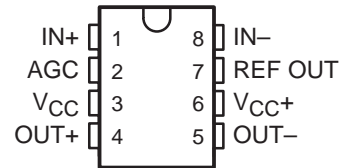


# TL026C DIFFERENTIAL HIGH-FREQUENCY AMPLIFIER WITH AGC

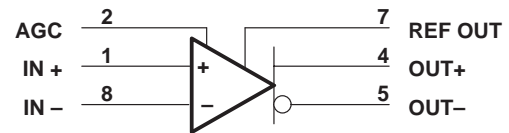
SLFS007A – JUNE 1985 – REVISED JULY 1990

- Low Output Common-Mode Sensitivity to AGC Voltages
- Input and Output Impedances Independent of AGC Voltage
- Peak Gain . . . 38 dB Typ
- Wide AGC Range . . . 50 dB Typ
- 3-dB Bandwidth . . . 50 MHz
- Other Characteristics Similar to NE592 and uA733

D OR P PACKAGE  
(TOP VIEW)



symbol



## description

This device is a monolithic two-stage high-frequency amplifier with differential inputs and outputs.

Internal feedback provides wide bandwidth, low phase distortion, and excellent gain stability. Variable gain based on signal summation provides large AGC control over a wide bandwidth with low harmonic distortion. Emitter-follower outputs enable the device to drive capacitive loads. All stages are current-source biased to obtain high common-mode and supply-voltage rejection ratios. The gain may be electronically attenuated by applying a control voltage to the AGC pin. No external compensation components are required.

This device is particularly useful in TV and radio IF and RF AGC circuits, as well as magnetic-tape and disk-file systems where AGC is needed. Other applications include video and pulse amplifiers where a large AGC range, wide bandwidth, low phase shift, and excellent gain stability are required.

The TL026C is characterized for operation from 0°C to 70°C.

## absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, $V_{CC+}$ (see Note 1)	8 V
Supply voltage, $V_{CC-}$ (see Note 1)	– 8 V
Differential input voltage	±5 V
Common-mode input voltage	±6 V
Output current	±10 mA
Continuous total dissipation	See Dissipation Rating Table
Operating free-air temperature range	0°C to 70°C
Storage temperature range	– 65°C to 150°C
Lead temperature range 1,6 mm (1/16 inch) from case for 10 seconds	260°C

† Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at these or any other conditions beyond those indicated in the recommended operating conditions section of this specification is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: All voltages are with respect to the midpoint of  $V_{CC+}$  and  $V_{CC-}$  except differential input and output voltages.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25^\circ\text{C}$ POWER RATING	OPERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$	$T_A = 70^\circ\text{C}$ POWER RATING
D	725 mW	5.8 mW/°C	464 mW
P	1000 mW	8.0 mW/°C	640 mW

# TL026C

## DIFFERENTIAL HIGH-FREQUENCY AMPLIFIER WITH AGC

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### recommended operating conditions

	MIN	NOM	MAX	UNIT
Supply voltage, $V_{CC+}$	3	6	8	V
Supply voltage, $V_{CC-}$	-3	-6	-8	V
Operating free-air temperature range, $T_A$	0		70	°C

### electrical characteristics at 25°C operating free-air temperature, $V_{CC+} = \pm 6$ V, $V_{AGC} = 0$ , REF OUT pin open (unless otherwise specified)

