# QUADRUPLE OPERATIONAL AMPLIFIER

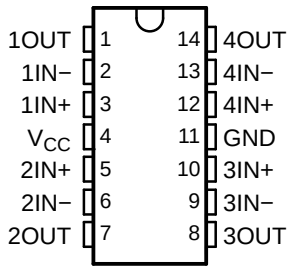
## FEATURES

- **Controlled Baseline**
  - **One Assembly/Test Site, One Fabrication Site**
- **Extended Temperature Performance of -55°C to 125°C**
- **Enhanced Diminishing Manufacturing Sources (DMS) Support**
- **Enhanced Product-Change Notification**
- **Qualification Pedigree**

(1) Component qualification in accordance with JEDEC and industry standards to ensure reliable operation over an extended temperature range. This includes, but is not limited to, Highly Accelerated Stress Test (HAST) or biased 85/85, temperature cycle, autoclave or unbiased HAST, electromigration, bond intermetallic life, and mold compound life. Such qualification testing should not be viewed as justifying use of this component beyond specified performance and environmental limits.

- **ESD Protection <500 V Per MIL-STD-883, Method 3015; Exceeds 200 V Using Machine Model C = 200 pF, R = 0); 1500 V Using Charged Device Model**
- **ESD Human Body Model >2 kV Machine Model >200 V and Charge Device Model = 2 kV For K-Suffix Devices.**
- **Low Supply-Current Drain Independent of Supply Voltage . . . 0.8 mA Typ**
- **Low Input Bias and Offset Parameters:**
  - **Input Offset Voltage . . . 3 mV Typ**
  - **Input Offset Current . . . 2 nA Typ**
  - **Input Bias Current . . . 20 nA Typ**
- **Common-Mode Input Voltage Range Includes Ground, Allowing Direct Sensing Near Ground**
- **Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage:**
  - **Non-V devices . . . 26 V**
  - **V-Suffix devices . . . 32 V**
- **V-Suffix devices . . . 32 V D Open-Loop Differential Voltage Amplification . . . 100 V/mV Typ**
- **Internal Frequency Compensation**

**D OR PW PACKAGE**
**(TOP VIEW)**




## DESCRIPTION

This device consists of four independent high-gain frequency-compensated operational amplifiers that are designed specifically to operate from a single supply over a wide range of voltages. Operation from split supplies is possible when the difference between the two supplies is 3 V to 26 V (3 V to 32 V for V-suffixed devices) and $V_{CC}$ is at least 1.5 V more positive than the input common-mode voltage. The low supply-current drain is independent of the magnitude of the supply voltage.

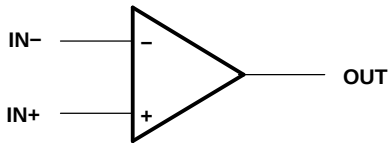
Applications include transducer amplifiers, dc amplification blocks, and all the conventional operational-amplifier circuits that now can be more easily implemented in single-supply voltage systems. For example, the LM2902 can be operated directly from the standard 5-V supply that is used in digital systems and easily provides the required interface electronics without requiring additional ±15-V supplies.

