LM4041-N LM4041-N-Q1 Precision Micro Power Shunt Voltage Reference

1 Features

Updated the numbering format for tables, figures, and cross-references throughout the document

- Qualified for automotive applications
- AEC-Q100 qualified with the following results:
  - Device temperature Grade 1: –40°C to +125°C ambient temperature range
  - Device temperature Grade 3: –40°C to +85°C ambient temperature range (for SOT-23 only)
- Available in standard, AEC-Q100 Grade 1 (extended temperature range), and Grade 3 (industrial temperature range) qualified versions (SOT-23 only)
- Small packages: SOT-23, TO-92, and SC70
- No output capacitor required
- Tolerates capacitive loads
- Reverse breakdown voltage options of 1.225V and adjustable
- Output voltage tolerance (A grade, 25°C) = ±0.1% (maximum)
- Low output noise (10Hz to 10kHz) = 20μV_{RMS}
- Wide operating current range of 60μA to 12mA
- Industrial temperature range (LM4041A/B-N LM4041-N-Q1A/Q1B) of −40°C to +85°C
- Extended temperature range (LM4041C/D/E-N LM4041-N-Q1C/Q1D/Q1E) of −40°C to +125°C
- Low temperature coefficient of 100ppm/°C (maximum)

2 Applications

- Battery-Powered Equipment
- Data-Acquisition Systems
- Instrumentation and Test Equipment
- Process Control
- Energy Management/Metering
- Automotive Electronics
- Precision Audio

3 Description

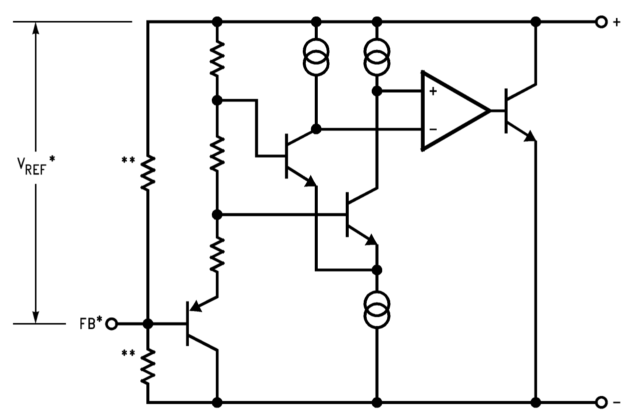
Excellent for space-critical applications, the LM4041-N LM4041-N-Q1 precision voltage reference is available in the sub-miniature SC70 and SOT-23 surface-mount packages. The advanced design of the LM4041-N LM4041-N-Q1 eliminates the need for an external stabilizing capacitor while providing stability with any capacitive load, thus making the LM4041-N LM4041-N-Q1 easy to use. Further reducing design effort is the availability of a fixed (1.225V) and adjustable reverse breakdown voltage. The minimum operating current is 60μA for the LM4041-N LM4041-N-Q1 1.2 and the LM4041-N LM4041-N-Q1 ADJ. Both versions have a maximum operating current of 1mA.

The LM4041-N LM4041-N-Q1 uses fuse and Zener-zap reverse breakdown or reference voltage trim during wafer sort to make sure that the prime parts have an accuracy of better than ±0.1% (A grade) at 25°C. Band gap reference temperature drift curvature correction and low dynamic impedance provide stable reverse breakdown voltage accuracy over a wide range of operating temperatures and currents.

Device Information

PART NUMBER	PACKAGE (1)	BODY SIZE (NOM) (2)
LM4041-N	SC70 (5)	1.25mm × 2.00mm
	SOT-23 (3)	1.30mm × 2.92mm
	TO-92 (3)	4.30mm × 4.30mm
LM4041-N-Q1	SOT-23 (3)	1.30mm × 2.92mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Block Diagram

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4 Pin Configuration and Functions

Pin Functions

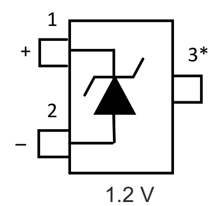


**Figure 4-1. DBZ Package
3-Pin SOT-23
Top View**

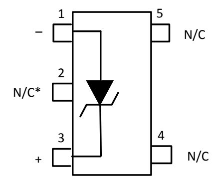


**Figure 4-2. DCK Package
5-Pin SC70
Top View**

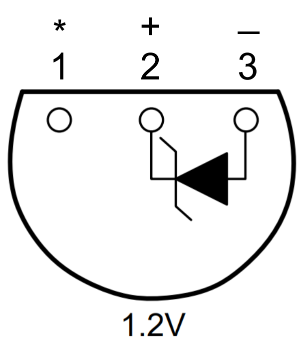


**Figure 4-3. LP Package
3-Pin TO-92
Bottom View**

Pin Functions

PIN				I/O	DESCRIPTION
NAME	SOT-23	SC70	TO-92		
Anode	2	1	3	O	Anode pin, normally grounded
Cathode	1	3	2	I/O	Shunt current and output voltage
FB	—	—	—	I	Feedback pin for adjustable output voltage
NC*	3	2	1	—	**Must float or connect to anode [(1)]
NC	—	4, 5	—	—	No connect

(1) **In applications with high electromagnetic interference (for example, when placed near transformers or other electromagnetic sources) or significant high-frequency switching noise, TI recommends to connect this pin to the anode.**

Pin Functions: ADJ Pinouts

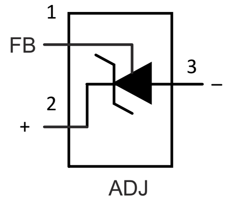


**Figure 4-4. DBZ Package
3-Pin SOT-23
Top View**

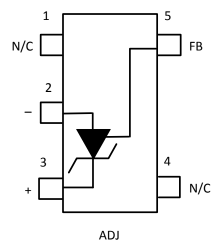


**Figure 4-5. DCK Package
5-Pin SC70
Top View**

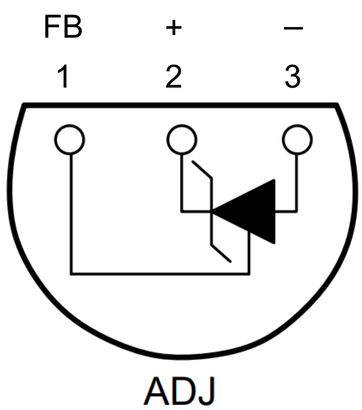


**Figure 4-6. LP Package
3-Pin TO-92
Bottom View**

PIN				I/O	DESCRIPTION
NAME	SOT-23	SC70	TO-92		
Anode	3	2	3	O	Anode pin, normally grounded
Cathode	2	3	2	I/O	Shunt current and output voltage
FB	1	5	1	I	Feedback pin for adjustable output voltage
NC**	—	—	—	—	**Must float or connect to anode
NC	—	1, 4	—	—	No connect

5 Specifications

5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)[(1)] [(2)]

<table>
<tr><th colspan="3"></th><th>MIN</th><th>MAX</th><th>UNIT</th></tr>
<tr><td colspan="3">Reverse current</td><td></td><td>20</td><td>mA</td></tr>
<tr><td colspan="3">Forward current</td><td></td><td>10</td><td>mA</td></tr>
<tr><td colspan="3">Maximum output voltage (LM4041-N LM4041-N-Q1 ADJ)</td><td></td><td>15</td><td>V</td></tr>
<tr><td colspan="2" rowspan="3">Power dissipation (T_A = 25°C)[(3)]</td><td>DBZ package</td><td></td><td>306</td><td rowspan="3">mW</td></tr>
<tr><td>LP package</td><td></td><td>550</td></tr>
<tr><td>DCK package</td><td></td><td>241</td></tr>
<tr><td rowspan="3">Lead temperature</td><td rowspan="2">DBZ packages</td><td>Vapor phase (60 seconds)</td><td></td><td>215</td><td>°C</td></tr>
<tr><td>Infrared (15 seconds)</td><td></td><td>220</td><td>°C</td></tr>
<tr><td>LP package</td><td>Soldering (10 seconds)</td><td></td><td>260</td><td>°C</td></tr>
<tr><td colspan="3">Storage temperature, T_{stg}</td><td>–65</td><td>150</td><td>°C</td></tr>
</table>

(1) Stresses beyond those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods can affect device reliability.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/ Distributors for availability and specifications.
(3) The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), θ_{JA} (junction to ambient thermal resistance), and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is $PD_{max} = (T_{Jmax} - T_A)/R_{\theta JA}$ or the number given in the *Absolute Maximum Ratings*, whichever is lower. For the LM4041-N, T_{Jmax} = 125°C, and the typical thermal resistance ($R_{\theta JA}$), when board mounted, is 326°C/W for the SOT-23 package, 415°C/W for the SC70 package and 180°C/W with 0.4-in lead length and 170°C/W with 0.125-in lead length for the TO-92 package.

5.2 ESD Ratings

<table>
<tr><th colspan="3"></th><th>VALUE</th><th>UNIT</th></tr>
<tr><td rowspan="2">$V_{(ESD)}$</td><td rowspan="2">Electrostatic discharge</td><td>Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[(1)] [(2)]</td><td>±2000</td><td rowspan="2">V</td></tr>
<tr><td>Charged-device model (CDM), per JEDEC specification JESD22-C101[(3)]</td><td>±500</td></tr>
</table>

(1) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process.
(2) The human-body model is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin. All pins are rated at 2kV for human-body model, but the feedback pin which is rated at 1kV.
(3) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process. Manufacturing with less than 250V CDM is possible with the necessary precautions.

5.3 Recommended Operating Conditions

See [(1)]

<table>
<tr><th colspan="2"></th><th>MIN</th><th>NOM</th><th>MAX</th><th>UNIT</th></tr>
<tr><td colspan="2">Temperature</td><td>T_{min}</td><td>T_A</td><td>T_{max}</td><td>°C</td></tr>
<tr><td colspan="2">Industrial temperature</td><td>–40</td><td>T_A</td><td>85</td><td>°C</td></tr>
<tr><td colspan="2">Extended temperature</td><td>–40</td><td>T_A</td><td>125</td><td>°C</td></tr>
<tr><td rowspan="2">Reverse current</td><td>LM4041-N LM4041-N-Q1 1.2</td><td>60</td><td></td><td>12000</td><td>µA</td></tr>
<tr><td>LM4041-N LM4041-N-Q1 ADJ</td><td>60</td><td></td><td>12000</td><td>µA</td></tr>
<tr><td>Output voltage</td><td>LM4041-N LM4041-N-Q1 ADJ</td><td>1.24</td><td></td><td>10</td><td>V</td></tr>
</table>

(1) *Absolute Maximum Ratings* indicate limits beyond which damage to the device can occur. *Recommended Operating Conditions* indicate conditions for which the device is functional, but do not ensure specific performance limits. For specifications and test conditions, see the *Electrical Characteristics*. The specifications apply only for the test conditions listed. Some performance characteristics can degrade when the device is not operated under the listed test conditions.

5.4 Thermal Information

THERMAL METRIC[(1)]		LM4041-N SC70 5 PINS	LM4041-N TO-92 3 PINS	LM4041-N SOT-23 3 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	265.3	161.5	291.9	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	93.1	84.5	114.3	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	46.7	—	62.3	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	2.2	28.4	7.4	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	45.9	140.6	61	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	—	—	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* (SPRA953) application report.

5.5 LM4041-N LM4041-N-Q1 1.2 Electrical Characteristics (Industrial Temperature Range)

All limits $T_A = T_J$ = 25°C for the LM4041AIM3, LM4041BIM3, LM4041AIZ, LM4041BIZ and LM4041BIM7 LM4041QAIM3 and LM4041QBIM3 devices, unless otherwise specified. The grades A and B designate initial reverse breakdown voltage tolerances of ±0.1% and ±0.2%, respectively.

PARAMETER		TEST CONDITIONS		MIN[(1)]	TYP[(2)]	MAX[(1)]	UNIT
V_R	Reverse breakdown voltage	I_R = 100μA			1.225		V
V_R	Reverse breakdown voltage tolerance[(3)]	I_R = 100μA	LM4041AIM3 LM4041QAIM3 LM4041AIM3, LM4041AIZ			±1.2	mV
			LM4041BIM3 LM4041QBIM3 LM4041BIZ, LM4041BIM7			±2.4	mV
		$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041AIM3 LM4041QAIM3 LM4041AIM3, LM4041AIZ			±9.2	mV
			LM4041BIM3 LM4041QBIM3 LM4041BIZ, LM4041BIM7			±10.4	mV
I_{RMIN}	Minimum operating current	$T_A = T_J$ = 25°C			45	60	μA
		$T_A = T_J = T_{MIN}$ to T_{MAX}				65	μA
$\Delta V_R/\Delta T$	Average reverse breakdown voltage temperature Coefficient[(3)]	I_R= 10mA			±20		ppm/°C
		I_R = 1mA	$T_A = T_J$ = 25°C		±15		ppm/°C
			$T_A = T_J = T_{MIN}$ to T_{MAX}			±100	ppm/°C
		I_R = 100μA			±15		ppm/°C
$\Delta V_R/\Delta I_R$	Reverse breakdown voltage change with operating current change[(4)]	$I_{RMIN} \le I_R \le$ 1mA	$T_A = T_J$ = 25°C		0.7	1.5	mV
			$T_A = T_J = T_{MIN}$ to T_{MAX}			2	mV
		1mA $\le I_R \le$ 12mA	$T_A = T_J$ = 25°C		4	6	mV
			$T_A = T_J = T_{MIN}$ to T_{MAX}			8	mV
Z_R	Reverse dynamic impedance	I_R = 1mA, f = 120Hz, I_{AC}= 0.1 I_R			0.5	1.5	Ω
e_N	Wide band noise	I_R = 100μA 10Hz ≤ f ≤ 10kHz			20		μV_{RMS}
ΔV_R	Reverse breakdown voltage long-term stability	t = 1000 hrs T = 25°C ±0.1°C I_R = 100μA			120		ppm
V_{HYST}	Thermal hysteresis[(5)]	ΔT = −40°C to +125°C			0.08%		

(1) Limits are 100% production tested at 25°C. Limits over temperature are made sure through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.

(2) Typical values are at T_J = 25°C and represent most likely parametric norm.