PARAMETER	FIGURE	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$A_{VD}$ Large-signal differential voltage amplification	1	$V_{O(PP)} = 3$ V, $R_L = 2$ k $\Omega$	65	85	105	V/V
$\Delta A_{VD}$ Change in voltage amplification	1	$V_{IPP} = 28.5$ mV, $R_L = 2$ k $\Omega$ , $V_{AGC} - V_{ref} = \pm 180$ mV		-50		dB
$V_{ref}$ Voltage at REF OUT		$I_{ref} = -1$ mA to 100 $\mu$ A	1.3		1.5	V
BW Bandwidth (-3 dB)	2	$V_{O(PP)} = 1$ V, $V_{AGC} - V_{ref} = \pm 180$ mV		50		MHz
$I_{IO}$ Input offset current				0.4	5	$\mu$ A
$I_{IB}$ Input bias current				10	30	$\mu$ A
$V_{ICR}$ Common-mode input voltage range	3		$\pm 1$			V
$V_{OC}$ Common-mode output voltage	1	$R_L = \infty$	3.25	3.75	4.25	V
$\Delta V_{OC}$ Change in common-mode output voltage	1	$V_{AGC} = 0$ to 2 V, $R_L = \infty$			300	mV
$V_{OO}$ Output offset voltage	1	$V_{ID} = 0$ , $R_L = \infty$			0.75	V
$V_{O(PP)}$ Maximum peak-to-peak output voltage swing	1	$R_L = 2$ k $\Omega$	3	4		V
$r_i$ Input resistance at AGC, IN+, or IN-			10	30		k $\Omega$
$r_o$ Output resistance				20		$\Omega$
CMRR Common-mode rejection ratio	3	$V_{IC} = \pm 1$ V, $f = 100$ kHz	60	86		dB
		$V_{IC} = \pm 1$ V, $f = 5$ mHz		60		
$k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{CC+} / \Delta V_{IO}$ )	4	$\Delta V_{CC+} = \pm 0.5$ V, $\Delta V_{CC-} = \pm 0.5$ V	50	70		dB
$V_n$ Broadband equivalent noise voltage	4	BW = 1 kHz to 10 MHz		12		$\mu$ V
$t_{pd}$ Propagation delay time	2	$\Delta V_O = 1$ V		6	10	ns
$t_r$ Rise time	2	$\Delta V_O = 1$ V		4.5	12	ns
$I_{sink(max)}$ Maximum output sink current		$V_{ID} = 1$ V, $V_O = 3$ V	3	4		mA
$I_{CC}$ Supply current		No load, No signal		22	27	mA

# TL026C

## DIFFERENTIAL HIGH-FREQUENCY AMPLIFIER WITH AGC

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electrical characteristics over recommended operating free-air temperature range,  $V_{CC\pm} = \pm 6\text{ V}$ ,  $V_{AGC} = 0$ , REF OUT pin open (unless otherwise specified)

PARAMETER	FIGURE	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$A_{VD}$ Large-signal differential voltage amplification	1	$V_{O(PP)} = 3\text{ V}$ , $R_L = 2\text{ k}\Omega$	55		115	V/V
$I_{IO}$ Input offset current					6	$\mu\text{A}$
$I_{IB}$ Input bias current					40	$\mu\text{A}$
$V_{ICR}$ Common-mode input voltage range	3		$\pm 1$			V
$V_{OO}$ Output offset voltage	1	$V_{ID} = 0$ , $R_L = \infty$			1.5	V
$V_{O(PP)}$ Maximum peak-to-peak output voltage swing	1	$R_L = 2\text{ k}\Omega$	2.8			V
$r_i$ Input resistance at AGC, IN+, or IN –			8			$\text{k}\Omega$
CMRR Common-mode rejection ratio	3	$V_{IC} = \pm 1\text{ V}$ , $f = 100\text{ kHz}$	50			dB
$k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{CC} / \Delta V_{IO}$ )	4	$\Delta V_{CC+} = \pm 0.5\text{ V}$ , $\Delta V_{CC-} = \pm 0.5\text{ V}$	50			dB
$I_{\text{sink(max)}}$ Maximum output sink current		$V_{ID} = 1\text{ V}$ , $V_O = 3\text{ V}$	2.8	4		mA
$I_{CC}$ Supply current	1	No load, No signal			30	mA

