

AN-1292 LM5642 Evaluation Board

1 Introduction

The LM5642 IC is a dual channel, current-mode, synchronous buck converter controller. It can handle input voltages of up to 36V and delivers two independent output voltages from 1.23V up to 90% of the input voltage. Current sensing can be done using a dedicated resistor or using the $R_{DS(ON)}$ of the high-side FET. This application note describes the dedicated evaluation PCBs that are available for both methods.

2 Resistor Sense PCB

The first, more common method of sensing current in current-mode controllers is with an external sense resistor, placed in series with the high-side FET of each channel. Sense resistors provide an accurate voltage as the load current passes through them, and have stable, linear resistance change with temperature. As shipped the Resistor Sense PCB is designed to deliver 1.8V on Channel 1 at a maximum current of 7A, and 3.3V on Channel 2 at a maximum current of 4A. The input voltage can vary anywhere from 5.5 to 36V. The board has been designed to be flexible and allow many other circuit configurations by replacing the original components with user selected ones. [Figure 1](#) shows the circuit diagram representing the standard BOM that comes with the PCB. [Table 1](#) lists all the components that are used for this standard configuration BOM. [Figure 2](#) shows the complete circuit diagram with all extra footprints.

Two SPST switches, S1 and S2, are provided to turn the two channels of the converter on and off. The standard BOM that comes with the LM5642 Resistor Sense evaluation board uses 10m Ω current sense resistors (R7 for Channel 1 and R15 for Channel 2) to provide independent feedback signals to the IC. The board provides additional resistor and capacitor footprints for noise filtering, ringing control, and to enable operation at low input voltages.

3 Current Sense Filters

R-C filters have been added to the current sense amplifier inputs of the Resistor Sense evaluation board, comprised of components C3, C4, C14, C15, R2, R6, and R16. These resistors and capacitors reduce the sensitivity to switching noise, especially during high currents, load-transients, and circuits with short on-times.

4 Parallel Operation

The two channels of the LM5642 Resistor Sense evaluation board can be paralleled to provide one high current rail. At the nominal switching frequency of 200kHz the converter will run 180° out-of-phase. Care must be taken when using this feature combined with the frequency synchronization, as the two channels of the converter are no longer 180° out-of-phase when the frequency is above or below 200kHz. The two feedback inputs FB1 and FB2 should be tied together by soldering a 0 Ω resistor in the position marked J1 on the bottom side of the PCB. The two COMP pins should be tied together by soldering a 0 Ω resistor in the position J3. The ON/SS1 and ON/SS2 pins must also be connected using a 0 Ω resistor in the position J2. One of the two SPDT switches S1 and S2 should be left 'ON' and the other used to turn the converter off and on. Finally, the two outputs VO1 and VO2 must be tied together by the user, external to the PCB. Only one of the two resistor divider networks (R10/R11 or R19/R20) and only one of the compensation networks should be used (C18/C19/R22/R23 or C20/C21/R24/R25).

5 V_{DS} Sense PCB

The LM5642 IC offers a second current sensing mechanism that uses the $R_{DS(ON)}$ of the high-side FET to sense the load current. This method reduces the parts count on the BOM, however the $R_{DS(ON)}$ of a FET is not as tightly controlled as a sense resistor, and suffers from non-linear changes in resistance with temperature. As a result, the IC is more sensitive to noise in this mode, especially at input voltages above 30V. The maximum recommended current using VDS sensing is 5A per channel. The VDS Sense board has been designed to deliver 1.8V on Channel 1 with a maximum current of 5A, and 3.3V on Channel 2 with a maximum current of 4A. [Figure 3](#) shows the circuit diagram representing the standard BOM that comes with the PCB. Table 2 lists all the components that are used for this standard configuration BOM. [Figure 4](#) shows the complete circuit diagram with all extra footprints.

6 Frequency Synchronization

A connection point labeled 'SYNC' is available on both versions of the LM5642 evaluation boards in order to adjust the switching frequency of the IC between 150 and 250kHz. Both CMOS and TTL level square wave signals can be used. The SYNC input has a minimum low-to-high transition threshold of 2.0V and a maximum high-to-low threshold of 0.8V. The SYNC pin is grounded by a 220k Ω pull-down resistor.

7 Low Input Voltage Operation

When the input voltage is between 4.5V and 5.5 on either evaluation board, a 4.7 Ω resistor should be installed in position R26. This will ensure that V_{LIN5} does not fall below the UVLO threshold of the IC. When R26 is in place the input voltage must not exceed 5.5V.

8 Gate Drive Current Limiting

The LM5642 IC includes powerful gate drivers which can drive small FETs at high speed, often inducing noise or ringing into the board. Slowing the gate drivers can help reduce this noise by increasing the drain current transition time. While slowing the gate drives can help suppress noise, it also increases switching losses and gate-charge losses in the top FET. Slowing of the gate drives can be accomplished with resistors in series with the CBOOT1 and CBOOT2 pins. (R9,R18) Placing resistors in series with the CBOOT pins will slow the top FET rise time only. Generally the values for gate drive limiting resistors are between 1 and 5 Ω . R9 and R18 are 0 Ω by default.

9 Parallel Low-Side Schottky Diode

The LM5642 evaluation boards include footprints for Schottky diodes D4 and D5 (SMB footprint or smaller) in parallel to the low side FETs. Placing these diodes on the PCB can improve efficiency because Schottky diodes have a lower forward voltage drop and lower reverse recovery charge than the parasitic diode of the bottom FET.

10 Parallel Low-Side FET

Footprints Q3 and Q6 have been placed on both boards so that two SO-8 N-FETs can be placed in parallel for the low-side of each channel. Paralleling FETs reduces the $R_{DS(ON)}$ of the system and spreads the heat dissipated by the load current over two packages. This is especially important for converters with high input voltage and low output voltage, where the low duty cycle forces the low side FET or FETs to carry the load current for a much greater percentage than the high-side FET.

