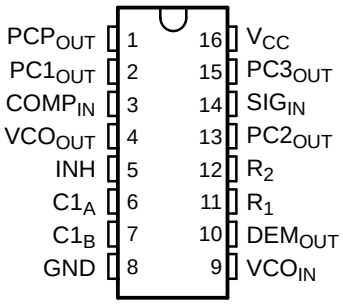
SN74LV4046A HIGH-SPEED CMOS LOGIC PHASE-LOCKED LOOP WITH VCO

SCES656A – FEBRUARY 2006 – REVISED FEBRUARY 2006

FEATURES

- **Choice of Three Phase Comparators**
  - **Exclusive OR**
  - **Edge-Triggered J-K Flip-Flop**
  - **Edge-Triggered RS Flip-Flop**
- **Excellent VCO Frequency Linearity**
- **VCO-Inhibit Control for ON/OFF Keying and for Low Standby Power Consumption**
- **Optimized Power-Supply Voltage Range From 3 V to 5.5 V**
- **Wide Operating Temperature Range . . . –40°C to 125°C**
- **Latch-Up Performance Exceeds 250 mA Per JESD 17**
- **ESD Protection Exceeds JESD 22**
  - **2000-V Human-Body Model (A114-A)**
  - **200-V Machine Model (A115-A)**
  - **1000-V Charged-Device Model (C101)**

D, DGV, NS, OR PW PACKAGE
(TOP VIEW)



DESCRIPTION

The SN74LV4046A is a high-speed silicon-gate CMOS device that is pin compatible with the CD4046B and the CD74HC4046. The device is specified in compliance with JEDEC Std 7.

The SN74LV4046A is a phase-locked-loop circuit that contains a linear voltage-controlled oscillator (VCO) and three different phase comparators (PC1, PC2, and PC3). A signal input and a comparator input are common to each comparator.

The signal input can be directly coupled to large voltage signals, or indirectly coupled (with a series capacitor) to small voltage signals. A self-bias input circuit keeps small voltage signals within the linear region of the input amplifiers. With a passive low-pass filter, the SN74LV4046A forms a second-order loop PLL. The excellent VCO linearity is achieved by the use of linear operational amplifier techniques.

ORDERING INFORMATION

T_A	PACKAGE	ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 125°C	SOP – NS	SN74LV4040ANS	74LV4046A
		SN74LV4040ANSR	
	SOIC – D	SN74LV4040AD	LV4046A
		SN74LV4040ADR	
	TSSOP – PW	SN74LV4040APW	LW046A
		SN74LV4040APWR	
	TVSOP – DGV	SN74LV4040ADGVR	LW046A

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PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION
1	PCP_{OUT}	Phase comparator pulse output
2	$PC1_{OUT}$	Phase comparator 1 output
3	$COMP_{IN}$	Comparator input
4	VCO_{OUT}	VCO output
5	INH	Inhibit input
6	$C1_A$	Capacitor C1 connection A
7	$C1_B$	Capacitor C1 connection B
8	GND	Ground (0 V)
9	VCO_{IN}	VCO input
10	DEM_{OUT}	Demodulator output
11	R_1	Resistor R1 connection
12	R_2	Resistor R2 connection
13	$PC2_{OUT}$	Phase comparator 2 output
14	SIG_{IN}	Signal input
15	$PC3_{OUT}$	Phase comparator 3 output
16	V_{CC}	Positive supply voltage

Absolute Maximum Ratings(1)

over operating free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
V_{CC}	DC supply voltage range		–0.5	7	V
V_I	Input voltage range		–0.5	V_{CC} + 0.5	V
V_O	Output voltage range		–0.5	V_{CC} + 0.5	V
I_{IK}	Input clamp current	$V_I < 0$		–20	mA
I_{OK}	Output clamp current	$V_O < 0$		–50	mA
I_O	Continuous output curent	$V_O = 0$ to V_{CC}		±35	mA
I_{CC}	DC V_{CC} or ground current			±70	mA
θ_{JA}	Package thermal impedance(2)	D package		73	°C/W
		DGV package		120	
		NS package		64	
		PW package		108	
T_{stg}	Storage temperature range		–65	150	°C

(1) 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-rated conditions for extended periods may affect device reliability.
(2) The package thermal impedance is calculated in accordance with JESD 51-7.

