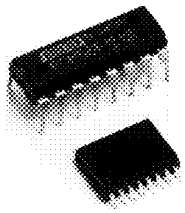
BURR - BROWN®



PCM56P
PCM56U

DESIGNED FOR AUDIO

Serial Input 16-Bit Monolithic DIGITAL-TO-ANALOG CONVERTER

FEATURES

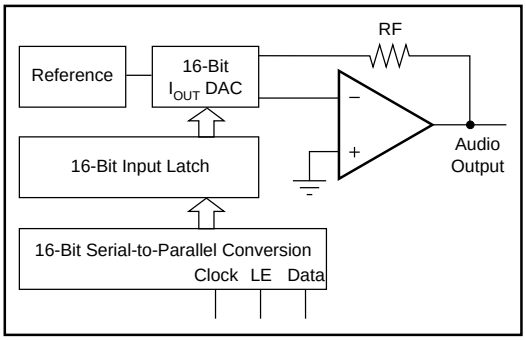
- **SERIAL INPUT**
- **–92dB MAX THD: FS Input, K Grade**
- **–74dB MAX THD: –20dB Input, K Grade**
- **96dB DYNAMIC RANGE**
- **NO EXTERNAL COMPONENTS REQUIRED**
- **16-BIT RESOLUTION**
- **15-BIT MONOTONICITY, TYP**
- **0.001% OF FSR TYP DIFFERENTIAL LINEARITY ERROR**
- **1.5μs SETTLING TIME, TYP: Voltage Out**
- **±3V OR ±1mA AUDIO OUTPUT**
- **EIAJ STC-007-COMPATIBLE**
- **OPERATES ON ±5V TO ±12V SUPPLIES**
- **PINOUT ALLOWS I_{OUT} OPTION**
- **PLASTIC DIP OR SOIC PACKAGE**

DESCRIPTION

The PCM56 is a state-of-the-art, fully monotonic, digital-to-analog converter that is designed and specified for digital audio applications. This device employs ultra-stable nichrome (NiCr) thin-film resistors to provide monotonicity, low distortion, and low differential linearity error (especially around bipolar zero) over long periods of time and over the full operating temperature.

This converter is completely self-contained with a stable, low noise, internal zener voltage reference; high speed current switches; a resistor ladder network; and a fast settling, low noise output operational amplifier all on a single monolithic chip. The converters are operated using two power supplies that can range from ±5V to ±12V. Power dissipation with ±5V supplies is typically less than 200mW. Also included is a provision for external adjustment of the MSB error (differential linearity error at bipolar zero) to further improve total harmonic distortion (THD) specifications if desired. Few external components are necessary for operation, and all critical specifications are 100% tested. This helps assure the user of high system reliability and outstanding overall system performance.

The PCM56 is packaged in a high-quality 16-pin molded plastic DIP package or SOIC and has passed operating life tests under simultaneous high-pressure, high-temperature, and high-humidity conditions.



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PDS-700D Printed in U.S.A. August, 1993

SBAS149

SPECIFICATIONS

ELECTRICAL

Typical at +25°C, and nominal power supply voltages ±5V, unless otherwise noted.

PARAMETER	PCM56U, PCM56P-J, -K MIN	TYP	MAX	UNITS
DIGITAL INPUT				
Resolution		16		Bits
Digital Inputs[1]: V_{IH}	+2.4		$+V_L$	V
V_{IL}	0		+0.8	V
I_{IH}, V_{IN} = +2.7V			+1.0	µA
I_{IL}, V_{IN} = +0.4V			–50	µA
Input Clock Frequency	10.0			MHz
TRANSFER CHARACTERISTICS				
ACCURACY				
Gain Error		±2.0		%
Bipolar Zero Error		±30		mV
Differential Linearity Error		±0.001		% of FSR[2]
Noise (rms, 20Hz to 20kHz) at Bipolar Zero (V_{OUT} models)		6		µV
TOTAL HARMONIC DISTORTION				
V_O = ±FS at f = 991Hz: PCM56P-K		–94	–92	dB
PCM56P-J		–94	–88	dB
PCM56P, PCM56U		–94	–82	dB
PCM56P-L		–94	–80	dB
V_O = –20dB at f = 991Hz: PCM56P-K		–75	–74	dB
PCM56P-J		–75	-68	dB
PCM56P, PCM56U		–75	–68	dB
PCM56P-L		–75	–60	dB
V_O = –60dB at f = 991Hz: PCM56P-K		–35	–34	dB
PCM56P-J		–35	–28	dB
PCM56P, PCM56U		–35	–28	dB
PCM56P-L		–35	–20	dB
MONOTONICITY		15		Bits
DRIFT (0°C to +70°C)				
Total Drift[3]		±25		ppm of FSR/°C
Bipolar Zero Drift		±4		ppm of FSR/°C
SETTLING TIME (to ±0.006% of FSR)				
Voltage Output: 6V Step		1.5		µs
1LSB		1.0		µs
Slew Rate		10		V/µs
Current Output, 1mA Step: 10Ω to 100Ω Load		350		ns
1kΩ Load[4]		350		ns
WARM-UP TIME	1			Min
OUTPUT				
Voltage Output Configuration: Bipolar Range		±3.0		V
Output Current	±2.0			mA
Output Impedance		0.10		Ω
Short Circuit Duration		Indefinite to Common		
Current Output Configuration:				
Bipolar Range (±30%)		±1.0		mA
Output Impedance (±30%)		1.2		kΩ
POWER SUPPLY REQUIREMENTS[5]				
Voltage: $+V_S$ and $+V_L$	+4.75	+5.00	+13.2	V
$–V_S$ and $–V_L$	–4.75	–5.00	–13.2	V
Supply Drain (No Load): +V ($+V_S$ and $+V_L$ = +5V)		+10.00	+17.0	mA
–V ($–V_S$ and $–V_L$ = –5V)		–25.0	–35.0	mA
+V ($+V_S$ and $+V_L$ = +12V)		+12.0		mA
–V ($–V_S$ and $–V_L$ = –12V)		–27.0		mA
Power Dissipation: V_S and V_L = ±5V		175	260	mW
V_S and V_L = ±12V		468		mW
TEMPERATURE RANGE				
Specification	0		+70	°C
Operation	–25		+70	°C
Storage	–60		+100	°C

NOTES: (1) Logic input levels are TTL/CMOS-compatible. (2) FSR means full-scale range and is equivalent to 6V (±3V) for PCM56 in the V_{OUT} mode. (3) This is the combined drift error due to gain, offset, and linearity over temperature. (4) Measured with an active clamp to provide a low impedance for approximately 200ns. (5) All specifications assume $+V_S$ connected to $+V_L$ and $–V_S$ connected to $–V_L$. If supplies are connected separately, $–V_L$ must not be more negative than $–V_S$ supply voltage to assure proper operation. No similar restriction applies to the value of $+V_L$ with respect to $+V_S$.

