

TANDEM 64-TAP DIGITAL POTENTIOMETER

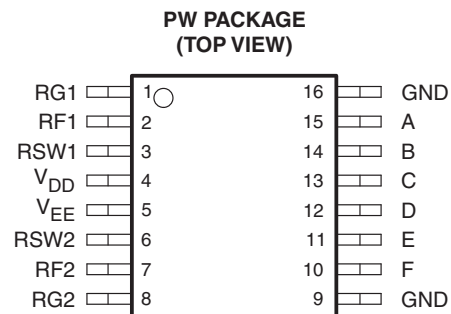
Check for Samples: [TPL8002-25](#)

FEATURES

- Adjustable Gain From 23.25 dB to –24 dB
- 64-Tap Positions With 0.75 dB Per Step
- Supports 8-MHz Analog Bandwidth
- Operating Range up to $-4\text{-V } V_{EE}/+4\text{-V } V_{DD}$
- 100- μA Maximum Static Supply Current
- $\pm 30\%$ End-to-End Resistance Tolerance
- Absolute Tolerance of ± 0.3 dB
- Operating Temperature Range From -40°C to 85°C
- ESD Performance Tested Per JESD 22
 - 2000-V Human-Body Model (A114-B, Class II)

APPLICATIONS

- Tandem Adjustable Feedback and Gain Resistors for Operational Amplifiers



DESCRIPTION/ORDERING INFORMATION

The TPL8002-25 is a programmable resistor device implementing two digital potentiometers with 64 wiper positions each that are tandem controlled through a 6-bit parallel interface. The device has fixed wiper resistances at the respective wiper contacts that tap the potentiometer resistors at a point determined by the binary code present at its digital inputs.

The resistive wiper tap terminals, RSW, of the TPL8002-25 are typically connected to the inverting inputs (–) of an external differential path inverting operational amplifier configuration, with the non-inverting inputs (+) connected through to ground. The application's differential input to the configuration is the device's RG terminals. The differential output of the external operational amplifiers is connected to the device's RF terminals, and thus becomes the differential output of the application configuration.

The resistance between the wiper contacts and the end points RG and RF of the TPL8002-25 provides a logarithmic gain/attenuation response of the configuration. With a digital code of decimal 0 (b000000) the configuration has an inverting maximum attenuation of –24 dB. With a digital code of decimal 32 (b100000) the configuration has inverting unity gain of 0.00 dB. With a digital code of decimal 63 (b111111) the configuration has an inverting maximum gain of +23.25 dB. The response of the configuration with respect to the digital code varies in fixed steps of 0.75 dB.

ORDERING INFORMATION

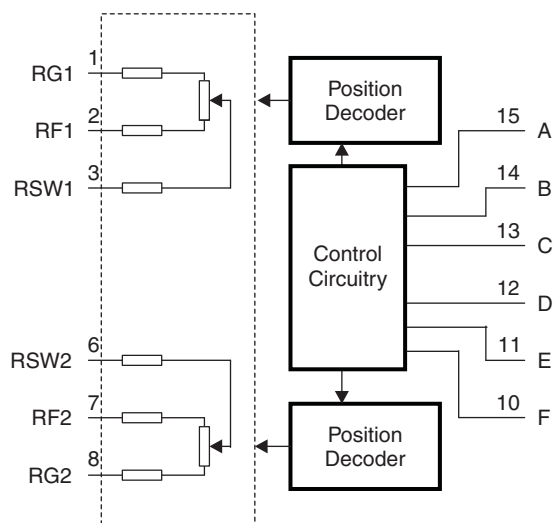
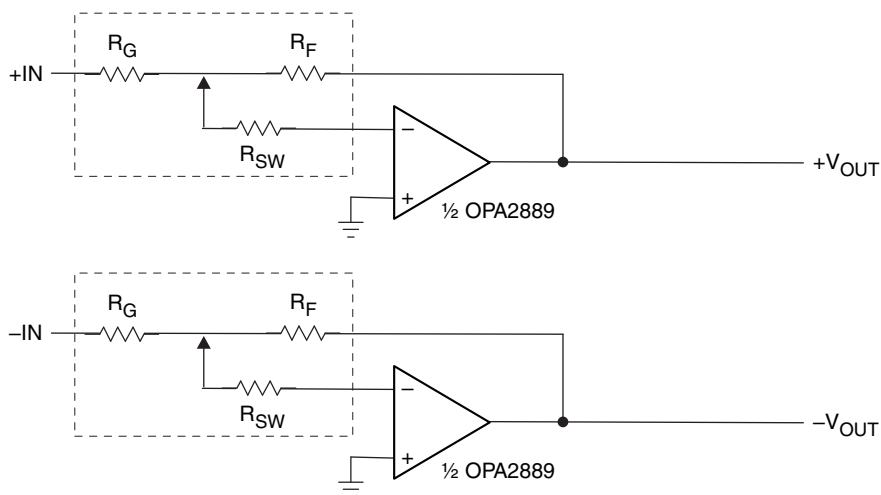
T _A	PACKAGE ⁽¹⁾ (2)		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	TSSOP – PW	Tape and reel	TPL8002-25PWR	PHY03A

