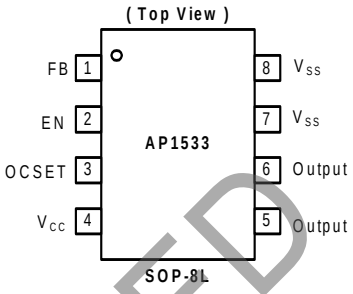
Description

AP1533 consists of step-down switching regulator with PWM control. These devices include a reference voltage source, oscillation circuit, error amplifier, internal PMOS.

AP1533 provides low-ripple power, high efficiency, and excellent transient characteristics. The PWM control circuit is able to vary the duty ratio linearly from 0 up to 99%. This converter also contains an error amplifier circuit as well as a soft-start circuit that prevents overshoot at startup. An enable function, an over current protect function and a short circuit protect function are built inside, and when OCP or SCP happens, the operation frequency will be reduced from 300KHz to 50KHz. Also, an internal compensation block is built in to minimum external component count.

With the addition of an internal P-channel Power MOS, a coil, capacitors, and a diode connected externally, these ICs can function as step-down switching regulators. They serve as ideal power supply units for portable devices when coupled with the SOP-8L mini-package, providing such outstanding features as low current consumption. Since this converter can accommodate an input voltage up to 23V, it is also suitable for the operation via an AC adapter.

Pin Assignments



Applications

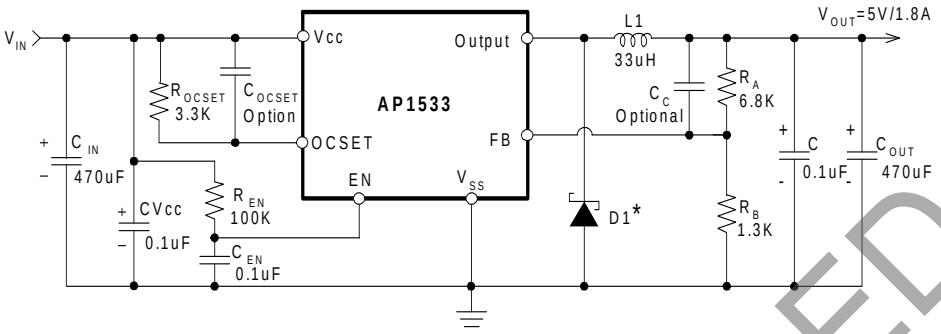
- PC Motherboard
- LCD Monitor
- Graphic Card
- DVD-Video Player
- Telecom Equipment
- ADSL Modem
- Printer and other Peripheral Equipment
- Microprocessor core supply

Features

- Input voltage: 4V to 23V
- Output voltage: 0.8V to V_{CC}
- Output current: 1.8A up to peak 2A
- Duty ratio: 0% to 99% PWM control
- Oscillation frequency: 300KHz typ.
- Soft-start like, Current limit and Enable function
- Thermal Shutdown function
- Built-in internal SW P-channel MOS
- SOP-8L: Available in “Green” Molding Compound (No Br, Sb)
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. “Green” Device (Note 3)**

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated’s definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green” products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Typical Application Circuit



