

Off-line Power Supply Controller

FEATURES

- Transformerless Off-line Power Supply
- Wide 100VDC to 400VDC Allowable Input Range
- Fixed 5VDC or Adjustable Low Voltage Output
- Output Sinks 200mA, Sources 150mA Into a MOSFET Gate
- Uses Low Cost SMD Inductors
- Short Circuit Protected
- Optional Isolation Capability

DESCRIPTION

The UCC3888 controller is optimized for use as an off-line, low power, low voltage, regulated bias supply. The unique circuit topology utilized in this device can be visualized as two cascaded flyback converters, each operating in the discontinuous mode, both driven from a single external power switch. The significant benefit of this approach is the ability to achieve voltage conversion ratios as high as 400V to 2.7V with no transformer and low internal losses.

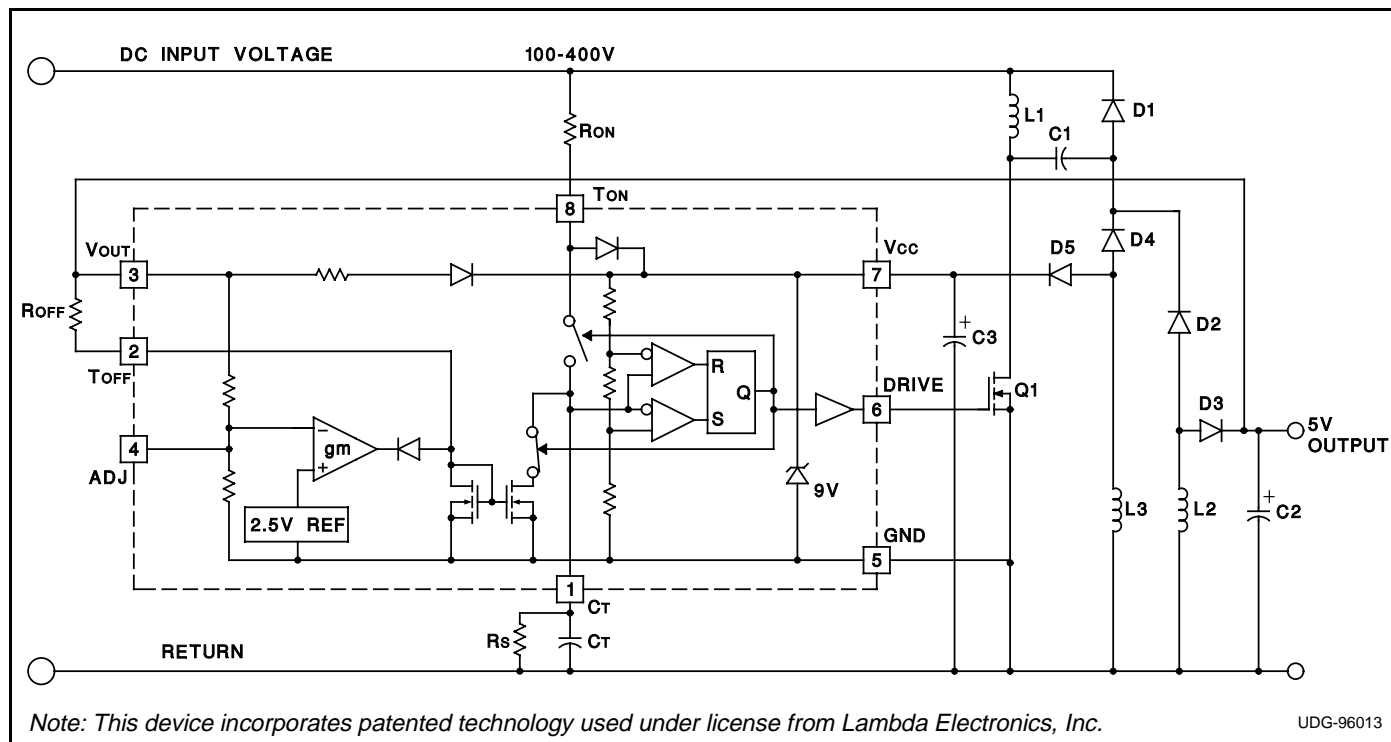
The control algorithm utilized by the UCC3888 sets the switch on time inversely proportional to the input line voltage and sets the switch off time inversely proportional to the output voltage. This action is automatically controlled by an internal feedback loop and reference. The cascaded configuration allows a voltage conversion from 400V to 2.7V to be achieved with a switch duty cycle of 7.6%. This topology also offers inherent short circuit protection since as the output voltage falls to zero, the switch off time approaches infinity.

