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## UCC2888 UCC3888

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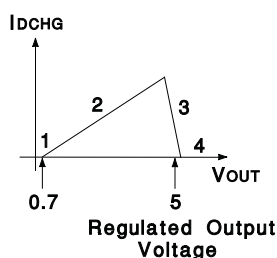


### THEORY OF OPERATION

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 8.4 V. At this time, DRIVE goes high, turning on the power switch, Q1, and redirecting the current into  $T_{ON}$  to the timing capacitor,  $C_T$ .  $C_T$  charges to a fixed threshold with a current  $I_{CHG} = 0.8 \cdot (V_{IN} - 4.5 \text{ V})/R_{ON}$ . Because DRIVE is high only as long as  $C_T$  charges, the power switch on time will be inversely proportional to line voltage. This provides a constant (line voltage) • (switch on time) product.

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  $C_T$ , which, in turn, is programmed by the regulated output voltage. The relationship between  $C_T$  discharge current,  $I_{DCHG}$ , 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 0.7 V to its regulated value,  $I_{DCHG}$  is defined by  $R_{OFF}$ , and is equal to:

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

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  $I_{DCHG}$  to maintain a regulated  $V_{OUT}$ .

Region 4. If  $V_{OUT}$  should rise above its regulation range,  $I_{DCHG}$  falls to zero and the circuit returns to the minimum frequency established by  $R_S$  and  $C_T$ .

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

$$\text{Frequency} = 1/(T_{ON} + T_{OFF})$$

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

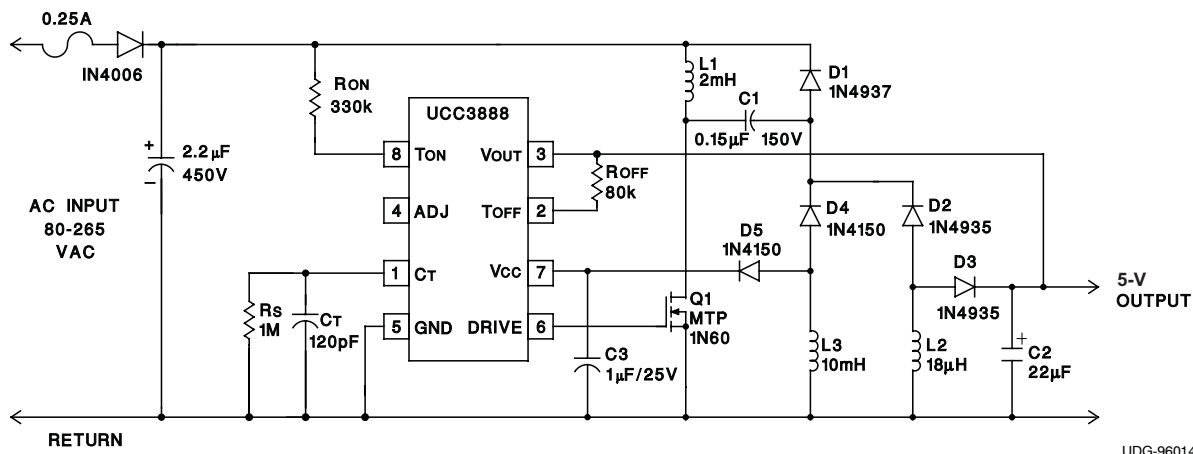
$$T_{OFF} (\text{max}) = 1.4 \cdot R_S \cdot C_T \text{ Regions 1 and 4}$$

$$T_{OFF} = R_{OFF} \cdot C_T \cdot 3.7 \text{ V}/(V_{OUT} - 0.7 \text{ V}) \text{ Region 2, excluding the effects of } R_S, \text{ which have a minimal impact on } T_{OFF}.$$

The above equations assume that  $V_{CC}$  equals 9 V. The voltage at  $T_{ON}$  increases from approximately 2.5 V to 6.5 V while  $C_T$  is charging. To take this into account,  $V_{IN}$  is adjusted by 4.5 V in the calculation of  $T_{ON}$ . The voltage at  $T_{OFF}$  is approximately 0.7 V.

