖ ELECTRICAL CHARACTERISTICS (CONTINUOUS)

(V_{IN}=5V, C_{IN}=1uF, C_{OUT}=10uF, T_A = 25°C, unless otherwise specified)

Characteristics	Symbol	Conditions	Min	Typ	Max	Units
FLG Output Resistance	R_{FLG}	I_{SINK}=1mA	-	20	40	Ω
FLG Off Current		$V_{\overline{FLG}}$ = 5V	-	0.01	1	μA
FLG DELAY TIME	T_{Blank}	From Fault Condition to $\overline{FLG}$ assertion	5	15	20	ms
Output Shutdown Discharge Resistance		Disabled	-	100	150	Ω
Thermal Shutdown Threshold	T_{SD}	Enabled	-	150	-	°C
Thermal Shutdown Hysteresis	T_{HYS}	V_{OUT} = 0V	-	20	-	°C

Note 1: Thermal Resistance is specified with approximately 1 square of 1 oz copper.

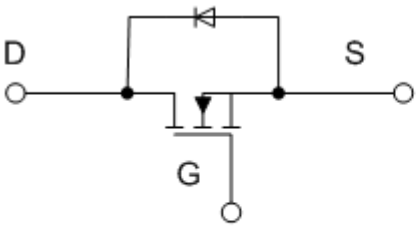
Note 2: 100% production test at +25°C. Specifications over the temperature range are guaranteed by design and characterization. The device is not guaranteed to function outside its operating conditions.

❖ APPLICATION INFORMATION

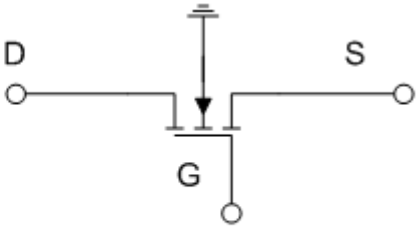
The AX8713/8723 is a single N-MOSFET high-side power switch with enable input, optimized for self-powered and bus-powered Universal Serial Bus (USB) applications. The AX8713/AX8723 series are equipped with a charge pump circuitry to drive the internal N-MOSFET switch; The switch's low Rds(on),70mΩ meets USB voltage drop requirements and a flag output is available to indicate fault conditions to the local USB controller.

Input and Output

V_{IN} (Input) is the power source connection to the internal circuitry and the drain of the N-MOSFET. V_{OUT} (Output) is the source of the N-MOSFET. In a typical application, current flows through the switch from V_{IN} to V_{OUT} toward the load. If V_{OUT} is greater than V_{IN}, current will flow from V_{OUT} to V_{IN} since the MOSFET is bidirectional when on. Unlike a normal MOSFET, there is no a parasitic body diode between drain and source of the MOSFET, the AX8713/8723 prevents reverse current flow if V_{OUT} being externally forced to a higher voltage than V_{IN} when the output disabled (V_{EN} < 0.8V or $V_{\overline{EN}}$ > 2V).



Normal MOSFET



AX8713

Enable

The switch will be disabled when the EN pin is low or $\overline{EN}$ is high. During this condition, the internal circuitry and MOSFET are all turned off and the supply current reduces to 0.1uA typically. Floating the EN/$\overline{EN}$ may cause unpredictable operation. EN should not be allowed to be negative to GND. The EN/$\overline{EN}$ pin may be directly tied to VIN (GND) to keep the part on.

UVLO

Under-Voltage Lockout (UVLO) prevents the power MOSFET from turning on until the input voltage is up to approximately 2.1V. If the input voltage drops blow about 2.0V, UVLO turns off the power MOSFET switch and $\overline{FLG}$ will be asserted accordingly. Under voltage protection is function when the part is enabled.

Soft Start for Hot Plug Application

In order to eliminate the upstream voltage droop caused by the large inrush current during the hot plug events, the soft start feature effectively isolates the power source from extremely large load capacitor, satisfying the USB voltage droop requirement.

Fault Flag

The AX8713/AX8723 series provides a $\overline{FLG}$ signal pin which is an N-Channel open drain MOSFET output. This open drain output goes low when $V_{OUT} < V_{IN} - 1V$, current limit or the die temperature exceeds 150°C approximately. The $\overline{FLG}$ output is typically about 200mV when sinking a 10mA load. A 100K pull up resistor is required at the $\overline{FLG}$ pin. $\overline{FLG}$ Pin will be asserted at the over-current condition after the flag response delay time TD. This ensures that $\overline{FLG}$ is asserted only at the valid over-current conditions and error reporting is eliminated.

Current Limiting and Short-Circuit Protection

The current limit circuitry prevents damage to the MOSFET switch and the hub downstream port but can deliver load current up to the current limit threshold of typically 3.0A through the switch of AX8713/AX8723. When a heavy load or short circuit is applied to an enabled switch, a large transient current may flow until the current limit circuitry responds. Once this current limit threshold is exceeded the device enters constant current mode until the thermal shutdown occurs or the fault is removed.

