SBAS365B – OCTOBER 2005 – REVISED JULY 2007

12-Bit, Parallel Input, Multiplying Digital-to-Analog Converter

FEATURES

- **2.5V to 5.5V Supply Operation**
- **Fast Parallel Interface: 17ns Write Cycle**
- **Update Rate of 20.4MSPS**
- **10MHz Multiplying Bandwidth**
- **±10V Reference Input**
- **Low Glitch Energy: 5nV-s**
- **Extended Temperature Range: –40°C to +125°C**
- **20-Lead TSSOP Packages**
- **12-Bit Monotonic**
- **±1LSB INL**
- **4-Quadrant Multiplication**
- **Power-On Reset with Brownout Detection**
- **Readback Function**
- **Industry-Standard Pin Configuration**

APPLICATIONS

- **Portable Battery-Powered Instruments**
- **Waveform Generators**
- **Analog Processing**
- **Programmable Amplifiers and Attenuators**
- **Digitally-Controlled Calibration**
- **Programmable Filters and Oscillators**
- **Composite Video**
- **Ultrasound**

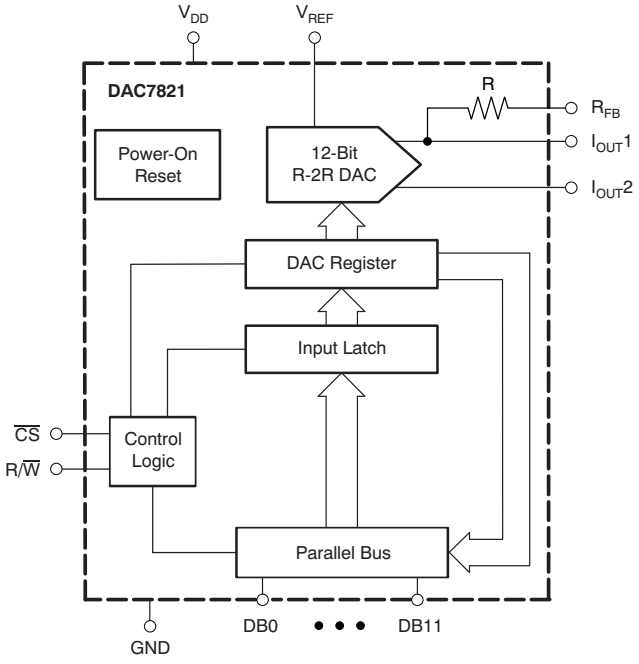
DESCRIPTION

The DAC7821 is a CMOS 12-bit current output digital-to-analog converter (DAC). This device operates from a single 2.5V to 5.5V power supply, making it suitable for battery-powered and many other applications.

This DAC operates with a fast parallel interface. Data readback allows the user to read the contents of the DAC register via the DB pins. On power-up, the internal register and latches are filled with zeroes and the DAC outputs are at zero scale.

The DAC7821 offers excellent 4-quadrant multiplication characteristics, with a large signal multiplying bandwidth of 10MHz. The applied external reference input voltage (V_{REF}) determines the full-scale output current. An integrated feedback resistor (R_{FB}) provides temperature tracking and full-scale voltage output when combined with an external current-to-voltage precision amplifier.

The DAC7821 is available in a 20-lead TSSOP package.



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

PACKAGE/ORDERING INFORMATION

For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)(1)

	DAC7821	UNIT
V_{DD} to GND	–0.3 to +7	V
Digital input voltage to GND	–0.3 to V_{DD} + 0.3	V
$V_{(IOUT)}$ to GND	–0.3 to V_{DD} + 0.3	V
Operating temperature range	–40 to +125	°C
Storage temperature range	–65 to +150	°C
Junction temperature (T_J max)	+150	°C
ESD Rating, HBM	3000	V
ESD Rating, CDM	1000	V

(1) Stresses above those listed under absolute maximum ratings may cause permanent damage to the device. Exposure to absolute maximum conditions for extended periods may affect device reliability.

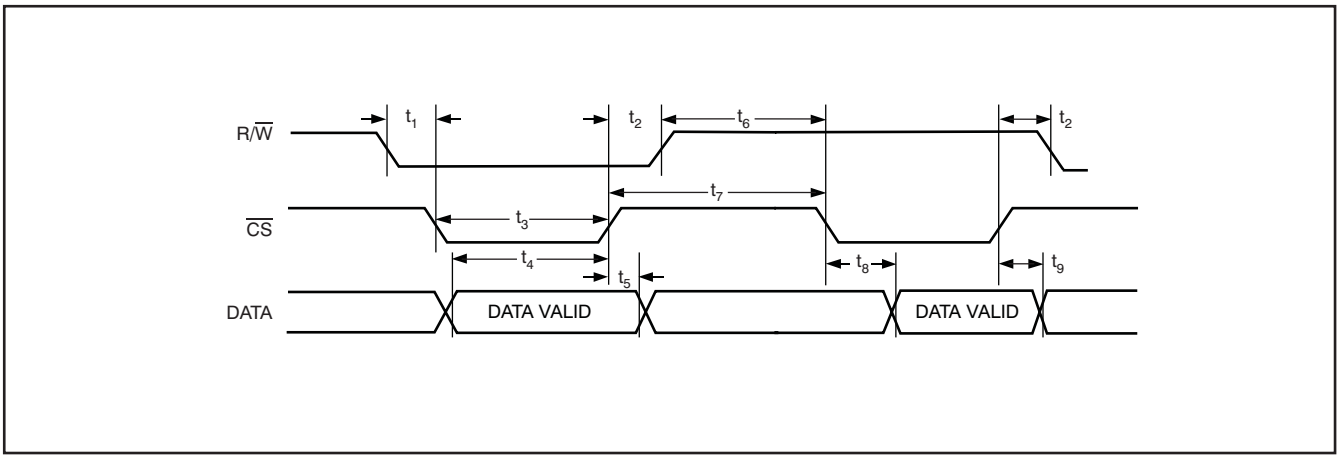
ELECTRICAL CHARACTERISTICS

V_{DD} = +2.5V to +5.5V; $I_{OUT}1$ = Virtual GND; $I_{OUT}2$ = 0V; V_{REF} = +10V; T_A = full operating temperature. All specifications –40°C to +125°C, unless otherwise noted.

PARAMETER	CONDITIONS	DAC7821			UNITS
		MIN	TYP	MAX	
STATIC PERFORMANCE					
Resolution		12			Bits
Relative accuracy				±1	LSB
Differential nonlinearity				±1	LSB
Output leakage current	Data = 000h, T_A = +25°C			±10	nA
Output leakage current	Data = 000h, $T_A = T_{MAX}$			±20	nA
Full-scale gain error	All is loaded to DAC register		±5	±10	mV
Full-scale tempco			±5		ppm/°C
Output capacitance	Code dependent		30		pF
REFERENCE INPUT					
V_{REF} range		–15		15	V
Input resistance		8	10	12	kΩ
R_{FB} resistance		8	10	12	kΩ
LOGIC INPUTS AND OUTPUT(1)					
Input low voltage V_{IL}	V_{DD} = +2.7V			0.6	V
V_{IL}	V_{DD} = +5V			0.8	V
Input high voltage V_{IH}	V_{DD} = +2.7V	2.1			V
V_{IH}	V_{DD} = +5V	2.4			V
Input leakage current I_{IL}				10	µA
Input capacitance C_{IL}				10	pF
POWER REQUIREMENTS					
V_{DD}		2.7		5.5	V
I_{DD} (normal operation)	Logic inputs = 0V			5	µA
V_{DD} = +4.5V to +5.5V	$V_{IH} = V_{DD}$ and V_{IL} = GND		0.8	5	µA
V_{DD} = +2.5V to +3.6V	$V_{IH} = V_{DD}$ and V_{IL} = GND		0.4	2.5	µA
AC CHARACTERISTICS					
Output voltage settling time				0.2	µs
Reference multiplying BW	$V_{REF} = 7V_{PP}$, Data = FFFh		10		MHz
DAC glitch impulse	V_{REF} = 0V to 10V, Data = 7FFh to 800h to 7FFh		5		nV-s
Feedthrough error V_{OUT}/V_{REF}	Data = 000h, V_{REF} = 100kHz		–70		dB
Digital feedthrough			2		nV-s
Total harmonic distortion			–105		dB
Output spot noise voltage			18		nV/√Hz

(1) Specified by design and characterization; not production tested.

TIMING INFORMATION



TIMING REQUIREMENTS: 2.5 V to 4.5 V

At $t_r = t_f$ = 1ns (10% to 90% of V_{DD}) and timed from a voltage level of $(V_{IL} + V_{IH})/2$; V_{DD} = +2.5V to +4.5V, V_{REF} = +10V, $I_{OUT}2$ = 0V. All specifications –40°C to +125°C, unless otherwise noted.

