High Power Factor and Accuracy Constant Current LED Driver

❖ GENERAL DESCRIPTION

The AX9300 is a highly-integrated, low startup current, average current mode, one cycle control PFC and fixed switching frequency PWM controller. These functions enable the LED driver to easily meet the accuracy average LED current and high power factor requirements. The integrated functions also include the LED short protection, open protection, and internal over temperature protection. The COMP pin controls the duty by connected an RC compensation network to ground and forming the closed loop feedback control. To protect the external power MOSFET from being damaged by supply over voltage, the AX9300 OUT pin voltage is clamped to about 15V.

The AX9300 improves the performance and reduces the cost of the LED driver. It is a 6-pin SOT-26 package.

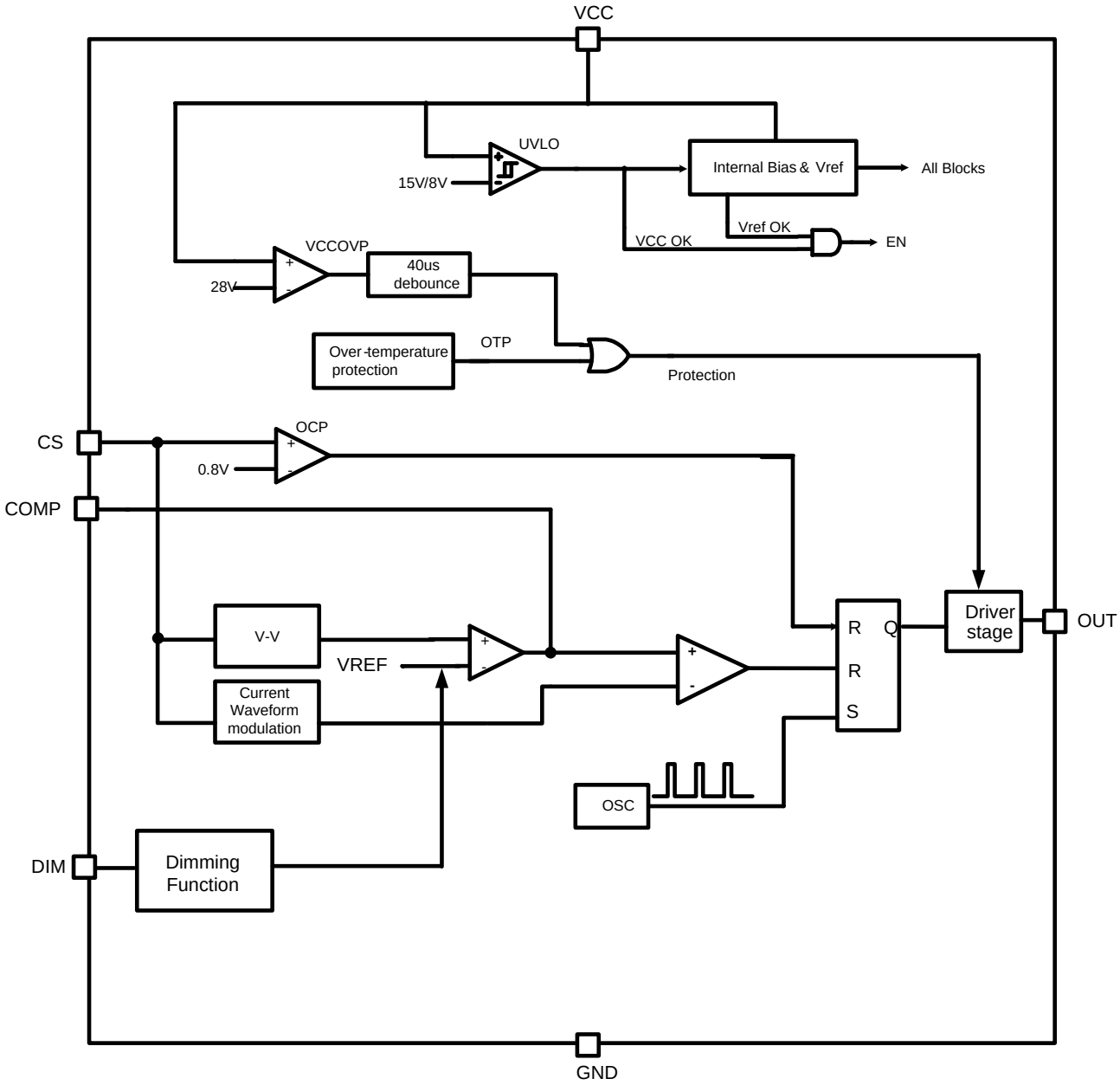
❖ FEATURES

- High Power Factor by One Cycle Control
- Accuracy Constant Current
- Low BOM Cost
- Linear Dimming on DIM Pin
- Average Current / Fixed Frequency Control
- Gate Output Voltage Clamp
- LED Open Protection (OVP)
- LED Short Protection (SCP)
- Over Current Protection (OCP)
- Internal OTP Protection
- 300mA Driving Capability for OUT Pin

❖ APPLICATION

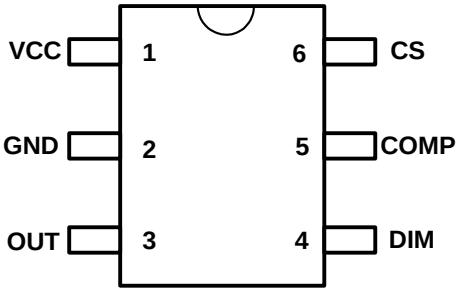
- E26/27, T5/T8 LED Lamp
- Others LED Lighting Applications

❖ BLOCK DIAGRAM