11 Additional Footprints

Additional footprints are provided to add more surface mount or through-hole capacitors (with 3.5 or 5mm lead spacing) in parallel to the input and output capacitors.

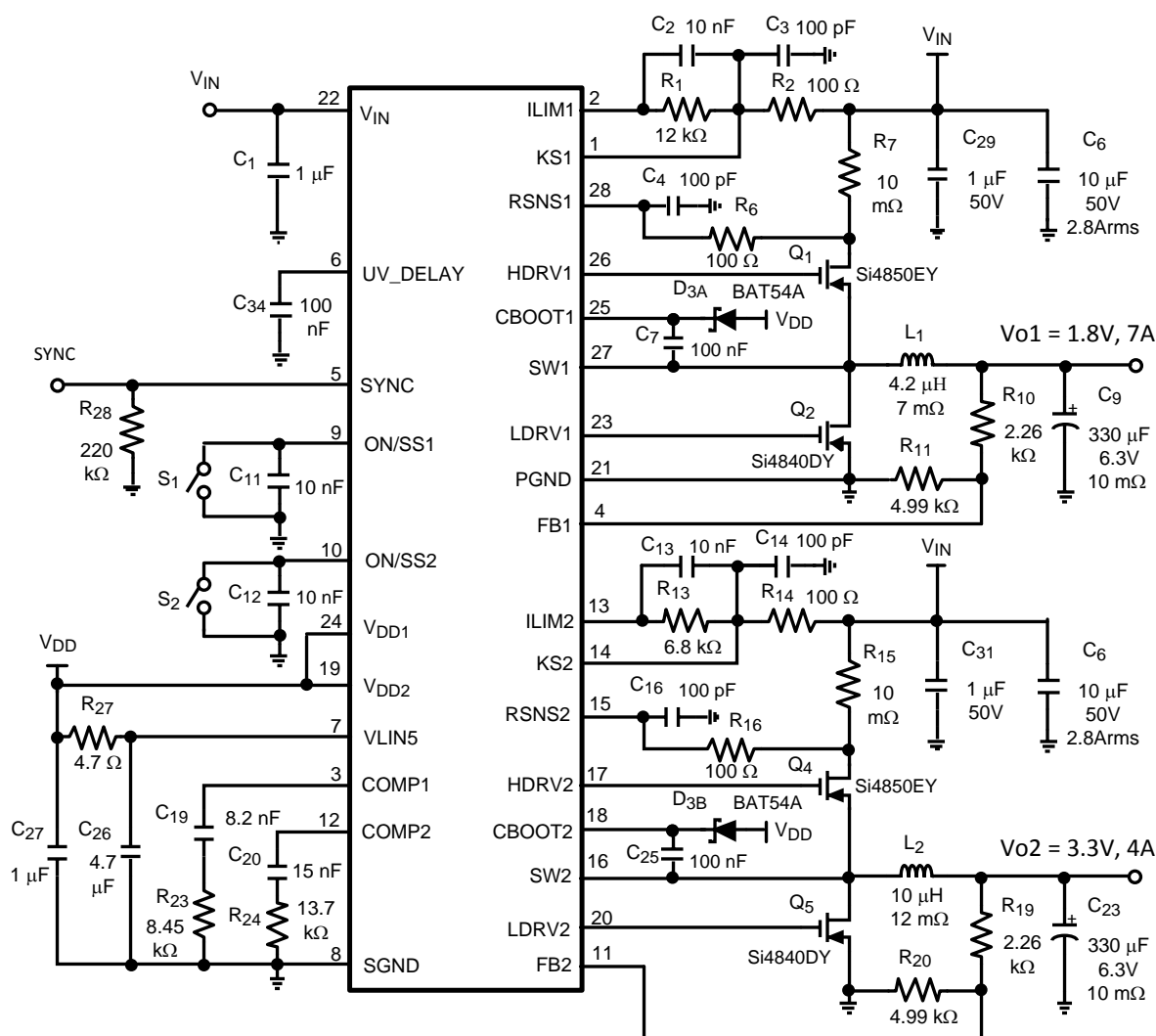


Figure 1. Standard Resistor Sense Circuit

Table 1. Standard Resistor Sense Bill of Materials

ID	Part Number	Type	Size	Parameters	Qty	Vendor
U1	LM5642	Dual Synchronous Controller	TSSOP-28		1	Texas Instruments
Q1, Q4	Si4850EY	N-MOSFET	SO-8	60V	2	Vishay
Q2, Q5	Si4840DY	N-MOSFET	SO-8	40V	2	Vishay
D3	BAT54A	Schottky Diode	SOT-23	30V	1	ON
L1	RLF12560T-4R2N100	Inductor	12.5 x 12.5 x 6mm	4.2μH, 7mΩ, 10A	1	TDK
L2	RLF12545T-100M5R1	Inductor	12.5 x 12.5 x 4.5mm	10μH, 12mΩ, 5.1A	1	TDK
C1, C29, C31	C3216X7R1H105K	Capacitor	1206	1μF, 50V	3	TDK
C3, C4, C14, C15	VJ1206Y101KXXAT	Capacitor	1206	100pF, 25V	3	Vishay
C27	C2012X5R1C105K	Capacitor	0805	1μF, 16V	1	TDK
C6, C16	C5750X5R1H106M	Capacitor	2220	10μF, 50V, 2.8A	2	TDK
C9, C23	6TPD330M	Capacitor	7.3 x 4.3 x 3.8mm	330μF, 6.3V, 10mΩ	2	Sanyo
C2, C11, C12, C13	VJ1206Y103KXXAT	Capacitor	1206	10nF, 25V	4	Vishay
C7, C25, C34	VJ1206Y104KXXAT	Capacitor	1206	100nF, 25V	3	Vishay
C19	VJ1206Y822KXXAT	Capacitor	1206	8.2nF, 10%	1	Vishay
C20	VJ1206Y153KXXAT	Capacitor	1206	15nF, 10%	1	Vishay
C26	C3216X7R1C475K	Capacitor	1206	4.7μF, 25V	1	TDK
R1	CRCW1206123J	Resistor	1206	12kΩ, 5%	1	Vishay
R2, R6, R14, R16	CRCW1206100J	Resistor	1206	100Ω, 5%	1	Vishay
R13	CRCW1206682J	Resistor	1206	6.8kΩ, 12%	1	Vishay
R7, R15	WSL-2512 .010 1%	Resistor	2512	10mΩ, 1W	2	Vishay
R18, R9	CRCW1206000Z	Resistor	1206	0Ω	2	Vishay
R10	CRCW12062261F	Resistor	1206	2.26kΩ, 1%	1	Vishay
R23	CRCW12068451F	Resistor	1206	8.45kΩ, 1%	1	Vishay
R24	CRCW12061372F	Resistor	1206	13.7kΩ, 1%	1	Vishay
R11, R20	CRCW12064991F	Resistor	1206	4.99kΩ, 1%	2	Vishay
R19	CRCW12068251F	Resistor	1206	8.25kΩ, 1%	1	Vishay
R27	CRCW12064R7J	Resistor	1206	4.7Ω, 5%	1	Vishay
R28	CRCW1206224J	Resistor	1206	220kΩ, 5%	1	Vishay