The output voltage is set internally to 5V. It can be programmed for other output voltages with two external resistors. An isolated version can be achieved with this topology as described further in Unitrode Application Note U-149.

OPERATION

With reference to the application diagram below, when input voltage is first applied, the current through R_{ON} into T_{ON} is directed to V_{CC} where it charges the external capacitor, C_3 , connected to V_{CC} . As voltage builds on V_{CC} , an internal undervoltage lockout holds the circuit off and the output at $DRIVE$ low until V_{CC} reaches 8.4V. At this time, $DRIVE$ goes high turning on the power switch, Q_1 , and redirecting the current into T_{ON} to the timing capacitor, C_T . C_T charges to a fixed threshold with a current $I_{CHG} = 0.8 \cdot (V_{IN} - 4.5V)/R_{ON}$. Since $DRIVE$ will only be high for as long as C_T charges, the power switch on time will be inversely proportional to line voltage. This provides a constant (line voltage) \cdot (switch on time) product.

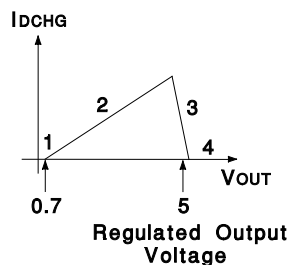
TYPICAL APPLICATION



OPERATION (cont.)

At the end of the on time, Q1 is turned off and the current through R_{ON} is again diverted to V_{CC} . Thus the current through R_{ON} , which charges C_T during the on time, contributes to supplying power to the chip during the off time.

The power switch off time is controlled by the discharge of CT which, in turn, is programmed by the regulated output voltage. The relationship between CT discharge current, IDCHG, and output voltage is illustrated as follows:



Region 1. When $V_{OUT} = 0$, the off time is infinite. This feature provides inherent short circuit protection. However, to ensure output voltage startup when the output is not a short, a high value resistor, R_S , is placed in parallel with C_T to establish a minimum switching frequency.

Region 2. As V_{OUT} rises above approximately 0.7V to its regulated value, I_{DCHG} is defined by R_{OFF} , and is equal to:

$$I_{DCHG} = (V_{OUT} - 0.7V) / R_{OFF}$$

As V_{OUT} increases, I_{DCHG} increases reducing off time. The operating frequency increases and V_{OUT} rises quickly to its regulated value.

Region 3. In this region, a transconductance amplifier reduces IDCHG in order to maintain a regulated VOUT.

Region 4. If VOUT should rise above its regulation range, IDCHG falls to zero and the circuit returns to the minimum frequency established by RS and CT.

The range of switching frequencies is established by R_{ON} , R_{OFF} , R_S , and C_T as follows:

$$\text{Frequency} = 1/(\text{TON} + \text{TOFF})$$

$$T_{ON} = R_{ON} \bullet C_T \bullet 4.6 \text{ V}/(V_{IN} - 4.5\text{V})$$

$$T_{OFF}(\max) = 1.4 \cdot R_S \cdot C_T$$

Regions 1 and 4

$$T_{OFF} = R_{OFF} \cdot C_T \cdot 3.7V / (V_{OUT} - 0.7V)$$

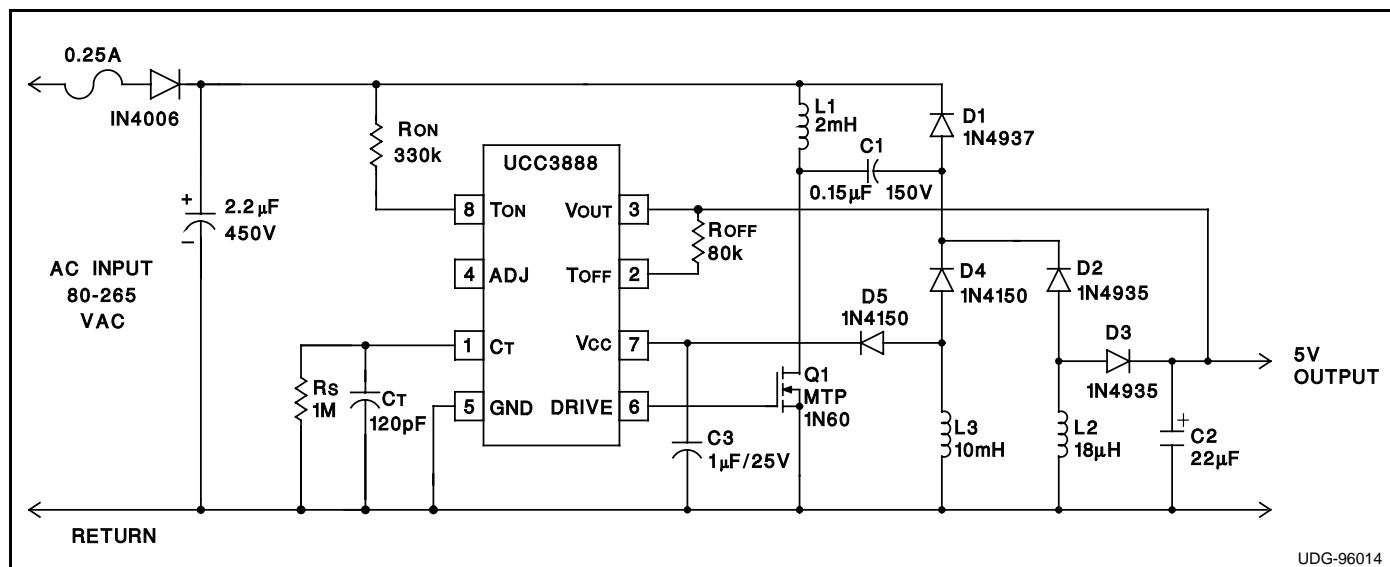
Region 2, excluding the effects of RS

which have a minimal impact on TOFF.

The above equations assume that VCC equals 9V. The voltage at TON increases from approximately 2.5V to 6.5V while CT is charging. To take this into account, VIN is adjusted by 4.5V in the calculation of TON. The voltage at TOFF is approximately 0.7V.

DESIGN EXAMPLE

The UCC3888 regulates a 5 volt, 1 Watt nonisolated DC output from AC inputs between 80 and 265 volts. In this example, the IC is programmed to deliver a maximum on time gate drive pulse width of 2.2 microseconds which occurs at 80 VAC. The corresponding switching frequency is approximately 100kHz at low line, and overall efficiency is approximately 50%. Additional design information is available in Unitrode Application Note U-149.



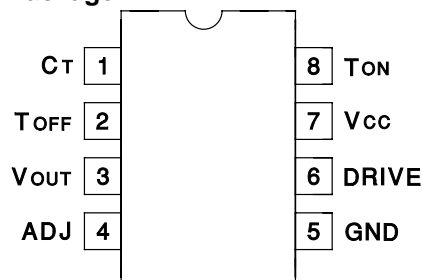
ABSOLUTE MAXIMUM RATINGS

I _{CC}	8mA
Current into TON Pin	1.5mA
Voltage on VOUT Pin	20V
Current into TOFF Pin	250μA
Storage Temperature	-65°C to +150°C

Note: Unless otherwise indicated, voltages are referenced to ground and currents are positive into, negative out of, the specified terminals.

