Description

The HY3110 is a continuous mode inductive step-down converter, designed for driving single or multiple series connected LEDs efficiently from a voltage source higher than the LED voltage. The device operates from an input supply between 7V and 36V and provides an externally adjustable output current of up to 1A. Depending on supply voltage and external components, this can provide up to 10 watts of output power.

The HY3110 includes the output switch and a high-side output current sensing circuit, which uses an external resistor to set the nominal average output current. Output current can be adjusted below the set value, by applying an external control signal to the ADJ pin. The ADJ pin will accept either a DC voltage or a PWM waveform.

The PWM filter provides a soft-start feature by controlling the rise of input/output current. The soft-start time can be increased using an external capacitor from the ADJ pin to ground. Applying a voltage of 0.35V or lower to the ADJ pin turns the output off and switches the device into a low current standby state.

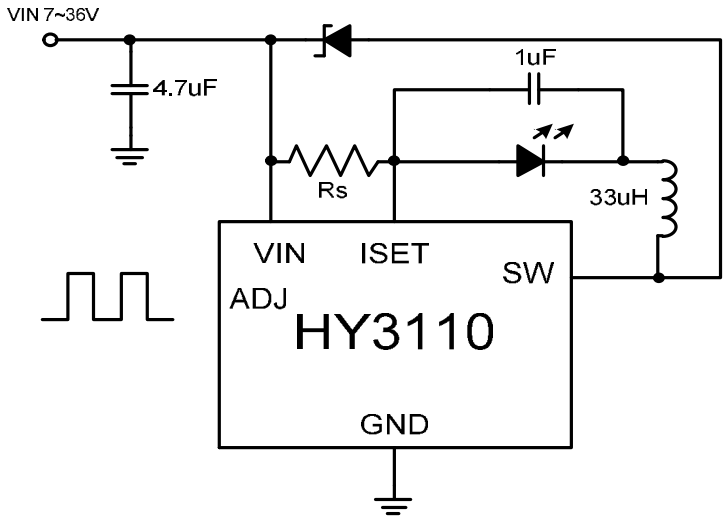
FEATURES

- Wide input voltage range : 7V to 36V
- Simple low parts count
- Internal 40V NDMOS switch
- 1A output current
- Single pin on /off and brightness control Using DC voltage or PWM
- Internal PWM filter
- Soft –start function
- High efficiency (up to 95 %)
- Cycle by cycle current limit
- PFM mode. Switching frequency up to 1.0 MHz
- Inherent open -circuit LED protection
- Typical 4 % output current accuracy
- SOT89-5L , SOP8

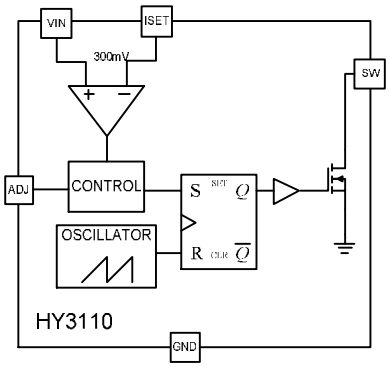
Applications

- Low voltage halogen replacement LEDs
- Automotive lighting
- Low voltage industrial lighting
- MR16 lighting