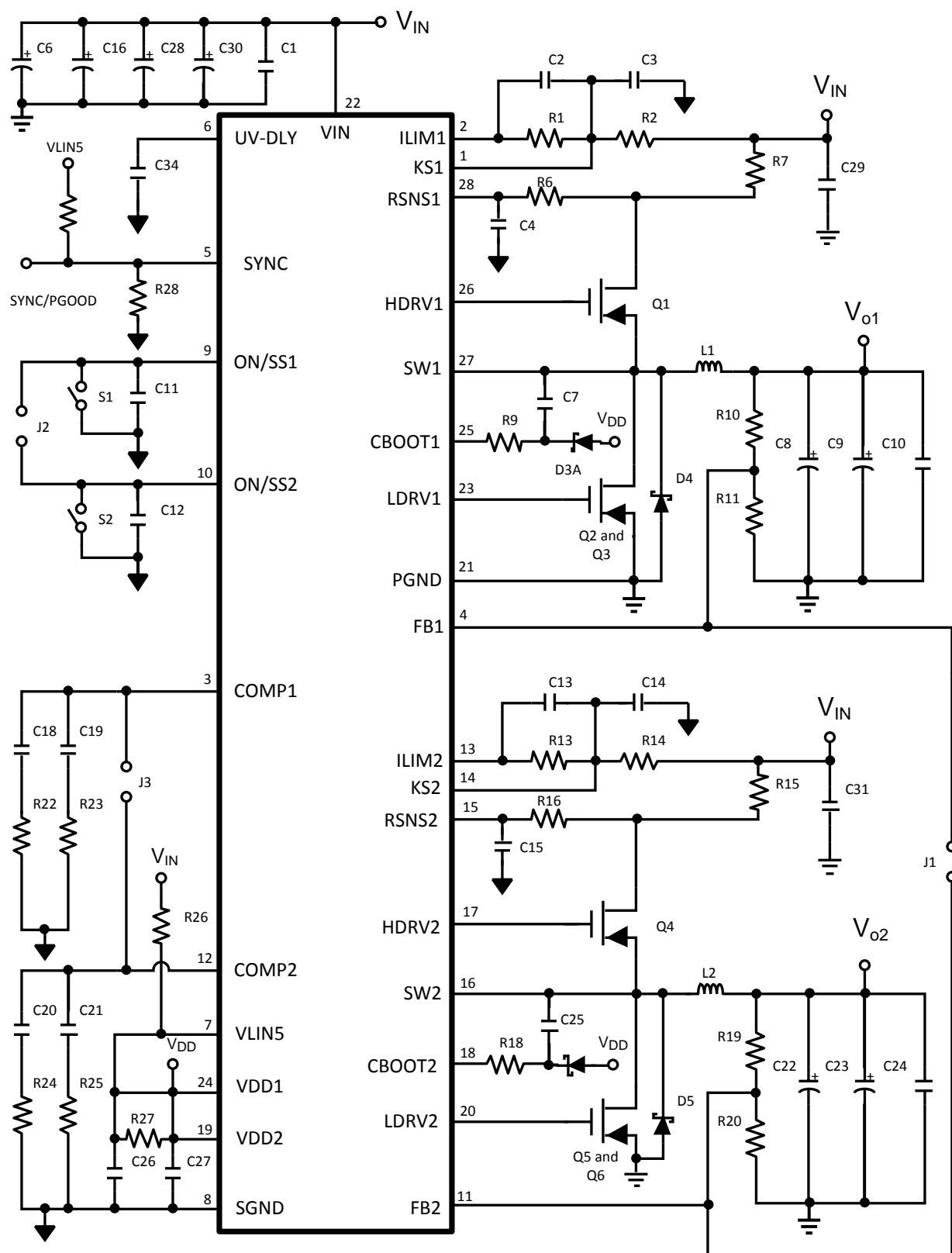


Figure 2. Complete Resistor Sense Evaluation Board Schematic

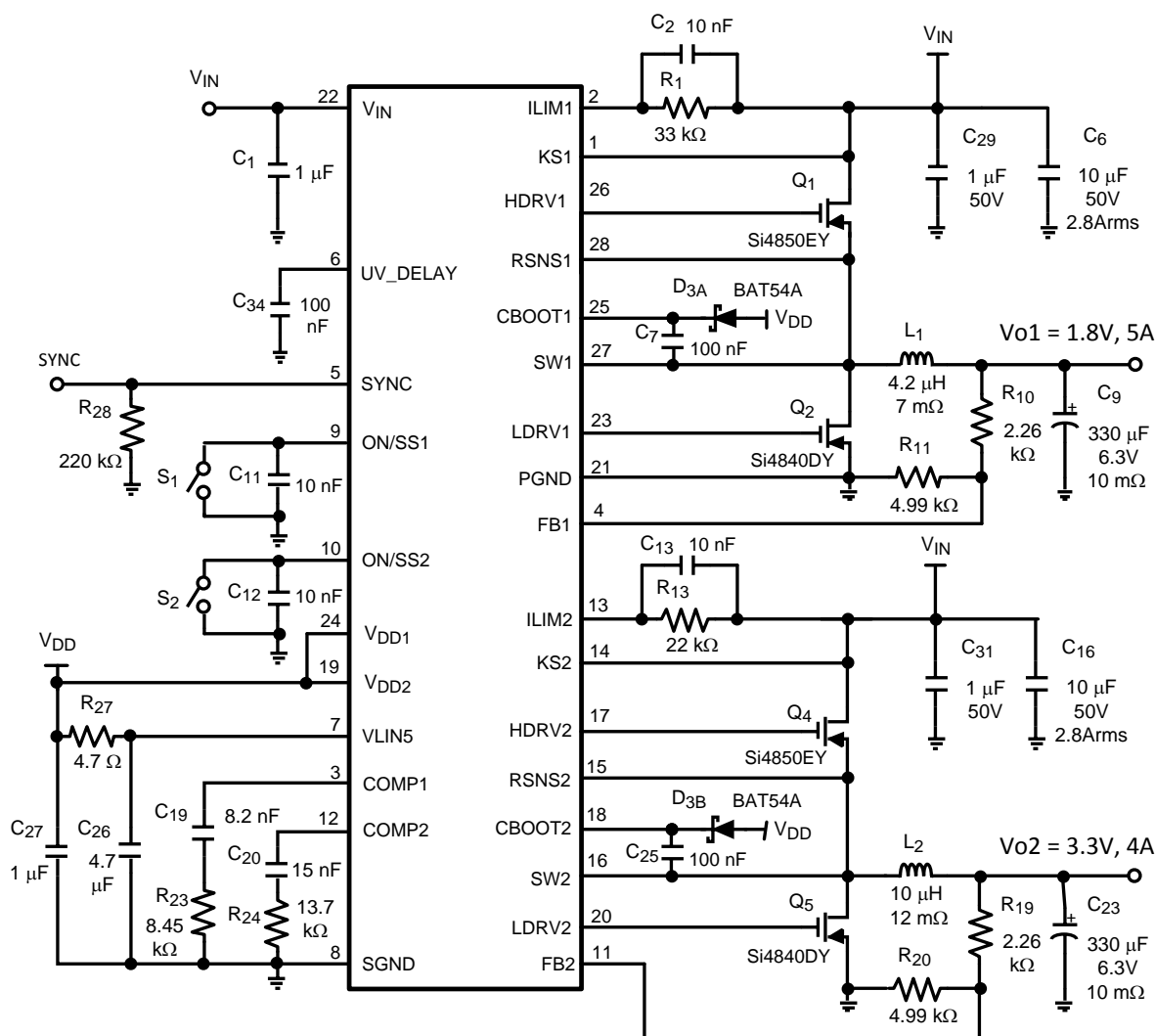


Figure 3. Standard V_{DS} Sense Circuit

Table 2. Standard V_{DS} Sense Bill of Materials

ID	Part Number	Type	Size	Parameters	Qty	Vendor
U1	LM5642	Dual Synchronous Controller	TSSOP-28		1	Texas Instruments
Q1, Q4	Si4850EY	N-MOSFET	SO-8	60V	2	Vishay
Q2, Q5	Si4840DY	N-MOSFET	SO-8	40V	2	Vishay
D3	BAT54A	Schottky Diode	SOT-23	30V	1	ON
L1	RLF12560T-4R2N100	Inductor	12.5 x 12.5 x 6mm	4.2 μ H, 7m Ω , 10A	1	TDK
L2	RLF12545T-100M5R1	Inductor	12.5 x 12.5 x 4.5mm	10 μ H, 12m Ω , 5.1A	1	TDK
C1, C29, C31	C3216X7R1H105K	Capacitor	1206	1 μ F, 50V	1	TDK
C27	C2012X5R1C105K	Capacitor	0805	1 μ F, 16V	1	TDK
C6, C16	C5750X5R1H106M	Capacitor	2220	10 μ F, 50V, 2.8A	2	TDK
