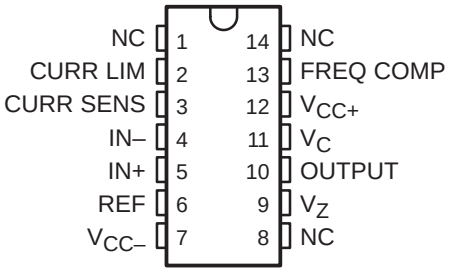
SLVS057D – AUGUST 1972 – REVISED JULY 1999

- **150-mA Load Current Without External Power Transistor**
- **Adjustable Current-Limiting Capability**
- **Input Voltages up to 40 V**
- **Output Adjustable From 2 V to 37 V**
- **Direct Replacement for Fairchild μA723C**

D OR N PACKAGE
(TOP VIEW)



description

The μA723 is a precision integrated-circuit voltage regulator, featuring high ripple rejection, excellent input and load regulation, excellent temperature stability, and low standby current. The circuit consists of a temperature-compensated reference-voltage amplifier, an error amplifier, a 150-mA output transistor, and an adjustable-output current limiter.

The μA723 is designed for use in positive or negative power supplies as a series, shunt, switching, or floating regulator. For output currents exceeding 150 mA, additional pass elements can be connected as shown in Figures 4 and 5.

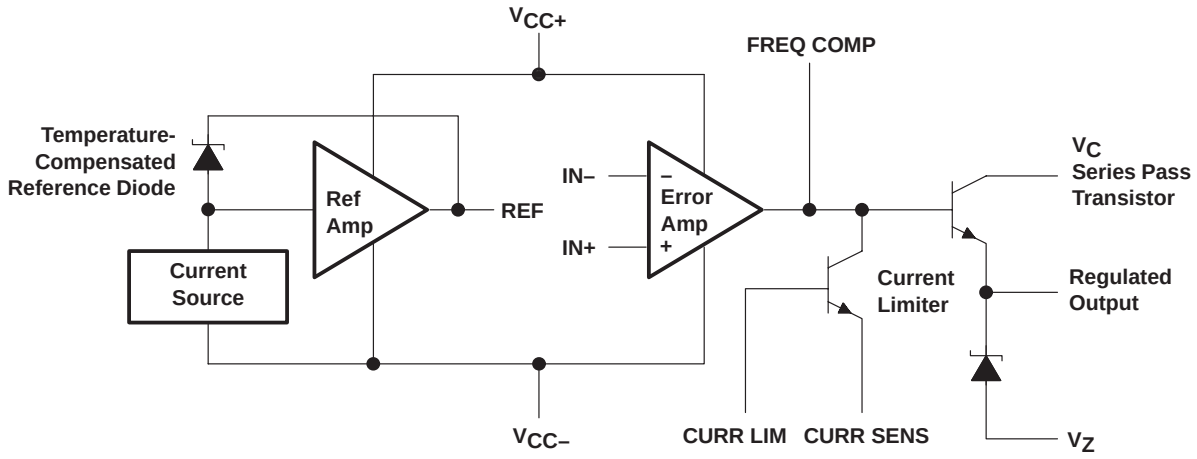
The μA723C is characterized for operation from 0°C to 70°C.

AVAILABLE OPTIONS

T_A	PACKAGED DEVICES		CHIP FORM (Y)
	PLASTIC DIP (N)	SMALL OUTLINE (D)	
0°C to 70°C	μA723CN	μA723CD	μA723Y

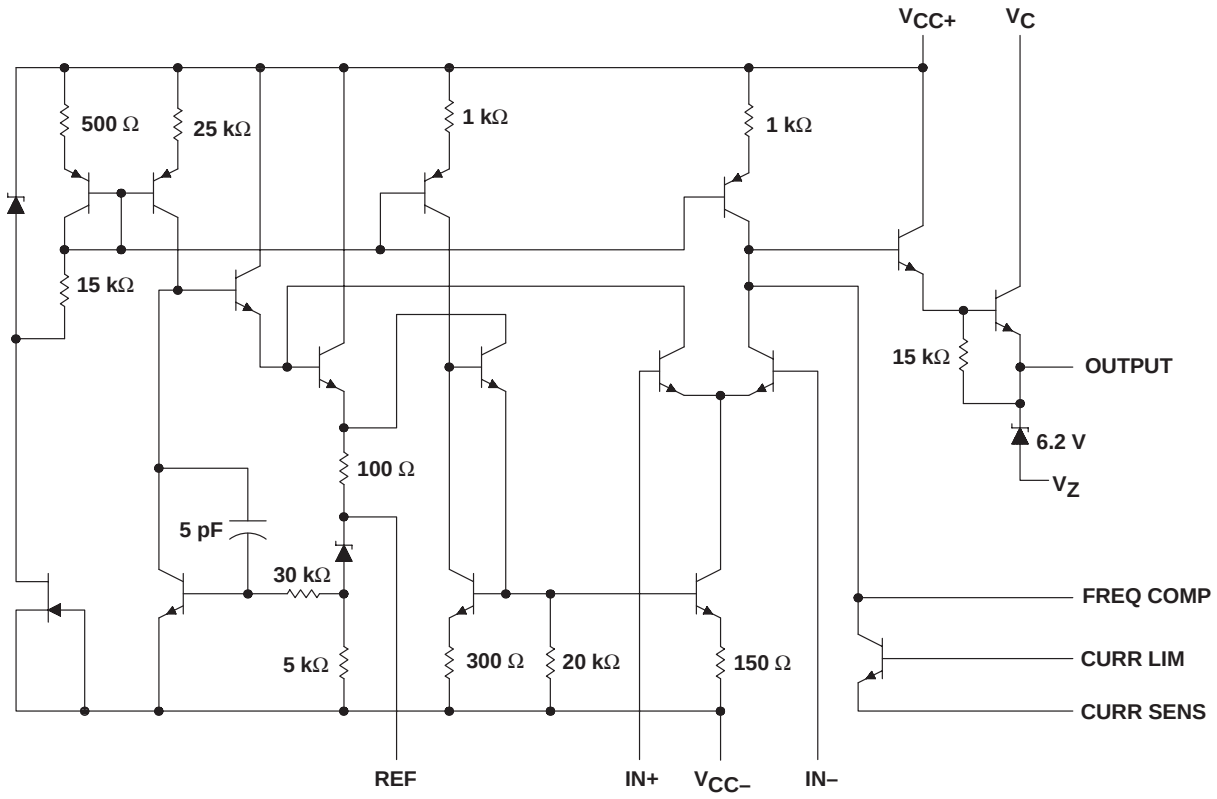
The D package is available taped and reeled. Add the suffix R to the device type (e.g., μA723CDR). Chip forms are tested at 25°C.

functional block diagram



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.

schematic



Resistor and capacitor values shown are nominal.

