

## Dual and quad, rail-to-rail input/output, 60 $\mu$ A, 880 kHz operational amplifiers

Datasheet - production data



### Features

- Rail-to-rail input and output
- Low power consumption: 60  $\mu$ A typ at 5 V
- Low supply voltage: 1.5 V - 5.5 V
- Gain bandwidth product: 880 kHz typ
- Unity gain stable on 100 pF capacitor
- Low power shutdown mode: 5 nA typ
- Low offset voltage: 800  $\mu$ V max (A version)
- Low input bias current: 1 pA typ
- EMI hardened op amps
- Automotive qualification

### Related products

- See the TSV52x series for higher merit factor (1.15 MHz for 45  $\mu$ A)
- See the TSV61x (120 kHz for 9  $\mu$ A) or TSV62x (420 kHz for 29  $\mu$ A) for more power savings

### Applications

- Battery-powered applications
- Portable devices
- Signal conditioning
- Active filtering
- Medical instrumentation

### Description

The TSV63x and TSV63xA series of dual and quad operational amplifiers offers low voltage operation and rail-to-rail input and output.

This family features an excellent speed/power consumption ratio, offering an 880 kHz gain-bandwidth product while consuming only 60  $\mu$ A at 5 V supply voltage. The devices also feature an ultralow input bias current and TSV633 and TSV635 have a shutdown mode.

These features make the TSV63x and TSV63xA family ideal for sensor interfaces, battery-supplied and portable applications, and active filtering.

Table 1: Device summary

| Reference | Dual version    |              | Quad version    |              |
|-----------|-----------------|--------------|-----------------|--------------|
|           | Without standby | With standby | Without standby | With standby |
| TSV63x    | TSV632          | TSV633       | TSV634          | TSV635       |
| TSV63xA   | TSV632A         | TSV633A      | TSV634A         | TSV635A      |

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# 1 Package pin connections

Figure 1: Pin connections for each package (top view)



1. The exposed pads of the DFN8 2x2 and the QFN16 3x3 can be connected to  $V_{CC-}$  or left floating.

## 2 Absolute maximum ratings and operating conditions

Table 2: Absolute maximum ratings (AMR)

| Symbol                    | Parameter   | Value                                  | Unit |      |
|---------------------------|---|--|------|------|
| $V_{CC}$                  | Supply voltage <sup>(1)</sup>                           | 6                                      | V    |      |
| $V_{id}$                  | Differential input voltage <sup>(2)</sup>               | $\pm V_{CC}$                           |      |      |
| $V_{in}$                  | Input voltage <sup>(3)</sup>                            | $(V_{CC-}) - 0.2$ to $(V_{CC+}) + 0.2$ |      |      |
| $I_{in}$                  | Input current <sup>(4)</sup>                            | 10                                     | mA   |      |
| $\overline{SHDN}$<br>SHDN | Shutdown voltage <sup>(3)</sup>                         | $(V_{CC-}) - 0.2$ to $(V_{CC+}) + 0.2$ | V    |      |
| $T_{stg}$                 | Storage temperature                                     | -65 to 150                             | °C   |      |
| $R_{thja}$                | Thermal resistance junction to ambient <sup>(5/6)</sup> | DFN8 2x2                               | 57   | °C/W |
|                           |   | SOT23-8                                | 105  |      |
|                           |   | MiniSO8                                | 190  |      |
|                           |   | MiniSO10                               | 113  |      |
|                           |   | SO8                                    | 125  |      |
|                           |   | QFN16 3x3                              | 39   |      |
|                           |   | TSSOP14                                | 100  |      |
| TSSOP16                   | 95  |  |      |      |
| $T_j$                     | Maximum junction temperature                            | 150                                    | °C   |      |
| ESD                       | HBM: human body model <sup>(7)</sup>                    | 4000                                   | V    |      |
|                           | MM: machine model <sup>(8)</sup>                        | 300                                    |      |      |
|                           | CDM: charged device model <sup>(9)</sup>                | 1500                                   |      |      |
|                           | Latch-up immunity                                       | 200                                    | mA   |      |

**Notes:**

- <sup>(1)</sup>All voltage values, except the differential voltage are with respect to the network ground terminal.
- <sup>(2)</sup>Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
- <sup>(3)</sup> $V_{CC} - V_{IN}$  must not exceed 6 V,  $V_{IN}$  must not exceed 6 V.
- <sup>(4)</sup>Input current must be limited by a resistor in series with the inputs
- <sup>(5)</sup> $R_{th}$  are typical values
- <sup>(6)</sup>Short-circuits can cause excessive heating and destructive dissipation
- <sup>(7)</sup>Human body model: 100 pF discharged through a 1.5 kΩ resistor between two pins of the device, done for all couples of pin combinations with other pins floating.
- <sup>(8)</sup>Machine model: a 200 pF cap is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω), done for all couples of pin combinations with other pins floating
- <sup>(9)</sup>Charged device model: all pins plus package are charged together to the specified voltage and then discharged directly to the ground.

Table 3: Operating conditions

| Symbol     | Parameter                            | Value                                  | Unit |
|------------|--------------------------------------|--|------|
| $V_{CC}$   | Supply voltage                       | 1.5 to 5.5                             | V    |
| $V_{ICM}$  | Common-mode input voltage range      | $(V_{CC-}) - 0.1$ to $(V_{CC+}) + 0.1$ |      |
| $T_{oper}$ | Operating free-air temperature range | -40 to 125                             | °C   |

### 3 Electrical characteristics

Table 4: Electrical characteristics at VCC+ = 1.8 V with VCC- = 0 V, Vicm = VCC/2, Tamb = 25° C, and RL connected to VCC/2 (unless otherwise specified)

| Symbol                | Parameter  | Conditions   | Min. | Typ. | Max.              | Unit    |
|-----------------------|--|--|------|------|-------------------|---------|
| <b>DC performance</b> |  |  |      |      |                   |         |
| V <sub>io</sub>       | Offset voltage   | TSV63x   |      |      | 3                 | mV      |
|                       |  | TSV63xA  |      |      | 0.8               |         |
|                       |  | TSV633AIST (MiniSO10)  |      |      | 1                 |         |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub> - TSV63x     |      |      | 4.5               |         |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub> - TSV63xA    |      |      | 2                 |         |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub> - TSV633AIST |      |      | 2.2               |         |
| ΔV <sub>io</sub> /ΔT  | Input offset voltage drift   |  |      | 2    |                   | μV/°C   |
| I <sub>io</sub>       | Input offset current   | (V <sub>out</sub> = V <sub>CC</sub> /2)                            |      | 1    | 10 <sup>(1)</sup> | pA      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              |      | 1    | 100               |         |
| I <sub>ib</sub>       | Input bias current   | (V <sub>out</sub> = V <sub>CC</sub> /2)                            |      | 1    | 10 <sup>(1)</sup> | pA      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              |      | 1    | 100               |         |
| CMR                   | Common mode rejection ratio 20 log (ΔV <sub>ic</sub> /ΔV <sub>io</sub> )           | 0 V to 1.8 V, V <sub>out</sub> = 0.9 V                             | 53   | 74   |                   | dB      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              | 51   |      |                   |         |
| A <sub>vd</sub>       | Large signal voltage gain  | R <sub>L</sub> = 10 kΩ, V <sub>out</sub> = 0.5 V to 1.3 V          | 85   | 95   |                   | dB      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              | 80   |      |                   |         |
| V <sub>OH</sub>       | High level output voltage, (V <sub>OH</sub> = V <sub>CC</sub> - V <sub>out</sub> ) | R <sub>L</sub> = 10 kΩ   |      | 5    | 35                | mV      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              |      |      | 50                |         |
| V <sub>OL</sub>       | Low level output voltage   | R <sub>L</sub> = 10 kΩ   |      | 4    | 35                | mV      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              |      |      | 50                |         |
| I <sub>out</sub>      | I <sub>sink</sub>  | V <sub>o</sub> = 1.8 V   | 6    | 12   |                   | mA      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              | 4    |      |                   |         |
|                       | I <sub>source</sub>  | V <sub>o</sub> = 0 V   | 6    | 10   |                   |         |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              | 4    |      |                   |         |
| I <sub>CC</sub>       | Supply current (per channel)   | No load, V <sub>out</sub> = V <sub>CC</sub> /2                     | 40   | 50   | 60                | μA      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              |      |      | 62                |         |
| <b>AC performance</b> |  |  |      |      |                   |         |
| GBP                   | Gain bandwidth product   | R <sub>L</sub> = 2 kΩ, C <sub>L</sub> = 100 pF, f = 100 kHz        | 700  | 790  |                   | kHz     |
| φ <sub>m</sub>        | Phase margin   | R <sub>L</sub> = 2 kΩ, C <sub>L</sub> = 100 pF                     |      | 45   |                   | Degrees |
| G <sub>m</sub>        | Gain margin  | R <sub>L</sub> = 2 kΩ, C <sub>L</sub> = 100 pF                     |      | 13   |                   | dB      |
| SR                    | Slew rate  | R <sub>L</sub> = 2 kΩ, C <sub>L</sub> = 100 pF, A <sub>v</sub> = 1 | 0.2  | 0.27 |                   | V/μs    |
| e <sub>n</sub>        | Equivalent input noise voltage   | f = 1 kHz  |      | 60   |                   | nV/√Hz  |
|                       |  | f = 10 kHz   |      | 33   |                   |         |