### PARAMETER MEASUREMENT INFORMATION

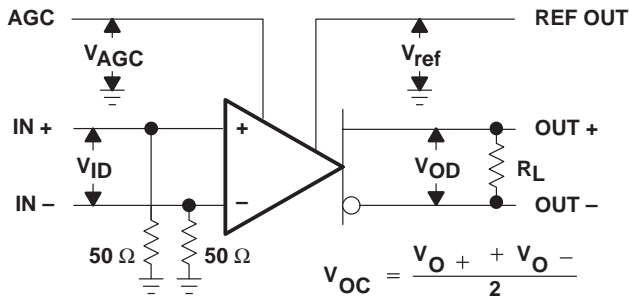


Figure 1. Test Circuit

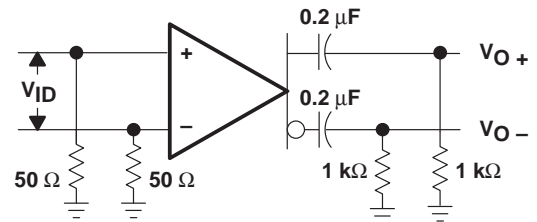


Figure 2. Test Circuit

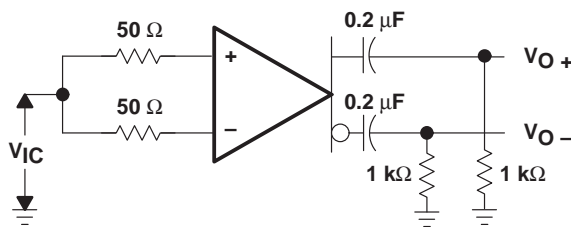


Figure 3. Test Circuit

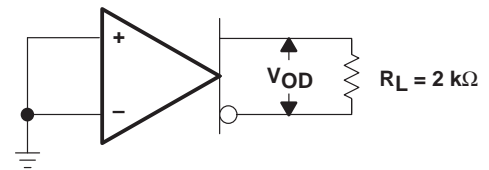


Figure 4. Test Circuit

# TL026C

## DIFFERENTIAL HIGH-FREQUENCY AMPLIFIER WITH AGC

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### TYPICAL CHARACTERISTICS

DIFFERENTIAL VOLTAGE AMPLIFICATION  
vs  
DIFFERENTIAL GAIN-CONTROL VOLTAGE

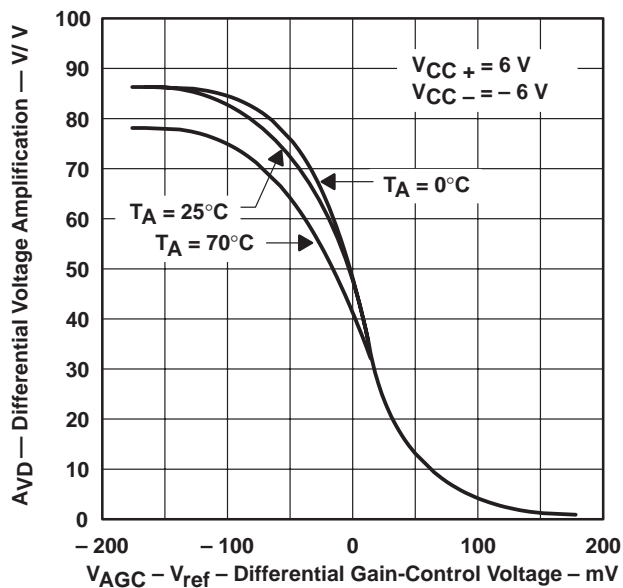


Figure 5

## APPLICATION INFORMATION

### gain characteristics

Figure 5 shows the differential voltage amplification versus the differential gain-control voltage ( $V_{AGC} - V_{ref}$ ).  $V_{AGC}$  is the absolute voltage applied to the  $A_{GC}$  input and  $V_{ref}$  is the dc voltage at the REF OUT output. As  $V_{AGC}$  increases with respect to  $V_{ref}$ , the TL026C gain changes from maximum to minimum. As shown in Figure 5 for example,  $V_{AGC}$  would have to vary from approximately 180 mV less than  $V_{ref}$  to approximately 180 mV greater than  $V_{ref}$  to change the gain from maximum to minimum. The total signal change in  $V_{AGC}$  is defined by the following equation.