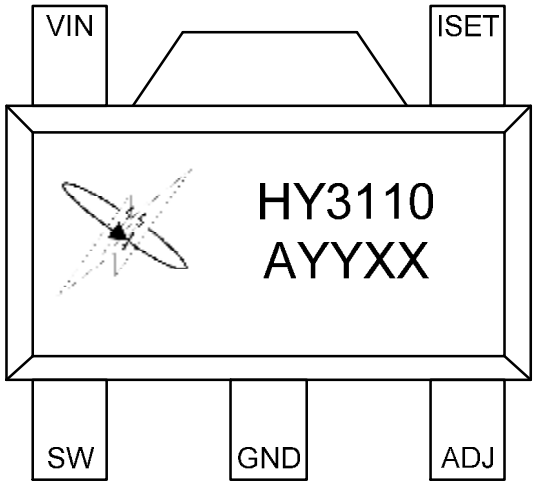
Typical Applications Circuit



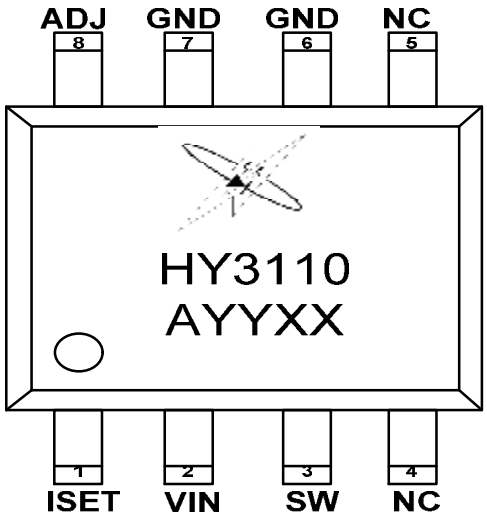
SCHEMATIC DIAGRAM AND PIN DESCRIPTION



1	**SW**	Drain of NDMOS switch
2	**GND**	Ground
3	**ADJ**	Drive with PWM signal from open-collector or open-drain transistor, to adjust output current. Adjustment range 30% to 100% of IOUT nom for f >10KHz and 1% to 100% of IOUT for f < 500Hz .
4	**ISET**	Connect resistor RS from this pin to VIN to define nominal average output current IOUT nom =0.1/Rs
5	**VIN**	Input voltage (7V to 36V). Decouple to ground with 4.7μF or higher X7R ceramic capacitor close to device.



SOT89-5L



SOP-8L

A = ASSEMBLY LOCATION
YY=Yearly
XX=Weekly

ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	VALUE	UNIT
VIN	Supply Voltage	-0.3 to 40	**V**
ADJ	Adjust Voltage	-0.3 to 6	**V**
I_{OUT}	Output Current	1	**A**
T_J	Maximum Junction Temperature	150	℃
T_S	Storage Temperature	-65 to 150	℃
P_D	Power Dissipation	Internally limited	**W**
ESD	ESD Protection HBM	2000	**V**

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	MIN	MAX	UNIT
VIN	Supply Voltage	7	36	**V**
T_A	Ambient Temperature	-40	125	℃

ELECTRICAL CHARACTERISTICS

(VIN = 17V, TA = 25°C, UNLESS OTHERWISE SPECIFIED)

PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNIT
Input Voltage	V_{IN}		**7**		**36**	**V**
Supply Current	I_{CC}	ADJ Pin floating			**5**	**mA**
Shutdown Current	I_{SD}	ADJ to GND, VIN=24V		**40**		**uA**
Under Voltage Lockout	UVLO	VIN Rising		**5.65**		**V**
Under Voltage Lockout hysteresis	△UVLO	VIN Falling		**100**		**mV**
Current Sense Voltage	Vs	VIN - V_{ISET}	**98**		**102**	**mV**
Pin ADJ input High voltage	ADJH	V_{ADJ} Rising	**1.35**			**V**
Pin ADJ input Low voltage	ADJL	V_{ADJ} Falling			**0.25**	**V**
SW switch on resistance	RON	Switching Current @ 1.2A			**0.6**	Ω
SW switch leakage current	ISW	VDD=24V		**5**		**uA**
Soft start time	TSS	Vin=17V, and reach 90% output current		**500**		**uS**
Operating frequency	FREQ	Vi=17V, Vo=9.6V (3 LEDS), L=33μH, I=1.2A		**300**		**KHz**
Max duty circle	DMAX			**100**		**%**
Over temperature protection			**145**		**165**	℃

