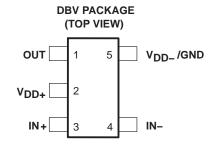
TLV2721, TLV2721Y Advanced LinCMOS™ RAÍL-TO-RAIL VERY LOW-POWER SINGLE OPERATIONAL AMPLIFIERS

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- **Output Swing Includes Both Supply Rails**
- Low Noise . . . 19 nV/ $\sqrt{\text{Hz}}$ Typ at f = 1 kHz
- Low Input Bias Current . . . 1 pA Typ
- Fully Specified for Single-Supply 3-V and 5-V Operation
- Very Low Power . . . 110 μ A Typ
- **Common-Mode Input Voltage Range Includes Negative Rail**
- Wide Supply Voltage Range 2.7 V to 10 V
- Macromodel Included



description

The TLV2721 is a single low-voltage operational amplifier available in the SOT-23 package. It offers a compromise between the ac performance and output drive of the TLV2731 and the micropower TLV2711.

It consumes only 150 µA (max) of supply current and is ideal for battery-powered applications. The device exhibits rail-to-rail output performance for increased dynamic range in single- or split-supply applications. The TLV2721 is fully characterized at 3 V and 5 V and is optimized for low-voltage applications.

The TLV2721, exhibiting high input impedance and low noise, is excellent for small-signal conditioning for high-impedance sources, such as piezoelectric transducers. Because of the micropower dissipation levels combined with 3-V operation, these devices work well in hand-held monitoring and remote-sensing applications. In addition, the rail-to-rail output feature with single or split supplies makes this family a great choice when interfacing with analog-to-digital converters (ADCs).

With a total area of 5.6mm², the SOT-23 package only requires one third the board space of the standard 8-pin SOIC package. This ultra-small package allows designers to place single amplifiers very close to the signal source, minimizing noise pick-up from long PCB traces.

AVAILABLE OPTIONS

| T. | V AT 2520 | PACKAGED DEVICES | CYMPOL | CHIP |
|---------------|-----------------------------|------------------|--------|--------------------------|
| TA | V _{IO} max AT 25°C | SOT-23 (DBV)† | | FORM [‡] (Y) |
| 0°C to 70°C | 3 mV | TLV2721CDBV | VAKC | TI V2721Y |
| -40°C to 85°C | 3 mV | TLV2721IDBV | VAKI | ILVZ/ZIY |

[†]The DBV package available in tape and reel only.



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

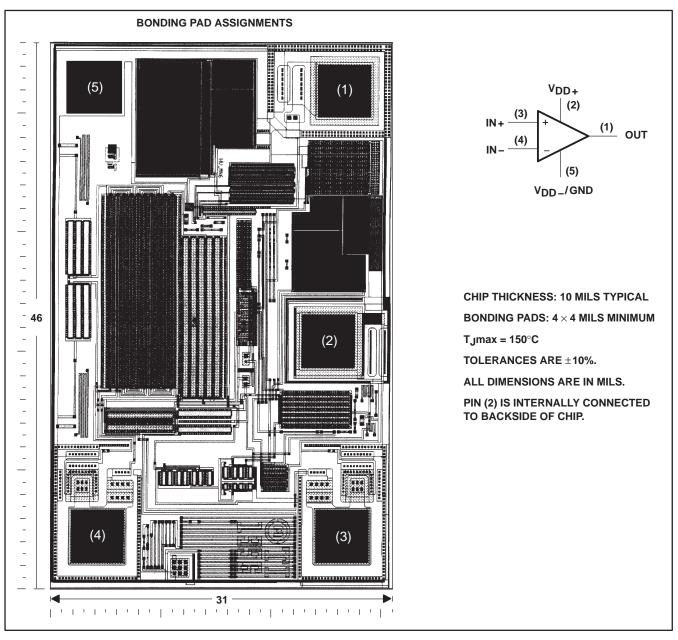
Advanced LinCMOS is a trademark of Texas Instruments



[‡]Chip forms are tested at T_A = 25°C only.

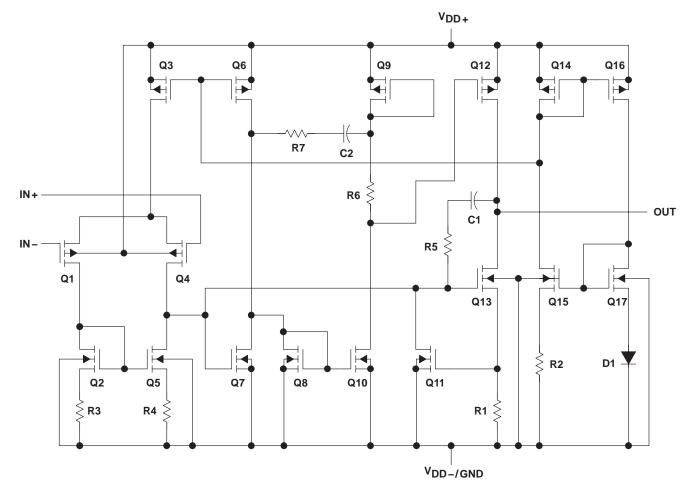
TLV2721Y chip information

This chip, when properly assembled, displays characteristics similar to the TLV2721C. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. This chip may be mounted with conductive epoxy or a gold-silicon preform.





equivalent schematic



| COMPONENT COUNT | | | | | | |
|-----------------|----|--|--|--|--|--|
| Transistors | 23 | | | | | |
| Diodes | 5 | | | | | |
| Resistors | 11 | | | | | |
| Capacitors | 2 | | | | | |

[†] Includes both amplifiers and all ESD, bias, and trim circuitry

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

| Supply voltage, V _{DD} (see Note 1) | |
|---|------------------------------|
| Differential input voltage, V _{ID} (see Note 2) | ±V _{DD} |
| Input voltage range, V _I (any input, see Note 1) | –0.3 V to V _{DD} |
| Input current, I _I (each input) | ±5 mA |
| Output current, I _O | ±50 mA |
| Total current into V _{DD+} | ±50 mA |
| Total current out of V _{DD} | ±50 mA |
| Duration of short-circuit current (at or below) 25°C (see Note 3) | unlimited |
| Continuous total power dissipation | See Dissipation Rating Table |
| Operating free-air temperature range, T _A : TLV2721C | 0°C to 70°C |
| TLV2721I | –40°C to 85°C |
| Storage temperature range, T _{stq} | –65°C to 150°C |
| Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: DBV package | 9 260°C |

[†] Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES: 1. All voltage values, except differential voltages, are with respect to V_{DD} _.
 - 2. Differential voltages are at the noninverting input with respect to the inverting input. Excessive current flows when input is brought below V_{DD} = 0.3 V.
 - 3. The output can be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.

DISSIPATION RATING TABLE

| PACKAGE | $T_{\mbox{A}} \le 25^{\circ}\mbox{C}$ Power rating | DERATING FACTOR ABOVE T _A = 25°C | T _A = 70°C POWER RATING | T _A = 85°C POWER RATING |
|---------|--|--|---------------------------------------|---------------------------------------|
| DBV | 150 mW | 1.2 mW/°C | 96 mW | 78 mW |

recommended operating conditions

| | TLV2721C | | TL | | |
|--|-----------|-----------------------|-----------|-----------------------|------|
| | MIN | MAX | MIN | MAX | UNIT |
| Supply voltage, V _{DD} (see Note 1) | 2.7 | 10 | 2.7 | 10 | V |
| Input voltage range, V _I | V_{DD-} | V _{DD+} -1.3 | V_{DD-} | V _{DD+} -1.3 | V |
| Common-mode input voltage, V _{IC} | V_{DD-} | V _{DD+} -1.3 | V_{DD-} | V _{DD+} -1.3 | V |
| Operating free-air temperature, TA | 0 | 70 | -40 | 85 | °C |

NOTE 1: All voltage values, except differential voltages, are with respect to VDD _.