$$\begin{aligned}\Delta V_{AGC} &= V_{ref} + 180 \text{ mV} - (V_{ref} - 180 \text{ mV}) \\ \Delta V_{AGC} &= 360 \text{ mV}\end{aligned}\tag{1}$$

However, because  $V_{AGC}$  varies as the ac AGC signal varies and also differentially around  $V_{ref}$ , then  $V_{AGC}$  should have an ac signal component and a dc component. To preserve the dc and thermal tracking of the device, this dc voltage must be generated from  $V_{ref}$ . To apply proper bias to the AGC input, the external circuit used to generate  $V_{AGC}$  must combine these two voltages. Figures 6 and 7 show two circuits that will perform this operation and are easy to implement. The circuits use a standard dual operational amplifier for AGC feedback. By providing rectification and the required feedback gain, these circuits are also complete AGC systems.

### circuit operation

Amplifier A1 amplifies and inverts the rectified and filtered AGC signal voltage  $V_C$  producing output voltage  $V_1$ . Amplifier A2 is a differential amplifier that inverts  $V_1$  again and adds the scaled  $V_{ref}$  voltage. This conditioning makes  $V_{AGC}$  the sum of the signal plus the scaled  $V_{ref}$ . As the signal voltage increases,  $V_{AGC}$  increases and the gain of the TL026C is reduced. This maintains a constant output level.

### feedback circuit equations

Following the AGC input signal (Figures 6 and 7) from the OUT output through the feedback amplifiers to the AGC input produces the following equations:

1. AC output to diode D1, assuming sinusoidal signals
 
$$V_O = V_{OP} (\sin wt)\tag{2}$$

where:

$$V_{OP} = \text{peak voltage of } V_O$$

2. Diode D1 and capacitor C1 output
 
$$V_C = V_{OP} - V_F\tag{3}$$

where:

$$V_F = \text{forward voltage drop of D1}$$

$$V_C = \text{voltage across capacitor C1}$$

3. A1 output
 
$$V_1 = -\frac{R_2}{R_1} V_C\tag{4}$$

4. A2 output ( $R_3 = R_4$ )
 
$$V_{AGC} = \frac{R_2}{R_1} V_C + 2\frac{R_6}{R_5 + R_6} V_{ref}\tag{5}$$

# TL026C

## DIFFERENTIAL HIGH-FREQUENCY AMPLIFIER WITH AGC

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### APPLICATION INFORMATION

Amplifier A2 inverts V1 producing a positive AGC signal voltage. Therefore, the input voltage to the TL026C AGC pin consists of an AGC signal equal to:

$$\frac{R2}{R1} V_C \quad (6)$$

and a dc voltage derived from  $V_{ref}$ , defined as the quiescent value of  $V_{AGC}$ .

$$V_{AGC}(q) = 2 \frac{R6}{R5 + R6} V_{ref} \quad (7)$$

For the initial resistor calculations,  $V_{ref}$  is assumed to be typically 1.4 V making quiescent  $V_{AGC}$  approximately 1.22 V ( $V_{AGC}(q) = V_{ref} - 180 \text{ mV}$ ). This voltage allows the TL026C to operate at maximum gain under no-signal and low-signal conditions. In addition, with  $V_{ref}$  used as both internal and external reference, its variation from device to device automatically adjusts the overall bias and makes AGC operation essentially independent of the absolute value of  $V_{ref}$ . The resistor divider needs to be calculated only once and is valid for the full tolerance of  $V_{ref}$ .

