

General Description

The TD1539 is a simple controller designed for use in Boost, SEPIC or flyback topologies that needs an external low-side NMOSFET acting as primary switch. Besides cycle-by-cycle current limiting, current mode control scheme also makes it wide bandwidth and good transient response. The current limit can be programmed simply with an external resistor.

The switching frequency can be set in any value between 100kHz and 1MHz with a resistor external clock source. The TD1539 can be operated at high switching frequency to save the solution board size.

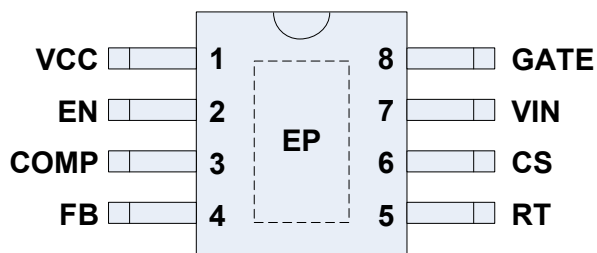
TD1539 built-in protection circuits such as thermal shutdown, under-voltage lockout, short circuit protection, and overvoltage protection.

The controller is available in an ESOP-8 package.

Features

- Wide supply voltage operating range: 2.8V-40V
- Adjustable switching frequency: 100kHz-1MHz
- Programmable switching MOSFET over current threshold
- External RC Compensation
- Input under voltage and over temperature protection
- Available in an ESOP-8 Package

Pin Configurations



(Top view)

Applications

- Portable Speakers
- Chargers
- Power Bank
- Battery Powered Device
- High-power Emergency Power Supply

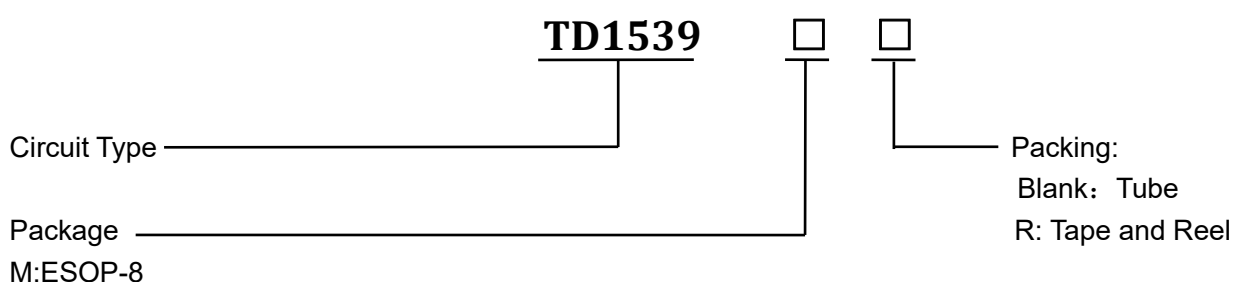
2.8V to 40V Input Asynchronous Boost Controller

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Pin Description

Pin Number	Pin Name	Description
1	VCC	Drive Supply Voltage.
2	EN	Chip Enable pin.
3	COMP	Compensation. Use a RC/C network to do proper loop compensation.
4	FB	Output Feedback.
5	RT	Frequency Adjust. A resistor connected from this pin to ground simply sets the oscillator frequency.
6	CS	MOSFET Switch Current Sense.
7	VIN	Power Supply Input.
8	GATE	Gate Driver Output.
EP	PGND	Power Ground (Exposed PAD) -Must connect to Ground.