CONNECTION DIAGRAM

DIL-8, SOIC-8 (Top View)
N or J, D Package

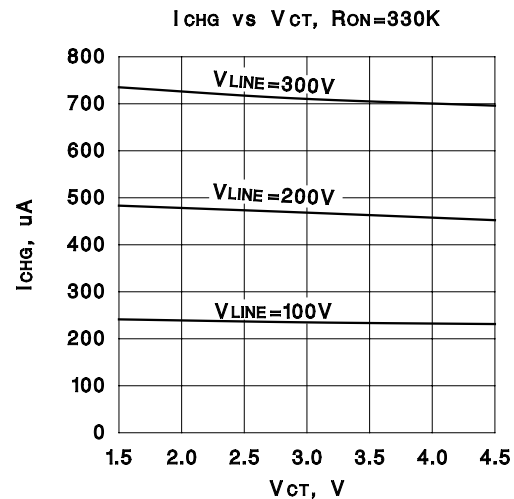
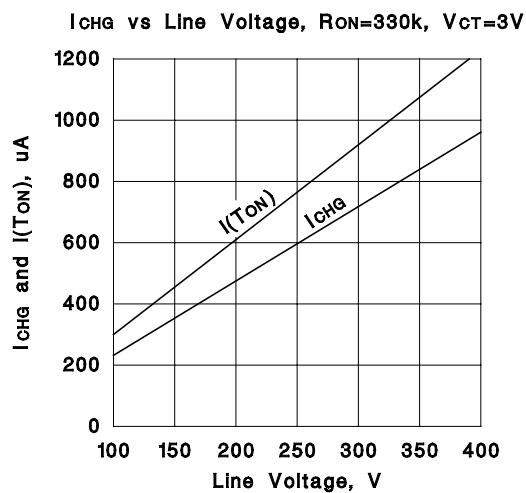


ELECTRICAL CHARACTERISTICS Unless otherwise stated, these specifications hold for T_A = 0°C to 70°C for the UCC3888, -40°C to +85°C for the UCC2888, and -55°C to +125°C for the UCC1888. No load at DRIVE pin (C_{LOAD}=0).

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
General					
V _{CC} Zener Voltage	I _{CC} < 1.5mA	8.6	9.0	9.3	V
Startup Current	V _{OUT} = 0		150	250	μA
Operating Current I(V _{CC})	V _{CC} = V _{CC} (zener) – 100mV, F = 150kHz		1.2	2.5	mA
Under-Voltage-Lockout					
Start Threshold	V _{OUT} = 0	8.0	8.4	8.8	V
Minimum Operating Voltage after Start	V _{OUT} = 0	6.0	6.3	6.6	V
Hysteresis	V _{OUT} = 0	1.8			V
Oscillator					
Amplitude	V _{CC} = 9V	3.5	3.7	3.9	V
C _T to DRIVE high Propagation Delay	Overdrive = 0.2V		100	200	ns
C _T to DRIVE low Propagation Delay	Overdrive = 0.2V		50	100	ns
Driver					
VOL	I = 20mA, V _{CC} = 9V		0.15	0.4	V
	I = 100mA, V _{CC} = 9V		0.7	1.8	V
VOH	I = –20mA, V _{CC} = 9V	8.5	8.8		V
	I = –100mA, V _{CC} = 9V	6.1	7.8		V
Rise Time	C _{LOAD} = 1nF		35	70	ns
Fall Time	C _{LOAD} = 1nF		30	60	ns
Line Voltage Detection					
Charge Coefficient: I _{CHG} / I(TON)	V _{CT} = 3V, DRIVE = High, I(TON) = 1mA	0.73	0.79	0.85	
Minimum Line Voltage for Fault	R _{ON} = 330k	60	80	100	V
Minimum Current I(TON) for Fault	R _{ON} = 330k		220		μA
On Time During Fault	C _T = 150pF, V _{LINE} = Min – 1V		2		μs
Oscillator Restart Delay after Fault			0.5		ms
Vout Error Amp					
VOUT Regulated 5V (ADJ Open)	V _{CC} = 9V, I _{DCHG} = I(TOFF)/2	4.5	5.0	5.5	V
Discharge Ratio: I _{DCHG} / I(TOFF)	I(TOFF) = 50μA	0.93	1.00	1.07	
Voltage at TOFF	I(TOFF) = 50μA	0.6	0.95	1.3	V
Regulation gm (Note 1)	Max I _{DCHG} = 50μA		2.4		mA/V
	Max I _{DCHG} = 125μA	1.9	4.1	7.0	mA/V

Note 1: gm is defined as $\frac{\Delta I_{DCHG}}{\Delta V_{OUT}}$ for the values of V_{OUT} when V_{OUT} is in regulation. The two points used to calculate gm are for I_{DCHG} at 65% and 35% of its maximum value.