C9, C23	6TPD330M	Capacitor	7.3 x 4.3 x 3.8mm	330 μ F, 6.3V, 10m Ω	2	Sanyo
C2, C11, C12, C13	VJ1206Y103KXXAT	Capacitor	1206	10nF, 25V	4	Vishay
C7, C25, C34	VJ1206Y104KXXAT	Capacitor	1206	100nF, 25V	3	Vishay
C19	VJ1206Y822KXXAT	Capacitor	1206	8.2nF, 10%	1	Vishay
C20	VJ1206Y153KXXAT	Capacitor	1206	15nF, 10%	1	Vishay
C26	C3216X7R1C475K	Capacitor	1206	4.7 μ F, 25V	1	TDK
R1	CRCW1206333J	Resistor	1206	33k Ω , 5%	1	Vishay
R13	CRCW1206223J	Resistor	1206	22k Ω , 5%	1	Vishay
R10	CRCW12062261F	Resistor	1206	2.26k Ω , 1%	1	Vishay
R23	CRCW12068451F	Resistor	1206	8.45k Ω , 1%	1	Vishay
R24	CRCW12061372F	Resistor	1206	13.7k Ω , 1%	1	Vishay
R11, R20	CRCW12064991F	Resistor	1206	4.99k Ω , 1%	2	Vishay
R19	CRCW12068251F	Resistor	1206	8.25k Ω , 1%	1	Vishay
R27	CRCW12064R7J	Resistor	1206	4.7 Ω , 5%	1	Vishay
R28	CRCW1206224J	Resistor	1206	220k Ω , 5%	1	Vishay