(1) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.

(2) 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.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

FUNCTIONAL BLOCK DIAGRAM**TYPICAL APPLICATION CIRCUIT**

FUNCTION TABLE

Table 1. Switch Truth Table

DECIMAL CONTROL	FEDCBA	GAIN/ATTN (dB)	R _G (Ω)	R _F (Ω)
63	111111	23.25	161	2339
62	111110	22.5	174	2326
61	111101	21.75	189	2311
60	111100	21	205	2295
59	111011	20.25	221	2279
58	111010	19.5	239	2261
57	111001	18.75	259	2241
56	111000	18	280	2220
55	110111	17.25	302	2198
54	110110	16.5	325	2175
53	110101	15.75	351	2149
52	110100	15	377	2123
51	110011	14.25	406	2094
50	110010	13.5	436	2064
49	110001	12.75	468	2032
48	110000	12	502	1998
47	101111	11.25	537	1963
46	101110	10.5	575	1925
45	101101	9.75	614	1886
44	101100	9	655	1845
43	101011	8.25	697	1803
42	101010	7.5	742	1758
41	101001	6.75	787	1713
40	101000	6	835	1665
39	100111	5.25	883	1617
38	100110	4.5	933	1567
37	100101	3.75	984	1516
36	100100	3	1036	1464
35	100011	2.25	1089	1411
34	100010	1.5	1142	1358
33	100001	0.75	1196	1304
32	100000	0	1250	1250
31	011111	-0.75	1304	1196
30	011110	-1.5	1358	1142
29	011101	-2.25	1411	1089
28	011100	-3	1464	1036
27	011011	-3.75	1516	984
26	011010	-4.5	1567	933
25	011001	-5.25	1617	883
24	011000	-6	1665	835
23	010111	-6.75	1713	787
22	010110	-7.5	1758	742
21	010101	-8.25	1803	697
20	010100	-9	1845	655

Table 1. Switch Truth Table (continued)

DECIMAL CONTROL	FEDCBA	GAIN/ATTN (dB)	R _G (Ω)	R _F (Ω)
19	010011	-9.75	1886	614
18	010010	-10.5	1925	575
17	010001	-11.25	1963	537
16	010000	-12	1998	502
15	001111	-12.75	2032	468
14	001110	-13.5	2064	436
13	001101	-14.25	2094	406
12	001100	-15	2123	377
11	001011	-15.75	2149	351
10	001010	-16.5	2175	325
9	001001	-17.25	2198	302
8	001000	-18	2220	280
7	000111	-18.75	2241	259
6	000110	-19.5	2261	239
5	000101	-20.25	2279	221
4	000100	-21	2295	205
3	000011	-21.75	2311	189
2	000010	-22.5	2326	174
1	000001	-23.25	2339	161
0	000000	-24	2352	148

ABSOLUTE MAXIMUM RATINGS^{(1) (2)}

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

			MIN	MAX	UNIT
$V_{DD} - V_{EE}$	Power supply delta voltage ⁽³⁾			10	V
V_{DD}	Positive supply voltage range ⁽³⁾		–0.3	5	V
V_{EE}	Negative supply voltage range ⁽³⁾		0.3	–5	V
V_{IN}	Control input voltage range ^{(2) (3)}		–0.3	$V_{DD} + 0.3$	V
$V_{I/O}$	Resistor I/O voltage range ^{(2) (3) (4)}		$V_{EE} - 0.3$	$V_{DD} + 0.3$	V
I_{IK}	Control input clamp current	$V_{IN} < 0$ and $V_{I/O} < 0$		–18	mA
$I_{I/OK}$	I/O port clamp current	$V_{IN} < 0$ and $V_{I/O} < 0$		–18	mA
T_{stg}	Storage temperature range		–40	85	°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) All voltages are with respect to ground, unless otherwise specified.
- (3) The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
- (4) V_I and V_O are used to denote specific conditions for $V_{I/O}$.