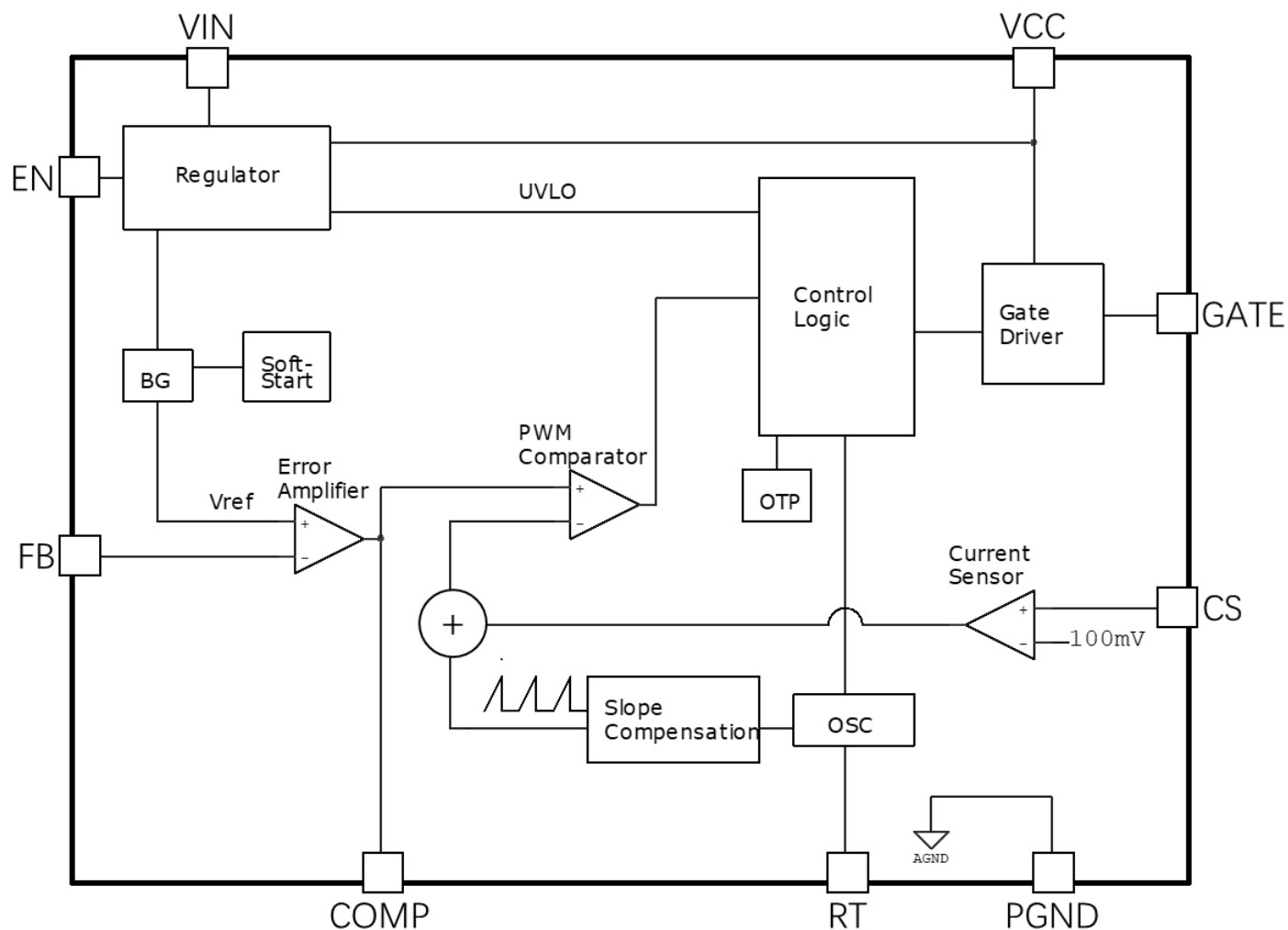
Ordering Information



2.8V to 40V Input Asynchronous Boost Controller

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Functional Block



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Absolute Maximum Ratings (Note1)

Symbol	Parameter	Rating	Unit
V _{IN}	Power supply voltage	-0.3 to 45	V
V _{CC} /V _{GATE}	VCC/GATE Voltage	7	V
	Others Pin Voltage	6	V
	Moisture Sensitivity Level (MSL)	MSL3	
T _A	Ambient Operating Temperature	-25 ~ 125	°C
T _J	Junction Temperature	-40 ~ 150	°C
T _{STG}	Storage Temperature	-40 ~ 150	°C

