

## **DRV632EVM Evaluation Module**

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This user's guide describes the operation of the DRV632 evaluation module. This document also provides measurement data and design information including a schematic, bill of materials, and printed-circuit board (PCB) layout drawings.

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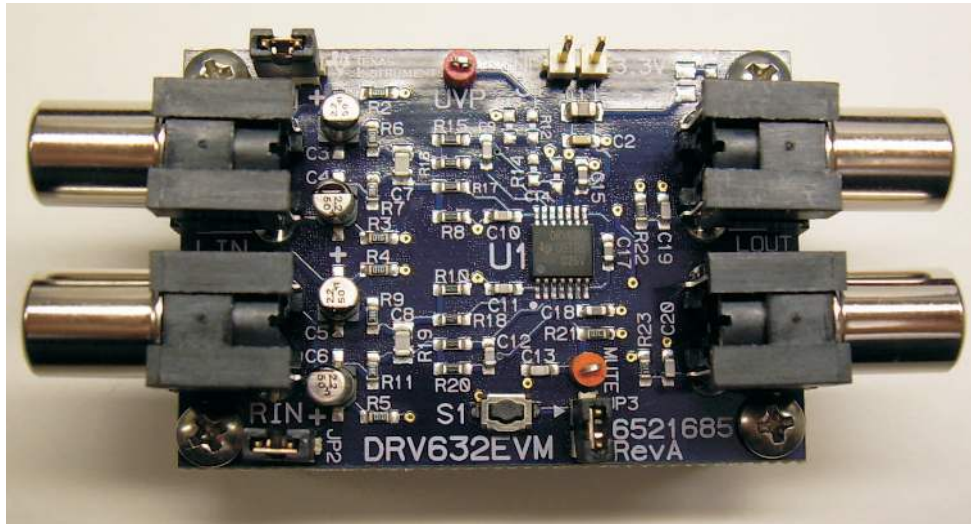
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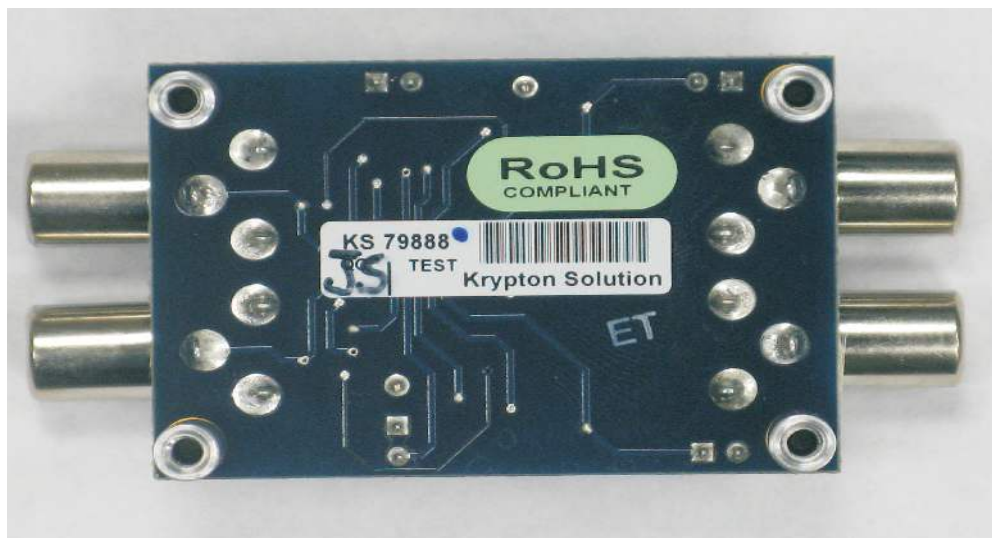
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## 1 Overview



**Figure 1. DRV632EVM Top View**



**Figure 2. DRV632EVM Bottom View**

The DRV632EVM customer evaluation module (EVM) demonstrates the capabilities and operation of the DRV632 integrated circuit from Texas Instruments.

The DRV632 is a 2- $V_{RMS}$ , pop-free, stereo line driver designed to allow removal of the output dc-blocking capacitors in audio applications to reduce component count and overall cost. The device is ideal for single-supply electronics where size and cost are critical design parameters.