RECOMMENDED OPERATING CONDITIONS

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

		MIN	TYP	MAX	UNIT
$V_{DD} - V_{EE}$	Power supply delta voltage			8	V
V_{DD}	Positive supply voltage	2.5	3.6	4	V
V_{EE}	Negative supply voltage	–2.5	–3.6	–4	V
V_{IH}	High-level control input voltage	$V_{DD} \times 0.65$			V
V_{IL}	Low-level control input voltage	$V_{DD} \times 0.35$			V
V_I	Control input voltage	GND			V
$V_{I/O}$	Resistor inputs/outputs	V_{EE}			V
T_A	Operating free-air temperature	–40			85
					°C

ELECTRICAL CHARACTERISTICS

Dual ± 4 -V Supply

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{IK}	Control inputs	$V_{DD} = 4\text{ V}$, $I_{IN} = -18\text{ mA}$			-1.8	V
I_{IN}		$V_{DD} = 4\text{ V}$, $V_{IN} = V_{DD}$ or GND			± 1	μA
$I_{DD} + I_{EE} $		$V_{DD} = 4\text{ V}$, $V_{EE} = -4\text{ V}$, $V_{IN} = V_{DD}$ or GND, $I_{IO} = 0$			100	μA
C_{IN}	Control capacitance ⁽¹⁾	$V_{DD} = 4\text{ V}$, $V_{IN} = V_{DD}$ or GND		3.2		pF
C_{RG}	RG capacitance ⁽¹⁾	$V_{IN} = 0\text{ V}$, frequency = 10 MHz		45		pF
C_{RF}	RF capacitance ⁽¹⁾	$V_{IN} = 0\text{ V}$, frequency = 10 MHz		45		pF
C_W	Wiper capacitance ⁽¹⁾	$V_{IN} = 0\text{ V}$, frequency = 10 MHz		45		pF
R	End-to-end resistance		1.75	2.5	3.25	k Ω
R_W	Wiper resistance				420	Ω
INL	Integral nonlinearity		-0.3		0.3	dB
DNL	Differential nonlinearity		-0.3		0.3	dB

- (1) The AC method is a frequency domain measurement. A 10-MHz ac voltage signal of known dc offset and amplitude of 82.5 mV are applied to the pin under test. The imaginary component of the complex current is measured and used in the equation:

$$C = I_{im} / (2 \times \pi \times F \times V_{IN}) \text{ where } I_{im} = \text{imaginary component of input current, } V_{IN} = \text{magnitude of input voltage, and } F = \text{frequency.}$$

SWITCHING CHARACTERISTICS⁽¹⁾

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{PS}	Control to output step delay			100		ns
BW	Analog signal bandwidth	For a typical example, see Figure 2	8			MHz

- (1) Typical bandwidth shown in [Figure 2](#) supports 6 MHz minimum.

