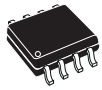
# RT2904WH

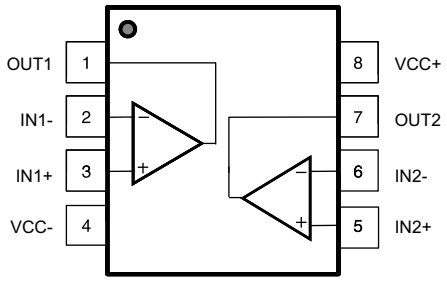
## RobuST low-power dual operational amplifier

**Datasheet - production data**



**D**
**SO8**
**(plastic micropackage)**

**Pin connections (top view)**




## Features

- Frequency compensation implemented internally
- Large DC voltage gain: 100 dB
- Wide bandwidth (unity gain): 1.1 MHz (temperature compensated)
- Very low supply current/amplifier, essentially independent of supply voltage
- Low input bias current: 20 nA (temperature compensated)
- Low input offset current: 2 nA
- Input common-mode voltage range includes negative rail
- Differential input voltage range equal to the power supply voltage
- Large output voltage swing 0 V to ($V_{CC+}$) - 1.5V
- Intended for use in aerospace and defense applications:
  - Dedicated traceability and part marking
  - Approval documents available for production parts
  - Adapted extended life time and obsolescence management
  - Extended product change notification process
  - Designed and manufactured to meet sub ppm quality goals
  - Advanced mold and frame designs for superior resilience to harsh environments (acceleration, EMI, thermal, humidity)
  - Extended screening capability on request
  - Single fabrication, assembly, and test site
  - Temperature range (-40 °C to 150 °C)

## Applications

- Aerospace and defense
- Harsh environments

## Description

This circuit consists of two independent, high gain operational amplifiers with frequency compensation implemented internally. It is designed specifically for aerospace and defense applications. The circuit operates from a single power supply over a wide range of voltages. Low power supply drain is independent of the magnitude of the power supply voltage.

In linear mode, the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from a single power supply.



This is information on a product in full production. www.st.com

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# 1 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}^+$ | Supply voltage | 32 | V |
| $V_{id}$ | Differential input voltage | -0.3 to $V_{CC}$+0.3 | |
| $V_{in}$ | Input voltage | -0.3 to $V_{CC}$+0.3 | |
| | Output short-circuit to ground(1) | 40 | mA |
| $T_j$ | Maximum junction temperature | 150 | °C |
| $R_{thja}$ | Thermal resistance junction to ambient(2) | 125 | °C/W |
| $R_{thjc}$ | Thermal resistance junction to case(2) | 40 | |
| $I_{in}$ | Input current(3) | 5 | mA |
| $T_{stg}$ | Storage temperature range | -65 to 150 | °C |
| ESD | HBM: human body model(4) | 2 | kV |
| | MM: machine model(5) | 200 | V |
| | CDM: charged device model(6) | 1.5 | kV |

1. Short-circuits from the output to $V_{CC}$ can cause excessive heating if $V_{CC}^+ > 15$ V. The maximum output current is approximately 40 mA, independent of the magnitude of $V_{CC}$. Destructive dissipation can result from simultaneous short-circuits on all amplifiers.
2. Short-circuits can cause excessive heating and destructive dissipation. Values are typical.
3. This input current only exists when the voltage values applied on the inputs is beyond the supply voltage line limits. This is not destructive if the current does not exceed 5 mA as indicated, and normal output is restored for input voltages above -0.3 V.
4. Human body model: A 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
5. Machine model: A 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω). This is done for all couples of connected pin combinations while the other pins are floating.
6. Charged device model: all pins and the package are charged together to the specified voltage and then discharged directly to the ground through only one pin. This is done for all pins.