Designed using TI's patented DirectPath™ technology, the DRV632 is able to drive 2  $V_{RMS}$  into a 10-k $\Omega$  load with 3.3-V supply voltage. The device has differential inputs and uses external gain-setting resistors that support a gain range of  $\pm 1$  V/V to  $\pm 10$  V/V, and line outputs that have  $\pm 8$  kV IEC electrostatic discharge (ESD) protection. The DRV632 also has built-in shutdown control for pop-free, on/off control.

Using the DRV632 in audio product applications can reduce component counts considerably, compared to traditional methods of generating a 2- $V_{RMS}$  output. The DRV632 does not require a power supply greater than 3.3 V to generate its 5.6- $V_{PP}$  output, nor does it require a split-rail power supply. The DRV632 integrates its own charge pump to generate a negative supply rail that provides a clean, pop-free, ground-biased 2- $V_{RMS}$  output. The DRV632 is available in a 14-pin TSSOP package.

This EVM is configured with two RCA phono input connectors for analog input; the output signal is available on two RCA phono connectors. The power supply is connected via a two-pin, 2,54-mm header.

This evaluation board is designed for testing applications such as set-top boxes, LCD/PDP TVs, Blu-ray Disc™ DVD players, DVD mini-component systems, home theater-in-a-box (HTIB) systems, or soundcards.

This document presents EVM specifications, audio performance measurements graphs, and design documentation that includes complete circuit descriptions, schematic diagrams, a parts list, and PCB layout design. Gerber (layout) files are available from the TI Web site at [www.ti.com](http://www.ti.com).

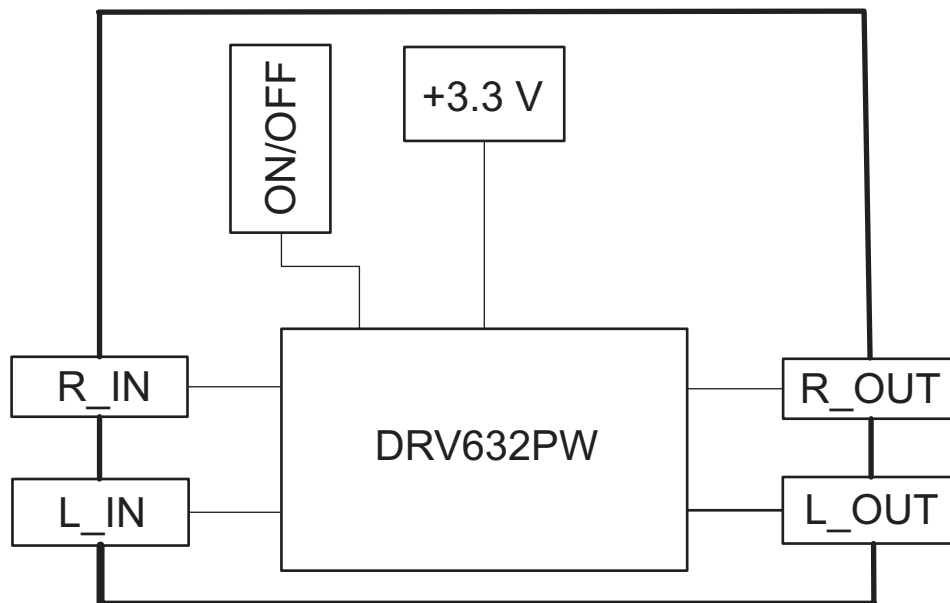
Throughout this document, the abbreviation *EVM* and the term *evaluation module* are synonymous with the DRV632EVM.

## 1.1 DRV632EVM Features

The DRV632EVM has these features:

- Two-channel evaluation module (double-sided, plated-through PCB layout)
- $2\text{-}V_{\text{RMS}}$  line output
- No output capacitor required
- Shutdown button

Figure 3 illustrates the functional diagram for the EVM. Table 1 summarizes the key parameters.



**Figure 3. DRV632EVM Functional Block Diagram**

**Table 1. Key Parameters**

Key Parameters	Specification/Unit
Supply Voltage	3.3 V
Number of Channels	Two
Load Impedance	600 $\Omega$ (min)
Output Voltage	2 $V_{\text{RMS}}$
Dynamic Range	> 90 dB

## 2 Quick Setup

This section describes the DRV632EVM board with regard to the power supply and system interfaces. It provides information about handling and unpacking the DRV632EVM, absolute operating conditions, and a description of the factory default switch and jumper configurations.

The following subsections provide a step-by-step guide to configuring the DRV632EVM for device evaluation.