$V_{OUT} = V_{FB} \times (1 + R_A/R_B)$

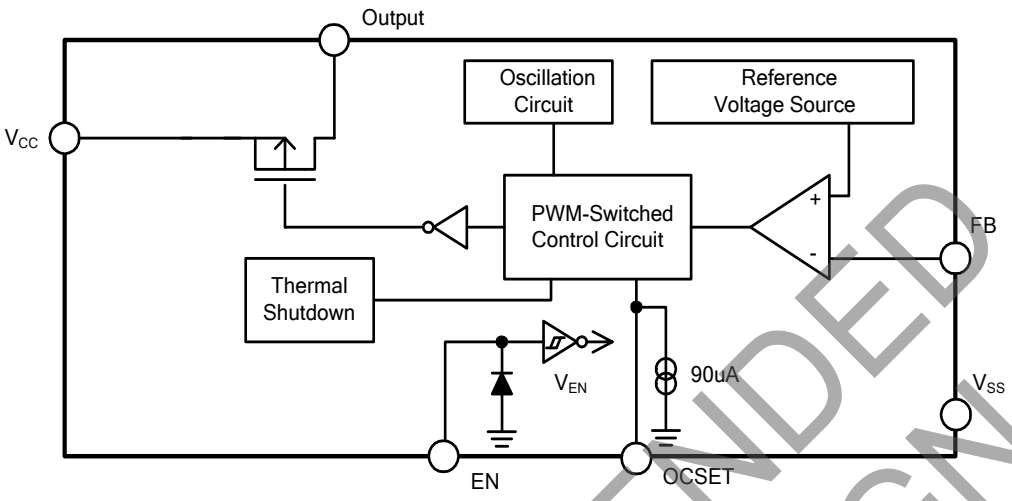
R_B = 0.7K~5K ohm

* Suggested Diodes Incorporated Power Schottky P/N: B340 series or PDS340.

Pin Descriptions

Pin Name	Pin No.	Description
FB	1	Feedback pin
EN	2	Power-off pin H: Normal operation (Step-down operation) L: Step-down operation stopped (All circuits deactivated)
OCSET	3	Add an external resistor to set max output current
V_{CC}	4	IC power supply pin
Output	5, 6	Switch Pin. Connect external inductor/diode here. Minimize trace area at this pin to reduce EMI
V_{SS}	7, 8	GND Pin

Block Diagram



Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
ESD HBM	Human Body Model ESD Protection	8	KV
ESD MM	Machine Model ESD Protection	500	V
V_{CC}	V_{CC} Pin Voltage	V_{SS} - 0.3 to V_{SS} + 24	V
V_{FB}	Feedback Pin Voltage	V_{SS} - 0.3 to V_{CC}	V
V_{EN}	EN Pin Voltage	V_{SS} - 0.3 to V_{IN} + 0.3	V
V_{OUT}	Switch Pin Voltage	V_{SS} - 0.3 to V_{IN} + 0.3	V
P_D	Power Dissipation	Internally limited	mW
T_J	Operating Junction Temperature Range	-20 to +125	°C
T_{ST}	Storage Temperature Range	-65 to +150	°C

Caution: The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
V_{IN}	Input Voltage	4	23	V
I_{OUT}	Output Current	0	1.8	A
T_A	Operating Ambient Temperature	-25	+85	°C

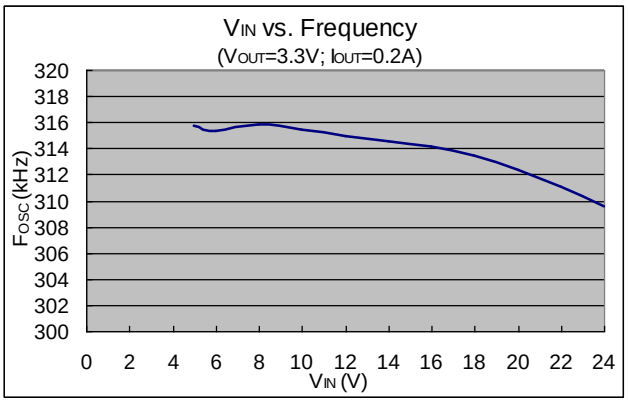
Electrical Characteristics

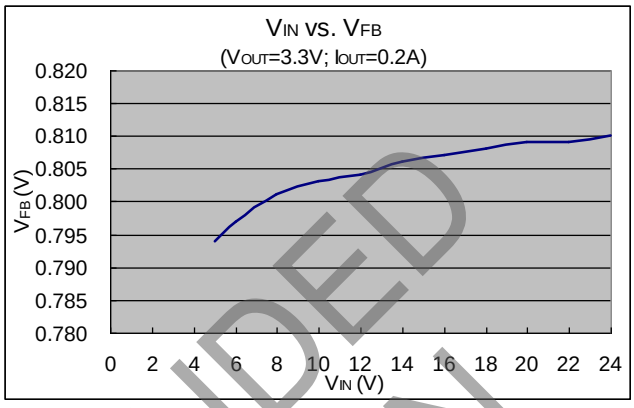
(V_{IN} = 12V, T_A = +25°C, unless otherwise specified)