PARAMETER(1)	TEST CONDITIONS	DAC7821			UNIT
		MIN	TYP	MAX	
t_1	R/$\overline{W}$ to $\overline{CS}$ setup time	0			ns
t_2	R/$\overline{W}$ to $\overline{CS}$ hold time	0			ns
t_3	$\overline{CS}$ low time (write cycle)	10			ns
t_4	Data setup time	6			ns
t_5	Data hold time	0			ns
t_6	R/$\overline{W}$ high to $\overline{CS}$ low	5			ns
t_7	$\overline{CS}$ min high time	9			ns
t_8	Data access time		20	40	ns
t_9	Bus relinquish time		5	10	ns

(1) Ensured by design; not production tested.

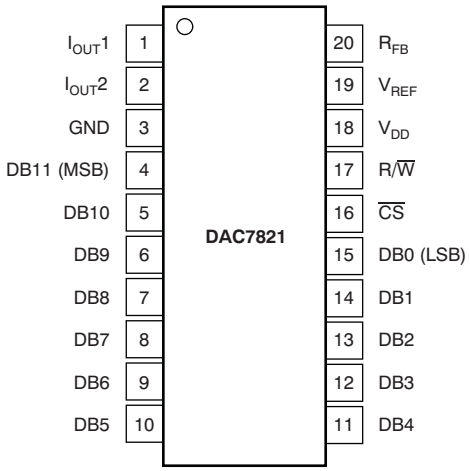
TIMING REQUIREMENTS: 4.5 V to 5.5 V

At $t_r = t_f$ = 1ns (10% to 90% of V_{DD}) and timed from a voltage level of $(V_{IL} + V_{IH})/2$; V_{DD} = +4.5V to +5.5V, V_{REF} = +10V, $I_{OUT}2$ = 0V. All specifications –40°C to +125°C, unless otherwise noted.

PARAMETER(1)	TEST CONDITIONS	DAC7821			UNIT
		MIN	TYP	MAX	
t_1	R/$\overline{W}$ to $\overline{CS}$ setup time	0			ns
t_2	R/$\overline{W}$ to $\overline{CS}$ hold time	0			ns
t_3	$\overline{CS}$ low time (write cycle)	10			ns
t_4	Data setup time	6			ns
t_5	Data hold time	0			ns
t_6	R/$\overline{W}$ high to $\overline{CS}$ low	5			ns
t_7	$\overline{CS}$ min high time	7			ns
t_8	Data access time		10	20	ns
t_9	Bus relinquish time		5	10	ns

(1) Ensured by design; not production tested.

DEVICE INFORMATION



TSSOP-20

TERMINAL FUNCTIONS

TERMINAL		DESCRIPTION
TSSOP NO.	NAME	
1	$I_{OUT}1$	DAC current output.
2	$I_{OUT}2$	DAC analog ground. This pin is normally tied to the analog ground of the system.
3	GND	Ground pin.
4–15	DB11 – DB0	Parallel data bits 11 to 0.
16	$\overline{CS}$	Chip select input. Active low. Used in conjunction with R/$\overline{W}$ to load parallel data to the input latch or read data from the DAC register. Rising edge of $\overline{CS}$ loads data.
17	R/$\overline{W}$	Read/Write. When low, use in conjunction with $\overline{CS}$ to load parallel data. When high, use with $\overline{CS}$ to read back contents of DAC register.
18	V_{DD}	Positive power supply input. These parts can be operated from a supply of 2.5V to 5.5V.
19	V_{REF}	DAC reference voltage input.
20	R_{FB}	DAC feedback resistor pin. Establish voltage output for the DAC by connecting to external amplifier output.

TYPICAL CHARACTERISTICS: V_{DD} = +5V

At T_A = +25°C, unless otherwise noted.

LINEARITY ERROR vs DIGITAL INPUT CODE

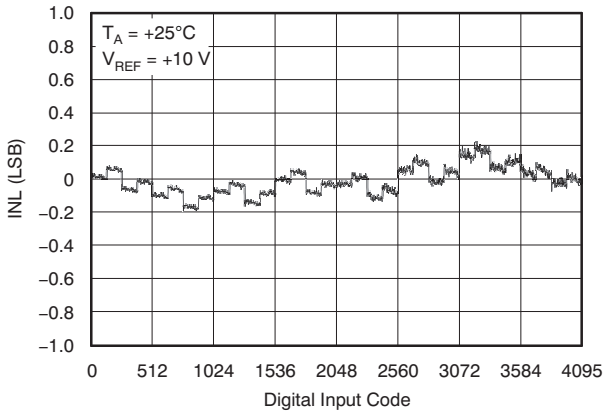


Figure 1.

DIFFERENTIAL LINEARITY ERROR vs DIGITAL INPUT CODE

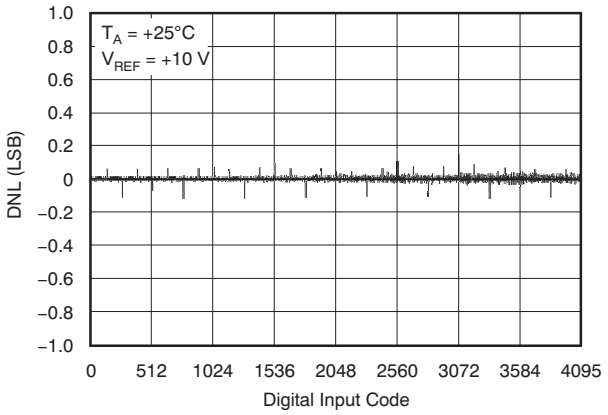


Figure 2.

LINEARITY ERROR vs DIGITAL INPUT CODE

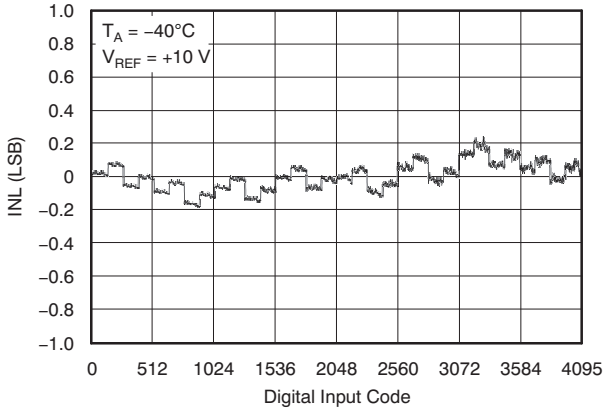


Figure 3.

DIFFERENTIAL LINEARITY ERROR vs DIGITAL INPUT CODE

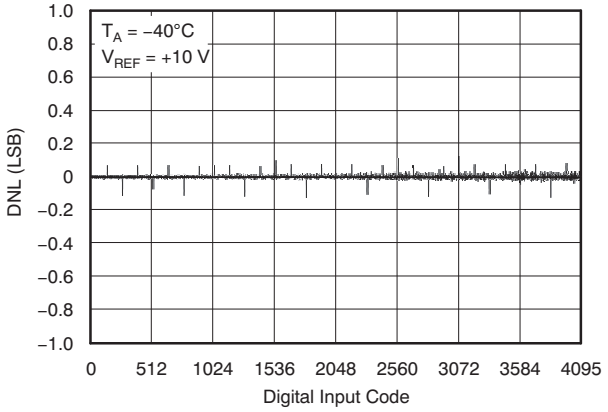


Figure 4.

LINEARITY ERROR vs DIGITAL INPUT CODE

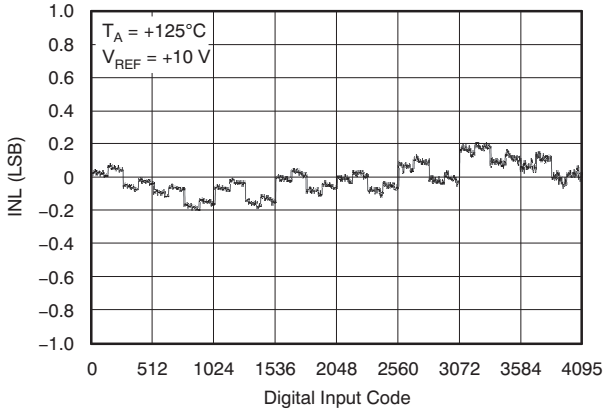


Figure 5.