ABSOLUTE MAXIMUM RATINGS

DC Supply Voltages	±16VDC
Input Logic Voltage	–1V to $+V_S/+V_L$
Power Dissipation	850mW
Operating Temperature	–25°C to +70°C
Storage Temperature	–60°C to +100°C
Lead Temperature (soldering, 10s)	+300°C

PACKAGE INFORMATION

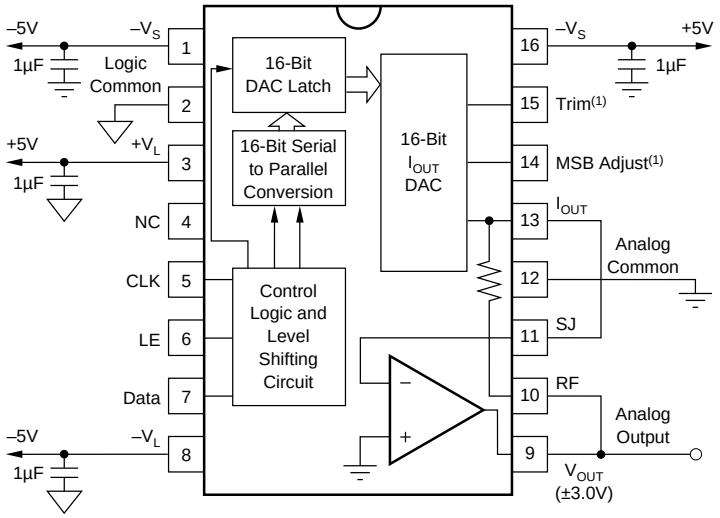
MODEL	PACKAGE	PACKAGE DRAWING NUMBER(1)
PCM56U	16-Pin SOIC	211
PCM56P	16-Pin Plastic DIP	180
PCM56P-J	16-Pin Plastic DIP	180
PCM56P-K	16-Pin Plastic DIP	180
PCM56P-L	16-Pin Plastic DIP	180

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix D of Burr-Brown IC Data Book.

PIN ASSIGNMENTS

PIN	DESCRIPTION	MNEMONIC
P1	Analog Negative Supply	$-V_S$
P2	Logic Common	LOG COM
P3	Logic Positive Supply	$+V_L$
P4	No Connection	NC
P5	Clock Input	CLK
P6	Latch Enable Input	LE
P7	Serial Data Input	DATA
P8	Logic Negative Supply	$-V_L$
P9	Voltage Output	V_{OUT}
P10	Feedback Resistor	RF
P11	Summing Junction	SJ
P12	Analog Common	ANA COM
P13	Current Output	I_{OUT}
P14	MSB Adjustment Terminal	MSB ADJ
P15	MSB Trim-pot Terminal	TRIM
P16	Analog Positive Supply	$+V_S$

CONNECTION DIAGRAM



NOTE: (1) MSB error (Bipolar Zero differential linearity error) can be adjusted to zero using the external circuit shown in Figure 6.

DISCUSSION OF SPECIFICATIONS

The PCM56 is specified to provide critical performance criteria for a wide variety of applications. The most critical specifications for D/A converter in audio applications are Total Harmonic Distortion, Differential Linearity Error, Bipolar Zero Error, parameter shifts with time and temperature, and settling time effects on accuracy.

The PCM56 is factory-trimmed and tested for all critical key specifications.

The accuracy of a D/A converter is described by the transfer function shown in Figure 1. Digital input to analog output relationship is shown in Table I. The errors in the D/A converter are combinations of analog errors due to the linear circuitry, matching and tracking properties of the ladder and scaling networks, power supply rejection, and reference errors. In summary, these errors consist of initial errors including Gain, Offset, Linearity, Differential Linearity, and Power Supply Sensitivity. Gain drift over temperature rotates the line (Figure 1) about the bipolar zero point and Offset drift shifts the line left or right over the operating temperature range. Most of the Offset and Gain drift with temperature or time is due to the drift of the internal reference zener diode. The converter is designed so that these drifts are in opposite directions. This way the Bipolar Zero voltage is virtually unaffected by variations in the reference voltage.

DIGITAL INPUT CODES

The PCM56 accepts serial input data (MSB first) in the Binary Two's Complement (BTC) form. Refer to Table I for input/output relationships.

DIGITAL INPUT	ANALOG OUTPUT		
Binary Two's Complement (BTC)	DAC Output	Voltage (V), V_{OUT} Mode	Current (mA), I_{OUT} Mode
7FFF Hex	+ Full Scale	+2.999908	–0.999970
8000 Hex	– Full Scale	–3.000000	+1.000000
0000 Hex	Bipolar Zero	0.000000	0.000000
FFFF Hex	Zero –1LSB	–0.000092	+0.030500µA

TABLE I. Digital Input to Analog Output Relationship.

BIPOLAR ZERO ERROR

Initial Bipolar Zero Error (Bit 1 "on" and all other bits "off") is the deviation from 0V out and is factory-trimmed to typically ±30mV at +25°C.

DIFFERENTIAL LINEARITY ERROR

Differential Linearity Error (DLE) is the deviation from an ideal 1LSB change from one adjacent output state to the next. DLE is important in audio applications because excessive DLE at Bipolar Zero (at the "major carry") can result in audible crossover distortion for low level output signals. Initial DLE on the PCM56 is factory trimmed to typically ±0.001% of FSR. The MSB DLE is adjustable to zero using the circuit shown in Figure 6.

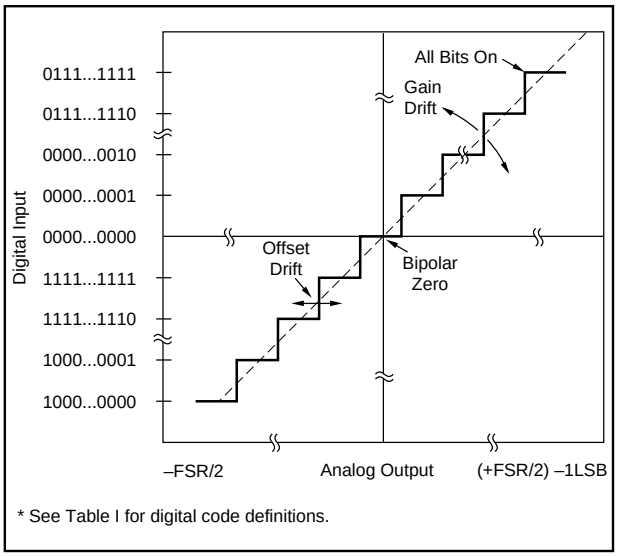


FIGURE 1. Input vs Output for an Ideal Bipolar D/A Converter.

POWER SUPPLY SENSITIVITY

Changes in the DC power supplies will affect accuracy. The PCM56 power supply sensitivity is shown by Figure 2. Normally, regulated power supplies with 1% or less ripple are recommended for use with the DAC. See also Power Supply Connections paragraph in the Installation and Operating Instructions section.

SETTLING TIME

Settling time is the total time (including slew time) required for the output to settle within an error band around its final value after a change in input (see Figure 3).