(3) The over temperature limit for Reverse Breakdown Voltage Tolerance is defined as the room temperature Reverse Breakdown Voltage Tolerance ±[($\Delta V_R/\Delta T$)(max ΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ is the V_R temperature coefficient, max ΔT is the maximum difference in temperature from the reference point of 25 °C to T_{MAX} or T_{MIN}, and V_R is the reverse breakdown voltage. The total over-temperature tolerance for the different grades in the industrial temperature range where max ΔT = 65°C is shown below:
A-grade: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
E-grade: ±2.98% = ±2.0% ±150ppm/°C × 65°C
The total over-temperature tolerance for the different grades in the extended temperature range where max ΔT = 100°C is shown below:
B-grade: ±1.2% = ±0.2% ±100ppm/°C × 100°C
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
E-grade: ±4.5% = ±2.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade LM4041-N LM4041-N-Q1 1.2 has an over-temperature Reverse Breakdown Voltage tolerance of ±1.2 V × 0.75% = ±9.2mV.

(4) Load regulation is measured on pulse basis from no load to the specified load current. Output changes due to die temperature change must be taken into account separately.

(5) Thermal hysteresis is defined as the difference in voltage measured at +25°C after cycling to temperature –40°C and the +25°C measurement after cycling to temperature +125°C.

5.6 LM4041-N LM4041-N-Q1 1.2 Electrical Characteristics (Industrial Temperature Range)

All limits $T_A = T_J = 25°C$. unless otherwise specified. The grades C, D, and E designate initial reverse breakdown voltage tolerances of ±0.5%, ±1.0%, and ±2.0%, respectively.

PARAMETER		TEST CONDITIONS			MIN[(1)]	TYP[(2)]	MAX[(1)]	UNIT
V_R	Reverse Breakdown Voltage	I_R = 100µA				1.225		V
V_R	Reverse breakdown voltage tolerance[(3)]	I_R = 100µA	$T_A = T_J$ = 25°C	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7			±6	mV
				LM4041DIM3 LM4041QDIM3 LM4041DIZ, LM4041DIM7			±12	mV
				LM4041EIM3 LM4041QEIM3 LM4041EIZ, LM4041EIM7			±25	mV
			$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7			±14	mV
				LM4041DIM3 LM4041QDIM3 LM4041DIZ, LM4041DIM7			±24	mV
				LM4041EIM3 LM4041QEIM3 LM4041EIZ, LM4041EIM7			±36	mV
I_{RMIN}	Minimum operating current	$T_A = T_J$ = 25°C		LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7		45	60	µA
				LM4041DIM3, LM4041QDIM3, LM4041DIZ, LM4041DIM7 LM4041EIM3, LM4041QEIM3 LM4041EIZ, LM4041EIM7			65	µA
		$T_A = T_J = T_{MIN}$ to T_{MAX}		LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7			65	µA
				LM4041DIM3, LM4041QDIM3, LM4041DIZ, LM4041DIM7 LM4041EIM3, LM4041QEIM3 LM4041EIZ, LM4041EIM7			70	µA
$\Delta V_R/\Delta T$	V_R Temperature coefficient[(3)]	I_R = 10mA				±20		ppm/°C
		I_R = 1mA	$T_A = T_J$ = 25°C			±15		ppm/°C
			$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7			±100	ppm/°C
				LM4041DIM3, LM4041QDIM3, LM4041DIZ, LM4041DIM7 LM4041EIM3, LM4041QEIM3 LM4041EIZ, LM4041EIM7			±150	ppm/°C
		I_R= 100µA				±15		ppm/°C
$\Delta V_R/\Delta I_R$	Reverse breakdown voltage change with operating current change[(4)]	$I_{RMIN} \le I_R \le$ 1mA	$T_A = T_J$ = 25°C	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7		0.7	1.5	mV
				LM4041DIM3, LM4041QDIM3, LM4041DIZ, LM4041DIM7 LM4041EIM3, LM4041QEIM3 LM4041EIZ, LM4041EIM7			2	mV
			$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7			2	mV
				LM4041DIM3, LM4041QDIM3, LM4041DIZ, LM4041DIM7 LM4041EIM3, LM4041QEIM3 LM4041EIZ, LM4041EIM7			2.5	mV
		1mA $\le I_R \le$ 12mA	$T_A = T_J$ = 25°C	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7		2.5	6	mV
				LM4041DIM3, LM4041QDIM3, LM4041DIZ, LM4041DIM7 LM4041EIM3, LM4041QEIM3 LM4041EIZ, LM4041EIM7			8	mV
			$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7			8	mV
				LM4041DIM3, LM4041QDIM3, LM4041DIZ, LM4041DIM7 LM4041EIM3, LM4041QEIM3 LM4041EIZ, LM4041EIM7			10	mV
Z_R	Reverse dynamic impedance	I_R = 1mA, f = 120Hz I_{AC} = 0.1 I_R		LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7		0.5	1.5	Ω
				LM4041DIM3, LM4041QDIM3, LM4041DIZ, LM4041DIM7 LM4041EIM3, LM4041QEIM3 LM4041EIZ, LM4041EIM7			2	Ω

5.6 LM4041-N LM4041-N-Q1 1.2 Electrical Characteristics (Industrial Temperature Range) (continued)

All limits $T_A = T_J$ = 25°C. unless otherwise specified. The grades C, D, and E designate initial reverse breakdown voltage tolerances of ±0.5%, ±1.0%, and ±2.0%, respectively.

PARAMETER		TEST CONDITIONS	MIN(1)	TYP(2)	MAX(1)	UNIT
e_N	Wide band noise	I_R = 100µA 10Hz ≤ f ≤ 10kHz		20		μV_{RMS}
ΔV_R	Reverse breakdown voltage long-term stability	t = 1000 hrs T = 25°C ±0.1°C I_R = 100µA		120		ppm
V_{HYST}	Thermal hysteresis(5)	ΔT = −40°C to +125°C		0.08%		

(1) Limits are 100% production tested at 25°C. Limits over temperature are specified through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
(2) Typical values are at T_J = 25°C and represent most likely parametric norm.
(3) The over temperature limit for reverse breakdown voltage tolerance is defined as the room temperature reverse breakdown voltage tolerance $\pm[(\Delta V_R/\Delta T)(\max \Delta T)(V_R)]$. Where, $\Delta V_R/\Delta T$ is the V_R temperature coefficient, max ΔT is the maximum difference in temperature from the reference point of 25 °C to T_{MAX} or T_{MIN}, and V_R is the reverse breakdown voltage. The total over-temperature tolerance for the different grades in the industrial temperature range where max ΔT = 65°C is shown below:
A-grade: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
E-grade: ±2.98% = ±2.0% ±150ppm/°C × 65°C
The total over-temperature tolerance for the different grades in the extended temperature range where max ΔT = 100 °C is shown below:
B-grade: ±1.2% = ±0.2% ±100ppm/°C × 100°C
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
E-grade: ±4.5% = ±2.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade LM4041-N LM4041-N-Q1 1.2 has an over-temperature reverse breakdown voltage tolerance of ±1.2 V × 0.75% = ±9.2mV.
(4) Load regulation is measured on pulse basis from no load to the specified load current. Output changes due to die temperature change must be taken into account separately.
(5) Thermal hysteresis is defined as the difference in voltage measured at +25°C after cycling to temperature –40°C and the +25°C measurement after cycling to temperature +125°C.

5.7 LM4041-N LM4041-N-Q1 1.2 Electrical Characteristics (Extended Temperature Range)

All limits $T_A = T_J = 25°C$, unless otherwise specified. The grades C, D, and E designate initial reverse breakdown voltage tolerance of ±0.5%, ±1.0%, and ±2.0% respectively.

PARAMETER		TEST CONDITIONS			MIN[1]	TYP[2]	MAX[1]	UNIT
V_R	Reverse breakdown voltage	I_R = 100µA				1.225		V
	Reverse breakdown voltage error[3]	I_R = 100µA	$T_A = T_J = 25°C$	LM4041CEM3 LM4041QCEM3			±6	mV
				LM4041DEM3 LM4041QDEM3			±12	
				LM4041EEM3 LM4041QEEM3			±25	
			$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CEM3 LM4041QCEM3			±18.4	
				LM4041DEM3 LM4041QDEM3			±31	
				LM4041EEM3 LM4041QEEM3			±43	
I_{RMIN}	Minimum operating current	$T_A = T_J = 25°C$		LM4041CEM3 LM4041QCEM3		45	60	µA
				LM4041DEM3, LM4041QDEM3, LM4041EEM3, LM4041QEEM3			65	
		$T_A = T_J = T_{MIN}$ to T_{MAX}		LM4041CEM3 LM4041QCEM3			68	
				LM4041DEM3, LM4041QDEM3, LM4041EEM3, LM4041QEEM3			73	
$\Delta V_R/\Delta T$	VR temperature coefficient[3]	I_R = 10mA				±20		ppm/°C
		I_R = 1mA	$T_A = T_J = 25°C$			±15		
			$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CEM3 LM4041QCEM3			±100	
				LM4041DEM3, LM4041QDEM3, LM4041EEM3, LM4041QEEM3			±150	
		I_R = 100µA				±15		
$\Delta V_R/\Delta I_R$	Reverse breakdown change with current[4]	$I_{RMIN} \le I_R \le 1.0mA$	$T_A = T_J = 25°C$	LM4041DEM3 LM4041QDEM3		0.7	1.5	mV
				LM4041EEM3 LM4041QEEM3			2	
			LM4041EEM3 LM4041QEEM3	LM4041CEM3 LM4041QCEM3			2	
				LM4041DEM3, LM4041QDEM3, LM4041EEM3, LM4041QEEM3			2.5	
		$1mA \le I_R \le 12mA$	LM4041EEM3 LM4041QEEM3	LM4041CEM3 LM4041QCEM3		2.5	6	mV
				LM4041DEM3, LM4041QDEM3, LM4041EEM3, LM4041QEEM3			8	
			LM4041EEM3 LM4041QEEM3	LM4041CEM3 LM4041QCEM3			8	
				LM4041DEM3, LM4041QDEM3, LM4041EEM3, LM4041QEEM3			10	

5.7 LM4041-N LM4041-N-Q1 1.2 Electrical Characteristics (Extended Temperature Range) (continued)

All limits $T_A = T_J$ = 25°C, unless otherwise specified. The grades C, D, and E designate initial reverse breakdown voltage tolerance of ±0.5%, ±1.0%, and ±2.0% respectively.

PARAMETER		TEST CONDITIONS			MIN(1)	TYP(2)	MAX(1)	UNIT
Z_R	Reverse dynamic impedance	I_R = 1mA, f = 120Hz, I_{AC}= 0.1 I_R	$T_A = T_J$ = 25°C			0.5		Ω
			$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CEM3 LM4041QCEM3			1.5	
				LM4041DEM3, LM4041QDEM3, LM4041EEM3, LM4041QEEM3			2	
e_N	Noise voltage	I_R = 100µA 10Hz ≤ f ≤ 10kHz				20		μV_{rms}
ΔV_R	Long-term stability (non-cumulative)	t = 1000 hrs T = 25°C ±0.1°C I_R = 100µA				120		ppm
V_{HYST}	Thermal hysteresis(5)	ΔT = −40°C to +125°C				0.08%		

(1) Limits are 100% production tested at 25°C. Limits over temperature are made sure through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
(2) Typical values are at T_J = 25°C and represent most likely parametric norm.
(3) The over temperature limit for reverse breakdown voltage tolerance is defined as the room temperature reverse breakdown voltage tolerance ±[($\Delta V_R / \Delta T$)(max ΔT)(V_R)]. Where, $\Delta V_R/\Delta T$ is the V_R temperature coefficient, max ΔT is the maximum difference in temperature from the reference point of 25 °C to T_{MAX} or T_{MIN}, and V_R is the reverse breakdown voltage. The total over-temperature tolerance for the different grades in the industrial temperature range where max ΔT = 65°C is shown below:
A-grade: ±0.75% = ±0.1% ±100ppm/°C × 65°C
B-grade: ±0.85% = ±0.2% ±100ppm/°C × 65°C
C-grade: ±1.15% = ±0.5% ±100ppm/°C × 65°C
D-grade: ±1.98% = ±1.0% ±150ppm/°C × 65°C
E-grade: ±2.98% = ±2.0% ±150ppm/°C × 65°C
The total over-temperature tolerance for the different grades in the extended temperature range where max ΔT = 100°C is shown below:
B-grade: ±1.2% = ±0.2% ±100ppm/°C × 100°C
C-grade: ±1.5% = ±0.5% ±100ppm/°C × 100°C
D-grade: ±2.5% = ±1.0% ±150ppm/°C × 100°C
E-grade: ±4.5% = ±2.0% ±150ppm/°C × 100°C
Therefore, as an example, the A-grade LM4041-N LM4041-N-Q1 1.2 has an over-temperature reverse breakdown voltage tolerance of ±1.2 V × 0.75% = ±9.2mV.
(4) Load regulation is measured on pulse basis from no load to the specified load current. Output changes due to die temperature change must be taken into account separately.
(5) Thermal hysteresis is defined as the difference in voltage measured at +25°C after cycling to temperature –40°C and the +25°C measurement after cycling to temperature +125°C.

5.8 LM4041-N LM4041-N-Q1 ADJ (Adjustable) Electrical Characteristics (Industrial Temperature Range)

All limits T_J = 25°C, unless otherwise specified (SOT-23, see[1]),
$I_{RMIN} \le I_R \le 12mA$, $V_{REF} \le V_{OUT} \le 10V$. The grades C and D designate initial Reference Voltage Tolerances of ±0.5% and ±1%, respectively for V_{OUT} = 5V.