electrical characteristics at specified free-air temperature, $V_{\mbox{\scriptsize DD}}$ = 3 V (unless otherwise noted)

| | DADAMETED | TEST CON | TEST CONDITIONS | | Т | LV27210 | C . | 7 | LV2721 | | LINUT |
|-----------------|--|---|---|------------------|-------------|------------------|-----|-------------|------------------|-----|-------|
| | PARAMETER | TEST CON | IDITIONS | T _A † | MIN | TYP | MAX | MIN | TYP | MAX | UNIT |
| VIO | Input offset voltage | | | | | 0.5 | 3 | | 0.5 | 3 | mV |
| αΛΙΟ | Temperature coefficient of input offset voltage | | | Full range | | 1 | | | 1 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | $V_{DD\pm} = \pm 1.5 \text{ V},$ $V_{O} = 0,$ | | 25°C | | 0.003 | | | 0.003 | | μV/mo |
| I _{IO} | Input offset current | | | 25°C | | 0.5 | 60 | | 0.5 | 60 | pА |
| טוי | input onset current | | | Full range | | | 150 | | | 150 | pΑ |
| I _{IB} | Input bias current | | | 25°C | | 1 | 60 | | 1 | 60 | рA |
| אוי | input bias current | | | Full range | | | 150 | | | 150 | рΑ |
| Vion | Common-mode input | $R_S = 50 \Omega$ | V _{IO} ≤5 mV | 25°C | 0 to 2 | -0.3 to 2.2 | | 0 to 2 | -0.3 to 2.2 | | V |
| VICR | voltage range | NS = 50 22, | IAIOI ≥2 IIIA | Full range | 0 to 1.7 | | | 0 to 1.7 | | | V |
| | | $I_{OH} = -100 \mu A$ | | 25°C | | 2.97 | | | 2.97 | | |
| Vон | High-level output voltage | 100 | | 25°C | | 2.88 | | | 2.88 | | V |
| | voltage | $I_{OH} = -400 \mu A$ | | Full range | 2.6 | | | 2.6 | | | |
| | Lavoland autout | $V_{IC} = 1.5 V,$ | $I_{OL} = 50 \mu A$ | 25°C | | 15 | | | 15 | | |
| VOL | Low-level output voltage | V _{IC} = 1.5 V, | = 1.5 V, | 25°C | | 150 | | | 150 | | mV |
| | | V _{IC} = 1.5 v, | - ΙΟΕ = 300 μΑ | Full range | | | 500 | | | 500 | |
| | Large-signal | $V_{IO} = 1.5 \text{ V}$ $R_{I} = 2 \text{ k}\Omega^{\ddagger}$ | C = 1.5 V, $C = 1.5 \text{ V}$ $R_L = 2 \text{ k}\Omega^{\ddagger}$ | 25°C | 2 | 3 | | 2 | 3 | | |
| A_{VD} | differential voltage | $V_0 = 1.5 \text{ V},$ $V_0 = 1 \text{ V to 2 V}$ | | Full range | 1 | | | 1 | | | V/mV |
| | amplification | Ŭ | $R_L = 1 M\Omega^{\ddagger}$ | 25°C | | 250 | | | 250 | | |
| ^r id | Differential input resistance | | | 25°C | | 10 ¹² | | | 10 ¹² | | Ω |
| r _{ic} | Common-mode input resistance | | | 25°C | | 10 ¹² | | | 10 ¹² | | Ω |
| c _{ic} | Common-mode input capacitance | f = 10 kHz | | 25°C | | 6 | | | 6 | | pF |
| z _o | Closed-loop output impedance | f = 10 kHz, | A _V = 10 | 25°C | | 90 | | | 90 | | Ω |
| CMDD | Common-mode | $V_{IC} = 0 \text{ to } 1.7 \text{ V},$ | | 25°C | 70 | 82 | | 70 | 82 | | 40 |
| CMRR | rejection ratio | V _O = 1.5 V, | $R_S = 50 \Omega$ | Full range | 65 | | | 65 | | | dB |
| | Supply voltage | $V_{DD} = 2.7 \text{ V to 8}$ | /pp = 27 \/ to 8 \/ | | 80 | 95 | | 80 | 95 | | |
| ksvr | rejection ratio (ΔV _{DD} /ΔV _{IO}) | $V_{IC} = V_{DD}/2$ | No load | Full range | 80 | | | 80 | | | dB |
| lDD | Supply current | V _O = 1.5 V, | No load | 25°C | | 100 | 150 | | 100 | 150 | μА |
| טט. | Supply Sulfolit | 1.0 = 1.0 v, | 110 1000 | Full range | | | 200 | | | 200 | μΛ |

[†] Full range for the TLV2721C is 0°C to 70°C. Full range for the TLV2721I is – 40°C to 85°C.



[‡]Referenced to 1.5 V

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A = 150^{\circ}C$ extrapolated to $T_A = 25^{\circ}C$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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operating characteristics at specified free-air temperature, $V_{DD} = 3 V$

| | | TEGT CONDITIONS | | T. † | Т | LV27210 | 2 | TLV2721I | | | LINUT |
|---------------------|--------------------------------------|---|---|------------------|------|---------|-----|----------|--------|------|--------------------|
| | PARAMETER | TEST COND | ITIONS | T _A † | MIN | TYP | MAX | MIN | TYP | MAX | UNIT |
| | Claus rata at units | V= 11V+010V | D Nict | 25°C | 0.1 | 0.25 | | 0.1 | 0.25 | | |
| SR | Slew rate at unity gain | $V_O = 1.1 \text{ V to } 1.9 \text{ V},$ $C_L = 100 \text{ pF}^{\ddagger}$ | $RL = 2 K\Omega + $ | Full range | 0.05 | | | 0.05 | | | V/μs |
| ., | Equivalent input | f = 10 Hz | | 25°C | | 120 | | | 120 | | nV/√ Hz |
| Vn | noise voltage | f = 1 kHz | | 25°C | | 20 | | | 20 | | nv/√HZ |
| \/ | Peak-to-peak equivalent input | f = 0.1 Hz to 1 Hz | | 25°C | | 680 | | | 680 | | mV |
| V _N (PP) | noise voltage | f = 0.1 Hz to 10 Hz | | 25°C | 860 | | 860 | | | IIIV | |
| In | Equivalent input noise current | | | 25°C | | 0.6 | | | 0.6 | | fA/√Hz |
| | Total harmonic distortion plus noise | V _O = 1 V to 2 V, | A _V = 1 | 0500 | | 2.52% | | | 2.52% | | |
| T. 15. A. | | f = 20 kHz, $R_L = 2 \text{ k}\Omega^{\ddagger}$ | A _V = 10 | 25°C | | 7.01% | | | 7.01% | | |
| THD+N | | $V_0 = 1 \text{ V to 2 V},$ | A _V = 1 | 25°C | | 0.076% | | | 0.076% | | |
| | | $f = 20 \text{ kHz},$ $R_L = 2 \text{ k}\Omega$ | A _V = 10 | 25°C | | 0.147% | | | 0.147% | | |
| | Gain-bandwidth product | f = 1 kHz, C _L = 100 pF‡ | $R_L = 2 k\Omega^{\ddagger}$, | 25°C | | 480 | | | 480 | | kHz |
| ВОМ | Maximum output-swing bandwidth | $V_{O(PP)} = 1 \text{ V},$ $R_{L} = 2 \text{ k}\Omega^{\ddagger},$ | A _V = 1, C _L = 100 pF‡ | 25°C | | 30 | | | 30 | | kHz |
| | Ostilla antica | $A_{V} = -1$, Step = 1 V to 2 V, | To 0.1% | 25°C | | 4.5 | | | 4.5 | | μs |
| t _S | Settling time | $R_L = 2 k\Omega^{\ddagger},$ $C_L = 100 pF^{\ddagger}$ | To 0.01% | 25°C | | 6.8 | | | 6.8 | | μs |
| φm | Phase margin at unity gain | $R_1 = 2 k\Omega^{\ddagger}$ | C _L = 100 pF‡ | 25°C | | 53° | _ | | 53° | _ | |
| | Gain margin | 1 | - ' | 25°C | | 12 | | | 12 | | dB |

[†] Full range is –40°C to 85°C.



