



LMV7275-Q1 Automotive Single 1.8-V Low Power Comparator With Rail-to-Rail Input

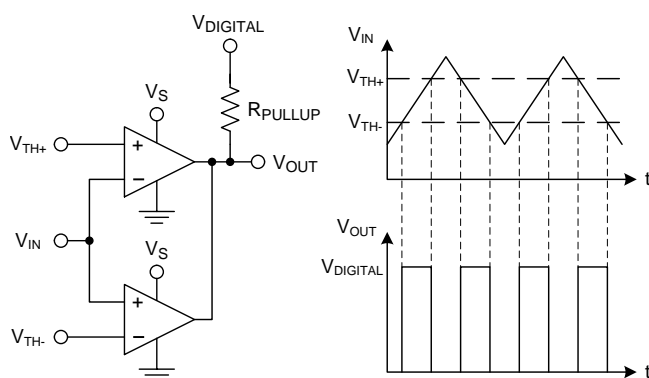
1 Features

- Qualified for Automotive Applications
- AEC-Q100 Qualified With the Following Results:
 - Device Temperature Grade 3: -40°C to 85°C Ambient Operating Temperature Range
 - Device HBM ESD Classification Level 2
 - Device CDM ESD Classification Level C6
- ($V_S = 1.8\text{ V}$, $T_A = 25^\circ\text{C}$, Typical Values Unless Specified).
- Single or Dual Supplies
- Open Drain Output
- Ultra Low Supply Current 9 μA Per Channel
- Low Input Bias Current 10 nA
- Low Input Offset Current 200 pA
- Low Ensured V_{OS} 4 mV
- Propagation Delay 880 ns (20-mV Overdrive)
- Input Common Mode Voltage Range 0.1 V Beyond Rails

2 Applications

- Wearable Devices
- Mobile Phones and Tablets
- Battery-Powered Electronics
- General Purpose Low Voltage Applications

LMV7275-Q1 as a Window Comparator



3 Description

The LMV7275-Q1 is a single rail-to-rail input low power comparator, characterized at supply voltages of 1.8 V, 2.7 V, and 5 V. It consumes as little as 9- μA supply current per channel while achieving a 800-ns propagation delay.

The LMV7275-Q1 is available in a SC-70 package. With these tiny packages, the PCB area can be significantly reduced. They are ideal for low voltage, low power, and space-critical designs.

The LMV7275-Q1 features an open-drain output stage that allows for wired-OR configurations. The open-drain output also offers the advantage of allowing the output to be pulled to any voltage up to 5.5 V, regardless of the supply voltage of the LMV7275-Q1, which is useful for level-shifting applications.

The LMV7275-Q1 is built with Texas Instruments' advance submicron silicon-gate BiCMOS process. It has bipolar inputs for improved noise performance, and CMOS outputs for lowest negative output swing.

Device Information⁽¹⁾

| PART NUMBER | PACKAGE | BODY SIZE (NOM) |
|-------------|----------|-------------------|
| LMV7275-Q1 | SC70 (5) | 1.25 mm x 2.00 mm |

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

Low Supply Current

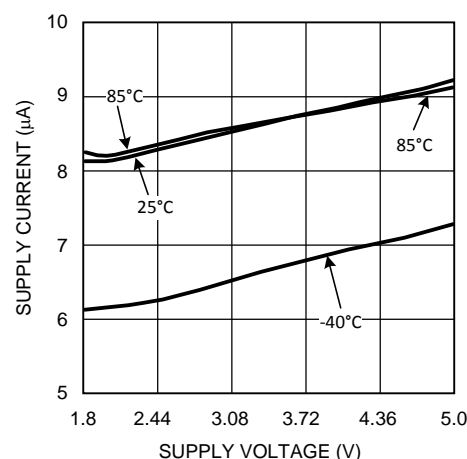


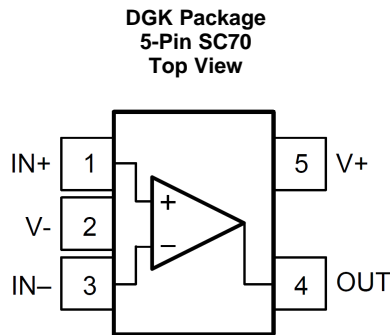
Table of Contents

| | | | |
|--|-----------|--|-----------|
| 1 Features | 1 | 7.2 Functional Block Diagram | 10 |
| 2 Applications | 1 | 7.3 Feature Description | 10 |
| 3 Description | 1 | 7.4 Device Functional Modes | 11 |
| 4 Revision History | 2 | 8 Application and Implementation | 17 |
| 5 Pin Configuration and Functions | 3 | 8.1 Application Information | 17 |
| 6 Specifications | 3 | 8.2 Typical Applications | 17 |
| 6.1 Absolute Maximum Ratings | 3 | 9 Power Supply Recommendations | 22 |
| 6.2 ESD Ratings LMV7275-Q1 | 3 | 10 Layout | 22 |
| 6.3 Recommended Operating Conditions | 3 | 10.1 Layout Guidelines | 22 |
| 6.4 Thermal Information | 4 | 10.2 Layout Example | 23 |
| 6.5 1.8-V Electrical Characteristics | 4 | 11 Device and Documentation Support | 24 |
| 6.6 1.8-V AC Electrical Characteristics | 4 | 11.1 Device Support | 24 |
| 6.7 2.7-V Electrical Characteristics | 5 | 11.2 Documentation Support | 24 |
| 6.8 2.7-V AC Electrical Characteristics | 5 | 11.3 Community Resources | 24 |
| 6.9 5-V Electrical Characteristics | 5 | 11.4 Trademarks | 24 |
| 6.10 5-V AC Electrical Characteristics | 6 | 11.5 Electrostatic Discharge Caution | 24 |
| 6.11 Typical Characteristics | 7 | 11.6 Glossary | 24 |
| 7 Detailed Description | 10 | 12 Mechanical, Packaging, and Orderable Information | 24 |
| 7.1 Overview | 10 | | |

4 Revision History

| DATE | REVISION | NOTES |
|----------------|----------|------------------|
| September 2015 | * | Initial release. |

5 Pin Configuration and Functions



Pin Functions

| PIN | | I/O | DESCRIPTION |
|------|------|-----|-------------------------|
| NAME | SC70 | | |
| IN+ | 1 | I | Non-Inverting Input |
| V- | 2 | P | Negative Supply Voltage |
| IN- | 3 | I | Inverting Input |
| OUT | 4 | O | Output |
| V+ | 5 | P | Positive Supply Voltage |

6 Specifications

6.1 Absolute Maximum Ratings ⁽¹⁾

| | MIN | MAX | UNIT |
|-------------------------------------|---------------|----------------------|------|
| V_{IN} Differential | | \pm Supply Voltage | V |
| Supply Voltage ($V^+ - V^-$) | | 6 | V |
| Voltage at Input/Output pins | $(V^-) - 0.1$ | $(V^+) + 0.1$ | V |
| Junction Temperature ⁽²⁾ | | 150 | °C |
| Storage Temperature, T_{stg} | -65 | 150 | °C |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) 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 into a PCB.

6.2 ESD Ratings LMV7275-Q1

| | | VALUE | UNIT |
|-------------------------------------|---|------------|------|
| $V_{(ESD)}$ Electrostatic discharge | Human-body model (HBM), per AEC Q100-002 ⁽¹⁾ | ± 2000 | V |
| | Charged-device model (CDM), per AEC Q100-011 | ± 1000 | |

- (1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

6.3 Recommended Operating Conditions

| | MIN | MAX | UNIT |
|----------------------------|-----|-----|------|
| Supply Voltage | 1.8 | 5.5 | V |
| Temperature ⁽¹⁾ | -40 | 85 | °C |

- (1) 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 into a PCB.

6.4 Thermal Information

| THERMAL METRIC ⁽¹⁾ | | LMV7275-Q1 | UNIT |
|-------------------------------|---|------------|------|
| | | DGK (SC70) | |
| | | 5 PINS | |
| R _{θJA} | Junction-to-ambient thermal resistance ⁽²⁾ | 273.8 | °C/W |
| R _{θJC(top)} | Junction-to-case (top) thermal resistance | 106.1 | °C/W |
| R _{θJB} | Junction-to-board thermal resistance | 54.9 | °C/W |
| ψ _{JT} | Junction-to-top characterization parameter | 3.6 | °C/W |
| ψ _{JB} | Junction-to-board characterization parameter | 54.1 | °C/W |

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

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

6.5 1.8-V Electrical Characteristics

Unless otherwise specified, all limits ensured for T_J = 25°C, V⁺ = 1.8 V, V⁻ = 0 V.

| PARAMETER | CONDITION | MIN ⁽¹⁾ | TYP ⁽²⁾ | MAX ⁽¹⁾ | UNIT |
|---|--|--------------------|--------------------|--------------------|-------|
| V _{OS} Input Offset Voltage | | | 0.3 | 4 | mV |
| | At the temperature extremes | | | 6 | |
| TC V _{OS} Input Offset Temperature Drift | V _{CM} = 0.9 V ⁽³⁾ | | 20 | | µV/°C |
| I _B Input Bias Current | | | 10 | | nA |
| I _{OS} Input Offset Current | | | 200 | | pA |
| I _S Supply Current | | | 9 | 12 | µA |
| | At the temperature extremes | | | 14 | |
| I _{SC} Output Short Circuit Current | Sinking, V _O = 0.9 V | 4 | 6 | | mA |
| V _{OL} Output Voltage Low | I _O = -0.5 mA | | 52 | 100 | mV |
| | I _O = -1.5 mA | | 166 | 220 | |
| V _{CM} Input Common-Mode Voltage Range | CMRR > 45 dB | -0.1 | | 1.9 | V |
| CMRR Common-Mode Rejection Ratio | 0 < V _{CM} < 1.8 V | 46 | 78 | | dB |
| PSRR Power Supply Rejection Ratio | V ⁺ = 1.8 V to 5 V | 55 | 80 | | dB |
| I _{LEAKAGE} Output Leakage Current | V _O = 1.8 V | | 2 | | pA |

(1) All limits are ensured by testing or statistical analysis.