**Notes:**

<sup>(1)</sup>Guaranteed by design

Table 5: Shutdown characteristics VCC = 1.8 V

| Symbol                | Parameter                                      | Conditions   | Min. | Typ. | Max. | Unit |
|-----------------------|--|--|------|------|------|------|
| <b>DC performance</b> |  |  |      |      |      |      |
| I <sub>CC</sub>       | Supply current in shutdown mode (all channels) | $\overline{\text{SHDN}} = V_{CC-}$   |      | 2.5  | 50   | nA   |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < 85° C   |      |      | 200  |      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < 125° C  |      |      |      | 1.5  |
| t <sub>on</sub>       | Amplifier turn-on time                         | R <sub>L</sub> = 2 kΩ, V <sub>out</sub> = (V <sub>CC-</sub> ) to (V <sub>CC-</sub> ) + 0.2 V         |      | 200  |      | ns   |
| t <sub>off</sub>      | Amplifier turn-off time                        | R <sub>L</sub> = 2 kΩ, V <sub>out</sub> = (V <sub>CC+</sub> ) - 0.5 V to (V <sub>CC+</sub> ) - 0.7 V |      | 20   |      |      |
| V <sub>IH</sub>       | $\overline{\text{SHDN}}$ logic high            |  | 1.35 |      |      | V    |
| V <sub>IL</sub>       | $\overline{\text{SHDN}}$ logic low             |  |      |      | 0.6  |      |
| I <sub>IH</sub>       | $\overline{\text{SHDN}}$ current high          | $\overline{\text{SHDN}} = V_{CC+}$   |      | 10   |      | pA   |
| I <sub>IL</sub>       | $\overline{\text{SHDN}}$ current low           | $\overline{\text{SHDN}} = V_{CC-}$   |      | 10   |      |      |
| I <sub>OLeak</sub>    | Output leakage in shutdown mode                | $\overline{\text{SHDN}} = V_{CC-}$   |      | 50   |      |      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < 125° C  |      | 1    |      | nA   |

Table 6: VCC+ = 3.3 V, VCC- = 0 V, Vicm = VCC/2, Tamb = 25° C, RL connected to VCC/2 (unless otherwise specified)

| Symbol                | Parameter  | Conditions   | Min. | Typ. | Max.              | Unit    |
|-----------------------|--|--|------|------|-------------------|---------|
| <b>DC performance</b> |  |  |      |      |                   |         |
| V <sub>io</sub>       | Offset voltage   | TSV63x   |      |      | 3                 | mV      |
|                       |  | TSV63xA  |      |      | 0.8               |         |
|                       |  | TSV633AIST (MiniSO10)  |      |      | 1                 |         |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub> - TSV63x     |      |      | 4.5               |         |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub> - TSV63xA    |      |      | 2                 |         |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub> - TSV633AIST |      |      | 2.2               |         |
| ΔV <sub>io</sub> /ΔT  | Input offset voltage drift   |  |      | 2    |                   | μV/°C   |
| I <sub>io</sub>       | Input offset current   | V <sub>out</sub> = V <sub>CC</sub> /2                              |      | 1    | 10 <sup>(1)</sup> | pA      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              |      | 1    | 100               |         |
| I <sub>ib</sub>       | Input bias current   | V <sub>out</sub> = V <sub>CC</sub> /2                              |      | 1    | 10 <sup>(1)</sup> | pA      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              |      | 1    | 100               |         |
| CMR                   | Common mode rejection ratio 20 log (ΔV <sub>ic</sub> /ΔV <sub>io</sub> )           | 0 V to 3.3 V, V <sub>out</sub> = 1.65 V                            | 57   | 79   |                   | dB      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              | 53   |      |                   |         |
| A <sub>vd</sub>       | Large signal voltage gain  | R <sub>L</sub> = 10 kΩ, V <sub>out</sub> = 0.5 V to 2.8 V          | 88   | 98   |                   | dB      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              | 83   |      |                   |         |
| V <sub>OH</sub>       | High level output voltage, (V <sub>OH</sub> = V <sub>CC</sub> - V <sub>out</sub> ) | R <sub>L</sub> = 10 kΩ   |      | 5    | 35                | mV      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              |      |      | 50                |         |
| V <sub>OL</sub>       | Low level output voltage   | R <sub>L</sub> = 10 kΩ   |      | 4    | 35                | mV      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              |      |      | 50                |         |
| I <sub>out</sub>      | I <sub>sink</sub>  | V <sub>o</sub> = 3.3 V   | 23   | 45   |                   | mA      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              | 20   |      |                   |         |
|                       | I <sub>source</sub>  | V <sub>o</sub> = 0 V   | 23   | 38   |                   |         |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              | 20   |      |                   |         |
| I <sub>CC</sub>       | Supply current, (per channel)  | No load, V <sub>out</sub> = 1.75 V                                 | 43   | 55   | 64                | μA      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              |      |      | 66                |         |
| <b>AC performance</b> |  |  |      |      |                   |         |
| GBP                   | Gain bandwidth product   | R <sub>L</sub> = 2 kΩ, C <sub>L</sub> = 100 pF, f = 100 kHz        | 710  | 860  |                   | kHz     |
| φ <sub>m</sub>        | Phase margin   | R <sub>L</sub> = 2 kΩ, C <sub>L</sub> = 100 pF                     |      | 46   |                   | Degrees |
| G <sub>m</sub>        | Gain margin  | R <sub>L</sub> = 2 kΩ, C <sub>L</sub> = 100 pF                     |      | 13   |                   | dB      |
| SR                    | Slew rate  | R <sub>L</sub> = 2 kΩ, C <sub>L</sub> = 100 pF, A <sub>V</sub> = 1 | 0.22 | 0.29 |                   | V/μs    |