❖ PIN ASSIGNMENT

The package of AX9300 is SOT-23-6L; the pin assignment is given by:



Name	Description
VCC	Power supply pin
GND	Ground pin
OUT	The output driver for driving the external MOSFET
DIM	Dimming control pin by input a DC voltage
COMP	Feedback compensation network
CS	Current sense pin, connect to sense the MOSFET current

❖ ORDER/MARKING INFORMATION

Order Information	Top Marking
AX9300 X X Package Type C: SOT-23-6L Packing A : Taping	11 X X XXX Code 2 Code 1 Serial No.

Code 1	8	9	A	B	• • •	G	H	I	J
Year	2008	2009	2010	2011		2016	2017	2018	2019
Code 2	1	2	3	4		9	A	B	C
Month	Jan.	Feb.	Mar.	Apr.		Sep.	Oct.	Nov.	Dec.

❖ ABSOLUTE MAXIMUM RATINGS (at T_A=25°C)

Characteristics	Symbol	Rating	Unit
Supply voltage	V_{CC}	30	V
DIM, COMP, CS		-0.3 ~ 7	V
OUT		15	V
Junction temperature		150	°C
Operating ambient temperature		-20 ~ 85	°C
Storage temperature range		-65 ~ 150	°C
SOT-26 package thermal resistance (junction to ambient)		250	°C/W
Power dissipation (SOT-26), at ambient temperature		250	mW
Lead temperature (All Pb free packages, soldering, 10 sec)		260	°C
ESD voltage protection, human body model		2	KV
ESD voltage protection, machine model		200	V

Note: θ_{JA} is measured with the PCB copper area of approximately 1 in^2(Multi-layer). That need connect to exposed pad.

❖ ELECTRICAL CHARACTERISTICS

(V_{IN}=15V, T_A=25°C, unless otherwise specified)