Settling times are specified to ±0.006% of FSR: one for a large output voltage change of 6V and one for a 1LSB change. The 1LSB change is measured at the major carry (0000 hex to ffff hex), the point at which the worst-case settling time occurs.

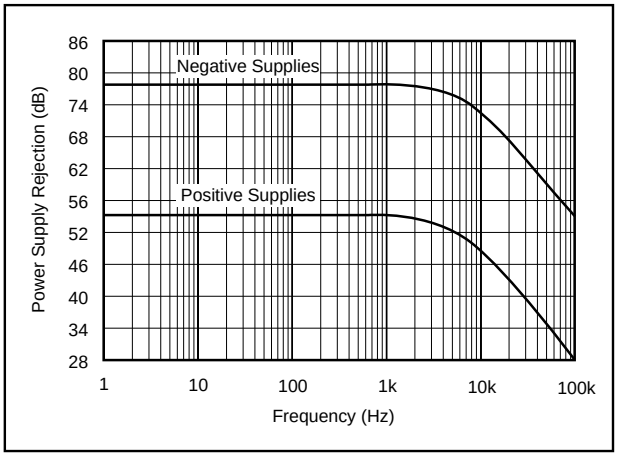


FIGURE 2. Power Supply Sensitivity.

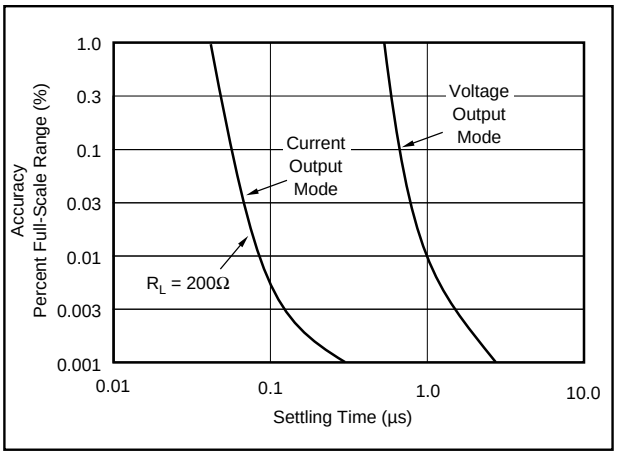


FIGURE 3. Full Scale Range Settling Time vs Accuracy.

STABILITY WITH TIME AND TEMPERATURE

The parameters of a D/A converter designed for audio applications should be stable over a relatively wide temperature range and over long periods of time to avoid undesirable periodic readjustment. The most important parameters are Bipolar Zero Error, Differential Linearity Error, and Total Harmonic Distortion. Most of the Offset and Gain drift with temperature or time is due to the drift of the internal reference zener diode. The PCM56 is designed so that these drifts are in opposite directions so that the Bipolar Zero voltage is virtually unaffected by variations in the reference voltage. Both DLE and THD are dependent upon the matching and tracking of resistor ratios and upon V_{BE} and h_{FE} of the current-source transistors. The PCM56 was designed so that any absolute shift in these components has virtually no effect on DLE or THD. The resistors are made of identical links of ultra-stable nichrome thin-film. The current density in these resistors is very low to further enhance their stability.

DYNAMIC RANGE

The Dynamic Range is a measure of the ratio of the smallest signals the converter can produce to the full-scale range and is usually expressed in decibels (dB). The theoretical dynamic range of a converter is approximately 6 x n, or about 96dB of a 16-bit converter. The actual, or useful, dynamic range is limited by noise and linearity errors and is therefore somewhat less than the theoretical limit. However, this does point out that a resolution of at least 16 bits is required to obtain a 90dB minimum dynamic range, regardless of the accuracy of the converter. Another specification that is useful for audio applications is Total Harmonic Distortion.

TOTAL HARMONIC DISTORTION

THD is useful in audio applications and is a measure of the magnitude and distribution of the Linearity Error, Differential Linearity Error, and Noise, as well as Quantization Error. To be useful, THD should be specified for both high level and low level input signals. This error is unadjustable and is the most meaningful indicator of D/A converter accuracy for audio applications.

The THD is defined as the ratio of the square root of the sum of the squares of the values of the harmonics to the value of the fundamental input frequency and is expressed in percent or dB. The rms value of the PCM56 error referred to the input can be shown to be:

$$\epsilon_{rms} = \sqrt{1/n \sum_{i=1}^{n} \left[E_L(i) + E_Q(i)\right]^2} \qquad (1)$$

where n is the number of samples in one cycle of any given sine wave, $E_L(i)$ is the linearity error of the PCM56 at each sampling point, and $E_Q(i)$ is the quantization error at each sampling point. The THD can then be expressed as:

$$THD = \epsilon_{rms} / E_{rms} = \frac{\sqrt{1/n \sum_{i=1}^{n} \left[E_L(i) + E_Q(i)\right]^2}}{E_{rms}} \times 100\% \qquad (2)$$

where E_{rms} is the rms signal-voltage level.

This expression indicates that, in general, there is a correlation between the THD and the square root of the sum of the squares of the linearity errors at each digital word of interest. However, this expression does not mean that the worst-case linearity error of the D/A is directly correlated to the THD.

For the PCM56 the test period was chosen to be 22.7µs (44.1kHz), which is compatible with the EIAJ STC-007 specification for PCM audio. The test frequency is 991Hz and the amplitude of the input signal is 0dB, –20dB, and –60dB down from full scale.

Figure 4 shows the typical THD as a function of output voltage.

Figure 5 shows typical THD as a function of frequency.

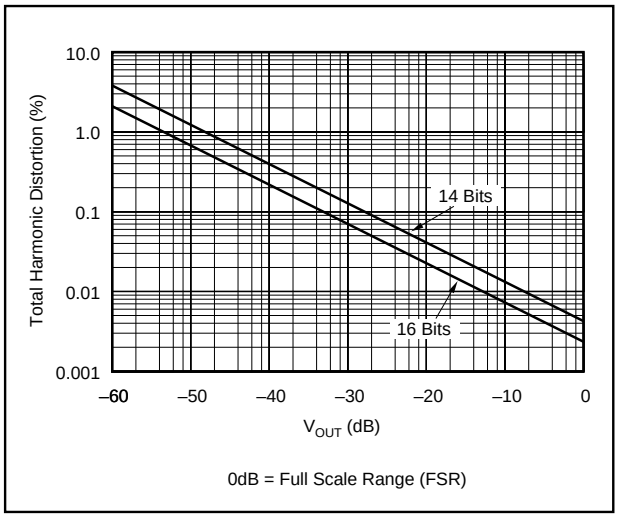


FIGURE 4. Total Harmonic Distortion (THD) vs V_{OUT}.