**Notes:**

<sup>(1)</sup>Guaranteed by design



Table 7: Electrical characteristics at VCC+ = 5 V with VCC- = 0 V, Vicm = VCC/2, Tamb = 25° C, and RL connected to VCC/2 (unless otherwise specified)

| Symbol                | Parameter  | Conditions   | Min. | Typ. | Max.              | Unit    |
|-----------------------|--|--|------|------|-------------------|---------|
| <b>DC performance</b> |  |  |      |      |                   |         |
| V <sub>io</sub>       | Offset voltages  | TSV63x   |      |      | 3                 | mV      |
|                       |  | TSV63xA  |      |      | 0.8               |         |
|                       |  | TSV633AIST ( MiniSO10)   |      |      | 1                 |         |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub> - TSV63x     |      |      | 4.5               |         |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub> - TSV63xA    |      |      | 2                 |         |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub> - TSV633AIST |      |      | 2.2               |         |
| ΔV <sub>io</sub> /ΔT  | Input offset voltage drift   |  |      | 2    |                   | μV/°C   |
| I <sub>io</sub>       | Input offset current   | (V <sub>out</sub> = V <sub>CC</sub> /2)                            |      | 1    | 10 <sup>(1)</sup> | pA      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              |      | 1    | 100               |         |
| I <sub>ib</sub>       | Input bias current   | (V <sub>out</sub> = V <sub>CC</sub> /2)                            |      | 1    | 10 <sup>(1)</sup> | pA      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              |      | 1    | 100               |         |
| CMR                   | Common mode rejection ratio 20 log (ΔV <sub>ic</sub> /ΔV <sub>io</sub> )           | 0 V to 5 V, V <sub>out</sub> = 2.5 V                               | 60   | 80   |                   | dB      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              | 55   |      |                   |         |
| SVR                   | Supply voltage rejection ratio 20 log (ΔV <sub>CC</sub> /ΔV <sub>io</sub> )        | V <sub>CC</sub> = 1.8 to 5 V                                       | 75   | 102  |                   | dB      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              | 73   |      |                   |         |
| A <sub>vd</sub>       | Large signal voltage gain  | R <sub>L</sub> = 10 kΩ, V <sub>out</sub> = 0.5 V to 4.5 V          | 89   | 98   |                   | dB      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              | 84   |      |                   |         |
| EMIRR                 | EMI rejection ratio, EMIRR = -20 log (V <sub>RFpeak</sub> /ΔV <sub>io</sub> )      | V <sub>RF</sub> = 100 mV <sub>rms</sub> , f = 400 MHz              |      | 61   |                   | dB      |
|                       |  | V <sub>RF</sub> = 100 mV <sub>rms</sub> , f = 900 MHz              |      | 85   |                   |         |
|                       |  | V <sub>RF</sub> = 100 mV <sub>rms</sub> , f = 1800 MHz             |      | 92   |                   |         |
|                       |  | V <sub>RF</sub> = 100 mV <sub>rms</sub> , f = 2400 MHz             |      | 83   |                   |         |
| V <sub>OH</sub>       | High level output voltage, (V <sub>OH</sub> = V <sub>CC</sub> - V <sub>out</sub> ) | R <sub>L</sub> = 10 kΩ   |      | 7    | 35                | mV      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              |      |      | 50                |         |
| V <sub>OL</sub>       | Low level output voltage   | R <sub>L</sub> = 10 kΩ   |      | 6    | 35                | mV      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              |      |      | 50                |         |
| I <sub>out</sub>      | I <sub>sink</sub>  | V <sub>o</sub> = 5 V   | 40   | 69   |                   | mA      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              | 35   |      |                   |         |
|                       | I <sub>source</sub>  | V <sub>o</sub> = 0 V   | 40   | 74   |                   |         |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              | 35   |      |                   |         |
| I <sub>CC</sub>       | Supply current, (per channel)  | No load, V <sub>out</sub> = V <sub>CC</sub> /2                     | 50   | 60   | 69                | μA      |
|                       |  | T <sub>min</sub> < T <sub>op</sub> < T <sub>max</sub>              |      |      | 72                |         |
| <b>AC performance</b> |  |  |      |      |                   |         |
| GBP                   | Gain bandwidth product   | R <sub>L</sub> = 2 kΩ, C <sub>L</sub> = 100 pF, f = 100 kHz        | 730  | 880  |                   | kHz     |
| F <sub>u</sub>        | Unity gain frequency   | R <sub>L</sub> = 2 kΩ, C <sub>L</sub> = 100 pF                     |      | 830  |                   |         |
| φ <sub>m</sub>        | Phase margin   | R <sub>L</sub> = 2 kΩ, C <sub>L</sub> = 100 pF                     |      | 48   |                   | Degrees |

Electrical characteristics

TSV632, TSV632A, TSV633, TSV633A, TSV634, TSV634A, TSV635, TSV635A

| Symbol     | Parameter                         | Conditions   | Min. | Typ.  | Max. | Unit                   |
|------------|-----------------------------------|--|------|-------|------|------------------------|
| $G_m$      | Gain margin                       | $R_L = 2\text{ k}\Omega, C_L = 100\text{ pF}$  |      | 13    |      | dB                     |
| SR         | Slew rate                         | $R_L = 2\text{ k}\Omega, C_L = 100\text{ pF}, A_v = 1$   | 0.25 | 0.34  |      | V/ $\mu$ s             |
| $e_n$      | Equivalent input noise voltage    | $f = 1\text{ kHz}$   |      | 60    |      | nV/ $\sqrt{\text{Hz}}$ |
|            |                                   | $f = 10\text{ kHz}$  |      | 33    |      |                        |
| THD+ $e_n$ | Total harmonic distortion + noise | $V_{CC} = 5\text{V}, f = 1\text{ kHz}, A_v = 1, R_L = 100\text{ k}\Omega, V_{icm} = V_{CC}/2, V_{out} = 2V_{pp}$ |      | 0.002 |      | %                      |

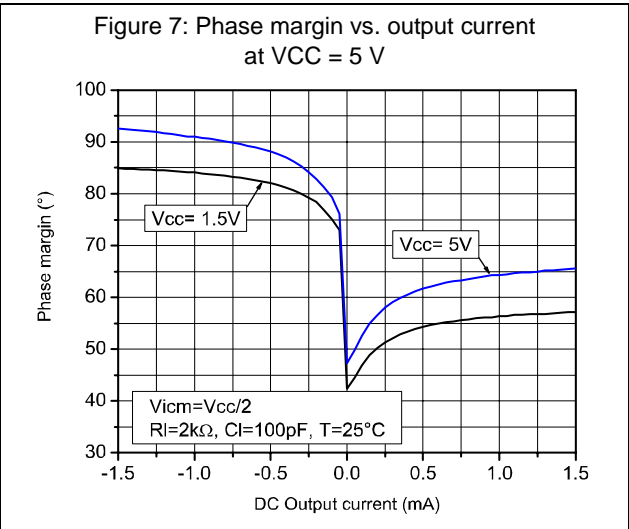
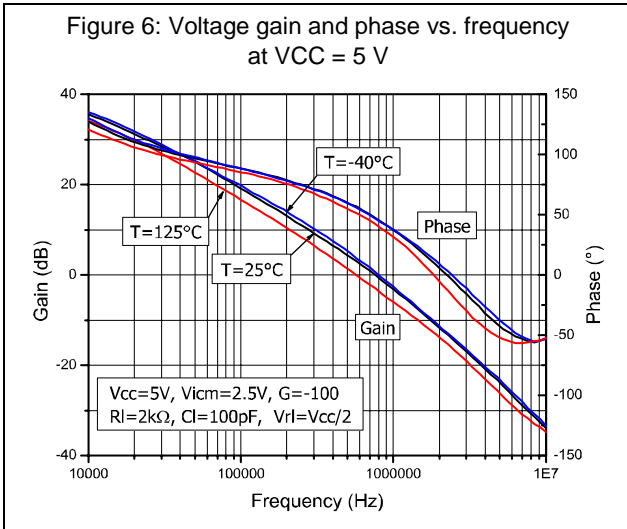
Notes:

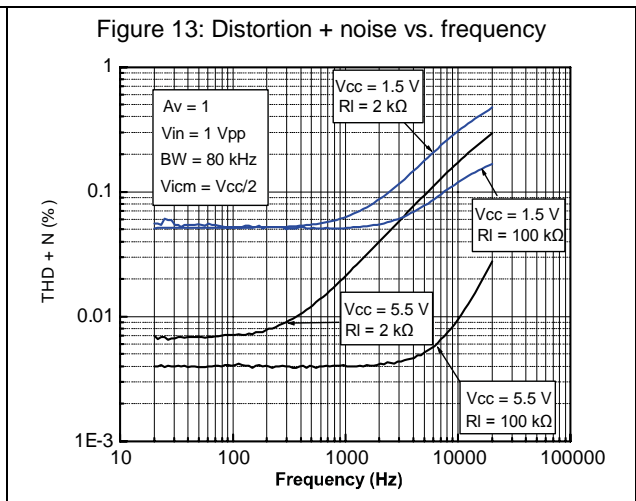
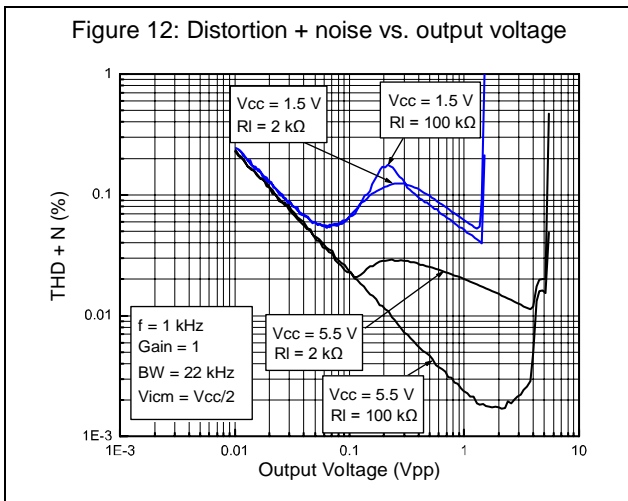
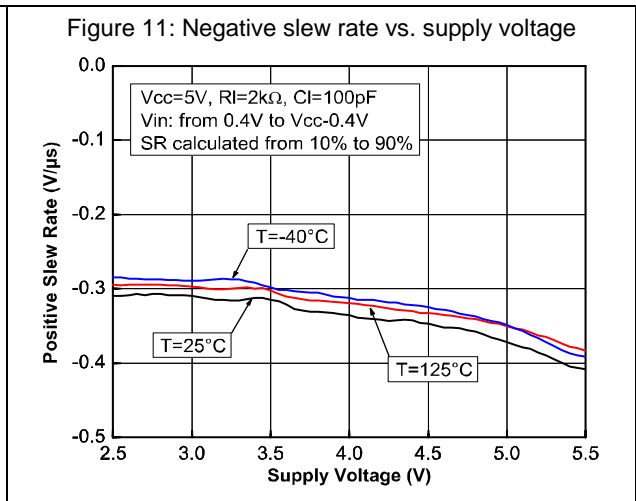
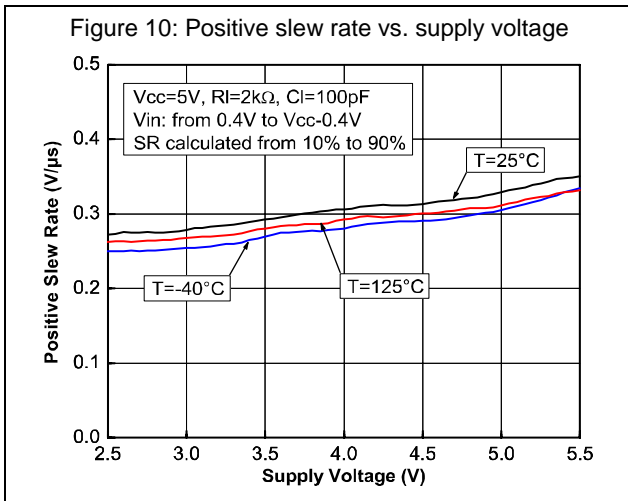
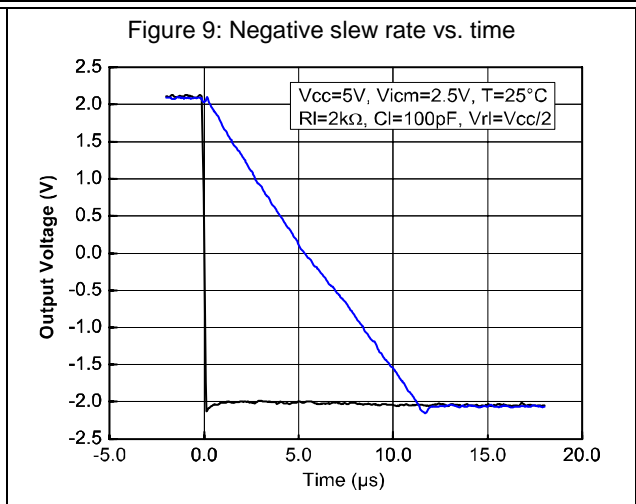
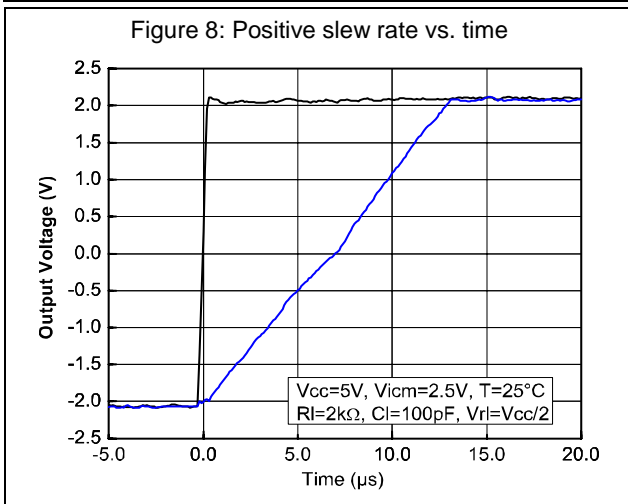
(1) Guaranteed by design

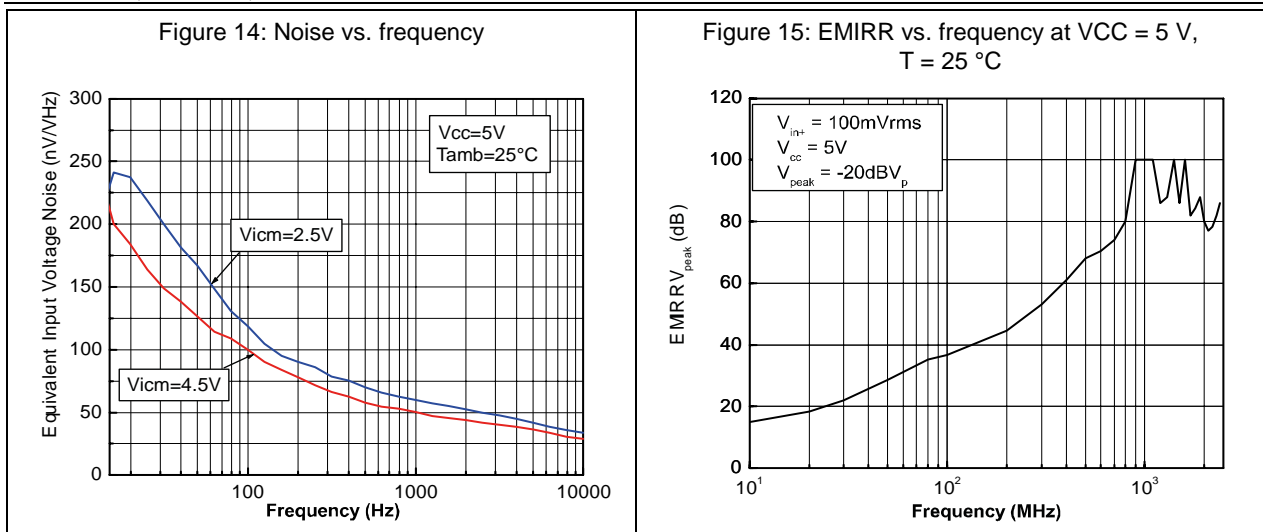
Table 8: Shutdown characteristics at  $V_{CC} = 5\text{ V}$