PARAMETER		TEST CONDITIONS			MIN[2]	TYP[3]	MAX[2]	UNIT
V_{REF}	Reference voltage	I_R = 100µA, V_{OUT} = 5V				1.233		V
	Reference voltage tolerance[4]	I_R = 100µA, V_{OUT} = 5V	T_J = 25°C	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7			±6.2	mV
				LM4041DIM3 LM4041QDIM3 LM4041DIZ, LM4041DIM7			±12	
			$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7			±14	
				LM4041DIM3 LM4041QDIM3 LM4041DIZ, LM4041DIM7			±24	
I_{RMIN}	Minimum operating current	T_J = 25°C		LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7		45	60	µA
				LM4041DIM3 LM4041QDIM3 LM4041DIZ, LM4041DIM7			65	
		$T_A = T_J = T_{MIN}$ to T_{MAX}		LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7			65	
				LM4041DIM3 LM4041QDIM3 LM4041DIZ, LM4041DIM7			70	
$\Delta V_{REF}/\Delta I_R$	Reference voltage change with operating current change[5]	$I_{RMIN} \le I_R \le 1mA$ SOT-23: $V_{OUT} \ge 1.6V$[1]	T_J = 25°C	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7		0.7	1.5	mV
				LM4041DIM3 LM4041QDIM3 LM4041DIZ, LM4041DIM7			2	
			$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7			2	
				LM4041DIM3 LM4041QDIM3 LM4041DIZ, LM4041DIM7			2.5	
		$1mA \le I_R \le 12mA$ SOT-23: $V_{OUT} \ge 1.6V$[1]	T_J = 25°C	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7		2	4	mV
				LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7			6	
			$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7			6	
				LM4041DIM3 LM4041QDIM3 LM4041DIZ, LM4041DIM7			8	
$\Delta V_{REF}/\Delta V_O$	Reference voltage change with output voltage change	I_R = 1mA	T_J = 25°C	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7		–1.55	–2	mV/V
				LM4041DIM3 LM4041QDIM3 LM4041DIZ, LM4041DIM7			–2.5	
			$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7			–2.5	
				LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7			–3	
I_{FB}	Feedback current	T_J = 25°C		LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7		60	100	nA
				LM4041DIM3 LM4041QDIM3 LM4041DIZ, LM4041DIM7			150	
		$T_A = T_J = T_{MIN}$ to T_{MAX}					120	

5.8 LM4041-N LM4041-N-Q1 ADJ (Adjustable) Electrical Characteristics (Industrial Temperature Range) (continued)

All limits T_J = 25°C, unless otherwise specified (SOT-23, see[1]), $I_{RMIN} \le I_R \le$ 12mA, $V_{REF} \le V_{OUT} \le$ 10V. The grades C and D designate initial Reference Voltage Tolerances of ±0.5% and ±1%, respectively for V_{OUT} = 5V.

PARAMETER		TEST CONDITIONS				MIN[2]	TYP[3]	MAX[2]	UNIT
$\Delta V_{REF}/\Delta T$	Average reference voltage temperature coefficient[4]	V_{OUT} = 5V	I_R = 10mA				20		ppm/°C
$\Delta V_{REF}/\Delta T$	Average reference voltage temperature coefficient[4]	V_{OUT} = 5V	I_R = 1 mA	T_J = 25°C			15		ppm/°C
$\Delta V_{REF}/\Delta T$	Average reference voltage temperature coefficient[4]	V_{OUT} = 5V	I_R = 1 mA	$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CIM3 LM4041QCIM3 LM4041CIZ, LM4041CIM7			±100	ppm/°C
$\Delta V_{REF}/\Delta T$	Average reference voltage temperature coefficient[4]	V_{OUT} = 5V	I_R = 1 mA	$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041DIM3 LM4041QDIM3 LM4041DIZ, LM4041DIM7			±150	ppm/°C
$\Delta V_{REF}/\Delta T$	Average reference voltage temperature coefficient[4]	V_{OUT} = 5V	I_R = 100μA				15		ppm/°C
Z_{OUT}	Dynamic output impedance	I_R = 1mA, f = 120Hz, I_{AC} = 0.1 I_R					0.3		Ω
Z_{OUT}	Dynamic output impedance	$V_{OUT} = V_{REF}$ V_{OUT} = 10 V					2		Ω
e_N	Wide band noise	$V_{OUT} = V_{REF}$ I_R = 100μA 10Hz ≤ f ≤ 10kHz					20		μV_{RMS}
ΔV_{REF}	Reference voltage long-term stability	t = 1000 hrs, I_R = 100μA, T = 25°C ±0.1°C					120		ppm
V_{HYST}	Thermal hysteresis[6]	ΔT = −40°C to +125°C					0.08%		

(1) When V_{OUT} ≤ 1.6V, the LM4041-N LM4041-N-Q1 ADJ in the SOT-23 package must operate at reduced I_R. This is caused by the series resistance of the die attach between the die (–) output and the package (–) output pin. See the *Output Saturation (SOT-23 only)* curve in the *Typical Characteristics* section.
(2) Limits are 100% production tested at 25°C. Limits over temperature are made sure through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
(3) Typical values are at T_J = 25°C and represent most likely parametric norm.
(4) Reference voltage and temperature coefficient can change with output voltage. See *Section 5.10* curves.
(5) Load regulation is measured on pulse basis from no load to the specified load current. Output changes due to die temperature change must be taken into account separately.
(6) Thermal hysteresis is defined as the difference in voltage measured at +25°C after cycling to temperature –40°C and the +25°C measurement after cycling to temperature +125°C.

5.9 LM4041-N LM4041-N-Q1 ADJ (Adjustable) Electrical Characteristics (Extended Temperature Range)

All limits T_J = 25°C, unless otherwise specified (SOT-23, see(1)), $I_{RMIN} \le I_R \le$ 12mA, $V_{REF} \le V_{OUT} \le$ 10V. The grades C and D designate initial Reference Voltage Tolerances of ±0.5% and ±1%, respectively for V_{OUT} = 5V.

PARAMETER		TEST CONDITIONS			MIN(2)	TYP(3)	MAX(2)	UNIT
V_{REF}	Reference voltage	I_R = 100µA, V_{OUT} = 5V				1.233		V
	Reference voltage tolerance(4)	I_R = 100µA, V_{OUT} = 5V	T_J = 25°C	LM4041CEM3 LM4041QCEM3			±6.2	mV
				LM4041DEM3 LM4041QDEM3			±12	
			$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CEM3 LM4041QCEM3			±18	
				LM4041DEM3 LM4041QDEM3			±30	
I_{RMIN}	Minimum operating current	T_J = 25°C		LM4041CEM3 LM4041QCEM3		45	60	µA
				LM4041DEM3 LM4041QDEM3			65	
		$T_A = T_J = T_{MIN}$ to T_{MAX}		LM4041CEM3 LM4041QCEM3			68	
				LM4041DEM3 LM4041QDEM3			73	
$\Delta V_{REF}/\Delta I_R$	Reference voltage change with operating current change(5)	$I_{RMIN} \le I_R \le$ 1mA SOT-23: $V_{OUT} \ge$ 1.6V(1)	T_J = 25°C	LM4041CEM3 LM4041QCEM3		0.7	1.5	mV
				LM4041DEM3 LM4041QDEM3			2	
			$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CEM3 LM4041QCEM3			2	
				LM4041DEM3 LM4041QDEM3			2.5	
		1mA $\le I_R \le$ 12mA SOT-23: $V_{OUT} \ge$ 1.6V(1)	T_J = 25°C	LM4041CEM3 LM4041QCEM3		2	8	mV
				LM4041DEM3 LM4041QDEM3			10	
			$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CEM3 LM4041QCEM3			6	
				LM4041DEM3 LM4041QDEM3			8	
$\Delta V_{REF}/\Delta V_O$	Reference voltage change with output voltage change	I_R = 1mA	T_J = 25°C	LM4041CEM3 LM4041QCEM3		–1.55	–2	mV/V
				LM4041DEM3 LM4041QDEM3			–2.5	
			$T_A = T_J = T_{MIN}$ to T_{MAX}	LM4041CEM3 LM4041QCEM3			–3	
				LM4041DEM3 LM4041QDEM3			–4	
I_{FB}	Feedback current	T_J = 25°C		LM4041CEM3 LM4041QCEM3		60	100	nA
				LM4041DEM3 LM4041QDEM3			150	
		$T_A = T_J = T_{MIN}$ to T_{MAX}		LM4041CEM3 LM4041QCEM3			120	
				LM4041DEM3 LM4041QDEM3			200	
$\Delta V_{REF}/\Delta T$	Average reference voltage temperature coefficient(4)	V_{OUT} = 5V,	I_R = 10mA			20		ppm/°C
			I_R = 1mA	T_J = 25°C		15		
				$T_A = T_J = T_{MIN}$ to T_{MAX}, LM4041CEM3 LM4041QCEM3			±100	
				$T_A = T_J = T_{MIN}$ to T_{MAX}, LM4041DEM3 LM4041QDEM3			±150	
			I_R = 100µA			15		
Z_{OUT}	Dynamic output impedance	I_R = 1mA, f = 120Hz, I_{AC} = 0.1 I_R	$V_{OUT} = V_{REF}$			0.3		Ω
			V_{OUT} = 10 V			2		
e_N	Wide band noise	I_R = 100µA, 10Hz ≤ f ≤ 10kHz	$V_{OUT} = V_{REF}$			20		$µV_{RMS}$
ΔV_{REF}	Reference voltage long-term stability	t = 1000 hrs, I_R = 100µA, T = 25°C ±0.1°C				120		ppm
V_{HYST}	Thermal hysteresis(6)	ΔT = −40°C to +125°C				0.08%		

(1) When $V_{OUT} \le$ 1.6V, the LM4041-N LM4041-N-Q1 ADJ in the SOT-23 package must operate at reduced I_R. This is caused by the series resistance of the die attach between the die (–) output and the package (–) output pin. See the *Output Saturation (SOT-23 only)* curve in the *Typical Characteristics* section.
(2) Limits are 100% production tested at 25°C. Limits over temperature are made sure through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate AOQL.
(3) Typical values are at T_J = 25°C and represent most likely parametric norm.
(4) Reference voltage and temperature coefficient can change with output voltage. See *Section 5.10* curves.
(5) Load regulation is measured on pulse basis from no load to the specified load current. Output changes due to die temperature change must be taken into account separately.
(6) Thermal hysteresis is defined as the difference in voltage measured at +25°C after cycling to temperature –40°C and the +25°C measurement after cycling to temperature +125°C.

5.10 Typical Characteristics

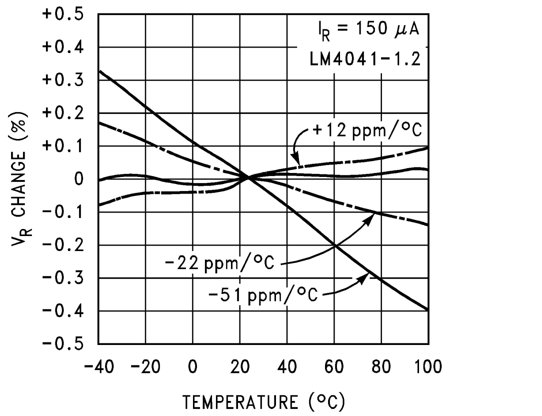


Figure 5-1. Temperature Drift for Different Average Temperature Coefficient

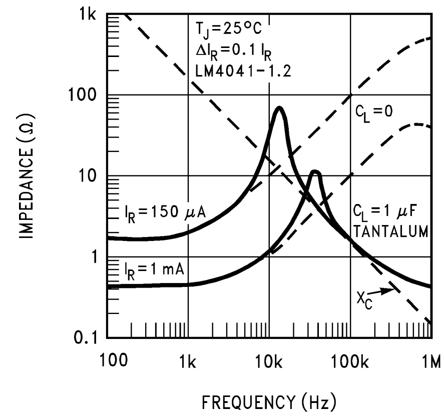


Figure 5-2. Output Impedance vs Frequency

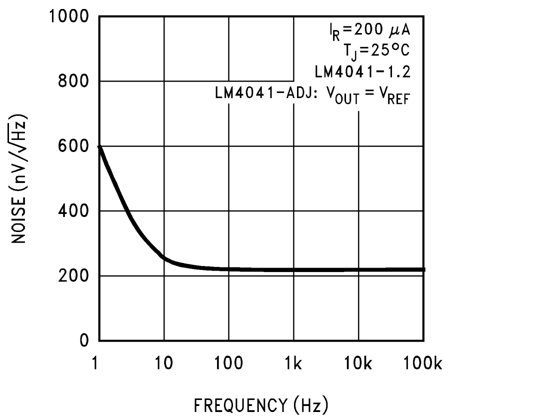


Figure 5-3. Noise Voltage

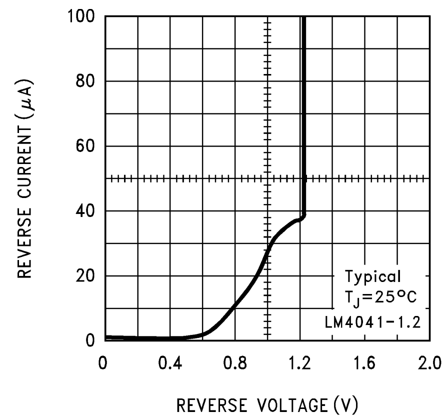


Figure 5-4. Reverse Characteristics and Minimum Operating Current

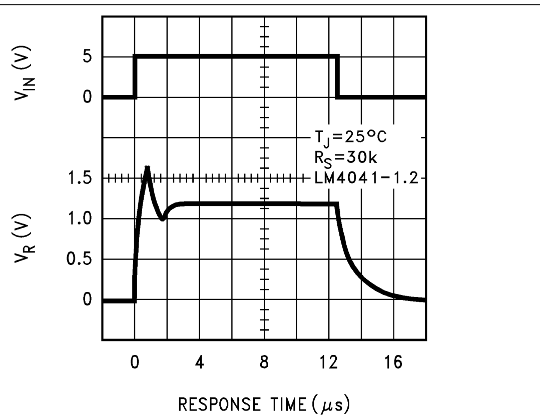


Figure 5-5. Start-Up Characteristics

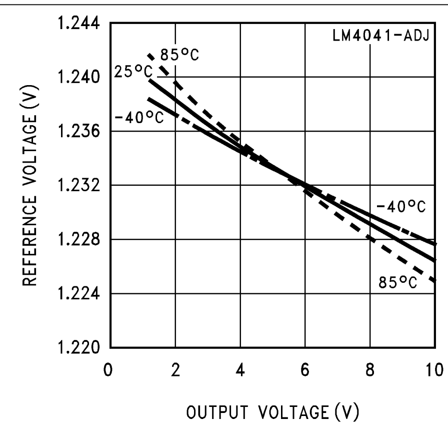


Figure 5-6. Reference Voltage vs Output Voltage and Temperature

5.10 Typical Characteristics (continued)

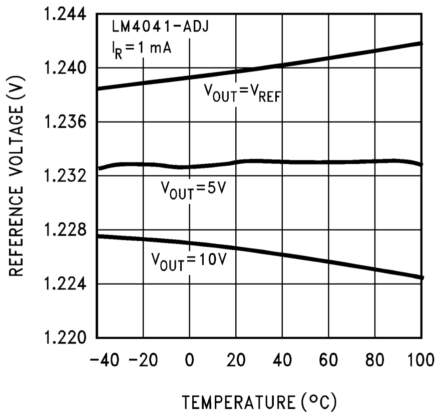


Figure 5-7. Reference Voltage vs Temperature and Output Voltage

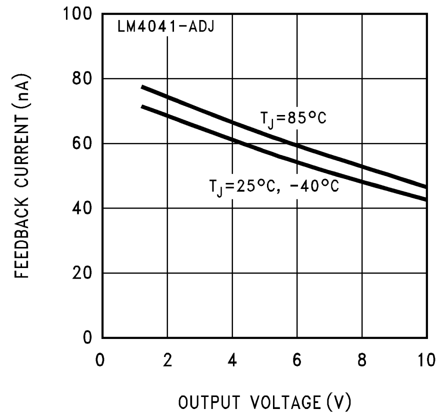


Figure 5-8. Feedback Current vs Output Voltage and Temperature

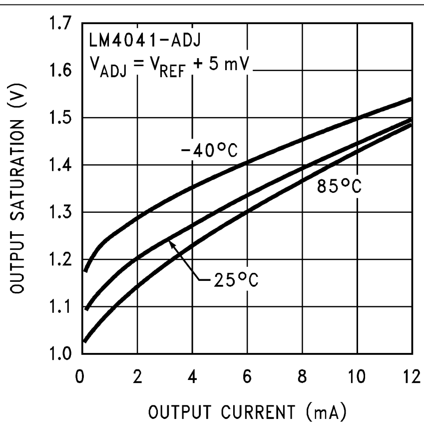


Figure 5-9. Output Saturation (SOT-23 Only)