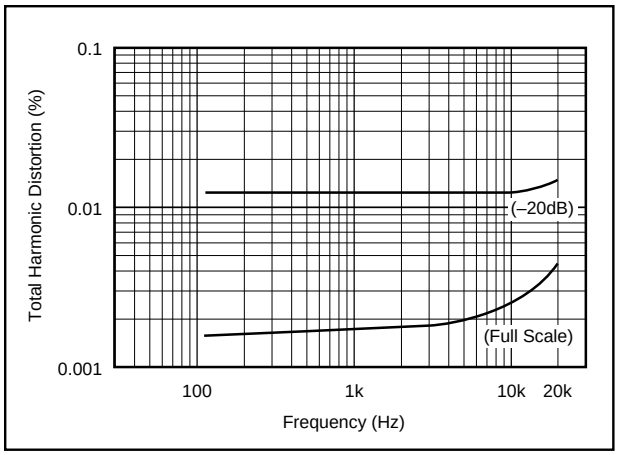


FIGURE 5. Total Harmonic Distortion (THD) vs Frequency.

INSTALLATION AND OPERATING INSTRUCTIONS

POWER SUPPLY CONNECTIONS

For optimum performance and noise rejection, power supply decoupling capacitors should be added as shown in the Connection Diagram. These capacitors (1µF tantalum or electrolytic recommended) should be located close to the converter.

MSB ERROR ADJUSTMENT PROCEDURE (OPTIONAL)

The MSB error of the PCM56 can be adjusted to make the differential linearity error (DLE) at BPZ essentially zero. This is important when the signal output levels are very low, because zero crossing noise (DLE at BPZ) becomes very significant when compared to the small code changes occurring in the LSB portion of the converter.

Differential linearity error at bipolar zero and THD are guaranteed to meet data sheet specifications without any external adjustment. However, a provision has been made for an optional adjustment of the MSB linearity point which makes it possible to eliminate DLE error at BPZ. Two procedures are given to allow either static or dynamic adjustment. The dynamic procedure is preferred because of the difficulty associated with the static method (accurately measuring 16-bit LSB steps).

To statically adjust DLE at BPZ, refer to the circuit shown in Figure 6, or the PCM56 connection diagram.

After allowing ample warm-up time (5-10 minutes) to assure stable operation of the PCM56, select input code FFFF hexadecimal (all bits on except the MSB). Measure the audio output voltage using a 6-1/2 digit voltmeter and record it. Change the digital input code to 0000 hexadecimal (all bits off except the MSB). Adjust the 100kΩ potentiometer to make the audio output read 92µV more than the voltage reading of the previous code (a 1LSB step = 92µV).

A much simpler method is to dynamically adjust the DLE at BPZ. Again, refer to Figure 6 for circuitry and component values. Assuming the device has been installed in a digital audio application circuit, send the appropriate digital input to produce a –80dB level sinusoidal output. While measuring the THD of the audio circuit output, adjust the 100kΩ potentiometer until a minimum level of distortion is observed.

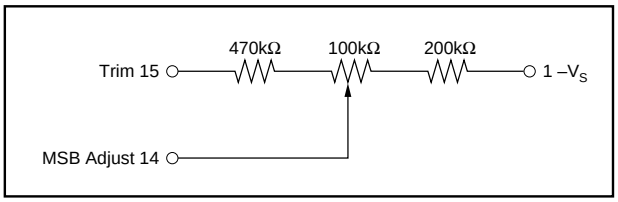


FIGURE 6. MSB Adjustment Circuit.

INPUT TIMING CONSIDERATIONS

Figure 7 and 8 refer to the input timing required to interface the inputs of PCM56 to a serial input data stream. Serial data is accepted in Binary Two's Complement (BTC) with the MSB being loaded first. Data is clocked in on positive going clock (CLK) edges and is latched into the DAC input register on negative going latch enable (LE) edges.

The latch enable input must be high for at least one clock cycle before going low, and then must be held low for at least one clock cycle. The last 16 data bits clocked into the serial input register are the ones that are transferred to the DAC input register when latch enable goes low. In other words, when more than 16 clock cycles occur between a latch enable, only the data present during the last 16 clocks will be transferred to the DAC input register.

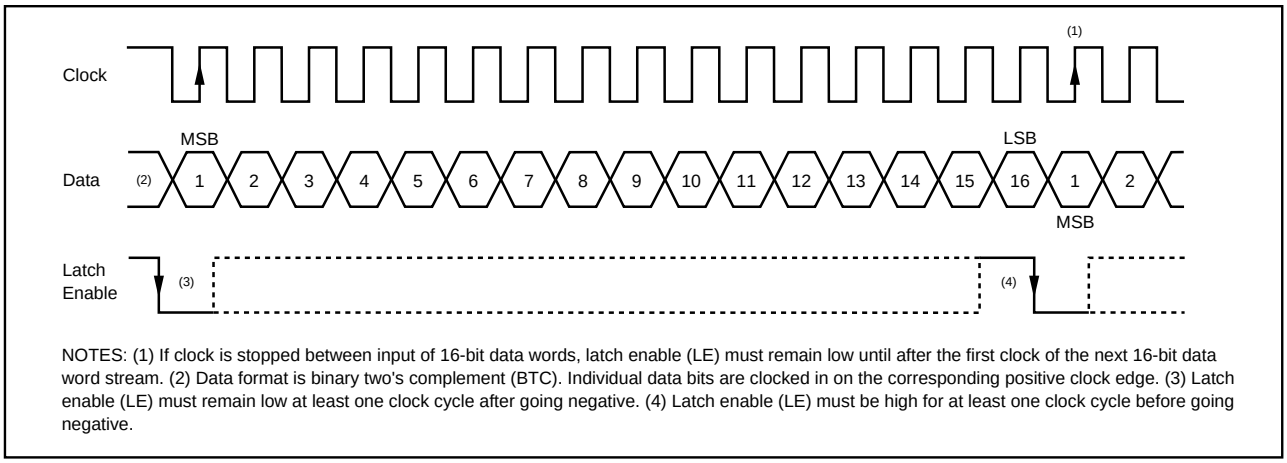
One requirement for clocking in all 16 bits is the necessity for a "17th" clock pulse. This automatically occurs when the clock is continuous (last bit shifts in on the first bit of the next data word). If the clock is stopped between input of 16-bit data words, the latch enable (LE) must remain low until after the first clock of the next 16-bit data word stream. This ensures that the latch is properly set up.

Figure 7 refers to the general input format required for the PCM56. Figure 8 shows the specific relationships between the various signals and their timing constraints.

INSTALLATION CONSIDERATIONS

If the optional external MSB error circuitry is used, a potentiometer with adequate resolution and a TCR of 100ppm/°C or less is required. Also, extra care must be taken to insure that no leakage path (either AC or DC) exists to pin 14. If the circuit is not used, pins 14 and 15 should be left open.

The PCM converter and the wiring to its connectors should be located to provide the optimum isolation from sources of RFI and EMI. The important consideration in the elimination



NOTES: (1) If clock is stopped between input of 16-bit data words, latch enable (LE) must remain low until after the first clock of the next 16-bit data word stream. (2) Data format is binary two's complement (BTC). Individual data bits are clocked in on the corresponding positive clock edge. (3) Latch enable (LE) must remain low at least one clock cycle after going negative. (4) Latch enable (LE) must be high for at least one clock cycle before going negative.