Thermal Shutdown

Thermal shutdown is employed to protect the device from damage if the die temperature exceeds approximately 150°C. If enabled, the switch automatically restarts when the die temperature falls 20°C. The output and $\overline{FLG}$ signal will continue to cycle on and off until the device is disabled or the fault is removed.

Reverse Current Limit & Reverse over Voltage Protect

The AX8713/23 series provides the reverse current limit(Rlimit) function to clamp the current through MOSFET switch from output side to the input side when output(Vout) is higher than input(V_{IN}) which is caused by external wrong connects. If 0V < (Vout - Vin) < 150mV(typically), the reverse current through the MOSFET switch could be limited to 500mA(typically) until the wrong connects be removed or (Vout - Vin) > 150mV.

In addition to Rlimit, the reverse over voltage protect(Rovp) function also be added in the AX8713/23 series, this function cut off any path from output side to input side and automatic recovery when fault issue be removed.

Input capacitor

A 1uF low ESR ceramic capacitor from V_{IN} to GND, located at the device is strongly recommended to prevent the input voltage drooping during hot-plug events. However, higher capacitor values will further reduce the voltage droop at the input. Furthermore, without the bypass capacitor, an output short may cause sufficient ringing on the input (from source lead inductance) to destroy the internal control circuitry. The input transient must not exceed 6.5V of the absolute maximum supply voltage even for a short duration.

Output capacitor

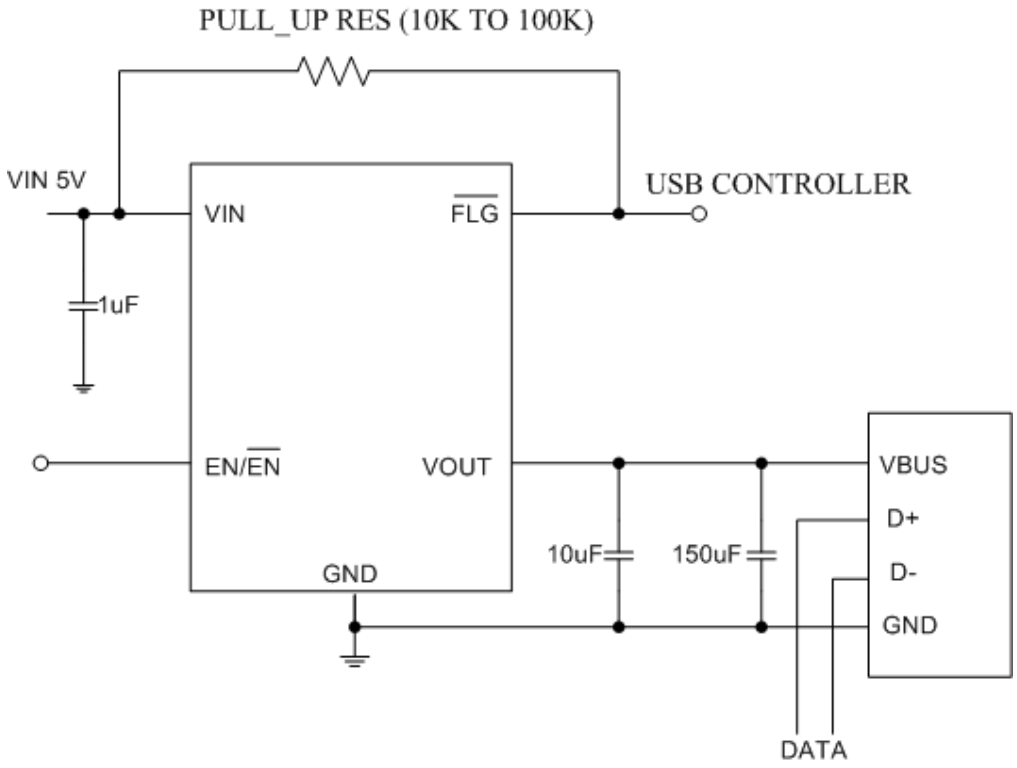
A low ESR 150uF aluminum electrolytic or tantalum between V_{OUT} and GND is strongly recommended to meet the 330mV maximum droop requirement in the hub VBUS (Per USB 2.0, output ports must have a minimum 120uF of low ESR bulk capacitor per hub). Standard bypass methods should be used to minimize inductance and resistance between the bypass capacitor and the downstream connector to reduce EMI and decouple voltage droop caused when downstream cables are hot insertion transients. Ferrite beads in series with VBUS, the ground line and the 0.1uF bypass capacitors at the power connector pins are recommended for EMI and ESD protection. The bypass capacitor itself should have a low dissipation factor to allow decoupling at higher frequencies.