APPLICATION INFORMATION

Function Description

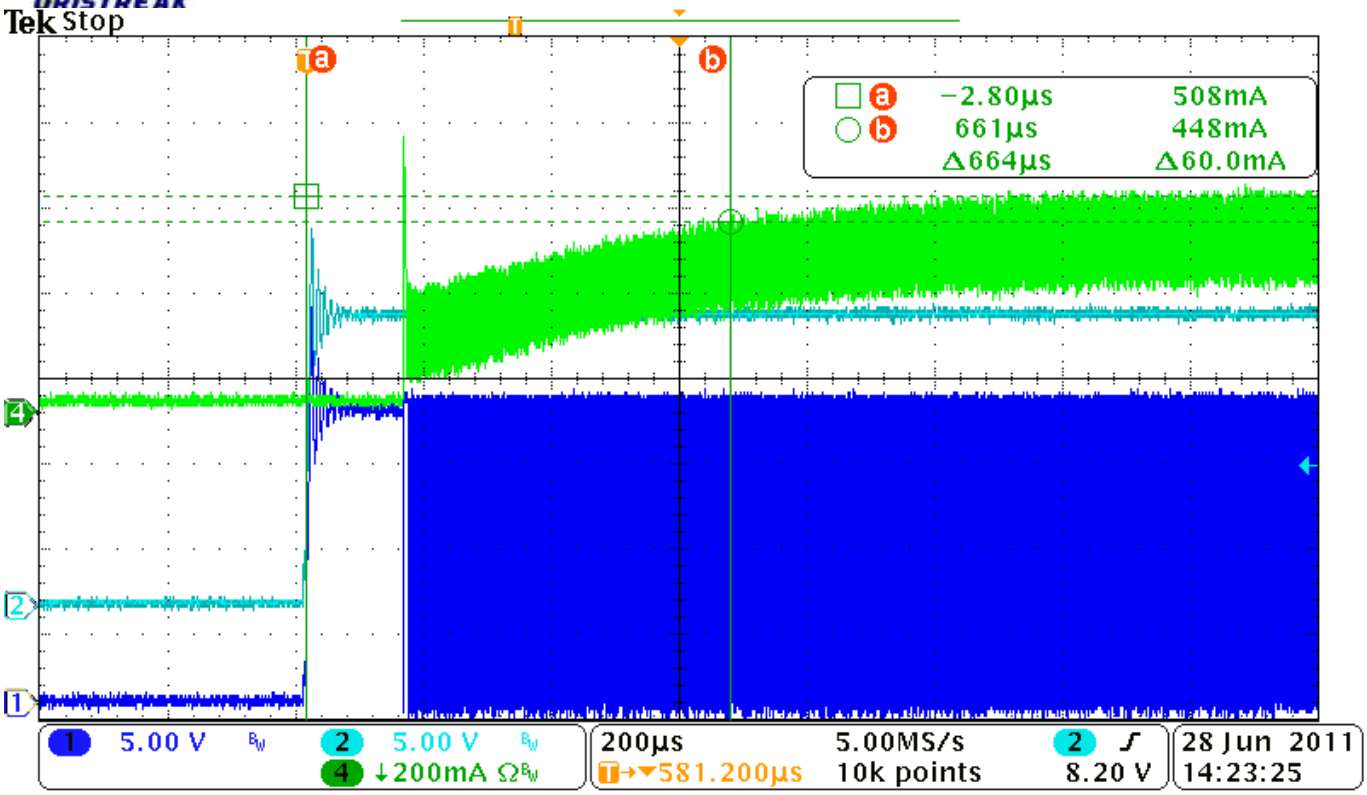
HY3110 in conjunction with the coil (L1) and current sense resistor (RS), forms a self-oscillating continuous-mode buck converter. Operation can be best understood by assuming that the ADJ pin of the device is unconnected and the voltage on this pin (VADJ) appears directly at the (+) input of the comparator.

When input voltage VIN is first applied, the initial current in L1 and RS is zero and there is no output from the current sense circuit. Under this condition, the (-) input to the comparator is at ground and its output is high. This turns internal driver on and switches the LX pin low, causing current to flow from VIN to ground, via RS, L1 and the LED(s). The current rises at a rate determined by VIN and L1 to produce a voltage ramp (VSENSE) across RS. The supply referred voltage VSENSE is forced across internal resistor by the current sense circuit and produces a proportional current in internal resistors. This produces a ground referred rising voltage at the (-) input of the comparator. When this reaches the threshold voltage (VADJ), the comparator output switches low and internal driver turns off. The comparator output also drives another NMOS switch, which bypasses internal resistor to provide a controlled amount of hysteresis. The hysteresis is set by internal resistor to be nominally 15% of VADJ.

When internal driver is off, the current in L1 continues to flow via D1 and the LED(s) back to VIN. The current decays at a rate determined by the LED(s) and diode forward voltages to produce a falling voltage at the input of the comparator. When this voltage returns to VADJ, the comparator output switches high again.