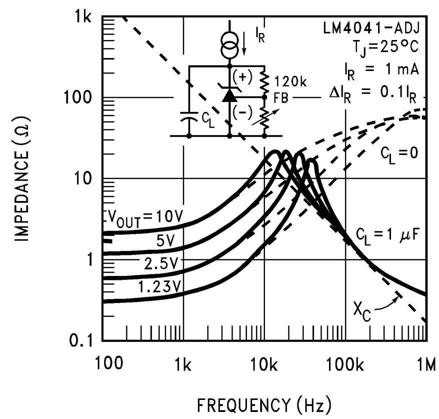


Figure 5-10. Output Impedance vs Frequency

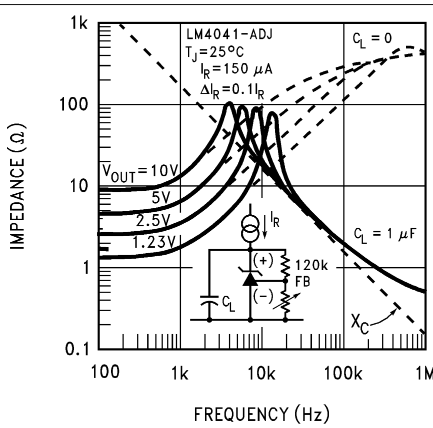


Figure 5-11. Output Impedance vs Frequency

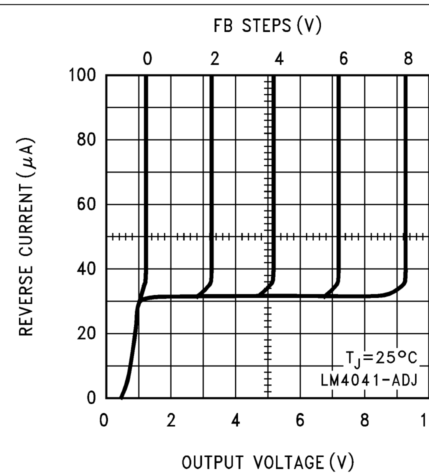


Figure 5-12. Reverse Characteristics

5.10 Typical Characteristics (continued)

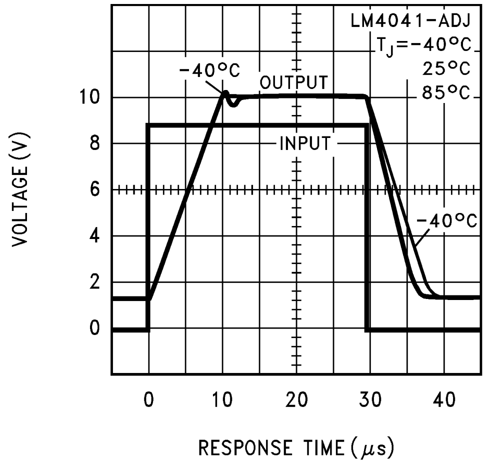


Figure 5-13. Large Signal Response

6 Parameter Measurement Information

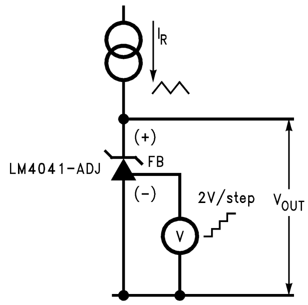


Figure 6-1. Adjustable Output Test Circuit

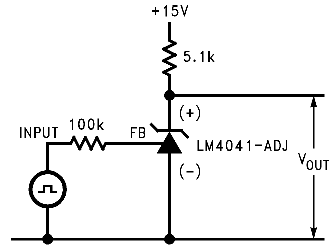


Figure 6-2. Line Transient Test Circuit

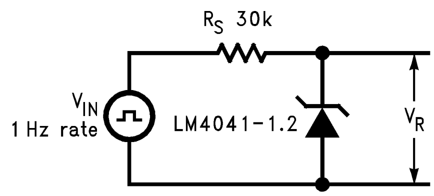


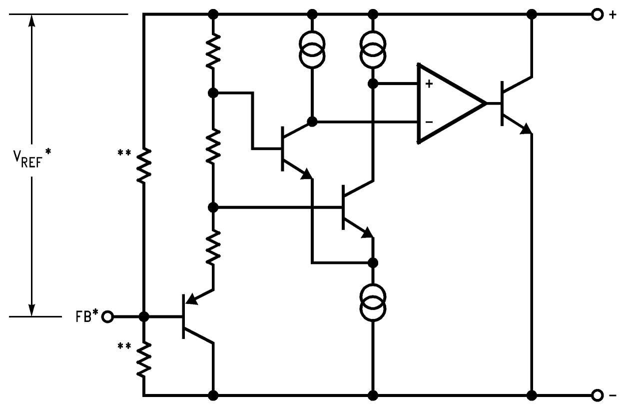
Figure 6-3. Start-Up and Shutdown Test Circuit

7 Detailed Description

7.1 Overview

The LM4041-N LM4041-N-Q1 is a precision micro-power shunt voltage reference available in both a fixed and output voltage and adjustable output voltage options. The part has three different packages available to meet small footprint requirements. The part is also available in five different tolerance grades.

7.2 Functional Block Diagram



*LM4041-N ADJ only **LM4041-N 1.2 only

7.3 Feature Description

The LM4041-N LM4041-N-Q1 is effectively a precision Zener diode. The part requires a small quiescent current for regulation, and regulates the output voltage by shunting more or less current to ground, depending on input voltage and load. The only external component requirement is a resistor between the cathode and the input voltage to set the input current. An external capacitor can be used on the input or output, but is not required.

7.4 Device Functional Modes

The LM4041-N LM4041-N-Q1 has fixed output voltage options as well as adjustable output voltage options. The fixed output parts can only be used in closed-loop operation, as the feedback is internal. The adjustable option parts are most commonly operated in closed-loop mode, where the feedback node is tied to the output voltage through a resistor divider. The output voltage remains as long as I_R is between I_{RMIN} and I_{RMAX}; see *Section 5.5*. This part can also be used in open-loop mode to act as a comparator, driving the feedback node from another voltage source.

8 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

The LM4041-N LM4041-N-Q1 is a precision micro-power curvature-corrected band gap shunt voltage reference. For space-critical applications, the LM4041-N LM4041-N-Q1 is available in the sub-miniature SOT-23 and SC70 surface-mount package. The LM4041-N LM4041-N-Q1 has been designed for stable operation without the need of an external capacitor connected between the + pin and the – pin. If, however, a bypass capacitor is used, the LM4041-N LM4041-N-Q1 remains stable. Design effort is further reduced with the choice of either a fixed 1.2V or an adjustable reverse breakdown voltage. The minimum operating current is 60μA for the LM4041-N LM4041-N-Q1 1.2V and the LM4041-N LM4041-N-Q1 ADJ. Both versions have a maximum operating current of 12mA.

The LM4041-N LM4041-N-Q1 devices using the SOT-23 package have pin 3 connected as the (–) output through the die attach interface of the package. Therefore, pin 3 of the LM4041-N LM4041-N-Q1 1.2 must be left floating or connected to pin 2 and pin 3 of the LM4041-N LM4041-N-Q1 ADJ pin out.

The LM4041-N LM4041-N-Q1 devices using the SC70 package have pin 2 connected as the (–) output through the die attach interface of the package. Therefore, the LM4041-N LM4041-N-Q1 pin 2 of the LM4041-N LM4041-N-Q1 1.2 must be left floating or connected to pin 1, and the pin 2 of the LM4041-N LM4041-N-Q1 ADJ is the (–) output.

The typical thermal hysteresis specification is defined as the change in 25°C voltage measured after thermal cycling. The device is thermal cycled to temperature –40°C and then measured at +25°C. Next the device is thermal cycled to temperature 125°C and again measured at 25°C. The resulting V_{OUT} delta shift between the 25°C measurements is thermal hysteresis. Thermal hysteresis is common in precision references and is induced by thermal-mechanical package stress. Changes in environmental storage temperature, operating temperature and board mounting temperature are all factors that can contribute to thermal hysteresis.

In a conventional shunt regulator application (Figure 8-1), an external series resistor (R_S) is connected between the supply voltage and the LM4041-N LM4041-N-Q1. R_S determines the current that flows through the load (I_L) and the LM4041-N LM4041-N-Q1 (I_Q). Because load current and supply voltage can vary, R_S must be small enough to supply at least the minimum acceptable I_Q to the LM4041-N LM4041-N-Q1 even when the supply voltage is at the minimum and the load current is at the maximum value. When the supply voltage is at the maximum and I_L is at the minimum, R_S must be large enough so that the current flowing through the LM4041-N is less than 12mA.

R_S must be selected based on the supply voltage, (V_S), the desired load and operating current, (I_L and I_Q), and the reverse breakdown voltage of the LM4041-N LM4041-N-Q1, V_R.

$$R_S = \frac{V_S - V_R}{I_L + I_Q} \quad (1)$$

The output voltage of the LM4041-N LM4041-N-Q1 SDJ can be adjusted to any value in the range of 1.24V through 10V. The output voltage is a function of the internal reference voltage (V_{REF}) and the ratio of the external feedback resistors as shown in Figure 8-3 . The output voltage is found using Equation 2.

$$V_O = V_{REF}[(R2/R1) + 1] \quad (2)$$

where

- V_O is the output voltage.

The actual value of the internal V_{REF} is a function of V_O. The *corrected* V_{REF} is determined by Equation 3.

$$V_{REF} = \Delta V_O \, (\Delta V_{REF}/\Delta V_O) + V_Y \tag{3}$$

where

- $V_Y = 1.240V$
- and $\Delta V_O = (V_O - V_Y)$

$\Delta V_{REF}/\Delta V_O$ is found in the electrical characteristics tables in the *Section 5* and is typically −1.55mV/V. You can get a more accurate indication of the output voltage by replacing the value of V_{REF} in Equation 2 with the value found using Equation 3.

Note

The actual output voltage can deviate from that predicted using the typical value of $\Delta V_{REF} / \Delta V_O$ in Equation 3. For C-grade parts, the worst-case $\Delta V_{REF} / \Delta V_O$ is −2.5mV/V. For D-grade parts, the worst-case $\Delta V_{REF} / \Delta V_O$ is −3.0mV/V.

8.2 Typical Applications

8.2.1 Shunt Regulator

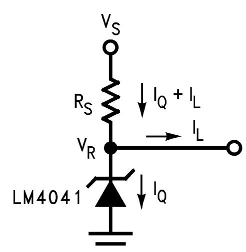


Figure 8-1. Shunt Regulator

8.2.1.1 Design Requirements

$V_{IN} > V_{OUT}$

Select R_S with Equation 4.

$$I_{RMIN} < I_R < I_{RMAX} = 15mA \tag{4}$$

See the electrical characteristics tables in the *Section 5* for minimum operating current for each voltage option and grade.

8.2.1.2 Detailed Design Procedure

The resistor R_S must be selected such that current I_R remains in the operational region of the part for the entire V_{IN} range and load current range. At the maximum, the R_S must be small enough for I_R to remain above I_{RMN}. The other extreme is when V_{IN} at the maximum and the load at the minimum; the R_S must be large enough to maintain $I_R < I_{RMAX}$. If unsure, try using 0.1mA ≤ I_R ≤ 1mA as starting point. Just remember the value of I_R varies with input and voltage load.

Use equations Equation 5 and Equation 6 to set R_S between R_{S_MIN} and R_{S_MAX}.

$$R_{S\_MIN} = \frac{V_{IN\_MAX} - V_{OUT}}{I_{LOAD\_MIN} + I_{R\_MAX}} \tag{5}$$

$$R_{S\_MAX} = \frac{V_{IN\_MIN} - V_{OUT}}{I_{LOAD\_MAX} + I_{R\_MIN}} \quad (6)$$

8.2.1.3 Application Curve

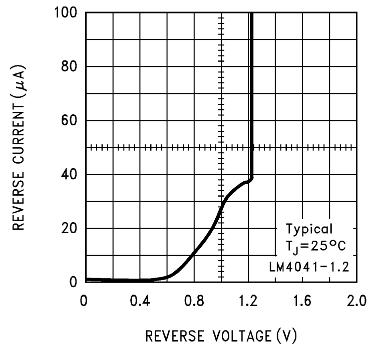
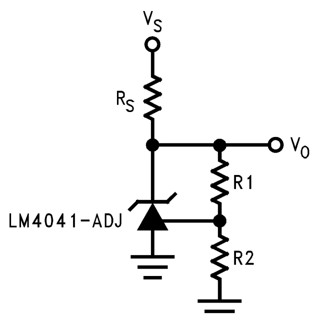


Figure 8-2. Reverse Characteristics and Minimum Operating Current

8.2.2 Adjustable Shunt Regulator



$V_O = V_{REF}[(R2/R1) + 1]$

Figure 8-3. Adjustable Shunt Regulator

8.2.2.1 Design Requirements

$V_{IN} > V_{OUT}$

V_{OUT} = 2.5V

Select R_S with Equation 7.

$$I_{RMIN} < L_R < I_{RMAX} \quad (7)$$

where

- I_{RMAX} = 15mA

See the electrical characteristics tables in the *Section 5* for minimum operating current for each voltage option and grade. When the output voltage, VZ, is set below 2.5V on adjustable versions of LM4041-N and LM4041-N-Q1, the device can experience increased reference voltage change with output voltage change (ΔVREF/ΔVKA) when compared to output voltages set equal to or above 2.5V

8.2.2.2 Detail Design Procedure

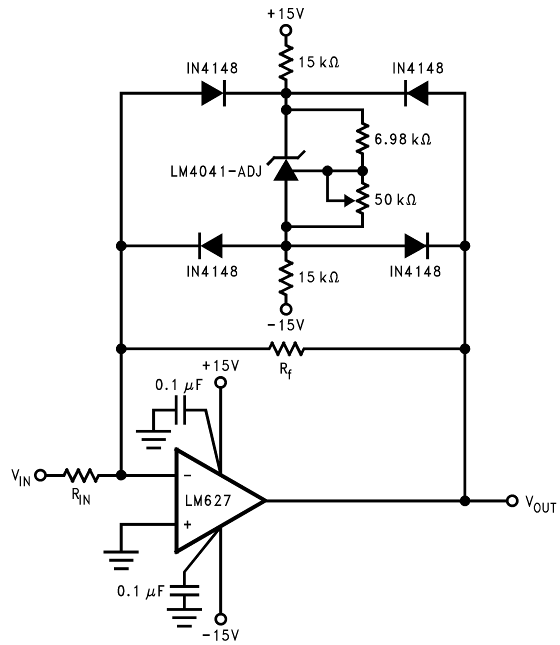
Select a value of R_S based on the same method shown in *Section 8.2.1.2*.