| Symbol                | Parameter                                      | Conditions  | Min. | Typ. | Max. | Unit |
|-----------------------|--|---|------|------|------|------|
| <b>DC performance</b> |  |   |      |      |      |      |
| $I_{CC}$              | Supply current in shutdown mode (all channels) | $\overline{\text{SHDN}} = V_{CC-}$  |      | 5    | 50   | nA   |
|                       |  | $T_{min} < T_{op} < 85^\circ\text{ C}$  |      |      | 200  |      |
|                       |  | $T_{min} < T_{op} < 125^\circ\text{ C}$   |      |      |      | 1.5  |
| $t_{on}$              | Amplifier turn-on time                         | $R_L = 2\text{ k}\Omega, V_{out} = (V_{CC-})\text{ to } (V_{CC-}) + 0.2\text{ V}$         |      | 200  |      | ns   |
| $t_{off}$             | Amplifier turn-off time                        | $R_L = 2\text{ k}\Omega, V_{out} = (V_{CC+}) - 0.5\text{ V to } (V_{CC+}) - 0.7\text{ V}$ |      | 20   |      |      |
| $V_{IH}$              | $\overline{\text{SHDN}}$ logic high            |   | 2    |      |      | V    |
| $V_{IL}$              | $\overline{\text{SHDN}}$ logic low             |   |      |      | 0.8  |      |
| $I_{IH}$              | $\overline{\text{SHDN}}$ current high          | $\overline{\text{SHDN}} = V_{CC+}$  |      | 10   |      | pA   |
| $I_{IL}$              | $\overline{\text{SHDN}}$ current low           | $\overline{\text{SHDN}} = V_{CC-}$  |      | 10   |      |      |
| $I_{OLeak}$           | Output leakage in shutdown mode                | $\overline{\text{SHDN}} = V_{CC-}$  |      | 50   |      |      |
|                       |  | $T_{min} < T_{op} < 125^\circ\text{ C}$   |      | 1    |      | nA   |









## 4 Application information

### 4.1 Operating voltages

The TSV63x and TSV63xA can operate from 1.5 to 5.5 V. Their parameters are fully specified for 1.8 V, 3.3 V, and 5 V power supplies. However, the parameters are very stable in the full  $V_{CC}$  range and several characterization curves show the TSV63x and TSV63xA characteristics at 1.5 V. Additionally, the main specifications are guaranteed in extended temperature ranges from  $-40\text{ }^{\circ}\text{C}$  to  $125\text{ }^{\circ}\text{C}$ .

### 4.2 Rail-to-rail input

The TSV63x and TSV63xA are built with two complementary PMOS and NMOS input differential pairs. The devices have a rail-to-rail input and the input common mode range is extended from  $(V_{CC-}) - 0.1\text{ V}$  to  $(V_{CC+}) + 0.1\text{ V}$ . The transition between the two pairs appears at  $(V_{CC+}) - 0.7\text{ V}$ . In the transition region, the performance of CMRR, PSRR,  $V_{io}$  (Figure 16 and Figure 17), and THD is slightly degraded.

Figure 16: Input offset voltage vs input common mode voltage at  $V_{CC} = 1.5\text{ V}$

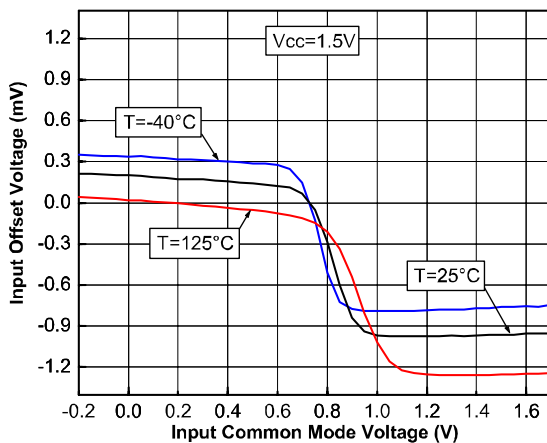
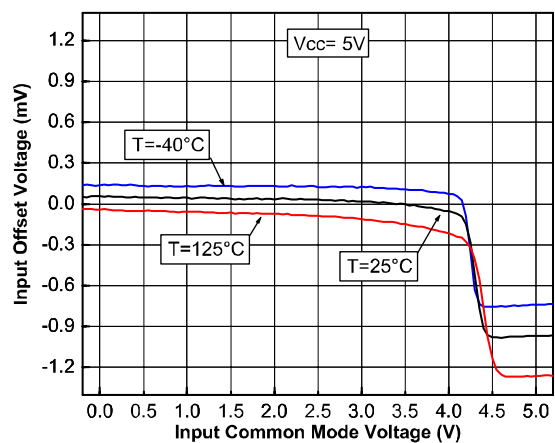


Figure 17: Input offset voltage vs input common mode voltage at  $V_{CC} = 5\text{ V}$



The devices are guaranteed without phase reversal.

### 4.3 Rail-to-rail output

The operational amplifiers' output levels can go close to the rails: 35 mV maximum above and below the rail when connected to a  $10\text{ k}\Omega$  resistive load to  $V_{CC}/2$ .

### 4.4 Shutdown function (TSV633, TSV635)

The operational amplifiers are enabled when the  $\overline{\text{SHDN}}$  pin is pulled high. To disable the amplifiers, the  $\overline{\text{SHDN}}$  must be pulled down to  $V_{CC-}$ . When in shutdown mode, the amplifiers' output is in a high impedance state. The  $\overline{\text{SHDN}}$  pin must never be left floating, but tied to  $V_{CC+}$  or  $V_{CC-}$ .

The turn-on and turn-off times are calculated for an output variation of  $\pm 200$  mV. [Figure 18](#) and [Figure 19](#) show the test configurations. [Figure 20](#) shows the time it takes the product to come out of shutdown mode and [Figure 21](#) shows the time it takes the product to enter shutdown mode.



## 4.5 Optimization of DC and AC parameters

These devices use an innovative approach to reduce the spread of the main DC and AC parameters. An internal adjustment achieves a very narrow spread of the current consumption (60  $\mu\text{A}$  typical, min/max at  $\pm 17\%$ ). Parameters linked to the current consumption value, such as GBP, SR, and  $A_{vd}$ , benefit from this narrow dispersion. All parts present a similar speed and the same behavior in terms of stability. In addition, the minimum values of GBP and SR are guaranteed (GBP = 730 kHz minimum and SR = 0.25 V/ $\mu\text{s}$  minimum).

## 4.6 Driving resistive and capacitive loads

These products are micropower, low-voltage, operational amplifiers optimized to drive rather large resistive loads, above 2 k $\Omega$ . For lower resistive loads, the THD level may significantly increase.

In a *follower* configuration, these operational amplifiers can drive capacitive loads up to 100 pF with no oscillations. When driving larger capacitive loads, adding an in-series resistor at the output can improve the stability of the devices (see [Figure 22](#) for recommended in-series resistor values). Once the in-series resistor value has been selected, the stability of the circuit should be tested on the bench and simulated with the simulation model.

Figure 22: In-series resistor vs. capacitive load



## 4.7 PCB layouts

For correct operation, it is advised to add 10 nF decoupling capacitors as close as possible to the power supply pins.



## 4.8 Macromodel

Two accurate macromodels (with or without the shutdown feature) of the TSV63x and TSV63xA are available on STMicroelectronics' web site at [www.st.com](http://www.st.com). These models are a trade-off between accuracy and complexity (that is, time simulation) of the TSV63x and TSV63xA operational amplifiers. They emulate the nominal performances of a typical device within the specified operating conditions mentioned in the datasheet. They also help to validate a design approach and to select the right operational amplifier, *but they do not replace on-board measurements*.