Soft Start

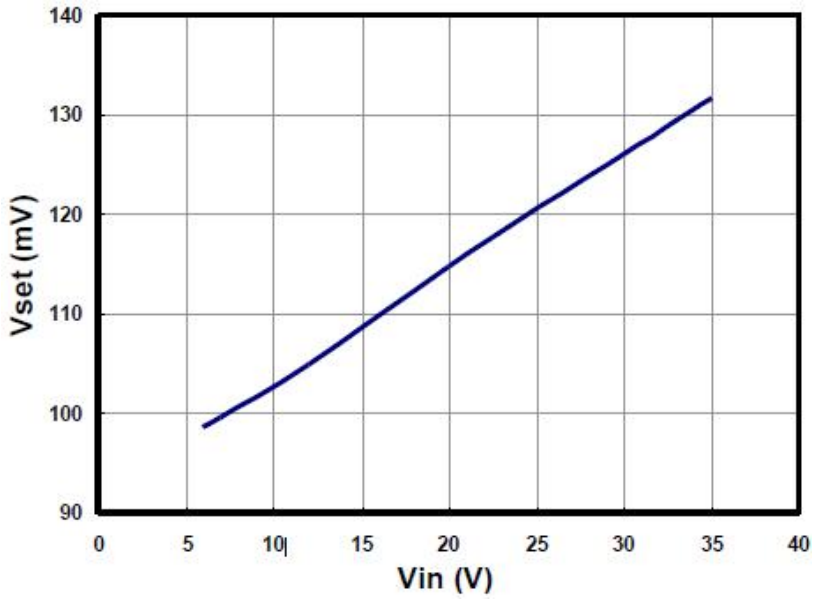
The device has built-in soft-start action due to the delay through the PWM filter, as shown in below figure. An external capacitor from the ADJ pin to ground will provide additional soft-start delay, by increasing the time taken for the voltage on this pin to rise to the turn-on threshold and by slowing down the rate of rise of the control voltage at the input of the comparator. With no external capacitor, the time taken for the output to reach 90% of its final value is approximately 500μs. Adding capacitance increases this delay by approximately 0.5ms/nF. The graph below shows the variation of soft-start time for different values of capacitor.



The soft-start waveform. Vin=17V, ADJ floating. CH1:SW; CH2:Vin; CH4:IL

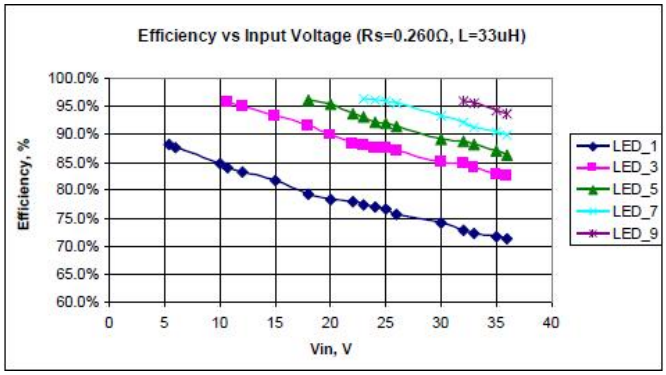
Sense Voltage

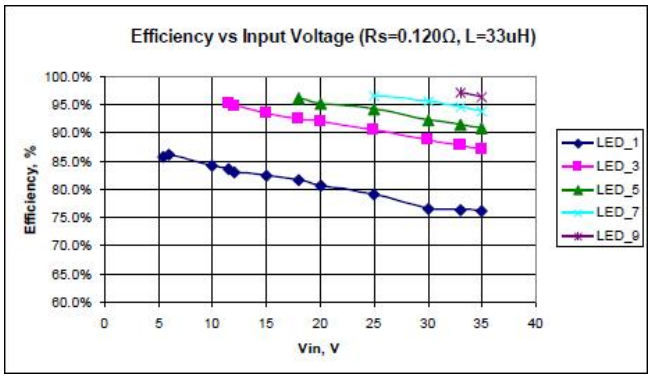
The output current is controlled by the voltage across between IN pin and ISET pin, which referred to be Vset. The output current is equal Vset/Rset. The Vset is designed to be stable at 100mV. The typical curve of Vset as a function of input voltage is shown in below figure.