Recommended Operating Conditions

PARAMETER		MIN	MAX	UNIT
T_A	Operating free-air temperature	–40	125	°C
V_{CC}	Supply voltage	3	5.5	V
V_I, V_O	DC input or output voltage	0	V_{CC}	V

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Electrical Specifications

PARAMETER				TEST CONDITIONS		V_{CC} (V)	MIN	TYP	MAX	UNIT
				V_I (V)	I_O (mA)					
VCO										
V_{IH}	High-level input voltage	INH				3 to 3.6	$V_{CC} \times 0.7$			V
						4.5 to 5.5	$V_{CC} \times 0.7$			
V_{IL}	Low-level input voltage	INH				3 to 5.5			$V_{CC} \times 0.3$	V
						4.5 to 5.5			$V_{CC} \times 0.3$	
V_{OH}	High-level output voltage	VCO_{OUT}	CMOS	V_{IL} or V_{IH}	–0.05	3 to 3.6	V_{CC} – 0.1			V
						4.5 to 5.5	V_{CC} – 0.1			
			TTL		–12	4.5 to 5.5	3.8			
V_{OL}	Low-level output voltage	VCO_{OUT}	CMOS	V_{IL} or V_{IH}	0.05	3 to 3.6			0.1	V
						4.5 to 5.5			0.1	
			TTL		12	4.5 to 5.5			0.55	
		C1A, C1B (test purposes only)			12	4.5 to 5.5			0.65	
I_I	Input leakage current	INH, VCO_{IN}		V_{CC} or GND		5.5			±1	µA
	R1 range(1)					3 to 5.5	3		50	kΩ
	R2 range(1)					3 to 4.5	3		50	kΩ
	C1 capacitance range					3 to 3.6	40		No Limit	pF
						4.5 to 5.5	40			
	Operating voltage range	VCO_{IN}		Over the range specified for R1 for linearity(2)		3 to 3.6	1.1		1.9	V
						4.5 to 5.5	1.1		3.2	
Phase Comparator										
V_{IH}	DC-coupled high-level input voltage		SIG_{IN}, $COMP_{IN}$			3 to 3.6	$V_{CC} \times 0.7$			
						4.5 to 5.5	$V_{CC} \times 0.7$			
V_{IL}	DC-coupled low-level input voltage		SIG_{IN}, $COMP_{IN}$			3 to 3.6			$V_{CC} \times 0.3$	V
						4.5 to 5.5			$V_{CC} \times 0.3$	
V_{OH}	High-level output voltage	PCP_{OUT}, PCN_{OUT}	CMOS	V_{IL} or V_{IH}	–0.05	3 to 5.5	V_{CC} – 0.1			V
					–6	3 to 3.6	2.48			
			TTL		–12	4.5 to 5.5	3.8			
V_{OL}	Low-level output voltage	PCP_{OUT}, PCN_{OUT}	CMOS	V_{IL} or V_{IH}	0.02	3 to 3.6			0.1	V
						4.5 to 5.5			0.1	
			TTL		4	4.5 to 5.5			0.4	
I_I	Input leakage current		SIG_{IN}, $COMP_{IN}$	V_{CC} or GND		3 to 3.6			±11	µA
						4.5 to 5.5			±29	
I_{OZ}	3-state off-state current		$PC2_{OUT}$	V_{IL} or V_{IH}		3 to 5.5			±5	µA
R_I	Input resistance		SIG_{IN}, $COMP_{IN}$	V_I at self-bias operating point, V_I = 0.5 V		3		800		kΩ
						4.5		250		
Demodulator										
R_S	Resistor range			R_S > 300 kΩ, Leakage current can influence V_{DEMOUT}		3 to 3.6	50		300	kΩ
						4.5 to 5.5	50		300	
V_{OFF}	Offset voltage VCO_{IN} to V_{DEM}			$V_I = V_{VCOIN} = V_{CC/2}$, Values taken over R_S range		3 to 3.6		±30		mV
						4.5 to 5.5		±20		
I_{CC}	Quiescent device current			Pins 3, 5, and 14 at V_{CC}, Pin 9 at GND, I_I at pins 3 and 14 to be excluded		5.5			50	µA

(1) The value for R1 and R2 in parallel should exceed 2.7 kΩ.
(2) The maximum operating voltage can be as high as V_{CC} – 0.9 V; however, this may result in an increased offset voltage.