### output voltage limits (see Figures 6 and 7)

The output voltage level desired must fall within the following limits:

1. Because the data sheet minimum output swing is 3 V peak-to-peak using a 2-k $\Omega$  load resistor, the user-selected design limit for the peak output swing should not exceed 1.5 V.
2. The voltage drop of the rectifying diode determines the lower voltage limit. When a silicon diode is used, this voltage is approximately 0.7 V. The output voltage  $V_O$  must have sufficient amplitude to exceed the rectifying diode drop. A Schottky diode can be used to reduce the  $V_O$  level required.

### gain calculations for a peak output voltage of 1 V

A peak output voltage of 1 V was chosen for gain calculations because it is approximately midway between the limits of conditions 1 and 2 in the preceding paragraph.

Using equation 3 ( $V_C = V_{OP} - V_d$ ),  $V_C$  is calculated as follows:

$$V_C = 1 \text{ V} - 0.7 \text{ V}$$

$$V_C = 0.3 \text{ V}$$

Therefore, the gain of A1 must produce a voltage V1 that is equal to or greater than the total change in  $V_{AGC}$  for maximum TL026C gain change.

With a total change in  $V_{AGC}$  of 360 mV and using equation 4, the calculation is as follows:

$$-\frac{V1}{V_C} = \frac{\Delta V_{AGC}}{V_C} = \frac{R2}{R1} = \frac{0.36}{0.3} = 1.2$$

If  $R1$  is 10 k $\Omega$ ,  $R2$  is 1.2 times  $R1$  or 12 k $\Omega$ .

Since the output voltage for this circuit must be between 0.85 V and 1.3 V, the component values in Figures 6 and 7 provide a nominal 1-V peak output limit. This limit is the best choice to allow for temperature variations of the diode and minimum output voltage specification.

## considerations for the use of the TL026C

A peak input voltage greater than 200 mV will begin to saturate the input stages of the TL026C and, while the circuit is in the AGC mode, the output signal may become distorted.

[illegible]

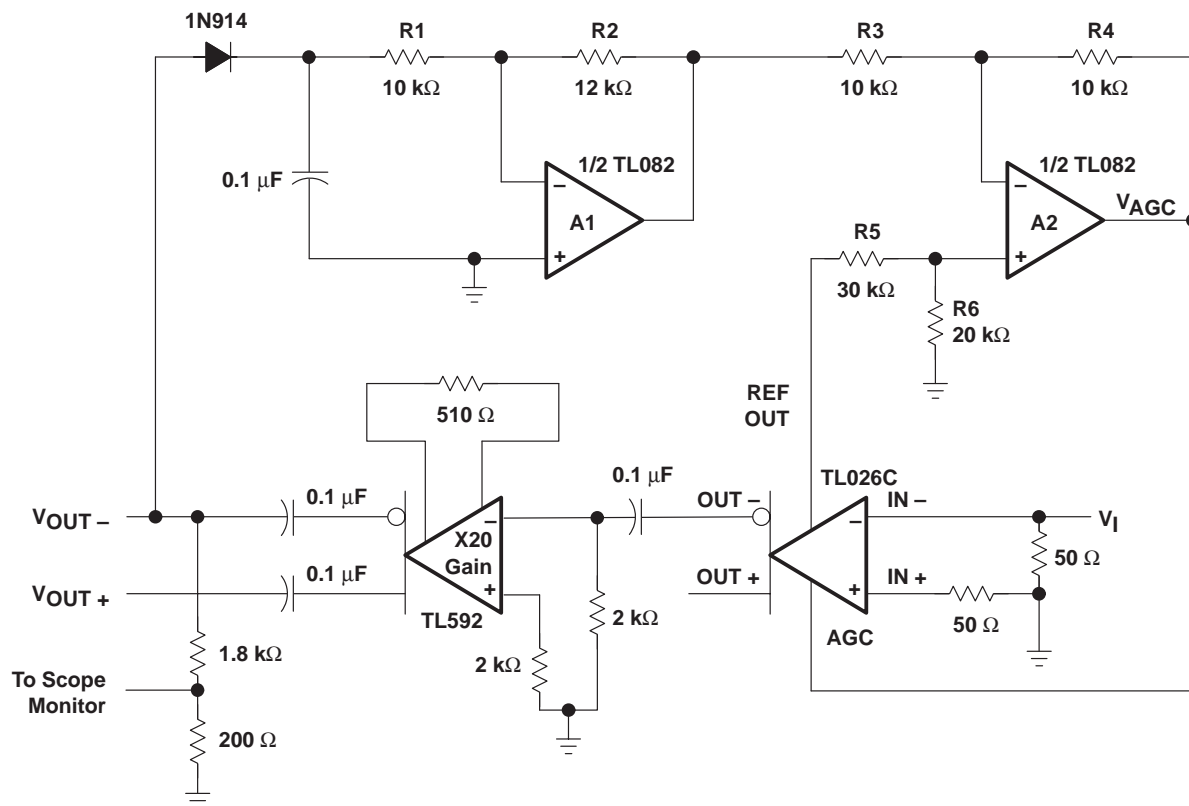
### Figure 6. Typical Application Circuit With No Attenuation