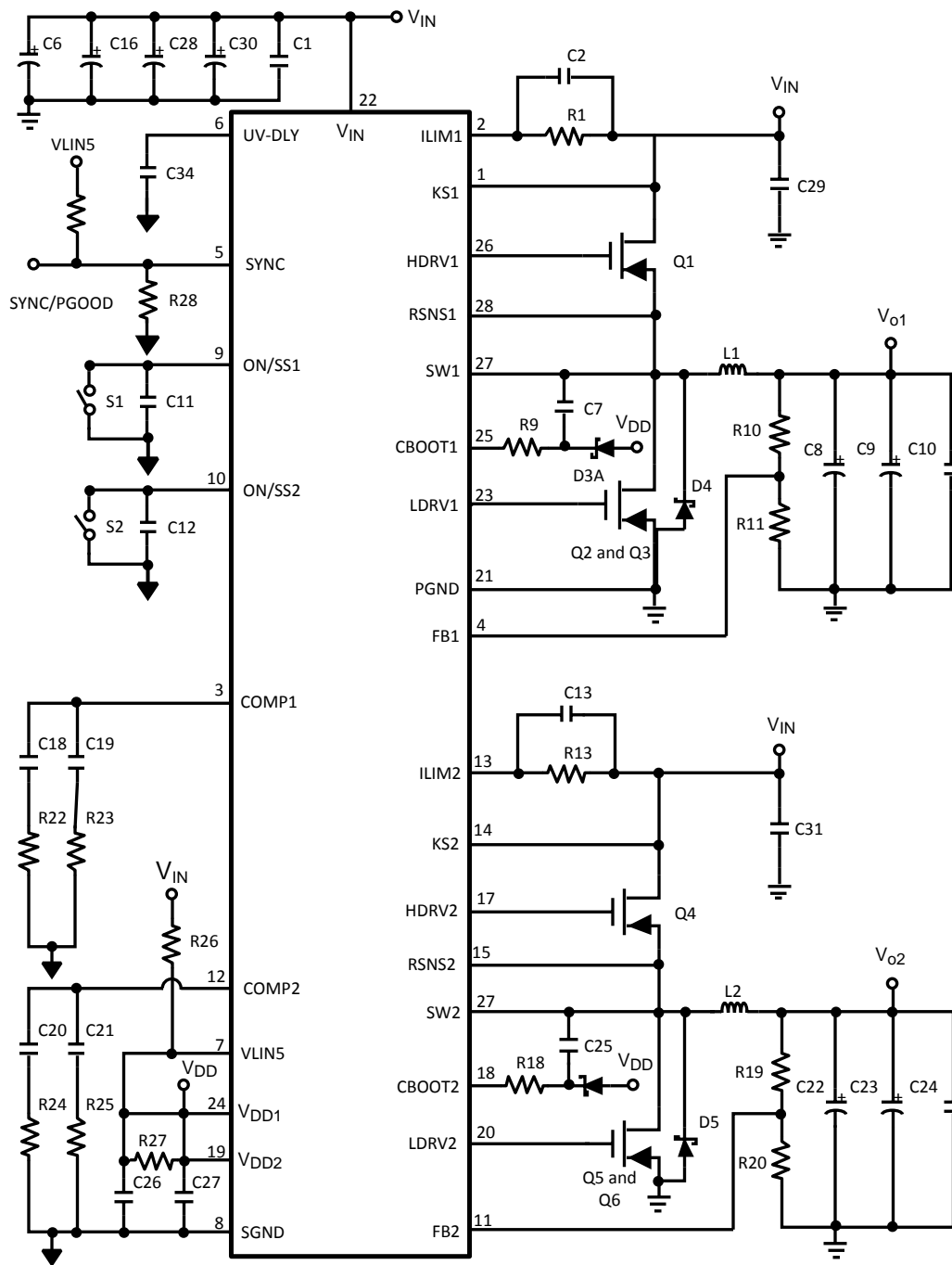


Figure 4. Complete V_{DS} Sense Eval Board Schematic

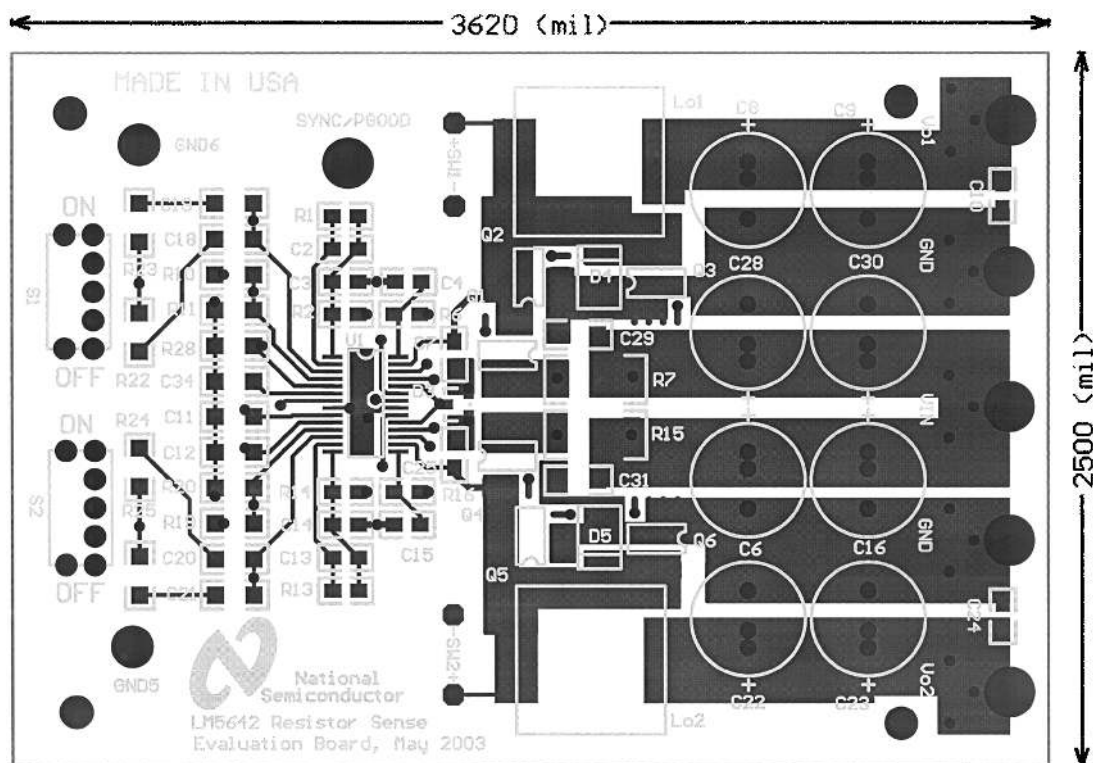


Figure 5. Resistor Sense PCB Top Layer