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Switching Specifications

C_L = 50 pF, Input t_r, t_f = 6 ns

PARAMETER			TEST CONDITIONS	V_{CC} (V)	MIN	TYP	MAX	UNIT
Phase Comparator								
t_{PLH}, t_{PHL}	Propagation delay	SIG_{IN}, $COMP_{IN}$ to $PC1_{OUT}$		3 to 3.6			135	ns
				4.5 to 5.5			50	
t_{PLH}, t_{PHL}	Propagation delay	SIGIN, $COMP_{IN}$ to PCP_{OUT}		3 to 3.6			300	ns
				4.5 to 5.5			60	
t_{PLH}, t_{PHL}	Propagation delay	SIG_{IN}, $COMP_{IN}$ to $PC3_{OUT}$		3 to 3.6			200	ns
				4.5 to 5.5			50	
t_{THL}, t_{TLH}	Output transition time			3 to 3.6			75	ns
				4.5 to 5.5			15	
t_{PZH}, t_{PZL}	3-state output enable time	SIG_{IN}, $COMP_{IN}$ to $PC2_{OUT}$		3 to 3.6			270	ns
				4.5 to 5.5			54	
t_{PHZ}, t_{PLZ}	3-state output disable time	SIG_{IN}, $COMP_{IN}$ to PC2OUT		3 to 3.6			320	ns
				4.5 to 5.5			65	
	AC-coupled input sensitivity	(P-P) at SIG_{IN} or $COMP_{IN}$	$V_{I(P-P)}$	3 to 3.6		11		mV
				4.5 to 5.5		15		
VCO								
$\Delta f/\Delta T$	Frequency stability with temperature change		V_I = VCO_{IN} = 1/2 V_{CC}, R_1 = 100 kΩ, R_2 = ∞, C_1 = 100 pF	3 to 3.6		0.11		%/°C
				4.5 to 5.5		0.11		
f_{MAX}	Maximum frequency		C_1 = 50 pF, R_1 = 3.5 kΩ, R_2 = ∞	3 to 3.6		24		MHz
				4.5 to 5.5		24		
			C_1 = 0 pF, R_1 = 9.1 kΩ, R2 = ∞	3 to 3.6		38		
				4.5 to 5.5		38		
	Center frequency (duty 50%)		C_1 = 40 pF, R_1 = 3 kΩ, R_2 = ∞, VCO_{IN} = V_{CC}/2	3 to 3.6	7	10		MHz
				4.5 to 5.5	12	17		
ΔfVCO	Frequency linearity		C_1 = 100 pF, R_1 = 100 kΩ, R_2 = ∞	3 to 3.6		0.4		%
				4.5 to 5.5		0.4		
	Offset frequency		C_1 = 1 nF, R_2 = 220 kΩ	3 to 3.6		400		kHz
				4.5 to 5.5		400		
Demodulator								
V_{OUT} vs f_{IN}			C_1 = 100 pF, C_2 = 100 pF, R_1 = 100 kΩ, R_2 = ∞, R_3 = 100 kΩ	3		8		mV/kHz
				4.5		330		

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APPLICATION INFORMATION

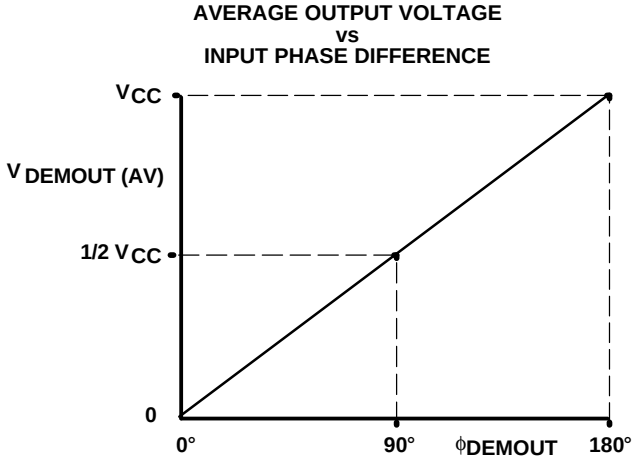

Figure 1. Phase Comparator 1:
$V_{DEMOUT} = V_{PC1OUT} = (V_{CC}/\pi)\ (SIG_{IN} - COMP_{IN})$;
DEMOUT = $(SIG_{IN} - COMP_{IN})$

