

AN-1683 LMH7324 High Speed Comparator Evaluation Board

1 General Description

This board is designed to demonstrate the LMH7324 quad comparator with RSPECL outputs. It will facilitate the evaluation of the LMH7324 configured as a window detector. The board detects the level of the incoming signal and presents the outcome in a 3-bit presentation. One bit indicates that the signal is below the lowest window level, another bit indicates that the signal is above the highest window level, and the third bit indicates that the incoming signal is just between both set levels. All three outputs are fed to SMA connectors mounted at the edge of the board. The impedance of the output track is 50Ω which makes it easy to connect these signals to any scope or analyzer by the use of a 50Ω coaxial cable. Each comparator of the LMH7324 has individual positive supplies for the input and output circuits. The negative supply is common for all input and output circuitry. This setup will work with a supply of ±2.5V as a minimum supply, with the window voltage centered at ground. If a setup with only one positive supply voltage is used, jumper J1 (see [Figure 7](#)) has to be placed between both positive supply connections. To examine the possibility of two separate supplies for the input and the output stage the jumper has to be removed and an extra supply has to be connected.

2 Basic Operation

2.1 Reference Levels

The circuit is built around the four comparators of one LMH7324. Two reference levels are created using four resistors and two capacitors (R3, R6, R7, R9 and C9, C12 see [Figure 7](#)) The 'ref high' level is a positive voltage referred to the ground level and the 'ref low' level is a negative voltage referred to ground. The input connector (con2) is also referenced to ground which means that any AC signal at the input will vary around the ground level, which is in the center of the reference levels.

2.2 Comparators

The comparators B and C form the window detector, while the comparator A is a level detector indicating that the input voltage exceeds the 'ref high' voltage in the positive direction. The comparator D is a level detector indicating that the input signal exceeds the 'ref low' voltage in the negative direction. The outputs are connected to a 50Ω connector via a 50Ω track. All three outputs are 'active low' as can be seen in [Table 1](#).

Table 1. Four Comparators Output

V_{IN}	\overline{QA}	\overline{QB}	\overline{QC}	\overline{QD}
High	0	1	0	1
In Window	1	0	0	1
Low	1	0	1	0

The window detector output is formed by the OR-function of combining both \overline{Q} outputs of comparators B and C. Outputs which have an ECL (Emitter Coupled Logic) structure can be wired together to form an OR function. The overall truth table is shown in [Table 2](#):

Table 2. Truth Table

V_{IN}	Con1	Con3	Con4
High	0	1	1
In Window	1	0	1
Low	1	1	0

2.3 Outputs

Every output has a Q and \bar{Q} connection and both outputs have been made active by a resistor connected to the V_{EE} terminal. An ECL output becomes active when current flows out of the emitters of the output stage. This can be done by connecting a resistor to a 'termination' voltage (VT) which is 2V below the V_{CCO} . When using the VT solution every output resistor has to be 50 Ω (R1, R2, R4, R5, R10, R11, R12). Another possibility is to connect a resistor to the most negative supply voltage. In case of a connection to V_{EE} , the resistor must have a value which causes a current that complies with the 'Normal Operating' conditions as mentioned in the datasheet. This demo board is designed for a supply voltage of 5V for the V_{CCO} with a resistor to V_{EE} with a value of 240 Ω (R4 = 360 while R1, R2, R5, R10, R11, R12 = 240). In case the V_{CCO} is raised to 12V all output resistors to V_{EE} should be replaced with 500 Ω resistors except R4 which should be 750 Ω . All three output signals are connected via a 50 Ω track and a combined capacitor and jumper which are connected in parallel. A customer can now make a choice between a DC or an AC coupled output signal. In the case of a DC coupled output be aware of the offset voltage which causes an extra DC current into a connected scope or analyzer with 50 Ω input impedance.