## ORDERING INFORMATION

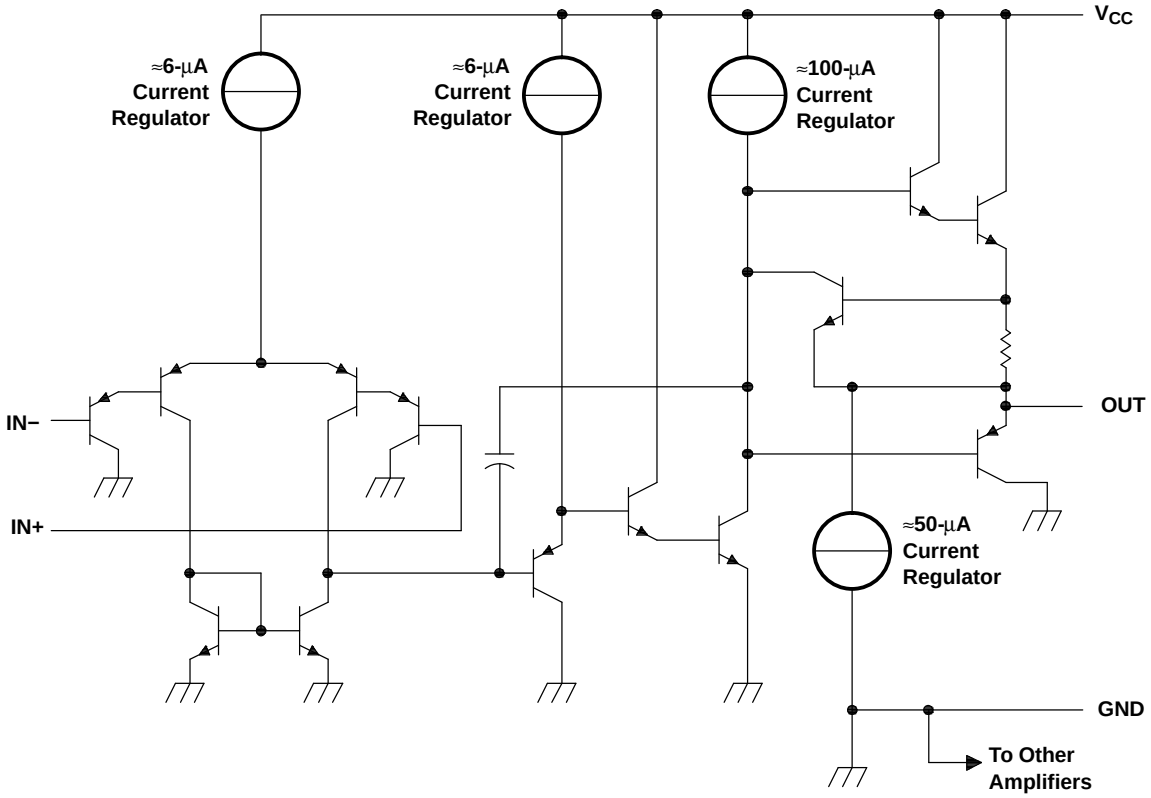
| $T_A$ | $V_{IO}$ max AT 25°C | MAX $V_{CC}$ | PACKAGE(1) | | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|---|---|---|---|---|---|---|
| –40°C to 125°C | 7 mV | 26 V | SOIC (D) | Reel of 2500 | LM2902QDREP(2) | 2902EP |
| | | | TSSOP(PW) | Reel of 2500 | LM2902QPWREP(2) | 2902EP |
| | 7 mV | 32 V | SOIC (D) | Reel of 2500 | LM2902KVQDREP(2) | 2902KVE |
| | | | TSSOP(PW) | Reel of 2500 | LM2902KVQPWREP(2) | 2902KVE |
| | 3 mV | 32 V | SOIC (D) | Reel of 2500 | LM2902KAVQDREP(2) | LM2902E |
| | | | TSSOP(PW) | Reel of 2500 | LM2902KAVQPWREP | LM2902E |
| –55°C to 125°C | 7 mV | 26 V | SOIC (D) | Reel of 2500 | LM2902MDREP(2) | 2902ME |
| | | | TSSOP(PW) | Reel of 2000 | LM2902MPWREP(2) | 2902ME |
| | 7 mV | 32 V | SOIC (D) | Reel of 2500 | LM2902KVMDREP(2) | 2902KME |
| | | | TSSOP(PW) | Reel of 2000 | LM2902KVMPWREP(2) | 2902KME |
| | 3 mV | 32 V | SOIC (D) | Reel of 2500 | LM2902KAVMDREP(2) | 2902KAE |
| | | | TSSOP(PW) | Reel of 2000 | LM2902KAVMPWREP(2) | 2902KAE |