PCB Layout Guide

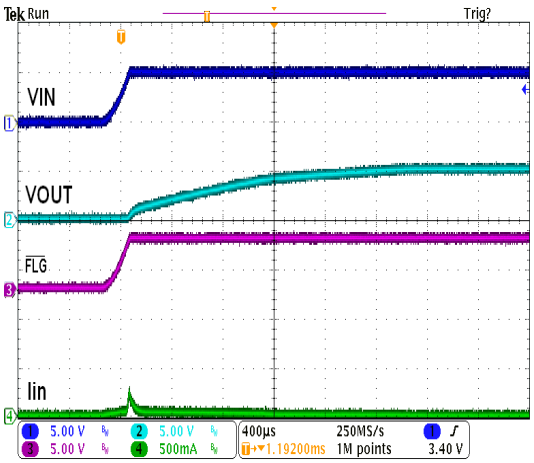
For best performance of the AX8713/AX8723 series, the following guidelines must be strictly followed:

1. Input and output capacitors should be placed close to the IC and connected to ground plane to reduce noise coupling.
2. The GND should be connected to a strong ground plane for heat sink.
3. Keep the main current traces as possible as short and wide.

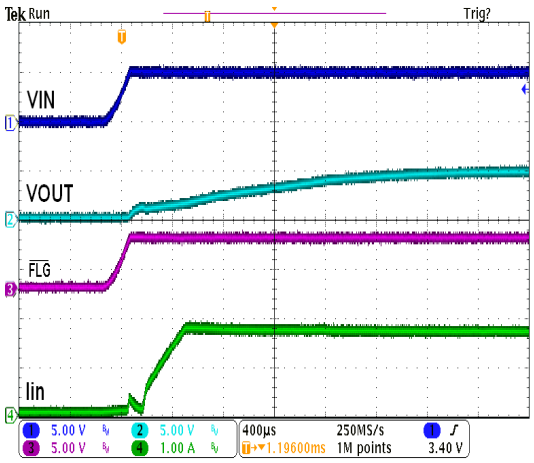
❖ APPLICATION CIRCUIT



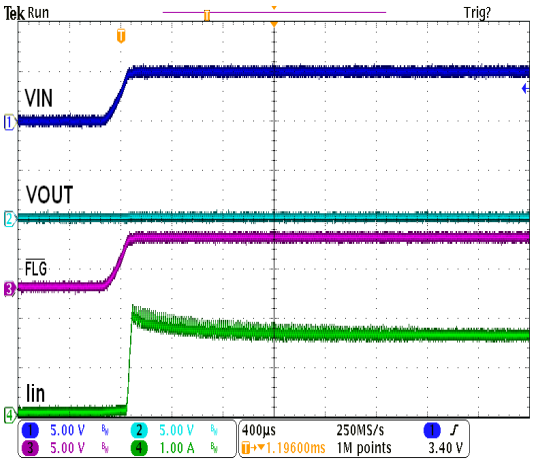