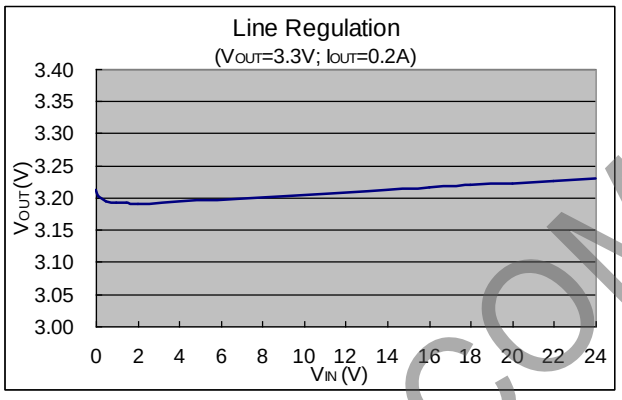
Symbol	Parameter	Conditions	Min	Typ.	Max	Unit
V_{FB}	Feedback Voltage	I_{OUT} = 0.1A	0.784	0.8	0.816	V
I_{FB}	Feedback Bias Current	I_{OUT} = 0.1A	—	0.1	0.5	μA
I_{SHDN}	Current Consumption During Power Off	V_{EN} = 0V	—	10	—	μA
ΔV_{OUT} / V_{IN}	Line Regulation	V_{IN} = 5V~23V	—	1	2	%
ΔV_{OUT} / V_{OUT}	Load Regulation	I_{OUT} = 0.1 to 1.8A	—	0.2	0.5	%
f_{OSC}	Oscillation Frequency	Measure waveform at SW pin	240	300	400	KHz
f_{OSC1}	Frequency of Current Limit or Short Circuit Protection	Measure waveform at SW pin	—	50	—	KHz
V_{IH}	EN Pin Input Voltage	Evaluate oscillation at SW pin	2.0	—	—	V
V_{IL}		Evaluate oscillation stop at SW pin	—	—	0.8	
I_{SH}	EN Pin Input Leakage Current	EN Pin High	—	20	—	μA
I_{SL}		EN Pin Low	—	-10	—	μA
I_{OCSET}	OCSET Pin Bias Current	—	75	90	105	μA
$R_{DS(ON)}$	Internal MOSFET $R_{DS(ON)}$	V_{IN}=5V, V_{FB}=0V	—	110	150	mΩ
		V_{IN}=12V, V_{FB}=0V	—	80	110	
EFFI	Efficiency	V_{IN}=12V, V_{OUT} = 5V I_{OUT}=1.8A	—	91	—	%
T_{SHDN}	Thermal shutdown threshold	—	—	+150	—	°C
T_{HYS}	Thermal shutdown hysteresis	—	—	+55	—	°C
θ_{JA}	Thermal Resistance Junction-to-Ambient	SOP-8L (Note 4)	—	134	—	°C/W
θ_{JC}	Thermal Resistance Junction-to-Case	SOP-8L (Note 4)	—	22	—	°C/W

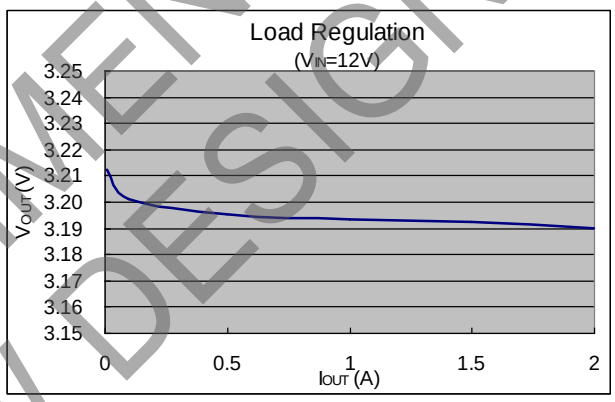
Note: 4. Test condition: Device mounted on FR-4 PCB, 2"x2", 2oz copper, minimum recommended pad layout, single side. For better thermal performance, larger copper pad for heatsink is needed.