Set feedback resistors R_1 and R_2 for a resistor divider on the equation shown in *Section 8.1* that is reproduced here as Equation 8.

$$V_{OUT} + V_{REF} \times ((R_2/R_1)+1) \quad (8)$$

So, for a 2.5V reference, of V_{REF} is 1.24V, then R_2/R_1 = 1.01. Select R_2= 1.01kΩ and R_1= 1.0kΩ.

8.2.3 Bounded Amplifier



Bounded amplifier reduces saturation-induced delays and can prevent succeeding stage damage. Nominal clamping voltage is $\pm V_O$ (the reverse breakdown voltage of the LM4041-N) +2 diode V_F.

Figure 8-4. Bounded Amplifier

8.2.3.1 Design Requirements

Design an amplifier with output clamped at ±11.5V.

8.2.3.2 Detail Design Procedure

With amplifier rails of ±15V, the output can be bound to ±11.5V with the LM4041-N LM4041-N-Q1 adjustable set for 10V and two nominal diode voltage drops of 0.7V.

$$V_{OUTBOUND} = 2 \times V_{FWD} + V_Z \quad (9)$$

$$V_{OUTBOUND} = 1.4V + 10V \quad (10)$$

Select R_S = 15kΩ to keep L_R low. Calculate L_R to confirm R_S selection.

Use Equation 11, but in this case, take the negative supply into account.

$$I_R = (V_{IN} – V_{OUT}) /R \quad (11)$$

$$I_R = (V_{IN+} – V_{IN} – V_{OUT}) / R = (30V – 10V) / (R_{S1} + R_{S2}) = 20V / 30k\Omega = 0.667mA \quad (12)$$

This is an acceptable value for I_R that does not draw excessive current, but prevents the part from being starved for current.

8.2.3.3 Application Curve

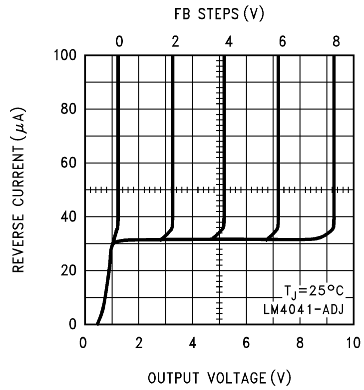


Figure 8-5. Reverse Characteristics

8.2.4 Voltage Level Detector

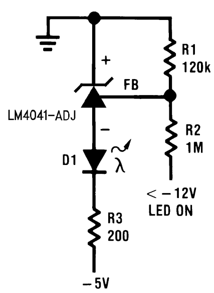


Figure 8-6. Voltage Level Detector

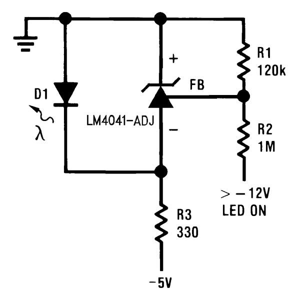


Figure 8-7. Voltage Level Detector

8.2.4.1 Design Procedure

Turn on an LED when voltage is above or below –12V.

8.2.4.2 Detail Design Procedure

Use the LM4041-N LM4041-N-Q1 in an open-loop configuration, where the feedback node is tied to a voltage divider driven by the input signal. The voltage divider is set such that when the input signal is at –12V, the feedback node is –1.24V. The high gain of the LM4041-N LM4041-N-Q1 enables the device to act like a comparator.

8.2.5 Precision Current Sink and Source

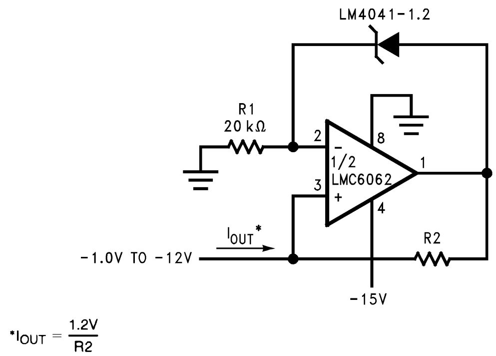


Figure 8-8. Precision 1µA to 1mA Current Sink

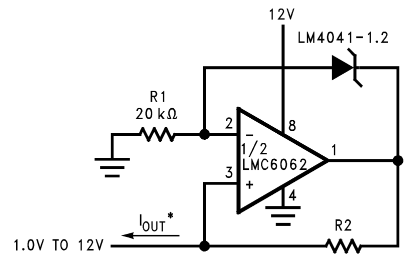


Figure 8-9. Precision 1µA to 1mA Current Sources

8.2.5.1 Design Requirements

Create precision 1mA current sink and 1mA current source.

8.2.5.2 Detailed Design Procedure

Set R1 such that the current through the shunt reference, I_R, is greater than I_{RMIN}.

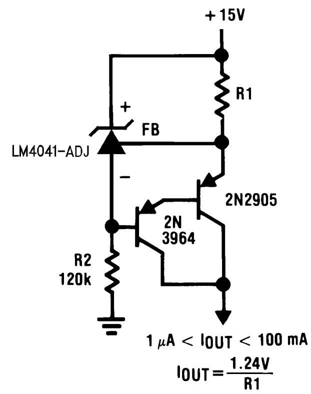
$$I_{OUT} = V_{OUT} / R_2 \quad (13)$$

where

- V_{OUT} is the voltage drop across the shunt reference

In this case, $I_{OUT} = 1.2 / R_2$.

8.2.6 100mA Current Source



*D1 can be any LED, V_F = 1.5V to 2.2V at 3mA. D1 can act as an indicator. D1 is on if $I_{THRESHOLD}$ falls below the threshold current, except with I = 0.

Figure 8-10. Current Source

8.2.6.1 Design Requirements

Create 100mA current source.

8.2.6.2 Detailed Design Procedure

$$I_{OUT} = V_{OUT} / R_1 \quad (14)$$

where

- V_{OUT} is the voltage drop across the shunt reference.

In this case, $I_{OUT} = 1.24 / R_1$.

8.2.7 LM4041 in Clamp Circuits

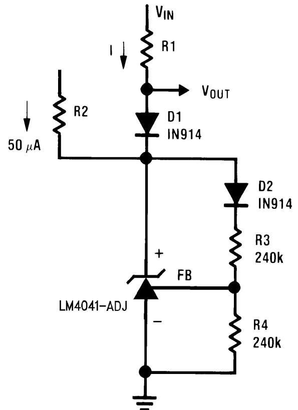


Figure 8-11. Fast Positive Clamp 2.4V + V_{D1}

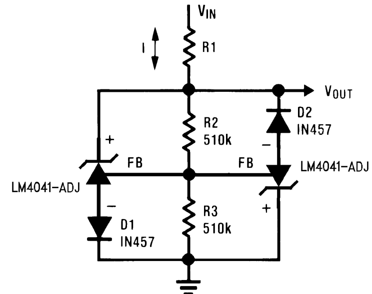


Figure 8-12. Bidirectional Clamp ±2.4V

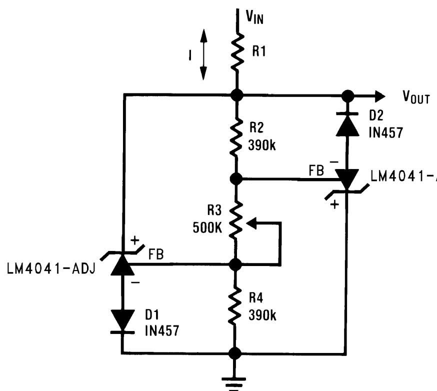


Figure 8-13. Bidirectional Adjustable Clamp ±18V to ±2.4V

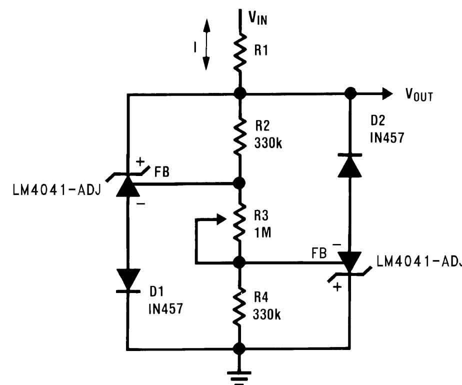


Figure 8-14. Bidirectional Adjustable Clamp ±2.4V to ±6V

8.2.7.1 Design Requirements

Create adjustable clamping circuits using the LM4041-N LM4041-N-Q1.

8.2.7.2 Detailed Design Procedure

Use the LM4041-N LM4041-N-Q1 in open-loop, as a 1.24V diode that can be on or off based on the voltage at the feedback. See Figure 8-11 through Figure 8-14 for examples.

8.2.8 Floating Current Detector

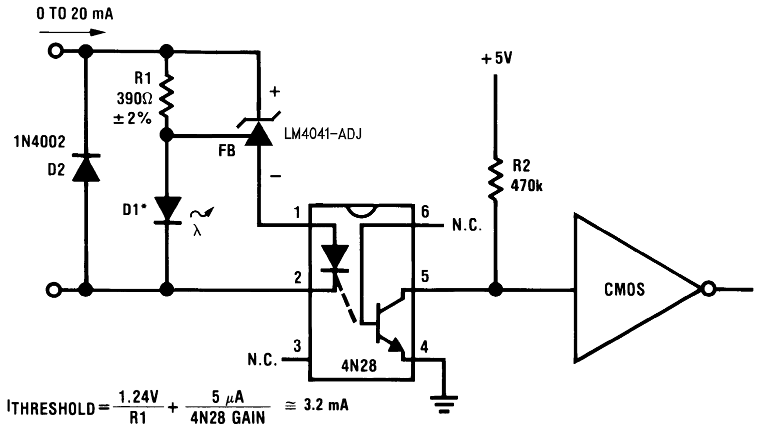


Figure 8-15. Simple Floating Current Detector

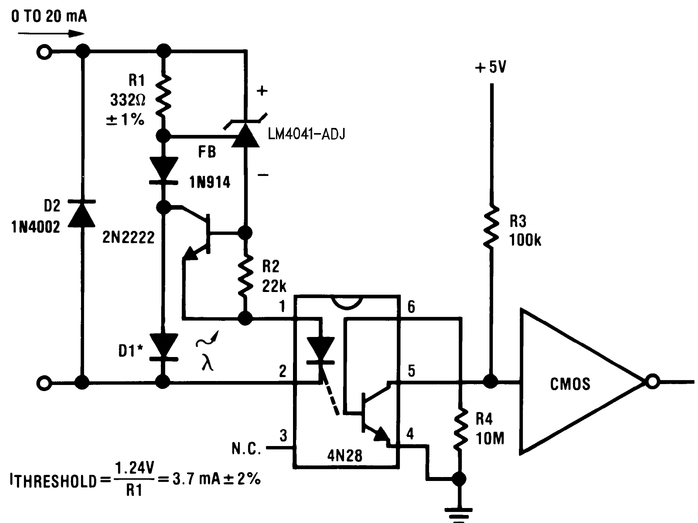


Figure 8-16. Precision Floating Current Detector

8.2.8.1 Design Requirement

Create a floating current detector using the LM4041-N LM4041-N-Q1.

8.2.8.2 Detailed Design Procedure

Use the LM4041-N LM4041-N-Q1 as a voltage dependent diode, which turns on and off based on the voltage drop across R1. See Figure 8-15 and Figure 8-16 for examples.

8.3 Power Supply Recommendations

While a bypass capacitor is not required on the input voltage line, TI recommends reducing noise on the input which can affect the output. A 0.1µF ceramic capacitor or larger is recommended.

8.4 Layout

8.4.1 Layout Guidelines

Place external components as close to the device as possible. Place R_S close the cathode, as well as the input bypass capacitor, if used. Keep feedback resistor close the device whenever possible.

8.4.2 Layout Example

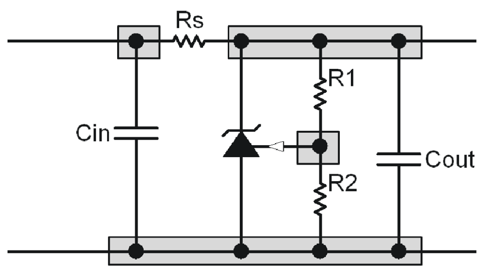


Figure 8-17. Recommended Layout

9 Device and Documentation Support

9.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

9.2 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

9.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

9.4 Electrostatic Discharge Caution

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.

9.5 Glossary

TI Glossary This glossary lists and explains terms, acronyms, and definitions.