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.
(2) Product Preview

## SYMBOL (EACH AMPLIFIER)



## SCHEMATIC (EACH AMPLIFIER)




| COMPONENT COUNT (TOTAL DEVICE) | |
|---|---|
| Epi-FET | 1 |
| Transistors | 95 |
| Diodes | 4 |
| Resistors | 11 |
| Capacitors | 4 |

## ABSOLUTE MAXIMUM RATINGS

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

| | | | LM2902-EP | LM2902KV-EP | UNIT |
|---|---|---|---|---|---|
| $V_{CC}$ | Supply voltage(2) | | 26 | 32 | V |
| $V_{ID}$ | Differential input voltage(3) | | ±26 | ±32 | V |
| $V_I$ | Input voltage (either input) | | –0.3 to 26 | –0.3 to 32 | V |
| | Duration of output short circuit (one amplifier) to ground at (or below) $T_A$ = 25°C, $V_{CC}$≤ 15 V(4) | | Unlimited | Unlimited | |
| $\theta_{JA}$ | Package thermal impedance(5)(6) | D package (0 LFPM) | 101 | 101 | °C/W |
| | | PW package | 113 | 113 | |
| $T_J$ | Operating virtual junction temperature | | 142 | 142 | °C |
| $T_{stg}$ | Storage temperature range(7) | | –65 to 150 | –65 to 150 | °C |

(1) Stresses beyond those listed under *absolute maximum ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values, except differential voltages and $V_{CC}$ specified for the measurement of $I_{OS}$, are with respect to the network GND.
(3) Differential voltages are at IN+ with respect to IN–.
(4) Short circuits from outputs to $V_{CC}$ can cause excessive heating and eventual destruction.
(5) Maximum power dissipation is a function of $T_J$(max), $\theta_{JA}$, and $T_A$. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(max) – T_A)/\theta J_A$. Operating at the absolute maximum $T_J$ of 142°C can affect reliability.
(6) The package thermal impedance is calculated in accordance with JESD 51-7.
(7) Long term high-temperature storage and/or extended use at maximum recommended operating conditions may result in reduction of overall device life. See http://www.ti.com/ep_quality for additional information on enhanced plastic packaging.

## ELECTRICAL CHARACTERISTICS

at specified free-air temperature, $V_{CC}$ = 5 V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS[1] | $T_A$[2] | LM2902-EP | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP[3] | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{CC}$ = 5 V to 26 V, $V_{IC}$ = $V_{ICR}$min, $V_O$ = 1.4 V | 25°C | | 3 | 7 | mV |
| | | | Full range | | | 10 | |
| $I_{IO}$ | Input offset current | $V_O$ = 1.4 V | 25°C | | 2 | 50 | nA |
| | | | Full range | | | 300 | |
| $I_{IB}$ | Input bias current | $V_O$ = 1.4 V | 25°C | | –20 | –250 | nA |
| | | | Full range | | | –500 | |
| $V_{ICR}$ | Common-mode input voltage range | $V_{CC}$ = 5 V to 26 V | 25°C | 0 to $V_{CC}$– 1.5 | | | V |
| | | | Full range | 0 to $V_{CC}$– 2 | | | |
| $V_{OH}$ | High-level output voltage | $R_L$ = 10 kΩ | 25°C | $V_{CC}$– 1.5 | | | V |
| | | $V_{CC}$ = 26 V, $R_L$ = 2 kΩ | Full range | 22 | | | |
| | | $V_{CC}$ = 26 V, $R_L$ ≥ 10 kΩ | 25°C | 23 | 24 | | |
| $V_{OL}$ | Low-level output voltage | $R_L$≤ 10 kΩ | Full range | | 5 | 20 | mV |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_{CC}$ = 15 V, $V_O$ = 1 V to 11 V, $R_L$≥ 2 kΩ | 25°C | | 100 | | V/mV |
| | | | Full range | 15 | | | |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min | 25°C | 50 | 80 | | dB |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$) | | 25°C | 50 | 100 | | dB |
| $V_{O1}/V_{O2}$ | Crosstalk attenuation | f = 1 kHz to 20 kHz | 25°C | | 120 | | dB |
| $I_O$ | Output current | $V_{CC}$ = 15 V, $V_{ID}$ = 1 V, $V_O$ = 0 | 25°C | –20 | –30 | | mA |
| | | | Full range | –10 | | | |
| | | $V_{CC}$ = 15 V, $V_{ID}$ = –1 V, $V_O$ = 15 V | 25°C | 10 | 20 | | mA |
| | | | Full range | 5 | | | |
| | | $V_{ID}$ = –1 V, $V_O$ = 200 mV | 25°C | | 30 | | µA |
| $I_{OS}$ | Short-circuit output current | $V_{CC}$ at 5 V, $V_O$ = 0, GND at –5 V | 25°C | | ±40 | ±60 | mA |
| $I_{CC}$ | Supply current (four amplifiers) | $V_O$ = 2.5 V, No load | Full range | | 0.7 | 1.2 | mA |
| | | $V_{CC}$ = 26 V, $V_O$ = 0.5 $V_{CC}$, No load | Full range | | 1.4 | 3 | |

