

# Nano-Power, CMOS Input, RRIO, Push-Pull Output Comparator

## 1 FEATURES

- **Low supply current**  
**400nA (TYP) at  $V_S = 1.4V$**
- **Low input offset voltage:  $V_{os(max)} = \pm 3mV$**
- **Rail-to-Rail Input and output**
- **SUPPLY RANGE: +1.4V to +5.5V**
- **SPECIFIED UP TO +125°C**
- **Micro SIZE PACKAGES: SOP8, MSOP8**

## 2 APPLICATIONS

- **OVERVOLTAGE AND UNDERVOLTAGE DETECTION**
- **MULTIVIBRATORS**
- **OVERCURRENT DETECTION**
- **SYSTEM MONITORING**
- **BATTERY POWERED SYSTEM**

## 3 DESCRIPTIONS

The RS8905 offers a wide supply range, It is a dual low power comparator with a typical power supply current of 400nA (per channel), and rail-to-rail inputs. All of these features come in industry-standard and extremely small packages, making this device an excellent choice for low-voltage and low-power applications for portable electronics and industrial systems.

Featuring a push-pull output stage, the RS8905 allows for operation with absolute minimum power consumption when driving any capacitive or resistive load.

The devices are ideal for system monitoring, include tablets, portable medical, smart phones. The RS8905 is specified at the full temperature range of  $-40^{\circ}C$  to  $+125^{\circ}C$  under single power supplies of 1.4V to 5.5V.

**Device Information <sup>(1)</sup>**

| PART NUMBER | PACKAGE | BODY SIZE (NOM) |
|-------------|---------|-----------------|
| RS8905      | SOP8    | 4.90mm×3.90mm   |
|             | MSOP8   | 3.00mm×3.00mm   |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

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## 4 REVISION HISTORY

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

| VERSION | Change Date | Change Item   |
|---------|-------------|---|
| A.6     | 2022/4/15   | 1. Delete the second remark in the Absolute Maximum Ratings in Page 3@A.5 Version.<br>2. Change Functional Block Diagram<br>3. Added TAPE AND REEL INFORMATION<br>4. Change ELECTRICAL CHARACTERISTICS in Page 5@A.5 Version.<br>5. Change TYPICAL CHARACTERISTICS in Page 6@A.5 Version. |
| A.6.1   | 2024/02/23  | Modify packaging naming   |
| A.7     | 2024/03/27  | 1. Added MSL on Page 5@RevA.6.1<br>2. Update Package thermal impedance<br>3. Update PACKAGE note  |
| A.8     | 2025/03/21  | Add Charged-device model (CDM)  |

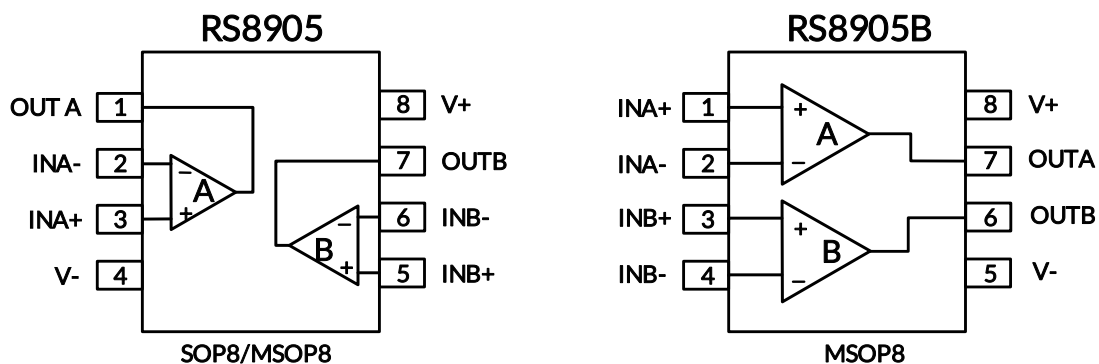
**5 PACKAGE/ORDERING INFORMATION <sup>(1)</sup>**

| Orderable Device | Package Type | Pin | Channel | Op Temp(°C)  | Device Marking <sup>(2)</sup> | MSL <sup>(3)</sup> | Package Qty         |
|------------------|--------------|-----|---------|--------------|-------------------------------|--------------------|---------------------|
| RS8905XK         | SOP8         | 8   | 2       | -40°C ~125°C | RS8905                        | MSL3               | Tape and Reel, 4000 |
| RS8905XM         | MSOP8        | 8   | 2       | -40°C ~125°C | RS8905                        | MSL3               | Tape and Reel, 4000 |
| RS8905BXM        | MSOP8        | 8   | 2       | -40°C ~125°C | RS8905B                       | MSL3               | Tape and Reel, 4000 |

## NOTE:

- (1) This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the right-hand navigation.
- (2) There may be additional marking, which relates to the lot trace code information (data code and vendor code), the logo or the environmental category on the device.
- (3) RUNIC classify the MSL level with using the common preconditioning setting in our assembly factory conforming to the JEDEC industrial standard J-STD-20F, Please align with RUNIC if your end application is quite critical to the preconditioning setting or if you have special requirement.