FIGURE 7. Input Timing Diagram.

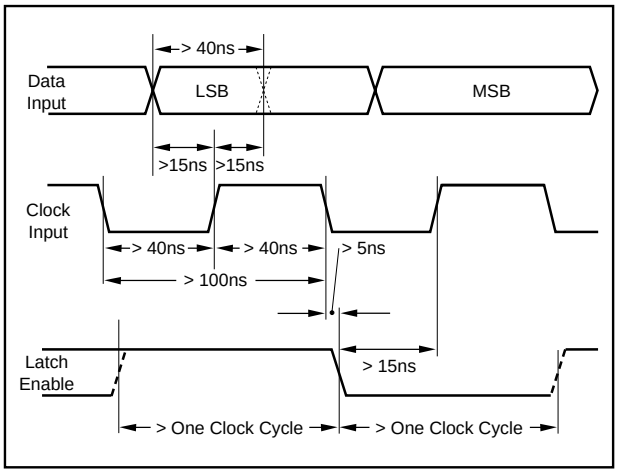


FIGURE 8. Input Timing Relationships.

of RF radiation or pickup is loop area; therefore, signal leads and their return conductors should be kept close together. This reduces the external magnetic field along with any radiation. Also, if a signal lead and its return conductor are wired close together, they represent a small flux-capture cross section for any external field. This reduces radiation pickup in the circuit.

APPLICATIONS

Figures 9 and 10 show a circuit and timing diagram for a single PCM56 used to obtain both left- and right-channel output in a typical digital audio system. The audio output of the PCM56 is alternately time-shared between the left and right channels. The design is greatly simplified because the PCM56 is a complete D/A converter requiring no external reference or output op amp.

A sample/hold (S/H) amplifier, or "deglitcher" is required at the output of the D/A for both the left and right channel, as shown in Figure 9. The S/H amplifier for the left channel is composed of A_1, SW_1, and associated circuitry. A_1 is used as an integrator to hold the analog voltage in C_1. Since the source and drain of the FET switch operate at a virtual ground when "C" and "B" are connected in the sample mode, there is no increase in distortion caused by the modulation effect of R_{ON} by the audio signal.

Figure 10 shows the deglitcher controls for both left and right channels which are produced by timing control logic. A delay of 1.5µs ($t\omega$) is provided to allow the output of the PCM56 to settle within a small error band around its final value before connecting it to the channel output. Due to the fast settling time of the PCM56 it is possible to minimize the delay between the left- and right-channel outputs when using a single D/A converter for both channels. This is important because the right- and left-channel data are recorded in-phase and the use of the slower D/A converter would result in significant phase error at higher frequencies.

The obvious solution to the phase shift problem in a two-channel system would be to use two D/A converters (one per channel) and time the outputs to change simultaneously. Figure 11 shows a block diagram of the final test circuitry used for PCM56. It should be noted that no deglitching circuitry is required on the DAC output to meet specified THD performance. This means that when one PCM56 is used per channel, the need for all the sample/hold and controls circuitry associated with a single DAC (two-channel) design is effectively eliminated. The PCM56 is tested to meet its THD specifications without the need for output deglitching.

A low-pass filter is required after the PCM56 to remove all unwanted frequency components caused by the sampling frequency as well as those resulting from the discrete nature of the D/A output. This filter must have a flat frequency response over the entire audio band (0-20kHz) and a very high attenuation above 20kHz.

Most previous digital audio circuits used a higher order (9-13 pole) analog filter. However, the phase response of an analog filter with these amplitude characteristics is nonlinear and can disturb the pulse-shaped characteristic transients contained in music.

SECOND GENERATION SYSTEMS

One method of avoiding the problems associated with a higher order analog filter would be to use digital filter oversampling techniques. Oversampling by a factor of two would move the sampling frequency (88.2kHz) out to a point where only a simple low-order phase-linear analog filter is required after the deglitcher output to remove unwanted intermodulation products. In a digital compact disc application, various VLSI chips perform the functions of error detection/correction, digital filtering, and formatting of the digital information to provide the clock, latch enable, and serial input to the PCM56. These VLSI chips are available from several sources (Sony, Yamaha, Signetics, etc.) and are specifically optimized for digital audio applications.

Oversampled circuitry requires a very fast D/A converter since the sampling frequency is multiplied by a factor of two or more (for each output channel). A single PCM56 can provide two-channel oversampling at a 4X rate (176.4kHz/channel) and still remain well within the settling time requirements for maintaining specified THD performance. This would reduce the complexities of the analog filter even further from that used in 2X oversampling circuitry.

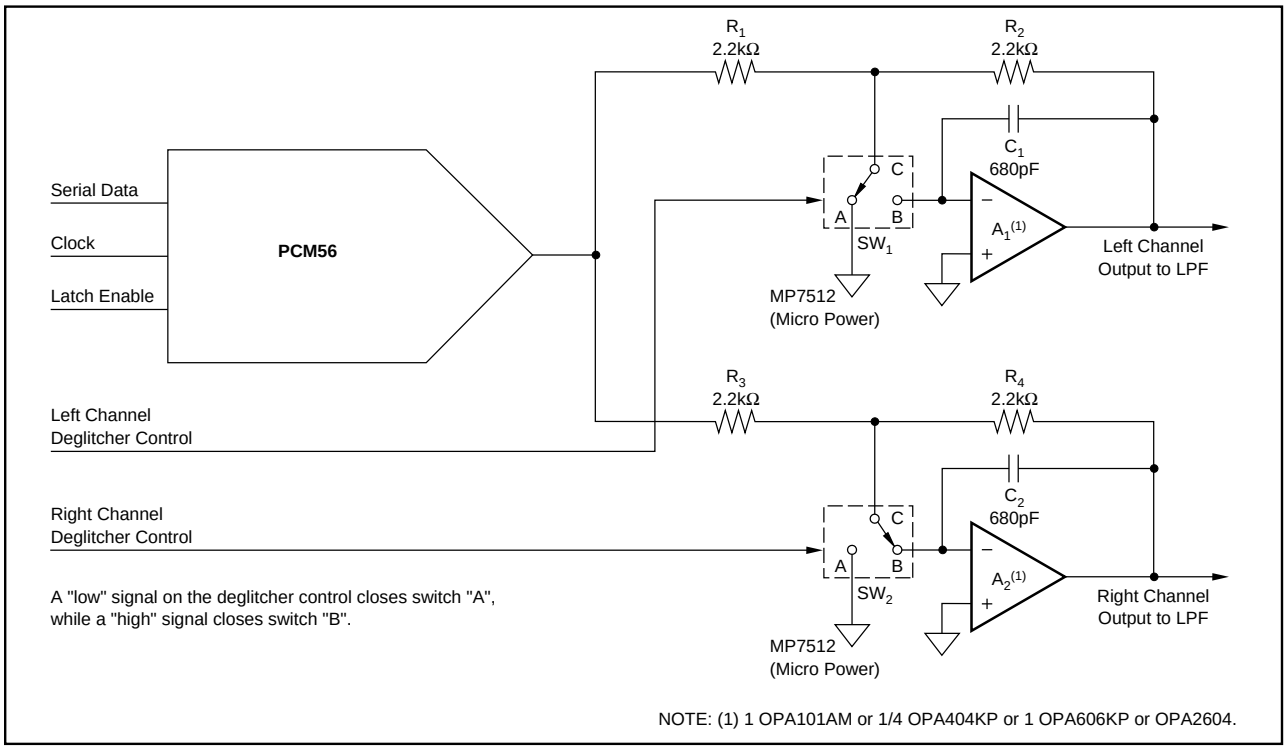


FIGURE 9. A Sample/Hold Amplifier (Deglitcher) is Required at the Digital-to-Analog Output for Both Left and Right Channels.