(1) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified.
(2) Full range is –55°C to 125°C.
(3) All typical values are at $T_A$ = 25°C.

## ELECTRICAL CHARACTERISTICS

at specified free-air temperature, $V_{CC}$ = 5 V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS[1] | | $T_A$[2] | LM2902KV-EP | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP[3] | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{CC}$ = 5 V to 32 V, $V_{IC}$ = $V_{ICR}$min, $V_O$ = 1.4 V | Non-A devices | 25°C | | 3 | 7 | mV |
| | | | | Full range | | | 10 | |
| | | | A-suffix devices | 25°C | | 1 | 3 | |
| | | | | Full range | | | 4.5 | |
| $\Delta V_{IO}/\Delta T$ | Temperature drift | $R_S$ = 0 Ω | | Full range | | 7 | | µV/°C |
| $I_{IO}$ | Input offset current | $V_O$ = 1.4 V | | 25°C | | 2 | 50 | nA |
| | | | | Full range | | | 150 | |
| $\Delta V_{IO}/\Delta T$ | Temperature drift | | | Full range | | 10 | | pA/°C |
| $I_{IB}$ | Input bias current | $V_O$ = 1.4 V | | 25°C | | –20 | –250 | nA |
| | | | | Full range | | | –500 | |
| $V_{ICR}$ | Common-mode input voltage range | $V_{CC}$ = 5 V to 32 V | | 25°C | 0 to $V_{CC}$– 1.5 | | | V |
| | | | | Full range | 0 to $V_{CC}$– 2 | | | |
| $V_{OH}$ | High-level output voltage | $R_L$ = 10 kΩ | | 25°C | $V_{CC}$– 1.5 | | | V |
| | | $V_{CC}$ = 32 V, | $R_L$ = 2 kΩ | Full range | 26 | | | |
| | | $V_{CC}$ = 32 V, | $R_L$≥ 10 kΩ | Full range | 27 | | | |
| $V_{OL}$ | Low-level output voltage | $R_L$ = 10 kΩ | | Full range | | 5 | 20 | mV |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_{CC}$ = 15 V, $V_O$ = 1 V to 11 V, $R_L$≥ 2 kΩ | | 25°C | 25 | 100 | | V/mV |
| | | | | Full range | 15 | | | |
| | Amplifier-to-amplifier coupling[4] | f = 1 kHz to 20 kHz, input referred | | 25°C | | 120 | | dB |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min | | 25°C | 60 | 80 | | dB |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC}$ /$\Delta V_{IO}$) | | | 25°C | 60 | 100 | | dB |
| $V_{O1}$/ $V_{O2}$ | Crosstalk attenuation | f = 1 kHz to 20 kHz | | 25°C | | 120 | | dB |
| $I_O$ | Output current | $V_{CC}$ = 15, $V_{ID}$ = 1 V, | $V_O$ = 0 | 25°C | –20 | –30 | | mA |
| | | | | Full range | –10 | | | |
| | | $V_{CC}$ = 15 V, $V_{ID}$ = -1 V, | $V_O$ = 15 V | 25°C | 10 | 20 | | mA |
| | | | | Full range | 5 | | | |
| | | $V_{ID}$ = –1 V, | $V_O$ = 200 mV | 25°C | 12 | 40 | | µA |
| $I_{OS}$ | Short-circuit output current | $V_{CC}$ at 5 V, GND at –5 V | $V_O$ = 0, | 25°C | | ±40 | ±60 | mA |
| $I_{CC}$ | Supply current (four amplifiers) | $V_O$ = 2.5 V, | No load | Full range | | 0.7 | 1.2 | mA |
| | | $V_{CC}$ = 32 V, $V_O$ = 0.5 $V_{CC}$, | No load | Full range | | 1.4 | 3 | |