❖ TYPICAL CHARACTERISTICS



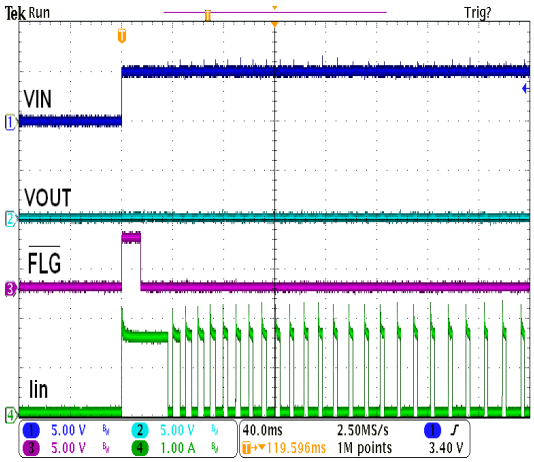
No load power on



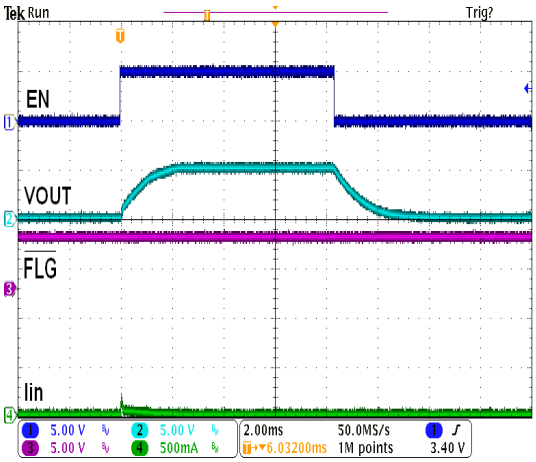
1.7A load power on



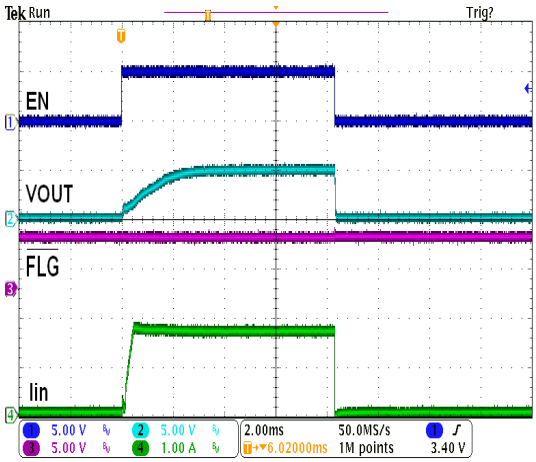
Output short circuit power on



output short circuit & over temperature protection

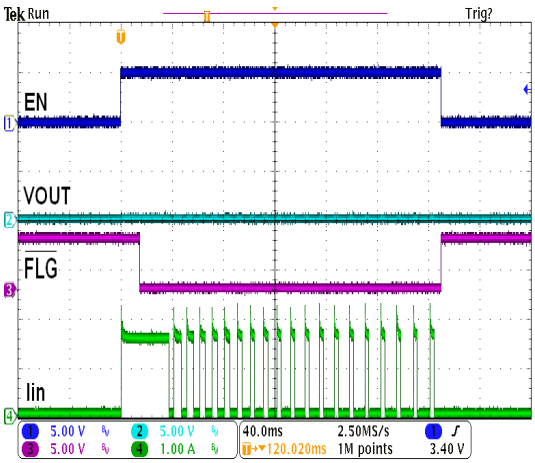


No load enable on/off

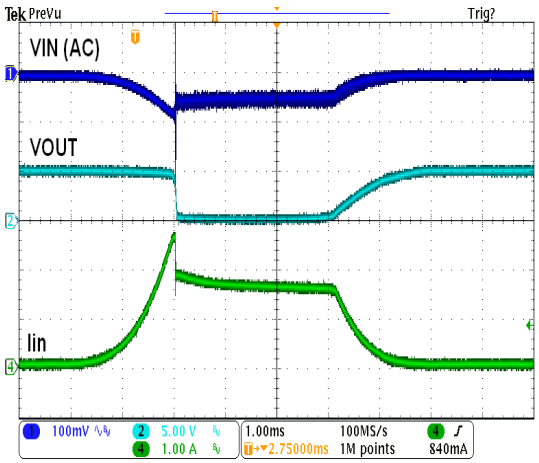


1.7A load enable on/off

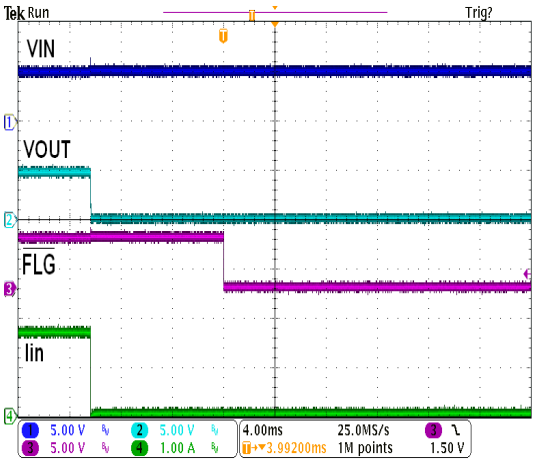
❖ TYPICAL CHARACTERISTICS (CONTINUOUS)