(2) Typical values represent the most likely parametric norm.

(3) Offset Voltage average drift determined by dividing the change in V_{OS} at temperature extremes into the total temperature change.

6.6 1.8-V AC Electrical Characteristics

Unless otherwise specified, all limits ensured for T_J = 25°C, V⁺ = 1.8 V, V⁻ = 0 V, V_{CM} = 0.5 V, V_O = V⁺/2 and R_L > 1 MΩ to V⁻.

| PARAMETER | CONDITION | MIN ⁽¹⁾ | TYP ⁽²⁾ | MAX ⁽¹⁾ | UNIT |
|--|---|--------------------|--------------------|--------------------|------|
| t _{PHL} Propagation Delay (High to Low) | Input Overdrive = 20 mV Load = 50 pF//5 kΩ | | 880 | | ns |
| | Input Overdrive = 50 mV Load = 50 pF//5 kΩ | | 570 | | ns |
| t _{PLH} Propagation Delay (Low to High) | Input Overdrive = 20 mV Load = 50 pF//5 kΩ | | 1100 | | ns |
| | Input Overdrive = 50 mV Load = 50 pF//5 kΩ | | 800 | | ns |

(1) All limits are ensured by testing or statistical analysis.

(2) Typical values represent the most likely parametric norm.

6.7 2.7-V Electrical Characteristics

Unless otherwise specified, all limits ensured for $T_J = 25^\circ\text{C}$, $V^+ = 2.7\text{ V}$, $V^- = 0\text{ V}$.

| PARAMETER | CONDITIONS | MIN ⁽¹⁾ | TYP ⁽²⁾ | MAX ⁽¹⁾ | UNIT |
|--|--------------------------------------|--------------------|--------------------|--------------------|------------------------------|
| V_{OS} Input Offset Voltage | | | 0.3 | 4 | mV |
| | At the temperature extremes | | | 6 | |
| TC V_{OS} Input Offset Temperature Drift | $V_{CM} = 1.35\text{ V}^{(3)}$ | | 20 | | $\mu\text{V}/^\circ\text{C}$ |
| I_B Input Bias Current | | | 10 | | nA |
| I_{OS} Input offset Current | | | 200 | | pA |
| I_S Supply Current | | | 9 | 13 | μA |
| | At the temperature extremes | | | 15 | |
| I_{SC} Output Short Circuit Current | Sinking, $V_O = 1.35\text{ V}$ | 10 | 15 | | mA |
| V_{OL} Output Voltage Low | $I_O = -0.5\text{ mA}$ | | 50 | 70 | mV |
| | $I_O = -2\text{ mA}$ | | 155 | 220 | |
| V_{CM} Input Common Voltage Range | CMRR > 45 dB | -0.1 | | 2.8 | V |
| CMRR Common-Mode Rejection Ratio | $0 < V_{CM} < 2.7\text{ V}$ | 46 | 78 | | dB |
| PSRR Power Supply Rejection Ratio | $V^+ = 1.8\text{ V}$ to 5 V | 55 | 80 | | dB |
| $I_{LEAKAGE}$ Output Leakage Current | $V_O = 2.7\text{ V}$ | | 2 | | pA |

(1) All limits are ensured by testing or statistical analysis.

(2) Typical values represent the most likely parametric norm.

(3) Offset Voltage average drift determined by dividing the change in V_{OS} at temperature extremes into the total temperature change.

6.8 2.7-V AC Electrical Characteristics

Unless otherwise specified, all limits ensured for $T_J = 25^\circ\text{C}$, $V^+ = 2.7\text{ V}$, $V^- = 0\text{ V}$, $V_{CM} = 0.5\text{ V}$, $V_O = V^+/2$ and $R_L > 1\text{ M}\Omega$ to V^- .

| PARAMETER | CONDITION | MIN ⁽¹⁾ | TYP ⁽²⁾ | MAX ⁽¹⁾ | UNIT |
|---|---|--------------------|--------------------|--------------------|------|
| t_{PHL} Propagation Delay (High to Low) | Input Overdrive = 20 mV Load = 50 pF//5 k Ω | | 1200 | | ns |
| | Input Overdrive = 50 mV Load = 50 pF//5 k Ω | | 810 | | ns |
| t_{PLH} Propagation Delay (Low to High) | Input Overdrive = 20 mV Load = 50 pF//5 k Ω | | 1300 | | ns |
| | Input Overdrive = 50 mV Load = 50 pF//5 k Ω | | 860 | | ns |

(1) All limits are ensured by testing or statistical analysis.

(2) Typical values represent the most likely parametric norm.

6.9 5-V Electrical Characteristics

Unless otherwise specified, all limits ensured for $T_J = 25^\circ\text{C}$, $V^+ = 5\text{ V}$, $V^- = 0\text{ V}$.

| PARAMETER | CONDITIONS | MIN ⁽¹⁾ | TYP ⁽²⁾ | MAX ⁽¹⁾ | UNIT |
|--|-------------------------------|--------------------|--------------------|--------------------|------------------------------|
| V_{OS} Input Offset Voltage | | | 0.3 | 4 | mV |
| | At the temperature extremes | | | 6 | |
| TC V_{OS} Input Offset Temperature Drift | $V_{CM} = 2.5\text{ V}^{(3)}$ | | 20 | | $\mu\text{V}/^\circ\text{C}$ |
| I_B Input Bias Current | | | 10 | | nA |
| I_{OS} Input Offset Current | | | 200 | | pA |
| I_S Supply Current | | | 10 | 14 | μA |
| | At the temperature extremes | | | 16 | |
| I_{SC} Output Short Circuit Current | Sinking, $V_O = 2.5\text{ V}$ | 18 | 34 | | mA |
| V_{OL} Output Voltage Low | $I_O = -0.5\text{ mA}$ | | 27 | 70 | mV |
| | $I_O = -4.0\text{ mA}$ | | 225 | 315 | |

(1) All limits are ensured by testing or statistical analysis.

(2) Typical values represent the most likely parametric norm.

(3) Offset Voltage average drift determined by dividing the change in V_{OS} at temperature extremes into the total temperature change.

5-V Electrical Characteristics (continued)

Unless otherwise specified, all limits ensured for $T_J = 25^\circ\text{C}$, $V^+ = 5\text{ V}$, $V^- = 0\text{ V}$.

| PARAMETER | | CONDITIONS | MIN ⁽¹⁾ | TYP ⁽²⁾ | MAX ⁽¹⁾ | UNIT |
|---------------|------------------------------|-------------------------------------|--------------------|--------------------|--------------------|------|
| V_{CM} | Input Common Voltage Range | CMRR > 45 dB | -0.1 | | 5.1 | V |
| CMRR | Common-Mode Rejection Ratio | $0 < V_{CM} < 5.0\text{ V}$ | 46 | 78 | | dB |
| PSRR | Power Supply Rejection Ratio | $V^+ = 1.8\text{ V to } 5\text{ V}$ | 55 | 80 | | dB |
| $I_{LEAKAGE}$ | Output Leakage Current | $V_O = 5\text{ V}$ | | 2 | | pA |

6.10 5-V AC Electrical Characteristics

Unless otherwise specified, all limits ensured for $T_J = 25^\circ\text{C}$, $V^+ = 5.0\text{ V}$, $V^- = 0\text{ V}$, $V_{CM} = 0.5\text{ V}$, $V_O = V^+/2$ and $R_L > 1\text{ M}\Omega$ to V^- .

| PARAMETER | | CONDITION | MIN ⁽¹⁾ | TYP ⁽²⁾ | MAX ⁽¹⁾ | UNIT |
|-----------|------------------------------------|---|--------------------|--------------------|--------------------|------|
| t_{PHL} | Propagation Delay (High to Low) | Input Overdrive = 20 mV Load = 50 pF//5 k Ω | | 2100 | | ns |
| | | Input Overdrive = 50 mV Load = 50 pF//5 k Ω | | 1380 | | ns |
| t_{PLH} | Propagation Delay (Low to High) | Input Overdrive = 20 mV Load = 50 pF//5 k Ω | | 1800 | | ns |
| | | Input Overdrive = 50 mV Load = 50 pF//5 k Ω | | 1100 | | ns |

(1) All limits are ensured by testing or statistical analysis.

(2) Typical values represent the most likely parametric norm.

6.11 Typical Characteristics

$T_A = 25^\circ\text{C}$, Unless otherwise specified.