2.4 Supply Voltages

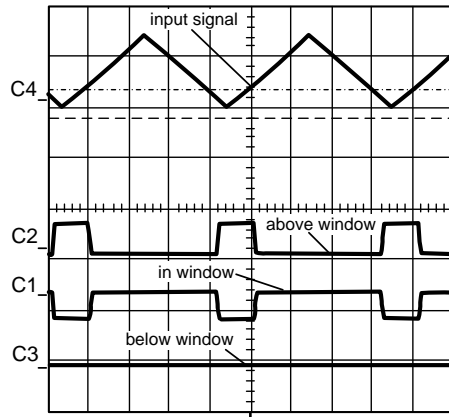
This demo board can operate with a simple dual supply of $\pm 2.5V$. The output voltages are now about 1.35V and 1.0V and comply with LVDS and RSPECL levels. In the case of a single supply voltage of +5V the output levels are 3.85V and 3.5V, which is only RSPECL level compliant. In a single supply configuration be aware that the detection window starts at V_{EE} level, which is actually the ground level. The LMH7324 is ground sensing but in this configuration the input signals cannot extend more than 200 mV below the ground level. Every comparator has a separate connection for the V_{CCI} , V_{CCO} and the V_{EE} . The supply pins are decoupled with a small capacitance of 10 nF to the ground plane. Since the outputs are referenced to the V_{CCO} the output resistors are decoupled to this supply pin. For better low frequency decoupling a 47 μF capacitor is placed at the supply connector (con5). The supplies V_{CCI} and V_{CCO} can be shortened by a jumper (J1) in case both positive supply voltages are the same value.

3 Layout Considerations

The layout is done with a four layer board which makes it easy to keep the design compact with small 50 Ω tracks. The advantage of this is that such tracks route easily and connect perfectly to small components. At the same time the length and number of supply lines are reduced, while decoupling to these supplies is easy and direct. Signals are routed on the top and bottom layer, making it easy to measure them.

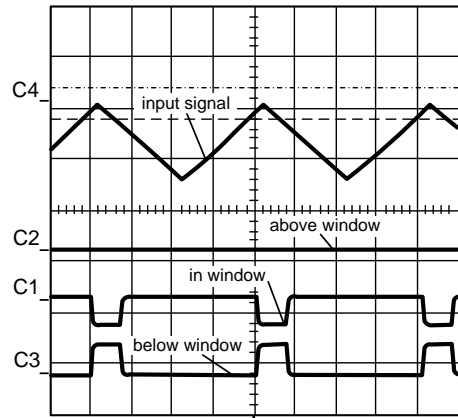
4 Measurement Hints and Results

Measurements can be done at the output connectors by connecting a scope or analyzer to the test board. The outputs are capable of driving a 50 Ω load. This board offers the possibility of making the output DC or AC coupled. When DC coupling is used be aware of the DC offset voltage present on the output signals. When working with a high supply voltage on the V_{CCO} it is possible to damage the output stage of the device or the input impedance of the equipment. To show what signals can be expected sample measurement results are shown in the following figures. Measurements were taken at different frequencies and waveforms. In the first instance measurements were taken at a frequency of 5 MHz with a sawtooth waveform. The supply voltages are +2.5V and -2.5V. This means that both thresholds are at the same level of approximately 50 mV. There are three results shown: one with the input signal crossing only the upper level (see [Figure 1](#)) and one while the input signal is only crossing the lowest level (see [Figure 2](#)). The third plot shows the waveforms when the input signal crosses the complete window from below the lowest level until above the upper level (see [Figure 3](#)).



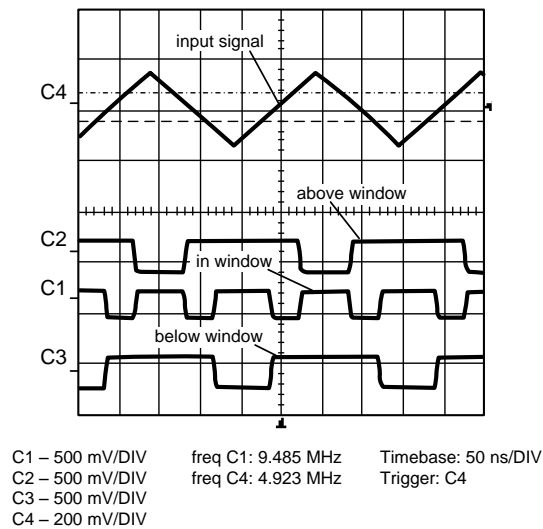
C1 – 500 mV/DIV freq C1: 4.921 MHz Timebase: 50 ns/DIV
 C2 – 500 mV/DIV freq C4: 4.917 MHz Trigger: C4
 C3 – 500 mV/DIV
 C4 – 200 mV/DIV