Note1: Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Recommended Operation Conditions (Note2)

Symbol	Parameter	Range	Unit
V _{IN}	Supply voltage	+5 to +40	V
V _{CC} /V _{GATE}	VCC/GATE Voltage	5	V
T _A	Operating Temperature Range	-25 ~ 85	°C

Note 2: Refer to the typical application circuit

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Electrical Characteristics

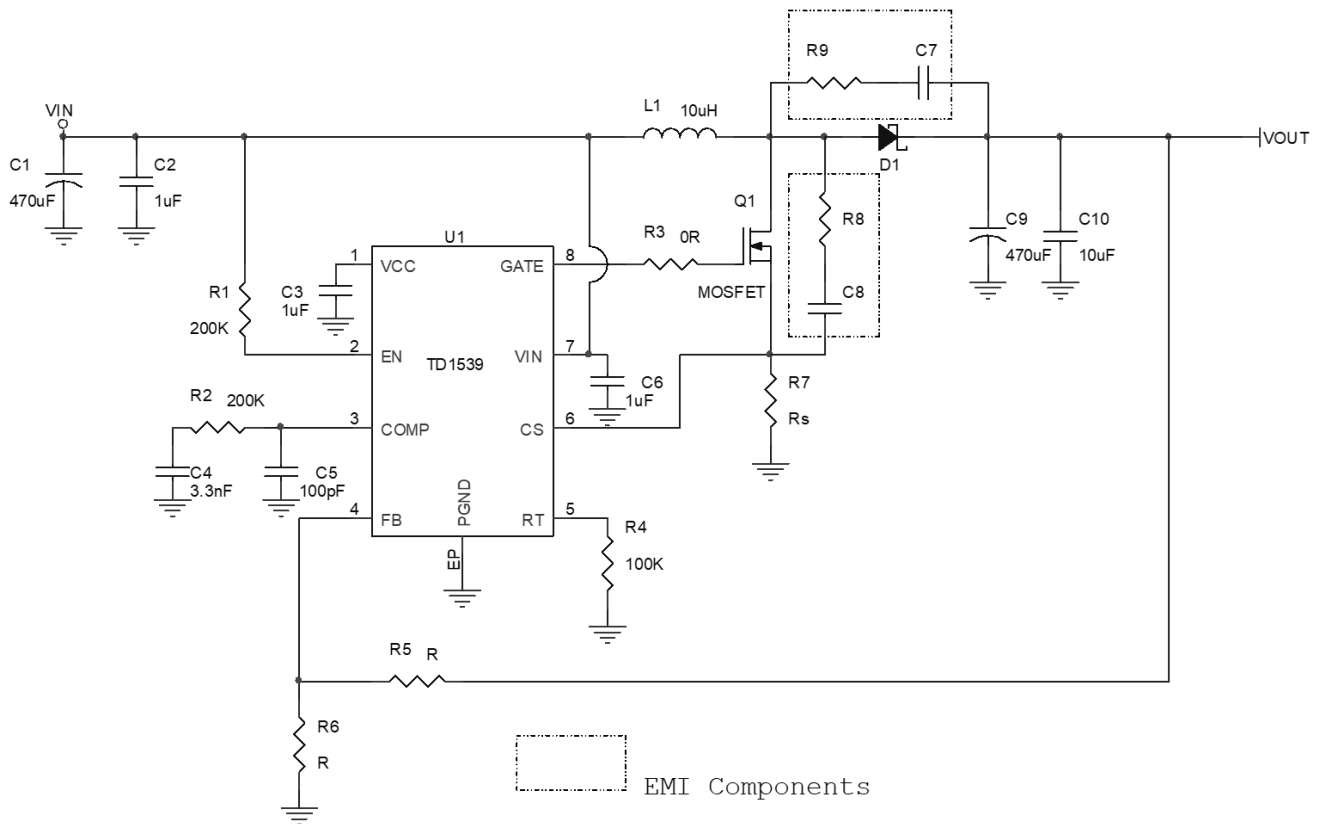
$T_A = +25^{\circ}\text{C}$, $V_{IN}=12\text{V}$ and $V_{EN}=2\text{V}$, unless otherwise specified.