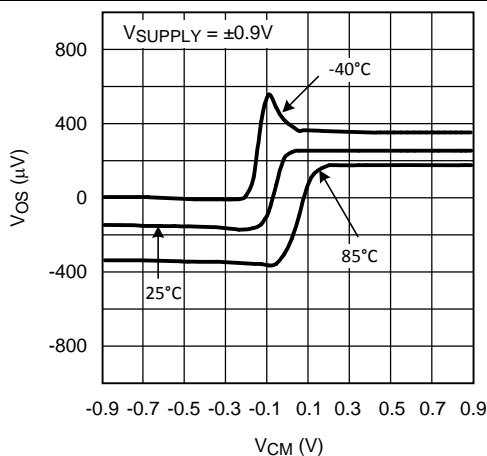


Figure 1. V_{OS} vs. V_{CM}

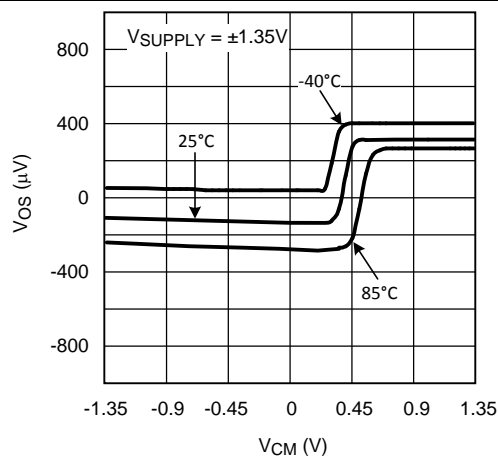


Figure 2. V_{OS} vs. V_{CM}

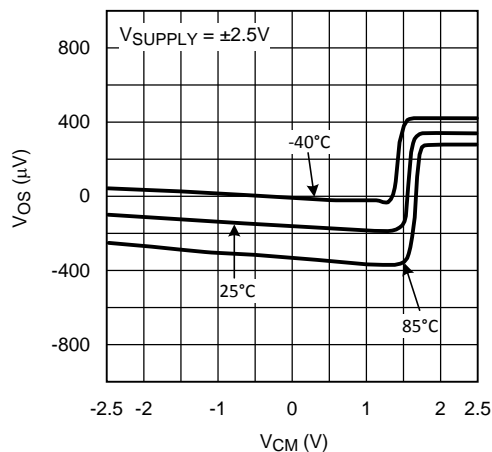


Figure 3. V_{OS} vs. V_{CM}

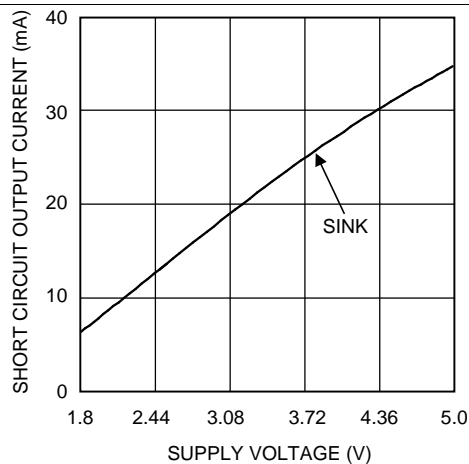


Figure 4. Short Circuit vs. Supply Voltage

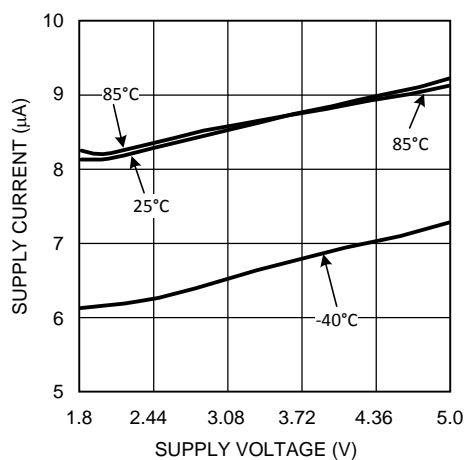


Figure 5. Supply Current vs. Supply Voltage

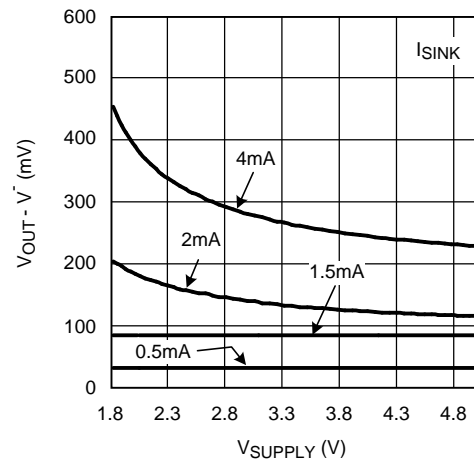


Figure 6. Output Negative Swing vs. V_{SUPPLY}

Typical Characteristics (continued)

$T_A = 25^\circ\text{C}$, Unless otherwise specified.

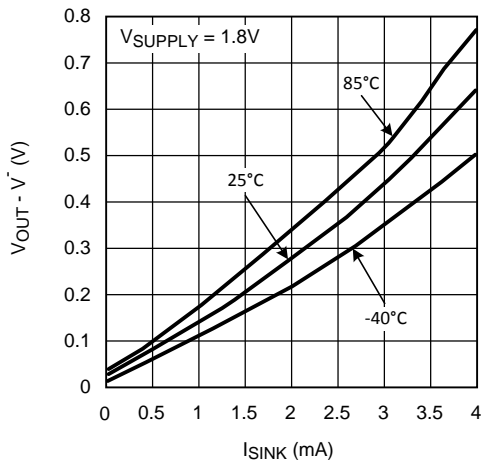


Figure 7. Output Negative Swing vs. I_{SINK}

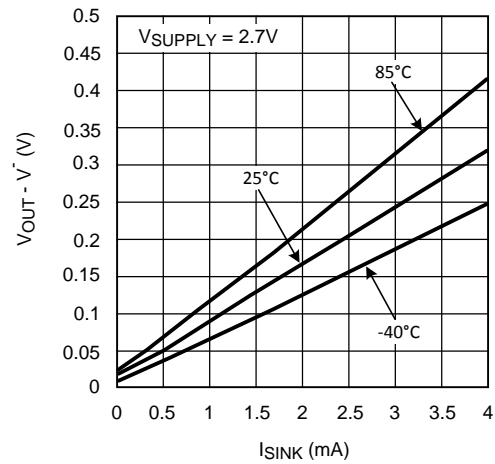


Figure 8. Output Negative Swing vs. I_{SINK}

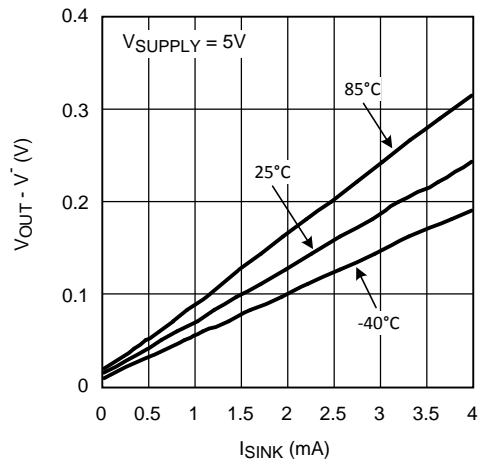


Figure 9. Output Negative Swing vs. I_{SINK}

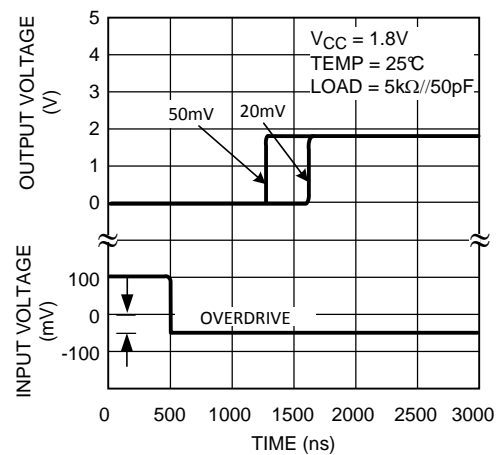


Figure 10. Propagation Delay (t_{PLH})

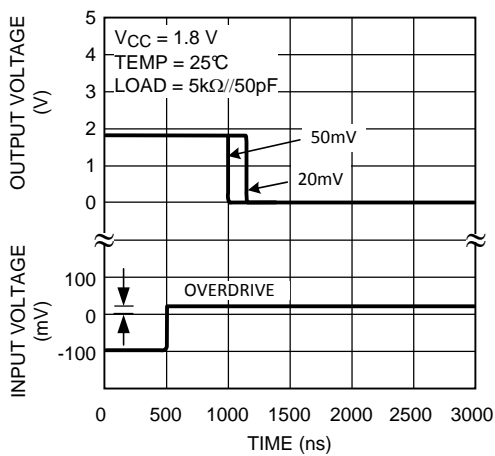


Figure 11. Propagation Delay (t_{PHL})

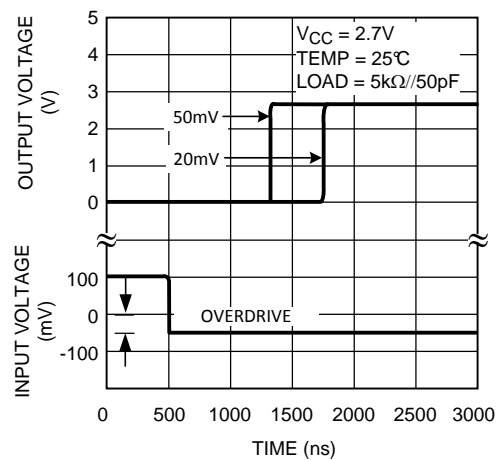


Figure 12. Propagation Delay (t_{PHL})

Typical Characteristics (continued)

$T_A = 25^\circ\text{C}$, Unless otherwise specified.