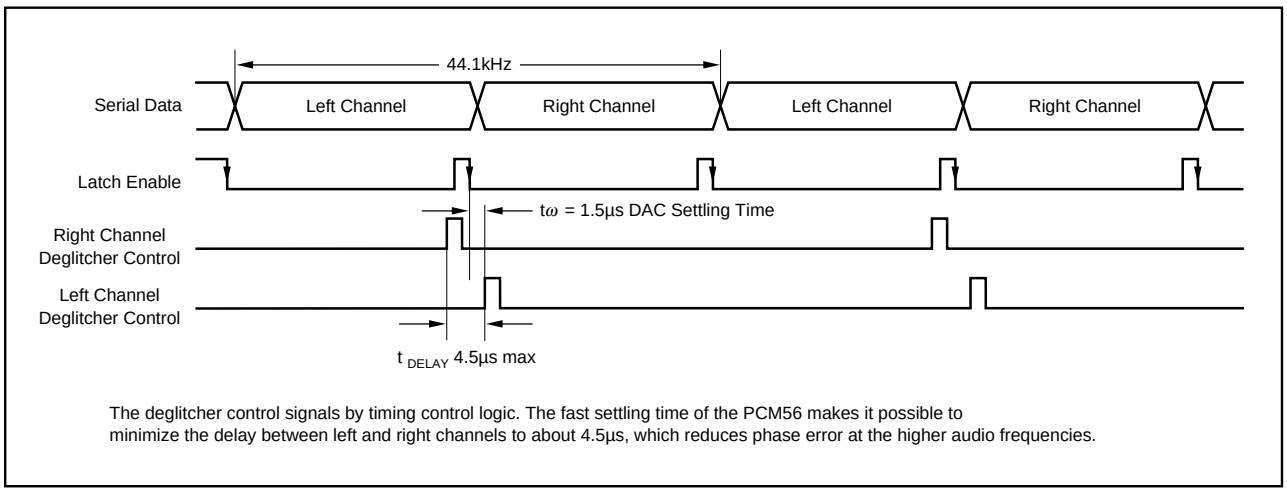


FIGURE 10. Timing Diagram for the Deglitcher Control Signals.

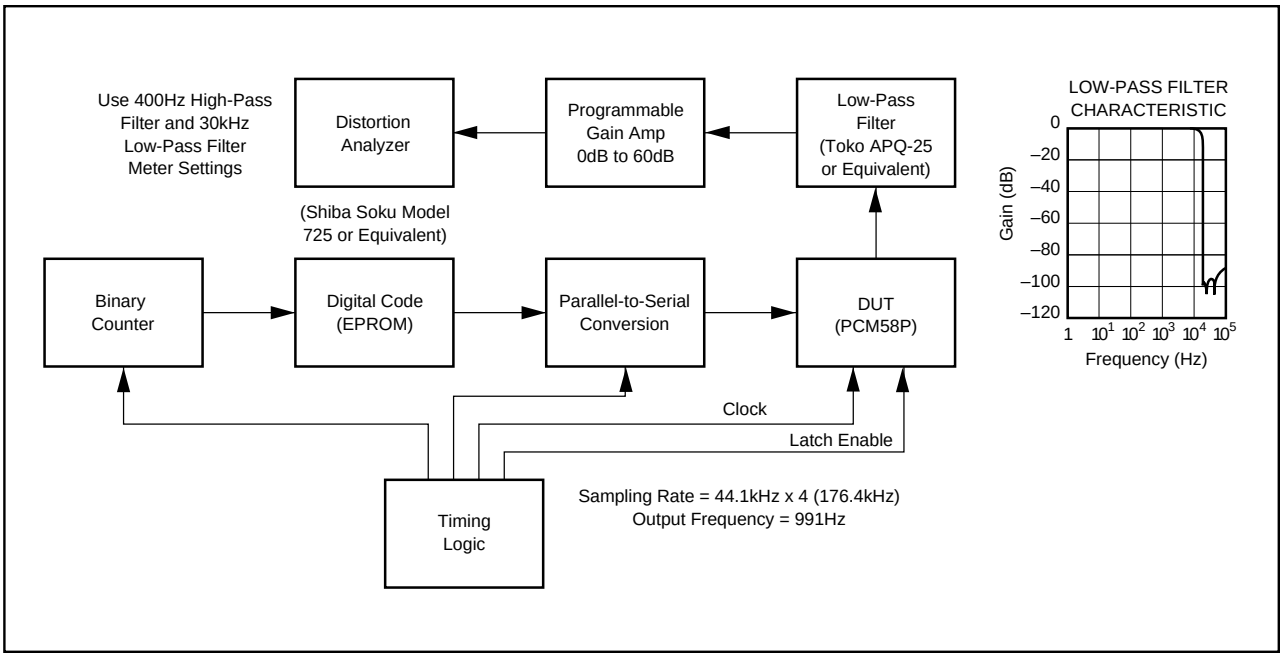


FIGURE 11. Block Diagram of Distortion Test Circuit.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
PCM56U	NRND	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR		PCM56U	
PCM56U/1K	NRND	SOIC	DW	16	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR		PCM56U	
PCM56U/1KG4	NRND	SOIC	DW	16	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR		PCM56U	
PCM56UG4	NRND	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR		PCM56U	

(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.

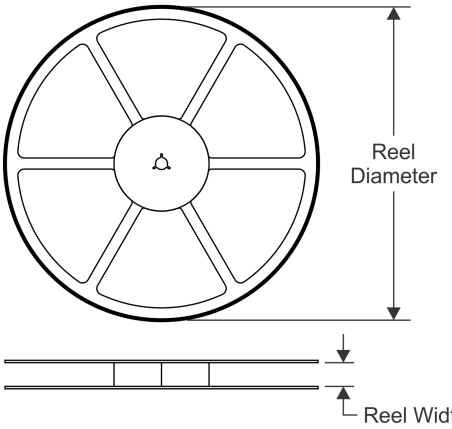
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device 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 Device Marking for that device.