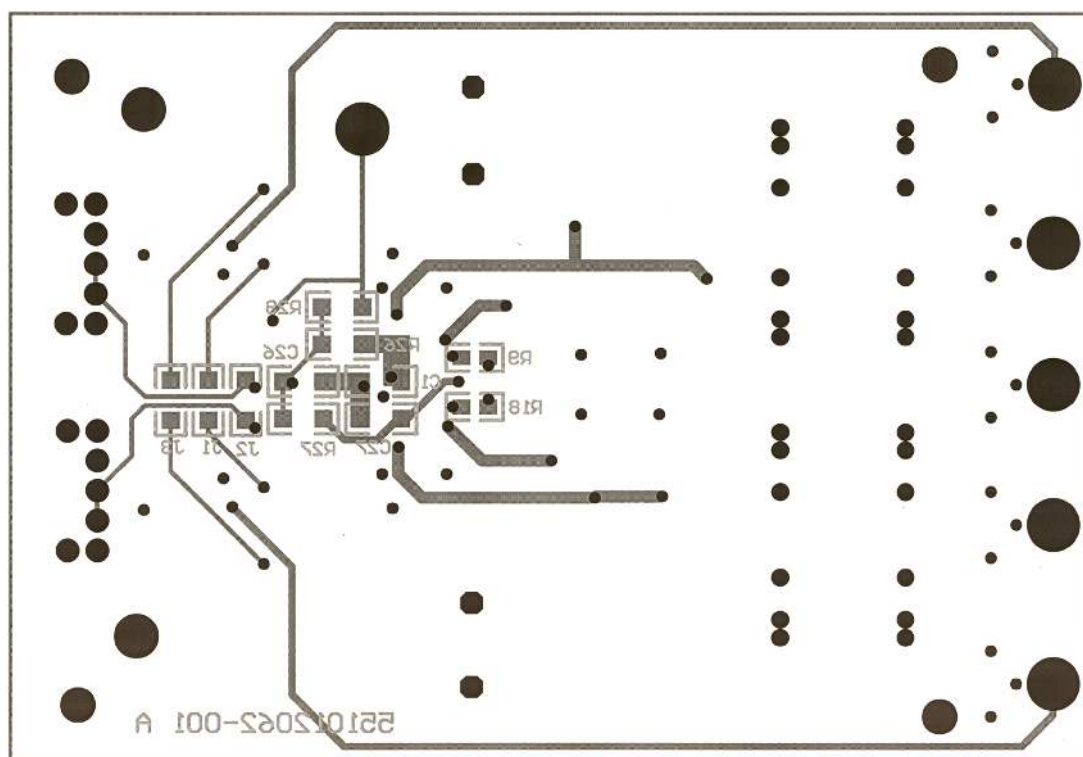


Figure 6. Resistor Sense PCB Bottom Layer

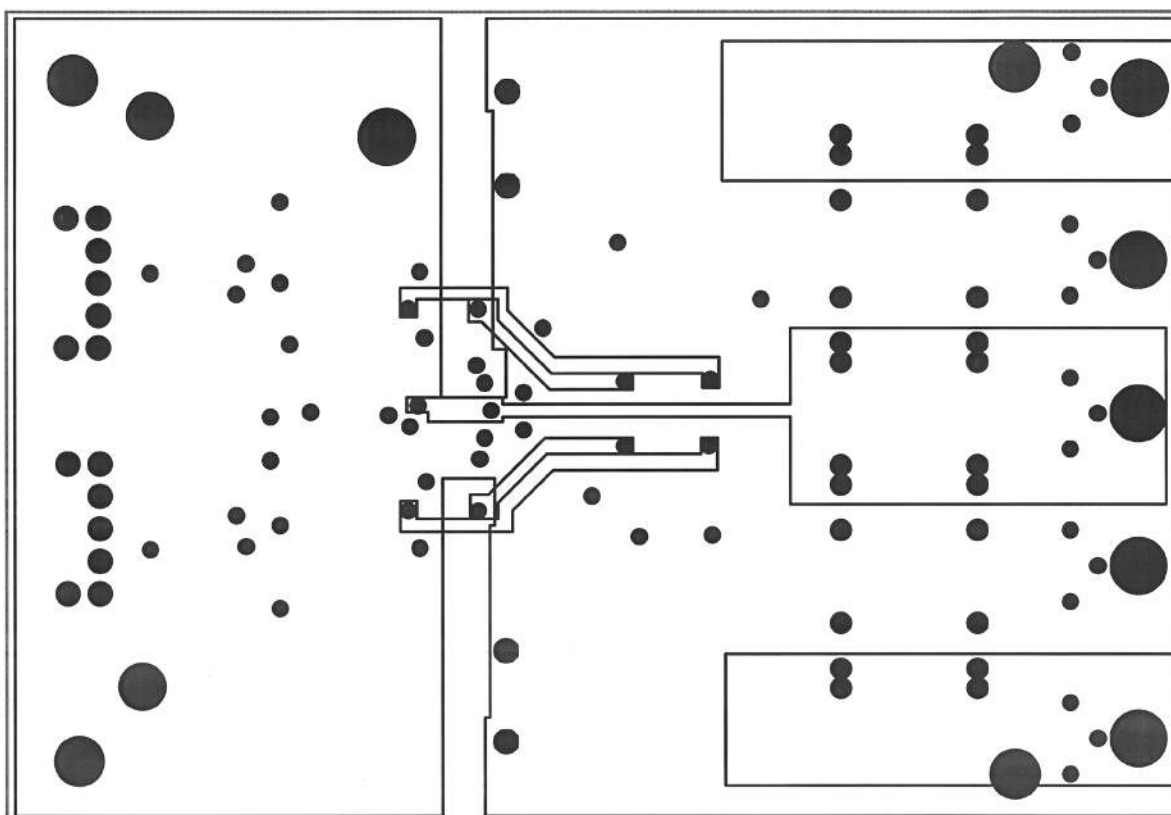