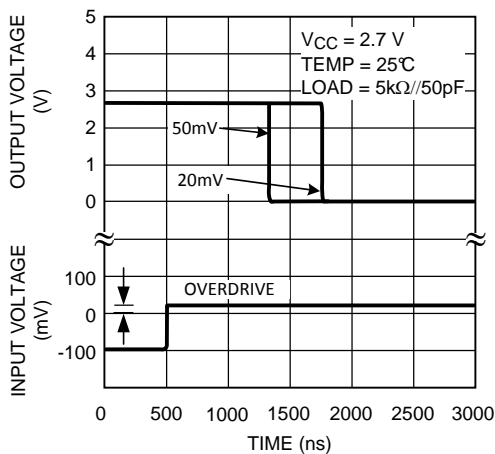


Figure 13. Propagation Delay (t_{PLH})

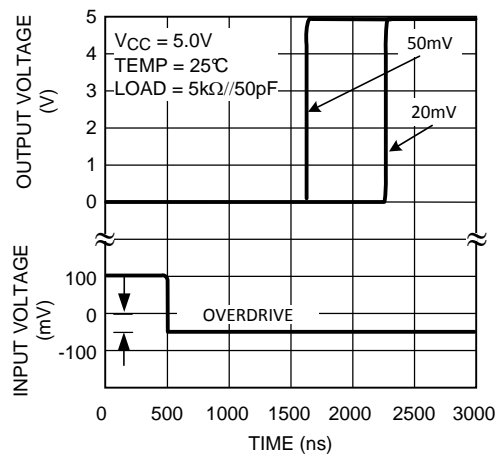


Figure 14. Propagation Delay (t_{PLH})

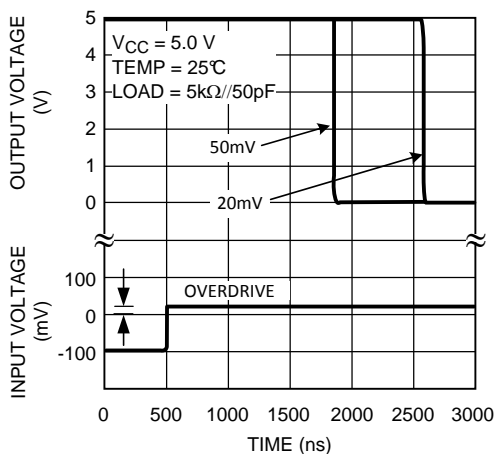


Figure 15. Propagation Delay (t_{PLH})

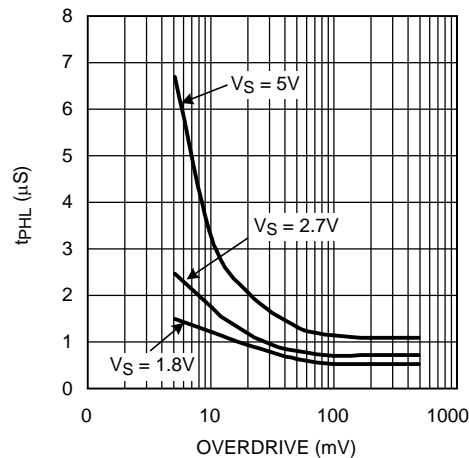


Figure 16. t_{PLH} vs. Overdrive

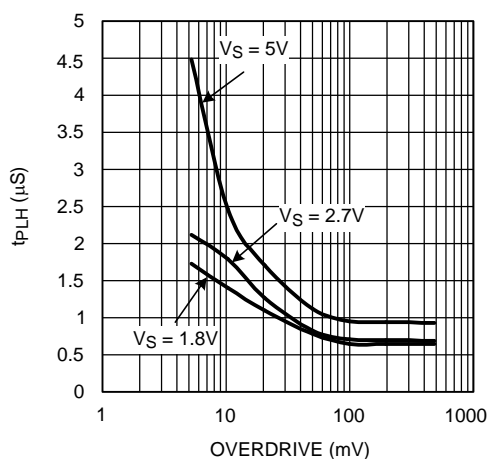


Figure 17. t_{PLH} vs. Overdrive

7 Detailed Description

7.1 Overview

A comparator is often used to convert an analog signal to a digital signal. As shown in [Figure 18](#), the comparator compares an input voltage (V_{IN}) to a reference voltage (V_{REF}). If V_{IN} is less than V_{REF} , the output transistor turns on and pulls the output to V^- , and thus the output (V_O) goes low.

However, if V_{IN} is greater than V_{REF} , the output transistor turns off and the voltage (V_O) is pulled high by the external pull-up resistor.

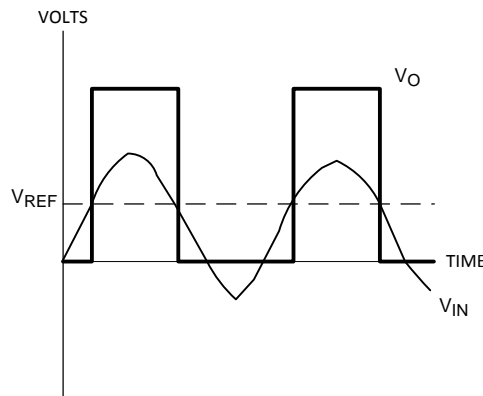
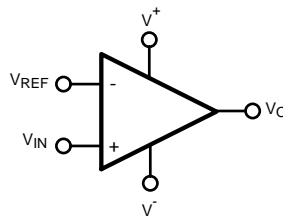


Figure 18. Basic Comparator

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Rail-to-Rail Input Stage

The LMV7275-Q1 has an input common mode voltage range (V_{CM}) of $-0.1V$ below the V^- to $0.1V$ above V^+ . This is achieved by using paralleled PNP and NPN differential input pairs. When the V_{CM} is near V^+ , the NPN pair is on and the PNP pair is off. When the V_{CM} is near V^- , the NPN pair is off and the PNP pair is on. The crossover point between the NPN and PNP input stages is around $950mV$ from V^+ . Because each input stage has its own offset voltage (V_{OS}), the V_{OS} of the comparator becomes a function of the V_{CM} . See curves for V_{OS} vs. V_{CM} in the [Typical Characteristics](#) section. In application design, it is recommended to keep the V_{CM} away from the crossover point to avoid problems. The wide input voltage range makes LMV7275-Q1 ideal in power supply monitoring circuits, where the comparators are used to sense signals close to ground and power supplies.

Feature Description (continued)

7.3.2 Output Stage

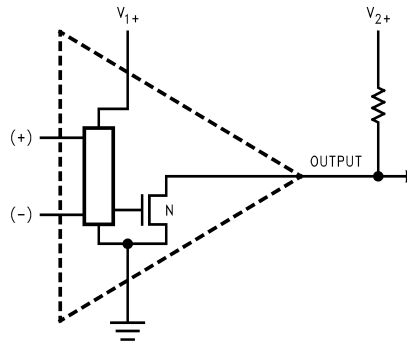


Figure 19. LMV7275-Q1 Open-Drain Output

The LMV7275-Q1 has an open-drain output that requires a pull-up resistor to a positive supply voltage for the output to operate properly. When the internal output transistor is off, the output voltage will be pulled up to the external positive voltage (V_{2+}) by the external pull-up resistor. This allows the output to be OR'ed with other open-drain outputs on the same bus.

The output pull-up resistor may be connected to any voltage level between V_- and V_+ for level shifting applications.

7.4 Device Functional Modes

7.4.1 Capacitive and Resistive Loads

The propagation delay on the rising edge of the LMV7275-Q1 depends on the load resistance and capacitance values.

7.4.2 Noise

Most comparators have rather low gain. This allows the output to alternate between high and low when the input signal changes slowly. The result is the output may oscillate between high and low when the differential input is near zero and triggers on noise. The high gain of this comparator eliminates this problem. Less than 1 μV of change on the input will drive the output from one rail to the other rail. If the input signal is noisy, the output cannot ignore the noise unless some hysteresis is provided by positive feedback. (See [Hysteresis](#).)

7.4.3 Hysteresis

It is a standard procedure to use hysteresis (positive feedback) around a comparator to prevent oscillation due to the comparator triggering its own noise on slowly ramping signals. The following sections will describe various ways to apply hysteresis.

7.4.3.1 Non-inverting Comparator With Hysteresis

Non-inverting comparator with hysteresis requires a two resistor network, and a voltage reference (V_{ref}) at the inverting input. When V_{in} is low, the output is also low. For the output to switch from low to high, V_{in} must rise up to V_{in1} where V_{in1} is calculated by:

$$V_{\text{in1}} = \frac{V_{\text{ref}}(R_1 + R_2)}{R_2} \quad (1)$$

When V_{in} is high, the output is also high. To make the comparator switch back to its low state, V_{in} must equal V_{ref} before V_A will again equal V_{ref} . V_{in} can be calculated by:

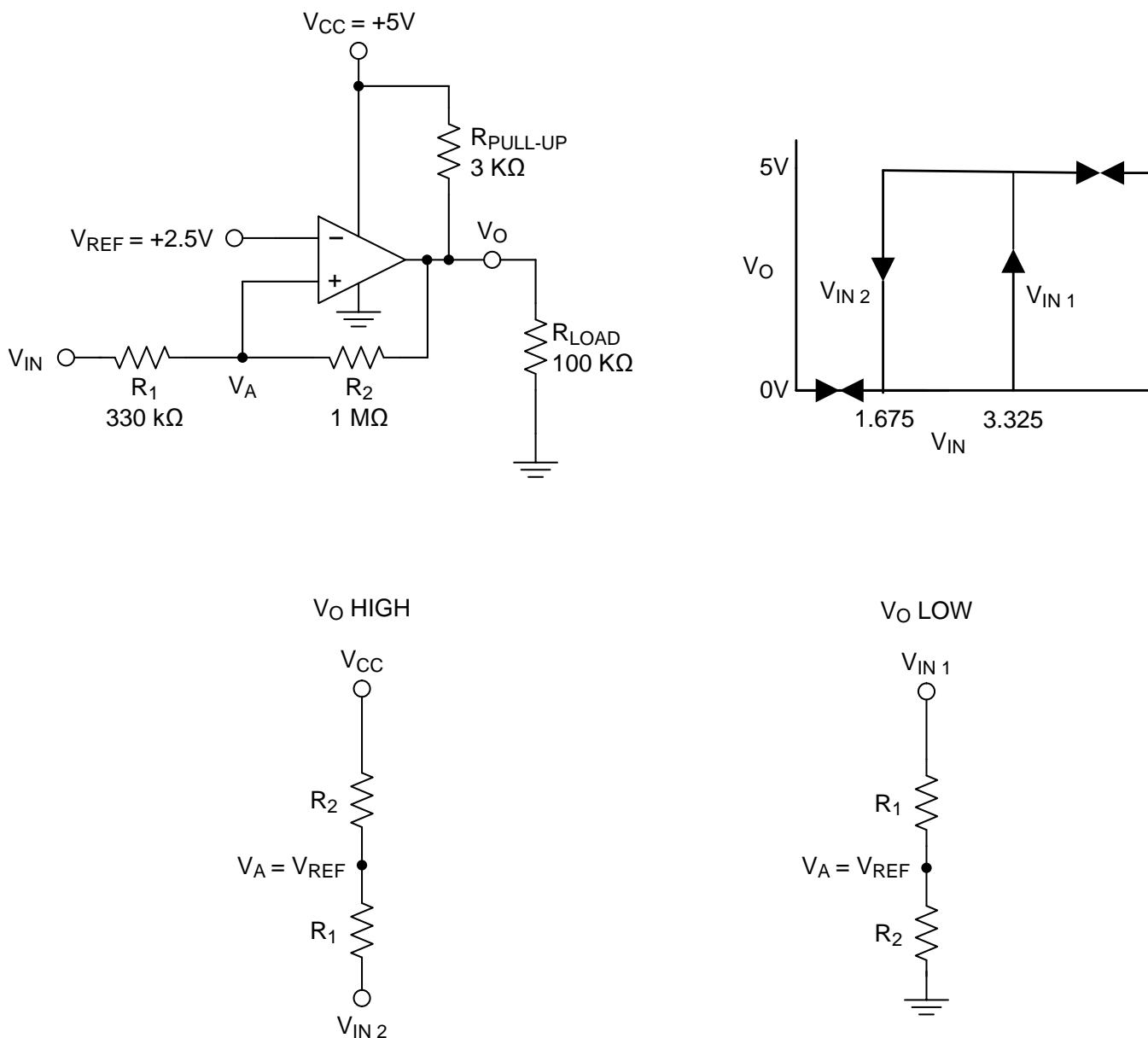
$$V_{\text{in2}} = \frac{V_{\text{ref}}(R_1 + R_2) - V_{\text{CC}} R_1}{R_2} \quad (2)$$

The hysteresis of this circuit is the difference between V_{in1} and V_{in2} .

Device Functional Modes (continued)

$$\Delta V_{in} = V_{CC} R_1 / R_2$$

(3)


Figure 20. Non-Inverting Comparator With Hysteresis
7.4.3.2 Inverting Comparator With Hysteresis

The inverting comparator with hysteresis requires a three resistor network that are referenced to the supply voltage V_{CC} of the comparator. When V_{in} at the inverting input is less than V_a , the voltage at the non-inverting node of the comparator ($V_{in} < V_a$), the output voltage is high (for simplicity assume V_O switches as high as V_{CC}). The three network resistors can be represented as $R_1 // R_3$ in series with R_2 . The lower input trip voltage V_{a1} is defined as:

$$V_{a1} = \frac{V_{CC} R_2}{(R_1 \parallel R_3) + R_2}$$

(4)

When V_{in} is greater than V_a ($V_{in} > V_a$), the output voltage is low very close to ground. In this case the three network resistors can be presented as $R_2 // R_3$ in series with R_1 . The upper trip voltage V_{a2} is defined as:

Device Functional Modes (continued)

$$V_{a2} = \frac{V_{CC}(R_2 // R_3)}{R_1 + (R_2 // R_3)} \quad (5)$$

The total hysteresis provided by the network is defined as:

$$\Delta V_a = V_{a1} - V_{a2} \quad (6)$$

To assure that the comparator will always switch fully to V_{CC} and not be pulled down by the load the resistors values should be chosen as follow:

$$R_{PULL-UP} \ll R_{LOAD} \quad (7)$$

$$\text{and } R_1 > R_{PULL-UP} \quad (8)$$

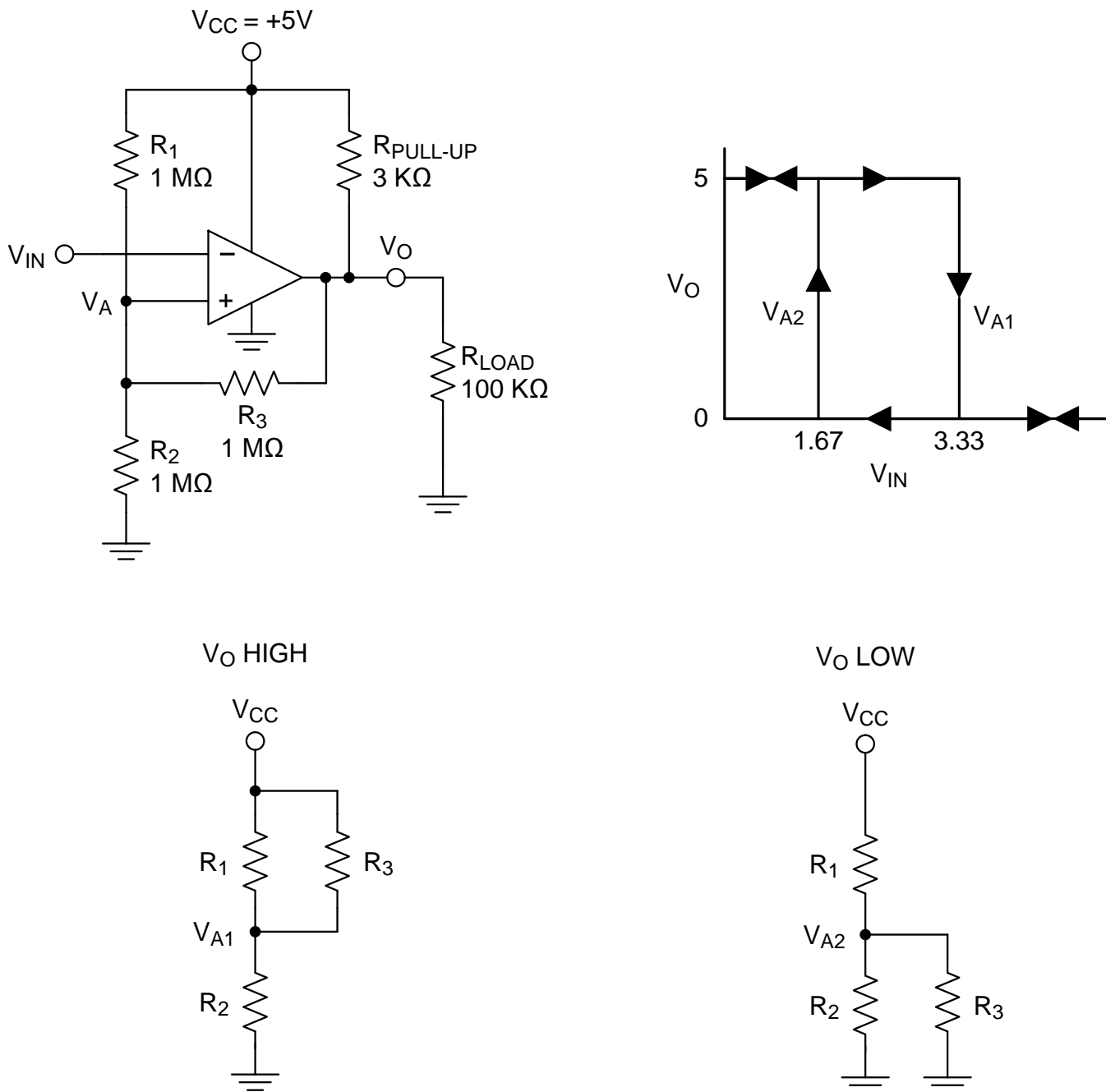


Figure 21. Inverting Comparator With Hysteresis

Device Functional Modes (continued)

7.4.4 Zero Crossing Detector

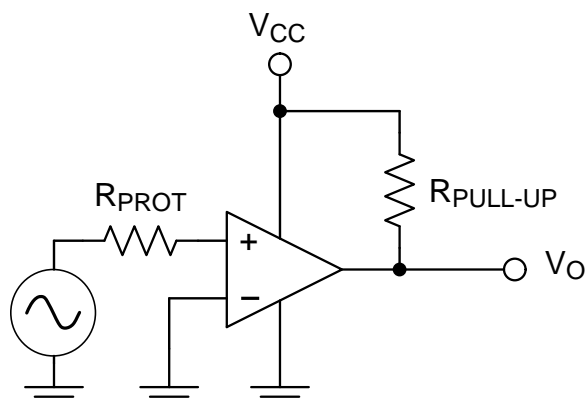


Figure 22. Simple Zero Crossing Detector

In a zero crossing detector circuit, the inverting input is connected to ground and the Non-Inverting input is connected to a 100 mV_{PP} AC signal. As the signal at the Non-Inverting input crosses 0 V, the output of the comparator changes state.

R_{PROT} is an optional input protection resistor to limit the current should the input voltage exceed the supply rails. R_{PROT} should be a minimum of 1 k Ω per volt of expected over-voltage and limit the current to less than ± 1 mA under worst case fault conditions.