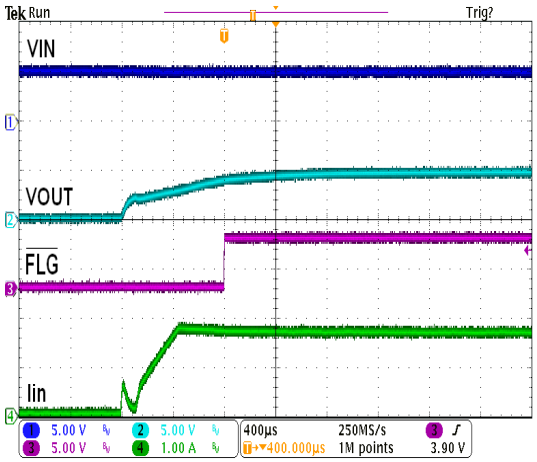
Output short circuit enable on/off



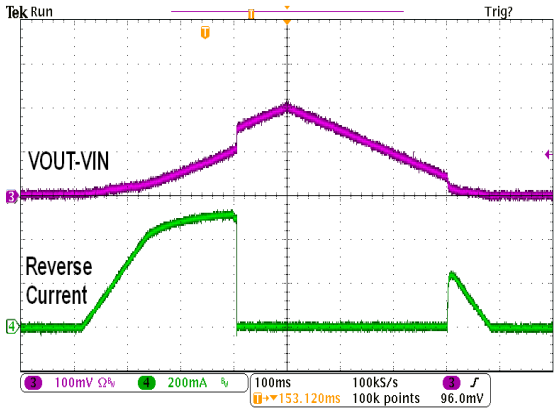
over current & short circuit protection



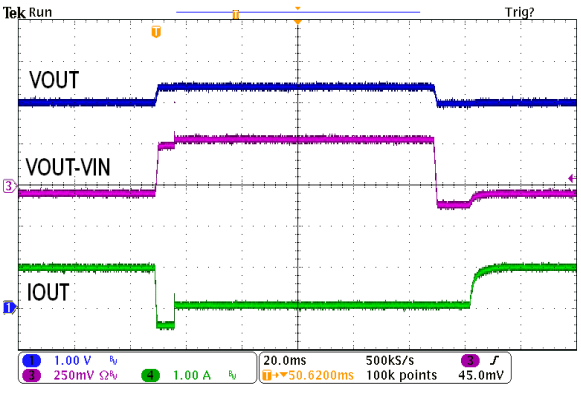
1.7A load thermal shutdown



1.7A load thermal shutdown release



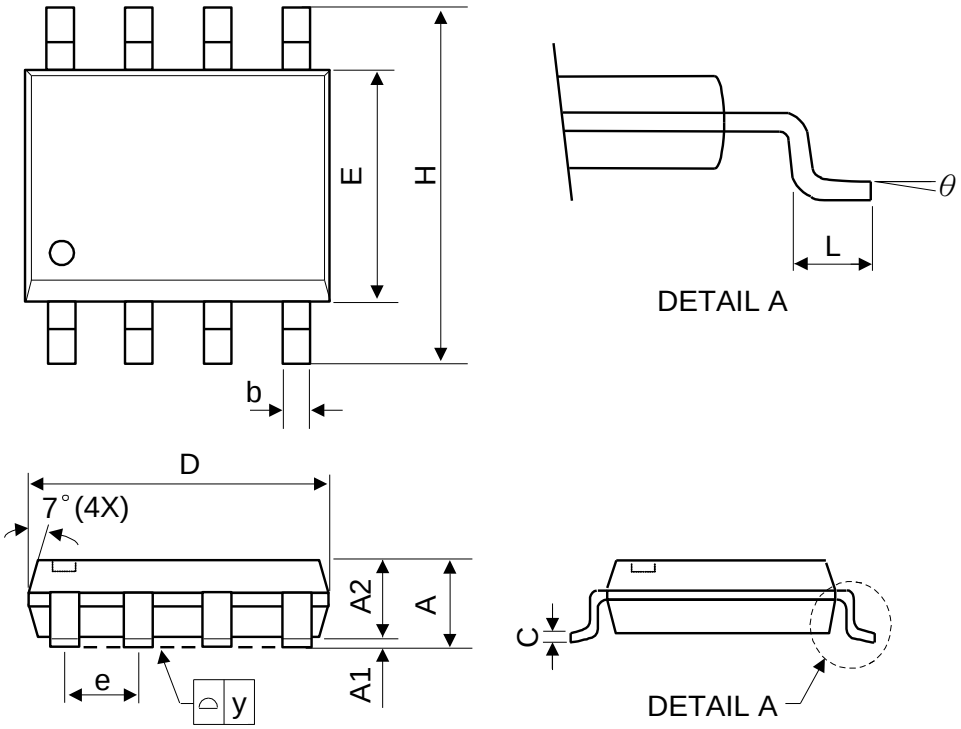
Reverse current protection



Reverse current protection

❖ PACKAGE OUTLINES

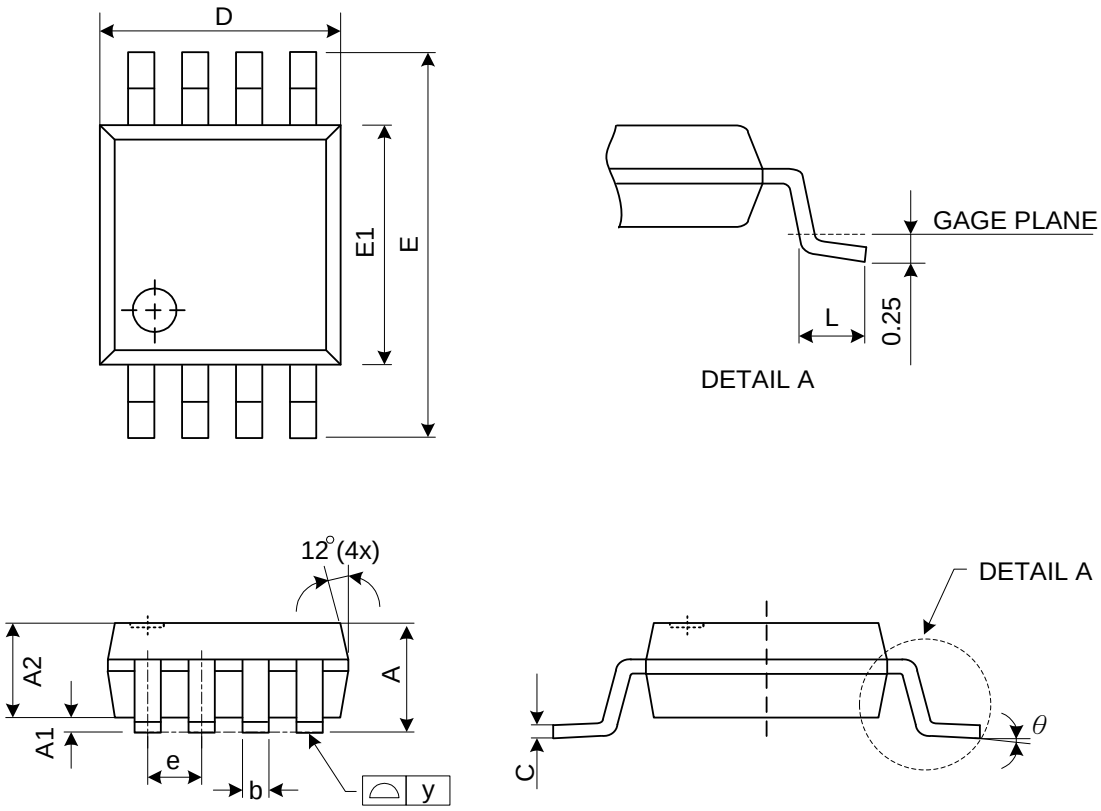
(1) SOP-8L



Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	1.75	-	-	0.069
A1	0.1	-	0.25	0.04	-	0.1
A2	1.25	-	-	0.049	-	-
C	0.1	0.2	0.25	0.0075	0.008	0.01
D	4.7	4.9	5.1	0.185	0.193	0.2
E	3.7	3.9	4.1	0.146	0.154	0.161
H	5.8	6	6.2	0.228	0.236	0.244