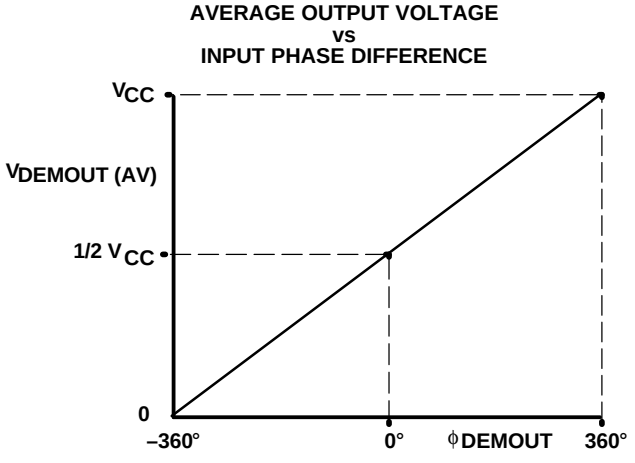

Figure 2. Phase Comparator 2:
$V_{DEMOUT} = V_{PC2OUT} = (V_{CC}/4)\ (SIG_{IN} - COMP_{IN})$;
DEMOUT = $(SIG_{IN} - COMP_{IN})$

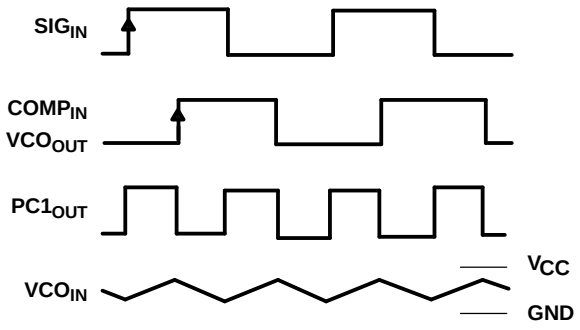

Figure 3. Typical Waveforms for PLL Using Phase Comparator 1, Loop Locked at f_o

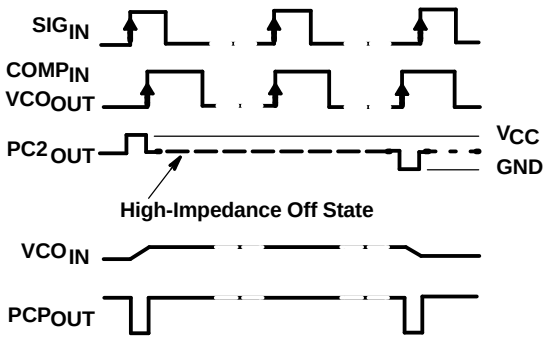

Figure 4. Typical Waveforms for PLL Using Phase Comparator 2, Loop Locked at f_o

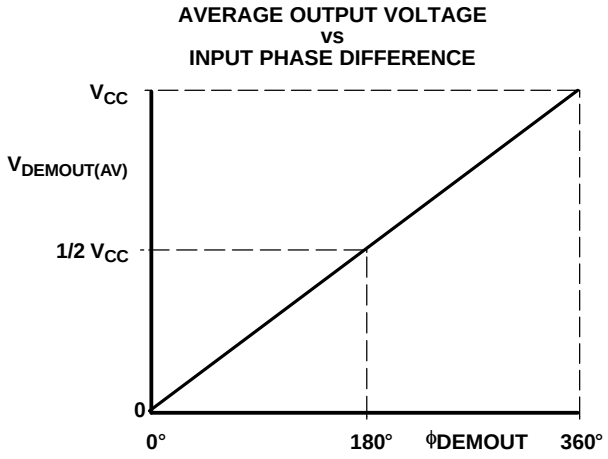

Figure 5. Phase Comparator 3:
$V_{DEMOUT} = V_{PC3OUT} = (V_{CC}/2\pi)\ (SIG_{IN} - COMP_{IN})$;
DEMOUT = $(SIG_{IN} - COMP_{IN})$