7.4.4.1 Zero Crossing Detector With Hysteresis

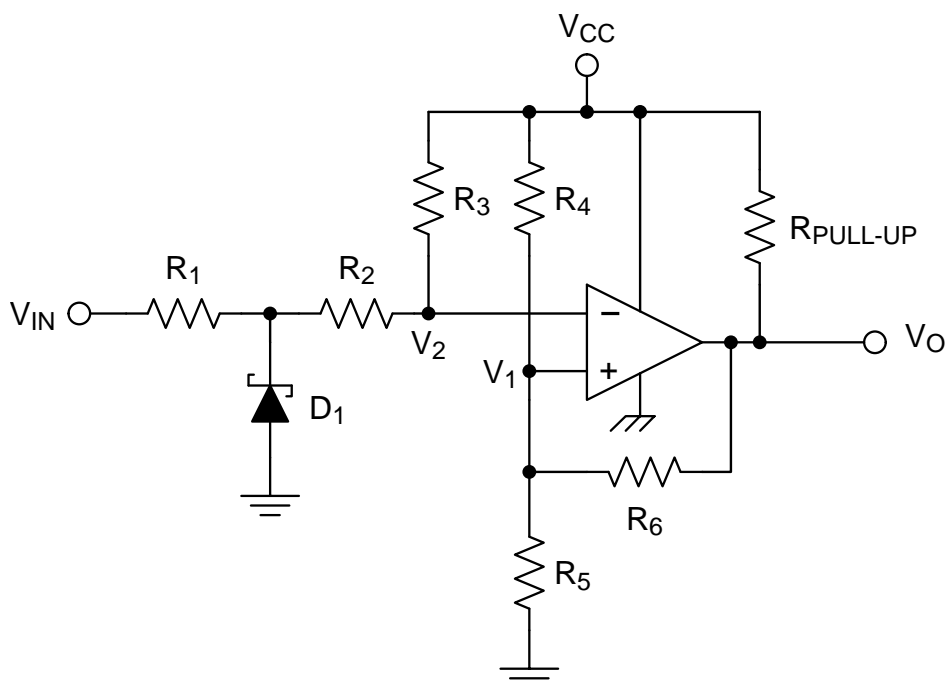


Figure 23. Zero Crossing Detector With Hysteresis

To improve switching times and centering the input threshold to ground a small amount of positive feedback is added to the circuit. Voltage divider R_4 and R_5 establishes a reference voltage, V_1 , at the positive input. By making the series resistance, R_1 plus R_2 equal to R_5 , the switching condition, $V_1 = V_2$, will be satisfied when $V_{\text{IN}} = 0$.

Device Functional Modes (continued)

The positive feedback resistor, R_6 , is made very large (with respect to $R_5 \parallel R_6 = 2000 R_5$). The resultant hysteresis established by this network is very small ($\Delta V_1 < 10 \text{ mV}$) but it is sufficient to insure rapid output voltage transitions.

Diode D_1 is used to insure that the inverting input terminal of the comparator never goes below approximately -100 mV . As the input terminal goes negative, D_1 will forward bias, clamping the node between R_1 and R_2 to approximately -300 mV . This sets up a voltage divider with R_2 and R_3 preventing V_2 from going below ground. The maximum negative input overdrive is limited by the current handling ability of D_1 .

7.4.5 Threshold Detector

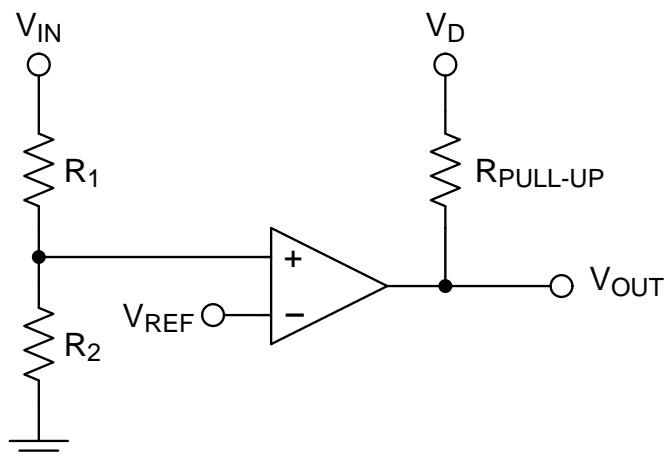


Figure 24. Threshold Detector

Instead of tying the inverting input to 0 V , the inverting input can be tied to a reference voltage. As the input on the Non-Inverting input passes the V_{REF} threshold, the output of the comparator changes state. It is important to use a stable reference voltage to ensure a consistent switching point.

7.4.6 Universal Logic Level Shifter

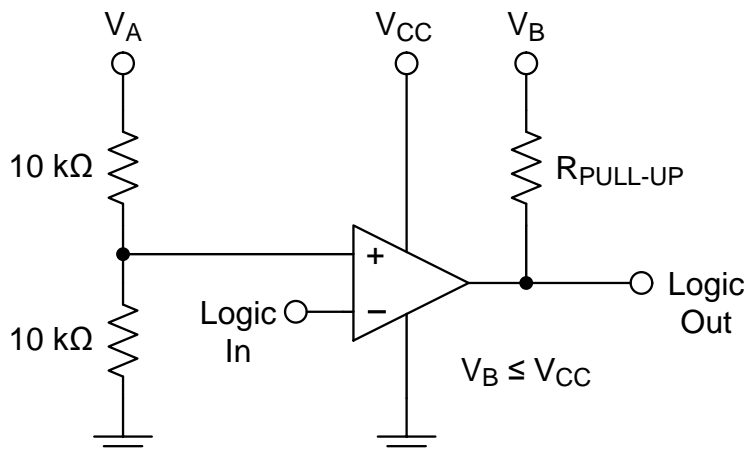


Figure 25. Logic Level Shifter

The output of LMV7275-Q1 is an unconnected drain of an NMOS device, which can be pulled up, through a resistor, to any desired output level below the comparators power supply voltage ($V_B \leq V_{CC}$). Hence, the following simple circuit works as a universal logic level shifter, pulling up the signal to the desired level.

Device Functional Modes (continued)

For example, V_A could be the 5-V analog supply voltage, where V_B could be the 3.3-V supply of the processor. The output will now be compatible with the 3.3-V logic.

7.4.7 OR'ING the Output

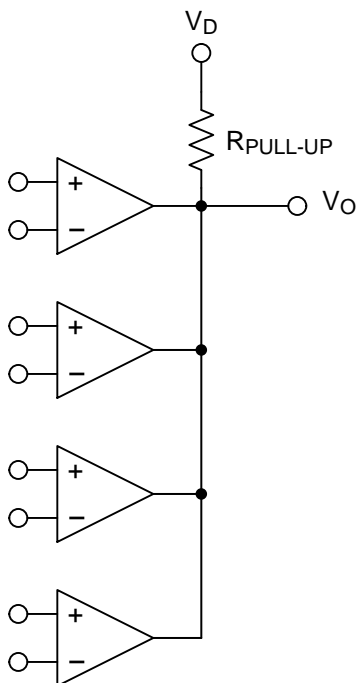


Figure 26. OR'ing the Outputs

Open-drain outputs may be tied together, pulled up to V_D by a common resistor to provide an output OR'ing function. If any of the comparator outputs goes low, the output V_O goes low.

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

The LMV7275-Q1 is a single-supply comparator with 880 ns of propagation delay and only 12 μ A of supply current.

8.2 Typical Applications

8.2.1 Square Wave Oscillator

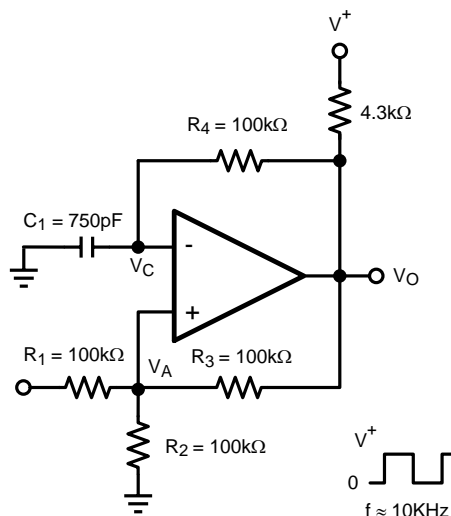


Figure 27. Square Wave Oscillator Application

8.2.1.1 Design Requirements

A typical application for a comparator is as a square wave oscillator. [Figure 27](#) generates a square wave whose period is set by the RC time constant of the capacitor C_1 and resistor R_4 . 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.

8.2.1.2 Detailed Design Procedure

To analyze the circuit, consider it when the output is high. That implies that the inverted input (V_C) is lower than the Non-Inverting input (V_A).

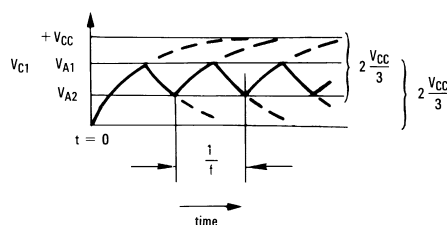


Figure 28. Squarewave Oscillator Timing Thresholds

Typical Applications (continued)

This causes the C_1 to get charged through R_4 , and the voltage V_C increases till it is equal to the Non-Inverting input. The value of V_A at this point is

$$V_{A1} = \frac{V_{CC} \cdot R_2}{R_2 + R_1 \parallel R_3} \quad (9)$$

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

At this point the comparator switches pulling down the output to the negative rail. The value of V_A at this point is

$$V_{A2} = \frac{V_{CC} (R_2 \parallel R_3)}{R_1 + (R_2 \parallel R_3)} \quad (10)$$

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 till 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 $2V_{CC}/3$ to $V_{CC}/3$, which is given by $R_4 C_1 \ln 2$. Hence the formula for the frequency is:

$$F = 1/(2 \cdot R_4 \cdot C_1 \cdot \ln 2)$$

8.2.1.3 Application Curve

Figure 29 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. $C_1 = 750 \text{ pF}$, $C_L = 20 \text{ pF}$
3. $V_+ = 5 \text{ V}$, $V_- = \text{GND}$
4. C_{STRAY} (not shown) from V_a to GND = 10 pF