DIFFERENTIAL LINEARITY ERROR vs DIGITAL INPUT CODE

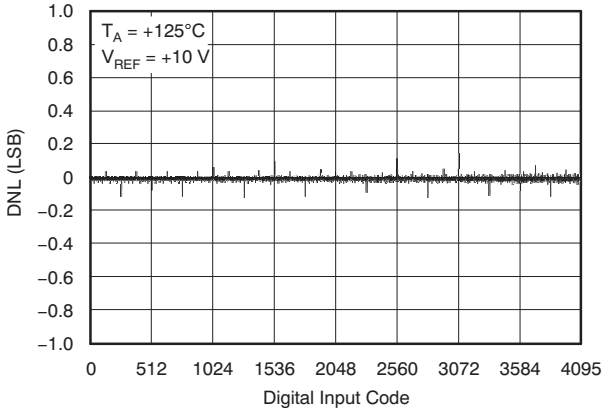


Figure 6.

TYPICAL CHARACTERISTICS: V_{DD} = +5V (continued)

At T_A = +25°C, unless otherwise noted.

SUPPLY CURRENT vs LOGIC INPUT VOLTAGE

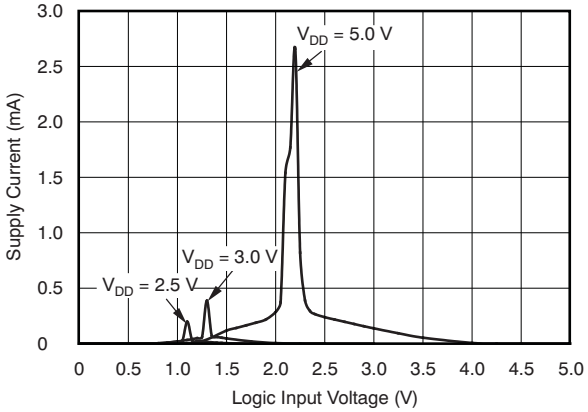


Figure 7.

REFERENCE MULTIPLYING BANDWIDTH

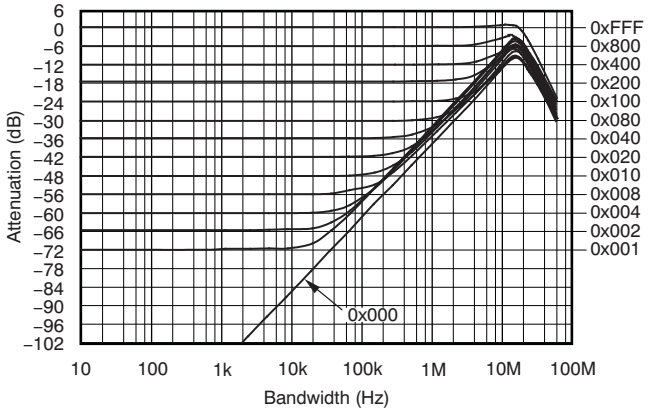


Figure 8.

MIDSCALE DAC GLITCH

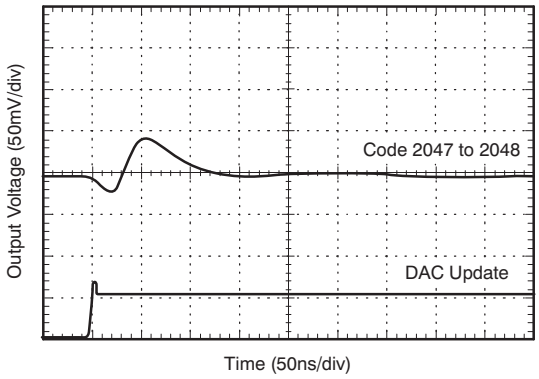


Figure 9.

MIDSCALE DAC GLITCH

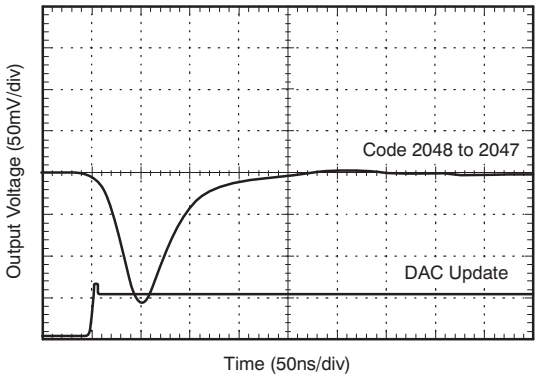


Figure 10.

DAC SETTLING TIME

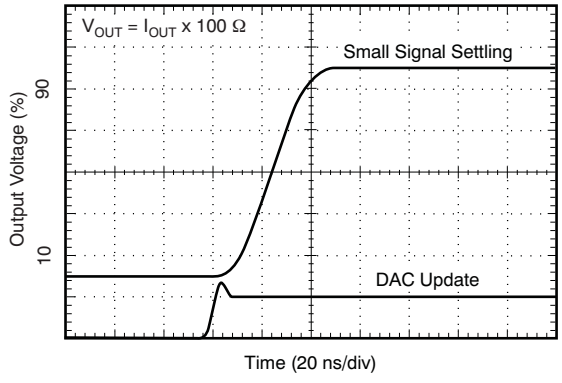


Figure 11.

GAIN ERROR vs TEMPERATURE

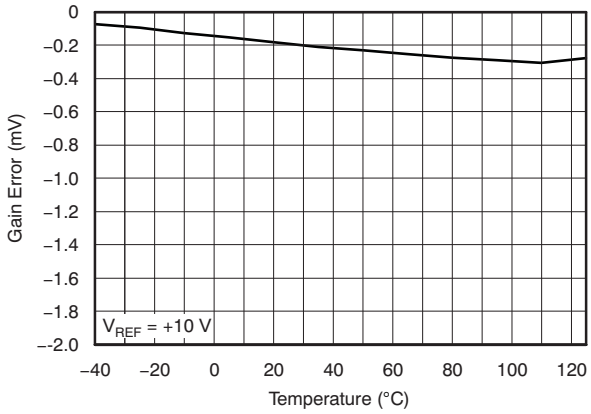


Figure 12.

TYPICAL CHARACTERISTICS: V_{DD} = +5V (continued)

At T_A = +25°C, unless otherwise noted.

SUPPLY CURRENT vs TEMPERATURE

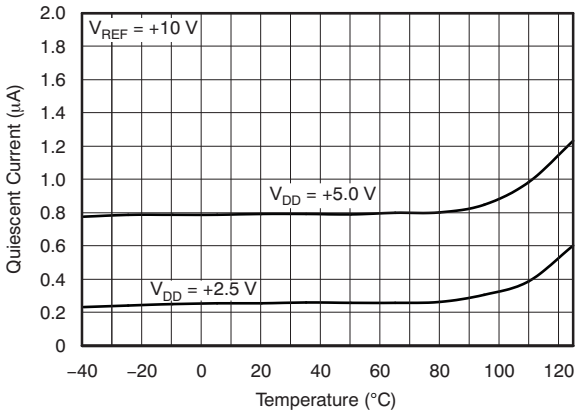


Figure 13.

LEAKAGE CURRENT vs TEMPERATURE

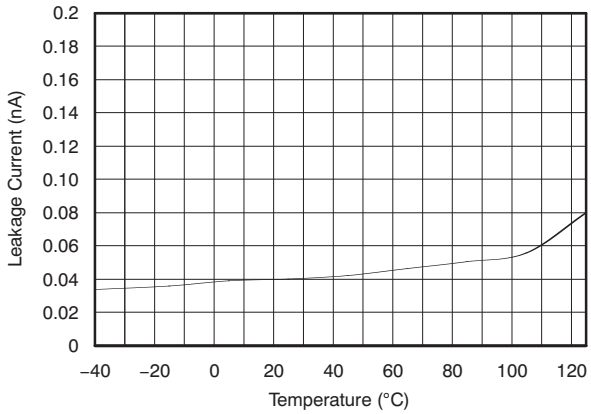


Figure 14.

TYPICAL CHARACTERISTICS: V_{DD} = +2.5V

At T_A = +25°C, unless otherwise noted.

LINEARITY ERROR vs DIGITAL INPUT CODE

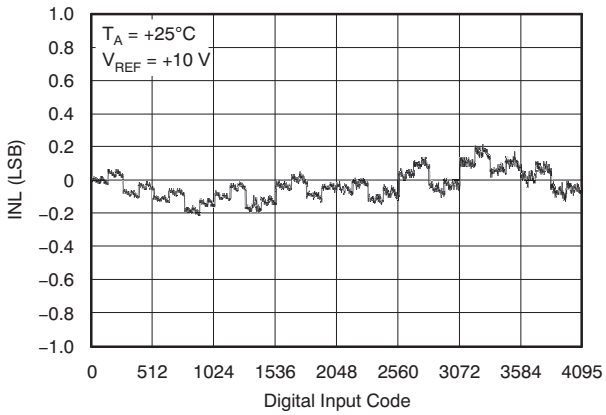


Figure 15.