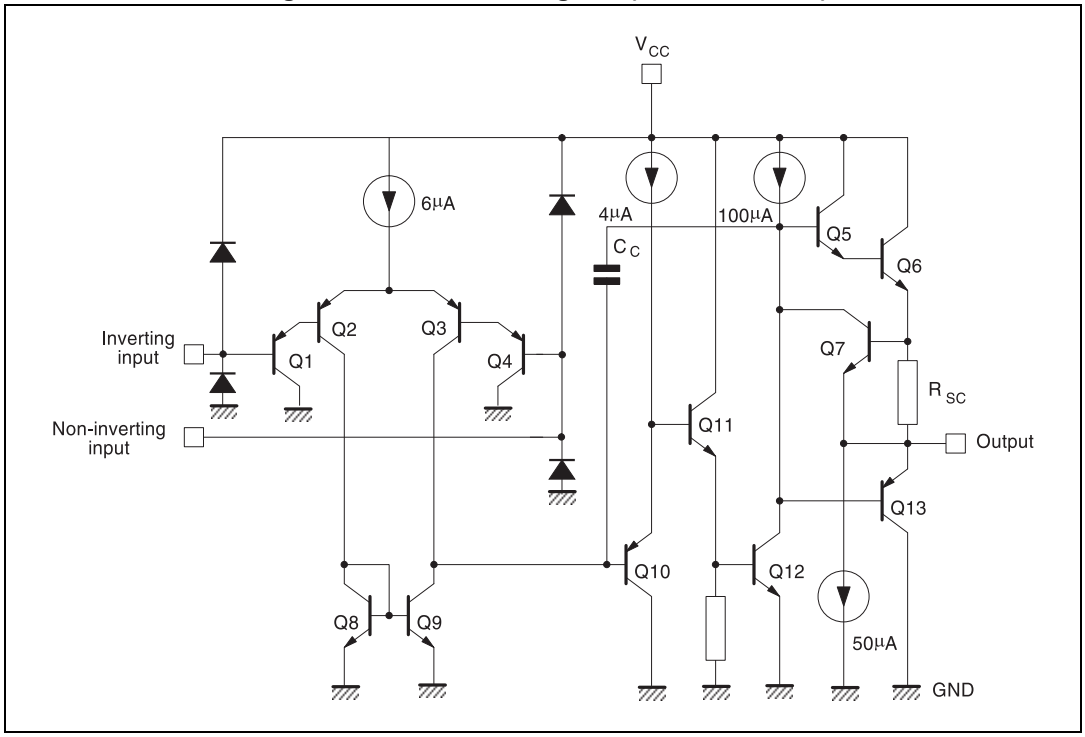
**Table 2. Operating conditions**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}^+$ | Supply voltage | 3 to 30 | V |
| $T_{oper}$ | Operating free-air temperature range | -40 to 150 | °C |
| $V_{icm}$ | Input common mode voltage range ($V_{CC}^+$=+30V)(1)<br>$T_{amb}$ = 25 °C<br>$T_{min} \le T_{amb} \le T_{max}$ | <br>0 to ($V_{CC}^+$) - 1.5<br>0 to ($V_{CC}^+$) - 2 | V |

1. The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is $V_{CC}^+$ –1.5 V, but either or both inputs can go to +32 V without damage.