# TL026C

## DIFFERENTIAL HIGH-FREQUENCY AMPLIFIER WITH AGC

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### APPLICATION INFORMATION



NOTE:  $V_{CC+} = +6\text{ V}$  and  $V_{CC-} = -6\text{ V}$  for TL026C and amplifiers A1 and A2.

**Figure 7. Typical Application Circuit With Attenuation**



## 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
TL026CD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	0 to 70	TL026C	<a href="#">Samples</a>
TL026CDG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	0 to 70	TL026C	<a href="#">Samples</a>
TL026CDR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR	0 to 70	TL026C	<a href="#">Samples</a>
TL026CP	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	TL026CP	<a href="#">Samples</a>
TL026CPE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	TL026CP	<a href="#">Samples</a>
TL026CPSR	ACTIVE	SO	PS	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	T026	<a href="#">Samples</a>
TL026ID	OBSOLETE	SOIC	D	8		TBD	Call TI	Call TI			

(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.

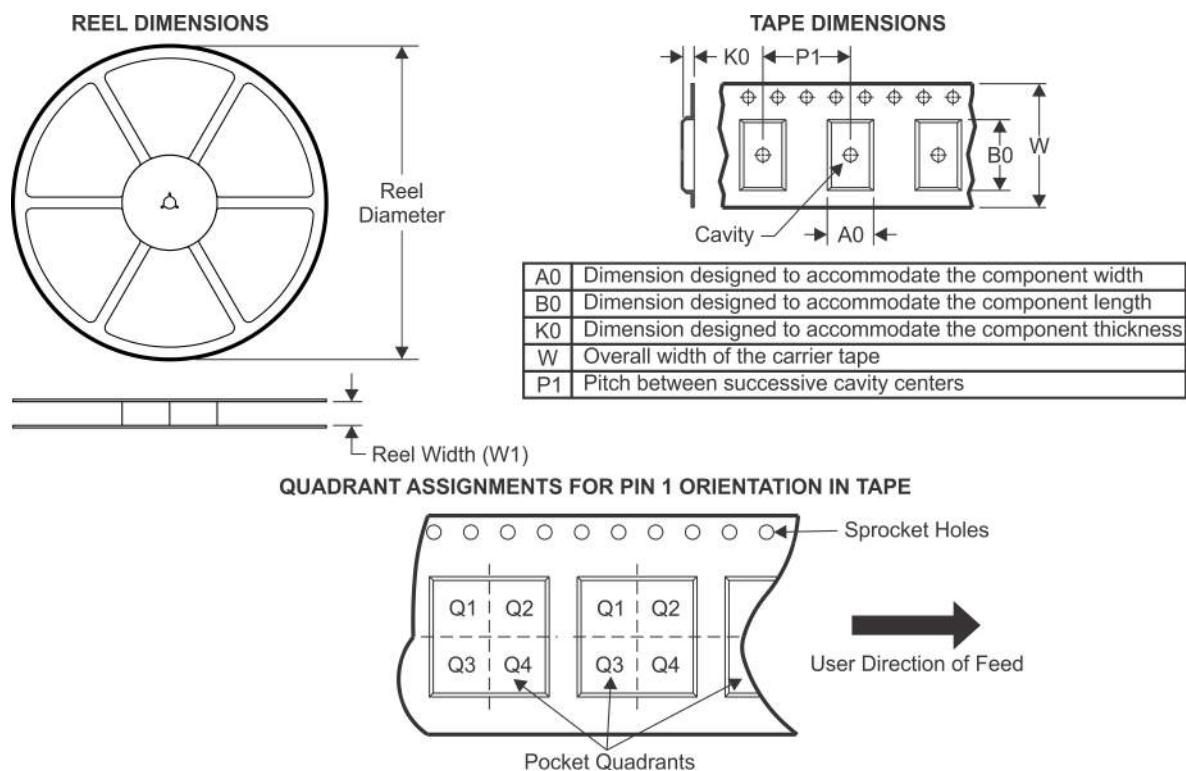
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