### 2.1 Electrostatic Discharge Notice

#### CAUTION

Many of the components on the DRV632EVM are susceptible to damage by electrostatic discharge (ESD). Customers are advised to observe proper ESD handling precautions when unpacking and handling the EVM, including the use of a grounded wrist strap at an approved ESD workstation.

Failure to observe proper ESD handling procedures may result in damage to EVM components.

### 2.2 Unpacking the EVM

On opening the DRV632EVM package, ensure that the following items are included:

- One DRV632EVM evaluation board, including:
  - One DRV632PW device

If either item is missing, contact the Texas Instruments Product Information Center nearest you to inquire about a replacement.

### 2.3 Power-Supply Setup

A single power supply is required to power up the EVM. The power supply is connected to the EVM board using a two-pin, 2,54-mm header (J1). [Table 2](#) lists the recommended supply voltage.

**Table 2. Recommended Supply Voltage**

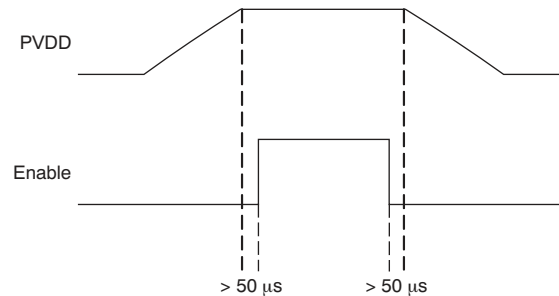
Description	Voltage Limitations	Current Requirement	Cable
Power supply	3.3 V	0.10 A	—

#### CAUTION

Applying voltages above the limitations given in [Table 2](#) may cause permanent damage to your hardware.

### 3 On/Off Sequence

For minimum click and pop interference during device power on and power off, the DRV632 Mute pin (pin 5) must be held low, primarily because of precharging of the ac-coupled input capacitors. The preferred power-up/-down sequence is shown in Figure 4.



**Figure 4. Power-Up/Down Sequence**

## 4 Component Selection

### 4.1 Charge Pump

The charge pump flying capacitor, C17, serves to transfer charge during the generation of the negative supply voltage. The PVSS capacitor must be at least equal to the charge pump capacitor in order to allow a maximum charge transfer. Low equivalent series resistance (ESR) capacitors are an ideal selection, with a typical value of 1  $\mu\text{F}$ . Capacitor values less than 1  $\mu\text{F}$  can be used, but the maximum output can be reduced. It is therefore recommended to validate the design with thorough testing.

### 4.2 Power-Supply Decoupling Capacitors

The DRV632 is a DirectPath™ line driver amplifier that requires adequate power-supply decoupling to ensure that noise and total harmonic distortion (THD) are low. A good low ESR ceramic capacitor, C15 (1  $\mu\text{F}$  typical), placed as close as possible to the device VDD leads is the best option. Placing this decoupling capacitor close to the DRV632 device is important for amplifier performance. For filtering lower-frequency noise signals, a 10- $\mu\text{F}$  or greater capacitor placed near the audio amplifier may also help, but is not required in most applications because of the high PSRR of the DRV632.

The charge pump circuit does apply ripple current on the VDD line, and an LC or RC filter may be needed if noise-sensitive audio devices share the VDD supply.

### 4.3 Using the DRV632 as a Second-Order, Low-Pass Filter in Single-Ended Input Mode

Several audio digital-to-audio converters (DAC) used in typical consumer applications require an external low-pass filter to remove out-of-band noise. This function is also possible with the DRV632; the EVM is configured as a 30-kHz, second-order active Butterworth filter to accomplish this filtering using an MFB (multiple feedback) topology. Furthermore, the DRV632 requires an ac-coupling capacitor to remove dc content from the source.

The active low-pass filter component values can be calculated with the help of the TI [FilterPro](http://focus.ti.com/docs/toolsw/folders/print/filterpro.html) active filter design program available at <http://focus.ti.com/docs/toolsw/folders/print/filterpro.html> on the TI Web site. Figure 5 illustrates the circuit design for this configuration.