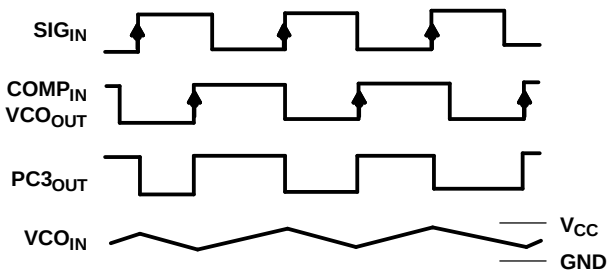

Figure 6. Typical Waveforms for PLL Using Phase Comparator 3, Loop Locked at f_o

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APPLICATION INFORMATION (continued)

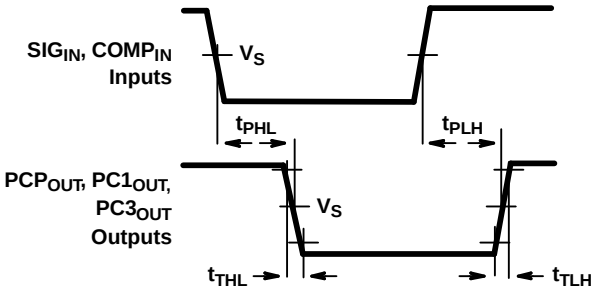

Figure 7. Input-to-Output Propagation Delays and Output Transition Times

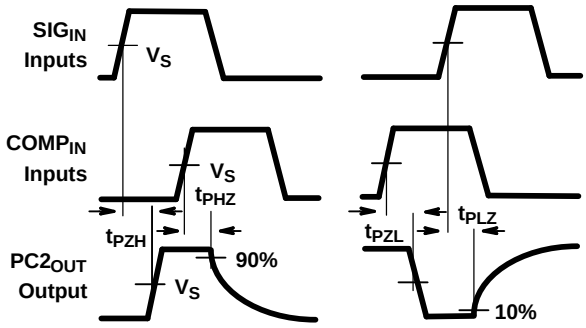

Figure 8. 3-State Enable and Disable Times for $PC2_{OUT}$

C_{PD} (1)

CHIP SECTION	C_{PD}	UNIT
Comparator 1	120	pF
VCO	120	

(1) R1 between 3 kΩ and 50 kΩ
R2 between 3 kΩ and 50 kΩ
R1 + R2 parallel value > 2.7 kΩ
C1 > 40 pF

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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
SN74LV4046AD	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74LV4046ADGVR	ACTIVE	TVSOP	DGV	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74LV4046ADR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74LV4046ANS	ACTIVE	SO	NS	16	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74LV4046ANSR	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74LV4046APW	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74LV4046APWR	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

(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.