DIFFERENTIAL LINEARITY ERROR vs DIGITAL INPUT CODE

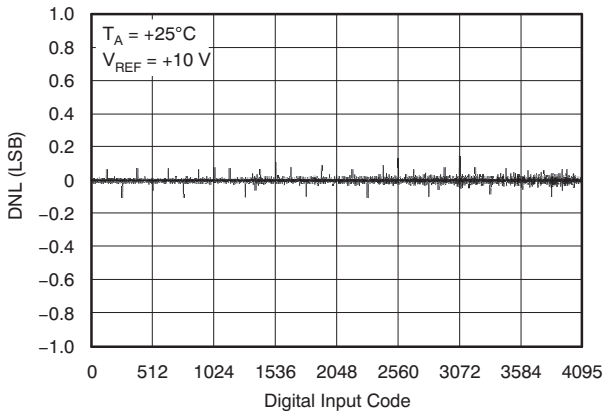


Figure 16.

LINEARITY ERROR vs DIGITAL INPUT CODE

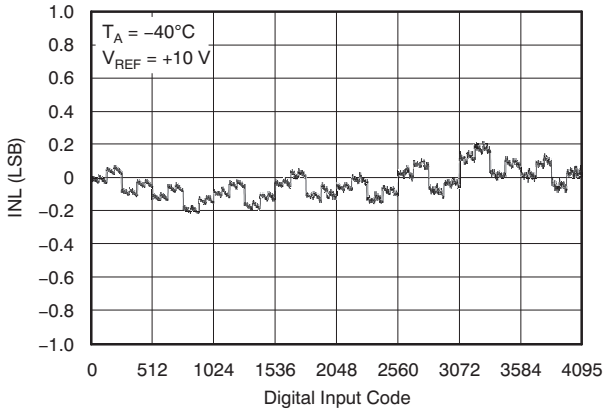


Figure 17.

DIFFERENTIAL LINEARITY ERROR vs DIGITAL INPUT CODE

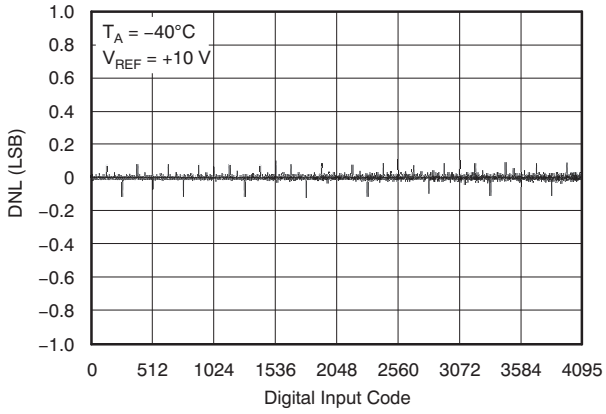


Figure 18.

LINEARITY ERROR vs DIGITAL INPUT CODE

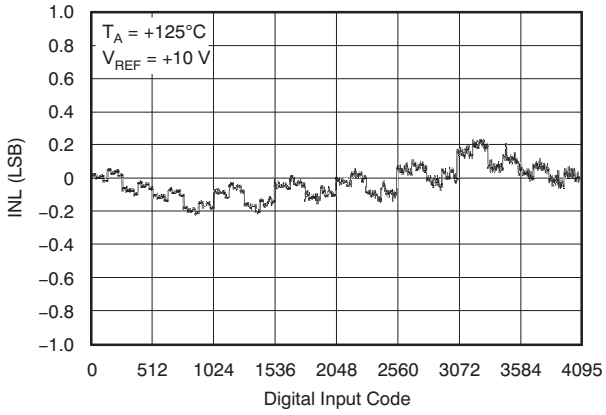


Figure 19.

DIFFERENTIAL LINEARITY ERROR vs DIGITAL INPUT CODE

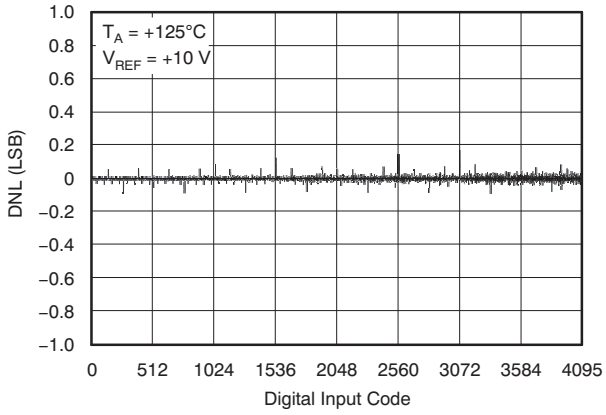


Figure 20.

TYPICAL CHARACTERISTICS: V_{DD} = +2.5V (continued)

At T_A = +25°C, unless otherwise noted.

MIDSCALE DAC GLITCH

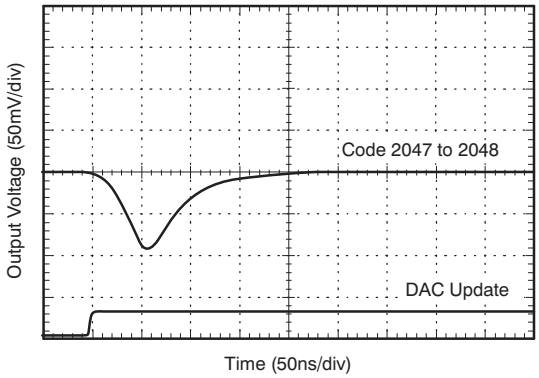


Figure 21.

MIDSCALE DAC GLITCH

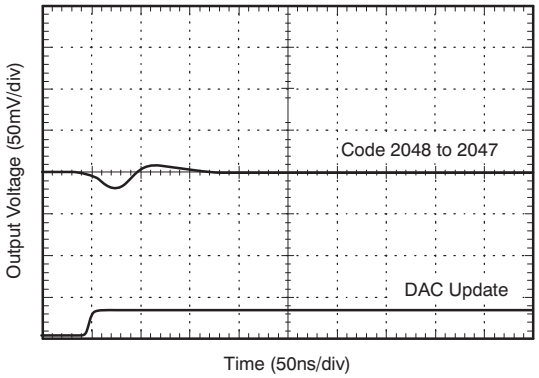


Figure 22.

GAIN ERROR vs TEMPERATURE

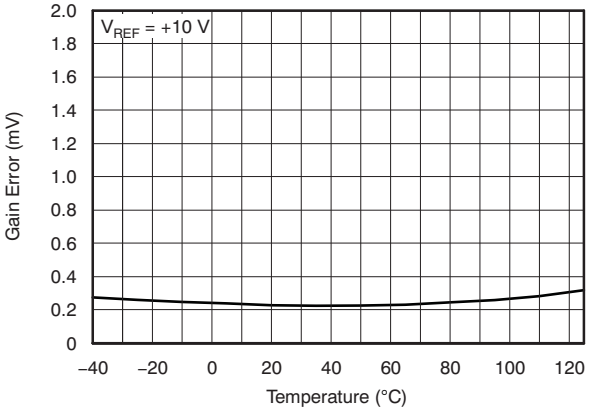


Figure 23.

LEAKAGE CURRENT vs TEMPERATURE

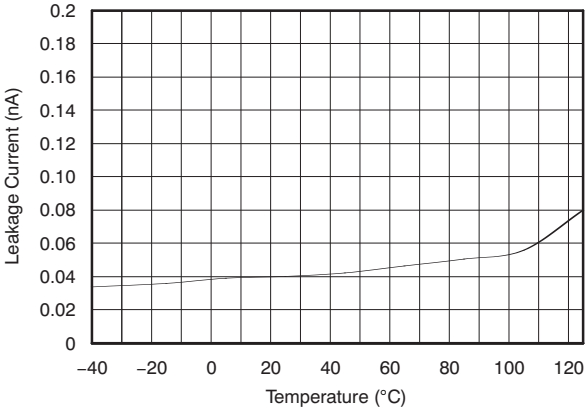


Figure 24.

THEORY OF OPERATION

The DAC7821 is a single channel, current output, 12-bit digital-to-analog converter (DAC). The architecture, illustrated in Figure 25, is an R-2R ladder configuration with the three MSBs segmented. Each 2R leg of the ladder is either switched to $I_{OUT}1$ or the $I_{OUT}2$ terminal. The $I_{OUT}1$ terminal of the DAC is held at a virtual GND potential by the use of an external I/V converter op amp. The R-2R ladder is connected to an external reference input V_{REF} that determines the DAC full-scale current. The R-2R ladder presents a code-independent load impedance to the external reference of 10kΩ ±20%. The external reference voltage can vary over a range of –15V to +15V, thus providing bipolar I_{OUT} current operation. By using an external I/V converter and the DAC7821 R_{FB} resistor, output voltage ranges of $–V_{REF}$ to V_{REF} can be generated.