Characteristics	Pin	Conditions	Min	Typ	Max	Units
SUPPLY VOLTAGE						
Startup Current	1	(V_{CC}=UVLO on - 1V)	-	8	15	uA
Operating Current	1	(with 1nF load on OUT pin), Vcomp = 2.5V	-	2	3	mA
Operating Current	1	(with 1nF load on OUT pin), Protection Tripped (OCP, OVP, SCP, OTP)	-	0.7	1	mA
UVLO(off)	1		7	8	9	V
UVLO(on)	1		14	15	16	V
OVP Level on VCC Pin	1		26.5	28	29.5	V
OVP De-Bounce Time	1		-	40	-	us
VOLTAGE FEEDBACK						
Feedback Reference Voltage	5		0.196	0.200	0.204	V
Tran-Conductance	5		-	120	-	uS
Output Sink Current	5		-	12	-	uA
Output Source Current	5		-	12	-	uA
CURRENT SENSING						
Input Over Voltage Protection	6		0.7	0.80	0.9	V
Open Loop Voltage, CS Pin Open	6		-	5	-	V
Leading-Edge Blanking Time	6		-	410	-	nS
Delay to Output	6		-	100	220	nS
SWITCHING FREQUENCY						
Switching Frequency	-		42	45	48	KHz
Maximum Duty	-		90	-	-	%
Frequency Jitter Range	-		-	+/-4	-	%
Temp. Stability	-	(-40°C ~ 125°C)	-	-	6	%
Voltage Stability	-	(V_{CC} = 11V~25V)	-	-	1	%

Note: Guarantee by design.

❖ ELECTRICAL CHARACTERISTICS (COUNTINOUS)

Characteristics	Pin	Conditions	Min	Typ	Max	Units
GATE DRIVER OUTPUT						
Rising Time	3	Load Capacitance = 1000pF	-	160	320	nS
Falling Time	3	Load Capacitance = 1000pF	-	80	160	nS
VGATE-Clamp	3	VCC = 25V	-	13.5	15	V
DIM INPUT SECTION						
Saturation Threshold Voltage	4		3.0	-	-	V
Linear Dimming Range	4		0.3	-	3.0	V
LED Current off Threshold Voltage	4		-	-	0.3	V
Current Source	4		290	300	310	uA