## 5 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK<sup>®</sup> packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

### 5.1 DFN8 2 x 2 (NB) package information

Figure 23: DFN8 2 x 2 mm (NB) package outline

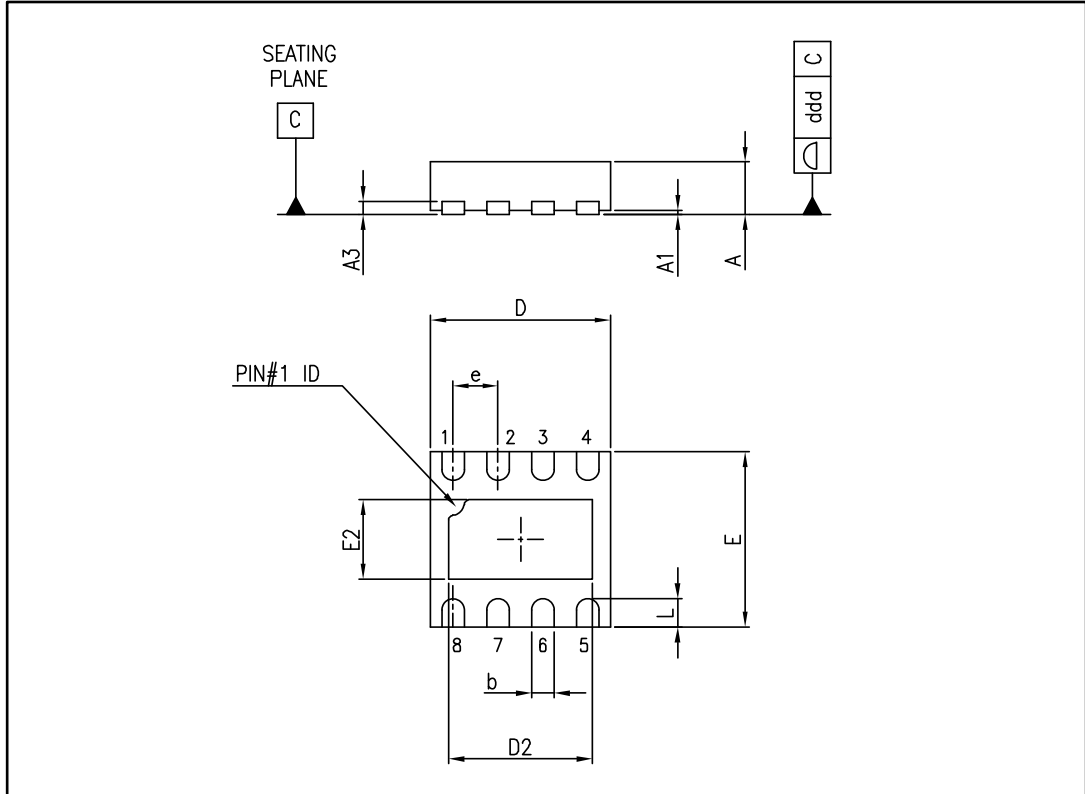


Table 9: DFN8 2 x 2 x 0.6 mm (NB) package mechanical data (pitch 0.5 mm)

| Ref. | Dimensions  |      |       |        |       |       |
|------|-------------|------|-------|--------|-------|-------|
|      | Millimeters |      |       | Inches |       |       |
|      | Min.        | Typ. | Max.  | Min.   | Typ.  | Max.  |
| A    | 0.51        | 0.55 | 0.60  | 0.020  | 0.022 | 0.024 |
| A1   |             |      | 0.05  |        |       | 0.002 |
| A3   |             | 0.15 |       |        | 0.006 |       |
| b    | 0.18        | 0.25 | 0.30  | 0.007  | 0.010 | 0.012 |
| D    | 1.85        | 2.00 | 2.15  | 0.073  | 0.079 | 0.085 |
| D2   | 1.45        | 1.60 | 1.70  | 0.057  | 0.063 | 0.067 |
| E    | 1.85        | 2.00 | 2.15  | 0.073  | 0.079 | 0.085 |
| E2   | 0.75        | 0.90 | 1.00  | 0.030  | 0.035 | 0.039 |
| e    |             | 0.50 |       |        | 0.020 |       |
| L    |             |      | 0.425 |        |       | 0.017 |
| ddd  |             |      | 0.08  |        |       | 0.003 |

Figure 24: DFN8 2 x 2 mm (NB) recommended footprint



## 5.2 SOT23-8 package information

Figure 25: SOT23-8 package outline



Table 10: SOT23-8 package mechanical data

| Ref. | Dimensions  |      |      |        |       |       |
|------|-------------|------|------|--------|-------|-------|
|      | Millimeters |      |      | Inches |       |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A    |             |      | 1.45 |        |       | 0.057 |
| A1   |             |      | 0.15 |        |       | 0.006 |
| A2   | 0.90        |      | 1.30 | 0.035  |       | 0.051 |
| b    | 0.22        |      | 0.38 | 0.009  |       | 0.015 |
| c    | 0.08        |      | 0.22 | 0.003  |       | 0.009 |
| D    | 2.80        |      | 3.00 | 0.110  |       | 0.118 |
| E    | 2.60        |      | 3.00 | 0.102  |       | 0.118 |
| E1   | 1.50        |      | 1.75 | 0.059  |       | 0.069 |
| e    |             | 0.65 |      |        | 0.026 |       |
| e1   |             | 1.95 |      |        | 0.077 |       |
| L    | 0.30        |      | 0.60 | 0.012  |       | 0.024 |
| <    | 0°          |      | 8°   | 0°     |       | 8°    |