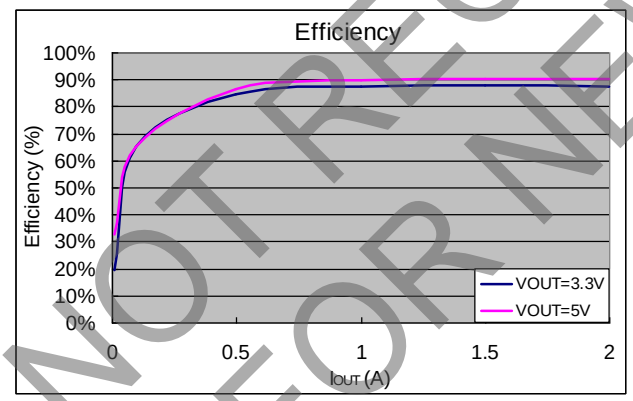
Typical Performance Characteristics





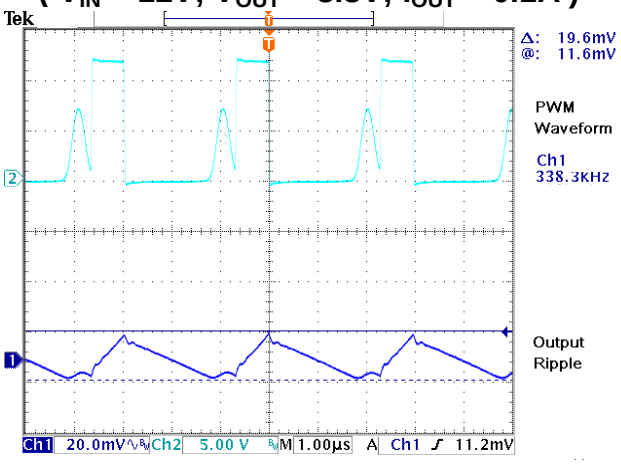




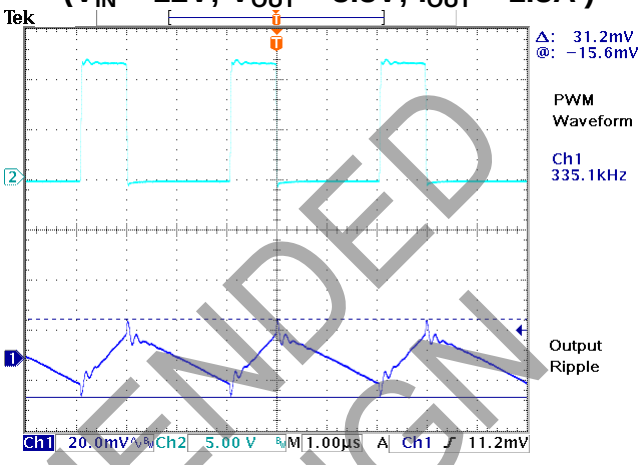


Typical Performance Characteristics (continued)

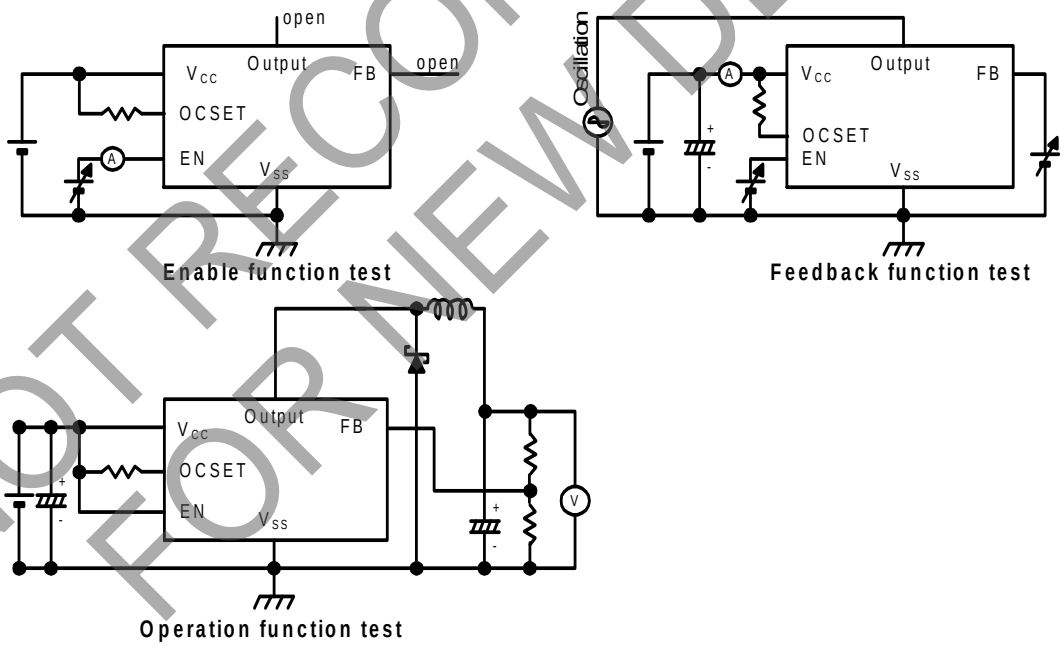
V_{OUT} Ripple
(V_{IN} = 12V; V_{OUT} = 3.3V; I_{OUT} = 0.1A)