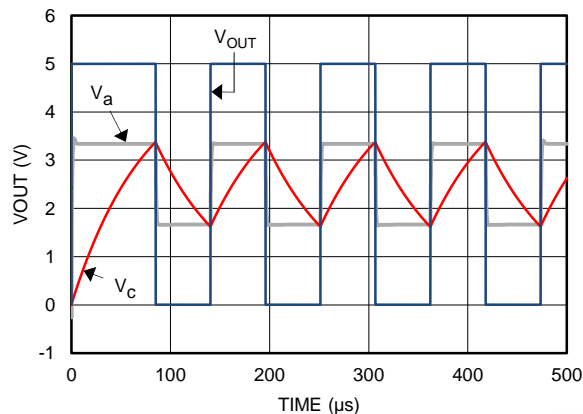


Figure 29. Square Wave Oscillator Output Waveforms

Typical Applications (continued)

8.2.2 Positive Peak Detector

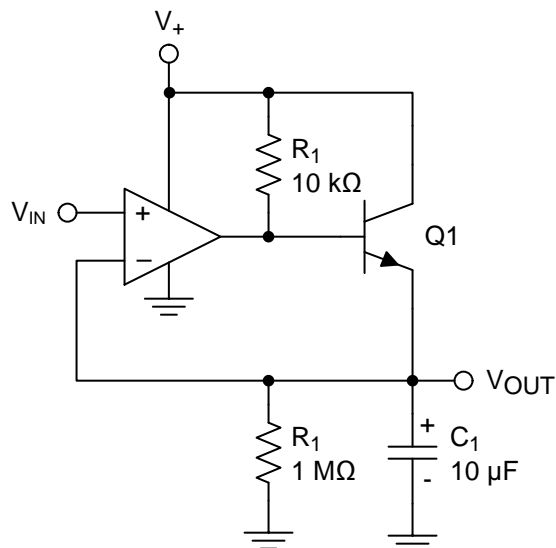


Figure 30. Positive Peak Detector

The positive peak detector is basically the comparator operated as a unity gain follower with a large holding capacitor from the output to ground. A transistor is added to the output to provide a low impedance current source. The upper output swing is limited by the emitter-base forward voltage. This allows capture of the most positive input signal between 0 V and $(V_+ - 0.7V)$.

When the output of the comparator goes high, current is passed through the transistor to charge up the capacitor. The only discharge path will be the 1-MΩ resistor shunting C_1 and any load that is connected to the output. The decay time can be altered simply by changing the 1-MΩ resistor.

8.2.3 Negative Peak Detector

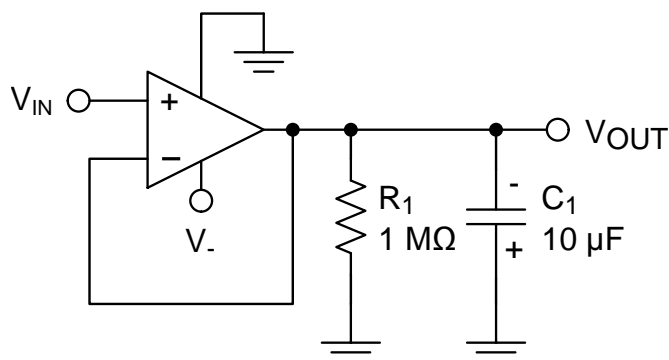


Figure 31. Negative Peak Detector for Negative Supply

The Negative Peak Detector circuit will store the peak negative voltage below ground (0 V to V_-). For the negative detector, the output transistor acts as a low-impedance current sink.

When V_{IN} is more negative than V_{OUT} , the output transistor will conduct and pull the output to $-V_{CC}$, charging C_1 . Charging stops when C_1 reaches the same level as V_{IN} . Because there is no pull-up resistor, the only discharge path will be the 1-MΩ resistor and any load impedance applied. Therefore, the decay time is set by varying the 1-MΩ resistor. Be sure to observe the polarity of C_1 !

Typical Applications (continued)

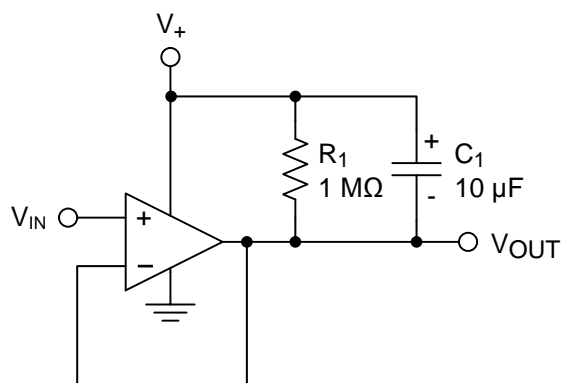


Figure 32. Negative Peak Detector for Positive Supply

An alternate positive supply version is shown in [Figure 32](#) that will capture the lowest applied V_{IN} value between $V+$ and ground ($V+$ to 0V).

The output of either version should be buffered by a high-impedance follower stage to prevent loading of the RC circuit.

8.2.4 Window Detector

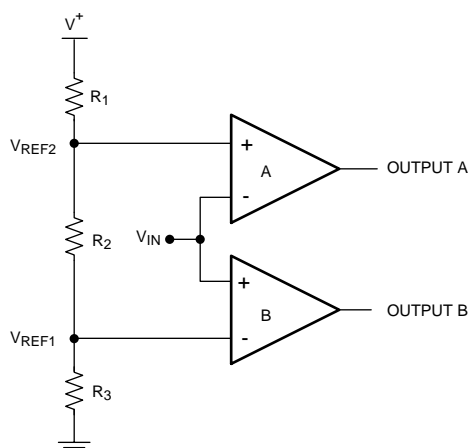


Figure 33. Window Detector

A window detector monitors the input signal to determine if it falls between two voltage levels. Both outputs are true (high) when $V_{REF1} < V_{IN} < V_{REF2}$.

Typical Applications (continued)

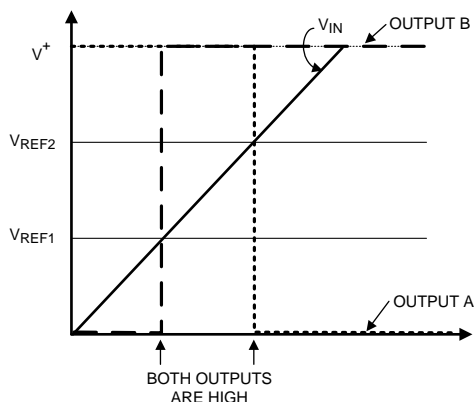


Figure 34. Window Detector Output Signal

The comparator outputs A and B are high only when $V_{REF1} < V_{IN} < V_{REF2}$, or *within the window*, where these are defined as:

$$V_{REF1} = R_3 / (R_1 + R_2 + R_3) \times V+ \quad (11)$$

$$V_{REF2} = (R_2 + R_3) / (R_1 + R_2 + R_3) \times V+ \quad (12)$$

To determine if the input signal falls outside of the two voltage levels, both inputs on each comparators can be reversed to invert the logic.

The outputs should be tied together and use a shared pull-up resistor for a common logic output. If individual limit outputs are needed, then each output will require it's own pull-up resistor.

Other names for window detectors are: threshold detector, level detector, and amplitude trigger or detector.

9 Power Supply Recommendations

To minimize supply noise, power supplies should be decoupled by a 0.01- μ F ceramic capacitor in parallel with a 10- μ F capacitor.

Due to the nanosecond edges on the output transition, peak supply currents will be drawn during the time the output is transitioning. Peak current depends on the capacitive loading on the output. The output transition can cause transients on poorly bypassed power supplies. These transients can cause a poorly bypassed power supply to *ring* due to trace inductance and low self-resonance frequency of high ESR bypass capacitors.

Treat the LMV7275-Q1 as a high-speed device. Keep the ground paths short and place small (low-ESR ceramic) bypass capacitors directly between the V+ and V– pins.

Output capacitive loading and output toggle rate will cause the average supply current to rise over the quiescent current.

10 Layout

10.1 Layout Guidelines

10.1.1 Circuit Techniques for Avoiding Oscillations in Comparator Applications

Feedback to almost any pin of a comparator can result in oscillation. In addition, when the input signal is a slow voltage ramp or sine wave, the comparator may also burst into oscillation near the crossing point. To avoid oscillation or instability, PCB layout should be engineered thoughtfully. Several precautions are recommended:

1. Power supply bypassing is critical, and will improve stability and response time. Resistance and inductance from power supply wires and board traces increase power supply line impedance. When supply current changes, the power supply line will move due to its impedance. Large enough supply line shift will cause the comparator to malfunction. To avoid problems, a small bypass capacitor, such as 0.1- μ F ceramic, should be placed immediately adjacent to the supply pins. An additional 6.8 μ F or greater tantalum capacitor should be placed at the point where the power supply for the comparator is introduced onto the board. These capacitors act as an energy reservoir and keep the supply impedance low. In a dual-supply application, a 0.1- μ F capacitor is recommended to be placed across V⁺ and V[–] pins.
2. Keep all leads short to reduce stray capacitance and lead inductance. It will also minimize any unwanted coupling from any high-level signals (such as the output). The comparators can easily oscillate if the output lead is inadvertently allowed to capacitively couple to the inputs through stray capacitance. This shows up only during the output voltage transition intervals as the comparator changes states. Try to avoid a long loop which could act as an inductor (coil).
3. It is a good practice to use an unbroken ground plane on a printed-circuit-board to provide all components with a low inductive ground connection. Make sure ground paths are low-impedance where heavier currents are flowing to avoid ground level shift. Preferably there should be a ground plane under the component.
4. The output trace should be routed away from inputs. The ground plane should extend between the output and inputs to act as a guard. This can be achieved by running a topside ground plane between the output and inputs. A typical PCB layout is shown in [Figure 35](#).
5. When the signal source is applied through a resistive network to one input of the comparator, it is usually advantageous to connect the other input with a resistor with the same value, for both DC and AC consideration. Input traces should be laid out symmetrically if possible.