[‡]Referenced to 1.5 V

[§] Referenced to 0 V

electrical characteristics at specified free-air temperature, $V_{DD} = 5 \text{ V}$ (unless otherwise noted)

| | PARAMETER | TEST CON | IDITIONS | T. + | TLV2721C | | ٦ | ΓLV2721I | | | | |
|-----------------|---|---|---|------------------|-------------|------------------|-----|-------------|------------------|-----|----------|--|
| | PARAWETER | TEST CON | DITIONS | T _A † | MIN | TYP | MAX | MIN | TYP | MAX | UNIT | |
| VIO | Input offset voltage | | | | | 0.5 | 3 | | 0.5 | 3 | mV | |
| αΝΙΟ | Temperature coefficient of input offset voltage | | | Full range | | 1 | | | 1 | | μV/°C | |
| | Input offset voltage long-term drift (see Note 4) | $V_{DD\pm} = \pm 2.5 \text{ V},$ $V_{O} = 0,$ | $V_{IC} = 0,$ RS = 50 Ω | 25°C | | 0.003 | | | 0.003 | | μV/mo | |
| lio | Input offset current | | | 25°C | | 0.5 | 60 | | 0.5 | 60 | pА | |
| liO | input onset current | | | Full range | | | 150 | | | 150 | PΑ | |
| I _{IB} | Input bias current | | | 25°C | | 1 | 60 | | 1 | 60 | pА | |
| ııB | input bias current | | | Full range | | | 150 | | | 150 | РΛ | |
| V | Common-mode input | D - 50 0 | $S = 50 \Omega$, $ V_{IO} \le 5 \text{ mV}$ | 25°C | 0 to 4 | -0.3 to 4.2 | | 0 to 4 | -0.3 to 4.2 | | V | |
| VICR | voltage range | RS = 50 12, | l∧IOI ≥2 m∧ | Full range | 0 to 3.5 | | | 0 to 3.5 | | | V | |
| | High-level output | $I_{OH} = -500 \mu A$ | | | 4.75 | 4.88 | | 4.75 | 4.88 | | | |
| VOH | voltage | I _{OH} = -1 mA | | 25°C | 4.6 | 4.76 | | 4.6 | 4.76 | | V | |
| | | V _{IC} = 2.5 V, | I _{OL} = 50 μA | 25°C | | 12 | | | 12 | | | |
| VOL | Low-level output voltage | V 0.5.V | I _{OL} = 500 μA | 25°C | | 120 | | | 120 | | mV | |
| | voltago | $V_{IC} = 2.5 V,$ | | Full range | | | 500 | | | 500 | | |
| | Large-signal | $V_{IC} = 2.5 \text{ V}, \qquad R_{L} = 2 \text{ k}\Omega^{\ddagger}$ | . D olot | 25°C | 3 | 5 | | 3 | 5 | | | |
| A_{VD} | differential voltage | $V_{IC} = 2.5 \text{ V},$ $V_{O} = 1 \text{ V to 4 V}$ | K[= 2 K22+ | Full range | 1 | | | 1 | | | V/mV | |
| | amplification | VO = 1 V 10 + V | $R_L = 1 M\Omega^{\ddagger}$ | 25°C | | 800 | | | 800 | | | |
| ^r id | Differential input resistance | | | 25°C | | 10 ¹² | | | 10 ¹² | | Ω | |
| r _{ic} | Common-mode input resistance | | | 25°C | | 10 ¹² | | | 1012 | | Ω | |
| c _{ic} | Common-mode input capacitance | f = 10 kHz | | 25°C | | 6 | | | 6 | | pF | |
| z ₀ | Closed-loop output impedance | f = 10 kHz, | A _V = 10 | 25°C | | 70 | | | 70 | | Ω | |
| CMDD | Common-mode | $V_{IC} = 0 \text{ to } 2.7 \text{ V},$ | V _O = 1.5 V, | 25°C | 70 | 85 | | 70 | 85 | | 40 | |
| CMRR | rejection ratio | $R_S = 50 \Omega$ | | Full range | 65 | | | 65 | | | dB | |
| ksvr | Supply voltage rejection ratio | $V_{DD} = 4.4 \text{ V to 8}$ | | 25°C | 80 | 95 | | 80 | 95 | | dB | |
| OVIX | $(\Delta V_{DD} / \Delta V_{IO})$ | vIC = vDD/2, | $IC = V_{DD}/2$, No load | Full range | 80 | | | 80 | | | <u> </u> | |
| I _{DD} | Supply current | V _O = 2.5 V, | No load | 25°C | | 110 | 150 | | 110 | 150 | μА | |
| יטט. | Cappi) carroin | . U = 2.5 v, | . 10 1000 | Full range | | | 200 | | | 200 | μι | |

[†] Full range for the TLV2721C is 0°C to 70°C. Full range for the TLV2721I is – 40°C to 85°C.



[‡]Referenced to 2.5 V

NOTE 5: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A = 150^{\circ}C$ extrapolated to $T_A = 25^{\circ}C$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

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operating characteristics at specified free-air temperature, $V_{DD} = 5 \text{ V}$

| | TEGT CONDITIONS | | T. † | Т | LV27210 | | 1 | TLV2721 | I | UNIT |
|------------------------------------|---|---|--|---|--|--|--|--|--|--|
| PARAMETER | TEST CONDITIONS | | TAT | MIN | TYP | MAX | MIN | TYP | MAX | UNIT |
| Class note at society | V- 45V4-25V | D 010+ | 25°C | 0.1 | 0.25 | | 0.1 | 0.25 | | |
| gain | $V_0 = 1.5 \text{ V to } 3.5 \text{ V},$ $C_L = 100 \text{ pF}^{\ddagger}$ | $R_L = 2 \text{ k}\Omega +$, | Full range | 0.05 | | | 0.05 | | | V/μs |
| Equivalent input | f = 10 Hz | | 25°C | | 90 | | | 90 | | nV/√ Hz |
| noise voltage | f = 1 kHz | | 25°C | 19 | | | | 19 | | NV/√HZ |
| Peak-to-peak | f = 0.1 Hz to 1 Hz | | 25°C | | 800 | | | 800 | | \/ |
| noise voltage | f = 0.1 Hz to 10 Hz | | 25°C | 960 | | 960 | | | mV | |
| Equivalent input noise current | | | 25°C | | 0.6 | | | 0.6 | | fA/√ Hz |
| Total harmonic | $V_0 = 1.5 \text{ V to } 3.5 \text{ V},$ | A _V = 1 | 25°C | | 2.45% | | | 2.45% | | |
| | $R_L = 2 \text{ kHz},$ $R_L = 2 \text{ k}\Omega^{\ddagger}$ | Ay = 10 | | | 5.54% | | | 5.54% | | |
| distortion plus noise | $V_0 = 1.5 \text{ V to } 3.5 \text{ V},$ | A _V = 1 | | | 0.142% | | | 0.142% | | |
| | $f = 20 \text{ kHz},$ $R_L = 2 \text{ k}\Omega$ | Ay = 10 | 25°C | | 0.257% | | | 0.257% | | |
| Gain-bandwidth product | f = 1 kHz, C _L = 100 pF‡ | $R_L = 2 k\Omega^{\ddagger}$, | 25°C | | 510 | | | 510 | | kHz |
| Maximum output- swing bandwidth | $V_O(PP) = 1 \text{ V},$ $R_L = 2 \text{ k}\Omega^{\ddagger},$ | $A_V = 1,$ $C_L = 100 \text{ pF}^{\ddagger}$ | 25°C | | 40 | | | 40 | | kHz |
| Cattling time | $A_V = -1$, Step = 1.5 V to 3.5 V, | To 0.1% | 25°C | | 6.8 | | | 6.8 | | |
| Settling time | $R_L = 2 k\Omega^{\ddagger},$ $C_L = 100 pF^{\ddagger}$ | To 0.01% | 25°C | | 9.2 | | | 9.2 | | μs |
| Phase margin at unity gain | $R_1 = 2 k\Omega^{\ddagger}$. $C_1 = 100 pF^{\ddagger}$ | | 25°C | | 53° | | | 53° | | |
| Gain margin | _ | | 25°C | | 12 | | | 12 | | dB |
| | Equivalent input noise voltage Peak-to-peak equivalent input noise voltage Equivalent input noise current Total harmonic distortion plus noise Gain-bandwidth product Maximum output- swing bandwidth Settling time Phase margin at unity gain | Slew rate at unity gain $ \begin{array}{c} \text{Slew rate at unity} \\ \text{gain} \end{array} $ | Slew rate at unity gain $ \begin{array}{c} V_O = 1.5 \ V \ to \ 3.5 \ V, \\ C_L = 100 \ pF^{\ddagger} \end{array} $ $ \begin{array}{c} F_L = 2 \ k\Omega^{\ddagger}, \\ F_L = 2 \ k\Omega$ | Slew rate at unity gain $ \begin{array}{c} & & & & & & & & & & & & & & & & & & &$ | Slew rate at unity gain $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 \text{ pF}^{\ddagger}$ $V_{O} = 1.5 \text{ V to } 3.5 \text{ V}, C_{L} = 100 $ | $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$ |

[†] Full range is –40°C to 85°C.