TYPICAL CHARACTERISTICS CURVES



PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
UCC2888D	ACTIVE	SOIC	D	8		Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UCC2888DG4	ACTIVE	SOIC	D	8		Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UCC3888D	ACTIVE	SOIC	D	8		Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UCC3888DG4	ACTIVE	SOIC	D	8		Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UCC3888DTR	ACTIVE	SOIC	D	8		Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UCC3888DTRG4	ACTIVE	SOIC	D	8		Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
UCC3888N	ACTIVE	PDIP	P	8		Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type
UCC3888NG4	ACTIVE	PDIP	P	8		Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSELETE: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

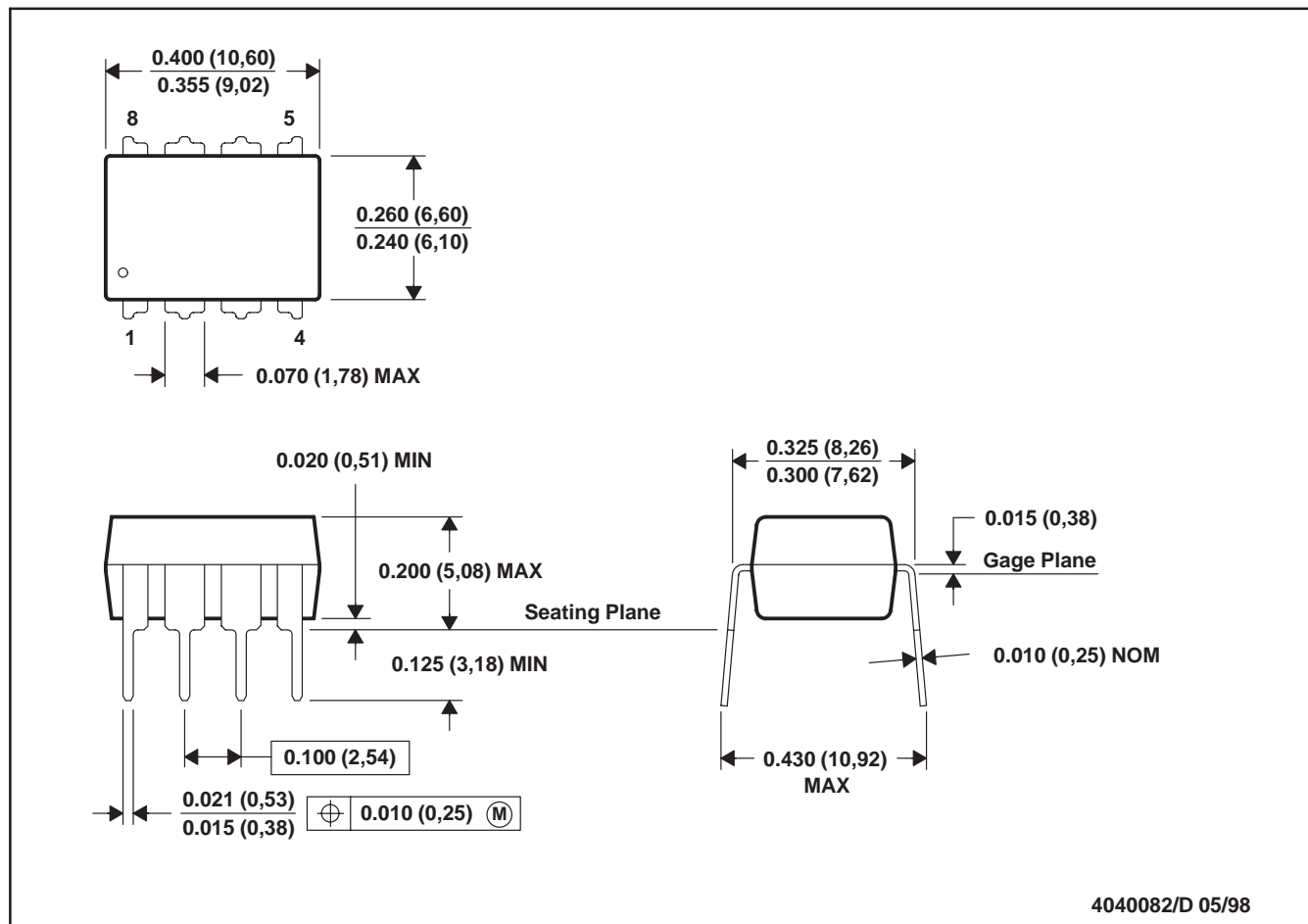
⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE

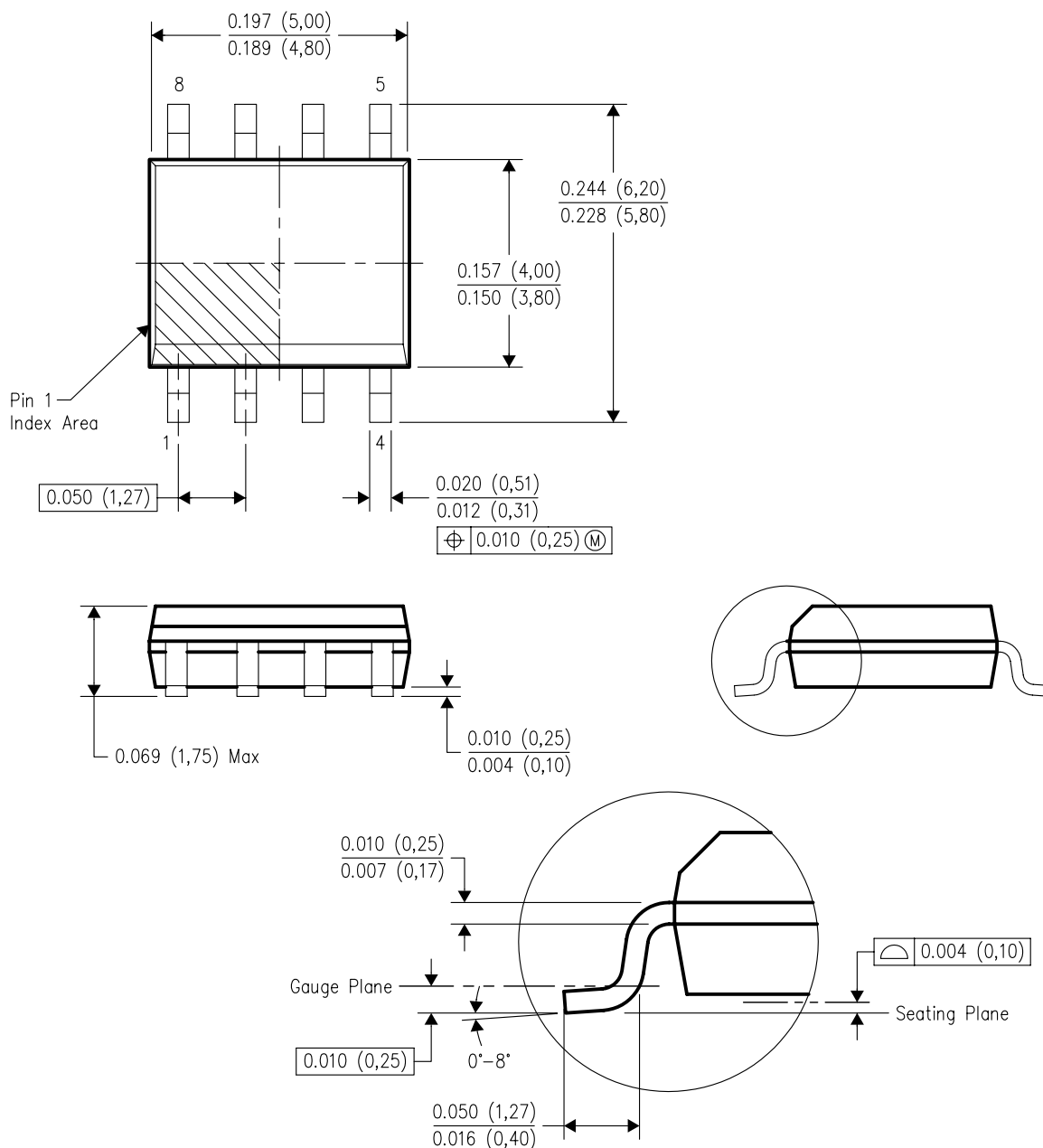


- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Falls within JEDEC MS-001

For the latest package information, go to http://www.ti.com/sc/docs/package/pkg_info.htm

D (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



4040047-2/F 07/2004

- NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
D. Falls within JEDEC MS-012 variation AA.

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