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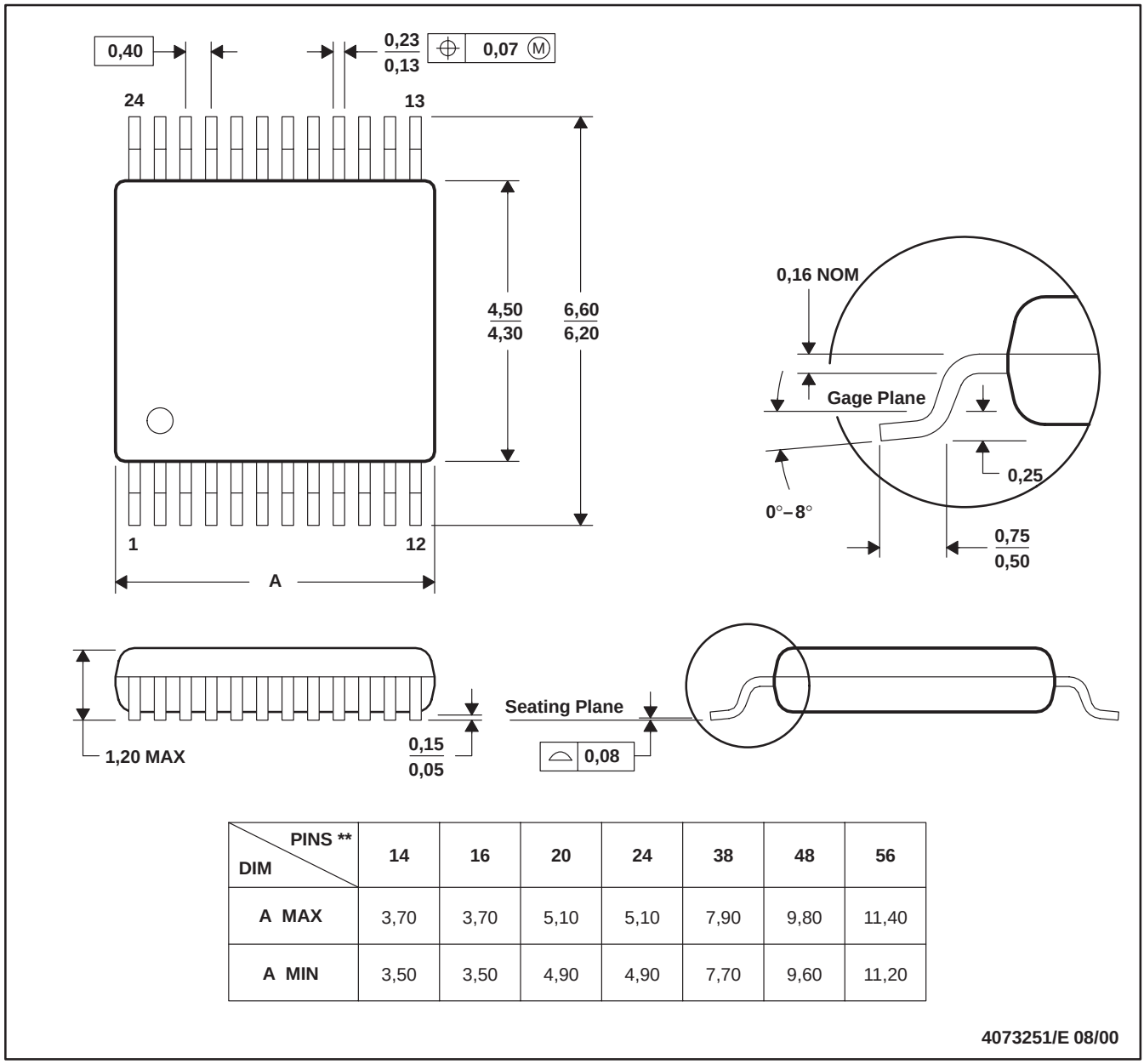
MPDS006C – FEBRUARY 1996 – REVISED AUGUST 2000

DGV (R-PDSO-G)** **PLASTIC SMALL-OUTLINE**

24 PINS SHOWN



DIM \ PINS **	14	16	20	24	38	48	56
A MAX	3,70	3,70	5,10	5,10	7,90	9,80	11,40
A MIN	3,50	3,50	4,90	4,90	7,70	9,60	11,20

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15 per side.
D. Falls within JEDEC: 24/48 Pins – MO-153
14/16/20/56 Pins – MO-194