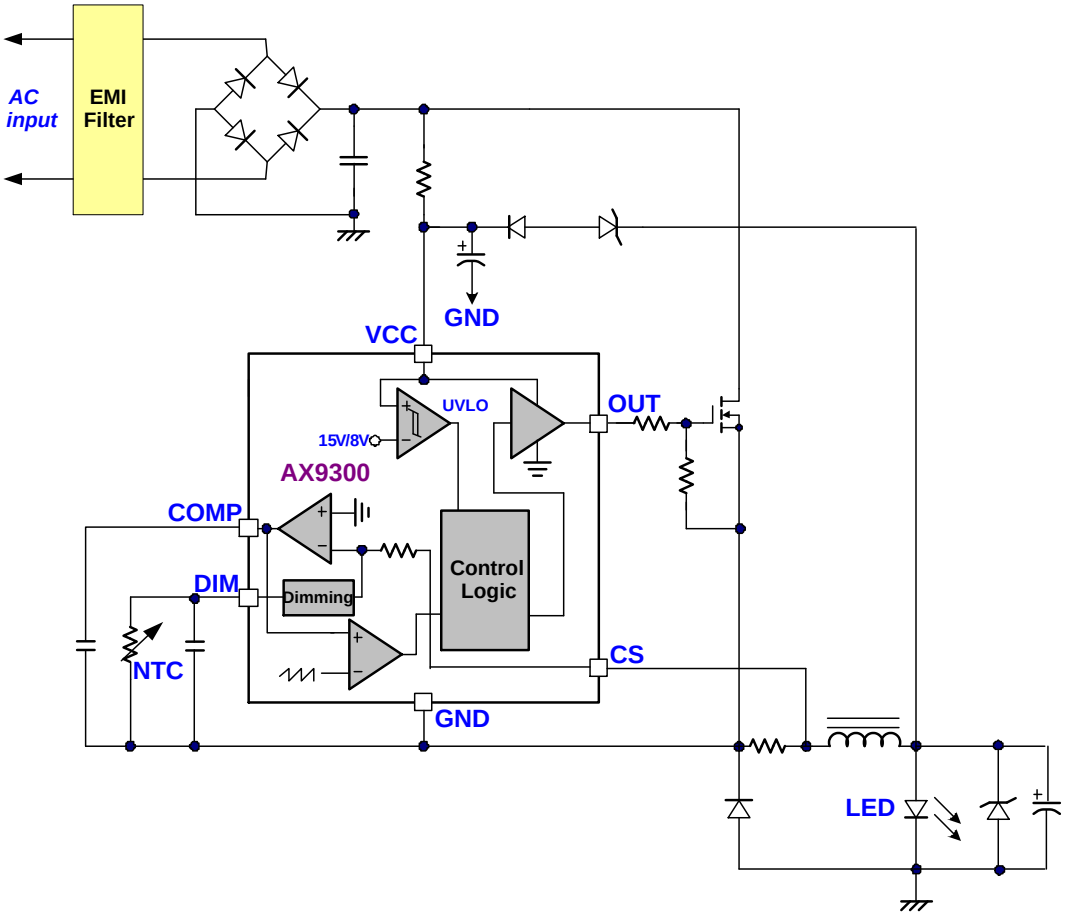
❖ OTP SECTION

Characteristics	Pin	Conditions	Min	Typ	Max	Units
OTP Trip Point	-		140	150	160	°C
OTP Release Point	-		120	130	140	°C
OTP Threshold Level	-			20		°C
OTP De-Bounce Time	-		40	80	120	uS

Note 1: OCP, SCP, OTP: Auto Recovery Type

Note 2: OVP: Auto Recovery Type (Latch off type optional)

❖ APPLICATION CIRCUIT



❖ APPLICATION INFORMATION

Start-up Current

The typical start-up current is around 8uA. Very low start-up current allows the PWM controller to increase the value of start-up resistor and then reduce the power dissipation on it.

UVLO (Under Voltage Lockout)

A hysteresis UVLO comparator is implemented in AX9300, then the turn-on and turn-off thresholds level are fixed at 15V and 8V respectively. This hysteresis shown in Fig.1 ensures that the start-up capacitor will be adequate to supply the chip during start-up. For quickly startup the LED driver, the start-up resistor should be matched with the startup capacitor. Due to the low UVLO on level, so the turn-on delay time will also never greater than the general PWM IC.

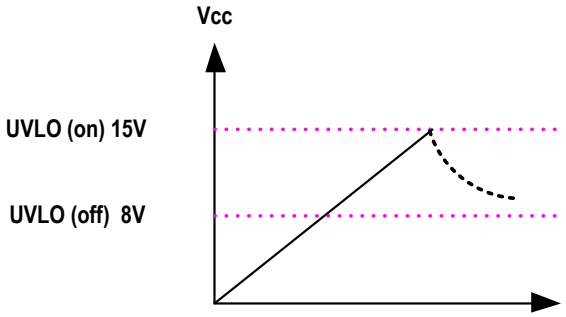


Fig.1

Oscillator

The maximum duty-cycle of internal oscillator is up to 90% for driving high LED voltage string. The frequency of the oscillator is fixed to 45KHz by internal setting.

LEB (Leading-Edge Blanking)

Each time the power MOSFET is switched on, a turn-on spike will inevitably occur at the sense resistor. To avoid fault trigger, a 410ns leading-edge blanking time is built in. Conventional RC filtering can therefore be omitted. During this blanking period, the current-limit comparator is disabled and can't switch off the gate driver.

OCP (Over Current Protection)

The AX9300 has an over current protection function on CS pin. An internal circuit detects the current level, when the current is larger than a threshold level, the gate output will keep on low level. Then VCC decreases below UVLO off level, the controller resets again.

OVP (Over Voltage Protection) on VCC

To prevent the LED driver from being damaged, the AX9300 is implemented an OVP function on VCC. When the VCC voltage is higher than the OVP threshold voltage 28V, the output gate driver circuit will be shut down immediately to stop the switching of power MOSFET. The VCC pin OVP function is an auto recovery type protection (latch off type optional). If the OVP condition happens, the pulses will be stopped and never recovery unless the VCC pin voltage is down to the UVLO off level. The AX9300 is working in an auto-recovery mode as shown in Fig. 2.