## 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 100 kHz at low line, and overall efficiency is approximately 50%. Additional design information is available in Unitrode Application Note U-149.

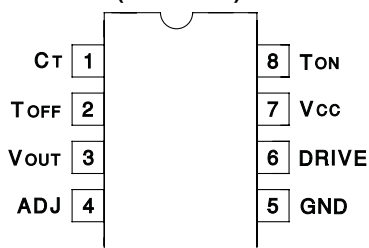


### ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

	VALUE	UNIT
I <sub>CC</sub>	8	mA
Current into T <sub>ON</sub> Pin	1.5	
Voltage on V <sub>OUT</sub> Pin	20	V
Current into T <sub>OFF</sub> Pin	250	μA
Storage temperature	−65 to 150	°C

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

**N OR J, D PACKAGE  
(TOP VIEW)**



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## ELECTRICAL CHARACTERISTICS

Unless otherwise stated, these specifications hold for  $T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$  for the UCC3888, and  $-40^\circ\text{C}$  to  $85^\circ\text{C}$  for the UCC2888. No load at DRIVE pin ( $C_{\text{LOAD}} = 0$ ).

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
General					
V <sub>CC</sub> Zener voltage	I <sub>CC</sub> < 1.5 mA	8.6	9	9.3	V
Startup current	V <sub>OUT</sub> = 0		150	250	μA
Operating current I(V <sub>CC</sub> )	V <sub>CC</sub> = V <sub>CC(zener)</sub> – 100 mV, F = 150 kHz		1.2	2.5	mA
Under-Voltage-Lockout					
Start threshold	V <sub>OUT</sub> = 0	8	8.4	8.8	V
Minimum operating voltage after start	V <sub>OUT</sub> = 0	6	6.3	6.6	
Hysteresis	V <sub>OUT</sub> = 0	1.8			
Oscillator					
Amplitude	V <sub>CC</sub> = 9 V	3.5	3.7	3.9	V
C <sub>T</sub> to DRIVE high propagation delay	Overdrive = 0.2 V		100	200	ns
C <sub>T</sub> to DRIVE low propagation delay	Overdrive = 0.2 V		50	100	
Driver					
VOL	I = 20 mA, V <sub>CC</sub> = 9 V		0.15	0.4	V
	I = 100 mA, V <sub>CC</sub> = 9 V		0.7	1.8	
VOH	I = –20 mA, V <sub>CC</sub> = 9 V	8.5	8.8		
	I = –100 mA, V <sub>CC</sub> = 9 V	6.1	7.8		
Rise time	C <sub>LOAD</sub> = 1 nF		35	70	ns
Fall time	C <sub>LOAD</sub> = 1 nF		30	60	
Line Voltage Detection					
Charge coefficient: I <sub>CHG</sub> /I(T <sub>ON</sub> )	V <sub>CT</sub> = 3 V, DRIVE = High, I(T <sub>ON</sub> ) = 1 mA	0.73	0.79	0.85	
Minimum line voltage for fault	R <sub>ON</sub> = 330k	60	80	100	V
Minimum current I(T <sub>ON</sub> ) for fault	R <sub>ON</sub> = 330k		220		μA
On time during fault	C <sub>T</sub> = 150 pF, V <sub>LINE</sub> = Min – 1 V		2		μs
Oscillator restart delay after fault			0.5		ms
V <sub>OUT</sub> Error Amp					
V <sub>OUT</sub> regulated 5 V (ADJ open)	V <sub>CC</sub> = 9 V, I <sub>DCHG</sub> = I(T <sub>OFF</sub> )/2	4.5	5	5.5	V
Discharge ratio: I <sub>DCHG</sub> / I(T <sub>OFF</sub> )	I(T <sub>OFF</sub> ) = 50 μA	0.9	1	1.1	
Voltage at T <sub>OFF</sub>	I(T <sub>OFF</sub> ) = 50 μA	0.6	0.95	1.3	
Regulation gm <sup>(1)</sup>	Max I <sub>DCHG</sub> = 50 μA		2.4		mA/V
	Max I <sub>DCHG</sub> = 125 μA	1.9	4.1	7	