PARAMETER MEASUREMENT INFORMATION

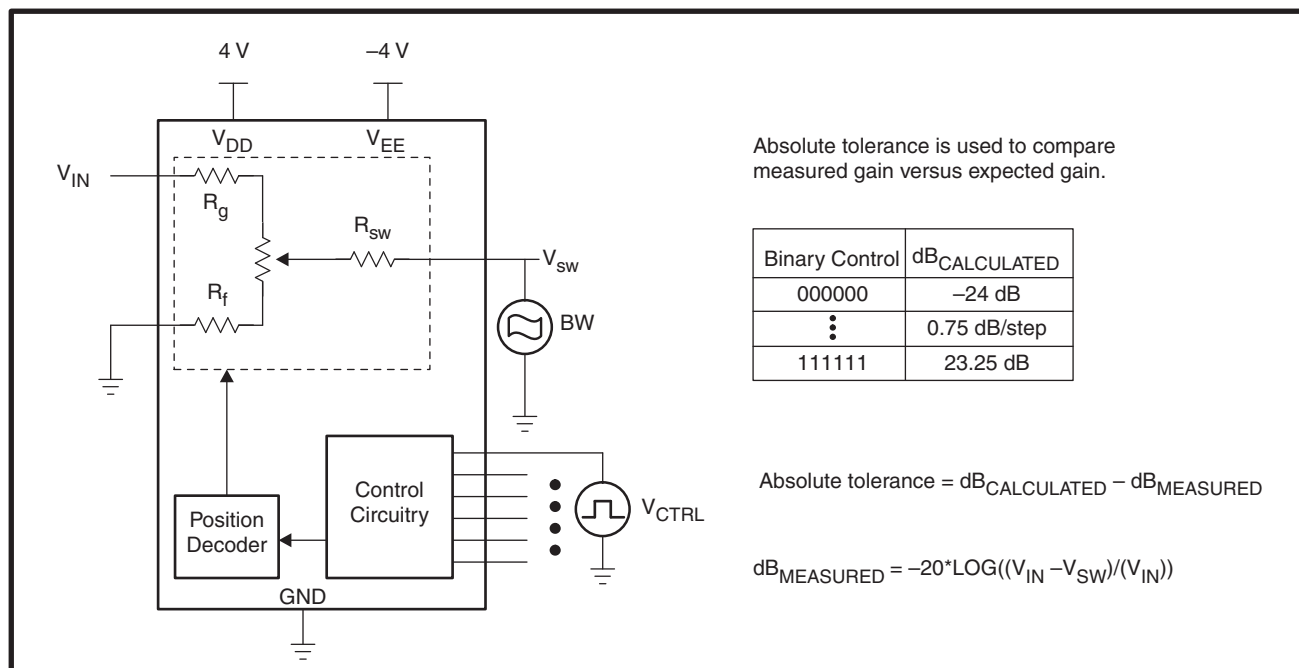


Figure 1. Analog Signal Bandwidth and Absolute Tolerance

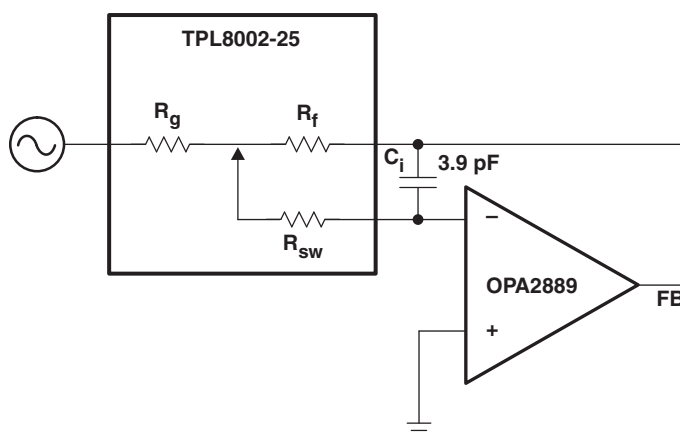


Figure 2. Bandwidth Setup

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)	Device Marking (4/5)	Samples
TPL8002-25PWR	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	PHY03A	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) 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.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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

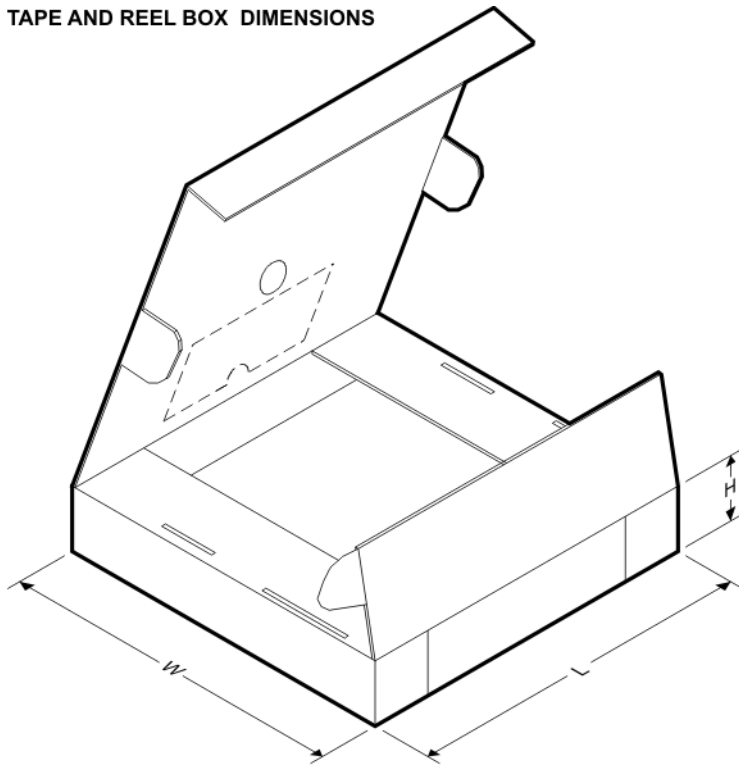

A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

TAPE AND REEL INFORMATION

*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
TPL8002-25PWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS

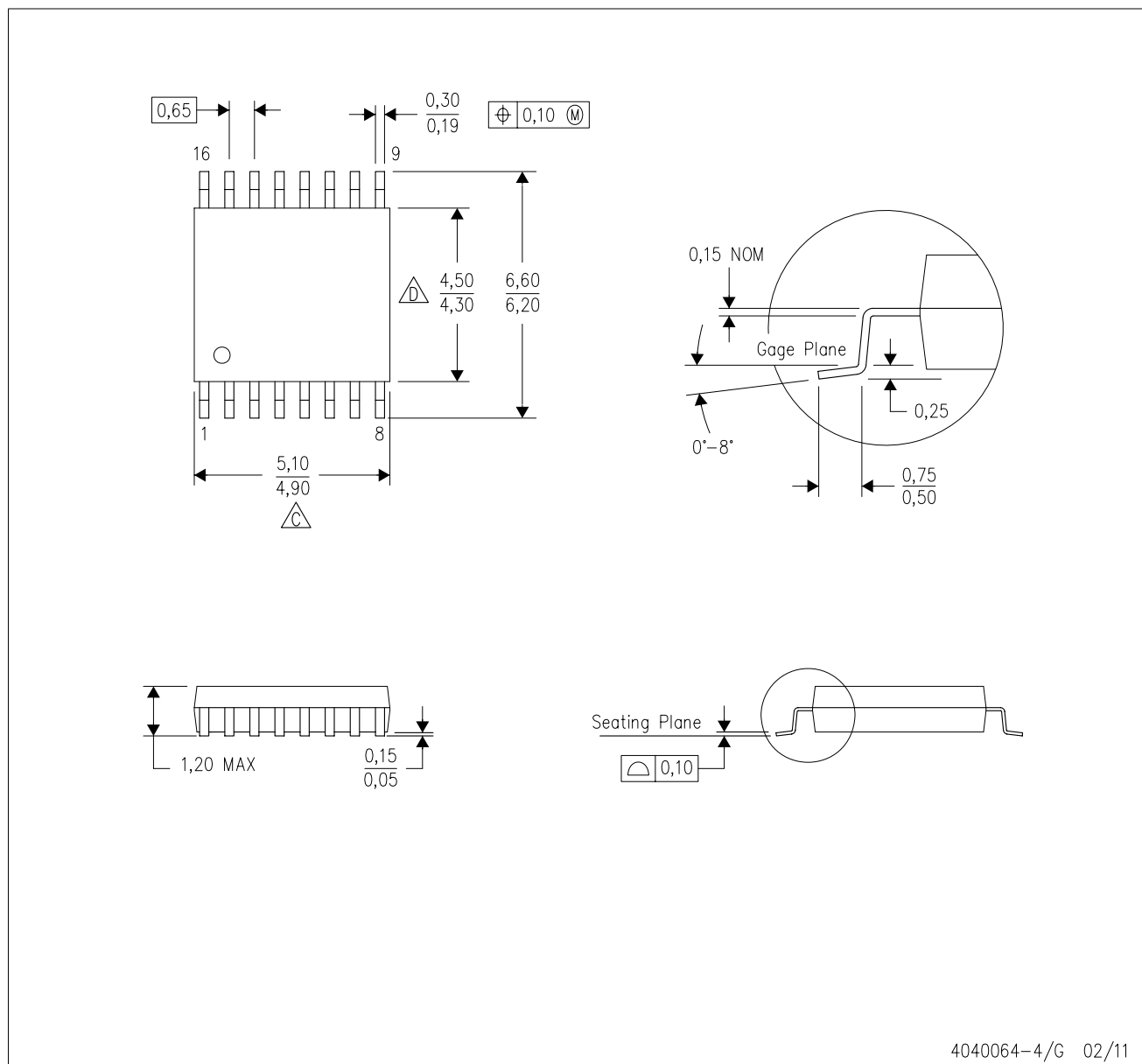


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPL8002-25PWR	TSSOP	PW	16	2000	367.0	367.0	35.0