L	0.4	-	1.27	0.015	-	0.05
b	0.31	0.41	0.51	0.012	0.016	0.02
e	1.27 BSC			0.050 BSC		
y	-	-	0.1	-	-	0.004
θ	0^{O}	-	8^{O}	0^{O}	-	8^{O}

Mold flash shall not exceed 0.25mm per side
JEDEC outline: MS-012 AA

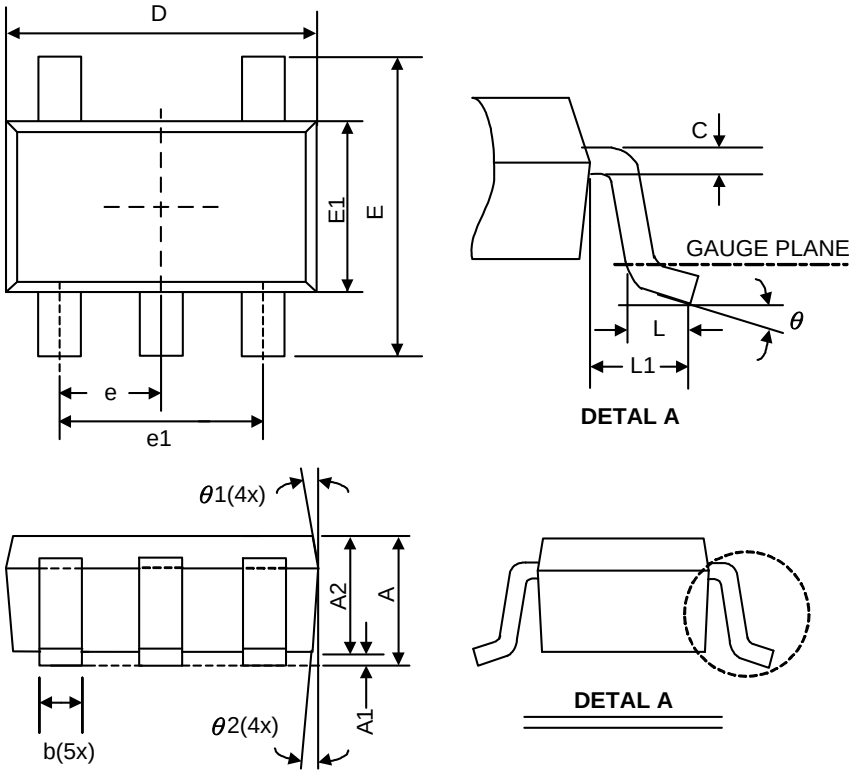
(2) MSOP-8L



Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	1.10	-	-	0.043
A1	0.00	0.08	0.15	0.000	0.003	0.006
A2	0.75	0.85	0.95	0.030	0.033	0.037
b	0.22	0.30	0.38	0.009	0.012	0.015
C	0.08	0.15	0.23	0.003	0.006	0.009
D	2.90	3.00	3.10	0.114	0.118	0.122
E	4.80	4.90	5.00	0.189	0.193	0.197
E1	2.90	3.00	3.10	0.114	0.118	0.122
e	0.65 BSC			0.026 BSC		
L	0.40	0.60	0.80	0.016	0.024	0.031
y	-	-	0.1	-	-	0.004
θ	0°	4°	8°	0°	4°	8°