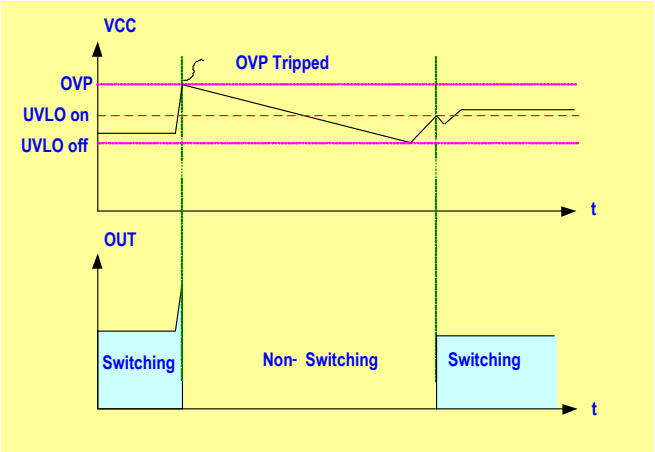


Fig. 2

Gate Clamp/Soft Driving

Driver is clamped to 15V by an internal clamping circuit. Those damages usually come from undesired over-voltage gate signals. Under the conditions listed below, the gate output will turn off immediately to protect the power circuit. The AX9300 also has soft driving function to minimize EMI.

Over Temperature Protection/Dimming Function

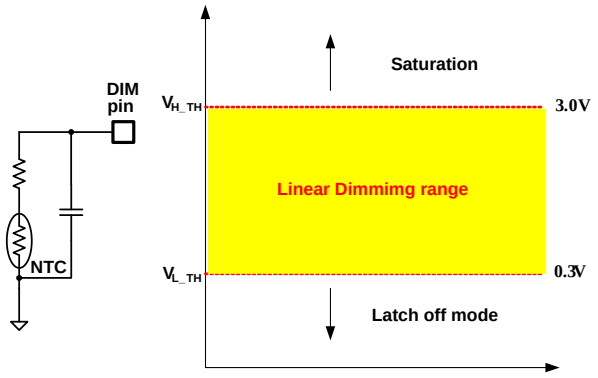
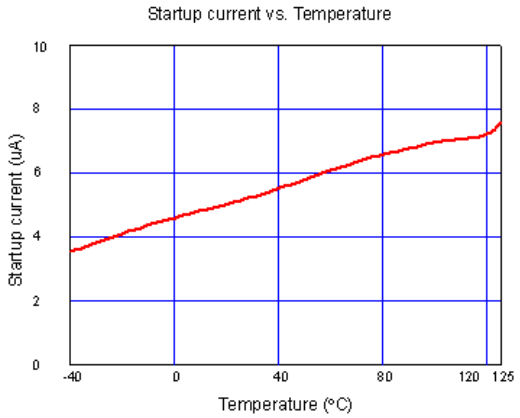
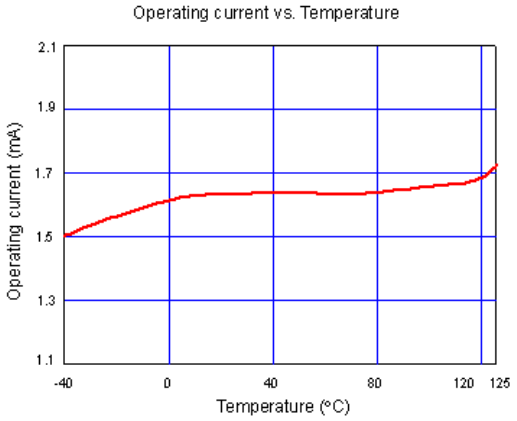