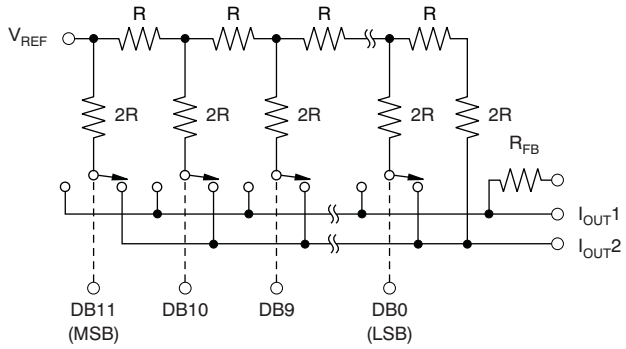


Figure 25. Equivalent R-2R DAC Circuit

When using an external I/V converter and the DAC7821 R_{FB} resistor, the DAC output voltage is given by Equation 1:

$$V_{OUT} = - V_{REF} \times \frac{CODE}{4096} \quad (1)$$

Each DAC code determines the 2R leg switch position to either GND or I_{OUT}. Because the DAC output impedance as seen looking into the $I_{OUT}1$ terminal changes versus code, the external I/V converter noise gain will also change. Because of this, the external I/V converter op amp must have a sufficiently low offset voltage such that the amplifier offset is not modulated by the DAC $I_{OUT}1$ terminal impedance change. External op amps with large offset voltages can produce INL errors in the transfer function of the DAC7821 as a result of offset modulation versus DAC code.

For best linearity performance of the DAC7821, an op amp with a low input offset voltage (OPA277) is recommended (see Figure 26). This circuit allows V_{REF} swinging from –10V to +10V.

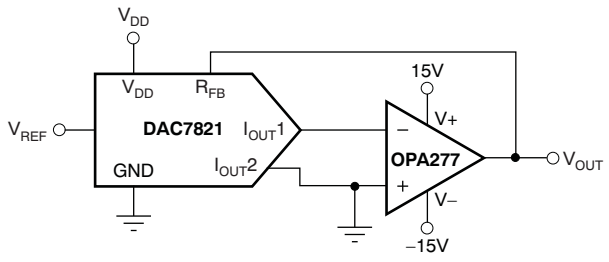


Figure 26. Voltage Output Configuration

APPLICATION INFORMATION

Stability Circuit

For a current-to-voltage design (see Figure 27), the DAC7821 current output (I_{OUT}) and the connection with the inverting node of the op amp should be as short as possible and according to correct printed circuit board (PCB) layout design practices. For each code change, there is a step function. If the gain bandwidth product (GBP) of the op amp is limited and parasitic capacitance is excessive at the inverting node, then gain peaking is possible. Therefore, for circuit stability, compensation capacitor C_1 (1pF to 5pF typ) can be added to the design, as shown in Figure 27.

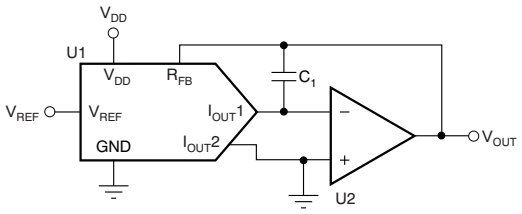


Figure 27. Gain Peaking Prevention Circuit with Compensation Capacitor

Amplifier Selection

There are many choices and many differences in selecting the proper operational amplifier for a multiplying DAC (MDAC). Making the analog signal out of the MDAC is one critical aspect. However, there are also other issues to take into account such as amplifier noise, input bias current, and offset voltage, as well as MDAC resolution and glitch energy. Table 1 and Table 2 suggest some suitable operational amplifiers for low power, fast settling, and high-speed applications. A greater selection of operational amplifiers can be found at www.ti.com/amplifer.

Table 1. Suitable Precision Operational Amplifiers from Texas Instruments

PRODUCT	TOTAL SUPPLY VOLTAGE (V) (min)	TOTAL SUPPLY VOLTAGE (V) (max)	I_Q PER CHANNEL (max) (mA)	GBW (typ) (MHz)	SLEW RATE (typ) (V/µs)	OFFSET DRIFT (typ) (µV/°C)	I_{IB} (max) (pA)	CMRR (min) (dB)	PACKAGE/ LEAD	DESCRIPTION
Low Power										
OPA703	4	12	0.2	1	0.6	4	10	70	SOT5-23, PDIP-8, SOIC-8	12V, CMOS, Rail-to-Rail I/O, Operational Amplifier
OPA735	2.7	12	0.75	1.6	1.5	0.01	200	115	SOT5-23, SOIC-8	0.05µV/°C (max), Single-Supply CMOS Zero-Drift Series Operational Amplifier
OPA344	2.7	5.5	0.25	1	1	2.5	10	80	SOT5-23, PDIP-8, SOIC-8	Low Power, Single-Supply, Rail-To-Rail Operational Amplifiers MicroAmplifier Series
OPA348	2.1	5.5	0.065	1	0.5	2	10	70	SC5-70, SOT5-23, SOIC-8	1MHz, 45µA, Rail-to-Rail I/O, Single Op Amp
OPA277	4	36	0.825	1	0.8	0.1	1000	130	PDIP-8, SOIC-8, SON-8	High Precision Operational Amplifiers
Fast Settling										
OPA350	2.7	5.5	7.5	38	22	4	10	76	MSOP-8, PDIP-8, SOIC-8	High-Speed, Single-Supply, Rail-to-Rail Operational Amplifiers MicroAmplifier Series
OPA727	4	12	6.5	20	30	0.6	500	86	MSOP-8, SON-8	e-trim 20MHz, High Precision CMOS Operational Amplifier
OPA227	5	36	3.8	8	2.3	0.1	10000	120	PDIP-8, SOIC-8	High Precision, Low Noise Operational Amplifiers

Table 2. Suitable High Speed Operational Amplifiers from Texas Instruments (Multiple Channel Options)

PRODUCT	SUPPLY VOLTAGE (V)	GBW PRODUCT (MHz)	VOLTAGE NOISE nV/√Hz	GBW (typ) (MHz)	SLEW RATE (V/µs)	V_{OS} (typ) (µV)	V_{OS} (max) (µV)	CMRR (min) (dB)	PACKAGE/ LEAD	DESCRIPTION
Single Channel										
THS4281	±2.7 to ±15	38	12.5	35	500	3500	500	1000	SOT5-23, MSOP-8, SOIC-8	Very Low-Power High Speed Rail-To-Rail Input/Output Voltage Feedback Operational Amplifier
THS4031	±4.5 to ±16.5	200	1.6	100	500	3000	3000	8000	CDIP-8, MSOP-8, SOIC-8	100-MHz Low Noise Voltage-Feedback Amplifier
THS4631	±4.5 to ±16.5	210	7	900	260	2000	50pA	2	SOIC-8, MSOP-8	High Speed FET-Input Operational Amplifier
OPA656	±4 to ±6	230	7	290	250	2600	2pA	5pA	SOIC-8, SOT5-23	Wideband, Unity Gain Stable FET-Input Operational Amplifier
OPA820	±2.5 to ±6	280	2.5	240	200	1200	900	23,000	SOIC-8, SOT5-23	Unity Gain Stable, Low Noise, Voltage Feedback Operational Amplifier
Dual Channel										
THS4032	±4.5 to ±16.5	200	1.6	100	500	3000	3000	8000	SOIC-8, MSOP-8	100-MHz Low Noise Voltage-Feedback Amplifier, Dual
OPA2822	±2 to ±6.3	220	2	170	200	1200	9600	12000	SOIC-8, MSOP-8	SpeedPlus Dual Wideband, Low-Noise Operational Amplifier

Positive Voltage Output Circuit

As Figure 28 illustrates, in order to generate a positive voltage output, a negative reference is input to the DAC7821. This design is suggested instead of using an inverting amp to invert the output because of possible resistor tolerance errors. For a negative reference, V_{OUT} and GND of the reference are level-shifted to a virtual ground and a –2.5V input to the DAC7821 with an op amp.