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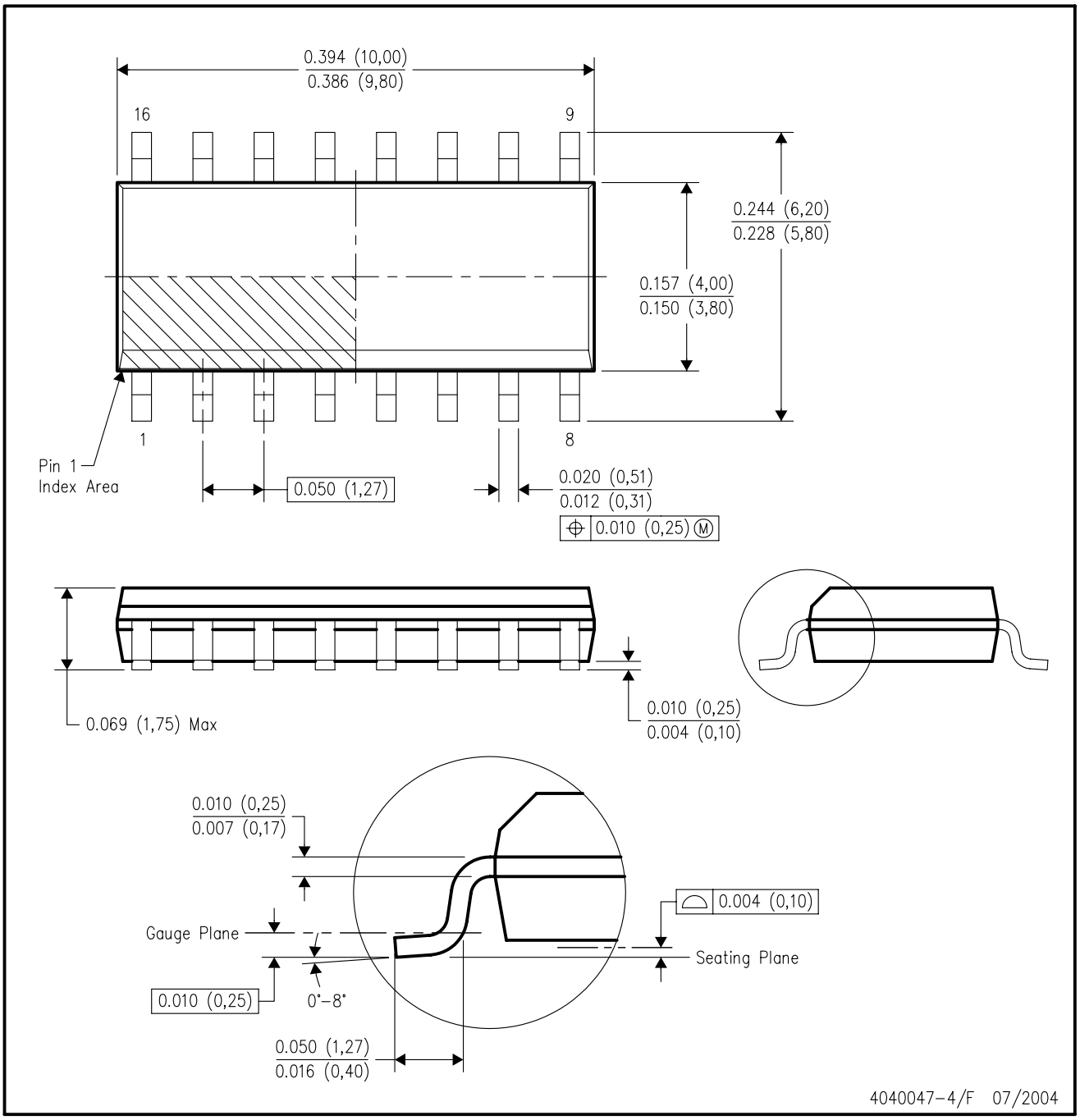
D (R–PDSO–G16) PLASTIC SMALL–OUTLINE PACKAGE



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 AC.

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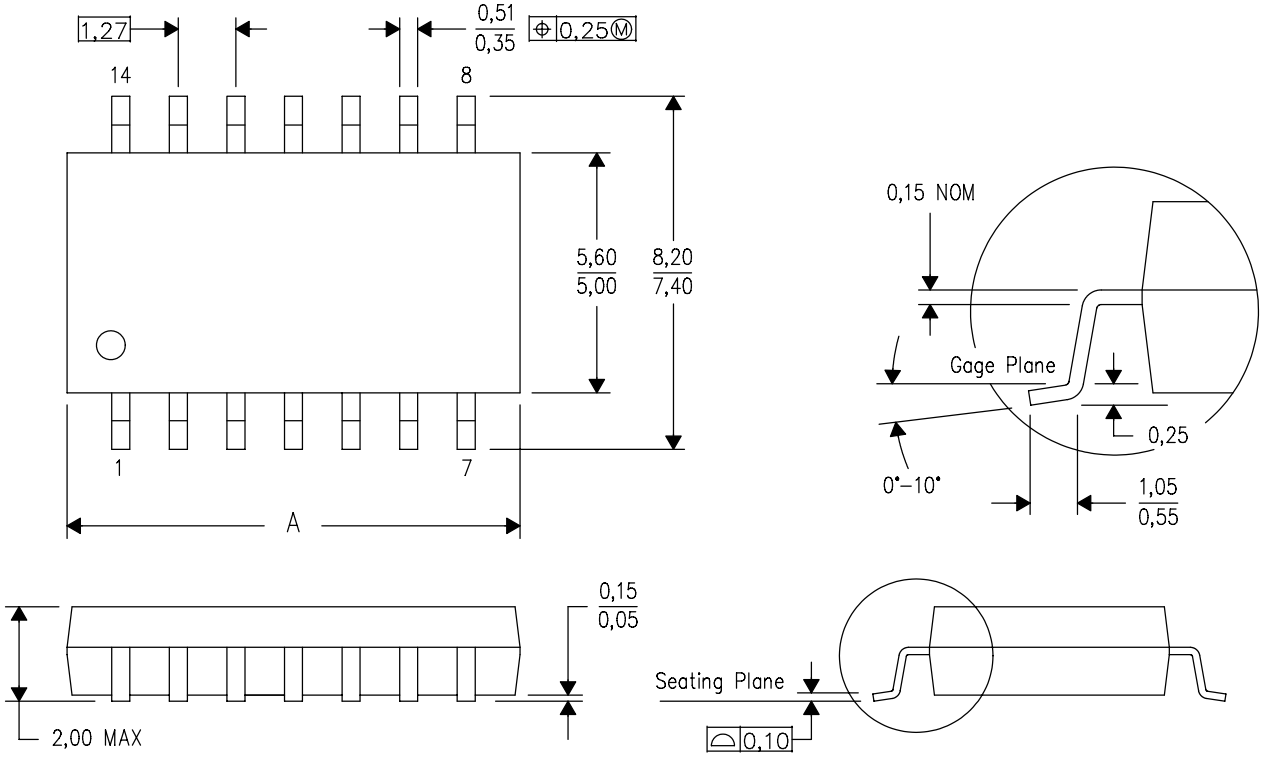
MECHANICAL DATA