PW (R-PDSO-G16)

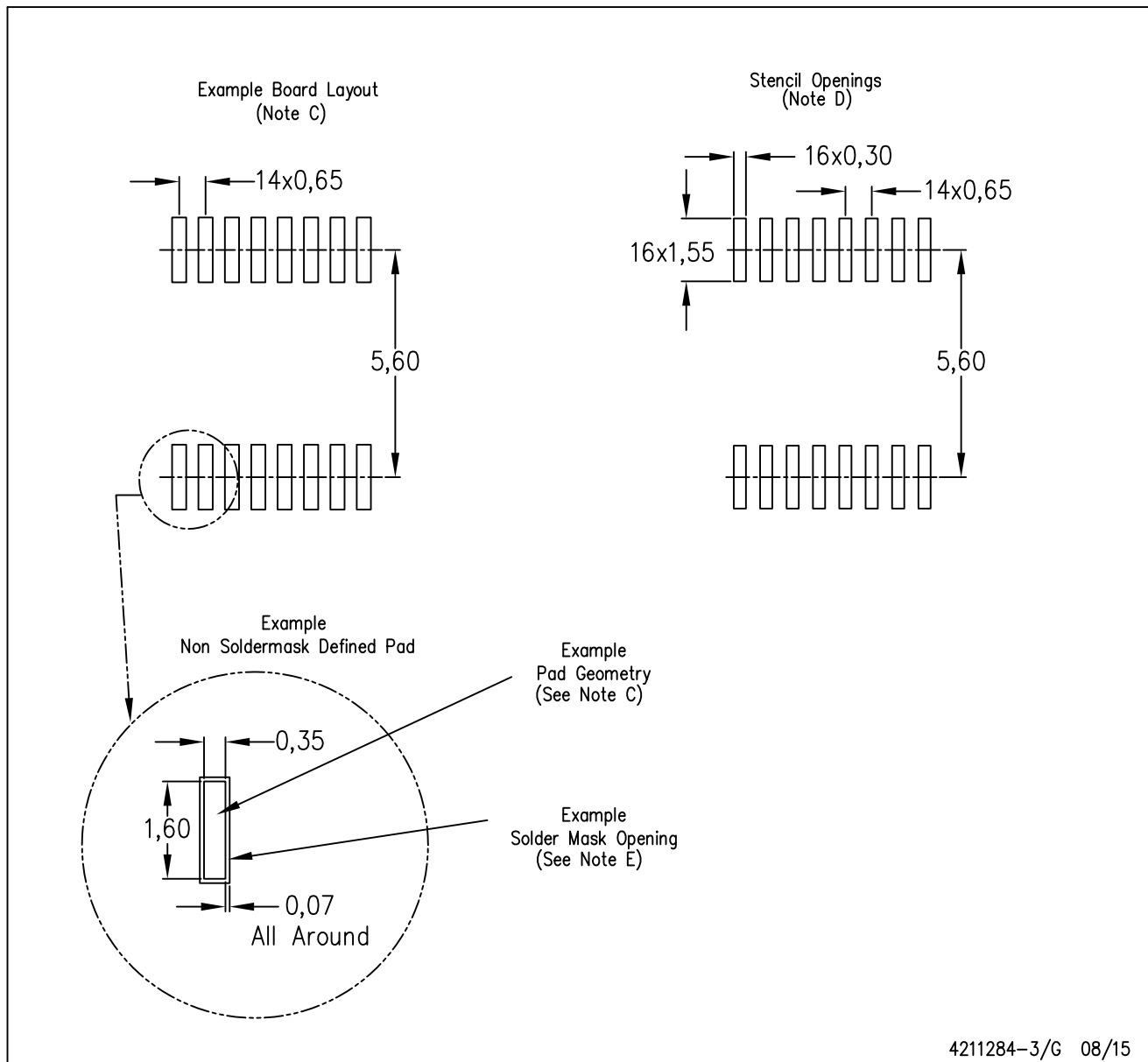
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
 - D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
 - E. Falls within JEDEC MO-153

PW (R-PDSO-G16)

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 designs.
 - 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.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com