[‡]Referenced to 2.5 V

[§] Referenced to 0 V

electrical characteristics at V_{DD} = 3 V, T_A = 25°C (unless otherwise noted)

| | PARAMETER | TEST C | ONDITIONS | | TI | _V2721Y | ′ | |
|-----------------|--|--|------------------------------------|-------------------|-----|----------------|-----|------|
| | PARAMETER | l lESI C | ОИДПІОИЗ | 1 | MIN | TYP | MAX | UNIT |
| VIO | Input offset voltage | | | | | 620 | | μV |
| IIO | Input offset current | $V_{DD} \pm = \pm 1.5 \text{ V},$ Rs = 50 \Omega | VIC = 0 | $V_{O} = 0$, | | 0.5 | 60 | pA |
| I _{IB} | Input bias current | 115 - 00 22 | | | | 1 | 60 | pA |
| VICR | Common-mode input voltage range | V _{IO} ≤5 mV, | Rs = 50 Ω | | | -0.3 to 2.2 | | ٧ |
| Vон | High-level output voltage | $I_{OH} = -100 \mu A$ | | | | 2.97 | | V |
| , , | Law law law and a street well- | V _{IC} = 1.5 V, | I _{OL} = 50 μ/ | 4 | | 15 | | \/ |
| VOL | Low-level output voltage | V _{IC} = 1.5 V, | I _{OL} = 500 μA | | | 150 | | mV |
| | Large-signal differential | | R _L = 2 kΩ [†] | - | | 3 | | |
| AVD | voltage amplification | $V_O = 1 \text{ V to 2 V}$ $R_L = 1 \text{ M}\Omega^{\dagger}$ | | † | | 250 | | V/mV |
| rid | Differential input resistance | | • | | | 1012 | | Ω |
| r _{ic} | Common-mode input resistance | | | | | 1012 | | Ω |
| c _{ic} | Common-mode input capacitance | f = 10 kHz | | | | 6 | | pF |
| z _o | Closed-loop output impedance | f = 10 kHz, | A _V = 10 | | | 90 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC} = 0 \text{ to } 1.7 \text{ V},$ | $V_{O} = 0$, | $R_S = 50 \Omega$ | | 82 | | dB |
| ksvr | Supply voltage rejection ratio (ΔV _{DD} /ΔV _{IO}) | $V_{DD} = 2.7 \text{ V to 8 V},$ | V _{IC} = 0, | No load | | 95 | | dB |
| I _{DD} | Supply current | V _O = 0, | No load | | | 100 | | μΑ |

[†] Referenced to 1.5 V

electrical characteristics at V_{DD} = 5 V, T_{A} = 25 $^{\circ}\text{C}$ (unless otherwise noted)

| | DADAMETED | TEST | ONDITIONS | | TI | LV2721Y | 1 | |
|-----------------|--|--|-----------------------------|-------------------|-----|----------------|-----|------|
| | PARAMETER | lesi c | ONDITIONS | ' | MIN | TYP | MAX | UNIT |
| VIO | Input offset voltage | | | | | 610 | | μV |
| IIO | Input offset current | $V_{DD} \pm = \pm 1.5 \text{ V},$ $R_S = 50 \Omega$ | VIC = 0, | VO = 0, | | 0.5 | 60 | рА |
| I _{IB} | Input bias current | 115 - 00 32 | | | | 1 | 60 | рА |
| VICR | Common-mode input voltage range | V _{IO} ≤5 mV, | Rs = 50 Ω | | | -0.3 to 4.2 | | ٧ |
| Vон | High-level output voltage | $I_{OH} = -500 \mu A$ | | | | 4.88 | | V |
| V | Lave lavel colored college | V _{IC} = 2.5 V, | Ι _Ο L = 50 μ | A | | 12 | | >/ |
| VOL | Low-level output voltage | V _{IC} = 2.5 V, | I _{OL} = 500 į | ıΑ | | 120 | | mV |
| | Large-signal differential | ., .,, | $R_L = 2 k\Omega^{\dagger}$ | - | | 5 | | |
| AVD | voltage amplification | $V_O = 1 \text{ V to 4 V}$ | R _L = 1 MΩ | † | | 800 | | V/mV |
| r _{id} | Differential input resistance | | • | | | 1012 | | Ω |
| r _{ic} | Common-mode input resistance | | | | | 1012 | | Ω |
| c _{ic} | Common-mode input capacitance | f = 10 kHz | | | | 6 | | pF |
| z _o | Closed-loop output impedance | f = 10 kHz, | A _V = 10 | | | 70 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC} = 0 \text{ to } 1.7 \text{ V},$ | $V_{O} = 0$, | $R_S = 50 \Omega$ | | 85 | | dB |
| ksvr | Supply voltage rejection ratio (ΔV _{DD} /ΔV _{IO}) | $V_{DD} = 2.7 \text{ V to 8 V},$ | V _{IC} = 0, | No load | | 95 | | dB |
| I _{DD} | Supply current | V _O = 0, | No load | | | 110 | | μΑ |