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V _{IN}	Start-up Voltage			2.8		V
V _{IN}	Input Supply Voltage		2.8		40	V
V _{UVLO}	Under Voltage Lockout		-	2.5	-	V
	UVLO Hysteresis		-	0.2	-	V
I _{CC}	Average Current	FB=1.0V, Switching	-	0.6	-	mA
I _{CC}	Quiescent Current	FB=1.3V, No Switching	-	400	-	μA
I _{CC}	Shutdown Current	V _{EN} =0V, V _{IN} =5V	-	20	-	μA
V _{CC}	VCC Regulator Voltage		-	5	-	V
F _{OSC}	Operation Frequency	RT=NC	-	160	-	kHz
		RT=51kΩ	-	300	-	kHz
	Maximum Duty Ratio	FB=1V, R _t =51K Ω	-	97	-	%
V _{FB}	Feedback Voltage	V _{IN} =12V	-	1.2	-	V
V _{EN}	Enable Voltage		-	0.9	-	V
R _{EXTH}	EXT Pull-Up Resistance	V _{DS} =8V	-	1.0	-	Ω
R _{EXTL}	EXT Pull-Down Resistance	V _{DS} =8V	-	0.5	-	Ω
V _{CS}	Sense Voltage		-	100	-	mV
T _{TS}	Thermal Shutdown Threshold		-	150	-	°C
T _{TSH}	Thermal Shutdown Threshold Hysteresis		-	30	-	°C

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Typical Application Circuit

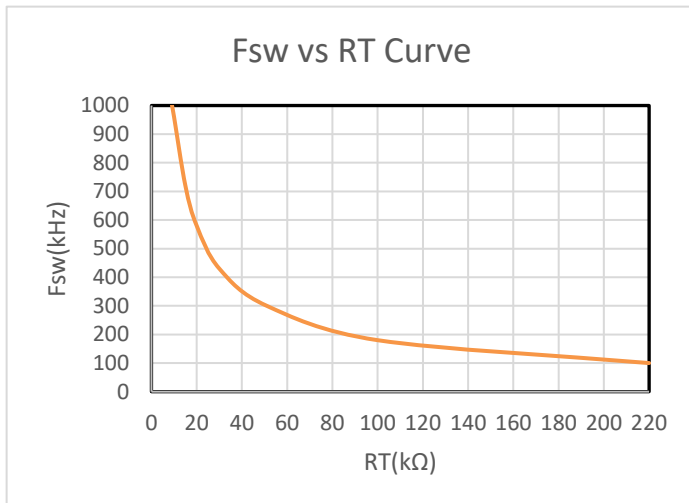


Functional Descriptions

The TD1539 is current mode boost controller. It operates with pulse width modulation (PWM). The internal resistive divider provides 1.2V reference for the error amplifier. It changes to PFM mode when the output is light load. In PFM mode, it can reduce switching lose to raise efficiency, but the output ripple is bigger.

Oscillator

The oscillator frequency can be set from 100kHz to 1000kHz by external resistance. Acceptable resistance values range from 220kΩ to 10kΩ. The frequency is 160kHz when the resistance is unconnected. The relationship between the timing resistance RT and frequency is shown in below curve:



Enable Mode / Shutdown Mode

Input voltage connects to EN pin through a resistive divider to set UVLO threshold. TD1539 is enabled when EN voltage greater than 0.9V. The EN voltage is lower than 0.9V to shutdown it. In shutdown mode, the device goes into low power consumption mode. If the applications don't need to set UVLO, the EN connects to input voltage through resistance 200kΩ, and EN internal clamping circuit limit V_{EN} is under 6V.