Figure 1. 5 MHz Crossing Upper Level

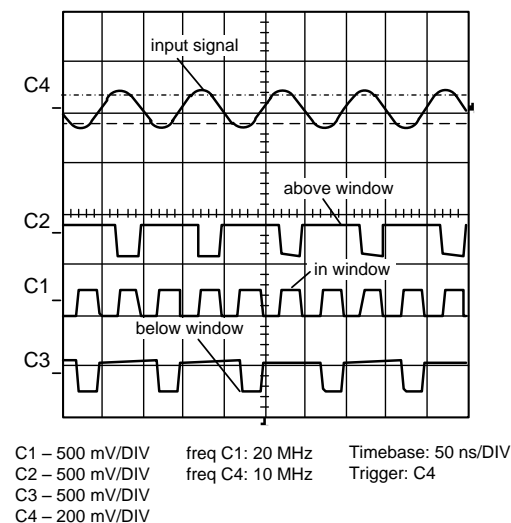


C1 – 500 mV/DIV freq C1: 4.923 MHz Timebase: 50 ns/DIV
 C2 – 500 mV/DIV freq C4: 4.916 MHz Trigger: C4
 C3 – 500 mV/DIV
 C4 – 200 mV/DIV

Figure 2. 5 MHz Crossing Lower Level


Figure 3. 5 MHz Crossing Whole Window

Higher frequencies will make the pulses much shorter, especially when a sine wave is used and the signal rises far above the window levels. This situation would make the time that the signal crosses the window levels very short, because a sine wave has the highest dV/dt at the transition points. [Figure 4](#), [Figure 5](#), and [Figure 6](#) show the measurements taken when a sine wave is used. In [Figure 4](#) a sine wave of 10 MHz is used and it just crosses both levels of the window. This creates a reasonable pulse width for both the detection signals “above window” and “below window” and for the detection signal “in window.” The added hysteresis works since no oscillations can be seen although the input signal crosses the levels very slowly and with low overdrive. When using a signal with the same frequency but with a much greater amplitude, the time it takes for the signal to cross the window becomes much shorter as can be seen in [Figure 5](#). Note that the frequency of the detection signal “in window” doubles compared to the input frequency. Also the crossing time through the window levels is very short and, for this example, it is equal to one period of a frequency of 227 MHz (see marker indication in plot). This means that the detection signal “in window” is the most critical of the three detection signals and will be the first to incur problems due to frequency limits. The setup of [Figure 6](#) uses an input frequency of 100 MHz with a big overdrive at the window levels. This results in a very small pulse for the detection signal “in window” which is equal to one period of a 1.05 GHz signal (see markers indication in plot). All signals are measured using a cable with a length of 1 meter connected to a four channel oscilloscope. All channels are AC coupled and terminated with 50Ω.