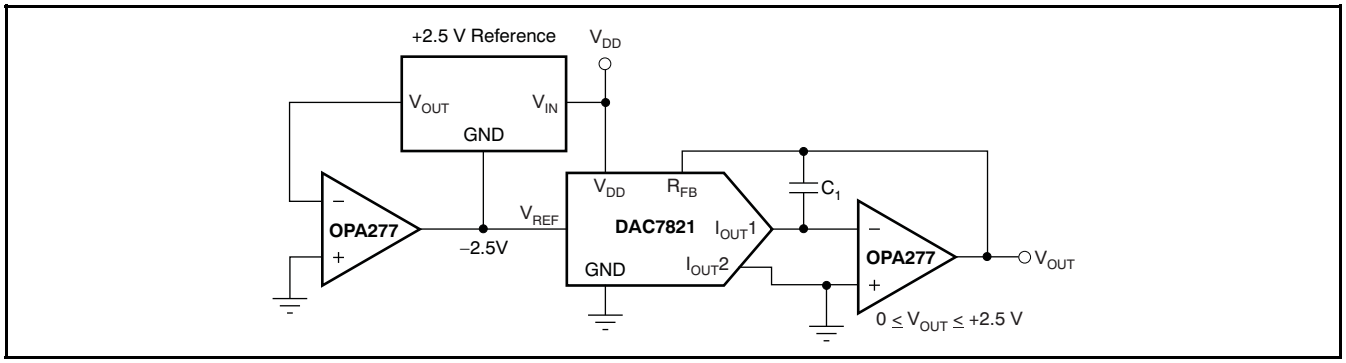


Figure 28. Positive Voltage Output Circuit

Bipolar Output Section

The DAC7821, as a 2-quadrant multiplying DAC, can be used to generate a unipolar output. The polarity of the full-scale output I_{OUT} is the inverse of the input reference voltage at V_{REF}.

Some applications require full 4-quadrant multiplying capabilities or bipolar output swing. As shown in Figure 29, external op amp U4 is added as a summing amp and has a gain of 2X that widens the output span to 5V. A 4-quadrant multiplying circuit is implemented by using a 2.5V offset of the reference voltage to bias U4. According to the circuit transfer equation given in Equation 2, input data (D) from code 0 to full-scale produces output voltages of V_{OUT} = –2.5V to V_{OUT} = +2.5V.

$$V_{OUT} = \left(\frac{D}{0.5 \times 2^{N}} - 1 \right) \times V_{REF} \quad (2)$$

External resistance mismatching is the significant error in Figure 29.

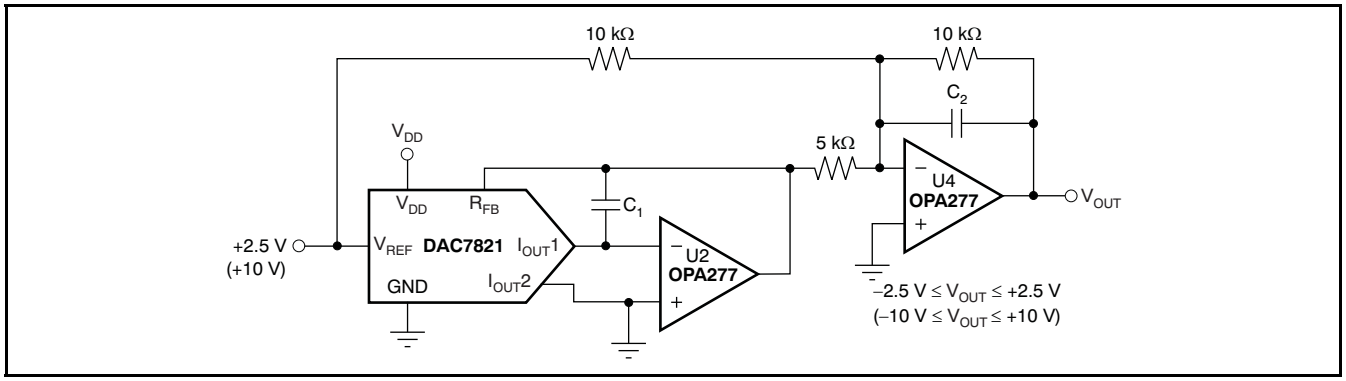


Figure 29. Bipolar Output Circuit

Programmable Current Source Circuit

A DAC7821 can be integrated into the circuit in Figure 30 to implement an improved Howland current pump for precise voltage-to-current conversions. Bidirectional current flow and high voltage compliance are two features of the circuit. With a matched resistor network, the load current of the circuit is shown by Equation 3:

$$I_L = \frac{(R2 + R3)/R1}{R3} \times V_{REF} \times D \quad (3)$$

The value of R3 in the previous equation can be reduced to increase the output current drive of U3. U3 can drive ±20mA in both directions with voltage compliance limited up to 15V by the U3 voltage supply. Elimination of the circuit compensation capacitor C_1 in the circuit is not suggested as a result of the change in the output impedance Z_O, according to Equation 4:

$$Z_O = \frac{R1'R3(R1 + R2)}{R1(R2' + R3') - R1'(R2 + R3)} \quad (4)$$

As shown in Equation 4, with matched resistors, Z_O is infinite and the circuit is optimum for use as a current source. However, if unmatched resistors are used, Z_O is positive or negative with negative output impedance being a potential cause of oscillation. Therefore, by incorporating C_1 into the circuit, possible oscillation problems are eliminated. The value of C_1 can be determined for critical applications; for most applications, however, a value of several pF is suggested.

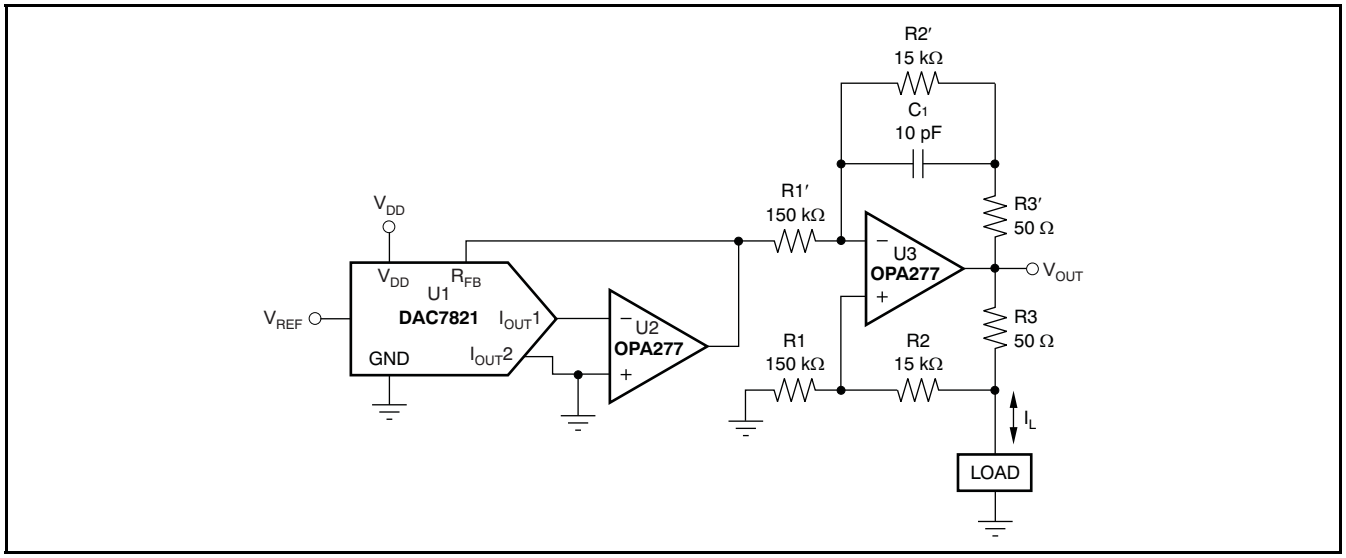


Figure 30. Programmable Bidirectional Current Source Circuit

Parallel Interface

Data are loaded to the DAC7821 as a 12-bit parallel word. The bidirectional bus is controlled with $\overline{CS}$ and R/$\overline{W}$, allowing data to be written to or read from the DAC register. To write to the device, $\overline{CS}$ and R/$\overline{W}$ are brought low, and data available on the data lines fill the input register. The rising edge of $\overline{CS}$ latches the data and transfers the latched data-word to the DAC register. The DAC latches are not transparent; therefore, a write sequence must consist of a falling and rising edge on $\overline{CS}$ in order to ensure that data are loaded to the DAC register and its analog equivalent is reflected on the DAC output.

To read data stored in the device, R/$\overline{W}$ is held high and $\overline{CS}$ is brought low. Data are loaded from the DAC register back to the input register and out onto the data line, where it can be read back to the controller.

Cross-Reference

The DAC7821 has an industry-standard pinout. Table 3 provides the cross-reference information.

Table 3. Cross-Reference

PRODUCT	INL (LSB)	DNL (LSB)	SPECIFIED TEMPERATURE RANGE	PACKAGE DESCRIPTION	PACKAGE OPTION	CROSS-REFERENCE PART
DAC7821	±1	±1	–40°C to +125°C	20-Lead TSSOP	TSSOP-20	AD5445

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
DAC7821IPW	ACTIVE	TSSOP	PW	20	70	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	DAC7821	Samples
DAC7821IPWG4	ACTIVE	TSSOP	PW	20	70	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	DAC7821	Samples
DAC7821IPWR	ACTIVE	TSSOP	PW	20	2000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	DAC7821	Samples

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(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.