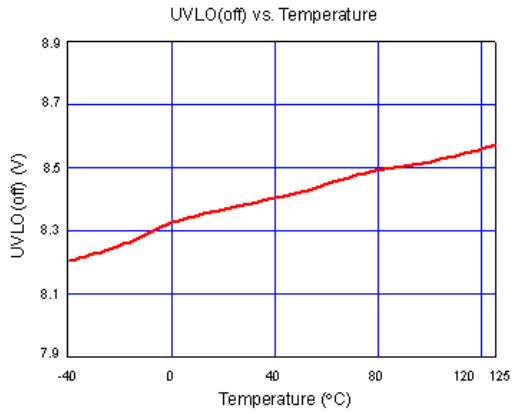
Fig. 3

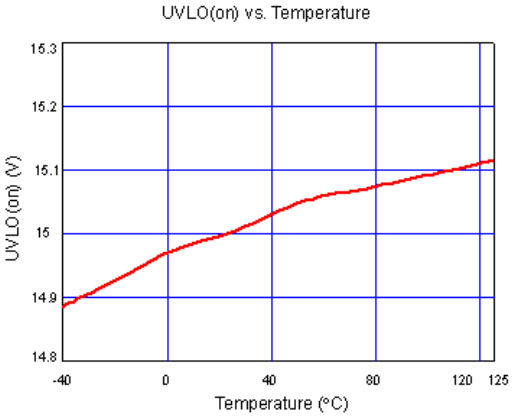
The typical application for DIM pin is shown in Fig. 3. The NTC thermistor is setting as an external OTP protection. In the DIM pin, there is one comparator for latch-off mode protection. While the voltage on this pin is lower than 0.3V, the AX9300 will shut down. When the voltage is in the range of 0.3 to 3.0V, the AX9300 is operating on the linear dimming range. While the voltage is higher than 3.0V, the AX9300 is operating on the normal status. It also could let this Pin open when the function is not required for the user.