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

Peak voltage from V_{CC+} to V_{CC-} ($t_w \leq 50$ ms)	50 V
Continuous voltage from V_{CC+} to V_{CC-}	40 V
Input-to-output voltage differential	40 V
Differential input voltage to error amplifier	±5 V
Voltage between noninverting input and V_{CC-}	8 V
Current from V_Z	25 mA
Current from REF	15 mA
Package thermal impedance, θ_{JA} (see Notes 1 and 2): D package	86°C/W
N package	101°C/W
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or N package	260°C
Storage temperature range, T_{stg}	–65°C to 150°C

† 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.

NOTES: 1. Maximum power dissipation is a function of $T_J(max)$, θ_{JA}, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) – T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can impact reliability.

2. The package thermal impedance is calculated in accordance with JESD 51, except for through-hole packages, which use a trace length of zero.

recommended operating conditions

		MIN	MAX	UNIT
Input voltage, V_I		9.5	40	V
Output voltage, V_O		2	37	V
Input-to-output voltage differential, $V_C - V_O$		3	38	V
Output current, I_O			150	mA
Operating free-air temperature range, T_A	μA723C	0	70	°C

electrical characteristics at specified free-air temperature (see Notes 3 and 4)

PARAMETER	TEST CONDITIONS		T_A	μA723C			UNIT
				MIN	TYP	MAX	
Input regulation	V_I = 12 V to V_I = 15 V		25°C		0.1	1	mV/V
	V_I = 12 V to V_I = 40 V		25°C		1	5	
	V_I = 12 V to V_I = 15 V		0°C to 70°C			3	
Ripple rejection	f = 50 Hz to 10 kHz,	C_{ref} = 0	25°C		74		dB
	f = 50 Hz to 10 kHz,	C_{ref} = 5 μF	25°C		86		
Output regulation			25°C		–0.3	–2	mV/V
			0°C to 70°C			–6	
Reference voltage, V_{ref}			25°C	6.8	7.15	7.5	V
Standby current	V_I = 30 V,	I_O = 0	25°C		2.3	4	mA
Temperature coefficient of output voltage			0°C to 70°C		0.003	0.015	%/°C
Short-circuit output current	R_{SC} = 10 Ω,	V_O = 0	25°C		65		mA
Output noise voltage	BW = 100 Hz to 10 kHz,	C_{ref} = 0	25°C		20		μV
	BW = 100 Hz to 10 kHz,	C_{ref} = 5 μF	25°C		2.5		

NOTES: 3. For all values in this table, the device is connected as shown in Figure 1 with the divider resistance as seen by the error amplifier ≤ 10 kΩ. Unless otherwise specified, $V_I = V_{CC+} = V_C$ = 12 V, V_{CC-} = 0, V_O = 5 V, I_O = 1 mA, R_{SC} = 0, and C_{ref} = 0.
4. Pulse-testing techniques must be used that will maintain the junction temperature as close to the ambient temperature as possible.

electrical characteristics, T_A = 25°C (see Notes 3 and 4)

PARAMETER	TEST CONDITIONS		μA723Y			UNIT
			MIN	TYP	MAX	
Input regulation	V_I = 12 V to V_I = 15 V			0.1		mV/V
	V_I = 12 V to V_I = 40 V			1		
Ripple rejection	f = 50 Hz to 10 kHz,	C_{ref} = 0		74		dB
	f = 50 Hz to 10 kHz,	C_{ref} = 5 μF		86		
Output regulation				–0.3		mV/V
Reference voltage, V_{ref}				7.15		V
Standby current	V_I = 30 V,	I_O = 0		2.3		mA
Short-circuit output current	R_{SC} = 10 Ω,	V_O = 0		65		mA
Output noise voltage	BW = 100 Hz to 10 kHz,	C_{ref} = 0		20		μV
	BW = 100 Hz to 10 kHz,	C_{ref} = 5 μF		2.5		

NOTES: 3. For all values in this table, the device is connected as shown in Figure 1 with the divider resistance as seen by the error amplifier ≤ 10 kΩ. Unless otherwise specified, $V_I = V_{CC+} = V_C$ = 12 V, V_{CC-} = 0, V_O = 5 V, I_O = 1 mA, R_{SC} = 0, and C_{ref} = 0.
4. Pulse-testing techniques must be used that will maintain the junction temperature as close to the ambient temperature as possible.

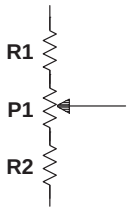
APPLICATION INFORMATION

Table 1. Resistor Values (kΩ) for Standard Output Voltages

OUTPUT VOLTAGE (V)	APPLICABLE FIGURES (SEE NOTE 5)	FIXED OUTPUT ±5%		OUTPUT ADJUSTABLE ±10% (SEE NOTE 6)		
		R1 (kΩ)	R2 (kΩ)	R1 (kΩ)	P1 (kΩ)	P2 (kΩ)
3.0	1, 5, 6, 9, 11, 12 (4)	4.12	3.01	1.8	0.5	1.2
3.6	1, 5, 6, 9, 11, 12 (4)	3.57	3.65	1.5	0.5	1.5
5.0	1, 5, 6, 9, 11, 12 (4)	2.15	4.99	0.75	0.5	2.2
6.0	1, 5, 6, 9, 11, 12 (4)	1.15	6.04	0.5	0.5	2.7
9.0	2, 4, (5, 6, 9, 12)	1.87	7.15	0.75	1.0	2.7
12	2, 4, (5, 6, 9, 12)	4.87	7.15	2.0	1.0	3.0
15	2, 4, (5, 6, 9, 12)	7.87	7.15	3.3	1.0	3.0
28	2, 4, (5, 6, 9, 12)	21.0	7.15	5.6	1.0	2.0
45	7	3.57	48.7	2.2	10	39
75	7	3.57	78.7	2.2	10	68
100	7	3.57	105	2.2	10	91
250	7	3.57	255	2.2	10	240
–6 (see Note 7)	3, 10	3.57	2.43	1.2	0.5	0.75
–9	3, 10	3.48	5.36	1.2	0.5	2.0
–12	3, 10	3.57	8.45	1.2	0.5	3.3
–15	3, 10	3.57	11.5	1.2	0.5	4.3
–28	3, 10	3.57	24.3	1.2	0.5	10
–45	8	3.57	41.2	2.2	10	33
–100	8	3.57	95.3	2.2	10	91
–250	8	3.57	249	2.2	10	240

NOTES: 5. The R1/R2 divider can be across either V_O or $V_{(ref)}$. If the divider is across $V_{(ref)}$, use the figure numbers without parentheses. If the divider is across V_O, use the figure numbers in parentheses.