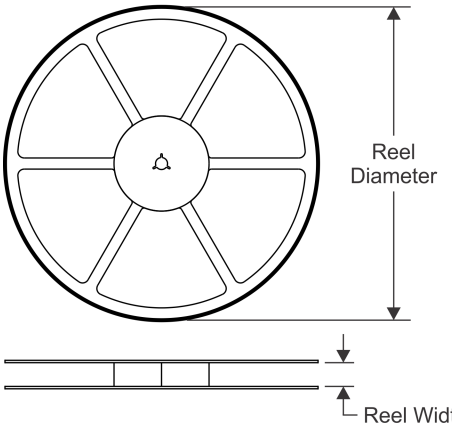
(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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

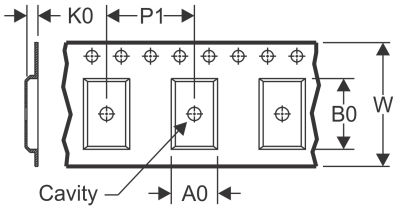
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

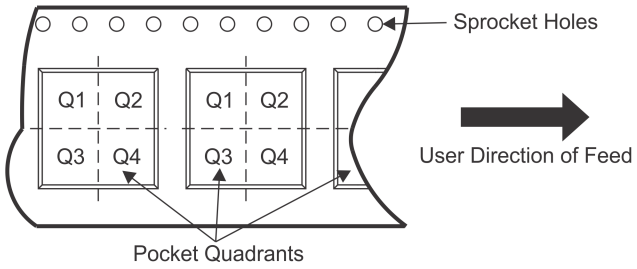


TAPE DIMENSIONS



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

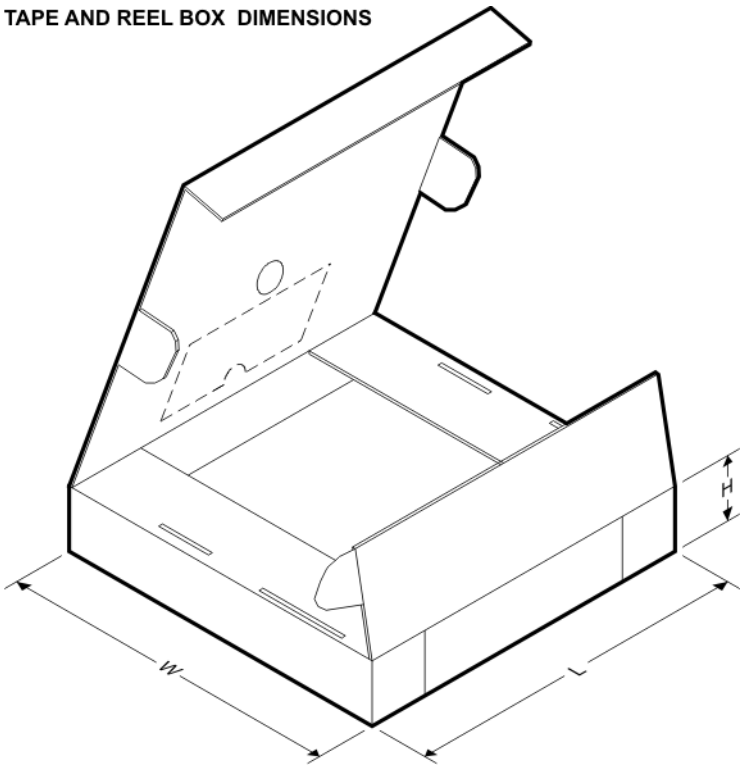
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
DAC7821IPWR	TSSOP	PW	20	2000	330.0	16.4	6.95	7.1	1.6	8.0	16.0	Q1

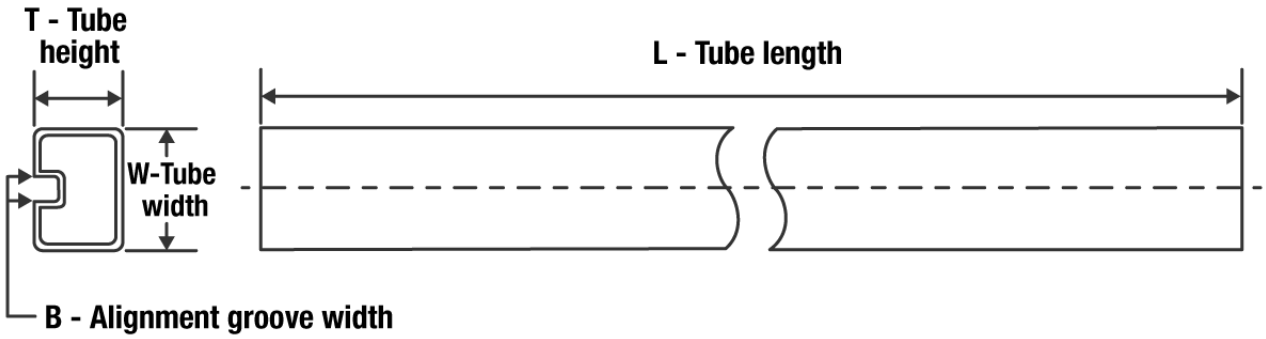
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DAC7821IPWR	TSSOP	PW	20	2000	350.0	350.0	43.0

TUBE



*All dimensions are nominal

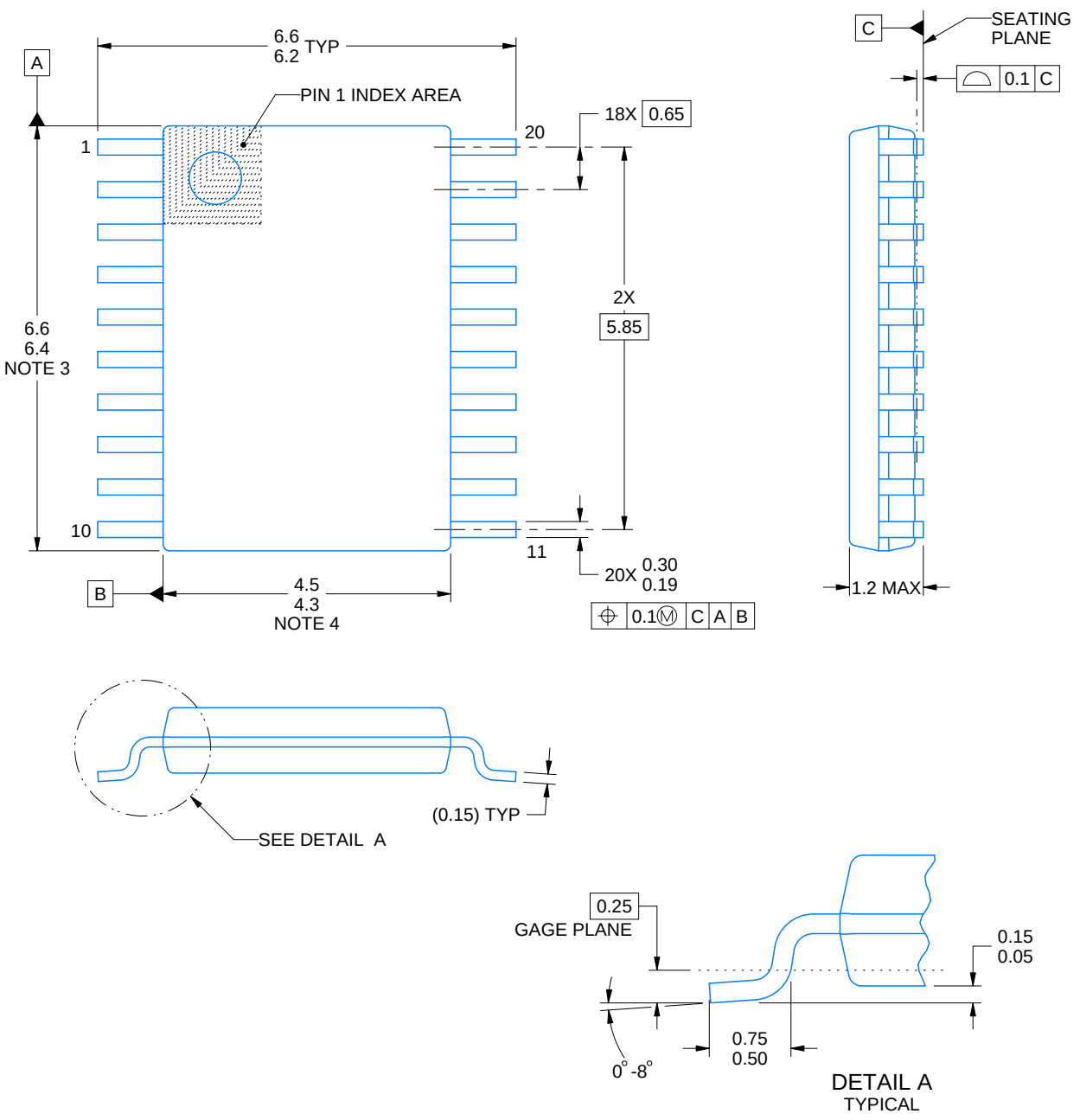
Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (µm)	B (mm)
DAC7821IPW	PW	TSSOP	20	70	530	10.2	3600	3.5
DAC7821IPWG4	PW	TSSOP	20	70	530	10.2	3600	3.5