### 5.3 MiniSO8 package information

Figure 26: MiniSO8 package outline

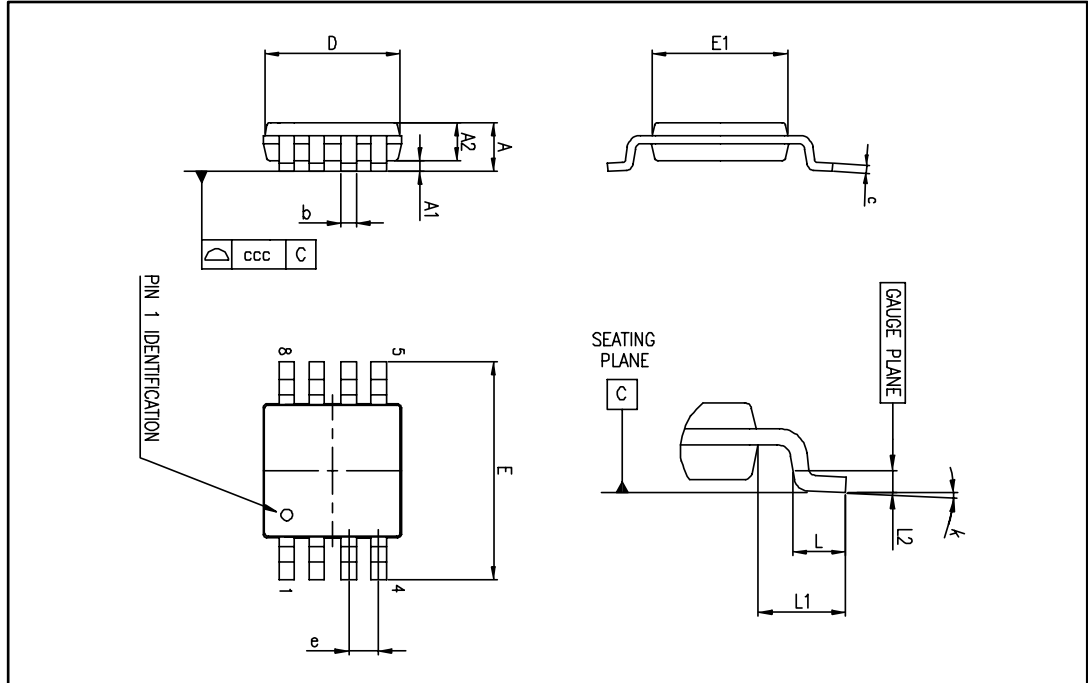


Table 11: MiniSO8 package mechanical data

| Ref. | Dimensions  |      |      |        |       |       |
|------|-------------|------|------|--------|-------|-------|
|      | Millimeters |      |      | Inches |       |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A    |             |      | 1.1  |        |       | 0.043 |
| A1   | 0           |      | 0.15 | 0      |       | 0.006 |
| A2   | 0.75        | 0.85 | 0.95 | 0.030  | 0.033 | 0.037 |
| b    | 0.22        |      | 0.40 | 0.009  |       | 0.016 |
| c    | 0.08        |      | 0.23 | 0.003  |       | 0.009 |
| D    | 2.80        | 3.00 | 3.20 | 0.11   | 0.118 | 0.126 |
| E    | 4.65        | 4.90 | 5.15 | 0.183  | 0.193 | 0.203 |
| E1   | 2.80        | 3.00 | 3.10 | 0.11   | 0.118 | 0.122 |
| e    |             | 0.65 |      |        | 0.026 |       |
| L    | 0.40        | 0.60 | 0.80 | 0.016  | 0.024 | 0.031 |
| L1   |             | 0.95 |      |        | 0.037 |       |
| L2   |             | 0.25 |      |        | 0.010 |       |
| k    | 0°          |      | 8°   | 0°     |       | 8°    |
| ccc  |             |      | 0.10 |        |       | 0.004 |

## 5.4 MiniSO10 package information

Figure 27: MiniSO10 package outline



Table 12: MiniSO-10 package mechanical data

| Ref. | Dimensions  |      |      |        |       |       |
|------|-------------|------|------|--------|-------|-------|
|      | Millimeters |      |      | Inches |       |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A    |             |      | 1.10 |        |       | 0.043 |
| A1   | 0.05        | 0.10 | 0.15 | 0.002  | 0.004 | 0.006 |
| A2   | 0.78        | 0.86 | 0.94 | 0.031  | 0.034 | 0.037 |
| b    | 0.25        | 0.33 | 0.40 | 0.010  | 0.013 | 0.016 |
| c    | 0.15        | 0.23 | 0.30 | 0.006  | 0.009 | 0.012 |
| D    | 2.90        | 3.00 | 3.10 | 0.114  | 0.118 | 0.122 |
| E    | 4.75        | 4.90 | 5.05 | 0.187  | 0.193 | 0.199 |
| E1   | 2.90        | 3.00 | 3.10 | 0.114  | 0.118 | 0.122 |
| e    |             | 0.50 |      |        | 0.020 |       |
| L    | 0.40        | 0.55 | 0.70 | 0.016  | 0.022 | 0.028 |
| L1   |             | 0.95 |      |        | 0.037 |       |
| k    | 0°          | 3°   | 6°   | 0°     | 3°    | 6°    |
| aaa  |             |      | 0.10 |        |       | 0.004 |

### 5.5 SO8 package information

Figure 28: SO8 package outline



Table 13: SO8 package mechanical data

| Ref. | Dimensions  |      |      |        |       |       |
|------|-------------|------|------|--------|-------|-------|
|      | Millimeters |      |      | Inches |       |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A    |             |      | 1.75 |        |       | 0.069 |
| A1   | 0.10        |      | 0.25 | 0.004  |       | 0.010 |
| A2   | 1.25        |      |      | 0.049  |       |       |
| b    | 0.28        |      | 0.48 | 0.011  |       | 0.019 |
| c    | 0.17        |      | 0.23 | 0.007  |       | 0.010 |
| D    | 4.80        | 4.90 | 5.00 | 0.189  | 0.193 | 0.197 |
| E    | 5.80        | 6.00 | 6.20 | 0.228  | 0.236 | 0.244 |
| E1   | 3.80        | 3.90 | 4.00 | 0.150  | 0.154 | 0.157 |
| e    |             | 1.27 |      |        | 0.050 |       |
| h    | 0.25        |      | 0.50 | 0.010  |       | 0.020 |
| L    | 0.40        |      | 1.27 | 0.016  |       | 0.050 |
| L1   |             | 1.04 |      |        | 0.040 |       |
| k    | 1°          |      | 8°   | 1°     |       | 8°    |
| ccc  |             |      | 0.10 |        |       | 0.004 |



### 5.6 QFN16 3x3 package information

Figure 29: QFN16 3x3 mm package outline



Table 14: QFN16 3x3 mm package mechanical data

| Ref. | Dimensions  |      |      |        |       |       |
|------|-------------|------|------|--------|-------|-------|
|      | Millimeters |      |      | Inches |       |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A    | 0.80        | 0.90 | 1.00 | 0.031  | 0.035 | 0.039 |
| A1   | 0           |      | 0.05 | 0      |       | 0.002 |
| A3   |             | 0.20 |      |        | 0.008 |       |
| b    | 0.18        |      | 0.30 | 0.007  |       | 0.012 |
| D    | 2.90        | 3.00 | 3.10 | 0.114  | 0.118 | 0.122 |
| D2   | 1.50        |      | 1.80 | 0.059  |       | 0.071 |
| E    | 2.90        | 3.00 | 3.10 | 0.114  | 0.118 | 0.122 |
| E2   | 1.50        |      | 1.80 | 0.059  |       | 0.071 |
| e    |             | 0.50 |      |        | 0.020 |       |
| L    | 0.30        |      | 0.50 | 0.012  |       | 0.020 |