<sup>(5)</sup> 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.

<sup>(6)</sup> 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.

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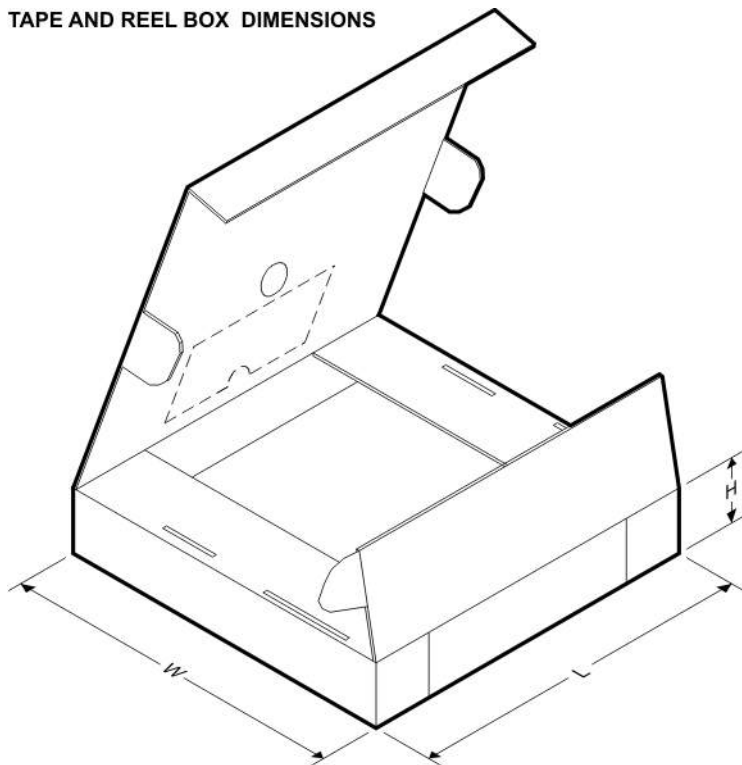
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**TAPE AND REEL INFORMATION**


\*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
TL026CDR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
TL026CPSR	SO	PS	8	2000	330.0	16.4	8.2	6.6	2.5	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)
TL026CDR	SOIC	D	8	2500	340.5	338.1	20.6
TL026CPSR	SO	PS	8	2000	367.0	367.0	38.0

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE



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

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



## NOTES:

- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- $\triangle C$  Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
- $\triangle D$  Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
- E. Reference JEDEC MS-012 variation AA.

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



4211283-2/E 08/12

- 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.