[†]Referenced to 2.5 V

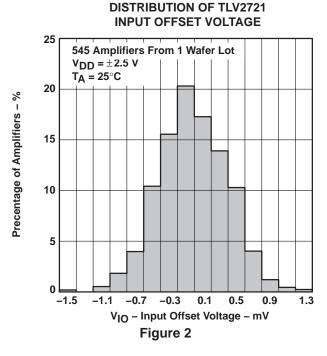


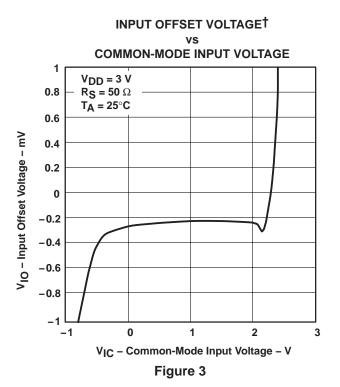
Table of Graphs

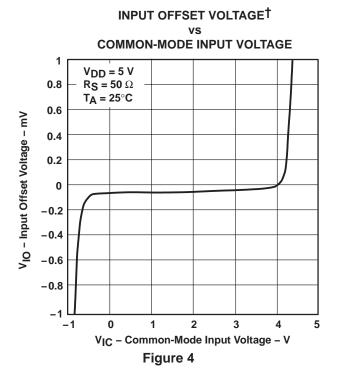
| | | | FIGURE |
|----------------------------------|---|---|------------------|
| V _{IO} | Input offset voltage | Distribution vs Common-mode input voltage | 1, 2 3, 4 |
| ανιο | Input offset voltage temperature coefficient | Distribution | 5, 6 |
| I _{IB} /I _{IO} | Input bias and input offset currents | vs Free-air temperature | 7 |
| VI | Input voltage | vs Supply voltage vs Free-air temperature | 8 9 |
| Vон | High-level output voltage | vs High-level output current | 10, 13 |
| V _{OL} | Low-level output voltage | vs Low-level output current | 11, 12, 14 |
| V _{O(PP)} | Maximum peak-to-peak output voltage | vs Frequency | 15 |
| los | Short-circuit output current | vs Supply voltage vs Free-air temperature | 16 17 |
| Vo | Output voltage | vs Differential input voltage | 18, 19 |
| AVD | Differential voltage amplification | vs Load resistance | 20 |
| A _{VD} | Large signal differential voltage amplification | vs Frequency vs Free-air temperature | 21, 22 23, 24 |
| z _O | Output impedance | vs Frequency | 25, 26 |
| CMRR | Common-mode rejection ratio | vs Frequency vs Free-air temperature | 27 28 |
| ksvr | Supply-voltage rejection ratio | vs Frequency vs Free-air temperature | 29, 30 31 |
| I _{DD} | Supply current | vs Supply voltage | 32 |
| SR | Slew rate | vs Load capacitance vs Free-air temperature | 33 34 |
| VO | Inverting large-signal pulse response | | 35, 36 |
| VO | Voltage-follower large-signal pulse response | | 37, 38 |
| VO | Inverting small-signal pulse response | | 39, 40 |
| VO | Voltage-follower small-signal pulse response | | 41, 42 |
| Vn | Equivalent input noise voltage | vs Frequency | 43, 44 |
| | Input noise voltage (referred to input) | Over a 10-second period | 45 |
| THD + N | Total harmonic distortion plus noise | vs Frequency | 46 |
| | Gain-bandwidth product | vs Free-air temperature vs Supply voltage | 47 48 |
| φm | Phase margin | vs Frequency vs Load capacitance | 21, 22 51, 52 |
| | Gain margin | vs Load capacitance | 49, 50 |
| B ₁ | Unity-gain bandwidth | vs Load capacitance | 53, 54 |



DISTRIBUTION OF TLV2721 INPUT OFFSET VOLTAGE 20 545 Amplifiers From 1 Wafer Lot 18 $V_{DD} = \pm 1.5 \text{ V}$ 16 T_A = 25°C Precentage of Amplifiers - % 14 12 10 8 6 4 2 -1.5 -1.1 -0.7 -0.3 0.1 0.5 1.3 0.9 VIO - Input Offset Voltage - mV Figure 1







 \dagger For all curves where $V_{DD} = 5$ V, all loads are referenced to 2.5 V. For all curves where $V_{DD} = 3$ V, all loads are referenced to 1.5 V.



DISTRIBUTION OF TLV2721 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT[†]

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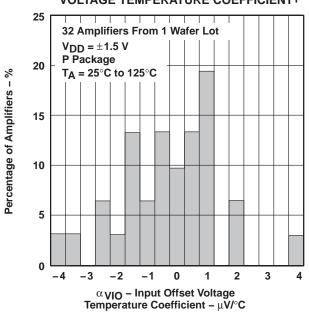
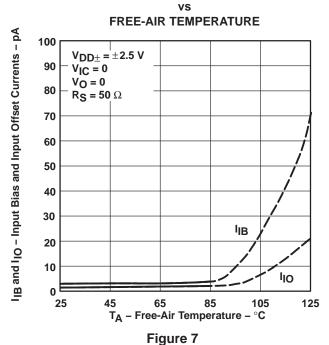


Figure 5

INPUT BIAS AND INPUT OFFSET CURRENTS



DISTRIBUTION OF TLV2721 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT[†]

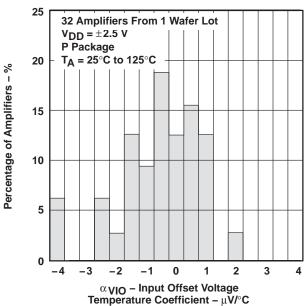
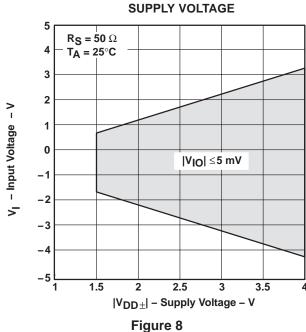


Figure 6

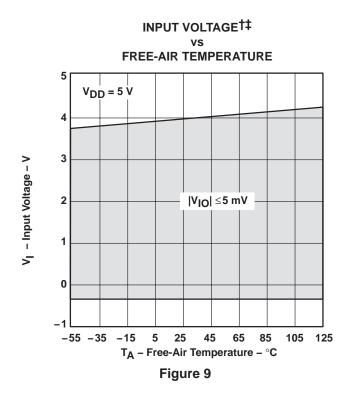
INPUT VOLTAGE VS SUPPLY VOLTAGE

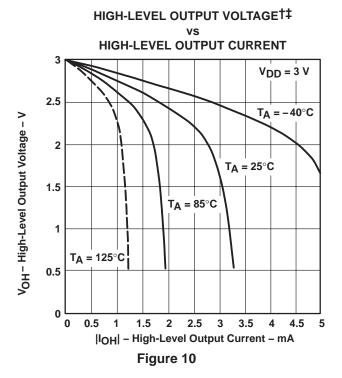


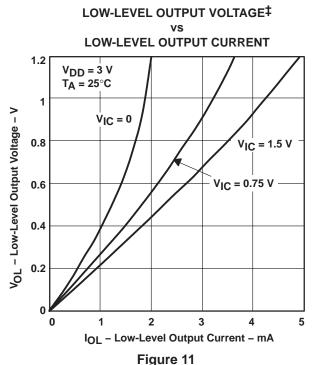
[†]Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

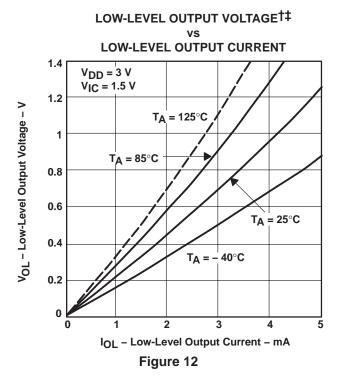


TYPICAL CHARACTERISTICS





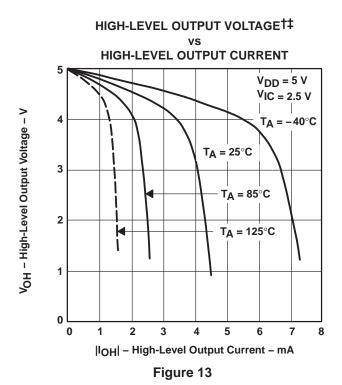


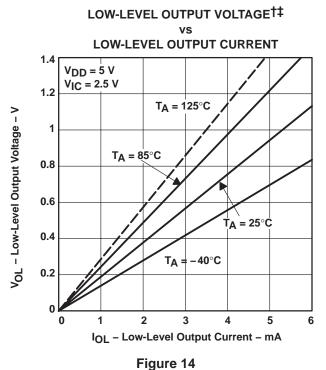


[†] Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

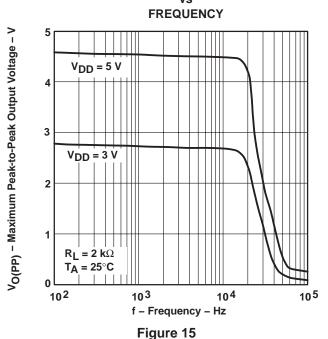
[‡] For all curves where V_{DD} = 5 V, all loads are referenced to 2.5 V. For all curves where V_{DD} = 3 V, all loads are referenced to 1.5 V.