6. To make the voltage adjustable, the R1/R2 divider shown in the figures must be replaced by the divider shown below.



Adjustable Output Circuit

7. For Figures 3, 8, and 10, the device requires a minimum of 9 V between V_{CC+} and V_{CC-} when V_O is equal to or more positive than –9 V.

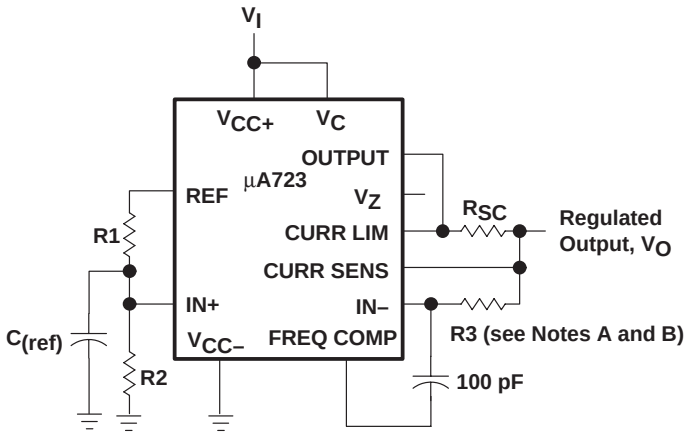
APPLICATION INFORMATION

Table 2. Formulas for Intermediate Output Voltages

OUTPUTS FROM 2 V TO 7 V SEE FIGURES 1, 5, 6, 9, 11, 12 (4) AND NOTE 5	OUTPUTS FROM 4 V TO 250 V SEE FIGURE 7 AND NOTE 5	CURRENT LIMITING
$V_O = V_{(ref)} \times \frac{R2}{R1 + R2}$	$V_O = \frac{V_{(ref)}}{2} \times \frac{R2 - R1}{R1}$ $R3 = R4$	$I_{(limit)} \approx \frac{0.65\ V}{R_{SC}}$
OUTPUTS FROM 7 V TO 37 V SEE FIGURES 2, 4, (5, 6, 9, 11, 12) AND NOTE 5	**OUTPUTS FROM –6 V TO –250 V SEE FIGURES 3, 8, 10 AND NOTES 5 AND 7**	**FOLDBACK CURRENT LIMITING SEE FIGURE 6**
$V_O = V_{(ref)} \times \frac{R1 + R2}{R2}$	$V_O = -\frac{V_{(ref)}}{2} \times \frac{R1 + R2}{R1}$ $R3 = R4$	$I_{(knee)} \approx \frac{V_O R3 + (R3 + R4)\ 0.65\ V}{R_{SC} R4}$ $I_{OS} \approx \frac{0.65\ V}{R_{SC}} \times \frac{R3 + R4}{R4}$

NOTES: 5. The R1/R2 divider can be across either V_O or $V_{(ref)}$. If the divider is across $V_{(ref)}$, use figure numbers without parentheses. If the divider is across V_O, use the figure numbers in parentheses.

7. For Figures 3, 8, and 10, the device requires a minimum of 9 V between V_{CC+} and V_{CC-} when V_O is equal to or more positive than –9 V.

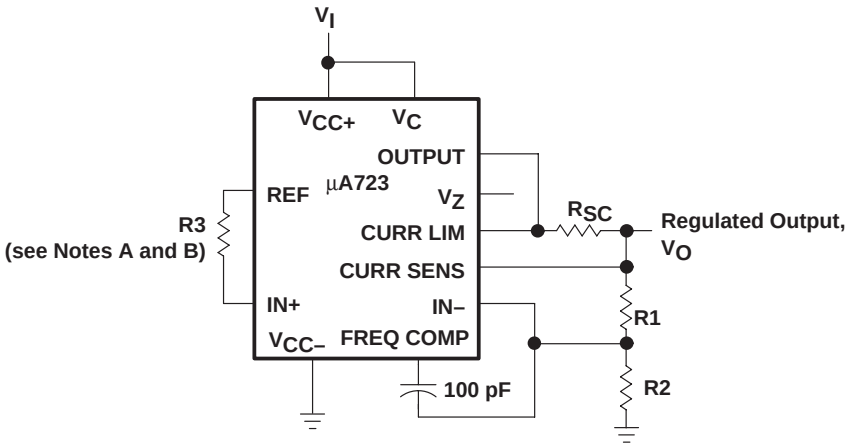


NOTES: A. $R3 = \frac{R1 \times R2}{R1 + R2}$ for a minimum α_{V_O}

B. R3 can be eliminated for minimum component count. Use direct connection (i.e., $R_3 = 0$).

Figure 1. Basic Low-Voltage Regulator (V_O = 2 V to 7 V)

APPLICATION INFORMATION



NOTES: A. $R3 = \frac{R1 \times R2}{R1 + R2}$ for a minimum α_{V_O}

B. R3 can be eliminated for minimum component count. Use direct connection (i.e., $R_3 = 0$).

Figure 2. Basic High-Voltage Regulator (V_O = 7 V to 37 V)

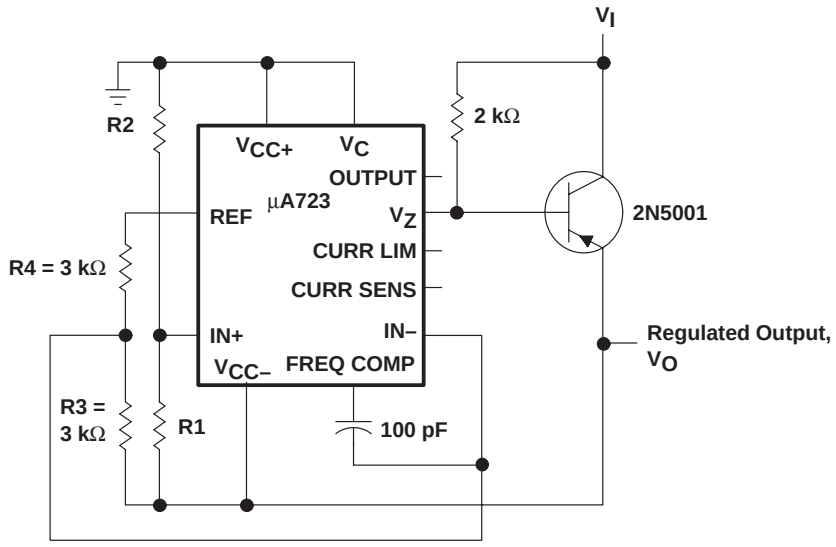


Figure 3. Negative-Voltage Regulator

APPLICATION INFORMATION

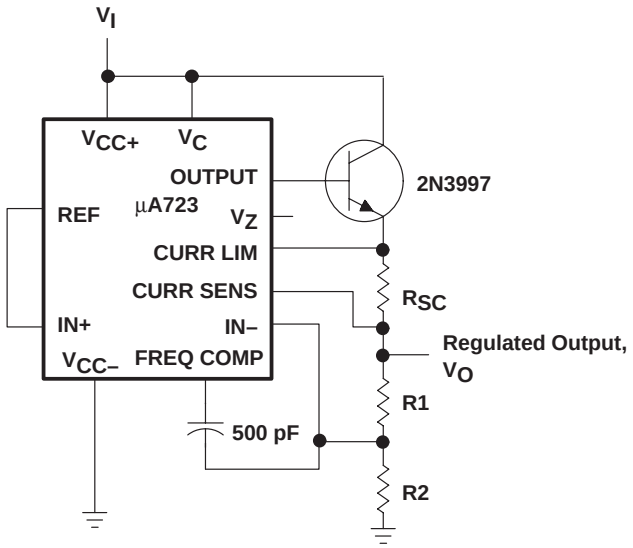


Figure 4. Positive-Voltage Regulator (External npn Pass Transistor)