# 2 Schematic diagram

**Figure 1. Schematic diagram (1/2 RT2904WH)**



# 3 Electrical characteristics

**Table 3. $V_{CC}^+$ = 5V, $V_{CC}^-$ = ground, $V_o$ = 1.4 V, $T_{amb}$ = 25 °C (unless otherwise specified)**

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $V_{io}$ | Input offset voltage(1)<br>$T_{min} \le T_{amb} \le T_{max}$ | | 2 | 7<br>9 | mV |
| $I_{io}$ | Input offset current<br>$T_{min} \le T_{amb} \le T_{max}$ | | 2 | 30<br>40 | nA |
| $I_{ib}$ | Input bias current(2)<br>$T_{min} \le T_{amb} \le T_{max}$ | | 20 | 150<br>200 | |
| $A_{vd}$ | Large signal voltage gain<br>$V_{CC}^+$ = 15 V, $R_L$=2 kΩ, $V_o$ = 1.4 V to 11.4 V<br>$T_{min} \le T_{amb} \le T_{max}$ | 50<br>2.5 | 100 | | V/mV |
| SVR | Supply voltage rejection ratio<br>$V_{CC}^+$ = 5 to 30 V, $R_S \le 10$ kΩ<br>$T_{min} \le T_{amb} \le T_{max}$ | 65<br>65 | 100 | | dB |
| $I_{CC}$ | Supply current, all amps, no load<br>$V_{CC}^+$ = 5 V<br>$T_{min} \le T_{amb} \le T_{max}$, $V_{CC}$ = 30 V | | 0.7 | 1.2<br>2 | mA |
| CMR | Common-mode rejection ratio ($R_S$ = 10 kΩ)<br>$T_{min} \le T_{amb} \le T_{max}$ | 70<br>60 | 85 | | dB |
| $I_{source}$ | Output short-circuit current<br>$V_{CC}^+$= 15 V, $V_o$ = 2 V, $V_{id}$ = 1 V<br>$T_{min} \le T_{amb} \le T_{max}$ | 20<br>10 | 40 | 60 | mA |
| $I_{sink}$ | Output sink current<br>$V_O$ = 2 V, $V_{CC}^+$ = 5 V<br>$T_{min} \le T_{amb} \le T_{max}$<br>$V_O$ = 0.2 V, $V_{CC}^+$ = 15 V<br>$T_{min} \le T_{amb} \le T_{max}$ | 10<br>5<br>12<br>10 | 20<br><br>50 | | mA<br><br>µA |
| $V_{OPP}$ | Output voltage swing ($R_L$ = 2 kΩ)<br>$T_{min} \le T_{amb} \le T_{max}$ | 0<br>0 | | ($V_{CC}^+$) - 1.5<br>($V_{CC}^+$) - 2 | V |
| $V_{OH}$ | High level output voltage ($V_{CC}^+$ = 30 V)<br>$R_L$ = 2 kΩ<br>$T_{min} \le T_{amb} \le T_{max}$<br>$R_L$ = 10 kΩ<br>$T_{min} \le T_{amb} \le T_{max}$ | 26<br>26<br>27<br>27 | 27<br><br>28 | | |
| $V_{OL}$ | Low level output voltage ($R_L$ = 10 kΩ)<br>$T_{min} \le T_{amb} \le T_{max}$ | | 5 | 20<br>20 | mV |

**Table 3. $V_{CC}^+$ = 5V, $V_{CC}^-$ = ground, $V_o$ = 1.4 V, $T_{amb}$ = 25 °C (unless otherwise specified) (continued)**

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| SR | Slew rate (unity gain)<br>$V_{CC}^+$ = 15 V, Vi = 0.5 to 3 V, $R_L$ = 2 kΩ, $C_L$ = 100 pF,<br>$T_{min} \le T_{amb} \le T_{max}$ | 0.3<br>0.2 | 0.6 | | V/µs |
| GBP | Gain bandwidth product f = 100 kHz<br>$V_{CC}^+$ = 30 V, $V_{in}$ = 10 mV, $R_L$ = 2 kΩ, $C_L$ = 100 pF<br>$T_{min} \le T_{amb} \le T_{max}$ | 0.7<br>0.45 | 1.1 | | MHz |
| THD | Total harmonic distortion<br>f = 1 kHz, $A_V$ = 20 dB, $R_L$ = 2 kΩ, $V_o$ = 2 $V_{pp}$,<br>$C_L$ = 100 pF, $V_{CC}$ = 30 V | | 0.02 | | % |
| $e_n$ | Equivalent input noise voltage, f = 1 kHz, $R_S$ = 100 Ω,<br>$V_{CC}$ = 30 V | | 55 | | nV/√Hz |
| $DV_{io}$ | Input offset voltage drift | | 7 | 30 | µV/°C |
| $DI_{io}$ | Input offset current drift | | 10 | 300 | pA/°C |
| $V_{O1}/V_{O2}$ | Channel separation(3)<br>1 kHz ≤ f ≤ 20 kHz | | 120 | | dB |

1. $V_O$ = 1.4 V, $R_S$ = 0 Ω, 5 V < $V_{CC}^+$ < 30 V, 0 V < $V_{ic}$ < ($V_{CC}^+$) - 1.5 V.
2. The direction of the input current is out of the IC. This current is essentially constant, independent of the state of the output, so there is no change in the loading charge on the input lines.
3. Due to the proximity of external components, ensure that stray capacitance does not cause coupling between these external parts. Typically, this can be detected because this type of capacitance increases at higher frequencies.