Figure 30: QFN16 3x3 mm recommended footprint



## 5.7 TSSOP14 package information

Figure 31: TSSOP14 package outline

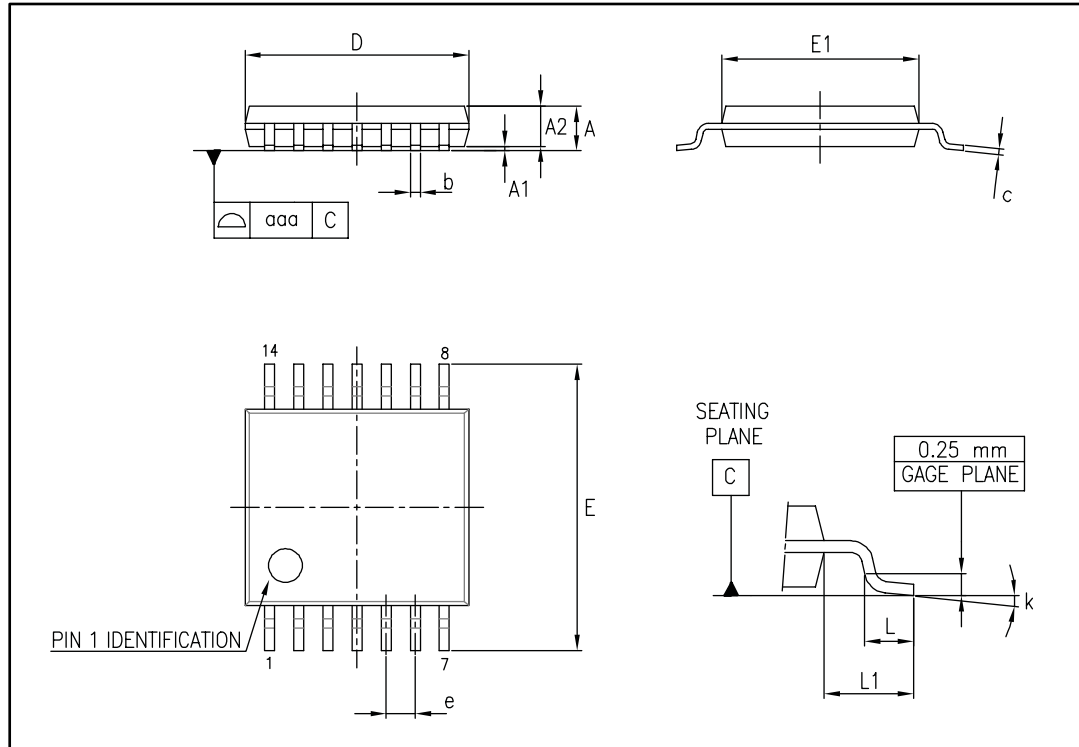


Table 15: TSSOP14 package mechanical data

| Ref. | Dimensions  |      |      |        |        |        |
|------|-------------|------|------|--------|--------|--------|
|      | Millimeters |      |      | Inches |        |        |
|      | Min.        | Typ. | Max. | Min.   | Typ.   | Max.   |
| A    |             |      | 1.20 |        |        | 0.047  |
| A1   | 0.05        |      | 0.15 | 0.002  | 0.004  | 0.006  |
| A2   | 0.80        | 1.00 | 1.05 | 0.031  | 0.039  | 0.041  |
| b    | 0.19        |      | 0.30 | 0.007  |        | 0.012  |
| c    | 0.09        |      | 0.20 | 0.004  |        | 0.0089 |
| D    | 4.90        | 5.00 | 5.10 | 0.193  | 0.197  | 0.201  |
| E    | 6.20        | 6.40 | 6.60 | 0.244  | 0.252  | 0.260  |
| E1   | 4.30        | 4.40 | 4.50 | 0.169  | 0.173  | 0.176  |
| e    |             | 0.65 |      |        | 0.0256 |        |
| L    | 0.45        | 0.60 | 0.75 | 0.018  | 0.024  | 0.030  |
| L1   |             | 1.00 |      |        | 0.039  |        |
| k    | 0°          |      | 8°   | 0°     |        | 8°     |
| aaa  |             |      | 0.10 |        |        | 0.004  |

### 5.8 TSSOP16 package information

Figure 32: TSSOP16 package outline



Table 16: TSSOP16 package mechanical data

| Ref. | Dimensions  |      |      |        |       |       |
|------|-------------|------|------|--------|-------|-------|
|      | Millimeters |      |      | Inches |       |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A    |             |      | 1.20 |        |       | 0.047 |
| A1   | 0.05        |      | 0.15 | 0.002  |       | 0.006 |
| A2   | 0.80        | 1.00 | 1.05 | 0.031  | 0.039 | 0.041 |
| b    | 0.19        |      | 0.30 | 0.007  |       | 0.012 |
| c    | 0.09        |      | 0.20 | 0.004  |       | 0.008 |
| D    | 4.90        | 5.00 | 5.10 | 0.193  | 0.197 | 0.201 |
| E    | 6.20        | 6.40 | 6.60 | 0.244  | 0.252 | 0.260 |
| E1   | 4.30        | 4.40 | 4.50 | 0.169  | 0.173 | 0.177 |
| e    |             | 0.65 |      |        | 0.026 |       |
| k    | 0°          |      | 8°   | 0°     |       | 8°    |
| L    | 0.45        | 0.60 | 0.75 | 0.018  | 0.024 | 0.030 |
| L1   |             | 1.00 |      |        | 0.039 |       |
| aaa  |             |      | 0.10 |        |       | 0.004 |

## 6 Ordering information

Table 17: Order codes

| Order code  | Temperature range                                    | Package <sup>(1)</sup> | Marking |
|-------------|--|------------------------|---------|
| TSV632AIDT  | -40 °C to 125 °C                                     | SO8                    | TV632A  |
| TSV632AILT  |  | SOT23-8                | K145    |
| TSV632AIQ2T |  | DFN8 2x2               | K1P     |
| TSV632AIST  |  | MiniSO8                | K145    |
| TSV632IDT   |  | SO8                    | TSV632  |
| TSV632ILT   |  | SOT23-8                | K110    |
| TSV632IQ2T  |  | DFN8 2x2               | K1N     |
| TSV632IST   |  | MiniSO8                | K110    |
| TSV632IYDT  | -40 °C to 125 °C,<br>automotive grade <sup>(2)</sup> | SO8                    | V632IY  |
| TSV633AIST  | -40 °C to 125 °C                                     | MiniSO10               | K146    |
| TSV633IST   |  |                        | K111    |
| TSV634AIPT  |  | TSSOP14                | TSV634A |
| TSV634IQ4T  |  | QFN16 3x3              | K112    |
| TSV634IPT   |  | TSSOP14                | TSV634  |
| TSV634IYPT  | -40 °C to 125 °C,<br>automotive grade <sup>(2)</sup> |                        | V634IY  |
| TSV635AIPT  | -40 °C to 125 °C                                     | TSSOP16                | TSV635A |
| TSV635IPT   |  |                        | TSV635  |

**Notes:**

<sup>(1)</sup>All devices are in tape and reel packing

<sup>(2)</sup>Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 and Q002.

## 7 Revision history

Table 18: Document revision history

| Date        | Revision | Changes   |
|-------------|----------|---|
| 25-May-2009 | 1        | Initial release.  |
| 15-Jun-2009 | 2        | Corrected pin connection diagram in <a href="#">Figure 1</a> .  |
| 03-Sep-2009 | 3        | Added root part numbers (TSV63xA) and <a href="#">Table 1: "Device summary"</a> on cover page.<br>Added order code TSV632AILT in <a href="#">Table 17: "Order codes"</a> .  |
| 07-Nov-2011 | 4        | Added DFN8 2x2 package mechanical drawing.<br>Added ordering information for DFN package to <a href="#">Table 17: "Order codes"</a> .<br>Corrected unit on Y axis of <a href="#">Figure 16</a> and <a href="#">Figure 17</a> .  |
| 13-Dec-2012 | 5        | Updated <a href="#">Features</a><br>Added QFN16 3x3 package<br>Updated <a href="#">Figure 1: "Pin connections for each package (top view)"</a> .<br><a href="#">Table 4</a> , <a href="#">Table 6</a> , and <a href="#">Table 7</a> : replaced $DV_{io}$ symbol with $\Delta V_{io}/\Delta T$<br><a href="#">Table 4</a> , <a href="#">Table 5</a> , <a href="#">Table 6</a> , <a href="#">Table 7</a> and <a href="#">Table 8</a> : for supply current parameter, replaced "operator" with "channel".<br><a href="#">Table 17: "Order codes"</a> : added automotive order codes and updated footnote<br>Deleted TSV632ID/AID from order codes in <a href="#">Table 17: "Order codes"</a> |
| 29-May-2015 | 6        | <a href="#">Table 4</a> , <a href="#">Table 6</a> , and <a href="#">Table 7</a> : $V_{OH}$ "min" values changed to "max" values.<br><a href="#">Table 17: "Order codes"</a> : added order code TSV632AIQ2T, updated footnote 1.   |

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Компания «Life Electronics» занимается поставками электронных компонентов импортного и отечественного производства от производителей и со складов крупных дистрибьюторов Европы, Америки и Азии.

С конца 2013 года компания активно расширяет линейку поставок компонентов по направлению коаксиальный кабель, кварцевые генераторы и конденсаторы (керамические, пленочные, электролитические), за счёт заключения дистрибьюторских договоров

Мы предлагаем:

- Конкурентоспособные цены и скидки постоянным клиентам.
- Специальные условия для постоянных клиентов.
- Подбор аналогов.
- Поставку компонентов в любых объемах, удовлетворяющих вашим потребностям.
- Приемлемые сроки поставки, возможна ускоренная поставка.
- Доставку товара в любую точку России и стран СНГ.
- Комплексную поставку.
- Работу по проектам и поставку образцов.
- Формирование склада под заказчика.
- Сертификаты соответствия на поставляемую продукцию (по желанию клиента).
- Тестирование поставляемой продукции.
- Поставку компонентов, требующих военную и космическую приемку.
- Входной контроль качества.
- Наличие сертификата ISO.

В составе нашей компании организован Конструкторский отдел, призванный помогать разработчикам, и инженерам.

Конструкторский отдел помогает осуществить:

- Регистрацию проекта у производителя компонентов.
- Техническую поддержку проекта.
- Защиту от снятия компонента с производства.
- Оценку стоимости проекта по компонентам.
- Изготовление тестовой платы монтаж и пусконаладочные работы.



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