JEDEC outline: MO-187 AA

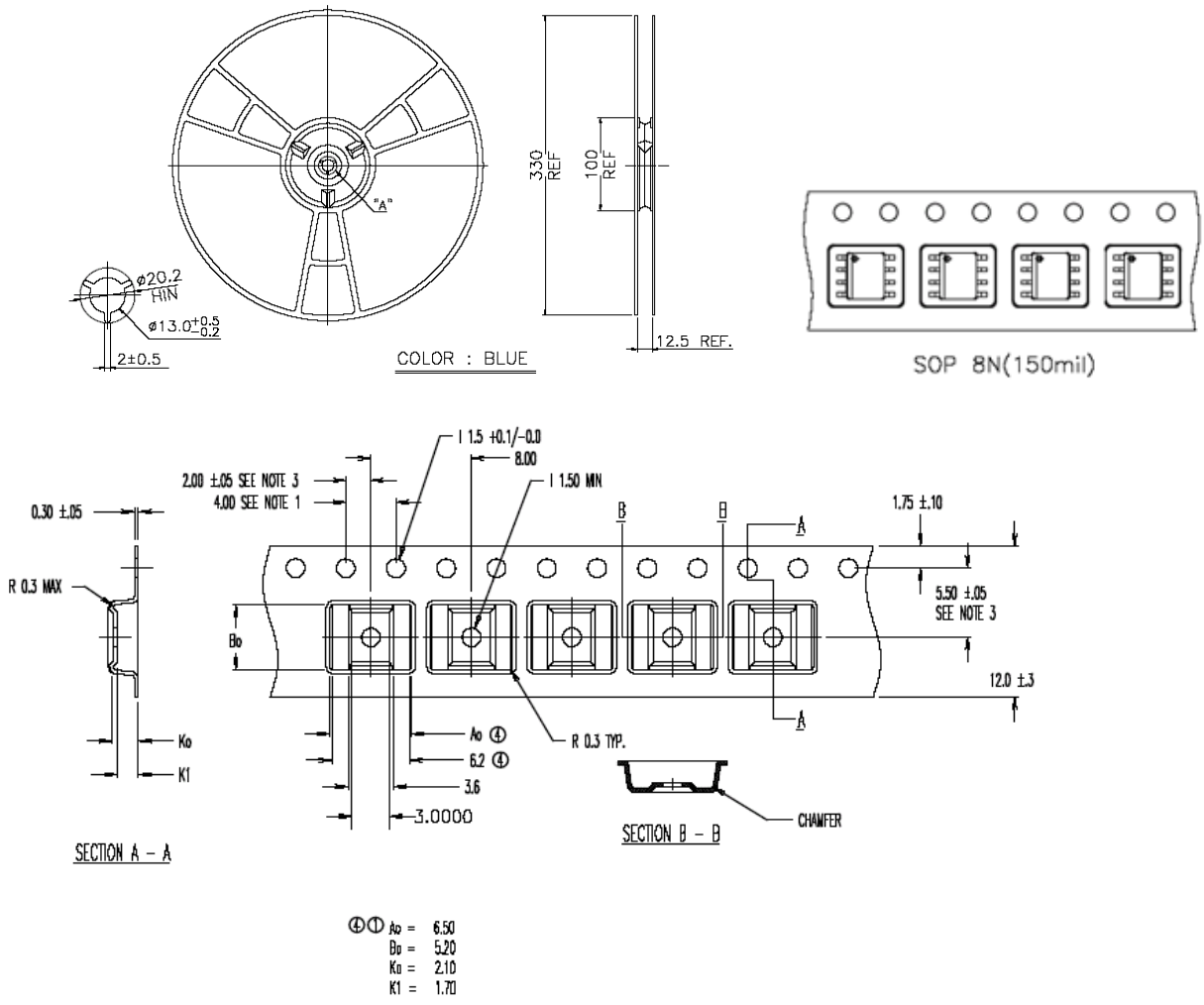
(3) SOT-23-5L



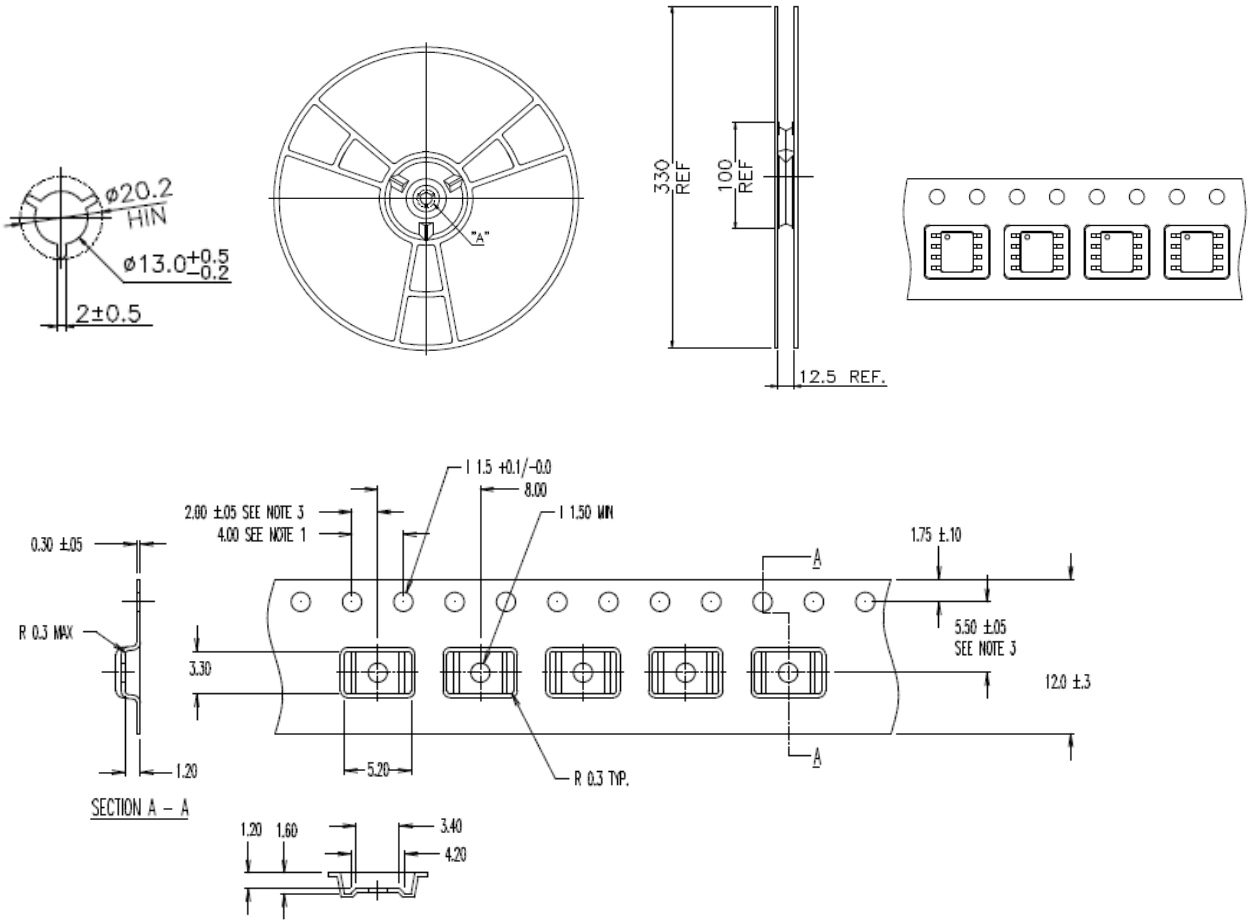
Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	1.45	-	-	0.057
A1	0	0.08	0.15	0	0.003	0.006
A2	0.9	1.1	1.3	0.035	0.043	0.051
b	0.3	0.4	0.5	0.012	0.016	0.02
C	0.08	0.15	0.22	0.003	0.006	0.009
D	2.7	2.9	3.1	0.106	0.114	0.122
E1	1.4	1.6	1.8	0.055	0.063	0.071
E	2.6	2.8	3	0.102	0.11	0.118
L	0.3	0.45	0.6	0.012	0.018	0.024
L1	0.5	0.6	0.7	0.02	0.024	0.028
e1	1.9 BSC			0.075 BSC		
e	0.95 BSC			0.037 BSC		