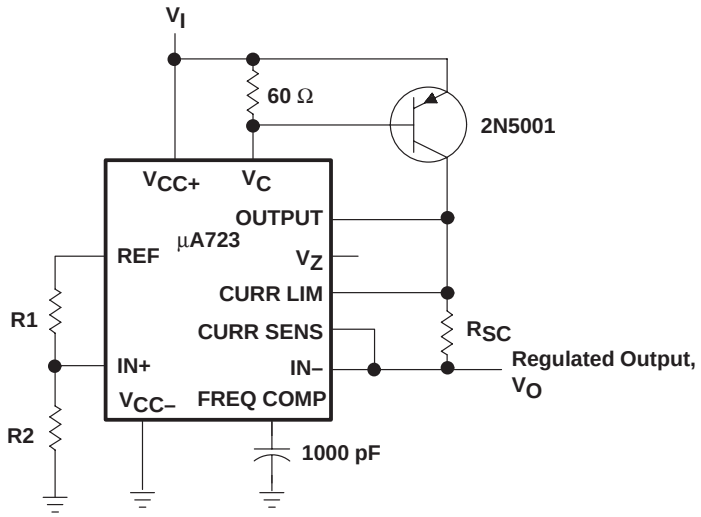


Figure 5. Positive-Voltage Regulator (External pnp Pass Transistor)

APPLICATION INFORMATION

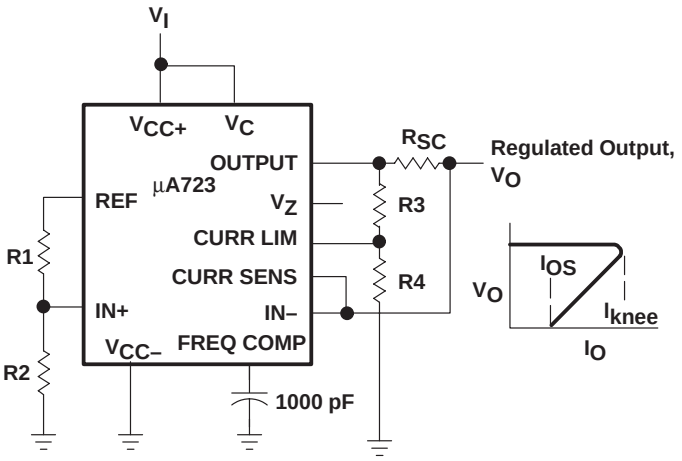


Figure 6. Foldback Current Limiting

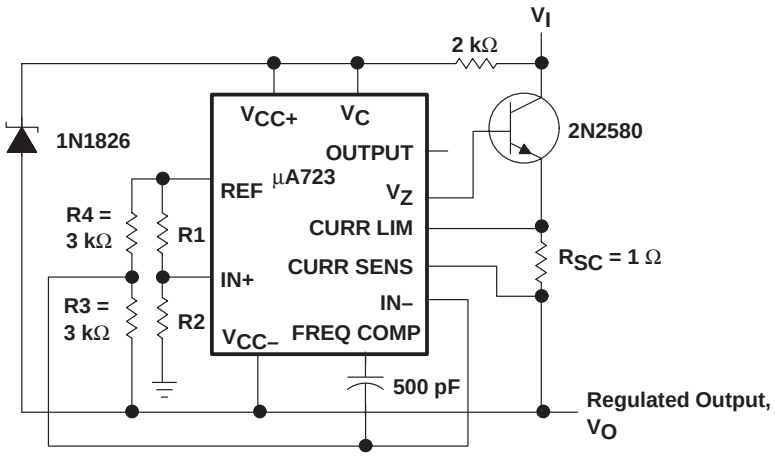


Figure 7. Positive Floating Regulator

APPLICATION INFORMATION

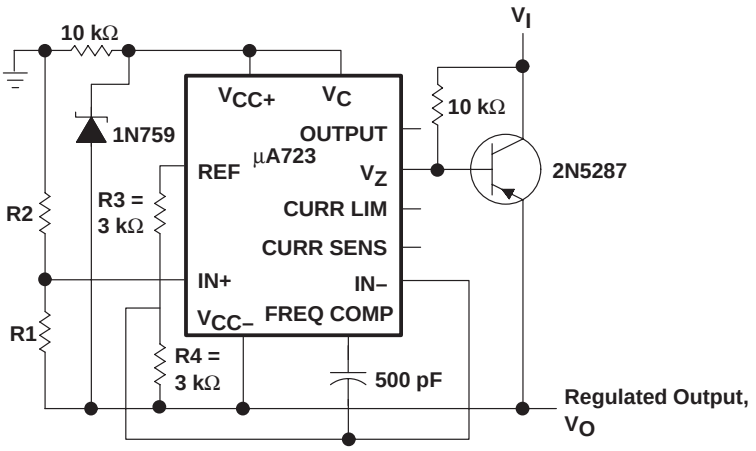
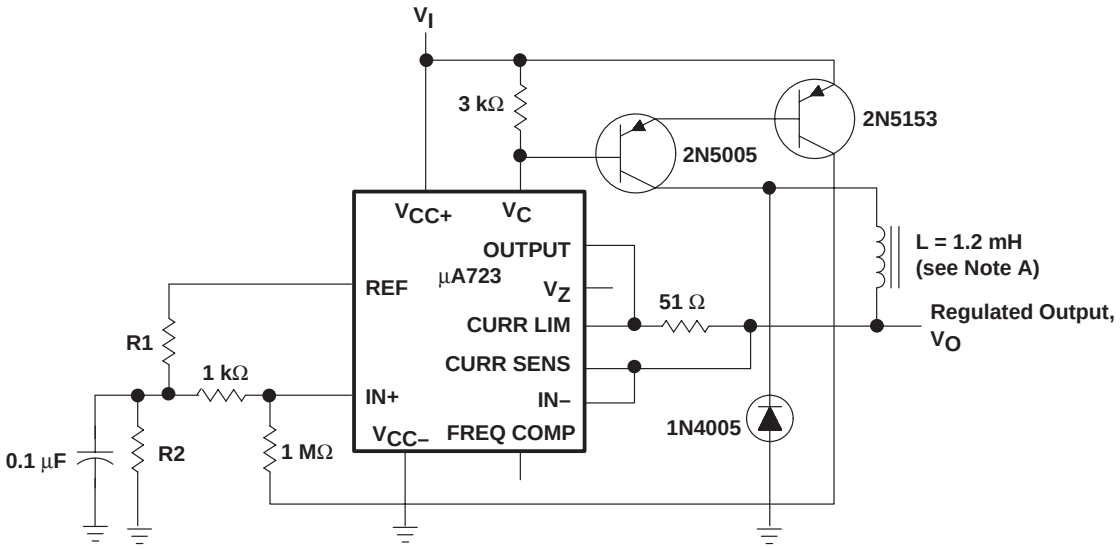