## 6 PIN CONFIGURATION AND FUNCTIONS (TOP VIEW)



### Pin Description

| NAME | PIN     |            | I/O <sup>(1)</sup> | DESCRIPTION                     |
|------|---------|------------|--------------------|---------------------------------|
|      | RS8905B | RS8905     |                    |                                 |
|      | MSOP8   | SOP8/MSOP8 |                    |                                 |
| INA+ | 1       | 3          | I                  | Noninverting input A            |
| INA- | 2       | 2          | I                  | Inverting input A               |
| INB+ | 3       | 5          | I                  | Noninverting input B            |
| INB- | 4       | 6          | I                  | Inverting input B               |
| V-   | 5       | 4          | P                  | Negative (lowest) power supply  |
| OUTB | 6       | 7          | O                  | Output B                        |
| OUTA | 7       | 1          | O                  | Output A                        |
| V+   | 8       | 8          | P                  | Positive (highest) power supply |

(1) I=Input, O=Output, P=Power.

## 7 SPECIFICATIONS

### 7.1 Absolute Maximum Ratings

Over operating free-air temperature range (unless otherwise noted) <sup>(1)</sup>

|               |  |       | MIN        | MAX       | UNIT |
|---------------|--|-------|------------|-----------|------|
| Voltage       | Supply, $V_S = (V+) - (V-)$              |       |            | 7         | V    |
|               | Input pin (IN+, IN-)                     |       | (V-)-0.5   | (V+) +0.5 |      |
|               | Signal output pin <sup>(2)</sup>         |       | (V-)-0.5   | (V+) +0.5 |      |
| Current       | Signal input pin (IN+, IN-)              |       | -10        | 10        | mA   |
|               | Signal output pin <sup>(2)</sup>         |       | -55        | 55        | mA   |
|               | Output short-circuit <sup>(3)</sup>      |       | Continuous |           |      |
| $\theta_{JA}$ | Package thermal impedance <sup>(4)</sup> | SOP8  |            | 110       | °C/W |
|               |  | MSOP8 |            | 170       |      |
| Temperature   | Operating range, $T_A$                   |       | -40        | 125       | °C   |
|               | Junction, $T_J$ <sup>(5)</sup>           |       | -40        | 150       |      |
|               | Storage, $T_{stg}$                       |       | -65        | 150       |      |

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

(2) Output terminals are diode-clamped to the power-supply rails. Output signals that can swing more than 0.5V beyond the supply rails should be current-limited to  $\pm 55\text{mA}$  or less.

(3) Short-circuit to ground, one amplifier per package.

(4) The package thermal impedance is calculated in accordance with JEDEC-51.

(5) The maximum power dissipation is a function of  $T_{J(MAX)}$ ,  $R_{\theta JA}$ , and  $T_A$ . The maximum allowable power dissipation at any ambient temperature is  $P_D = (T_{J(MAX)} - T_A) / R_{\theta JA}$ . All numbers apply for packages soldered directly onto a PCB.

### 7.2 ESD Ratings

The following ESD information is provided for handling of ESD-sensitive devices in an ESD protected area only.

|             |                         |                            | VALUE      | UNIT |
|-------------|-------------------------|----------------------------|------------|------|
| $V_{(ESD)}$ | Electrostatic discharge | Human-body model (HBM)     | $\pm 3000$ | V    |
|             |                         | Charged-device model (CDM) | $\pm 1000$ |      |
|             |                         | Machine Model (MM)         | $\pm 400$  |      |



#### ESD SENSITIVITY CAUTION

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 7.3 Recommended Operating Conditions

Over operating free-air temperature range (unless otherwise noted)

|                                     |               | MIN       | NOM | MAX        | UNIT |
|-------------------------------------|---------------|-----------|-----|------------|------|
| Supply voltage, $V_S = (V+) - (V-)$ | Single-supply | 1.4       |     | 5.5        | V    |
|                                     | Dual-supply   | $\pm 0.7$ |     | $\pm 2.75$ |      |