**Figure 2. Open-loop frequency response**

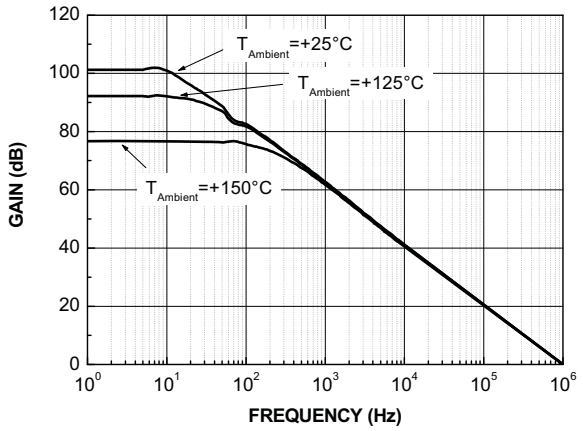



**Figure 3. Large signal frequency response**

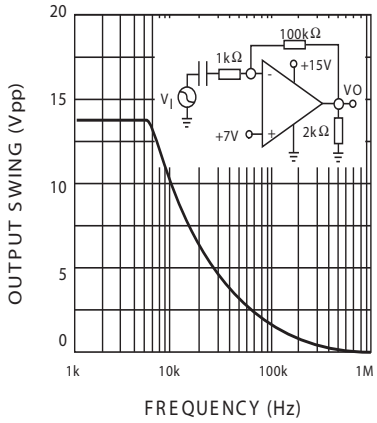



**Figure 4. Voltage follower pulse response**

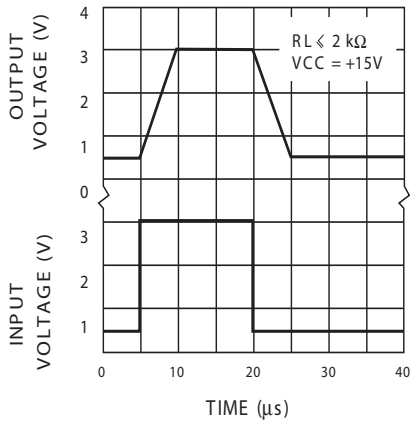



**Figure 5. Input bias current**

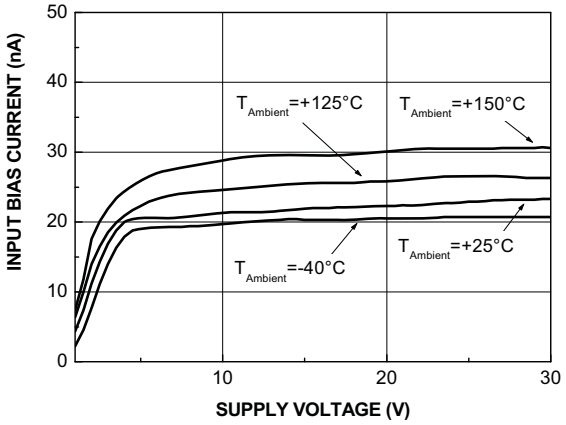



**Figure 6. Supply current**

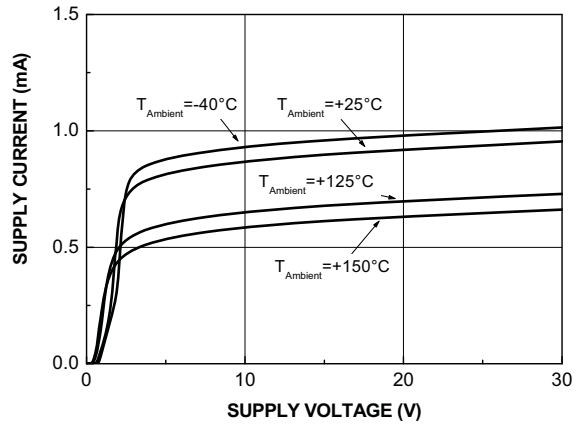



**Figure 7. Output characteristics vs. +$V_{CC}$**

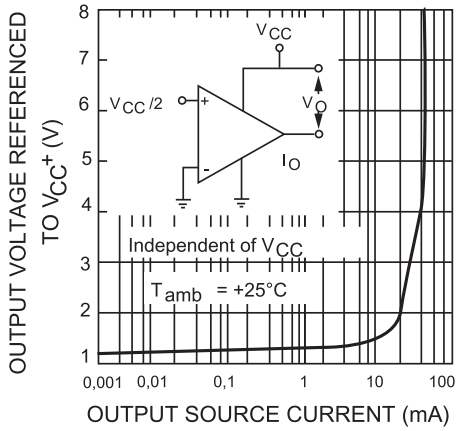


**Figure 8. Output characteristics vs. GND**

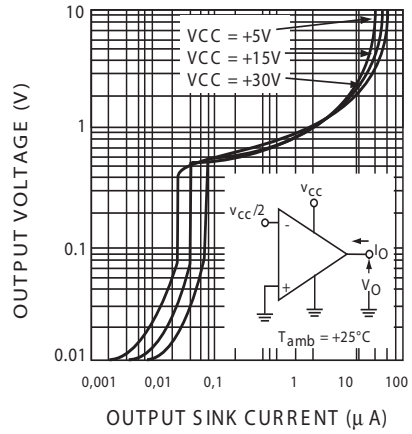