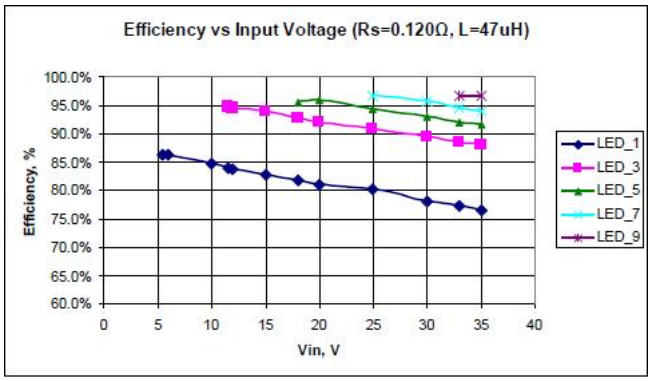


Efficiency

The efficiency of HY3110 is strongly dependent on the number of LEDs. The higher input also decreases the efficiency of this device. The efficiency of HY3110 under different operation conditions is shown in below figures.







Output current setting by Rs

The nominal average output current in the LED(s) is determined by the value of the external current sense resistor (RS) connected between VIN and ISENSE and is given by:

$$IOUTnom = 0.1/RS \text{ [for RS} > 0.1\ \Omega]$$

The table below gives values of nominal average output current for several preferred values of current setting resistor (RS) in the typical application circuit.

RS(Ω)	Nominal average output current (mA)
0.1	1000
0.13	760
0.15	667

The above values assume that the ADJ pin is floating and at a nominal voltage of VREF (=1.25V). Note that RS = 0.1Ω is the minimum allowed value of sense resistor under these conditions to maintain switch current below the specified maximum value.

Linear DC Dimming

The ADJ pin can be driven by an external dc voltage (VADJ) to adjust the output current to a value above or below the nominal average value defined by RS. The nominal average output current in this case is given by:

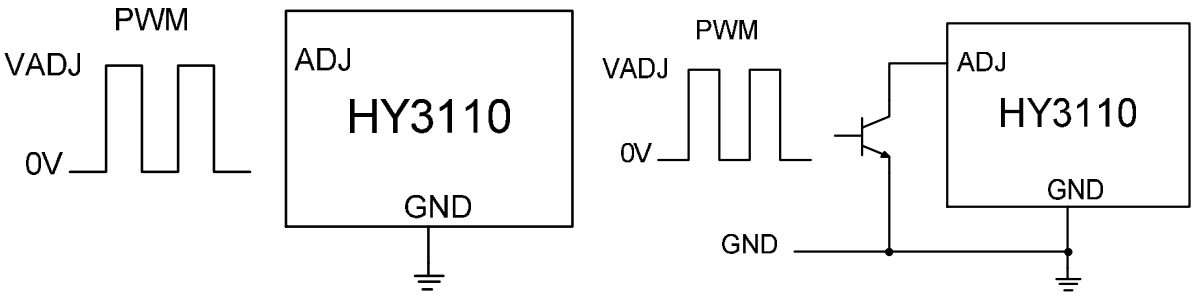
IOUTdc = (VADJ /1.25) x 100mV x RS [for 0.3< VADJ <2.5V]

Note that 100% brightness setting corresponds to VADJ = VREF. When driving the ADJ pin above 1.25V, RS must be increased in proportion to prevent IOUTdc exceeding 1A maximum.

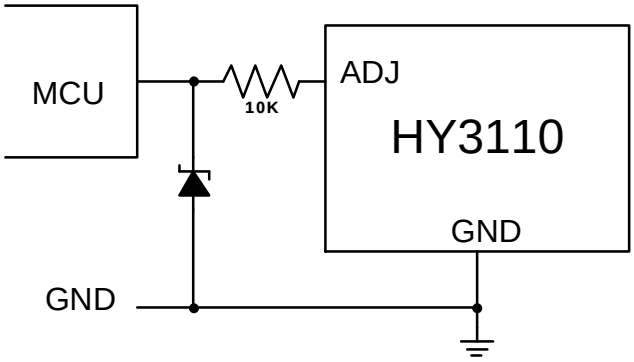
The input impedance of the ADJ pin is 200k□ ±25% for voltages below VREF and 20k □±25% for voltages above VREF +100mV.