(1) gm is defined as

$$\frac{\Delta I_{\text{DCHG}}}{\Delta V_{\text{OUT}}}$$

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

## PIN DESCRIPTIONS

**ADJ:** The ADJ pin is used to provide a 5-V regulated supply without additional external components. Other output voltages can be obtained by connecting a resistor divider between  $V_{OUT}$ , ADJ and GND. Use the formula:

$$V_{OUT} = 2.5 \text{ V} \cdot \frac{R1 + R2}{R2}$$

where R1 is connected between  $V_{OUT}$  and ADJ, and R2 is connected between ADJ and GND.  $R1 \parallel R2$  should be less than 1 k $\Omega$  to minimize the effect of the temperature coefficient of the internal 30-k $\Omega$  resistors, which also connect to  $V_{OUT}$ , ADJ, and GND. See [Figure 1](#).

**$C_T$  (timing capacitor):** The signal voltage at  $C_T$  has a peak-to-peak swing of 3.7 V for 9 V  $V_{CC}$ . As the voltage at  $C_T$  crosses the oscillator upper threshold, DRIVE goes low. As the voltage on  $C_T$  crosses the oscillator lower threshold, DRIVE goes high.

**DRIVE:** This output is a CMOS stage capable of sinking 200 mA peak and sourcing 150 mA peak. The output voltage swing is 0 to  $V_{CC}$ .

**GND (chip ground):** All voltages are measured with respect to GND.

**$T_{OFF}$  (regulated output control):**  $T_{OFF}$  sets the discharge current of the timing capacitor through an external resistor connected between  $V_{OUT}$  and  $T_{OFF}$ .

**$T_{ON}$  (line voltage control):**  $T_{ON}$  serves three functions. When  $C_T$  is discharging (off time), the current through  $T_{ON}$  is routed to  $V_{CC}$ . When  $C_T$  is charging (on time), the current through  $T_{ON}$  is split 80% to set the  $C_T$  charge time and 20% to sense minimum line voltage, which occurs for a  $T_{ON}$  current of 220  $\mu$ A. For a minimum line voltage of 80 V,  $R_{ON}$  is 330 k $\Omega$ .

The  $C_T$  voltage slightly affects the value of the charge current during the on time. During this time, the voltage at the  $T_{ON}$  pin increases from 2.5 V to 6.5 V.

**$V_{CC}$  (chip supply voltage):** The supply voltage of the device at pin  $V_{CC}$  is internally clamped at 9 V. The device needs an external supply, from a source such as the rectified ac line or derived from the switching circuit. Precautions must be taken to ensure that total ICC does not exceed 8 mA.