**Figure 9. Current limiting**

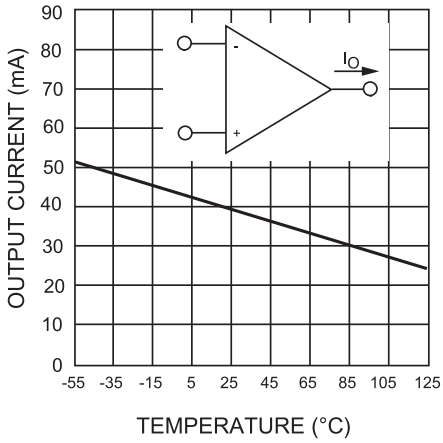



**Figure 10. Voltage follower pulse response on 50 pF**

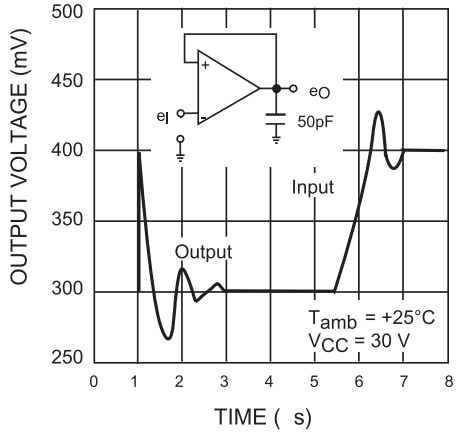



**Figure 11. Input voltage range**

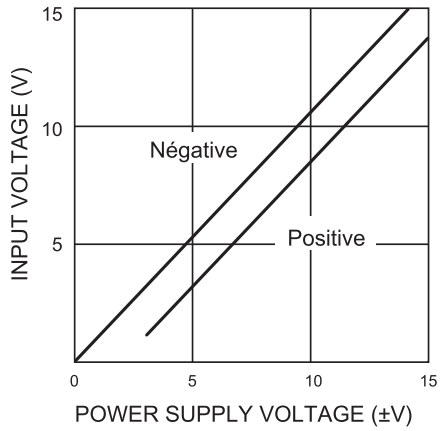



**Figure 12. Voltage gain**

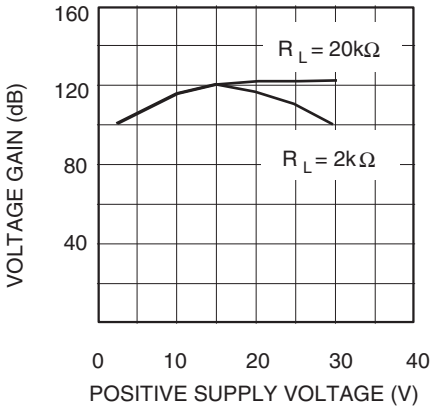



**Figure 13. Gain bandwidth product**

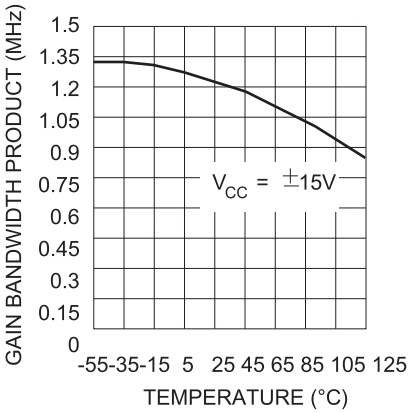


**Figure 14. Power supply rejection ratio versus temperature**

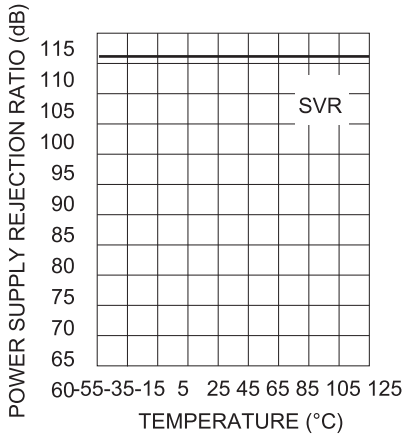
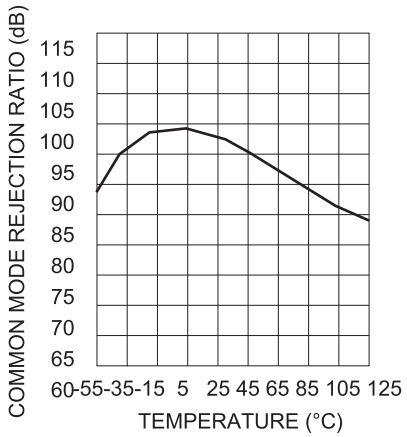



**Figure 15. Common mode rejection ratio versus temperature**



# 4 Package information

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