## 7.4 ELECTRICAL CHARACTERISTICS

(At  $T_A = +25^\circ\text{C}$ ,  $V_S = 1.4\text{V}$  to  $5.5\text{V}$ ,  $V_{CM} = V_S/2$ ,  $C_L = 15\text{pF}$ , unless otherwise noted.)<sup>(1)</sup>

| PARAMETER            |  | CONDITIONS  |                      | RS8905/RS8905B     |                    |                    |       |
|----------------------|--|---|----------------------|--------------------|--------------------|--------------------|-------|
|                      |  |   |                      | MIN <sup>(2)</sup> | TYP <sup>(3)</sup> | MAX <sup>(2)</sup> | UNITS |
| POWER SUPPLY         |  |   |                      |                    |                    |                    |       |
| V <sub>s</sub>       | Operating Voltage Range                          |   |                      | 1.4                |                    | 5.5                | V     |
| I <sub>Q</sub> /AMP  | Quiescent Current Per channel                    |   |                      |                    | 400                | 1500               | nA    |
| PSRR                 | Power-Supply Rejection Ratio                     | V <sub>s</sub> =1.4V to 5.5V, V <sub>CM</sub> =(V)+0.5V           |                      |                    | 70                 |                    | dB    |
| INPUT                |  |   |                      |                    |                    |                    |       |
| V <sub>OS</sub>      | Input Offset Voltage                             | V <sub>CM</sub> =V <sub>s</sub> /2                                | V <sub>s</sub> =1.4V | -6                 | 1                  | 6                  | mV    |
|                      |  |   | V <sub>s</sub> =5.0V | -3                 | 1                  | 3                  |       |
| ΔV <sub>OS</sub> /ΔT | Input Offset Voltage Drift                       | V <sub>CM</sub> =V <sub>s</sub> /2, -40°C ≤ T <sub>A</sub> ≤125°C |                      |                    | 2                  |                    | μV/°C |
| I <sub>B</sub>       | Input Bias Current <sup>(4)</sup> <sup>(5)</sup> |   |                      |                    | 1                  | 10                 | pA    |
| V <sub>CM</sub>      | Common-Mode Voltage Range                        | T <sub>A</sub> = -40°C to 125°C                                   |                      | (V-)-0.1           |                    | (V+)+0.1           | V     |
| CMRR                 | Common-Mode Rejection Ratio                      | V <sub>s</sub> =5.5V, V <sub>CM</sub> =-0.1 to 5.6V               |                      |                    | 70                 |                    | dB    |
| OUTPUT               |  |   |                      |                    |                    |                    |       |
| V <sub>OH</sub>      | Output Swing From Upper Rail                     | V <sub>s</sub> =1.4V, I <sub>o</sub> =0.1mA                       |                      |                    | 70                 | 75                 | mV    |
|                      |  | V <sub>s</sub> =5.0V, I <sub>o</sub> =2.5mA                       |                      |                    | 140                | 170                | mV    |
| V <sub>OL</sub>      | Output Swing From Lower Rail                     | V <sub>s</sub> =1.4V, I <sub>o</sub> =-0.1mA                      |                      |                    | 35                 | 40                 | mV    |
|                      |  | V <sub>s</sub> =5.0V, I <sub>o</sub> =-2.5mA                      |                      |                    | 85                 | 115                | mV    |
| I <sub>SC</sub>      | Short Circuit Sink Current                       | V <sub>s</sub> =5.0V  |                      |                    | 42                 |                    | mA    |
|                      | Short Circuit Source Current                     | V <sub>s</sub> =5.0V  |                      |                    | 38                 |                    | mA    |
| SWITCHING            |  |   |                      |                    |                    |                    |       |
| T <sub>PHL</sub>     | Propagation Delay H To L <sup>(6)</sup>          | V <sub>s</sub> = 5.0 V, Overdrive = 10 mV                         |                      |                    | 13                 | 20                 | μs    |
|                      |  | V <sub>s</sub> = 5.0 V, Overdrive = 100 mV                        |                      |                    | 9                  | 14                 |       |
|                      |  | V <sub>s</sub> = 2.5 V, Overdrive = 10 mV                         |                      |                    | 12                 | 18                 |       |
|                      |  | V <sub>s</sub> = 2.5 V, Overdrive = 100 mV                        |                      |                    | 8                  | 12                 |       |
|                      |  | V <sub>s</sub> = 1.4 V, Overdrive = 10 mV                         |                      |                    | 13                 | 20                 |       |
|                      |  | V <sub>s</sub> = 1.4 V, Overdrive = 100 mV                        |                      |                    | 9                  | 14                 |       |
| T <sub>PLH</sub>     | Propagation Delay L To H <sup>(6)</sup>          | V <sub>s</sub> = 5.0 V, Overdrive = 10 mV                         |                      |                    | 30                 | 50                 |       |
|                      |  | V <sub>s</sub> = 5.0 V, Overdrive = 100 mV                        |                      |                    | 21                 | 38                 |       |
|                      |  | V <sub>s</sub> = 2.5 V, Overdrive = 10 mV                         |                      |                    | 24                 | 45                 |       |
|                      |  | V <sub>s</sub> = 2.5 V, Overdrive = 100 mV                        |                      |                    | 15                 | 30                 |       |
|                      |  | V <sub>s</sub> = 1.4 V, Overdrive = 10 mV                         |                      |                    | 25                 | 50                 |       |
|                      |  | V <sub>s</sub> = 1.4 V, Overdrive = 100 mV                        |                      |                    | 15                 | 30                 |       |
| T <sub>R</sub>       | Rise Time  | Overdrive = 100 mV  |                      |                    | 240                |                    | ns    |
| T <sub>F</sub>       | Fall Time  | Overdrive = 100 mV  |                      |                    | 260                |                    | ns    |