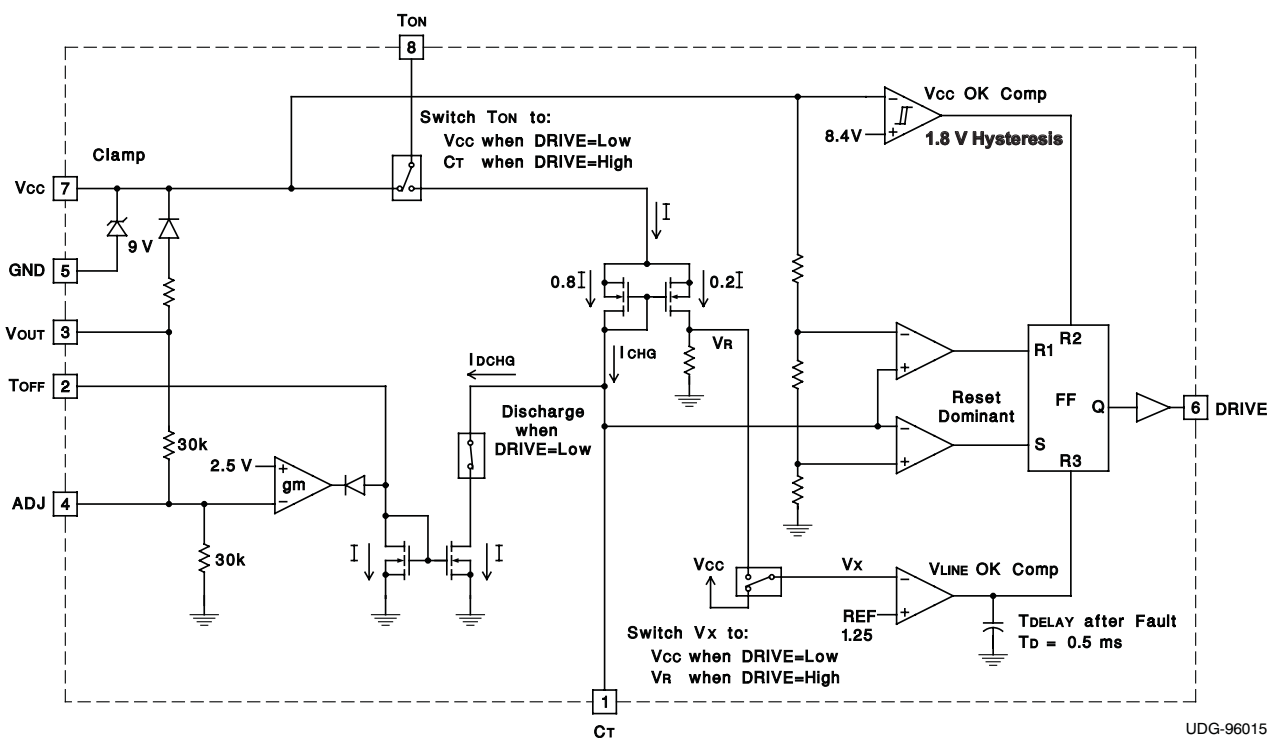
**$V_{OUT}$  (regulated output):** The  $V_{OUT}$  pin is directly connected to the power supply output voltage. When  $V_{OUT}$  is greater than  $V_{CC}$ ,  $V_{OUT}$  bootstraps  $V_{CC}$ .

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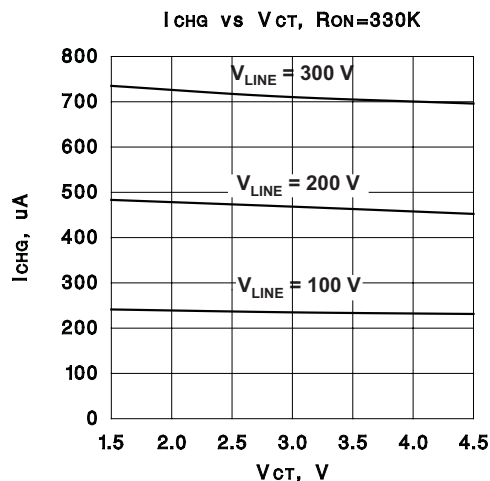
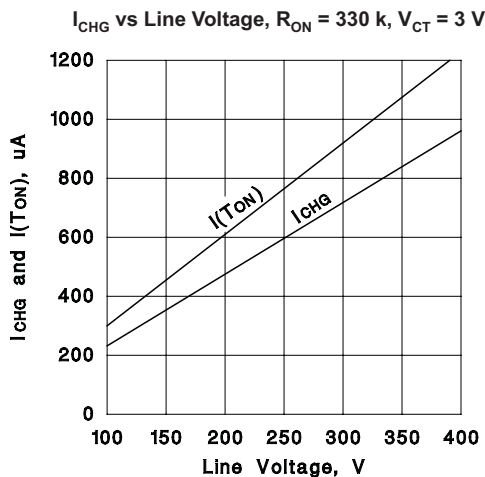
**PIN DESCRIPTIONS (continued)**



UDG-96015

Figure 1. Block Diagram

**TYPICAL CHARACTERISTICS**





## PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
UCC3888N	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI	0 to 70	UCC3888N	
UCC3888NG4	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI	0 to 70		

(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.