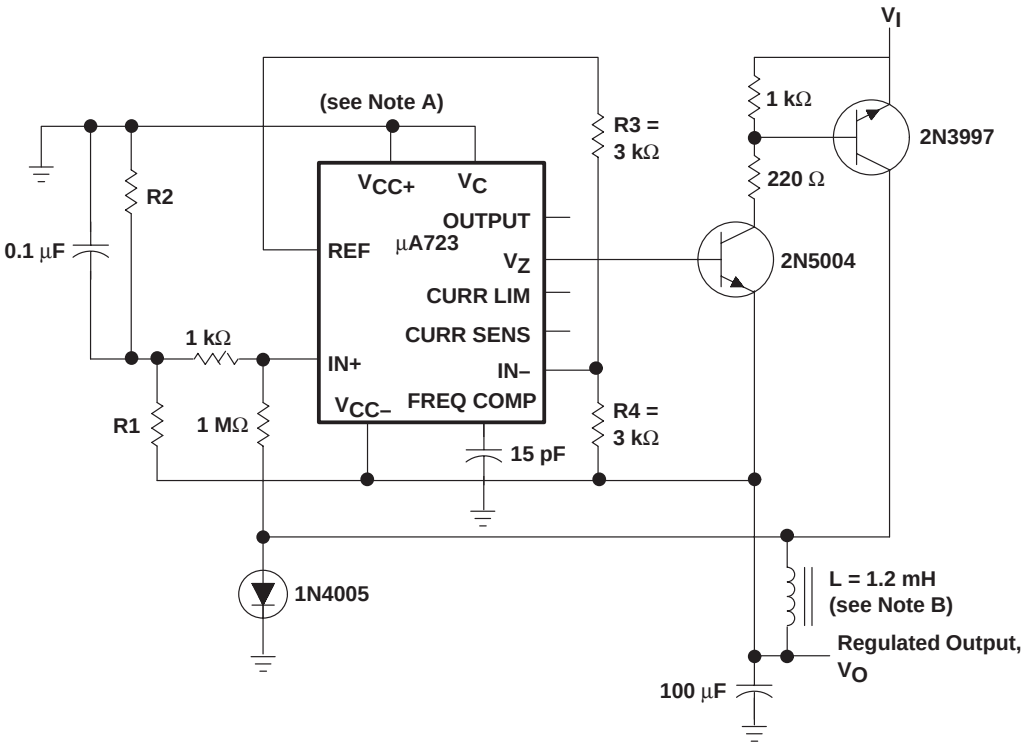
Figure 8. Negative Floating Regulator



NOTE A: L is 40 turns of No. 20 enameled copper wire wound on Ferroxcube P36/22-3B7 potted core, or equivalent, with a 0.009-inch air gap.

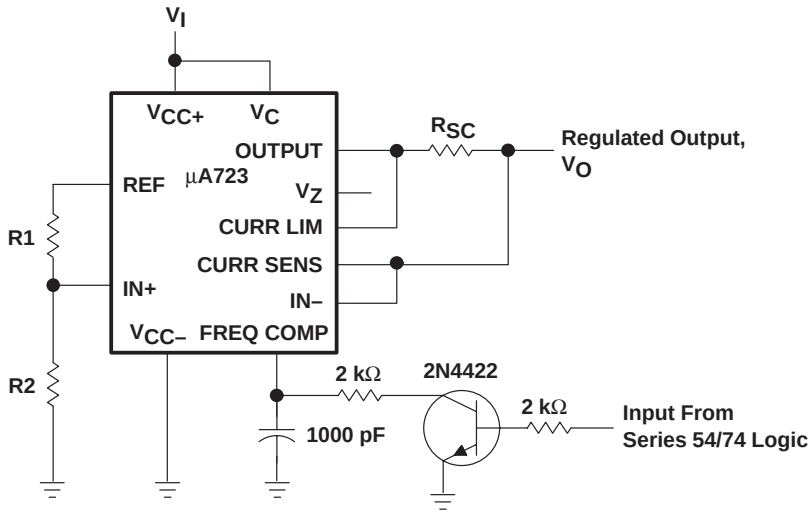
Figure 9. Positive Switching Regulator

APPLICATION INFORMATION



NOTES: A. The device requires a minimum of 9 V between V_{CC+} and V_{CC-} when V_O is equal to or more positive than –9 V.
B. L is 40 turns of No. 20 enameled copper wire wound on Ferroxcube P36/22-3B7 potted core, or equivalent, with a 0.009-inch air gap.

Figure 10. Negative Switching Regulator



NOTE A: A current-limiting transistor can be used for shutdown if current limiting is not required.