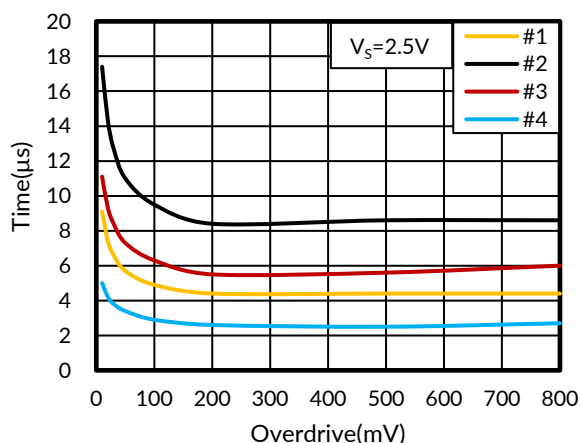
NOTE:

- (1) Electrical table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device.
- (2) Limits are 100% production tested at  $25^\circ\text{C}$ . Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.
- (3) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration.
- (4) This parameter is ensured by design and/or characterization and is not tested in production.
- (5) Positive current corresponds to current flowing into the device.
- (6) High-to-low and low-to-high refers to the transition at the input.

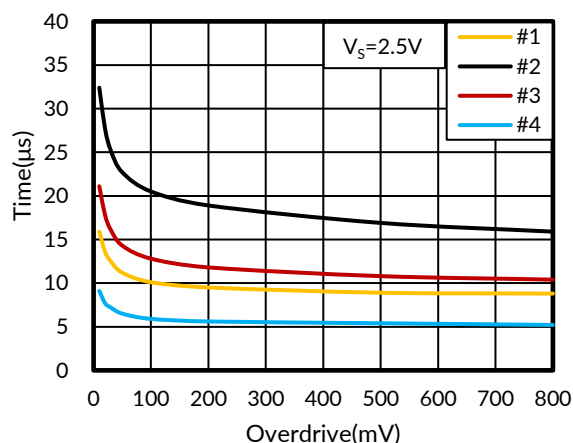
## 7.5 TYPICAL CHARACTERISTICS

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

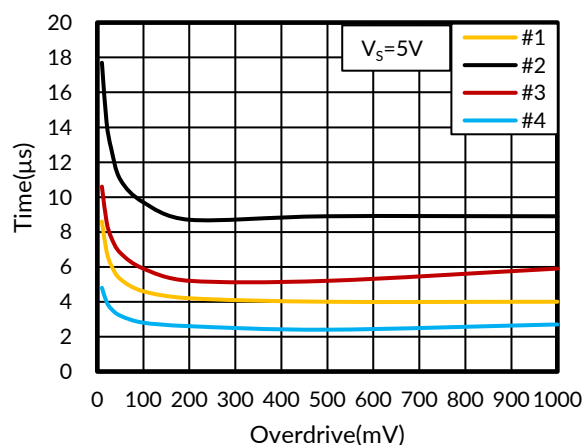
At  $T_A = +25^\circ\text{C}$ ,  $V_S = 5\text{V}$ ,  $V_{CM} = V_S/2$ ,  $C_L = 15\text{pF}$  unless otherwise noted.



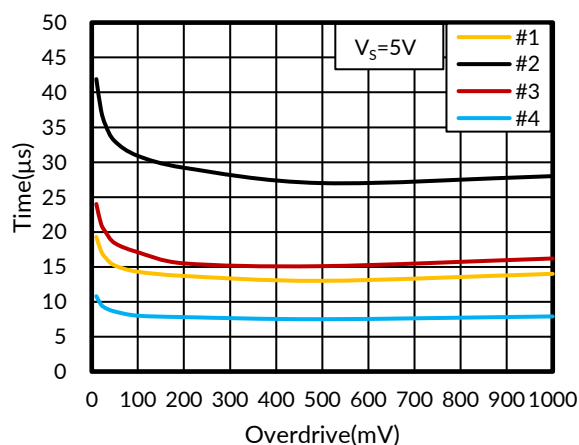
**Figure 1. Response Time vs Input Overdrives Negative Transition**



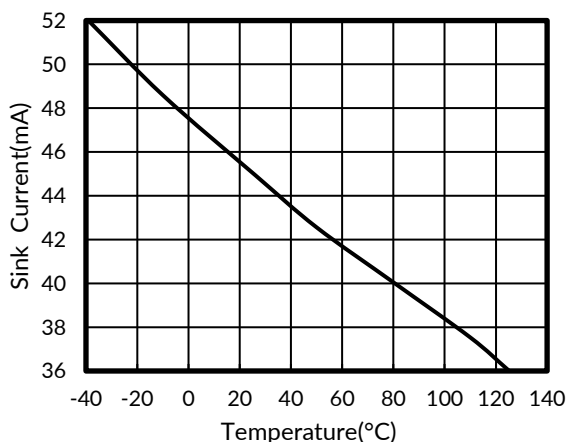
**Figure 2. Response Time vs Input Overdrives Positive Transition**