10 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision G (January 2016) to Revision H (March 2025) **Page**

- Updated the numbering format for tables, figures, and cross-references throughout the document................ 1
- Updated *Applications* links.. 1
- Updated LP pin numbering..3
- Added electromagnetic interference note and updated LP pinout numbering..3
- Removed machine model (MM) ESD specification, updated CDM ESD specification.....................................5
- Updated reverse current specification 5
- Changed minimum operating current test conditions from: LM4041EEM3, LM4041QEEM3 to: $T_A = T_J = T_{MIN}$ to T_{MAX} 10
- Changed VR temperature coefficient test conditions from: LM4041EEM3, LM4041QEEM3 to: I_R = 10mA.... 10
- Changed VR temperature coefficient test conditions from: LM4041EEM3, LM4041QEEM3 to: I_R = 100µA... 10
- Added ΔVREF/ΔVKA information for adjustable versions..22
- Added ordering information for part numbers which include "X"... 31

Changes from Revision F (July 2013) to Revision G (October 2015) **Page**

- Added *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section 1
- Updated pinout diagrams 3

Changes from Revision D (April 2013) to Revision E (April 2013)	Page
• Changed layout of National Data Sheet to TI format	25

11 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation. Part numbers containing an "X" contain the same electrical properties as those which do not contain an "X".

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
LM4041AIM3-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 85	R1A	Samples
LM4041AIM3X-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	R1A	Samples
LM4041AIZ-1.2/NOPB	ACTIVE	TO-92	LP	3	1800	RoHS & Green	Call TI | SN	N / A for Pkg Type	-40 to 85	4041A IZ1.2	Samples
LM4041BIM3-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	R1B	Samples
LM4041BIM3X-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	R1B	Samples
LM4041BIM7-1.2/NOPB	ACTIVE	SC70	DCK	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	R1B	Samples
LM4041BIM7X-1.2/NOPB	ACTIVE	SC70	DCK	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	R1B	Samples
LM4041BIZ-1.2/NOPB	ACTIVE	TO-92	LP	3	1800	RoHS & Green	Call TI | SN	N / A for Pkg Type	-40 to 85	4041B IZ1.2	Samples
LM4041CEM3-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	R1C	Samples
LM4041CEM3-ADJ/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	RAC	Samples
LM4041CEM3X-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	R1C	Samples
LM4041CEM3X-ADJ/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	RAC	Samples
LM4041CIM3-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	R1C	Samples
LM4041CIM3-ADJ/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	RAC	Samples
LM4041CIM3X-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	R1C	Samples
LM4041CIM3X-ADJ/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	RAC	Samples
LM4041CIM7-1.2/NOPB	ACTIVE	SC70	DCK	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	R1C	Samples
LM4041CIM7-ADJ/NOPB	ACTIVE	SC70	DCK	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	RAC	Samples
LM4041CIM7X-1.2/NOPB	ACTIVE	SC70	DCK	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	R1C	Samples

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
LM4041CIM7X-ADJ/NOPB	ACTIVE	SC70	DCK	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	RAC	Samples
LM4041CIZ-1.2/NOPB	ACTIVE	TO-92	LP	3	1800	RoHS & Green	Call TI | SN	N / A for Pkg Type	-40 to 85	4041C IZ1.2	Samples
LM4041CIZ-ADJ/NOPB	ACTIVE	TO-92	LP	3	1800	RoHS & Green	Call TI	N / A for Pkg Type	-40 to 85	4041C IZADJ	Samples
LM4041DEM3-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	R1D	Samples
LM4041DEM3-ADJ/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	RAD	Samples
LM4041DEM3X-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	R1D	Samples
LM4041DEM3X-ADJ/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	RAD	Samples
LM4041DIM3-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU | SN	Level-1-260C-UNLIM	-40 to 85	R1D	Samples
LM4041DIM3-ADJ/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	RAD	Samples
LM4041DIM3X-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	R1D	Samples
LM4041DIM3X-ADJ/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	RAD	Samples
LM4041DIM7-1.2/NOPB	ACTIVE	SC70	DCK	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	R1D	Samples
LM4041DIM7-ADJ/NOPB	ACTIVE	SC70	DCK	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	RAD	Samples
LM4041DIM7X-1.2/NOPB	ACTIVE	SC70	DCK	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	R1D	Samples
LM4041DIM7X-ADJ/NOPB	ACTIVE	SC70	DCK	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	RAD	Samples
LM4041DIZ-1.2/NOPB	ACTIVE	TO-92	LP	3	1800	RoHS & Green	Call TI | SN	N / A for Pkg Type	-40 to 85	4041D IZ1.2	Samples
LM4041DIZ-ADJ/LFT1	ACTIVE	TO-92	LP	3	2000	RoHS & Green	SN	N / A for Pkg Type		4041D IZADJ	Samples
LM4041DIZ-ADJ/NOPB	ACTIVE	TO-92	LP	3	1800	RoHS & Green	Call TI	N / A for Pkg Type	-40 to 85	4041D IZADJ	Samples
LM4041EEM3-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	1000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	R1E	Samples
LM4041EEM3X-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	R1E	Samples

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
LM4041EIM3-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	1000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	R1E	Samples
LM4041EIM3X-1.2/NOPB	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 85	R1E	Samples
LM4041EIM7-1.2/NOPB	ACTIVE	SC70	DCK	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	R1E	Samples
LM4041EIM7X-1.2/NOPB	ACTIVE	SC70	DCK	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	R1E	Samples
LM4041QAIM3-1.2/NO	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	RQA	Samples
LM4041QBIM3-1.2/NO	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	RQB	Samples
LM4041QCEM3-1.2NO	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	RQC	Samples
LM4041QCEM3-ADJ/NO	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	RZC	Samples
LM4041QCEM3X-1.2NO	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	RQC	Samples
LM4041QCIM3-1.2/NO	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	RQC	Samples
LM4041QCIM3-ADJ/NO	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	RZC	Samples
LM4041QDEM3-1.2/NO	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	RQD	Samples
LM4041QDEM3-ADJ/NO	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	RZD	Samples
LM4041QDIM3-1.2/NO	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	RQD	Samples
LM4041QDIM3-ADJ/NO	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	RZD	Samples
LM4041QEEM3-1.2/NO	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	RQE	Samples
LM4041QEEM3X-1.2NO	ACTIVE	SOT-23	DBZ	3	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 125	RQE	Samples
LM4041QEIM3-1.2/NO	ACTIVE	SOT-23	DBZ	3	1000	RoHS & Green	SN	Level-1-260C-UNLIM	-40 to 85	RQE	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.

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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.

OTHER QUALIFIED VERSIONS OF LM4041-N, LM4041-N-Q1 :

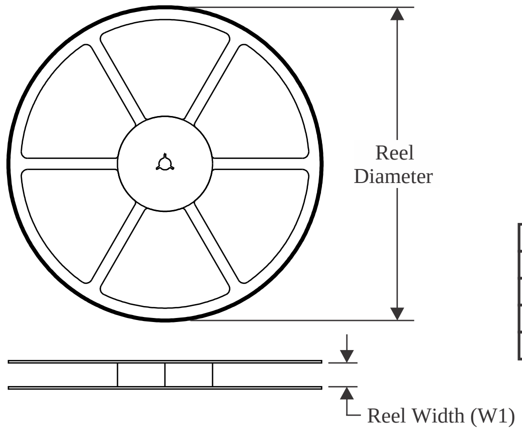
- Catalog : LM4041-N
- Automotive : LM4041-N-Q1

NOTE: Qualified Version Definitions:

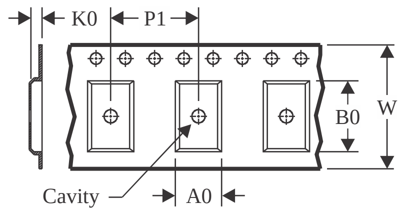
- Catalog - TI's standard catalog product
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

REEL DIMENSIONS

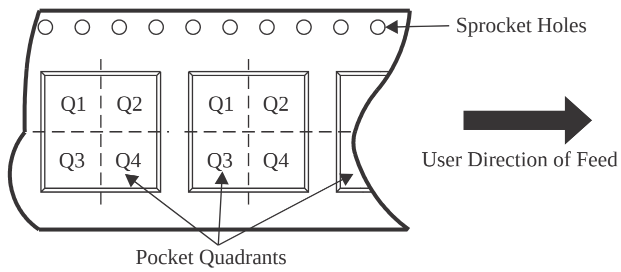


TAPE DIMENSIONS



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



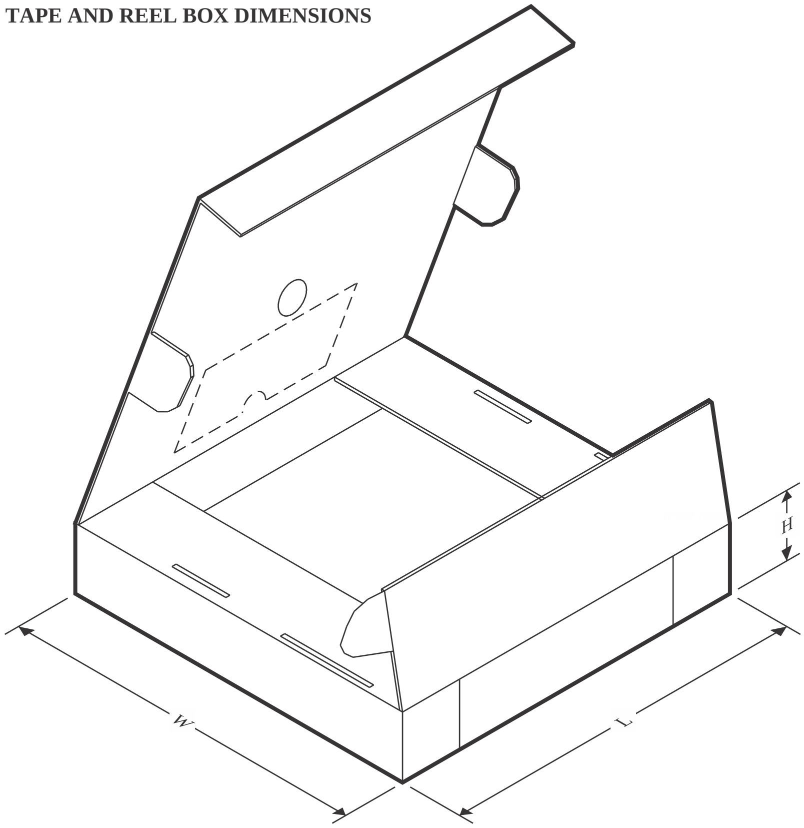
*All dimensions are nominal

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
LM4041AIM3-1.2/NOPB	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
LM4041AIM3X-1.2/NOPB	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
LM4041BIM3-1.2/NOPB	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
LM4041BIM3X-1.2/NOPB	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
LM4041BIM7-1.2/NOPB	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LM4041BIM7-1.2/NOPB	SC70	DCK	5	3000	180.0	8.4	2.3	2.5	1.2	4.0	8.0	Q3
LM4041BIM7X-1.2/NOPB	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LM4041BIM7X-1.2/NOPB	SC70	DCK	5	3000	180.0	8.4	2.3	2.5	1.2	4.0	8.0	Q3
LM4041CEM3-1.2/NOPB	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
LM4041CEM3-ADJ/NOPB	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041CEM3X-1.2/NOPB	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
LM4041CEM3X-ADJ/NOPB	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041CIM3-1.2/NOPB	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
LM4041CIM3-ADJ/NOPB	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041CIM3X-1.2/NOPB	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3

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
LM4041CIM3X-ADJ/NOPB	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041CIM7-1.2/NOPB	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LM4041CIM7-1.2/NOPB	SC70	DCK	5	3000	180.0	8.4	2.3	2.5	1.2	4.0	8.0	Q3
LM4041CIM7-ADJ/NOPB	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LM4041CIM7X-1.2/NOPB	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LM4041CIM7X-1.2/NOPB	SC70	DCK	5	3000	180.0	8.4	2.3	2.5	1.2	4.0	8.0	Q3
LM4041CIM7X-ADJ/NOPB	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LM4041DEM3-1.2/NOPB	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
LM4041DEM3-ADJ/NOPB	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041DEM3X-1.2/NOPB	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
LM4041DEM3X-ADJ/NOPB	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041DIM3-1.2/NOPB	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
LM4041DIM3-ADJ/NOPB	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041DIM3X-1.2/NOPB	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
LM4041DIM3X-ADJ/NOPB	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041DIM7-1.2/NOPB	SC70	DCK	5	3000	180.0	8.4	2.3	2.5	1.2	4.0	8.0	Q3
LM4041DIM7-1.2/NOPB	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LM4041DIM7-ADJ/NOPB	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LM4041DIM7X-1.2/NOPB	SC70	DCK	5	3000	180.0	8.4	2.3	2.5	1.2	4.0	8.0	Q3
LM4041DIM7X-1.2/NOPB	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LM4041DIM7X-ADJ/NOPB	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LM4041EEM3-1.2/NOPB	SOT-23	DBZ	3	1000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
LM4041EEM3X-1.2/NOPB	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
LM4041EIM3-1.2/NOPB	SOT-23	DBZ	3	1000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
LM4041EIM3X-1.2/NOPB	SOT-23	DBZ	3	3000	180.0	8.4	2.9	3.35	1.35	4.0	8.0	Q3
LM4041EIM7-1.2/NOPB	SC70	DCK	5	3000	180.0	8.4	2.3	2.5	1.2	4.0	8.0	Q3
LM4041EIM7-1.2/NOPB	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LM4041EIM7X-1.2/NOPB	SC70	DCK	5	3000	180.0	8.4	2.3	2.5	1.2	4.0	8.0	Q3
LM4041EIM7X-1.2/NOPB	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LM4041QAIM3-1.2/NO	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041QBIM3-1.2/NO	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041QCEM3-1.2NO	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041QCEM3-ADJ/NO	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041QCEM3X-1.2NO	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041QCIM3-1.2/NO	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041QCIM3-ADJ/NO	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041QDEM3-1.2/NO	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041QDEM3-ADJ/NO	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3

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
LM4041QDIM3-1.2/NO	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041QDIM3-ADJ/NO	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041QEEM3-1.2/NO	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041QEEM3X-1.2NO	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LM4041QEIM3-1.2/NO	SOT-23	DBZ	3	1000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3