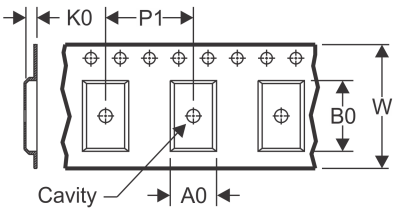
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

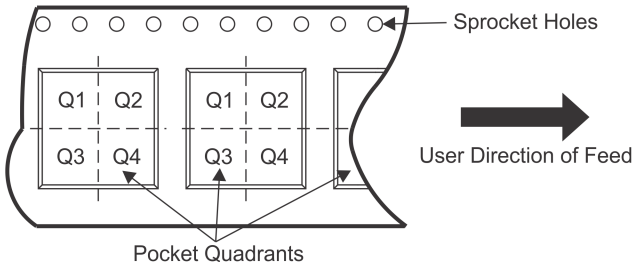


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

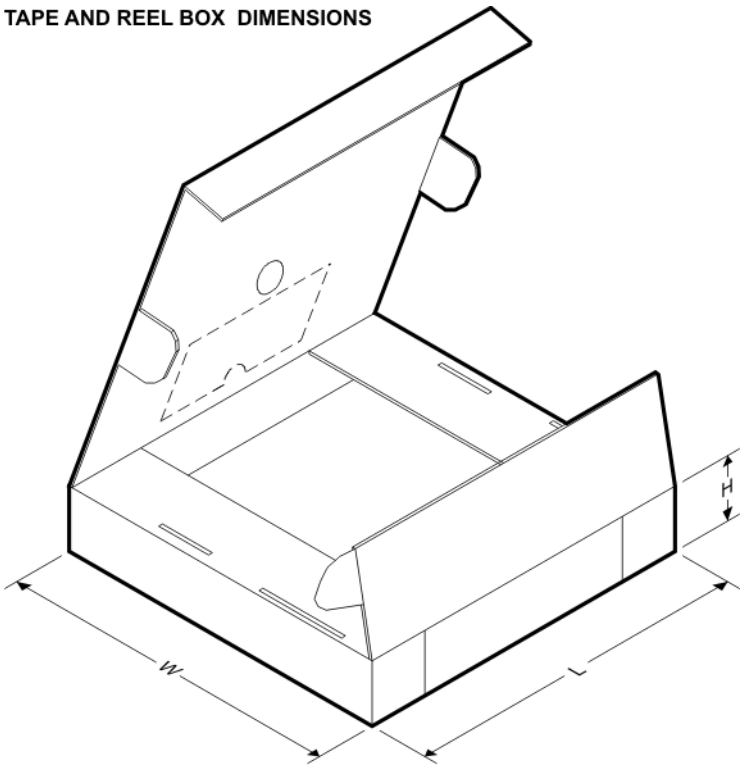
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
PCM56U/1K	SOIC	DW	16	1000	330.0	16.4	10.75	10.7	2.7	12.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



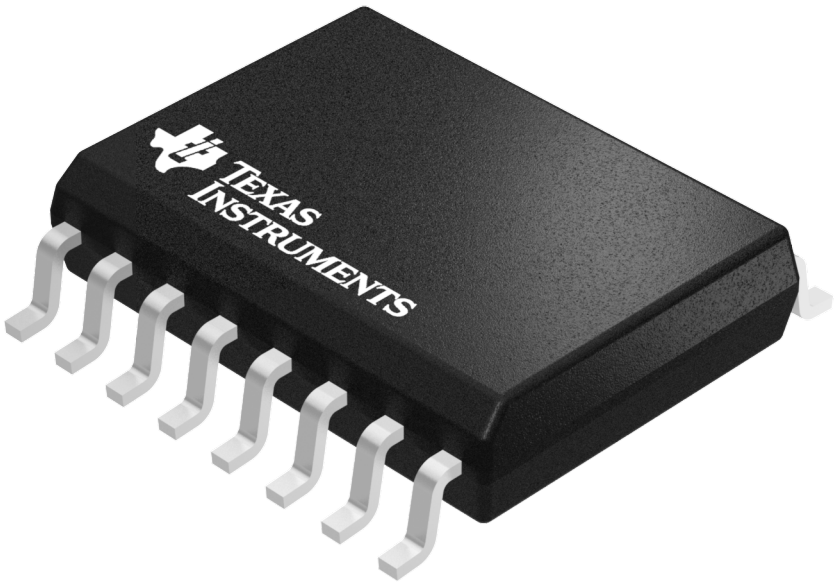
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
PCM56U/1K	SOIC	DW	16	1000	367.0	367.0	38.0