**OBSOLETE:** 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.

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

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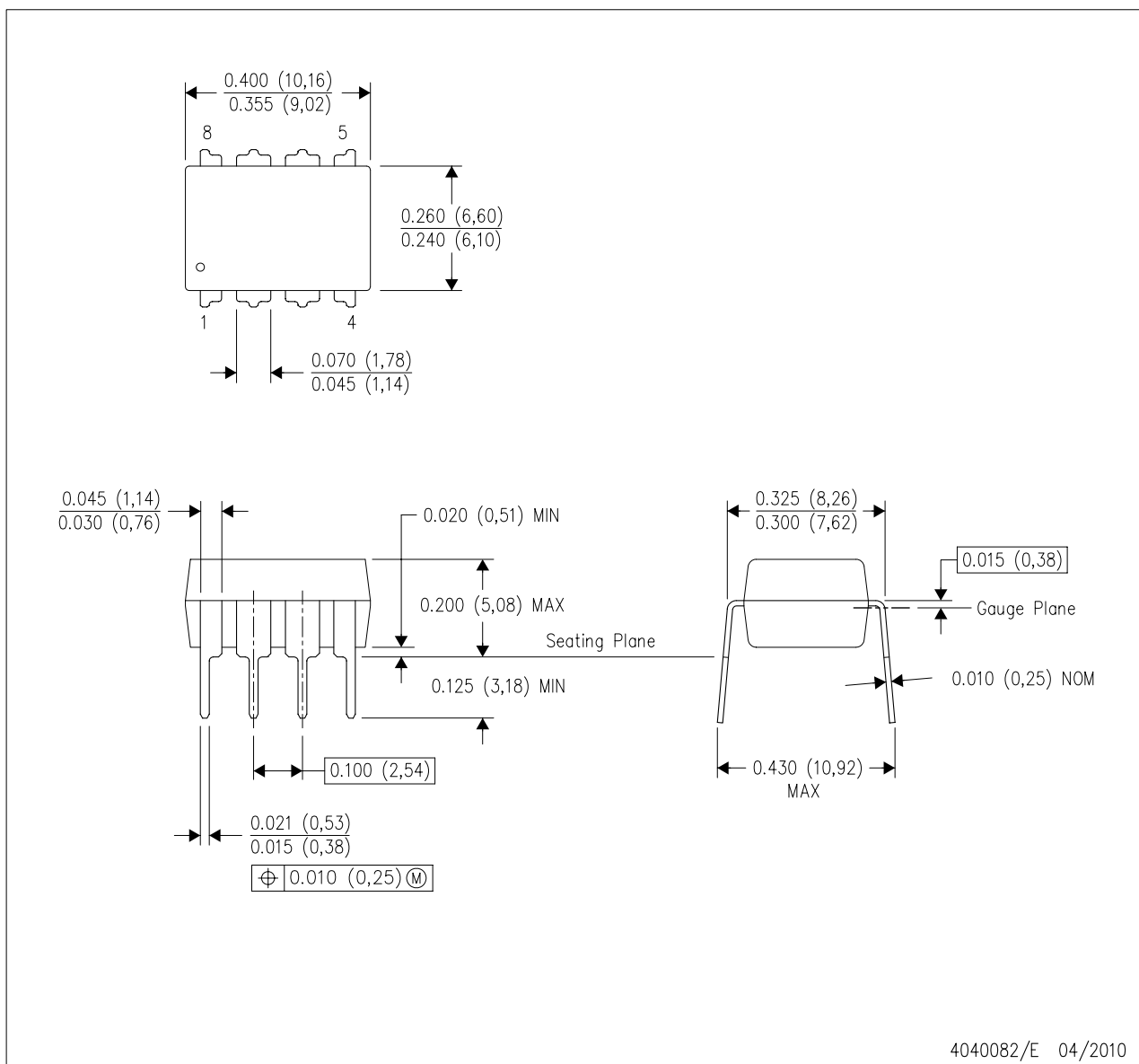
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## MECHANICAL DATA

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



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

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