(1) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified.
(2) Full range is –55°C to 125°C.
(3) All typical values are at $T_A$ = 25°C.
(4) Due to proximity of external components, ensure that coupling is not originating via stray capacitance between these external parts. Typically, this can be detected, as this type of coupling increases at higher frequencies.

## OPERATING CONDITIONS

$V_{CC}$ = ±15 V, $T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | TYP | UNIT |
|---|---|---|---|---|
| SR | Slew rate at unity gain | $R_L$ = 1 MΩ, $C_L$ = 30 pF, $V_I$ = ±10 V (see Figure 1) | 0.5 | V/μs |
| $B_1$ | Unity-gain bandwidth | $R_L$ = 1 MΩ, $C_L$ = 20 pF (see Figure 1) | 1.2 | MHz |
| $V_n$ | Equivalent input noise voltage | $R_S$ = 100 Ω, $V_I$ = 0 V, f = 1 kHz (see Figure 2) | 35 | nV/√Hz |

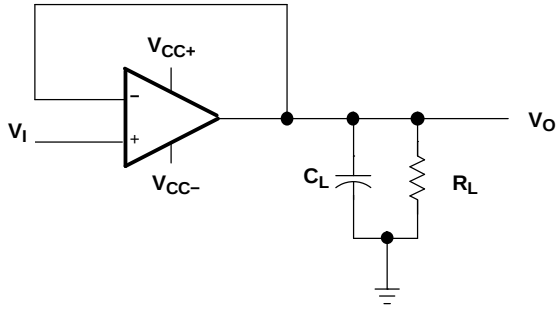



**Figure 1. Unity-Gain Amplifier**

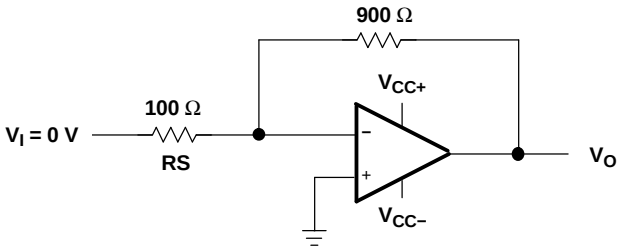
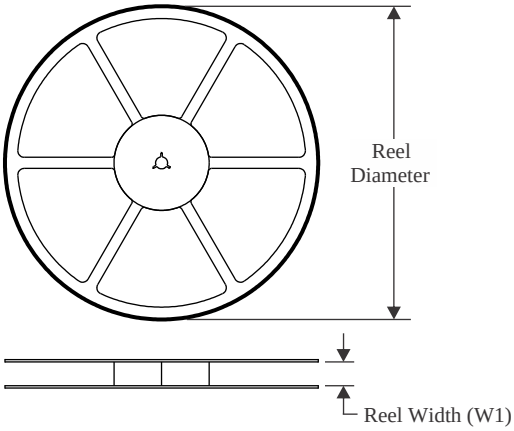