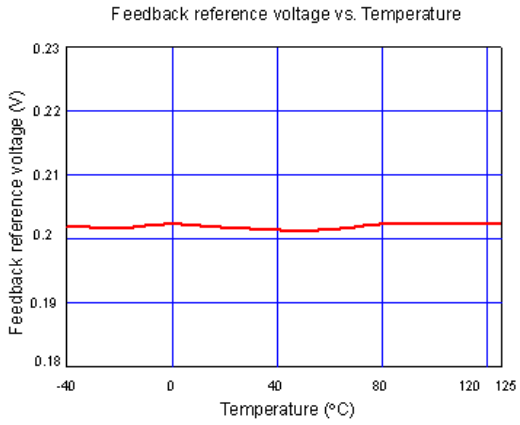
❖ TYPICAL CHARACTERISTICS

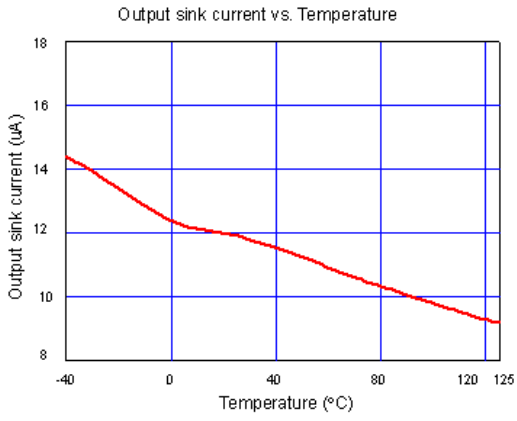




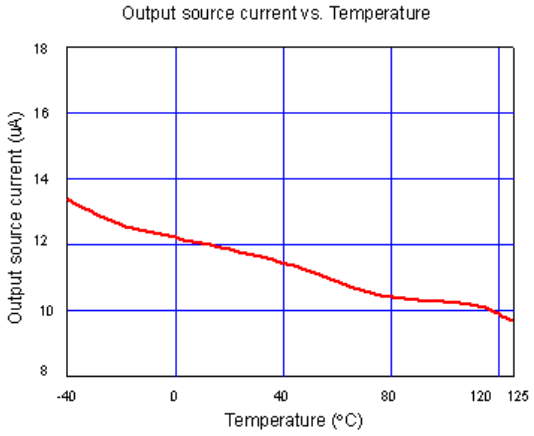


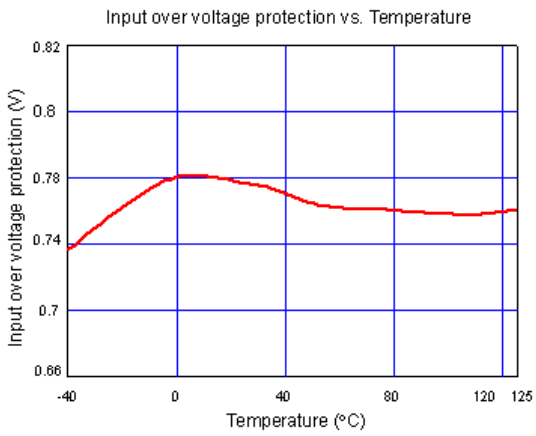


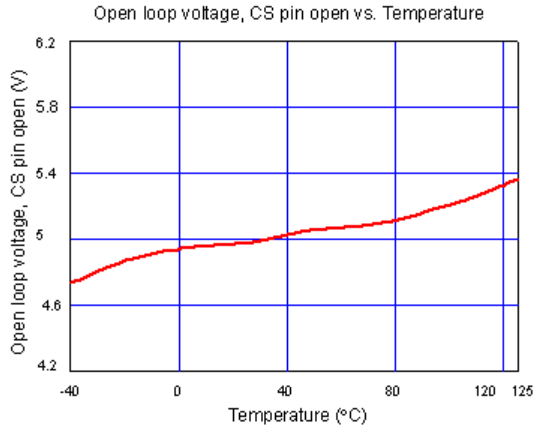


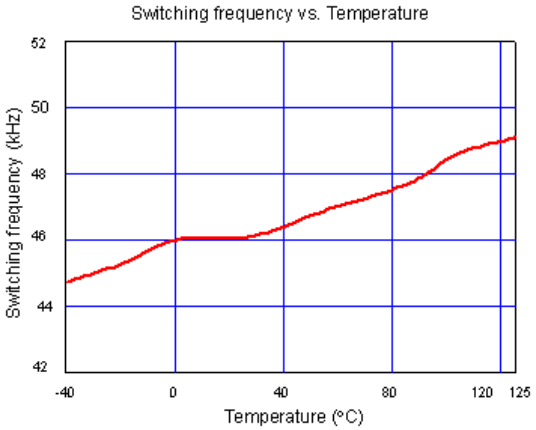


❖ TYPICAL CHARACTERISTICS (COUNTINOUS)