Figure 7. Resistor Sense PCB Internal Planes

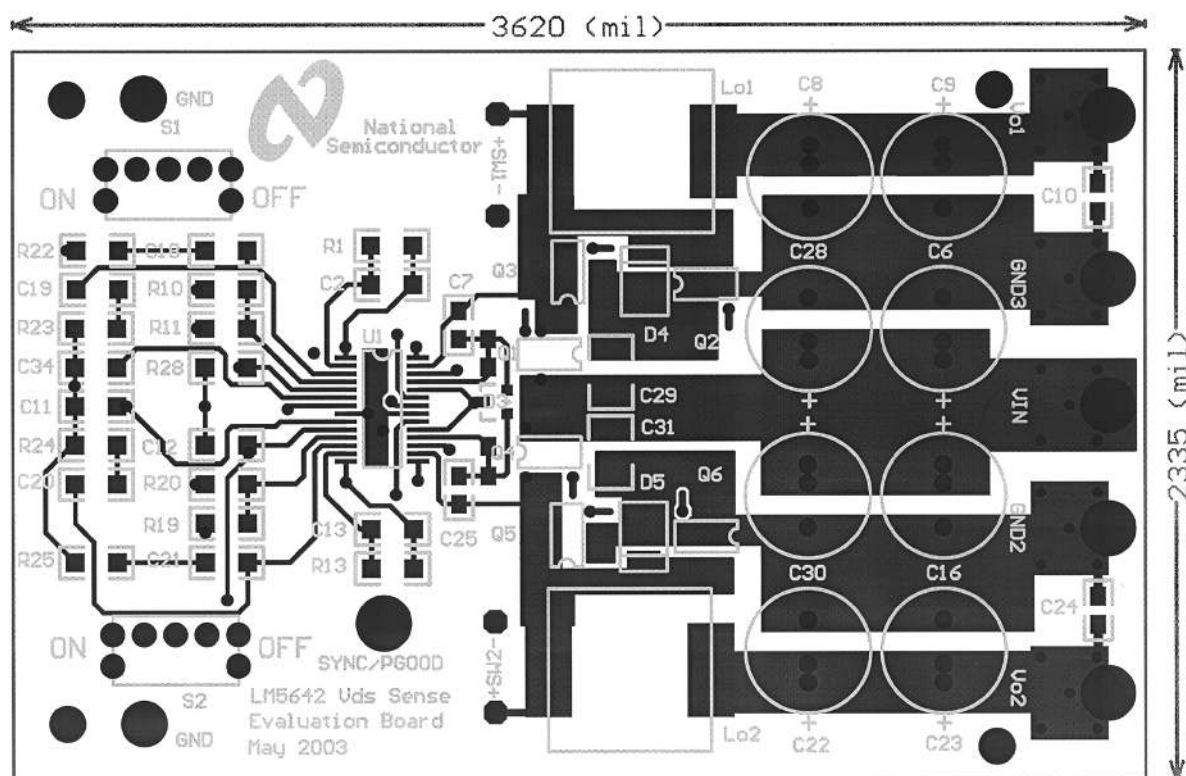


Figure 8. V_{DS} Sense PCB Top Layer

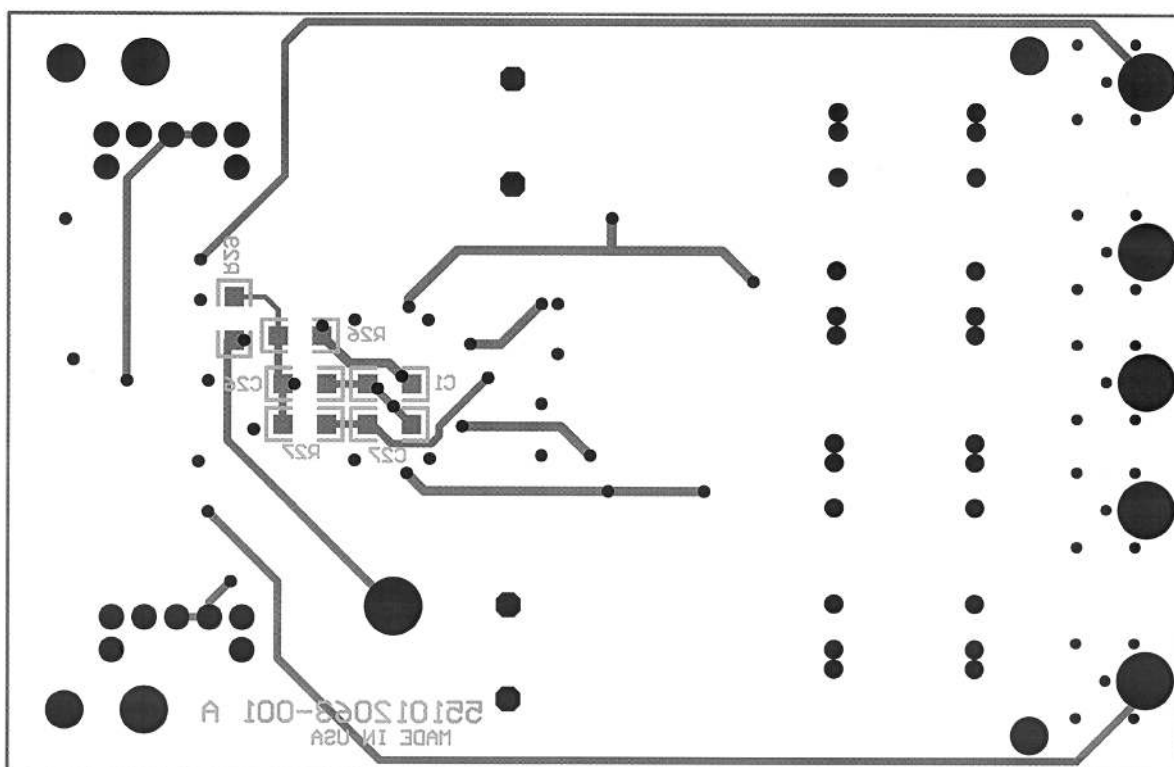