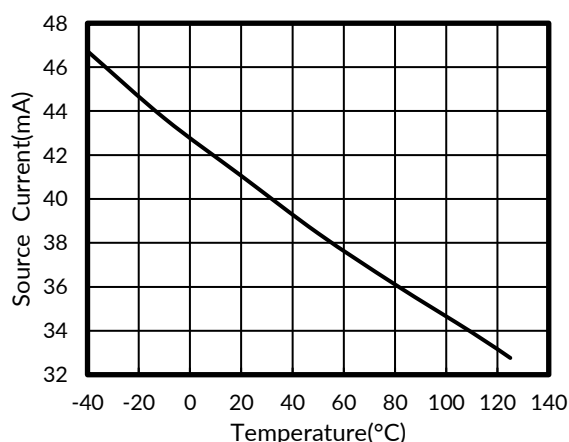
**Figure 3. Response Time vs Input Overdrives Negative Transition**



**Figure 4. Response Time vs Input Overdrives Positive Transition**



**Figure 5. SINK CURRENT vs TEMPERATURE**



**Figure 6. SOURCE CURRENT vs TEMPERATURE**

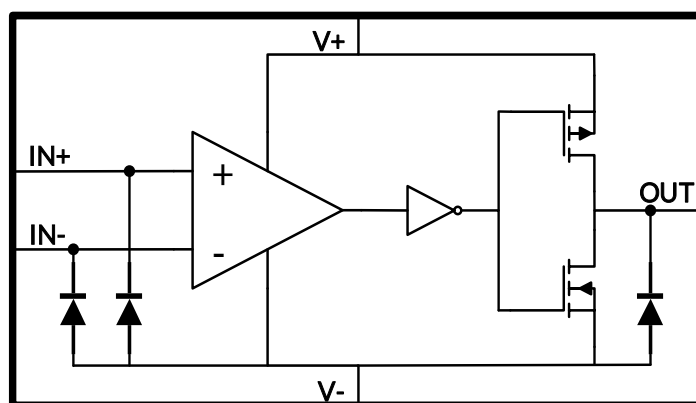


## 8 DETAILED DESCRIPTION

### 8.1 Overview

The RS8905 devices are double-channel, Nano-power comparators with a push-pull output stage. Operating from 1.4V to 5.5V and consuming only 400nA per channel. The push-pull output of the RS8905 supports rail-to-rail output swing and interfaces with TTL/CMOS logic.

### 8.2 Functional Block Diagram



### 8.3 Feature Description

The RS8905 devices are Nano-Power comparators that can operate at low voltages. The RS8905 feature a rail-to-rail input stage capable of operating up to 100 mV beyond the VCC power supply rail.

### 8.4 Input Stage

The RS8905 has rail-to-rail input common-mode voltage range. It can operate at any differential input voltage within this limit as long as the differential voltage is greater than zero. A differential input of zero volts may result in oscillation.

The differential input stage of the comparator is a pair of PMOS and NMOS transistors, therefore, no current flows into the device. The input bias current measured is the leakage current in the MOS transistors and input protection diodes. This low bias current allows the comparator to interface with a variety of circuitry and devices with minimal concern about matching the input resistances.

### 8.5 Output Stage

The RS8905 has a MOS push-pull rail-to-rail output stage. The push-pull transistor configuration of the output keeps the total system power consumption to a minimum. The only current consumed by the RS8905 is the less than 1 $\mu$ A supply current and the current going directly into the load. No power is wasted through the pullup resistor when the output is low. The output stage is specifically designed with dead time between the time when one transistor is turned off and the other is turned on (break-before-make) to minimize shoot through currents. The internal logic controls the break-before-make timing of the output transistors. The break-before-make delay varies with temperature and power condition.

### 8.6 Output Current

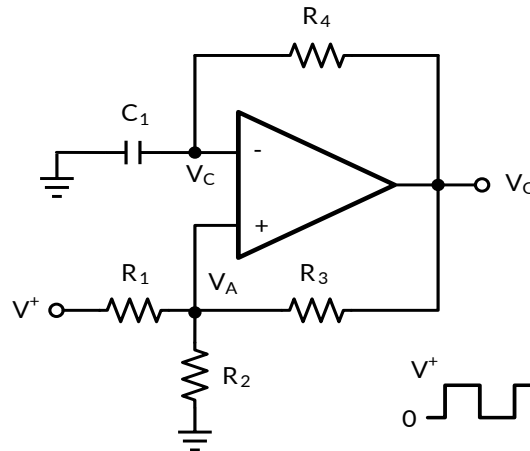
Even though the RS8905 uses less than 1 $\mu$ A supply current, the outputs are able to drive very large currents. The RS8905 can source up to 38mA and can sink up to 42mA, when operated at 5V supply. This large current handling capability allows driving heavy loads directly.