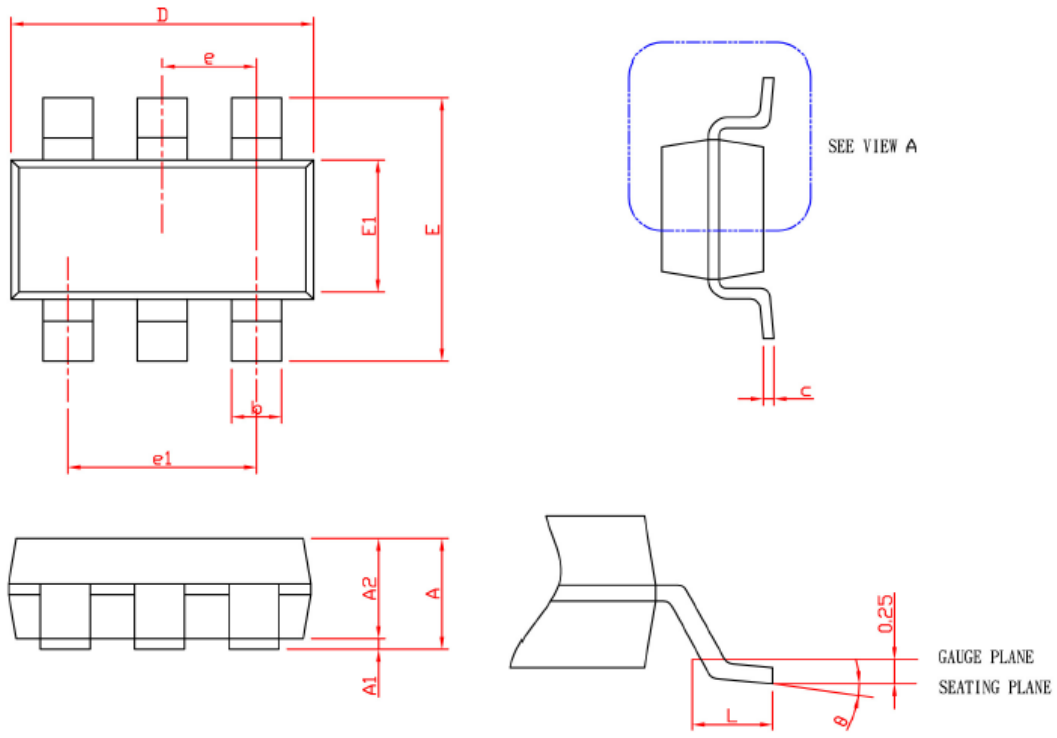






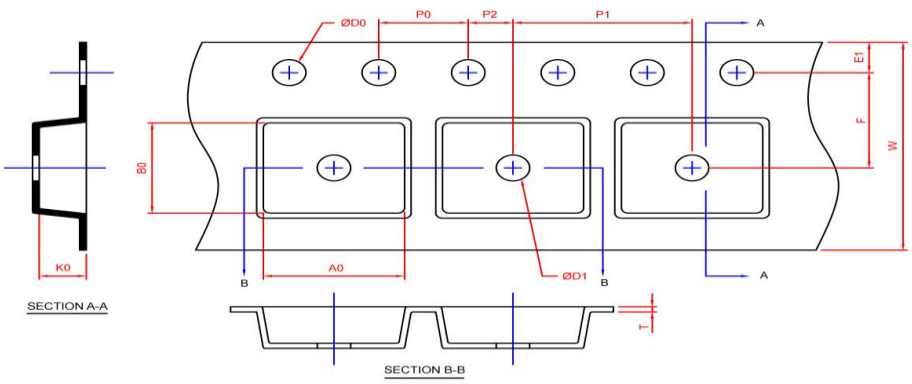


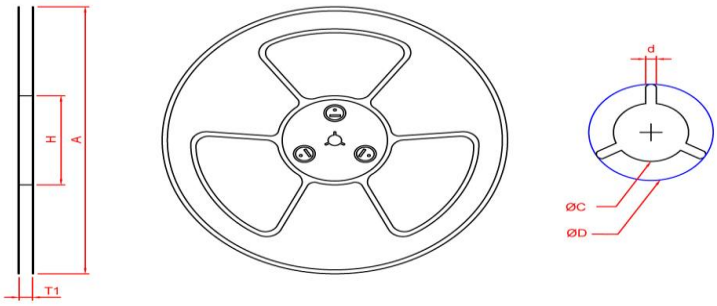
❖ PACKAGE OUTLINES



SYMBOL	SOT-26			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.45		0.057
A1	0.00	0.15	0.000	0.006
A2	0.90	1.30	0.035	0.051
b	0.30	0.50	0.012	0.020
c	0.08	0.22	0.003	0.009
D	2.70	3.10	0.106	0.122
E	2.60	3.00	0.102	0.118
E1	1.40	1.80	0.055	0.071
e	0.95 BSC		0.037 BSC	
e1	1.90 BSC		0.075 BSC	
L	0.30	0.60	0.012	0.024
θ	0°	8°	0°	8°

Carrier Tape & Reel Dimensions





Application	A	H	T1	C	d	D	W	E1	F
SOT-26	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

Application	Carrier Width	Cover Tape Width	Devices Per Reel
SOT -26	8	5.3	3000

Tape and Specification Reel