## 4.1 SO8 package information

**Figure 16. SO8 package mechanical drawing**

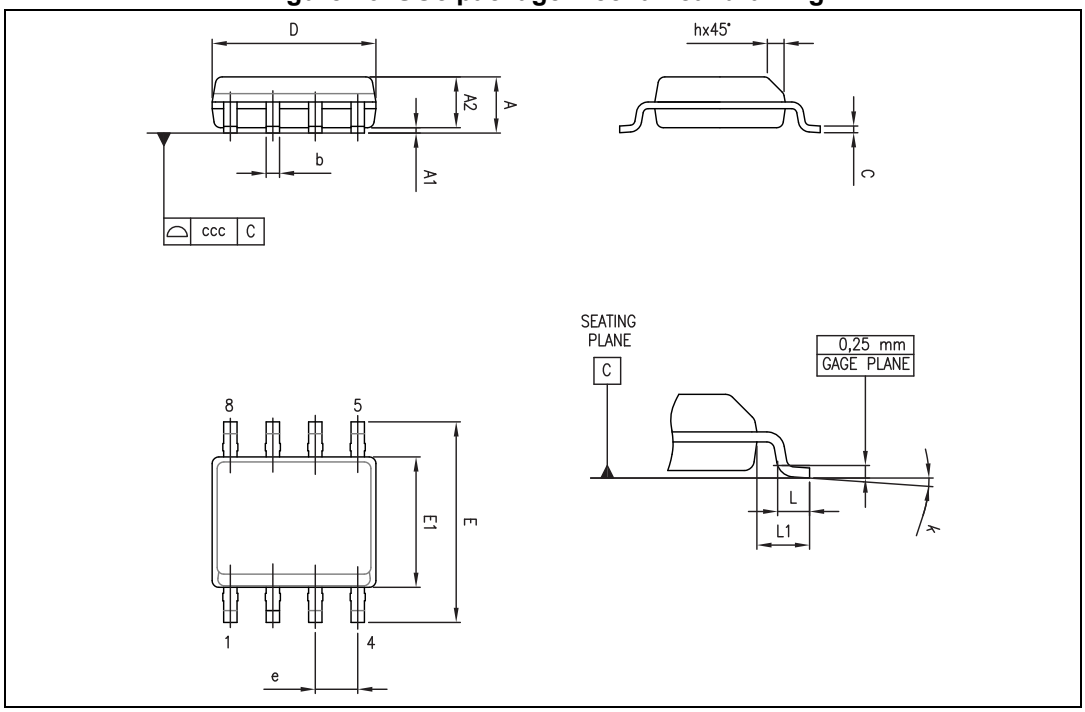



**Table 4. SO8 package mechanical data**

| 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 Ordering information

Table 5. Order codes

| Order code | Temperature range | Package | Packing | Marking |
|---|---|---|---|---|
| RT2904WHYDT | -40 °C to 150 °C | SO8 | Tape and reel | R2904WHY |

# 6 Revision history

Table 6. Document revision history

| Date | Revision | Changes |
|---|---|---|
| 08-Oct-2014 | 1 | Initial release. |