Current Sense Control

External switching MOSFET is turned on inductor current flows across the current sense resistor to generate VCS. VCS provides part of current mode control loop. Internal leading-

edge blanking is provided to prevent premature turn off the switching MOSFET in each switching cycle.

Current Limit Setting Resistor (R_{CS})

R_{CS} is connected between CS pin and ground, its calculation formula is as below. Where 0.085V is minimum threshold voltage of current sense, I_{LP} is peak inductor current, and the factor 1.3 provides a 30% margin for tolerances.

$$R_{CS}(\Omega) = \frac{0.085V}{I_{LP}(A) \times 1.3}$$

According to following equations calculate the peak inductor current I_{LP} . Where I_{Lavg} is the average inductor current, I_{LPP} is the peak-to-peak inductor current, V_{OUT} is the output voltage, $I_{OUT(max)}$ is the output maximum current, Eff is the efficiency, F_s is the switching frequency, and the L is inductance.

$$I_{LP} = I_{Lavg} + \frac{I_{LPP}}{2}$$

$$I_{Lavg} = \frac{V_{OUT} \times I_{OUT(max)}}{V_{IN} \times Eff}$$

$$I_{LPP} = \frac{V_{OUT} - V_{IN}}{F_s \times I_{OUT(max)}} \times \frac{Eff}{L} \times I_{Lavg}$$

Thermal Shutdown Protection

The IC will shut down automatically when the internal junction temperature exceeds +150°C. The device can restart until the junction temperature drops below +120°C approximately.

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Application Information

Inductor Selection

The Inductance value is decided based on different condition. 3.3μH to 47μH inductance value is recommended for general application circuit. There are three important inductor specifications, DC resistance, saturation current and core loss. Low DC resistance has better power efficiency. The inductance is calculated using formula:

$$L = \left(\frac{V_{IN}}{V_{OUT}}\right)^2 \times \frac{V_{OUT} - V_{IN}}{F_S \times I_{OUT(max)}} \times \frac{E_{ff}}{k}$$

Where V_{OUT} is output voltage, F_S is switching frequency, I_{OUT} is output maximum current, E_{ff} is boost efficiency and k is the ratio of the inductor peak-to-peak ripple current to the average DC inductor current at full load current. k is recommended between 0.3 and 0.5.

Power MOSFET Selection

The drive pin, Gate, of the TD1539 must be connected to the gate of an external MOSFET. In a boost topology, the drain of the external N-Channel MOSFET is connected to the inductor and the source is connected to the ground. The drive pin voltage, V_{GATE} , depends on the input voltage. In most applications, a logic level MOSFET can be used. For very low input voltages, a sub-logic level MOSFET should be used. The selected MOSFET directly controls the efficiency. The critical parameters for selection of a MOSFET are:

- Minimum threshold voltage, $V_{TH(MIN)}$
- On-resistance, $R_{DS(ON)}$
- Total gate charge, Q_g
- Reverse transfer capacitance, C_{rss}
- Maximum drain to source voltage, $V_{DS(MAX)}$

The off-state voltage of the MOSFET is approximately equal to the output voltage. $V_{DS(MAX)}$ of the MOSFET must be greater than the output voltage.

The power losses in the MOSFET can be categorized into conduction losses and ac switching or transition losses. $R_{DS(ON)}$ is needed to estimate the conduction losses. The conduction loss, P_{COND} , is the I^2R loss across the MOSFET. The maximum conduction loss is given by:

$$P_{COND(MAX)} = \left(\frac{I_{OUT(max)}}{1 - D_{MAX}}\right)^2 \times D_{MAX} \times R_{DS(ON)}$$

Where D_{MAX} is the maximum duty cycle:

$$D_{MAX} = 1 - \frac{V_{IN(MIN)}}{V_{OUT}}$$

At high switching frequencies the switching losses may be the largest portion of the total losses.