## 9 APPLICATION INFORMATION

The RS8905 is an ultra-low-power comparator with a typical power supply current of 400nA per channel. It has the best-in class power supply current versus propagation delay. The propagation delay is as low as 9μs with 100mV overdrive at 1.4V supply.

### Typical Applications

#### 9.1 Square Wave Generator

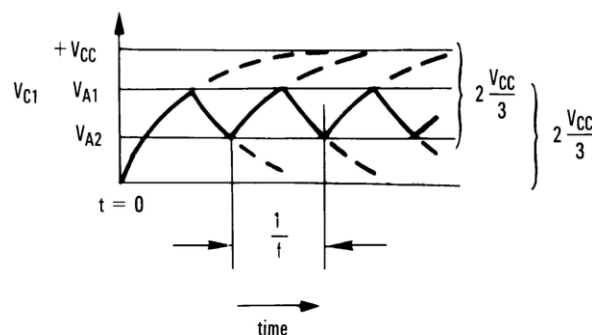


**Figure 7. Square Wave Generator Schematic**

#### 9.2 Design Requirements

A typical application for a comparator is as a square wave oscillator. The circuit in Figure 7 generates a square wave whose period is set by the RC time constant of the capacitor C1 and resistor R4. The maximum frequency is limited by the large signal propagation delay of the comparator and by the capacitive loading at the output, which limits the output slew rate.

#### 9.3 Detailed Design Procedure



**Figure 8. Square Wave Oscillator**

## Typical Applications(continued)

Consider the output of Figure 8 to be high to analyze the circuit. That implies that the inverted input ( $V_C$ ) is lower than the noninverting input ( $V_A$ ). This causes the  $C_1$  to be charged through  $R_4$ , and the voltage  $V_C$  increases until it is equal to the noninverting input. The value of  $V_A$  at this point is in Equation 1.

$$V_{A1} = \frac{V_{CC} \times R_2}{R_2 + R_1 \parallel R_3} \dots\dots\dots (1)$$

If  $R_1 = R_2 = R_3$  then  $V_{A1} = 2 V_{CC}/3$

At this point the comparator switches pulling down the output to the negative rail. The value of  $V_A$  at this point, as shown in Equation 2:

$$V_{A2} = \frac{V_{CC}(R_2 \parallel R_3)}{R_1 + (R_2 \parallel R_3)} \dots\dots\dots (2)$$

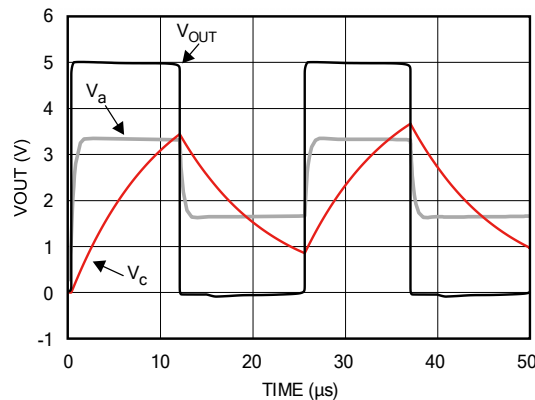
If  $R_1 = R_2 = R_3$  then  $V_{A2} = V_{CC}/3$  The capacitor  $C_1$  now discharges through  $R_4$ , and the voltage  $V_C$  decreases until it is equal to  $V_{A2}$ , at which point the comparator switches again, bringing it back to the initial stage. The time period is equal to twice the time it takes to discharge  $C_1$  from  $2 V_{CC}/3$  to  $V_{CC}/3$ , which is given by  $R_4 C_1 \times \ln 2$ . Hence the formula for the frequency is given by Equation 3:

$$F = 1/(2 \times R_4 \times C_1 \times \ln 2) \dots\dots\dots (3)$$

### 9.4 Application Curves

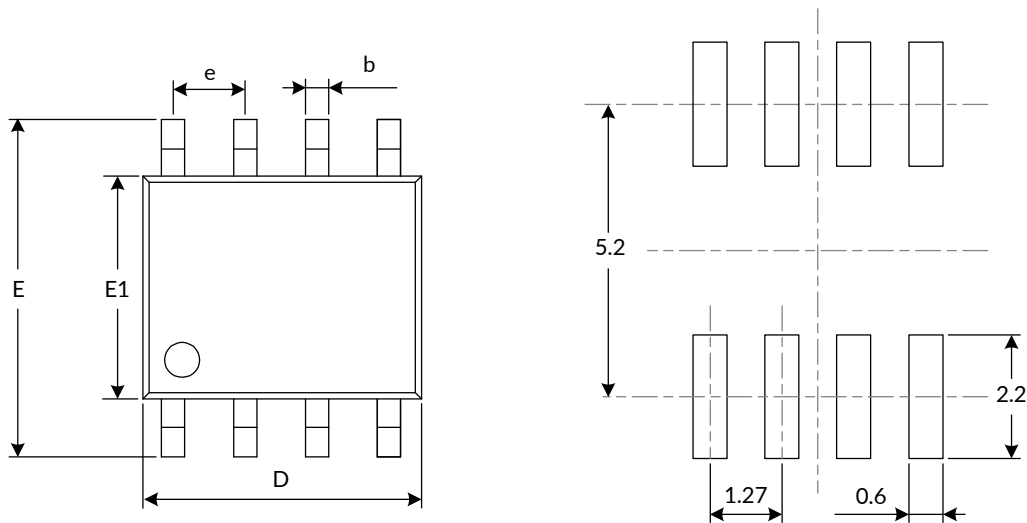
Figure 9 shows the simulated results of an oscillator using the following values:

1.  $R_1 = R_2 = R_3 = R_4 = 100 \text{ k}\Omega$
2.  $C_1 = 100 \text{ pF}$ ,  $C_L = 20 \text{ pF}$
3.  $V_+ = 5 \text{ V}$ ,  $V_- = \text{GND}$
4.  $C_{STRAY}$  (not shown) from  $V_a$  to GND =  $10 \text{ pF}$

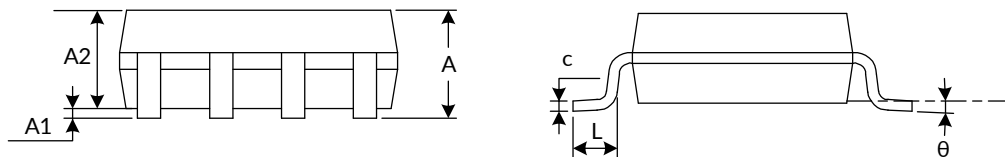


**Figure 9. Square Wave Oscillator Output Waveform**

# 10 PACKAGE OUTLINE DIMENSIONS SOP8<sup>(3)</sup>



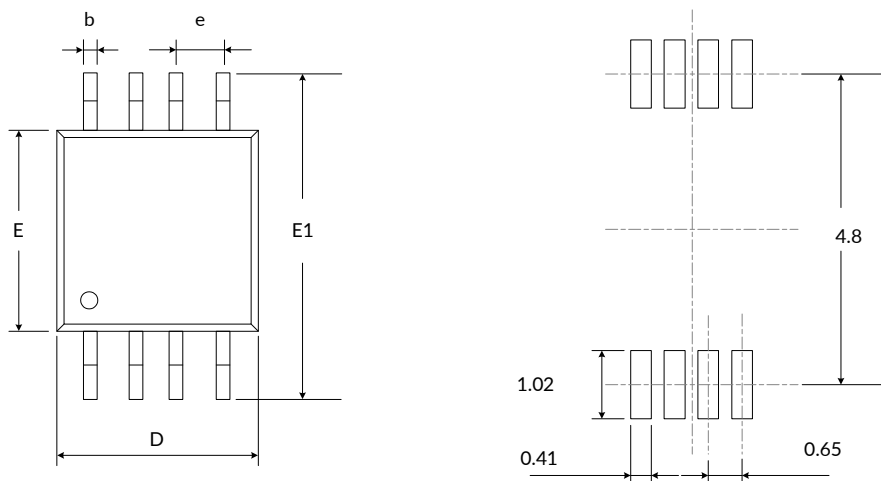
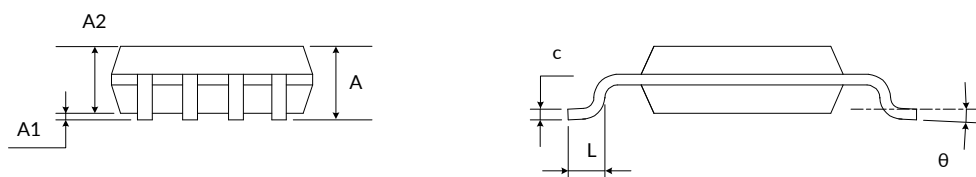
RECOMMENDED LAND PATTERN (Unit: mm)



| Symbol            | Dimensions In Millimeters  |       | Dimensions In Inches       |       |
|-------------------|----------------------------|-------|----------------------------|-------|
|                   | Min                        | Max   | Min                        | Max   |
| A <sup>(1)</sup>  | 1.350                      | 1.750 | 0.053                      | 0.069 |
| A1                | 0.100                      | 0.250 | 0.004                      | 0.010 |
| A2                | 1.350                      | 1.550 | 0.053                      | 0.061 |
| b                 | 0.330                      | 0.510 | 0.013                      | 0.020 |
| c                 | 0.170                      | 0.250 | 0.007                      | 0.010 |
| D <sup>(1)</sup>  | 4.800                      | 5.000 | 0.189                      | 0.197 |
| e                 | 1.270 (BSC) <sup>(2)</sup> |       | 0.050 (BSC) <sup>(2)</sup> |       |
| E                 | 5.800                      | 6.200 | 0.228                      | 0.244 |
| E1 <sup>(1)</sup> | 3.800                      | 4.000 | 0.150                      | 0.157 |
| L                 | 0.400                      | 1.270 | 0.016                      | 0.050 |
| θ                 | 0°                         | 8°    | 0°                         | 8°    |