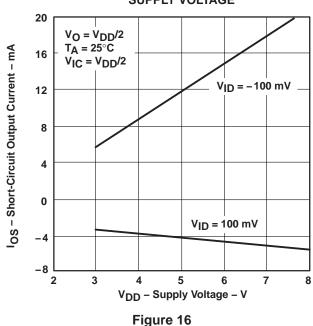




MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE‡



SHORT-CIRCUIT OUTPUT CURRENT vs SUPPLY VOLTAGE

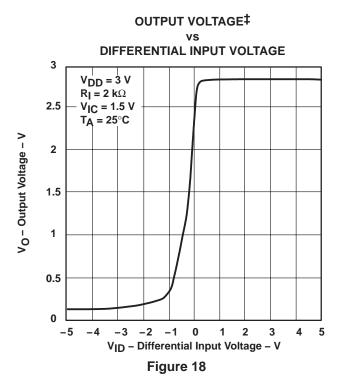


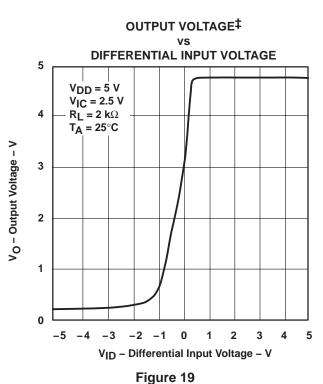
[†]Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

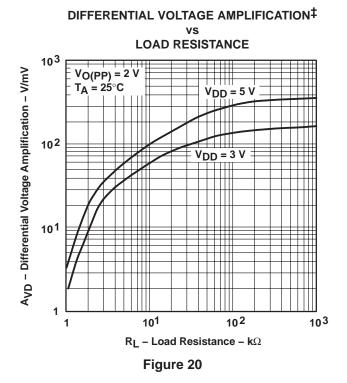
[‡] For all curves where V_{DD} = 5 V, all loads are referenced to 2.5 V. For all curves where V_{DD} = 3 V, all loads are referenced to 1.5 V.



SHORT-CIRCUIT OUTPUT CURRENT †‡ FREE-AIR TEMPERATURE 20 $V_{DD} = 5 V$ V_{IC} = 2.5 V IOS - Short-Circuit Output Current - mA 16 $V_0 = 2.5 \text{ V}$ 12 $V_{ID} = -100 \text{ mV}$ 8 $V_{ID} = 100 \text{ mV}$ -75 -50 -25 25 50 75 100 125 T_A - Free-Air Temperature - °C Figure 17







† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

‡ For all curves where V_{DD} = 5 V, all loads are referenced to 2.5 V. For all curves where V_{DD} = 3 V, all loads are referenced to 1.5 V.



LARGE-SIGNAL DIFFERENTIAL VOLTAGET **AMPLIFICATION AND PHASE MARGIN**

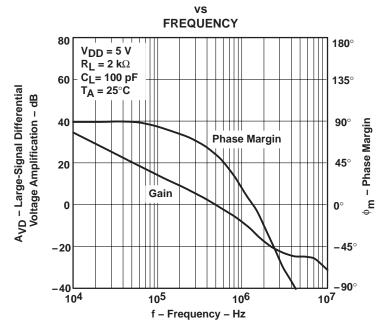
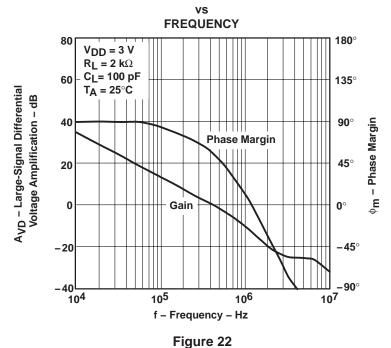


Figure 21

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGINT



† For all curves where V_{DD} = 5 V, all loads are referenced to 2.5 V. For all curves where V_{DD} = 3 V, all loads are referenced to 1.5 V.



LARGE-SIGNAL DIFFERENTIAL LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION†‡ **VOLTAGE AMPLIFICATION†**‡ FREE-AIR TEMPERATURE FREE-AIR TEMPERATURE 103 104 $V_{DD} = 5 V$ $V_{DD} = 3 V$ V_{IC} = 2.5 V V_{IC} = 1.5 V $V_0 = 1 \text{ V to 4 V}$ $V_0 = 0.5 \text{ V to } 2.5 \text{ V}$ A_{VD} - Large-Signal Differential Voltage A_{VD} - Large-Signal Differential Voltage $R_I = 1 M\Omega$ $R_L = 1 M\Omega$ 103 102 Amplification - V/mV Amplification - V/mV 102 101 $R_L = 2 k\Omega$ 101 $R_L = 2 k\Omega$ -75 -50 -25 25 100 -75 -50 -25 0 25 50 75 100 125 0 50 75 125 T_A - Free-Air Temperature - °C T_A - Free-Air Temperature - °C Figure 23 Figure 24 **OUTPUT IMPEDANCE**‡ **OUTPUT IMPEDANCE**‡ vs **FREQUENCY FREQUENCY** 1000 1000 $V_{DD} = 3 V$ $V_{DD} = 5 V$ $T_A = 25^{\circ}C$ T_A = 25°C $\mathbf{z_0}$ – Output Impedance – Ω 100 $\mathbf{z_0}$ – Output Impedance – Ω 100 $A_{V} = 100$ $A_{V} = 100$ 10 $A_{V} = 10$ 10

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

10⁵

 $A_{V} = 10$

 $A_V = 1$

101

10²

103

f- Frequency - Hz

Figure 25

104

[‡] For all curves where V_{DD} = 5 V, all loads are referenced to 2.5 V. For all curves where V_{DD} = 3 V, all loads are referenced to 1.5 V.



 $A_V = 1$

102

103

f- Frequency - Hz

Figure 26

104

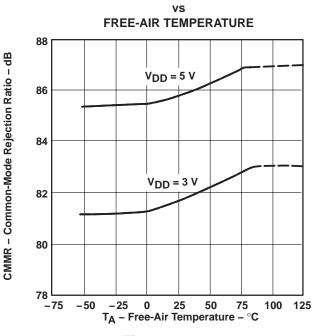
0.1

101

105

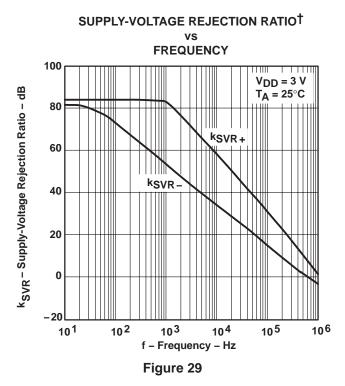
COMMON-MODE REJECTION RATIO† **FREQUENCY** 100 $T_A = 25^{\circ}C$ CMRR - Common-Mode Rejection Ratio - dB $V_{DD} = 5 V$ V_{IC} = 2.5 V 80 $V_{DD} = 3 V$ $V_{IC} = 1.5 V$ 60 40 20 101 102 103 104 105 106 f - Frequency - Hz

Figure 27



COMMON-MODE REJECTION RATIO†‡

Figure 28



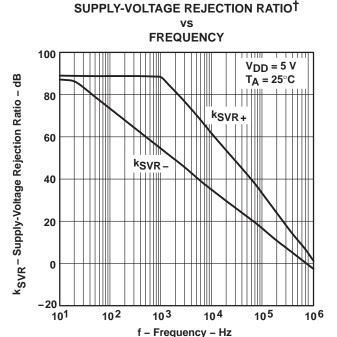


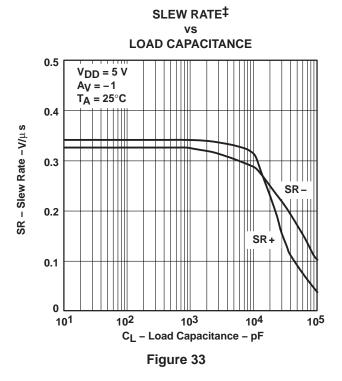
Figure 30

† For all curves where V_{DD} = 5 V, all loads are referenced to 2.5 V. For all curves where V_{DD} = 3 V, all loads are referenced to 1.5 V.

[‡] Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

SUPPLY-VOLTAGE REJECTION RATIO[†] FREE-AIR TEMPERATURE 100 $V_{DD} = 2.7 \text{ V to 8 V}$ k_{SVR} - Supply-Voltage Rejection Ratio - dB $V_{IC}^{--} = V_{O} = V_{DD}/2$ 98 96 94 92 90 -75 -50 -25 0 25 50 75 100 125 T_A - Free-Air Temperature - °C

Figure 31



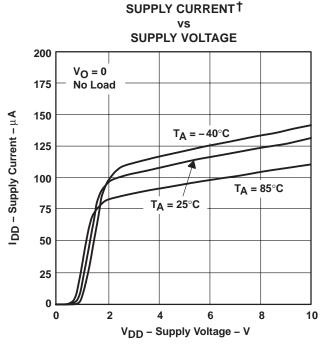
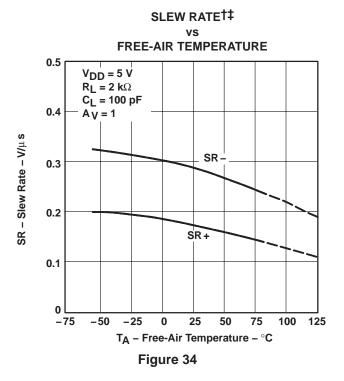


Figure 32



[†] Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

[‡] For all curves where V_{DD} = 5 V, all loads are referenced to 2.5 V. For all curves where V_{DD} = 3 V, all loads are referenced to 1.5 V.