Figure 11. Remote Shutdown Regulator With Current Limiting

APPLICATION INFORMATION

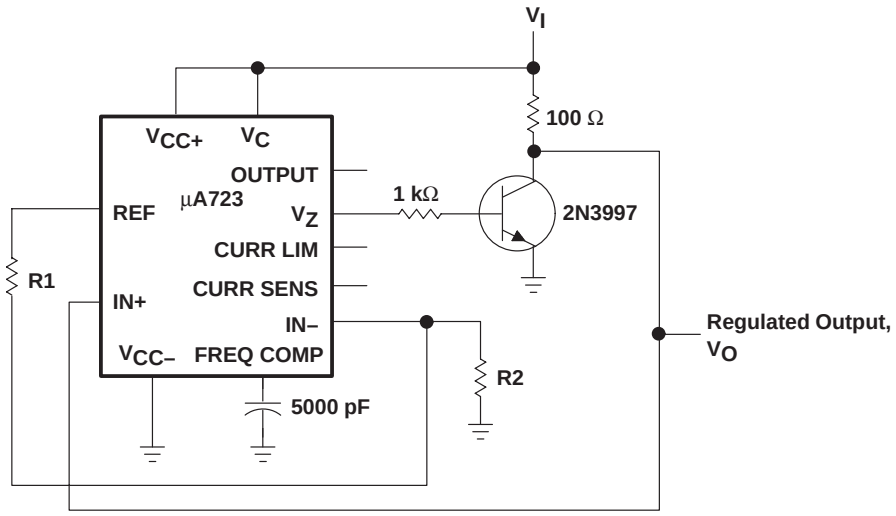


Figure 12. Shunt Regulator

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
UA723CD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	UA723C	Samples
UA723CDE4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	UA723C	Samples
UA723CDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	UA723C	Samples
UA723CDRE4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	UA723C	Samples
UA723CDRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	UA723C	Samples
UA723CN	ACTIVE	PDIP	N	14	25	Green (RoHS & no Sb/Br)	NIPDAU	N / A for Pkg Type	0 to 70	UA723CN	Samples
UA723CNE4	ACTIVE	PDIP	N	14	25	Green (RoHS & no Sb/Br)	NIPDAU	N / A for Pkg Type	0 to 70	UA723CN	Samples
UA723CNSR	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	NIPDAU	Level-1-260C-UNLIM	0 to 70	UA723	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.

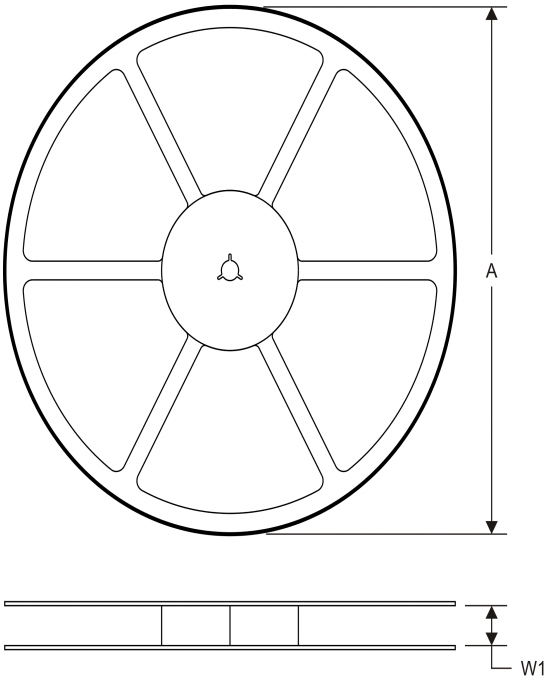
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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.

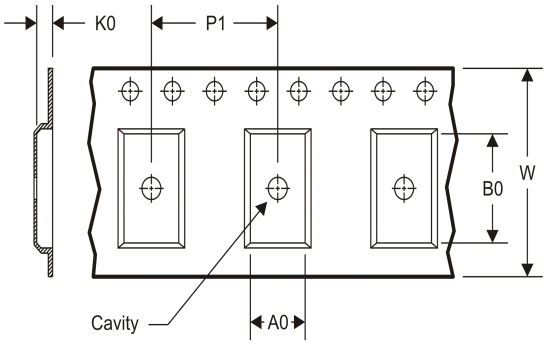
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



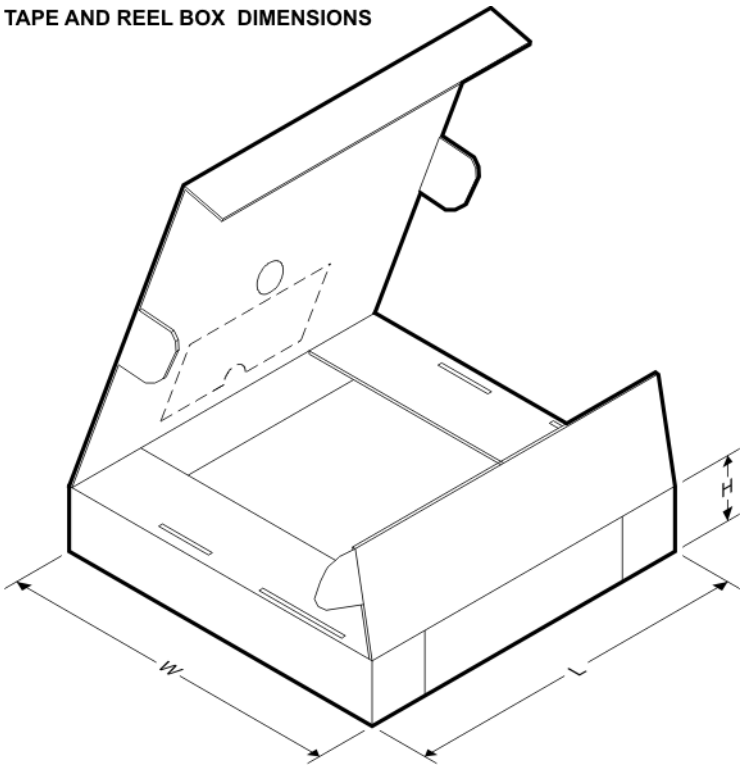
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

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
UA723CDR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
UA723CNSR	SO	NS	14	2000	330.0	16.4	8.2	10.5	2.5	12.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