Figure 9. V_{DS} Sense PCB Bottom Layer

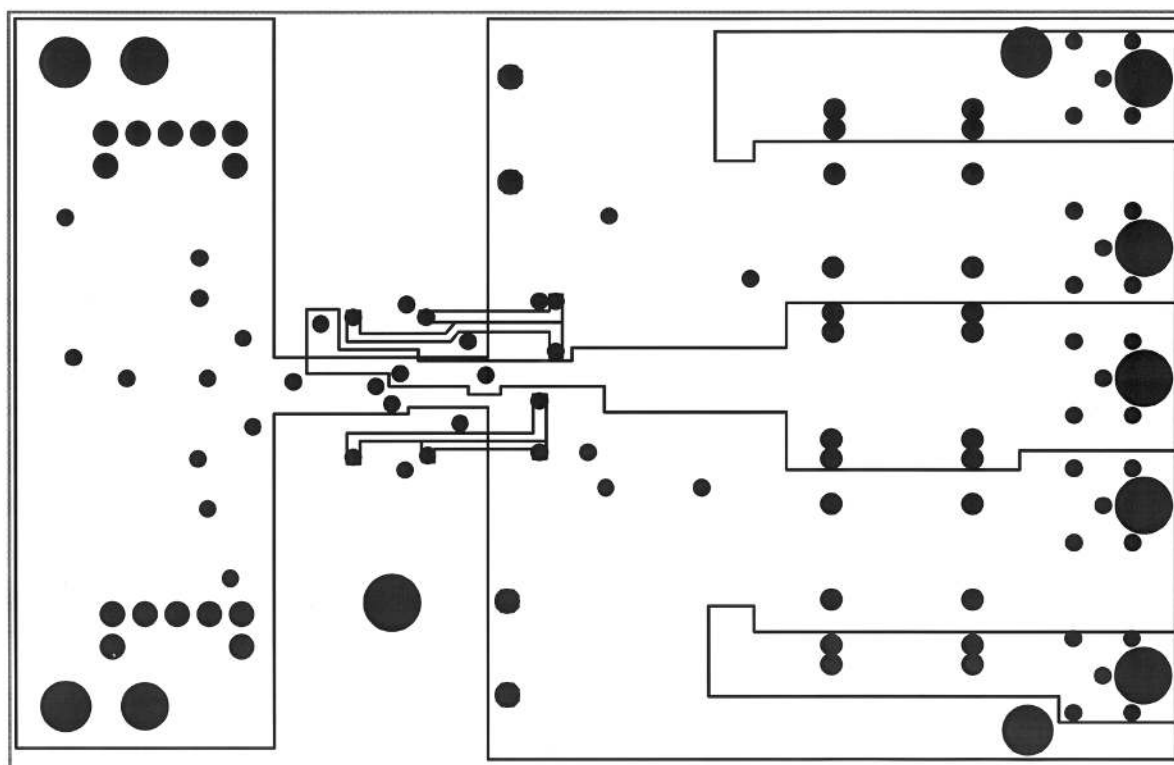


Figure 10. V_{DS} Sense PCB Internal Planes

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