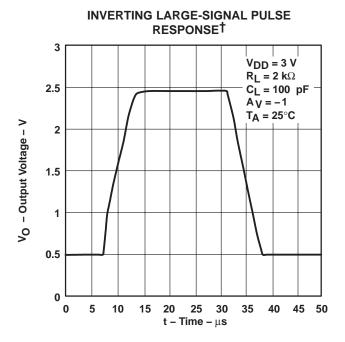


Figure 35

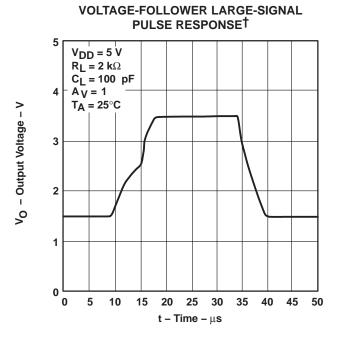


Figure 37

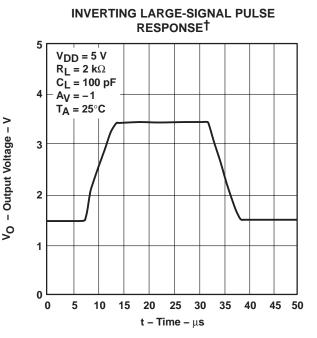


Figure 36

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE†

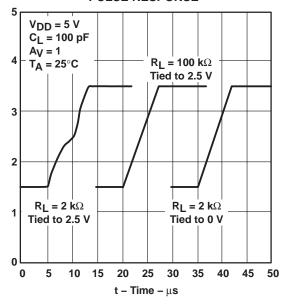


Figure 38

† For all curves where V_{DD} = 5 V, all loads are referenced to 2.5 V. For all curves where V_{DD} = 3 V, all loads are referenced to 1.5 V.

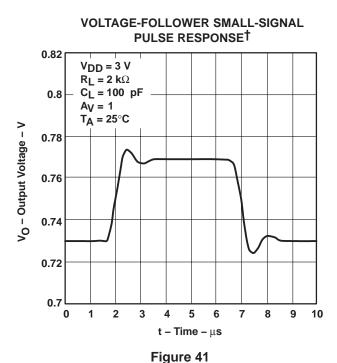


Output Voltage - V

S

INVERTING SMALL-SIGNAL PULSE RESPONSE† 0.82 $V_{DD} = 3 V$ $R_L = 2 k\Omega$ $C_{L} = 100 \text{ pF}$ 8.0 $A_V = -1$ Vo - Output Voltage - V T_A = 25°C 0.78 0.76 0.74 0.72 0.7 0.5 1 1.5 2 2.5 3 3.5 4 4.5 t – Time – μ s

Figure 39



INVERTING SMALL-SIGNAL PULSE RESPONSE†

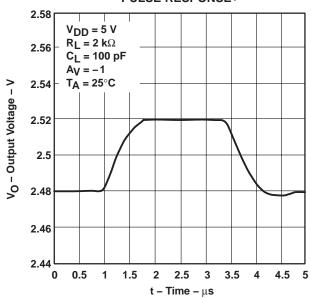


Figure 40

VOLTAGE-FOLLOWER SMALL-SIGNAL

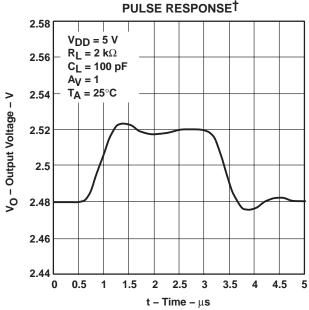


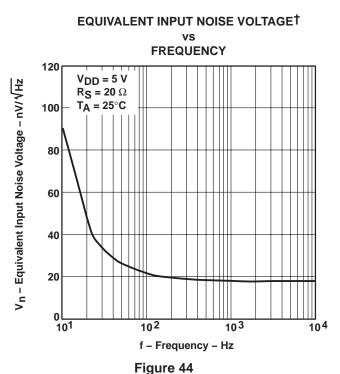
Figure 42

 \dagger For all curves where V_{DD} = 5 V, all loads are referenced to 2.5 V. For all curves where V_{DD} = 3 V, all loads are referenced to 1.5 V.



TYPICAL CHARACTERISTICS

EQUIVALENT INPUT NOISE VOLTAGE[†] **FREQUENCY** 120 V_{n} – Equivalent Input Noise Voltage – nV/\sqrt{Hz} $V_{DD} = 3 V$ $R_S = 20 \Omega$ $T_A = 25^{\circ}C$ 100 80 60 40 20 10² 10³ 10¹ 104 f - Frequency - Hz Figure 43



INPUT NOISE VOLTAGE OVER

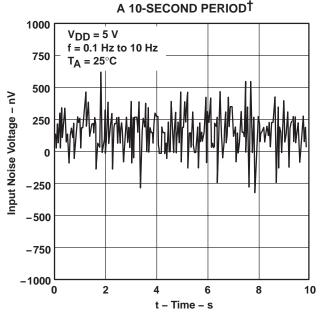


Figure 45

TOTAL HARMONIC DISTORTION PLUS NOISET

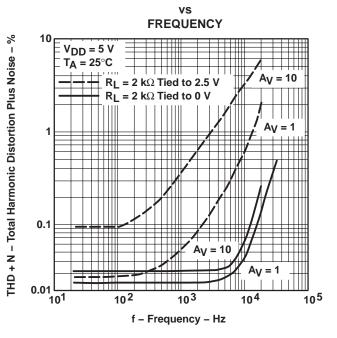
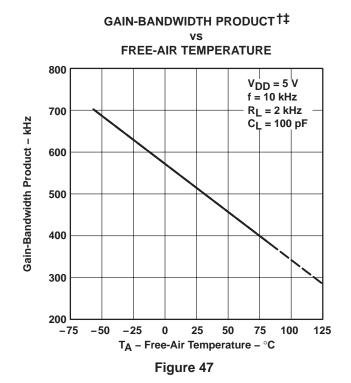


Figure 46

[†] For all curves where V_{DD} = 5 V, all loads are referenced to 2.5 V. For all curves where V_{DD} = 3 V, all loads are referenced to 1.5 V.





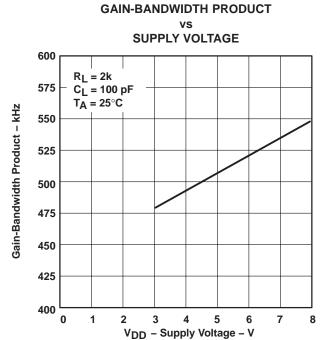
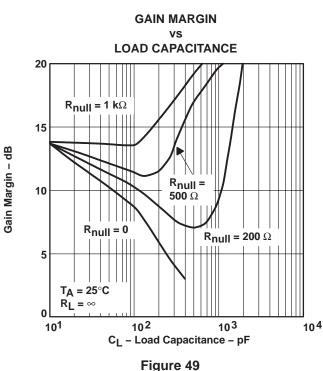
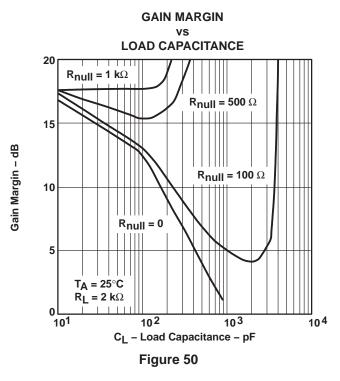