Figure 4. 10 MHz Just Above Thresholds

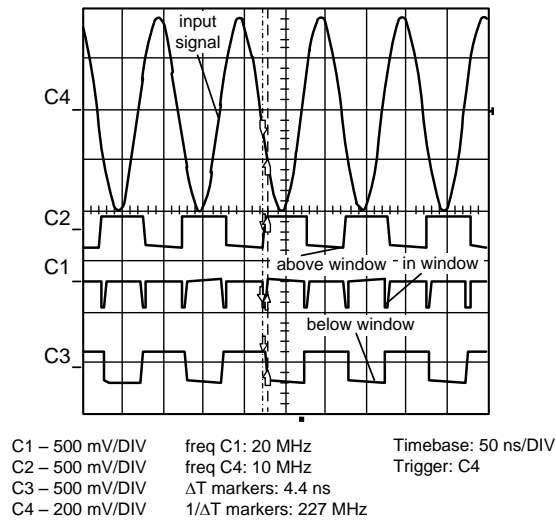


Figure 5. 10 MHz Far Above Thresholds

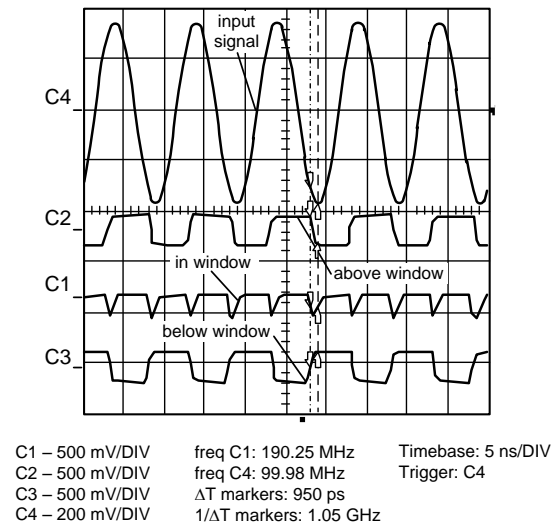


Figure 6. 100 MHz Far Above Thresholds

5 Board Schematic

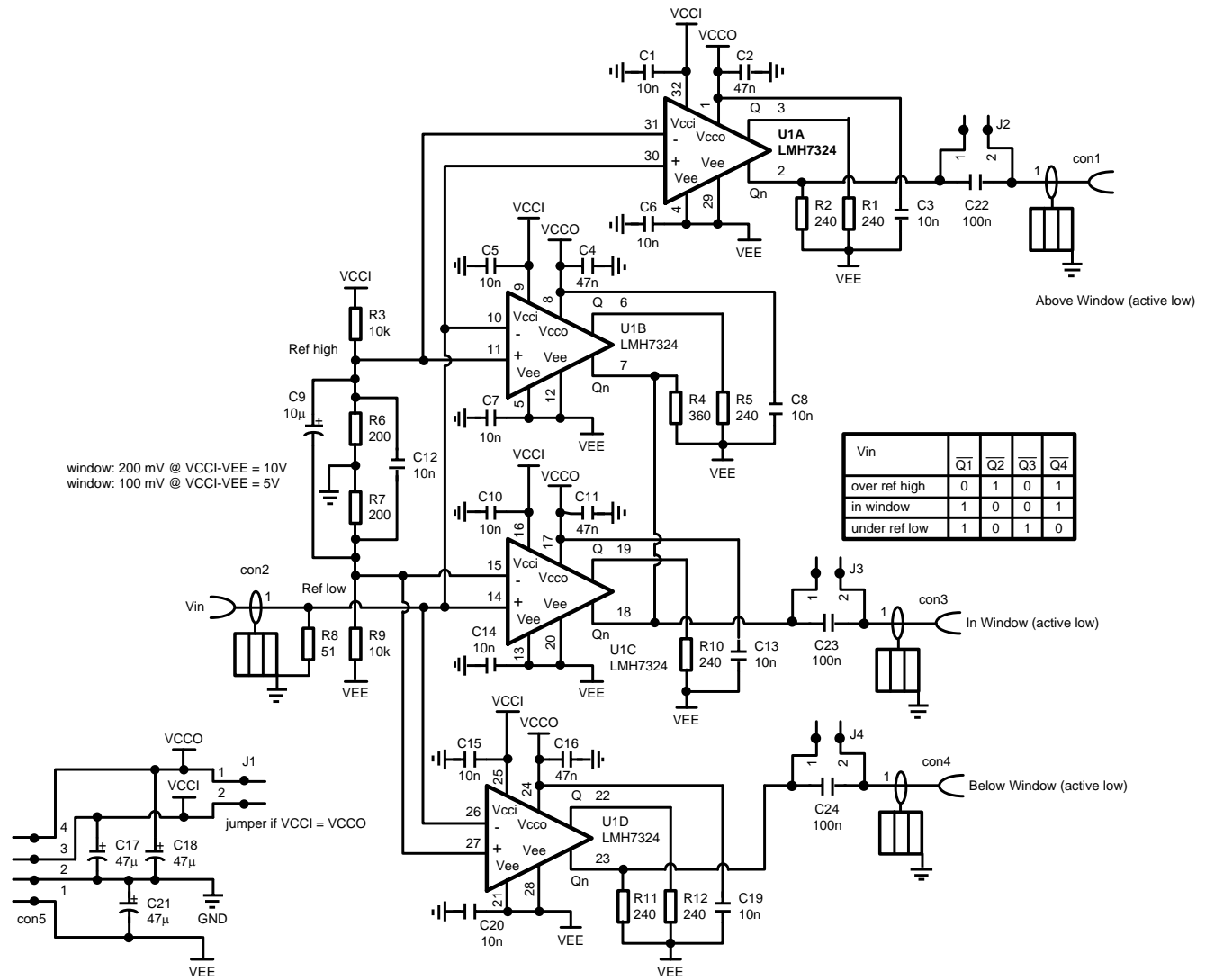


Figure 7. Schematic Diagram

6 Board Layout