NS (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

14-PINS SHOWN



DIM \ PINS **	14	16	20	24
A MAX	10,50	10,50	12,90	15,30
A MIN	9,90	9,90	12,30	14,70

4040062/C 03/03

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

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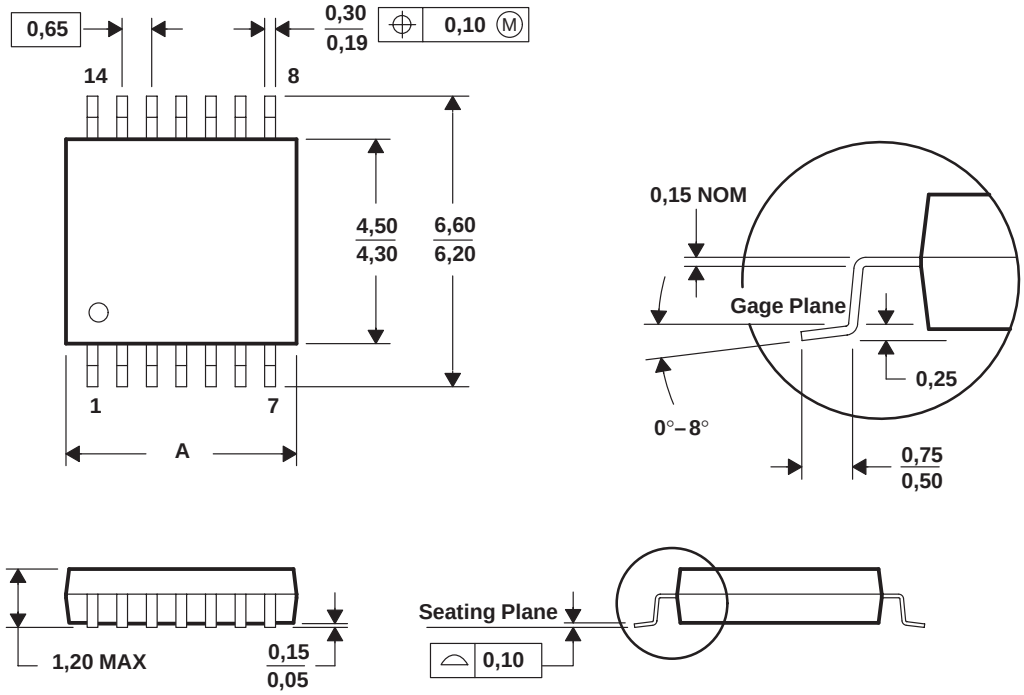
PW (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

14 PINS SHOWN



DIM \ PINS **	8	14	16	20	24	28
A MAX	3,10	5,10	5,10	6,60	7,90	9,80
A MIN	2,90	4,90	4,90	6,40	7,70	9,60

4040064/F 01/97

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-153

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