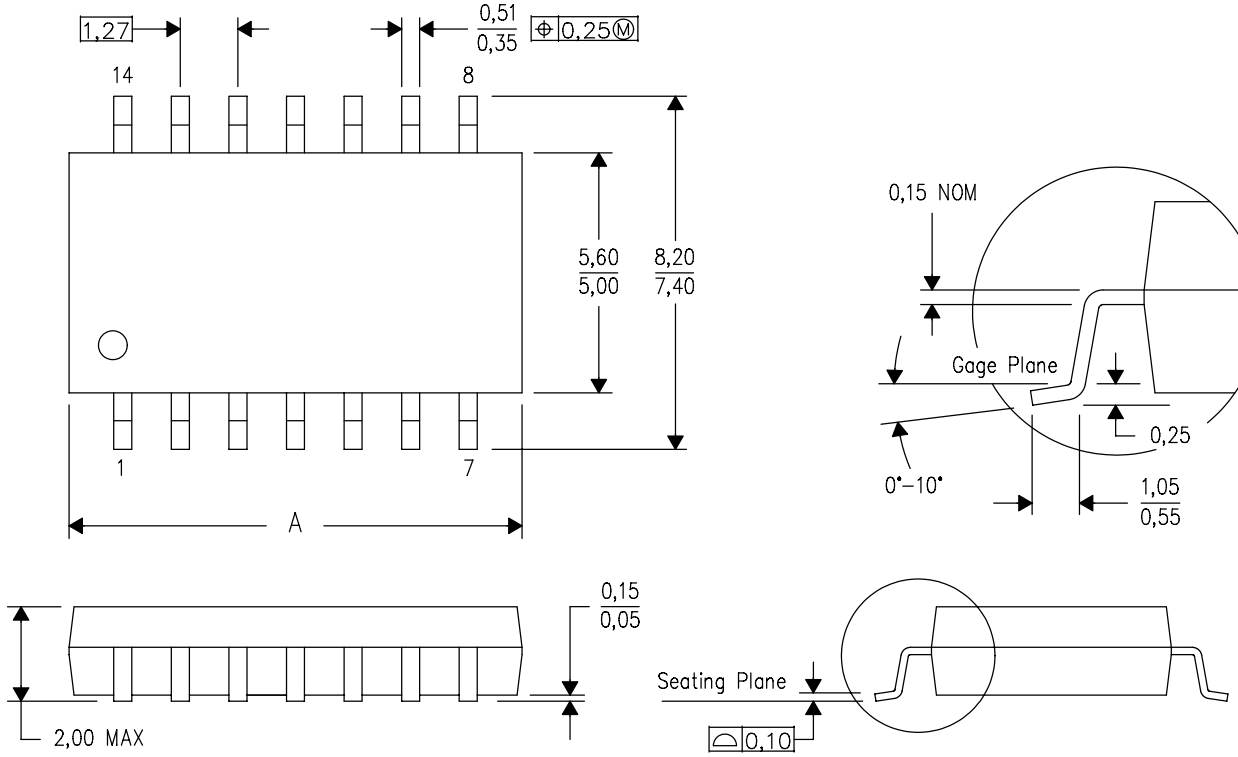
*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
UA723CDR	SOIC	D	14	2500	367.0	367.0	38.0
UA723CNSR	SO	NS	14	2000	367.0	367.0	38.0