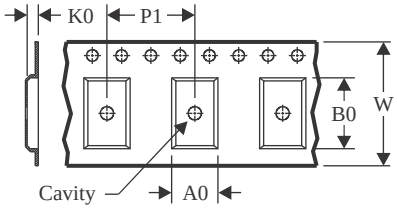

**Figure 2. Noise-Test Circuit**

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

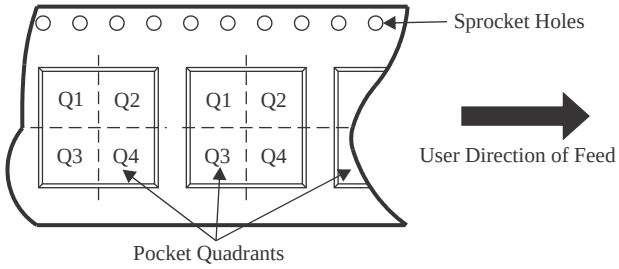



**TAPE DIMENSIONS**




| | |
|---|---|
| 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 |

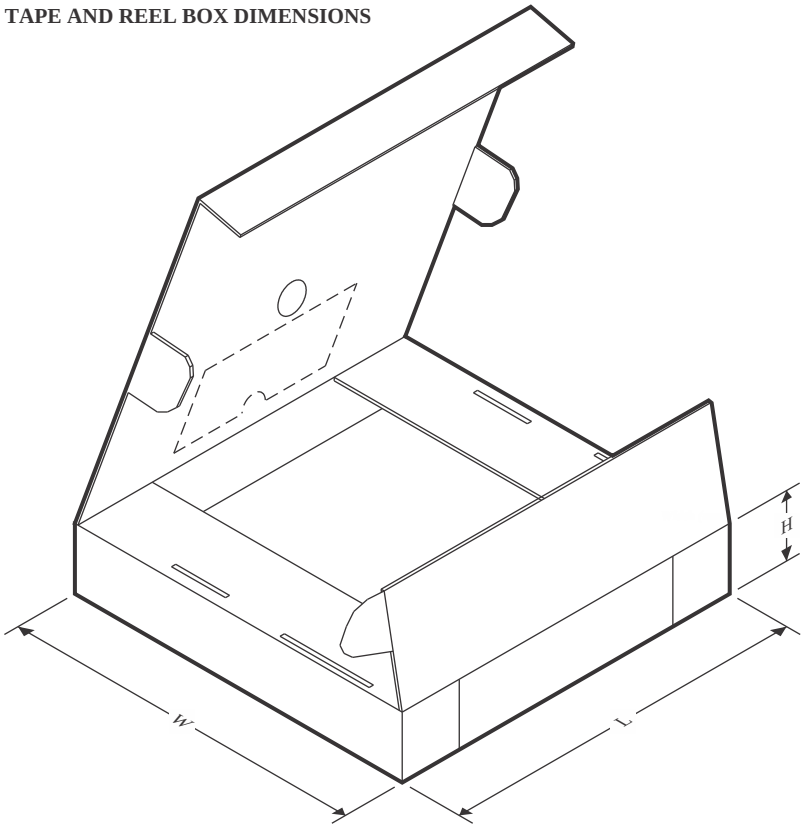
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LM2902KAVMPWREP | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |
| LM2902KAVQPWREP | TSSOP | PW | 14 | 2000 | 330.0 | 12.4 | 6.9 | 5.6 | 1.6 | 8.0 | 12.0 | Q1 |

TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

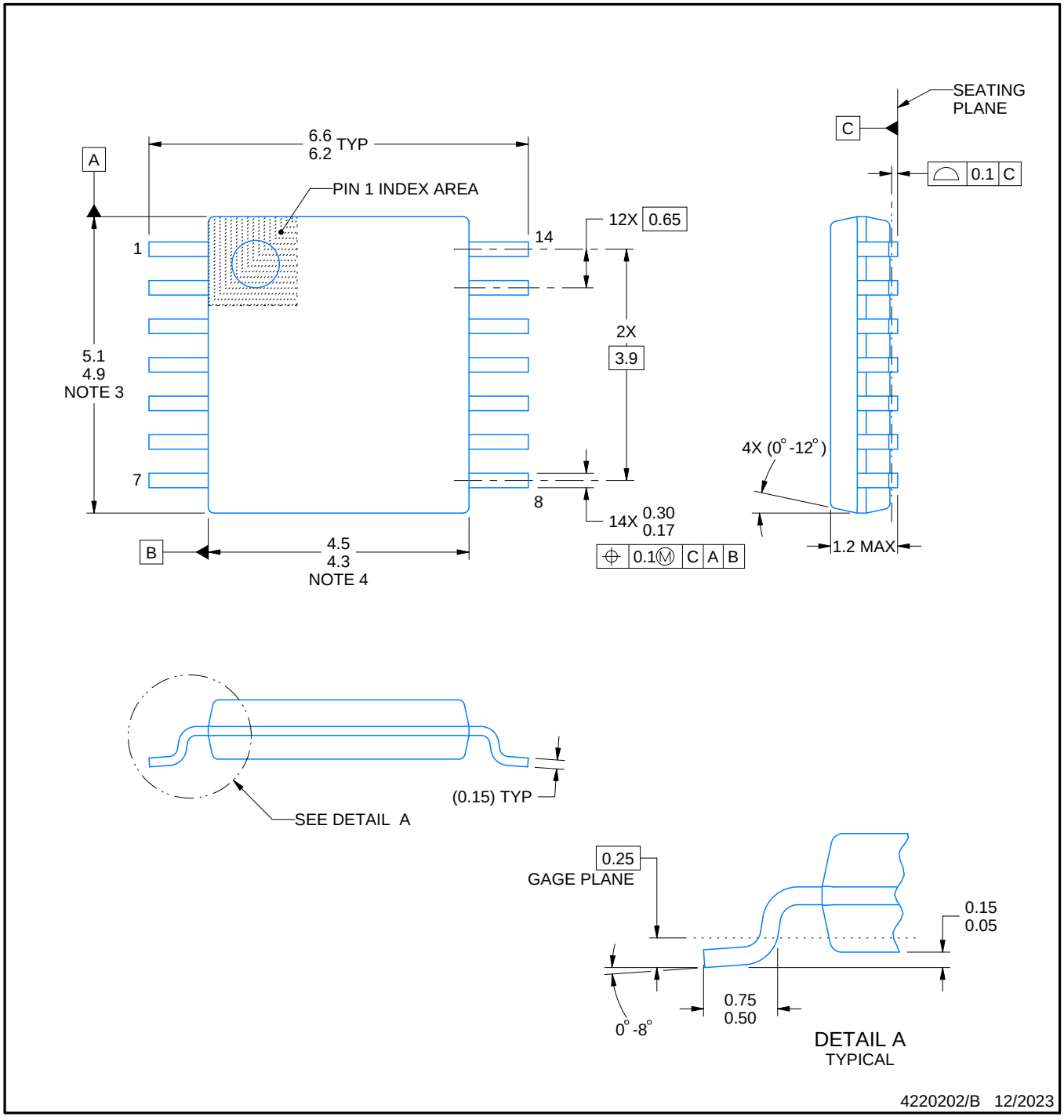
| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| LM2902KAVMPWREP | TSSOP | PW | 14 | 2000 | 356.0 | 356.0 | 35.0 |
| LM2902KAVQPWREP | TSSOP | PW | 14 | 2000 | 356.0 | 356.0 | 35.0 |