V_{OUT} Ripple
(V_{IN} = 12V; V_{OUT} = 3.3V; I_{OUT} = 1.8A)



Test Circuit



Functional Description

PWM Control

The AP1533 is a DC/DC converter that employs pulse width modulation (PWM) scheme. Its pulse width varies in the range of 0% to 99%, based on the output current loading. The output ripple voltage caused by the PWM high frequency switching can easily be reduced through an output filter. Therefore, this converter provides a low ripple output supply over a broad range of input voltage & output current loading.

Under Voltage Lockout

The under voltage lockout circuit of the AP1533 assures that the high-side MOSFET driver remains in the off state whenever the supply voltage drops below 3.3V. Normal operation resumes once V_{CC} rises above 3.5V.

Current Limit Protection

The current limit threshold is set by external resistor R_{OCSET} connected from V_{CC} supply to OCSET pin. The internal sink current I_{OCSET} (90μA typical) across this resistor sets the voltage at OCSET pin. When the PWM voltage is less than the voltage at OCSET, an over-current condition is triggered.

The current limit threshold is given by the following equation:

$$I_{PEAK} \times R_{DS(ON)} = I_{OCSET} \times R_{OCSET}$$

$$I_{PEAK} > I_{OUT(MAX)} + \frac{(\Delta I)}{2}$$

where,

$$\Delta I = \frac{V_{IN} - V_{OUT}}{fs \times L} \times \frac{V_{OUT}}{V_{IN}}$$

I_{PEAK} is the output peak current; $R_{DS\ (ON)}$ is the MOSFET ON resistance; f_S is the PWM frequency (300KHz typical). Also, the inductor value will affect the ripple current ΔI.

The above equation is recommended for input voltage range of 5V to 18V. For input voltage lower than 5V or ambient temperature over +100°C, higher R_{OCSET} is recommended.

The recommended minimum R_{OCSET} value is summarized below:

V_{IN} (V)	V_{OUT} (V)	R_{OCSET} (Ω)
4	0.8	3.9K
5	3.3	3.3K
12	5	3.3K
18	12	3.3K
23	12	4.7K

The maximum R_{OCSET} value should not exceed AP1533 maximum current output.

Inductor Selection

For most designs, the operation range with inductors is from 22μH to 33μH. The inductor value can be derived from the following equation:

$$L = \frac{V_{IN} - V_{OUT}}{fs \times \Delta I} \times \frac{V_{OUT}}{V_{IN}}$$

Where ΔI_L is inductor Ripple Current. Large value inductors lower ripple current and small value inductors result in high ripple current. Choose inductor ripple current approximately 15% of the maximum load current 1.8A, ΔI_L=0.27A. The DC current rating of the inductor should be at least equal to the maximum load current plus half the ripple current to prevent core saturation (1.8A+0.135A).

Functional Description (continued)

Input Capacitor Selection

This capacitor should be located close to the IC using short leads and the voltage rating should be approximately 1.5 times the maximum input voltage. The RMS current rating requirement for the input capacitor of a buck regulator is approximately 1⁄2 the DC load current. A low ESR input capacitor sized for maximum RMS current must be used. A 470µF low ESR capacitor for most applications is sufficient.

Output Capacitor Selection

The output capacitor is required to filter the output voltage and provides regulator loop stability. The important capacitor parameters are the 100KHz Equivalent Series Resistance (ESR), the RMS ripples current rating, voltage rating and capacitance value. For the output capacitor, the ESR value is the most important parameter. The output ripple can be calculated from the following formula.

$$V_{RIPPLE} = \Delta I_L \times ESR$$

The bulk capacitor's ESR will determine the output ripple voltage and the initial voltage drop after a high slew-rate transient.