PACKAGE OUTLINE

PW0020A

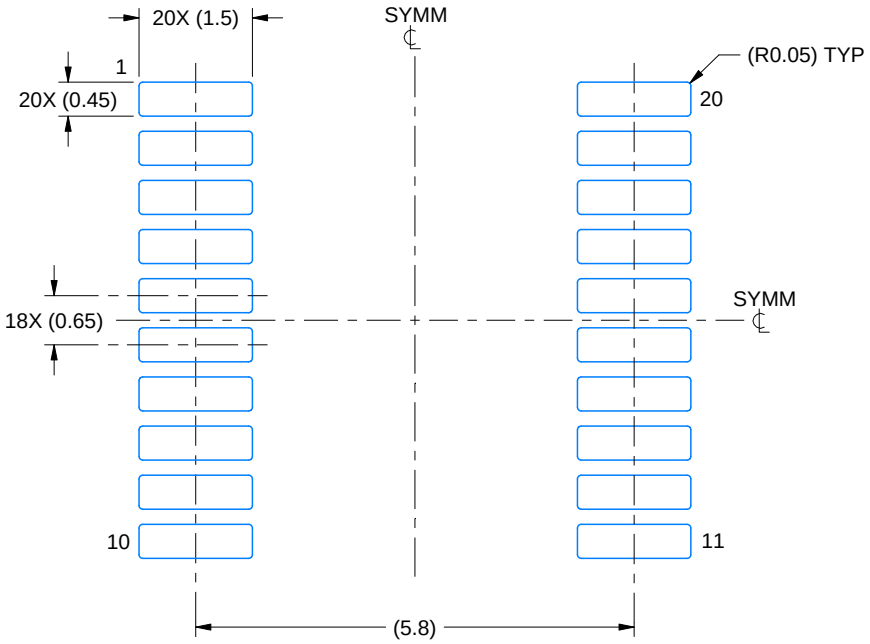
TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



NOTES:

1. All linear dimensions are in millimeters. Any 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 MO-153.



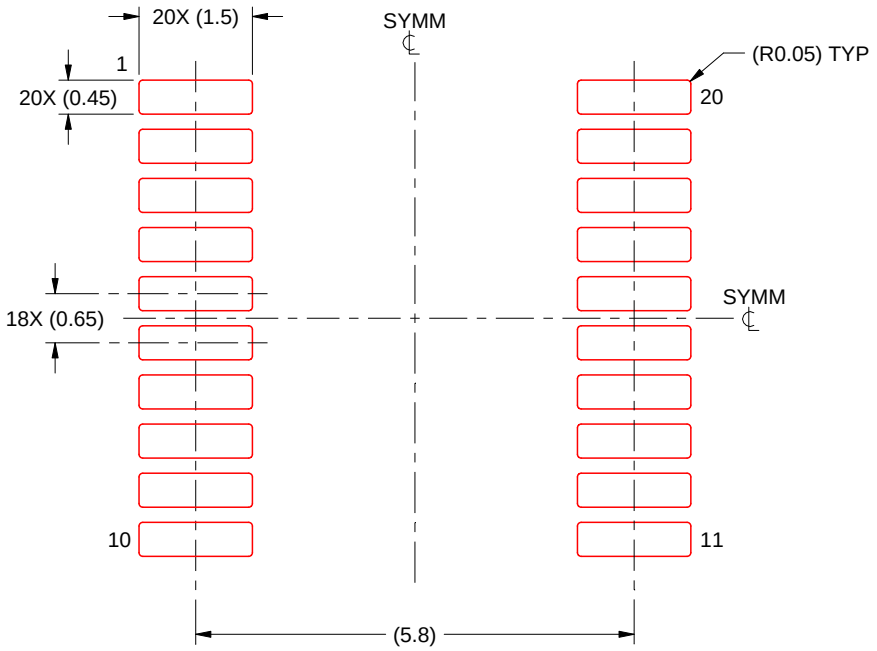
LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X

SOLDER MASK DETAILS

4220206/A 02/2017

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.



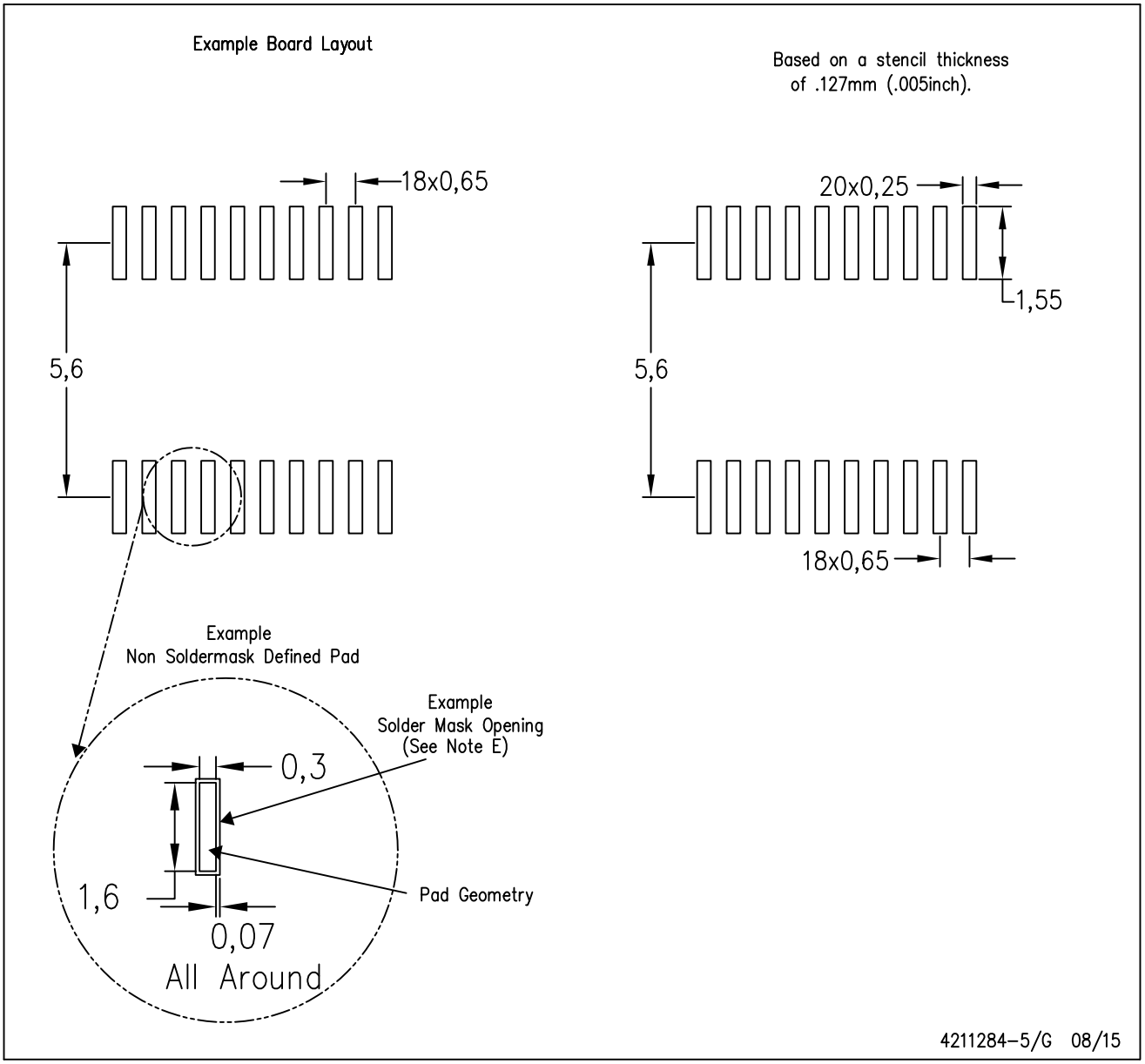
SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

4220206/A 02/2017

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.

PW (R–PDSO–G20) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate design.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC–7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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