Figure 48



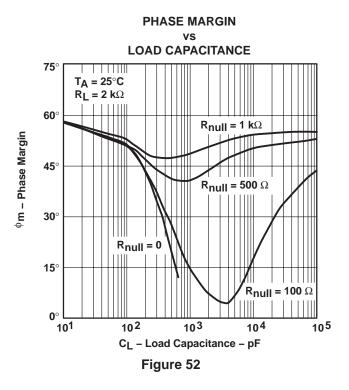


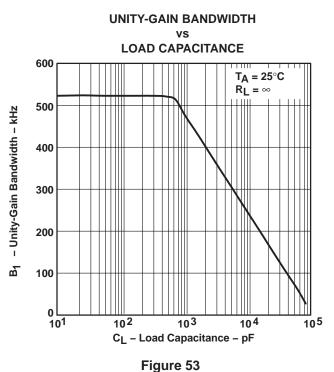
[†] Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

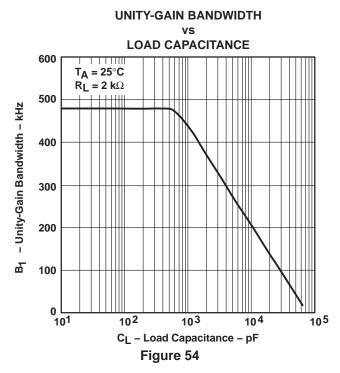
[‡] For all curves where V_{DD} = 5 V, all loads are referenced to 2.5 V. For all curves where V_{DD} = 3 V, all loads are referenced to 1.5 V.



PHASE MARGIN LOAD CAPACITANCE $T_A = 25^{\circ}C$ $R_L = \infty$ 60° R_{null} = 1 $k\Omega$ $R_{null} = 500 \Omega$ ^om – Phase Margin 45° 30° $R_{null} = 0$ $R_{null} = 200 \Omega$ 15° 0 101 103 102 105 CL - Load Capacitance - pF Figure 51







APPLICATION INFORMATION

driving large capacitive loads

The TLV2721 is designed to drive larger capacitive loads than most CMOS operational amplifiers. Figure 49 through Figure 54 illustrate its ability to drive loads greater than 100 pF while maintaining good gain and phase margins (R_{null} = 0).

A small series resistor (R_{null}) at the output of the device (Figure 55) improves the gain and phase margins when driving large capacitive loads. Figure 49 through Figure 52 show the effects of adding series resistances of $100\,\Omega$, $200\,\Omega$, $500\,\Omega$, and $1\,k\Omega$. The addition of this series resistor has two effects: the first effect is that it adds a zero to the transfer function and the second effect is that it reduces the frequency of the pole associated with the output load in the transfer function.

The zero introduced to the transfer function is equal to the series resistance times the load capacitance. To calculate the approximate improvement in phase margin, equation 1 can be used.

$$\Delta \phi_{m1} = \tan^{-1} \left(2 \times \pi \times \text{UGBW} \times R_{null} \times C_{L} \right)$$
Where:

Additional Learning and the Control of the Control

 $\Delta \varphi_{m1} \, = \, Improvement \ in \ phase \ margin$

UGBW = Unity-gain bandwidth frequency

R_{null} = Output series resistance

 C_1 = Load capacitance

The unity-gain bandwidth (UGBW) frequency decreases as the capacitive load increases (Figure 53 and Figure 54). To use equation 1, UGBW must be approximated from Figure 54 and Figure 55.

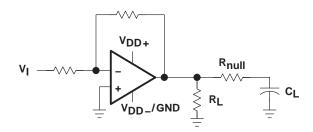


Figure 55. Series-Resistance Circuit

The TLV2721 is designed to provide better sinking and sourcing output currents than earlier CMOS rail-to-rail output devices. This device is specified to sink 500 μ A and source 1 mA at V_{DD} = 5 V at a maximum quiescent I_{DD} of 200 μ A. This provides a greater than 80% power efficiency.

When driving heavy dc loads, such as $2 \text{ k}\Omega$, the positive edge under slewing conditions can experience some distortion. This condition can be seen in Figure 37. This condition is affected by three factors:

- Where the load is referenced. When the load is referenced to either rail, this condition does not occur. The
 distortion occurs only when the output signal swings through the point where the load is referenced.
 Figure 38 illustrates two 2-kΩ load conditions. The first load condition shows the distortion seen for a 2-kΩ
 load tied to 2.5 V. The third load condition in Figure 38 shows no distortion for a 2-kΩ load tied to 0 V.
- Load resistance. As the load resistance increases, the distortion seen on the output decreases. Figure 38 illustrates the difference seen on the output for a 2-k Ω load and a 100-k Ω load with both tied to 2.5 V.
- Input signal edge rate. Faster input edge rates for a step input result in more distortion than with slower input edge rates.



APPLICATION INFORMATION

macromodel information

Macromodel information provided was derived using Microsim $Parts^{TM}$, the model generation software used with Microsim $PSpice^{TM}$. The Boyle macromodel (see Note 6) and subcircuit in Figure 56 are generated using the TLV2721 typical electrical and operating characteristics at $T_A = 25$ °C. Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

- Maximum positive output voltage swing
- Maximum negative output voltage swing
- Slew rate
- Quiescent power dissipation
- Input bias current
- Open-loop voltage amplification

- Unity-gain frequency
- Common-mode rejection ratio
- Phase margin
- DC output resistance
- AC output resistance
- Short-circuit output current limit

NOTE 6: G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, "Macromodeling of Integrated Circuit Operational Amplifiers", *IEEE Journal of Solid-State Circuits*, SC-9, 353 (1974).

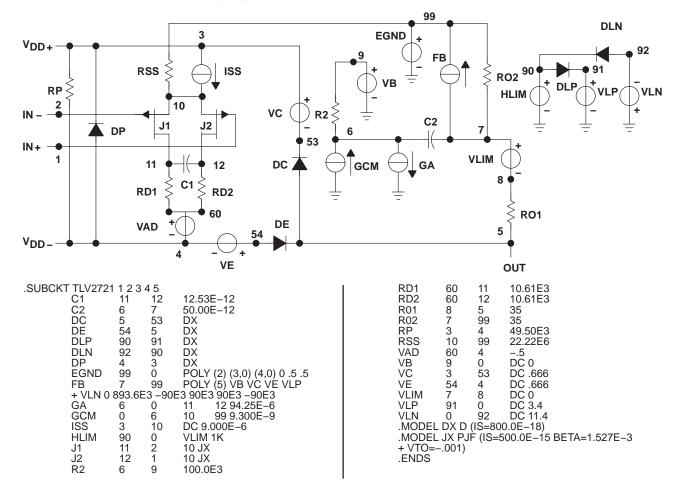


Figure 56. Boyle Macromodel and Subcircuit

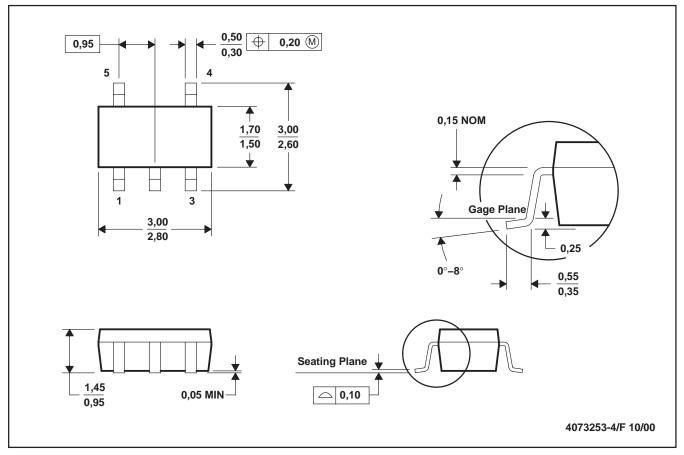
PSpice and Parts are trademark of MicroSim Corporation.



MECHANICAL INFORMATION

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE



NOTES: A. All linear dimensions are in millimeters.

B. This drawing is subject to change without notice.

C. Body dimensions do not include mold flash or protrusion.

D. Falls within JEDEC MO-178

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