PWM dimming

A Pulse Width Modulated (PWM) signal with duty cycle DPWM can be applied to the ADJ pin, as shown in below figures, to adjust the output current to a value above or below the nominal average value set by resistor RS:



The LED intensity can also be controlled with ADJ pin connected to a microcontroller, as connected as in below figure. If the NMOS transistor within the microcontroller has high Drain / Source capacitance, this arrangement can inject a negative spike into ADJ input and cause erratic operation but the addition of a Schottky clamp diode (cathode to ADJ) to ground and inclusion of a series resistor (10K) will prevent this issue.



The PWM signal frequency can be as low frequency (<500Hz) and also high frequency (>10KHz). At the low frequency, the ADJ waveform can follow the PWM signal since the low pass filter frequency is higher than this frequency. However, at high PWM frequency, the low pass filter can't follow such high frequency, such that the output of low pass filter will see a DC voltage which depends on the duty cycle of the high frequency PWM signal.

Capacitor Selection

A low ESR capacitor should be used for input decoupling, as the ESR of this capacitor appears in series with the supply source impedance and lowers overall efficiency. This capacitor has to supply the relatively high peak current to the coil and smooth the current ripple on the input supply. A minimum value of 4.7uF is acceptable if the input source is close to the device, but higher values will improve performance at lower input voltages, especially when the source impedance is high. The input capacitor should be placed as close as possible to the IC.

For maximum stability over temperature and voltage, capacitors with X7R, X5R, or better dielectric are recommended. Capacitors with Y5V dielectric are not suitable for decoupling in this application and should NOT be used.

Inductance Selection

Recommended inductor values for the HY3110 are in the range 33uH to 100uH. Higher values of inductance are recommended at higher supply voltages in order to minimize errors due to switching delays, which result in increased ripple and lower efficiency. Higher values of inductance also result in a smaller change in output current over the supply voltage range. The inductor should be mounted as close to the device as possible with low resistance connections to the LX and VIN pins.

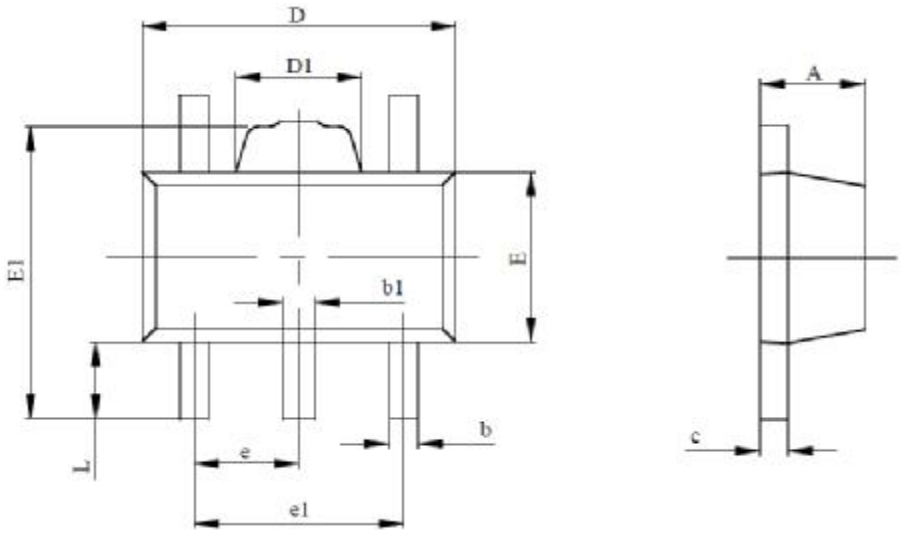
Diode selection

For maximum efficiency and performance, the rectifier (D1) should be a fast low capacitance Schottky diode with low reverse leakage at the maximum operating voltage and temperature. They also provide better efficiency than silicon diodes, due to a combination of lower forward voltage and reduced recovery time.

The higher forward voltage and overshoot due to reverse recovery time in silicon diodes will increase the peak voltage on the LX output. If a silicon diode is used, care should be taken to ensure that the total voltage appearing on the LX pin including supply ripple, does not exceed the specified maximum value.