θ	0°	4°	8°	0°	4°	8°
θ 1	5°	10°	15°	5°	10°	15°
θ 2	5°	10°	15°	5°	10°	15°

JEDEC outline: MO-178 AA

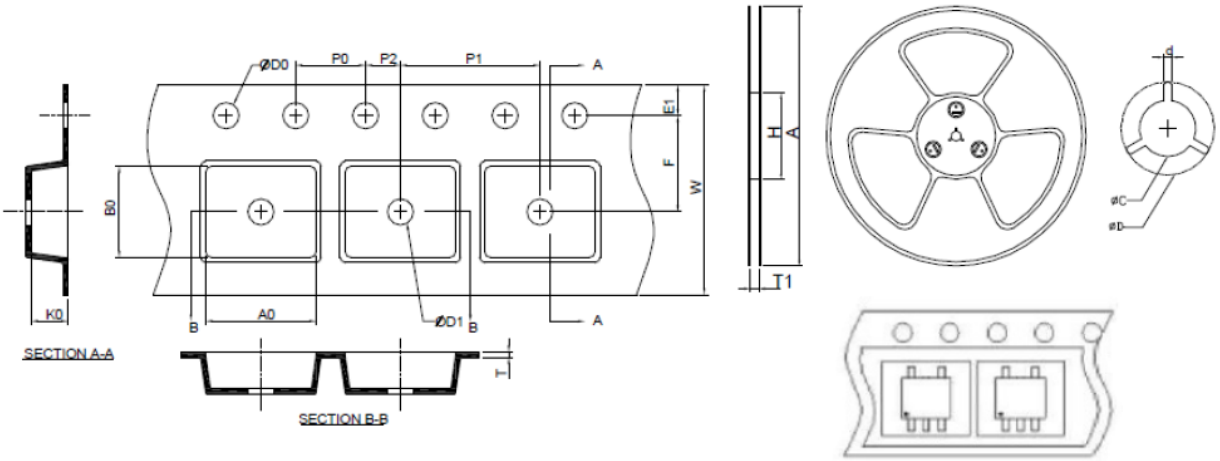
Carrier tape dimension(SOP-8L)



Carrier tape dimension(MSOP-8L)



Carrier tape dimension(SOT-23-5L)



A	H	T1	C	d	D	W	E1	F
178.0±2.00	50 MIN.	8.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	8.0±0.30	1.75±0.10	3.5±0.05
P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
4.0±0.10	4.0±0.10	2.0±0.05	1.5+0.10 -0.00	1.0 MIN.	0.6+0.00 -0.40	3.20±0.20	3.10±0.20	1.50±0.20

(mm)