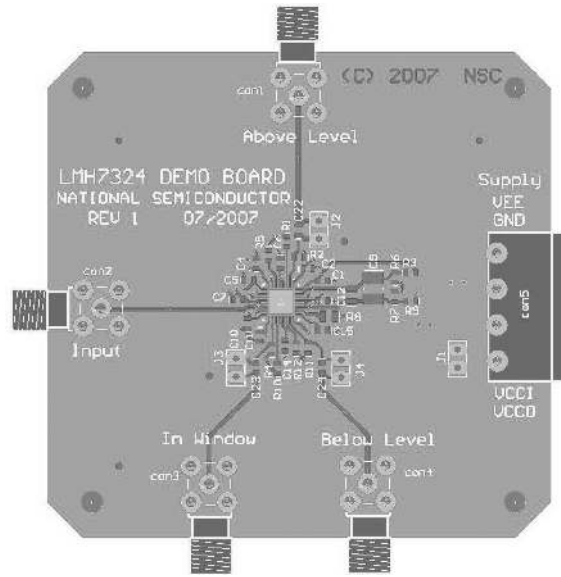


Figure 8. Top Side

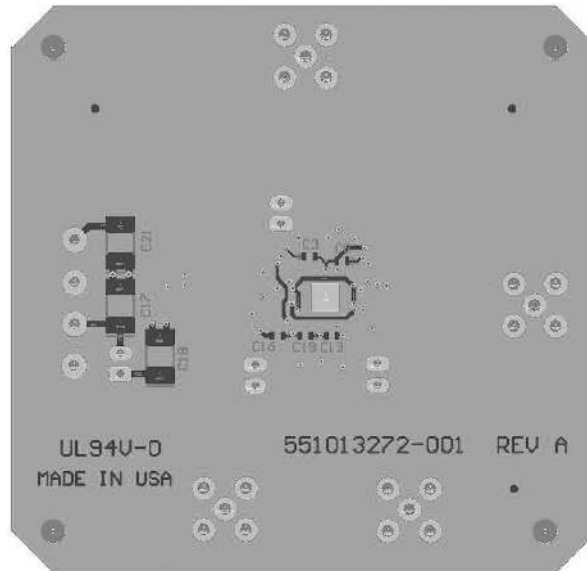


Figure 9. Bottom Side

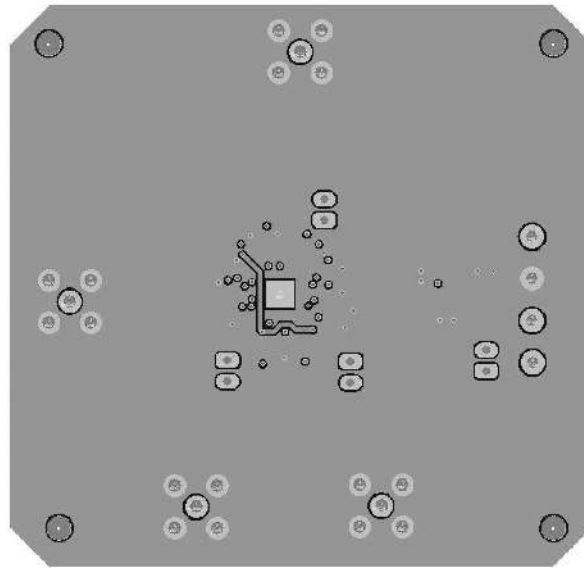


Figure 10. Mid Layer 1

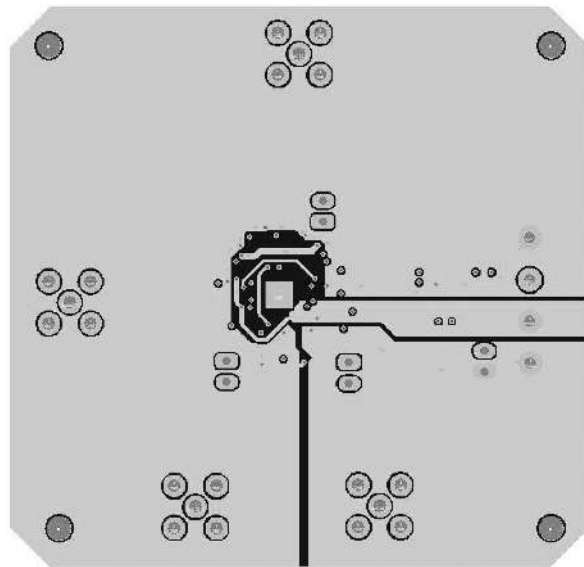


Figure 11. Mid Layer 2

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com