The switching losses are very difficult to calculate due to changing parasitics of a given MOSFET in operation. Often, the individual MOSFET datasheet does not give enough information to yield a useful result. As below equation give a rough idea how the switching losses are calculated:

$$P_{SW} = \frac{I_{Lmax} \times V_{OUT}}{2} \times f_{SW} \times (t_{LH} + t_{HL})$$

$$t_{LH} = (Q_{gd} + \frac{Q_{gs}}{2}) \times \frac{R_{Gate}}{V_{DR} - V_{gs_{th}}}$$

Capacitor Selection

Output capacitor is required to maintain the DC voltage during switching. Low ESR capacitors are preferred to reduce the output voltage ripple. Ceramic capacitor of X5R and X7R are recommended, which have low equivalent series resistance (ESR) and wider operation temperature range.

Diode Selection

Schottky diodes with fast recovery times and low forward voltages are recommended. Ensure the diode average and peak current rating exceed the average output current and peak inductor current. In addition, the diode's reverse breakdown voltage must exceed the output voltage.

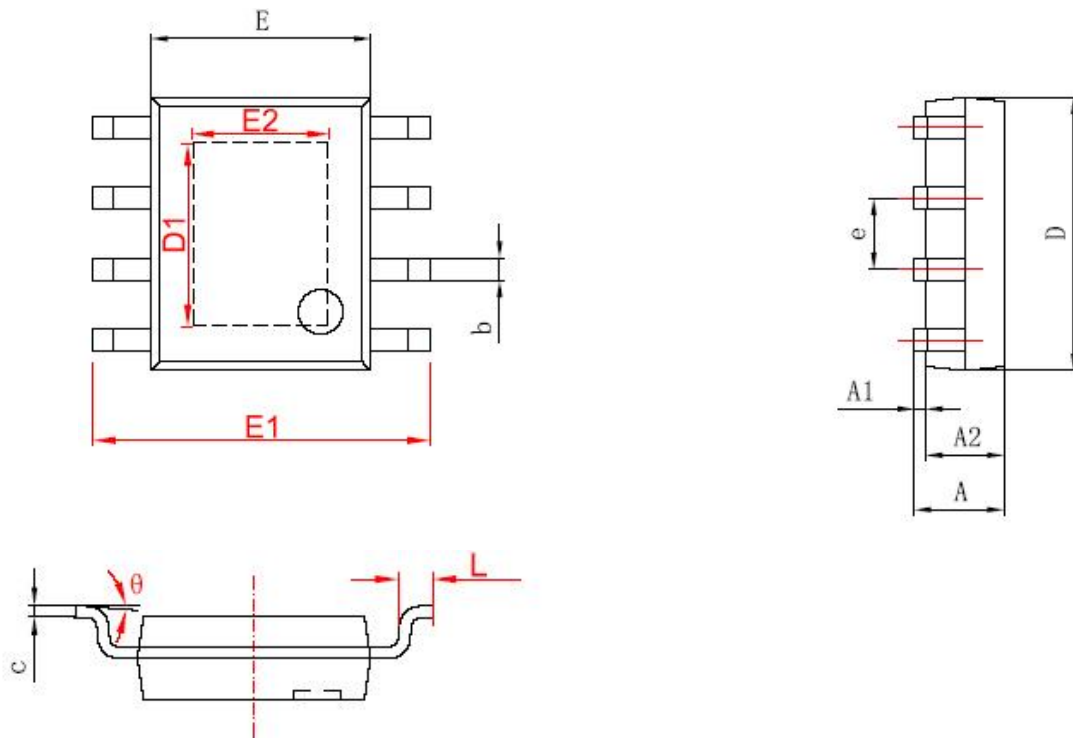
Output Voltage Programming

The output voltage is set by a resistive voltage divider from the output voltage to FB. The output voltage is:

$$V_{OUT} = 1.2V \times \left(1 + \frac{R5}{R6}\right)$$

Package Information

ESOP-8 Package Outline Dimensions



	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.150	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
E2	2.313	2.513	0.091	0.099
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Design Notes