# MECHANICAL DATA

PS (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



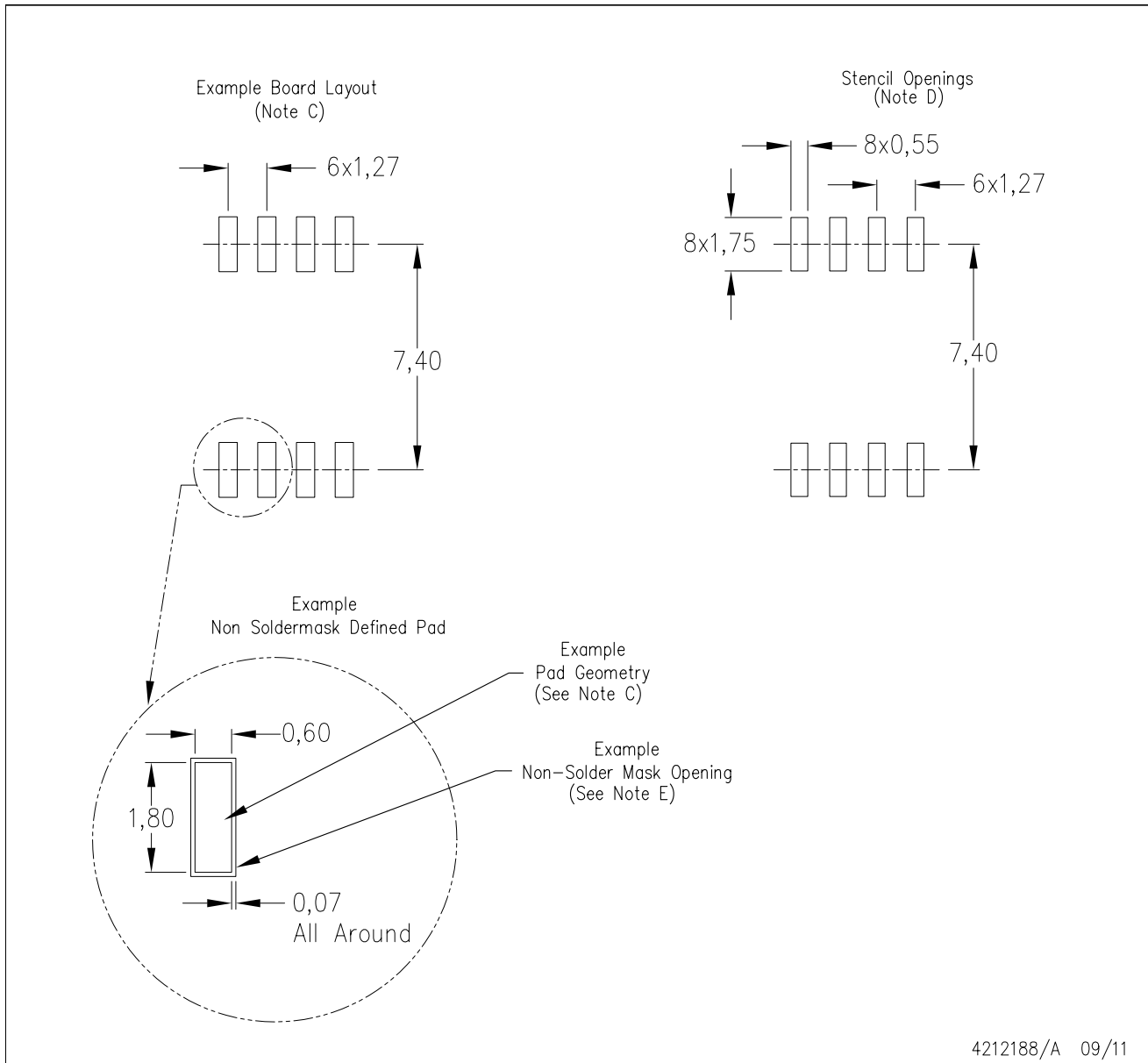
4040063/C 03/03

- 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.



## PS (R-PDSO-G8)

## PLASTIC SMALL OUTLINE



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - 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.
  - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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