MECHANICAL DATA

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

14-PINS SHOWN

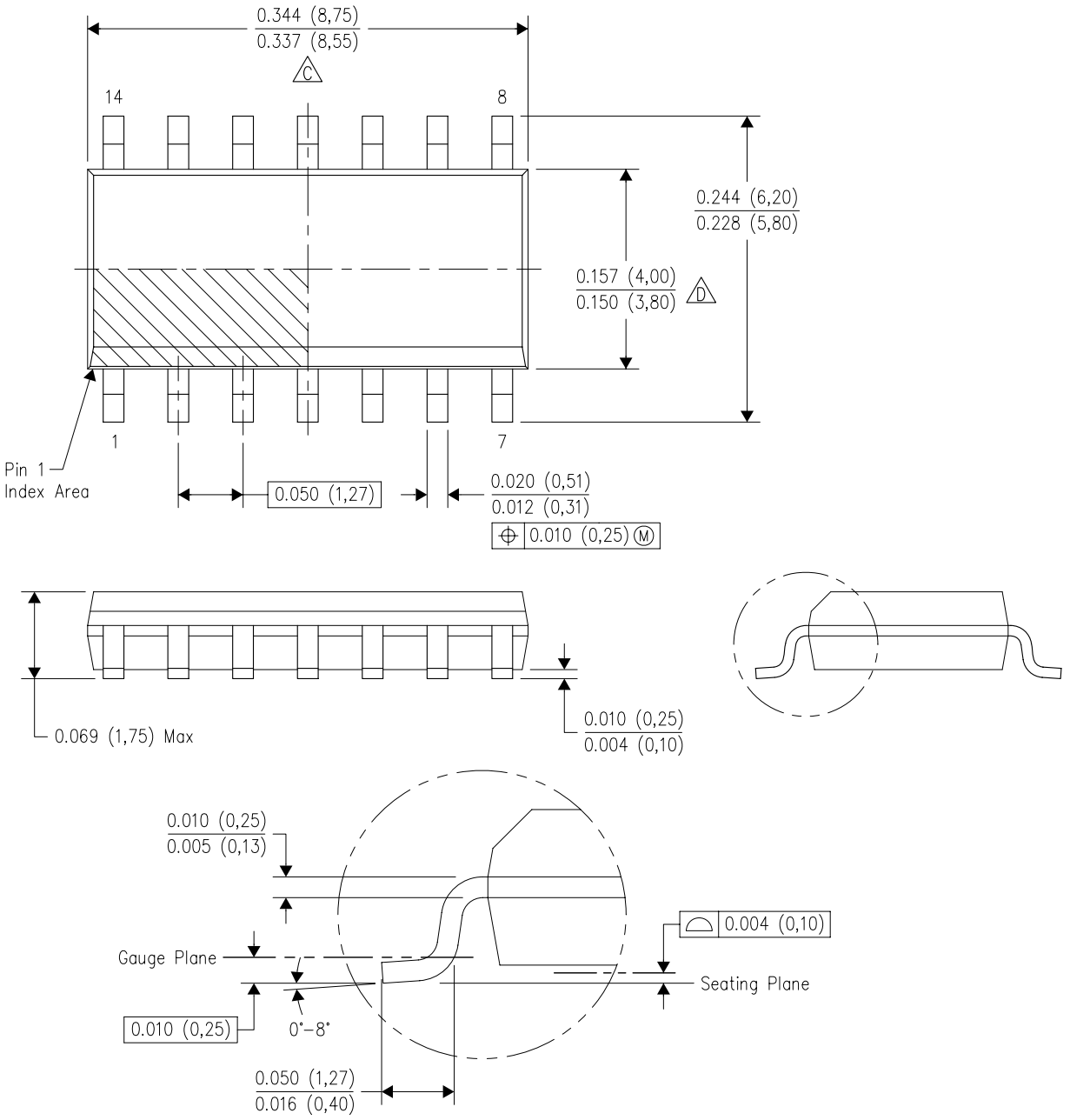


DIM \ PINS **	14	16	20	24
A MAX	10,50	10,50	12,90	15,30
A MIN	9,90	9,90	12,30	14,70

4040062/C 03/03

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

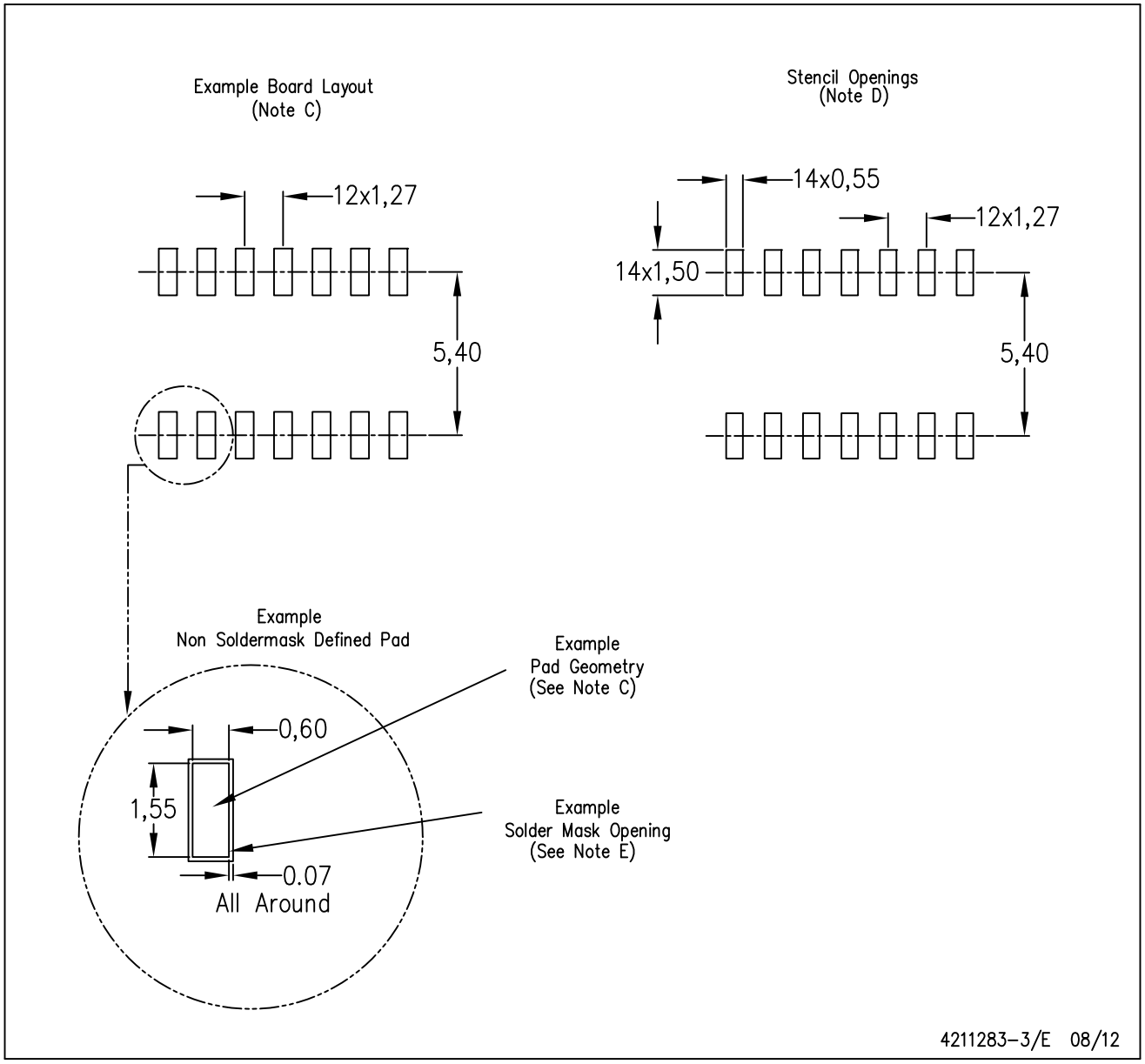
D (R–PDSO–G14) PLASTIC SMALL OUTLINE



4040047–5/M 06/11

NOTES:
A. All linear dimensions are in inches (millimeters).
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 0.006 (0,15) each side.
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 AB.

D (R–PDSO–G14) PLASTIC SMALL OUTLINE

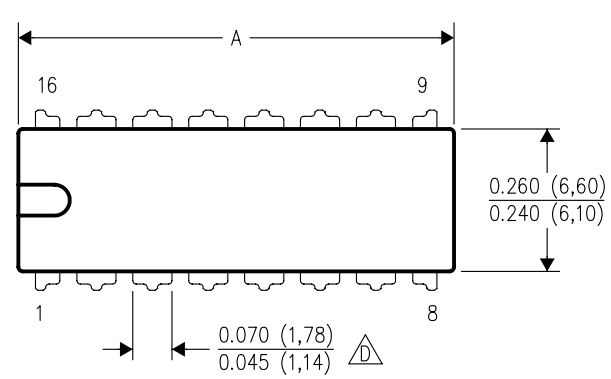


NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact 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.

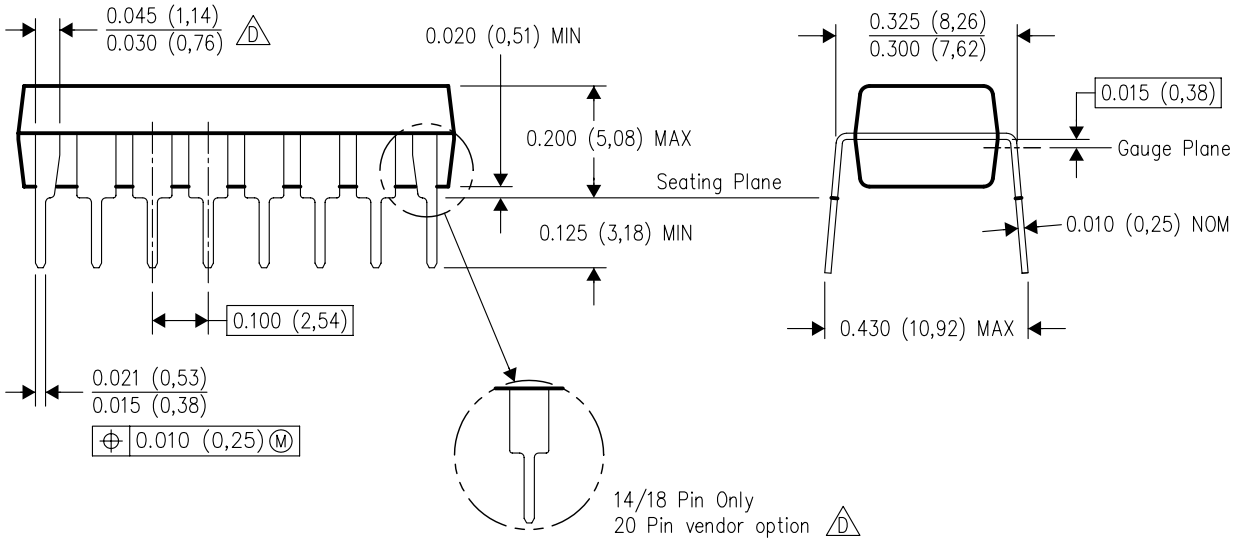
N (R–PDIP–T**)

PLASTIC DUAL–IN–LINE PACKAGE

16 PINS SHOWN



DIM \ PINS **	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS–001 VARIATION (C)	AA	BB	AC	AD



4040049/E 12/2002

NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS–001, except 18 and 20 pin minimum body length (Dim A).
D. The 20 pin end lead shoulder width is a vendor option, either half or full width.

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