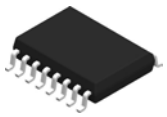
GENERIC PACKAGE VIEW

DW 16 SOIC - 2.65 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

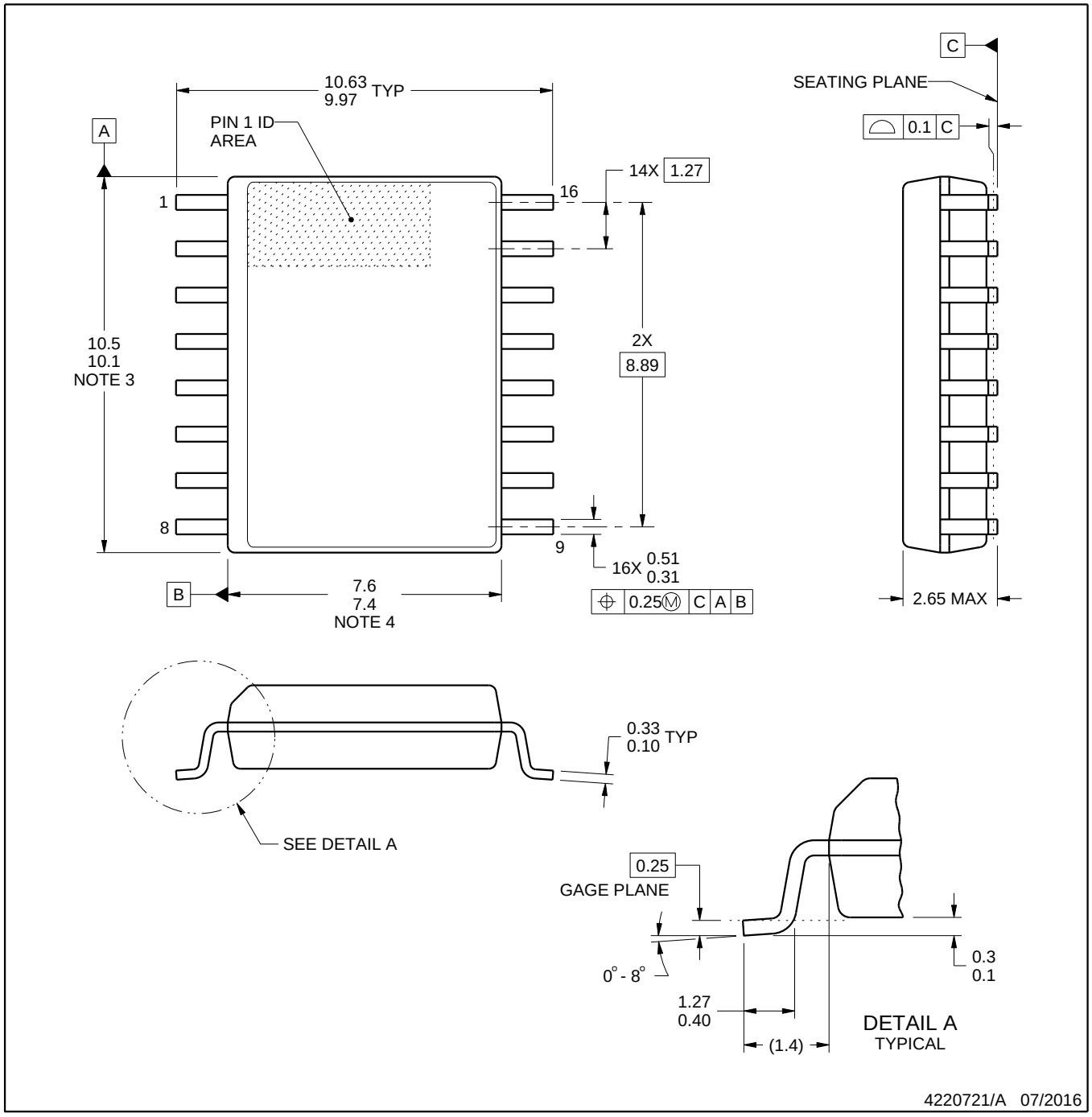


PACKAGE OUTLINE

DW0016A

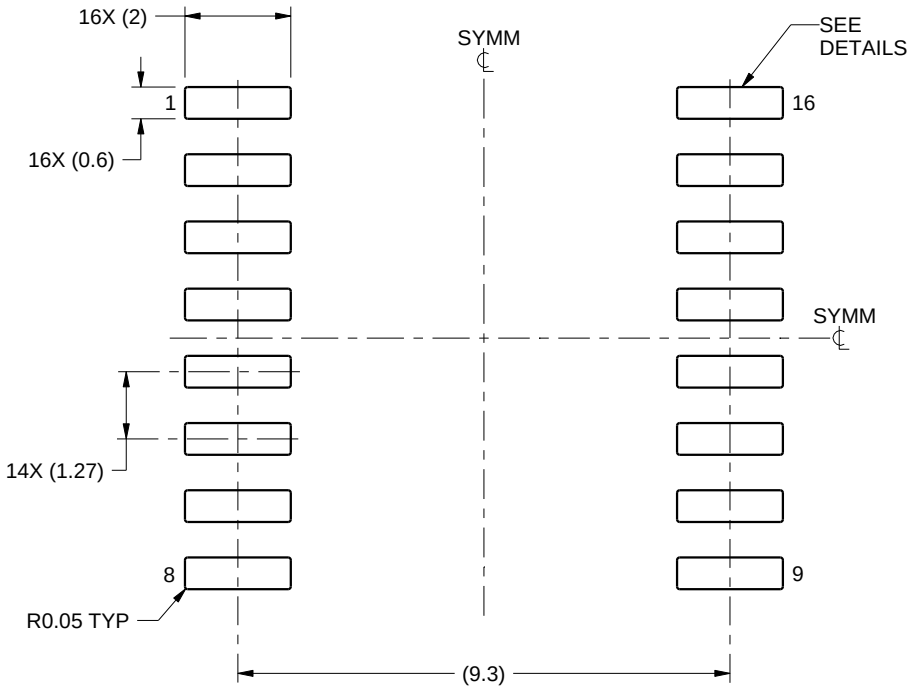
SOIC - 2.65 mm max height

SOIC

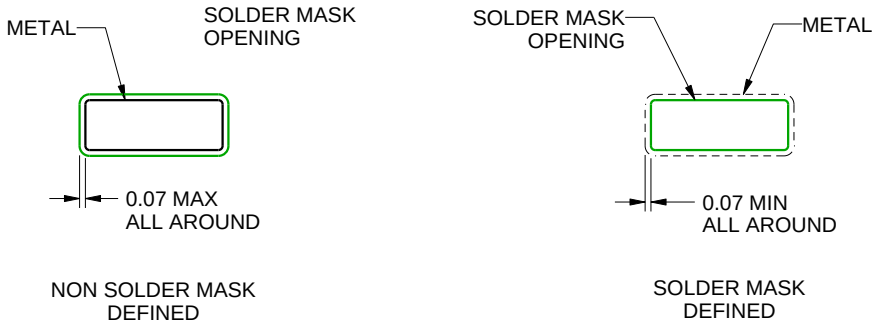


NOTES:

1. All linear dimensions are in millimeters. Dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm, per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm, per side.
5. Reference JEDEC registration MS-013.



LAND PATTERN EXAMPLE
SCALE:7X



SOLDER MASK DETAILS

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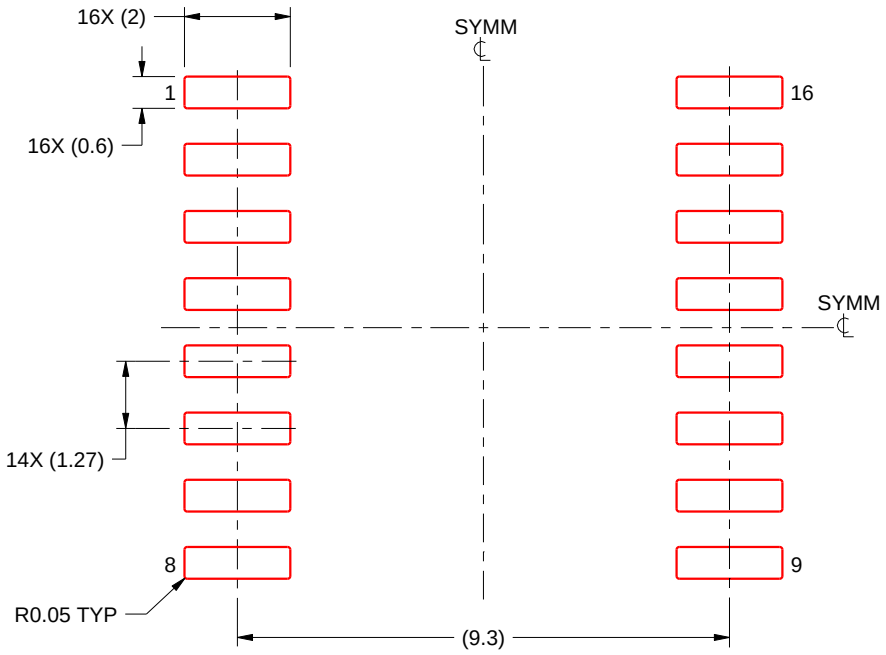
NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:7X

4220721/A 07/2016

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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