**NOTE:**

1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

**MSOP8<sup>(3)</sup>**

**RECOMMENDED LAND PATTERN (Unit: mm)**


| Symbol           | Dimensions In Millimeters  |       | Dimensions In Inches       |       |
|------------------|----------------------------|-------|----------------------------|-------|
|                  | Min                        | Max   | Min                        | Max   |
| A <sup>(1)</sup> | 0.820                      | 1.100 | 0.032                      | 0.043 |
| A1               | 0.020                      | 0.150 | 0.001                      | 0.006 |
| A2               | 0.750                      | 0.950 | 0.030                      | 0.037 |
| b                | 0.250                      | 0.380 | 0.010                      | 0.015 |
| c                | 0.090                      | 0.230 | 0.004                      | 0.009 |
| D <sup>(1)</sup> | 2.900                      | 3.100 | 0.114                      | 0.122 |
| e                | 0.650 (BSC) <sup>(2)</sup> |       | 0.026 (BSC) <sup>(2)</sup> |       |
| E <sup>(1)</sup> | 2.900                      | 3.100 | 0.114                      | 0.122 |
| E1               | 4.750                      | 5.050 | 0.187                      | 0.199 |
| L                | 0.400                      | 0.800 | 0.016                      | 0.031 |
| θ                | 0°                         | 6°    | 0°                         | 6°    |

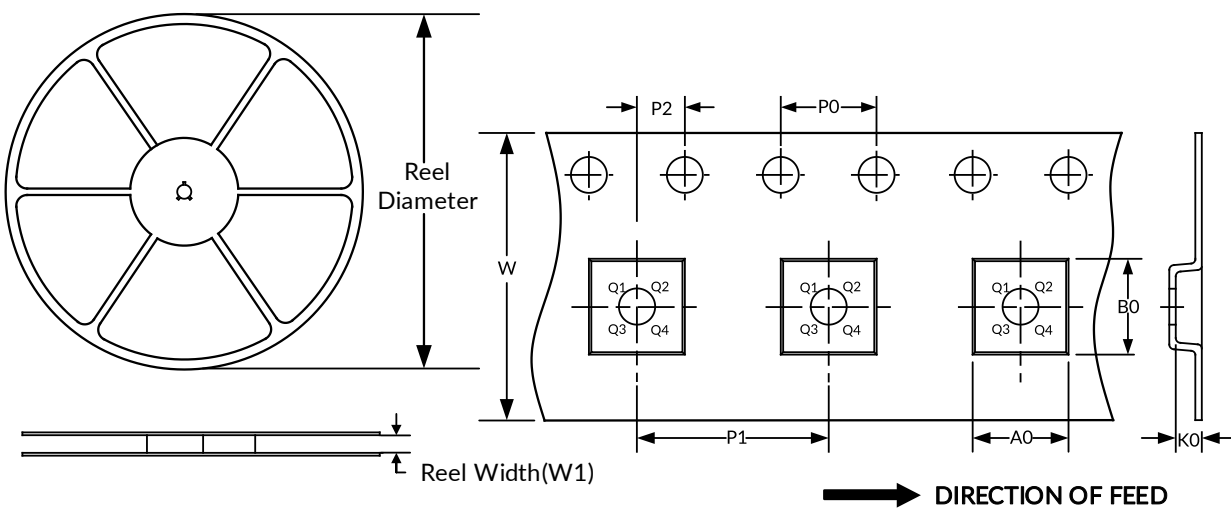
**NOTE:**

1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

## 11 TAPE AND REEL INFORMATION

### REEL DIMENSIONS

### TAPE DIMENSION



NOTE: The picture is only for reference. Please make the object as the standard.

### KEY PARAMETER LIST OF TAPE AND REEL

| Package Type | Reel Diameter | Reel Width(mm) | A0 (mm) | B0 (mm) | K0 (mm) | P0 (mm) | P1 (mm) | P2 (mm) | W (mm) | Pin1 Quadrant |
|--------------|---------------|----------------|---------|---------|---------|---------|---------|---------|--------|---------------|
| SOP8         | 13"           | 12.4           | 6.40    | 5.40    | 2.10    | 4.0     | 8.0     | 2.0     | 12.0   | Q1            |
| MSOP8        | 13"           | 12.4           | 5.20    | 3.30    | 1.50    | 4.0     | 8.0     | 2.0     | 12.0   | Q1            |

NOTE:

1. All dimensions are nominal.
2. Plastic or metal protrusions of 0.15mm maximum per side are not included.

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