10.2 Layout Example

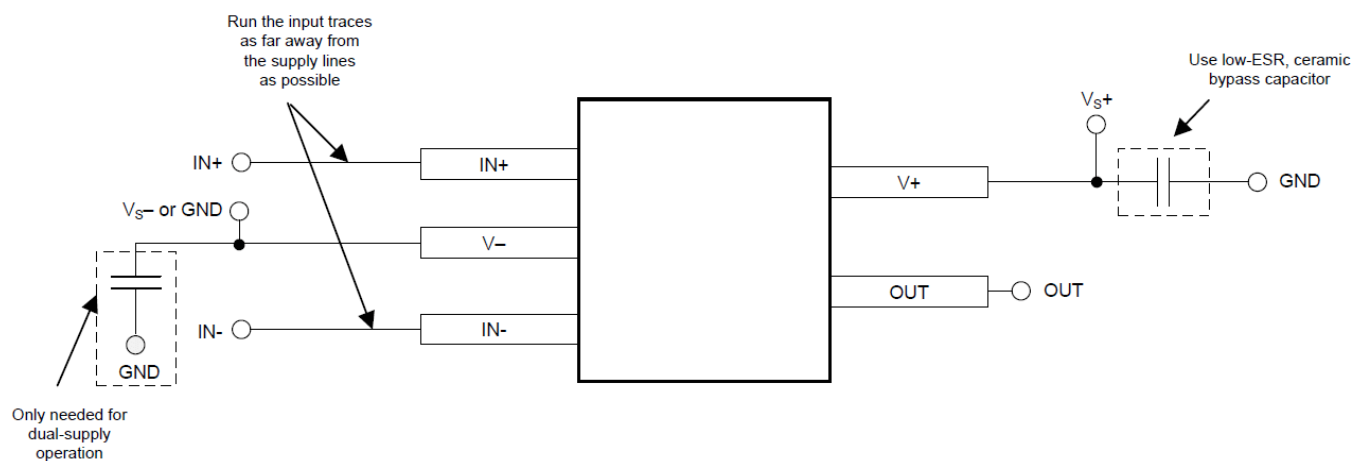


Figure 35. Typical PCB Layout

11 Device and Documentation Support

11.1 Device Support

11.1.1 Development Support

For developmental support, see the following:

- LMV7275 PSICE Model, [SNOM555](#)
- TINA-TI SPICE-Based Analog Simulation Program, <http://www.ti.com/tool/tina-ti>
- DIP Adapter Evaluation Module, <http://www.ti.com/tool/dip-adapter-evm>
- TI Universal Operational Amplifier Evaluation Module, <http://www.ti.com/tool/opampevm>

11.2 Documentation Support

11.2.1 Related Documentation

For related documentation, see the following:

- AN-74 *A Quad of Independently Functioning Comparators*, [SNOA654](#)

11.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

TI E2E™ Online Community *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

11.4 Trademarks

E2E is a trademark of Texas Instruments.

All other trademarks are the property of their respective owners.

11.5 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

11.6 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. 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 left-hand navigation.

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| LMV7275IDCKRQ1 | ACTIVE | SC70 | DCK | 5 | 3000 | RoHS & Green | SN | Level-1-260C-UNLIM | -40 to 85 | SKA | Samples |

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF LMV7275-Q1 :

-
- Catalog: [LMV7275](#)

NOTE: Qualified Version Definitions:

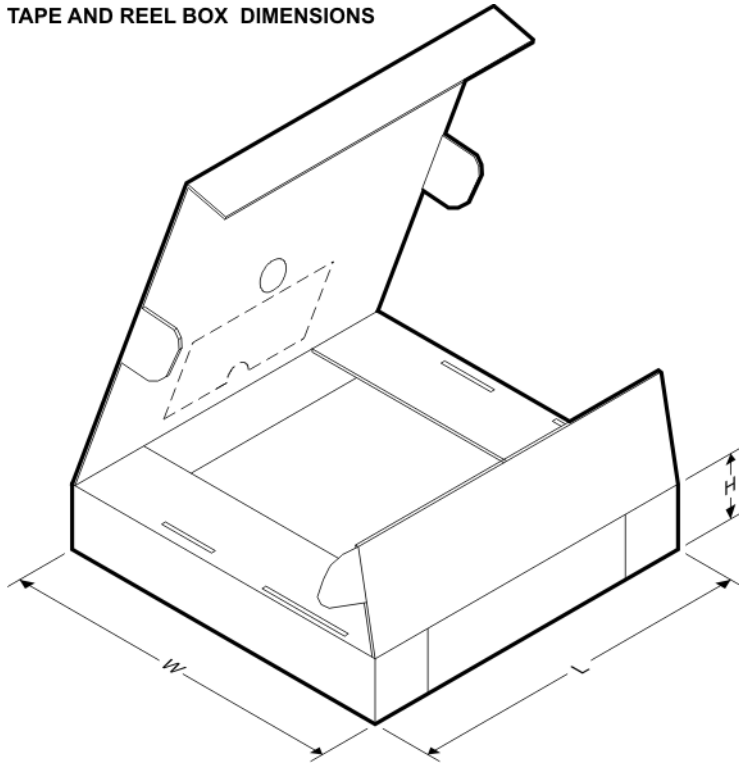
- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LMV7275IDCKRQ1 | SC70 | DCK | 5 | 3000 | 178.0 | 8.4 | 2.25 | 2.45 | 1.2 | 4.0 | 8.0 | Q3 |

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LMV7275IDCKRQ1 | SC70 | DCK | 5 | 3000 | 208.0 | 191.0 | 35.0 |



SOT - 1.1 max height

PIN 1 INDEX AREA

2X 0.65

1.3

2

3

5X 0.33
0.15

2.4
1.8

1.4
1.1

B

A

NOTE 4

(0.15)

(0.1)

1.3

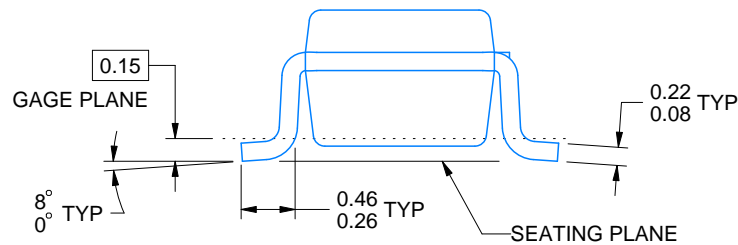
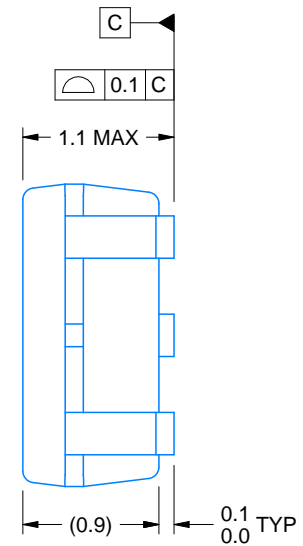
2.15
1.85

4

5

\oplus 0.1 M C A B

NOTE 5



1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC MO-203.
4. Support pin may differ or may not be present.
5. Lead width does not comply with JEDEC.

EXAMPLE BOARD LAYOUT

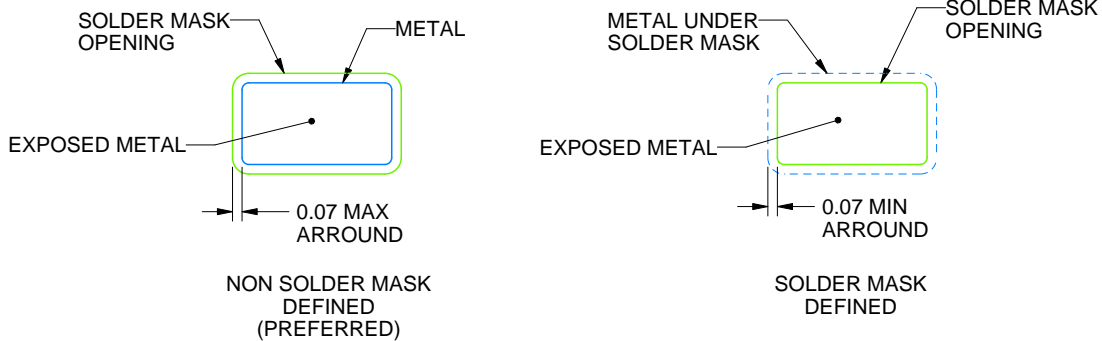
DCK0005A

SOT - 1.1 max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:18X



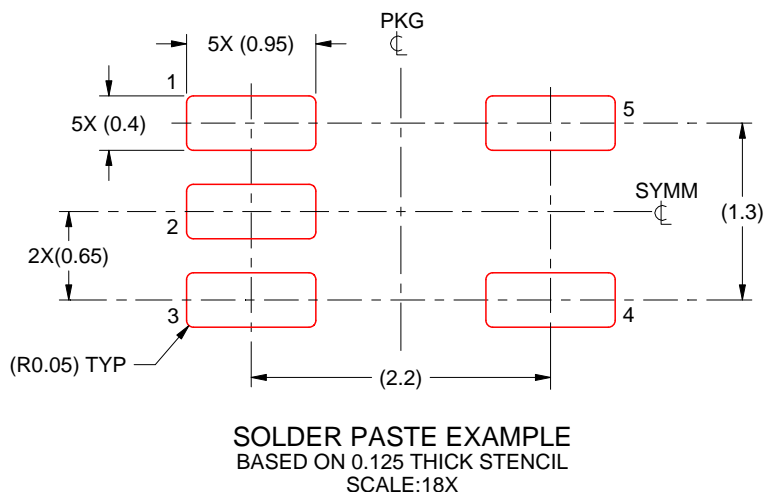
SOLDER MASK DETAILS

4214834/D 07/2023

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



4214834/D 07/2023

NOTES: (continued)

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

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2024, Texas Instruments Incorporated