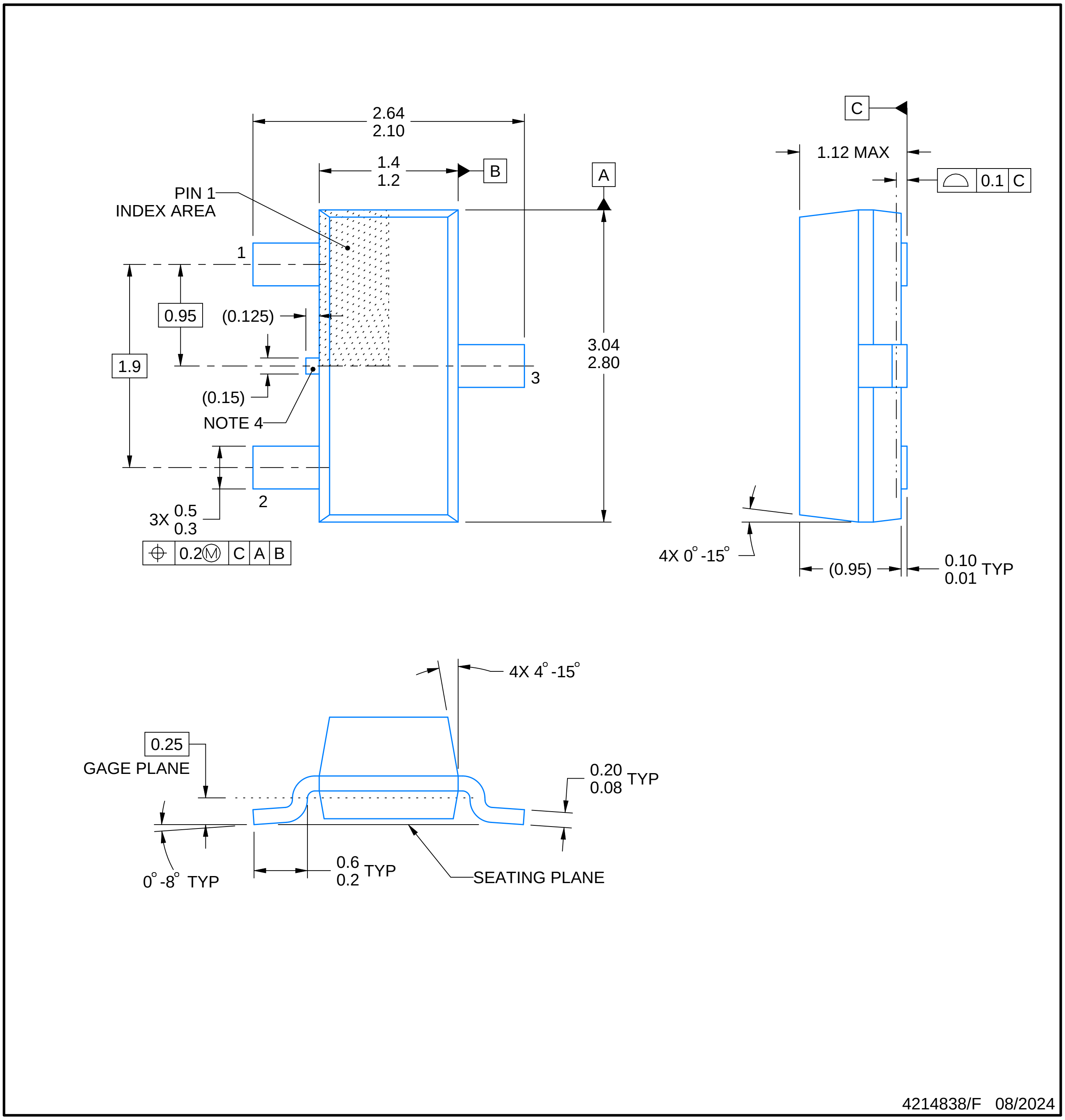
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

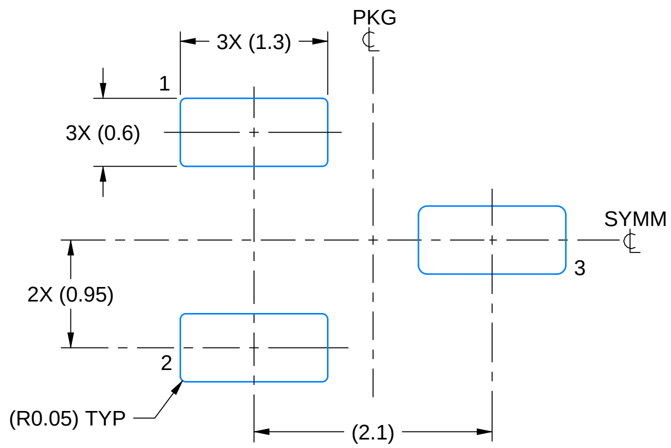
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM4041AIM3-1.2/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LM4041AIM3X-1.2/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LM4041BIM3-1.2/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LM4041BIM3X-1.2/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LM4041BIM7-1.2/NOPB	SC70	DCK	5	3000	208.0	191.0	35.0
LM4041BIM7-1.2/NOPB	SC70	DCK	5	3000	210.0	185.0	35.0
LM4041BIM7X-1.2/NOPB	SC70	DCK	5	3000	208.0	191.0	35.0
LM4041BIM7X-1.2/NOPB	SC70	DCK	5	3000	210.0	185.0	35.0
LM4041CEM3-1.2/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LM4041CEM3-ADJ/NOPB	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041CEM3X-1.2/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LM4041CEM3X-ADJ/NOPB	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041CIM3-1.2/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LM4041CIM3-ADJ/NOPB	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041CIM3X-1.2/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LM4041CIM3X-ADJ/NOPB	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041CIM7-1.2/NOPB	SC70	DCK	5	3000	208.0	191.0	35.0

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM4041CIM7-1.2/NOPB	SC70	DCK	5	3000	210.0	185.0	35.0
LM4041CIM7-ADJ/NOPB	SC70	DCK	5	3000	208.0	191.0	35.0
LM4041CIM7X-1.2/NOPB	SC70	DCK	5	3000	208.0	191.0	35.0
LM4041CIM7X-1.2/NOPB	SC70	DCK	5	3000	210.0	185.0	35.0
LM4041CIM7X-ADJ/NOPB	SC70	DCK	5	3000	208.0	191.0	35.0
LM4041DEM3-1.2/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LM4041DEM3-ADJ/NOPB	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041DEM3X-1.2/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LM4041DEM3X-ADJ/NOPB	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041DIM3-1.2/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LM4041DIM3-ADJ/NOPB	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041DIM3X-1.2/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LM4041DIM3X-ADJ/NOPB	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041DIM7-1.2/NOPB	SC70	DCK	5	3000	210.0	185.0	35.0
LM4041DIM7-1.2/NOPB	SC70	DCK	5	3000	208.0	191.0	35.0
LM4041DIM7-ADJ/NOPB	SC70	DCK	5	3000	208.0	191.0	35.0
LM4041DIM7X-1.2/NOPB	SC70	DCK	5	3000	210.0	185.0	35.0
LM4041DIM7X-1.2/NOPB	SC70	DCK	5	3000	208.0	191.0	35.0
LM4041DIM7X-ADJ/NOPB	SC70	DCK	5	3000	208.0	191.0	35.0
LM4041EEM3-1.2/NOPB	SOT-23	DBZ	3	1000	210.0	185.0	35.0
LM4041EEM3X-1.2/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LM4041EIM3-1.2/NOPB	SOT-23	DBZ	3	1000	210.0	185.0	35.0
LM4041EIM3X-1.2/NOPB	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LM4041EIM7-1.2/NOPB	SC70	DCK	5	3000	210.0	185.0	35.0
LM4041EIM7-1.2/NOPB	SC70	DCK	5	3000	208.0	191.0	35.0
LM4041EIM7X-1.2/NOPB	SC70	DCK	5	3000	210.0	185.0	35.0
LM4041EIM7X-1.2/NOPB	SC70	DCK	5	3000	208.0	191.0	35.0
LM4041QAIM3-1.2/NO	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041QBIM3-1.2/NO	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041QCEM3-1.2NO	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041QCEM3-ADJ/NO	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041QCEM3X-1.2NO	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041QCIM3-1.2/NO	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041QCIM3-ADJ/NO	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041QDEM3-1.2/NO	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041QDEM3-ADJ/NO	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041QDIM3-1.2/NO	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041QDIM3-ADJ/NO	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041QEEM3-1.2/NO	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041QEEM3X-1.2NO	SOT-23	DBZ	3	3000	208.0	191.0	35.0
LM4041QEIM3-1.2/NO	SOT-23	DBZ	3	1000	208.0	191.0	35.0

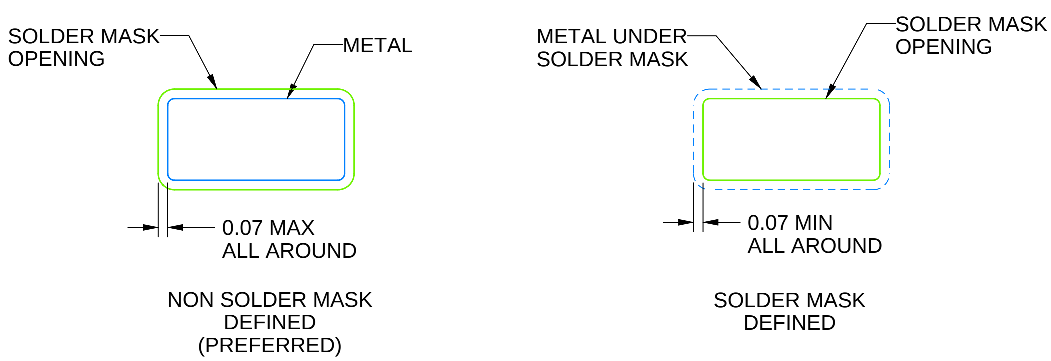


NOTES:

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. Reference JEDEC registration TO-236, except minimum foot length.
4. Support pin may differ or may not be present.
5. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25mm per side



LAND PATTERN EXAMPLE
SCALE:15X

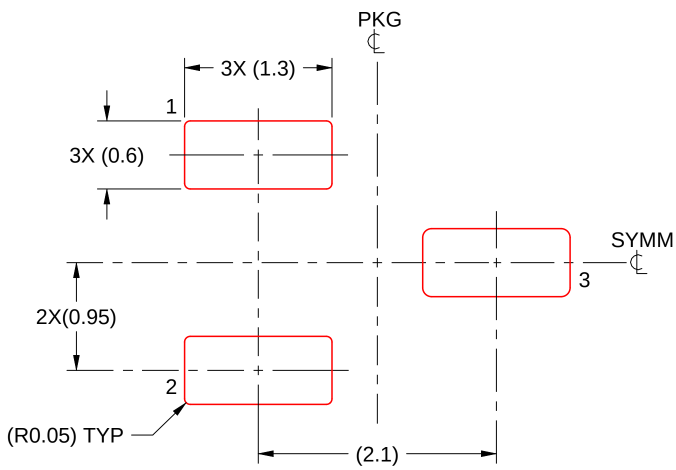


SOLDER MASK DETAILS

4214838/F 08/2024

NOTES: (continued)

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

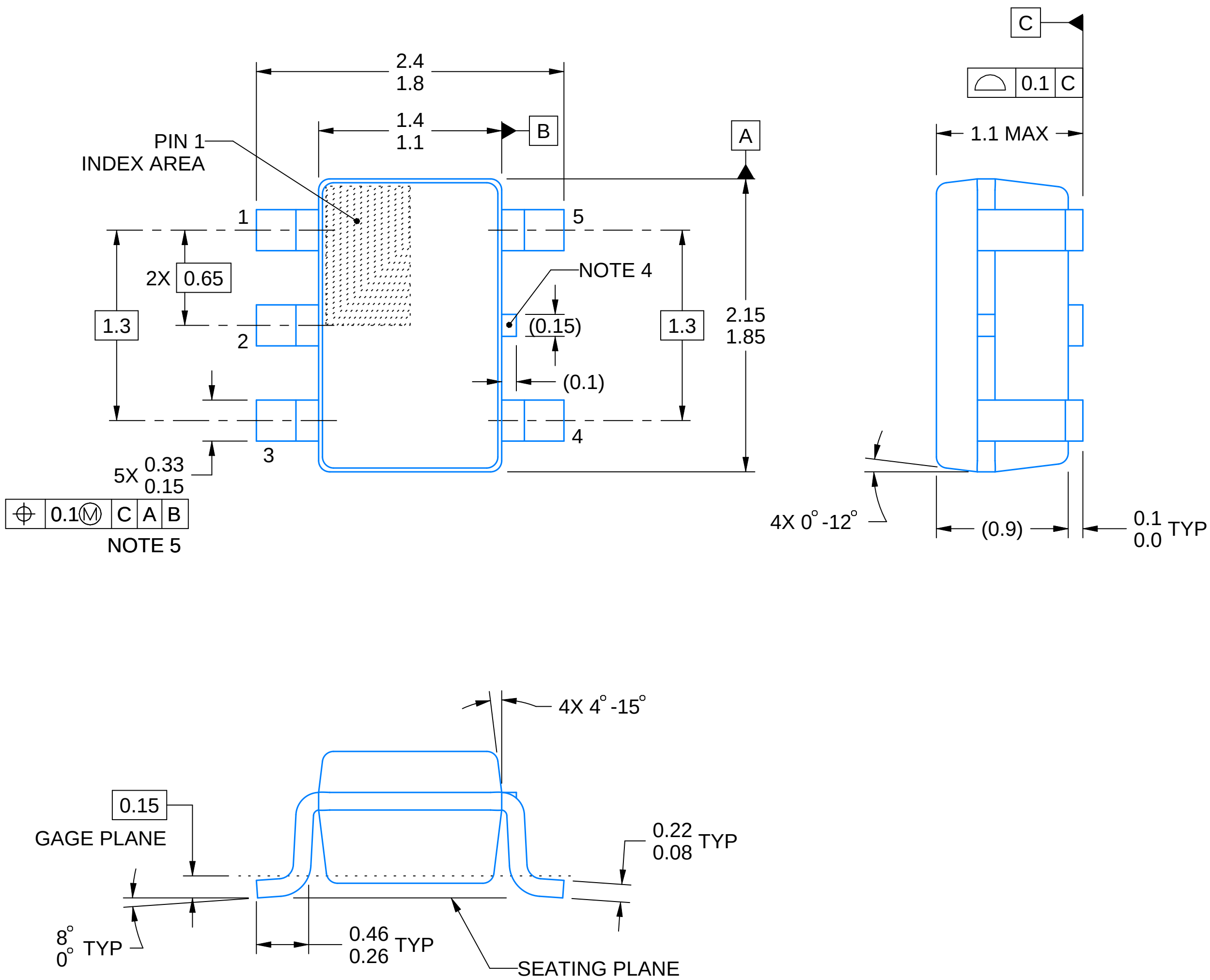


SOLDER PASTE EXAMPLE
BASED ON 0.125 THICK STENCIL
SCALE:15X

4214838/F 08/2024

NOTES: (continued)

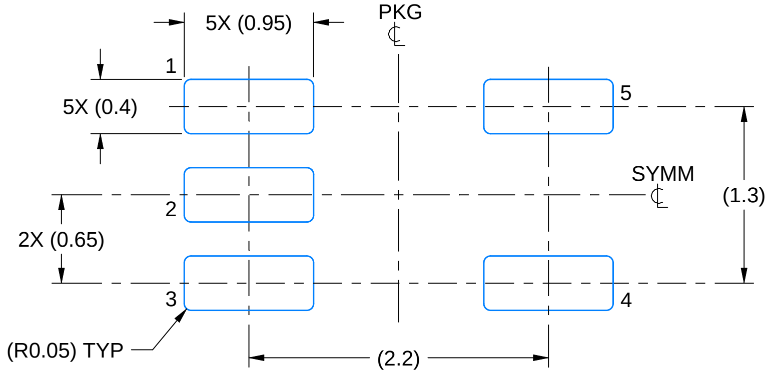
7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.