# PACKAGE OUTLINE

## PW0014A

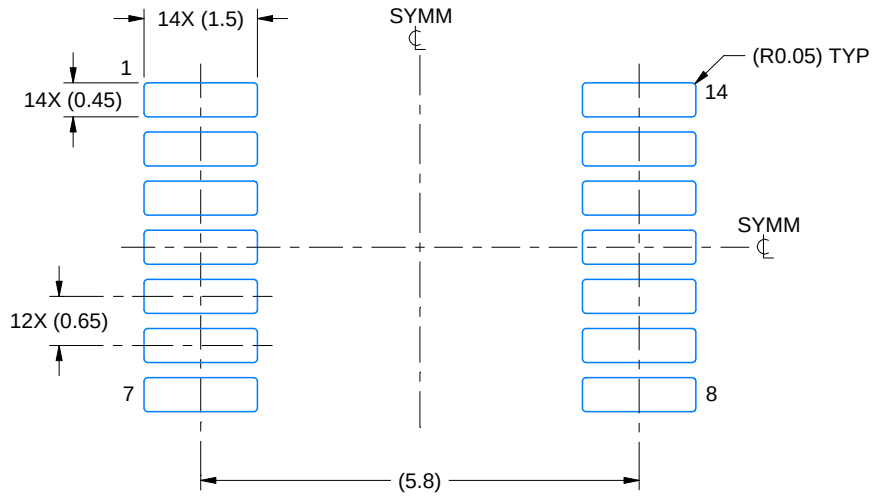
## TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE

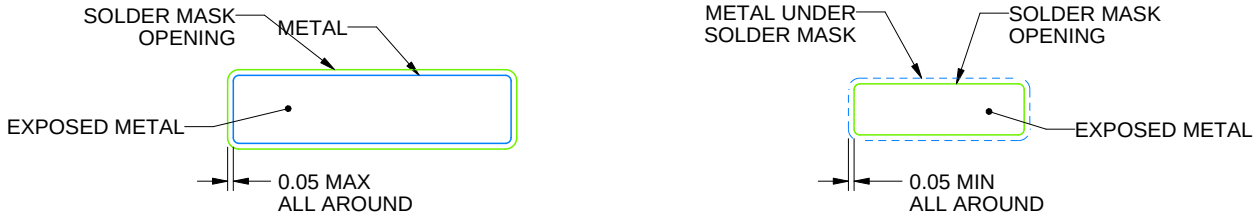



NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X




SOLDER MASK DETAILS

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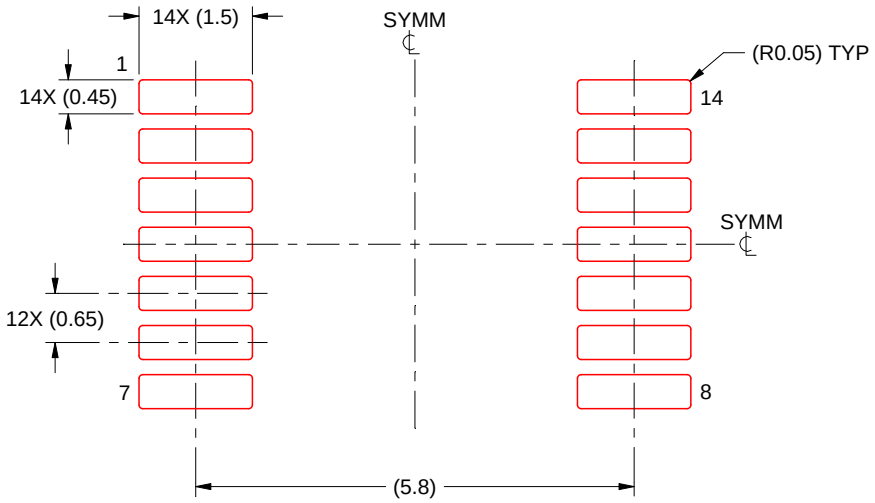
NOTES: (continued)

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




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

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NOTES: (continued)

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

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