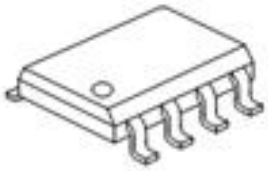
Package Outline Dimensions

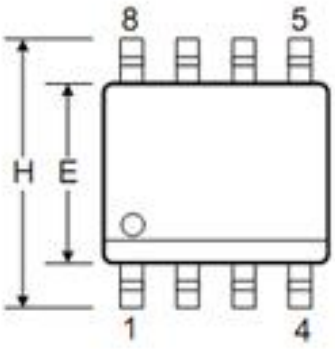
SOT89-5L



SYMBOL	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.400	1.600	0.055	0.063
b	0.320	0.520	0.013	0.020
b1	0.360	0.560	0.014	0.022
c	0.350	0.440	0.014	0.017
D	4.400	4.600	0.173	0.181
D1	1.400.	1.800	0.055	0.071
E	2.300	2.600	0.091	0.102
E1	3.940	4.250	0.155	0.167
e	1.500 TYP.		0.060 TYP.	
e1	2.900	3.100	0.114	0.122
L	0.900	1.100	0.035	0.043

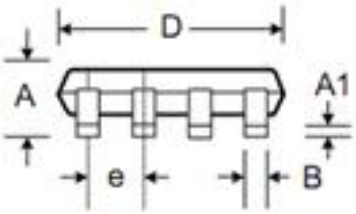
SOP-8L

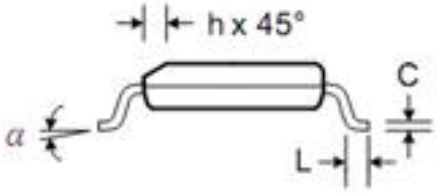




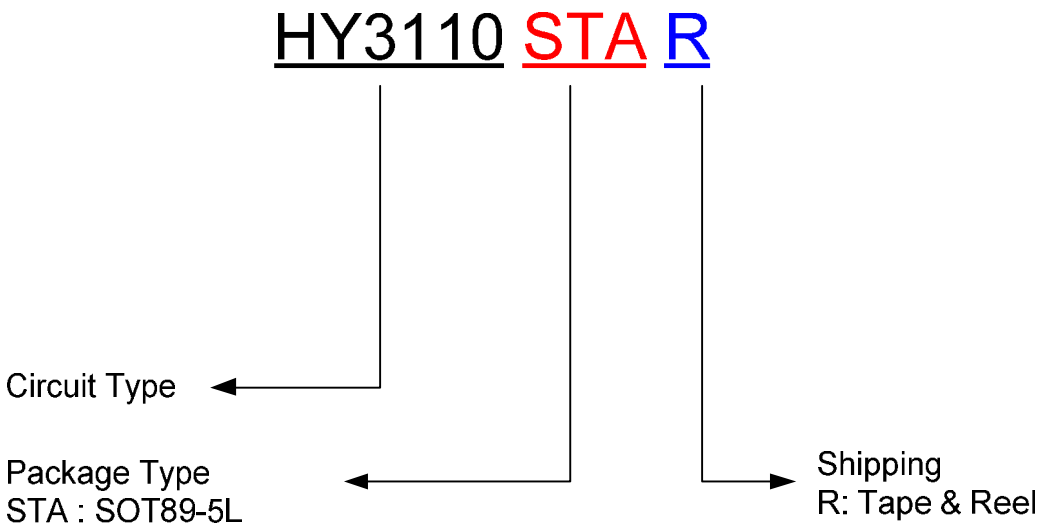
DIMENSIONS

Symbol	Millimeters	
	Min.	Max.
A	1.35	1.75
A1	0.10	0.25
B	0.33	0.50
C	0.19	0.20
D	4.80	5.00
E	3.81	4.00
e	1.25BSC	
H	5.80	6.00
h	0.25	0.50
L	0.40	0.50
α	0°	8°





ORDERING INFORMATION



ORDERING REMEMBER	OUTPUT VOLTAGE	PACKAGE	SHIPPING
HY3110STAR	N/A	SOT89-5L	3,000 Units/ Tape & Reel
HY3110S8R	N/A	SOP-8L	2,500 Units/ Tape & Reel