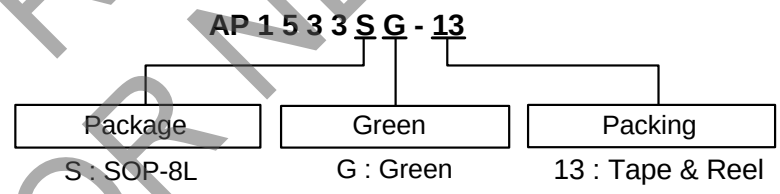
An aluminum electrolytic capacitor's ESR value is related to the capacitance and its voltage rating. In most case, higher voltage electrolytic capacitors have lower ESR values. Most of the time, capacitors with much higher voltage ratings may be needed to provide the low ESR values required for low output ripple voltage.

PCB Layout Guide

If you need low T_C & T_J or large P_D (Power Dissipation), The dual SW pins(5& 6) and V_{SS} pins(7& 8)on the SOP-8L package are internally connected to die pad, The evaluation board should be allowed for maximum copper area at output (SW) pins.

1. Connect FB circuits as closely as possible and keep away from inductor flux for pure V_{FB}.
2. Connect input capacitor to V_{CC} and V_{SS} pin as closely as possible to get good power filter effect.
3. Connect R_{OCSET} to V_{CC} and OCSET pin as closely as possible.
4. Connect ground side of the input capacitor & Schottky & output capacitor as closely as possible and use ground plane for best performance.

Ordering Information

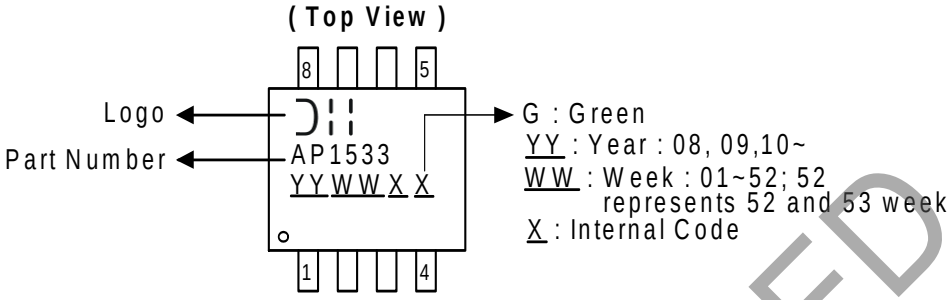


Device	Package Code	Packaging (Note 5)	13" Tape and Reel	
			Quantity	Part Number Suffix
AP1533SG-13	S	SOP-8L	2500/Tape & Reel	-13

Note: 5. Pad layout as shown as shown in Diodes Incorporated's package outline PDFs, which can be found on our website at http://www.diodes.com/package-outlines.html.

Marking Information

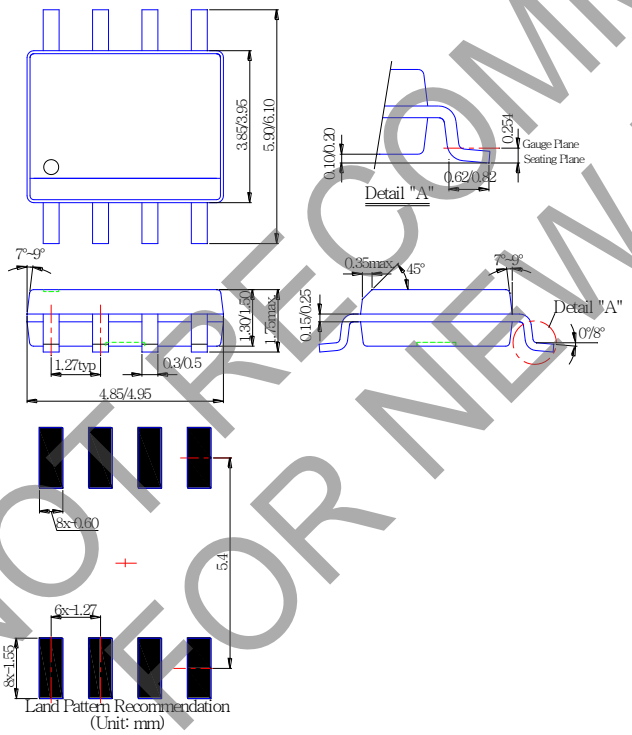
(1) SOP-8L



Package Outline Dimensions (All Dimensions in mm)

Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: SOP-8L



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