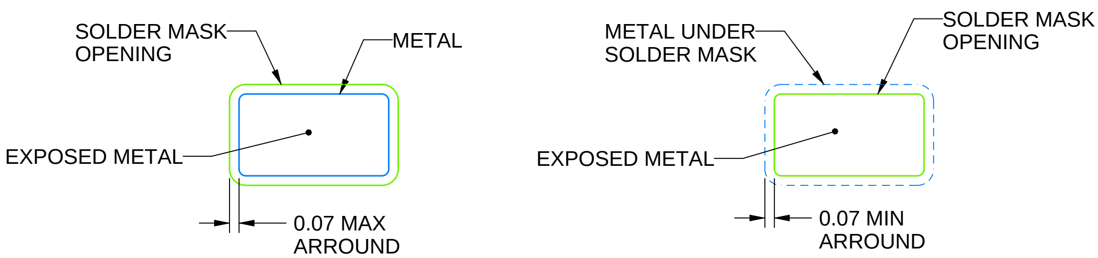
4214834/G 11/2024

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. Refernce JEDEC MO-203.
4. Support pin may differ or may not be present.
5. Lead width does not comply with JEDEC.
6. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25mm per side



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:18X

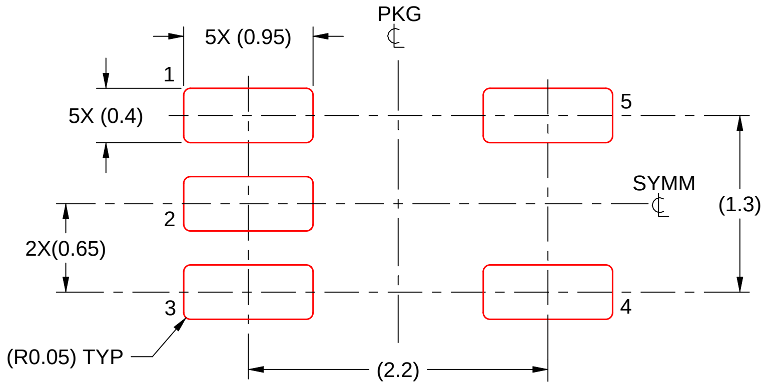


SOLDER MASK DETAILS

4214834/G 11/2024

NOTES: (continued)

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



SOLDER PASTE EXAMPLE
BASED ON 0.125 THICK STENCIL
SCALE:18X

4214834/G 11/2024

NOTES: (continued)

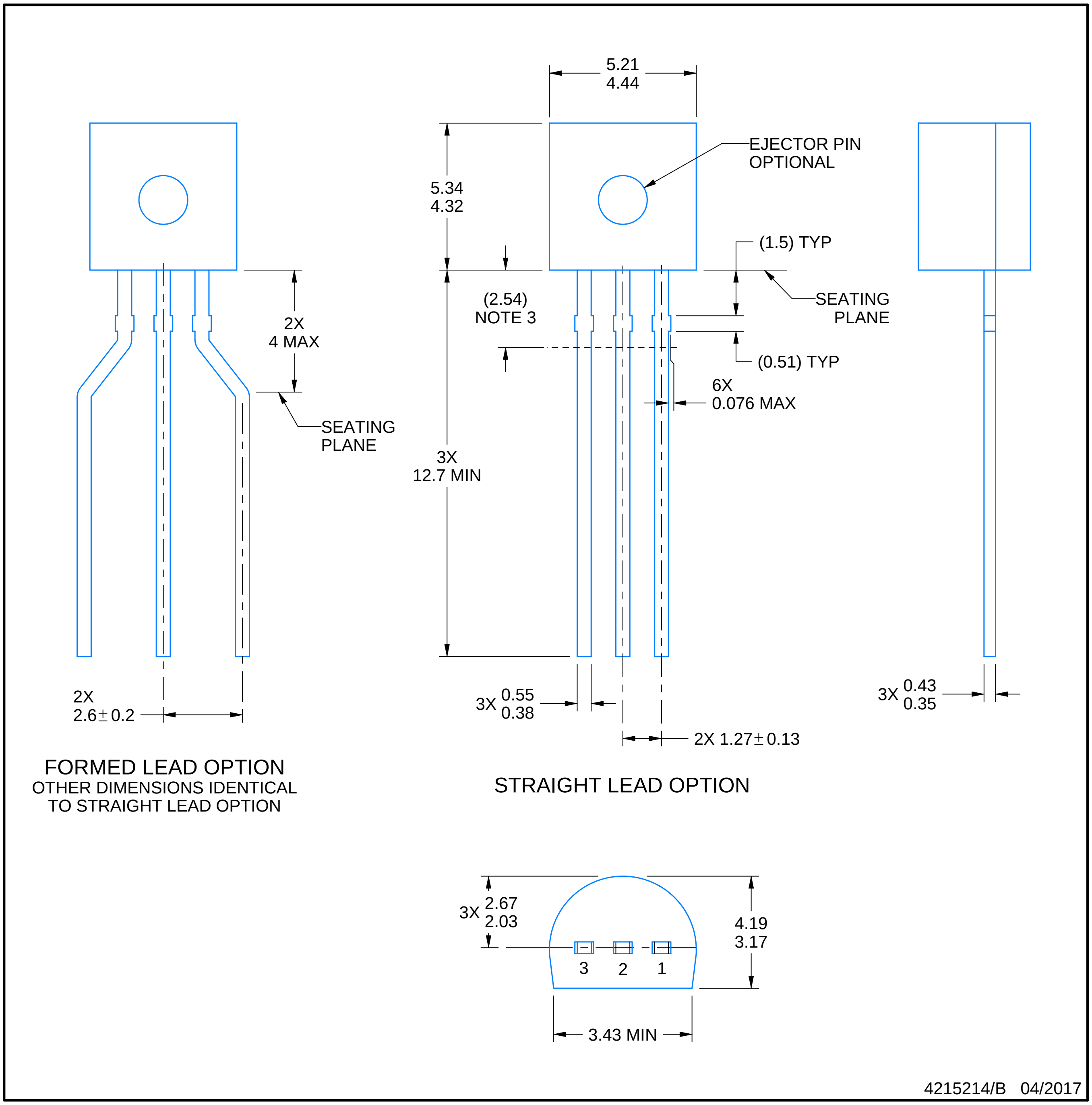
9. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
10. Board assembly site may have different recommendations for stencil design.

LP 3

TO-92 - 5.34 mm max height

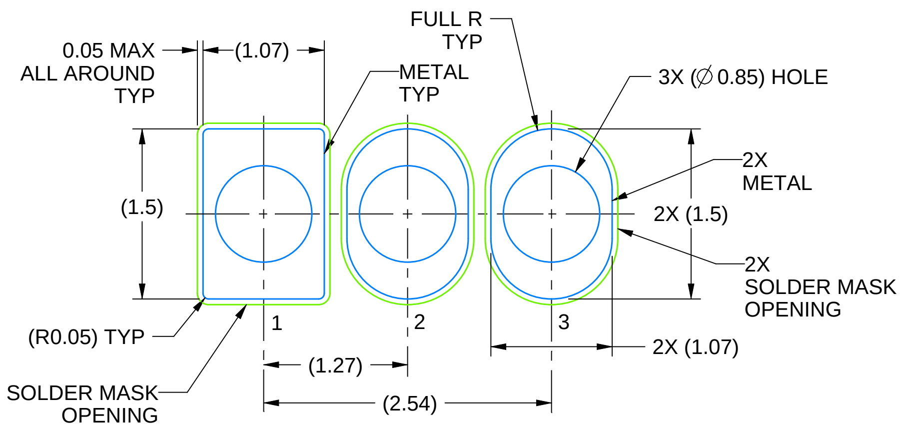
TRANSISTOR OUTLINE

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

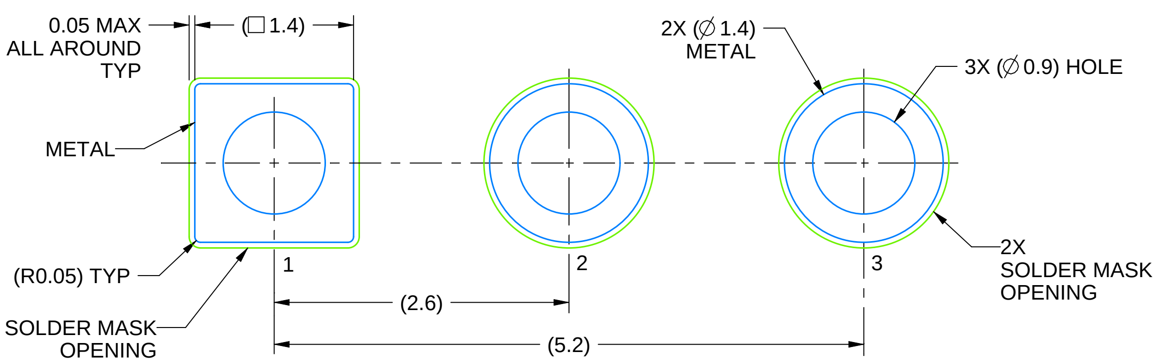


NOTES:

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. Lead dimensions are not controlled within this area.
4. Reference JEDEC TO-226, variation AA.
5. Shipping method:
   a. Straight lead option available in bulk pack only.
   b. Formed lead option available in tape and reel or ammo pack.
   c. Specific products can be offered in limited combinations of shipping medium and lead options.
   d. Consult product folder for more information on available options.

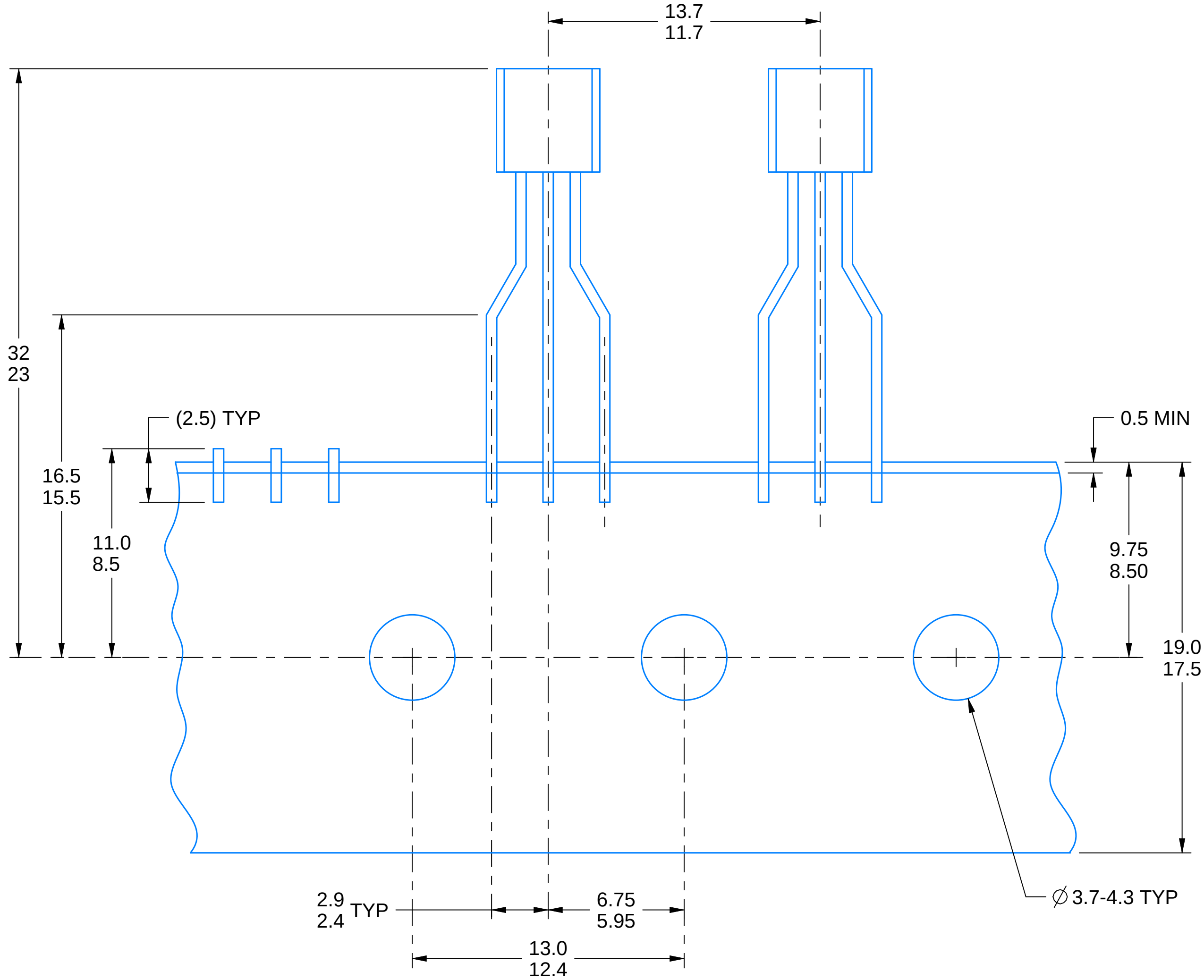


LAND PATTERN EXAMPLE
STRAIGHT LEAD OPTION
NON-SOLDER MASK DEFINED
SCALE:15X



LAND PATTERN EXAMPLE
FORMED LEAD OPTION
NON-SOLDER MASK DEFINED
SCALE:15X

4215214/B 04/2017



FOR FORMED LEAD OPTION PACKAGE

4215214/B 04/2017

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265