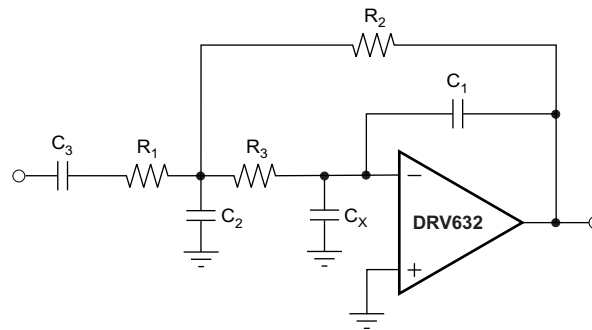


Figure 5. Second-Order, Active Low-Pass Filter

Table 3. DRV632EVM Filter Specifications

Gain	High Pass	Low Pass	C1	Single Ended C2	Differential C2	C3	R1	R2	R3
-1 V/V	16 Hz	40 kHz	100 pF	680 pF	270 pF	1 $\mu$ F	10 k $\Omega$	10 k $\Omega$	24 k $\Omega$
-1.5 V/V	19 Hz	40 kHz	68 pF	680 pF	270 pF	1 $\mu$ F	8.2 k $\Omega$	12 k $\Omega$	30 k $\Omega$
-2 V/V	11 Hz	30 kHz	47 pF	470 pF	180 pF	1 $\mu$ F	15 k $\Omega$	30 k $\Omega$	43 k $\Omega$
-3.33 V/V	12 Hz	30 kHz	33 pF	470 pF	180 pF	1 $\mu$ F	13 k $\Omega$	43 k $\Omega$	43 k $\Omega$
-10 V/V	15 Hz	30 kHz	22 pF	1 nF	330 pF	2.2 $\mu$ F	4.7 k $\Omega$	47k $\Omega$	27 k $\Omega$

The resistor values must be low value to achieve low noise, but must be of high enough value to obtain a small size ac-coupling capacitor. With the proposed values of 15 k $\Omega$ , 30 k $\Omega$ , and 43 k $\Omega$ , a dynamic range (DYR) of 102 dB can be achieved with a small 2.2- $\mu$ F input ac-coupling capacitor.

The MFB filter structure demands an operational amplifier that is unity-gain stable at high frequencies; this requirement can be relaxed by adding the  $C_x$  capacitor value to be equal to  $C_1$ . The DRV632 is unity-gain stable, but stray capacitance and inductance from the PCB layout can affect the phase margin. Therefore, TI recommends adding  $C_x$ .

#### 4.4 Using the DRV632 as a Differential Input, Second-Order Low-Pass Filter

The single-ended input, second-order filter described in Section 4.3 can easily be extended to have a differential input, as shown in Figure 6.

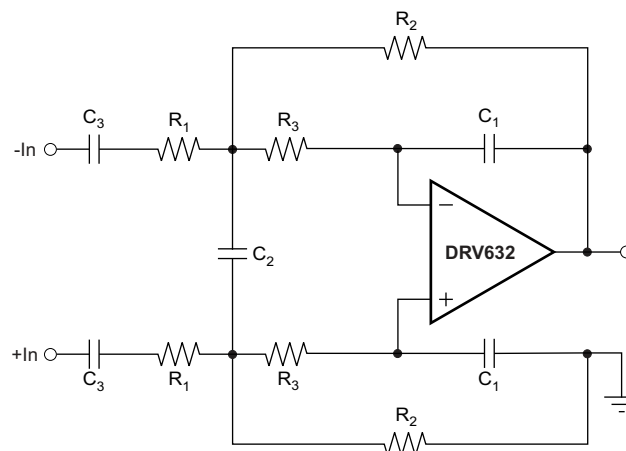


Figure 6. Differential Input, Second-Order Active Low-Pass Filter

$C_2$  can be split into separate capacitors to ground with the double value; this technique increases the common-mode filtering. Another capacitor,  $C_x$ , set equal to  $C_1$  can continue to be used from the negative input to ground to limit the high-frequency gain to 2.

As with the single-ended input, the differential input filter component values can be calculated with the help of the TI [FilterPro](#) active filter design program available on the TI Web site.

## 5 Layout Recommendations

### 5.1 GND Connections

The GND pins of the DRV632 must be routed separately back to the decoupling capacitor in order to facilitate proper device operation. If the GND pins are connected directly to each other, the device functions without risk of failure, but noise and THD performance can be reduced.

On the DRV632EVM, a star ground routing pattern is used; the star point is located directly below the DRV632 device itself.

## 6 Related Documentation from Texas Instruments

The following related documents are available through the Texas Instruments Web site at <http://www.ti.com>. These documents have detailed descriptions of the integrated circuits used in the design of the DRV632EVM.

**Table 4. Related Documentation**

Part Number	Literature Number
DRV632	SLOS681 data sheet

## 7 Design Documentation

### 7.1 Schematics

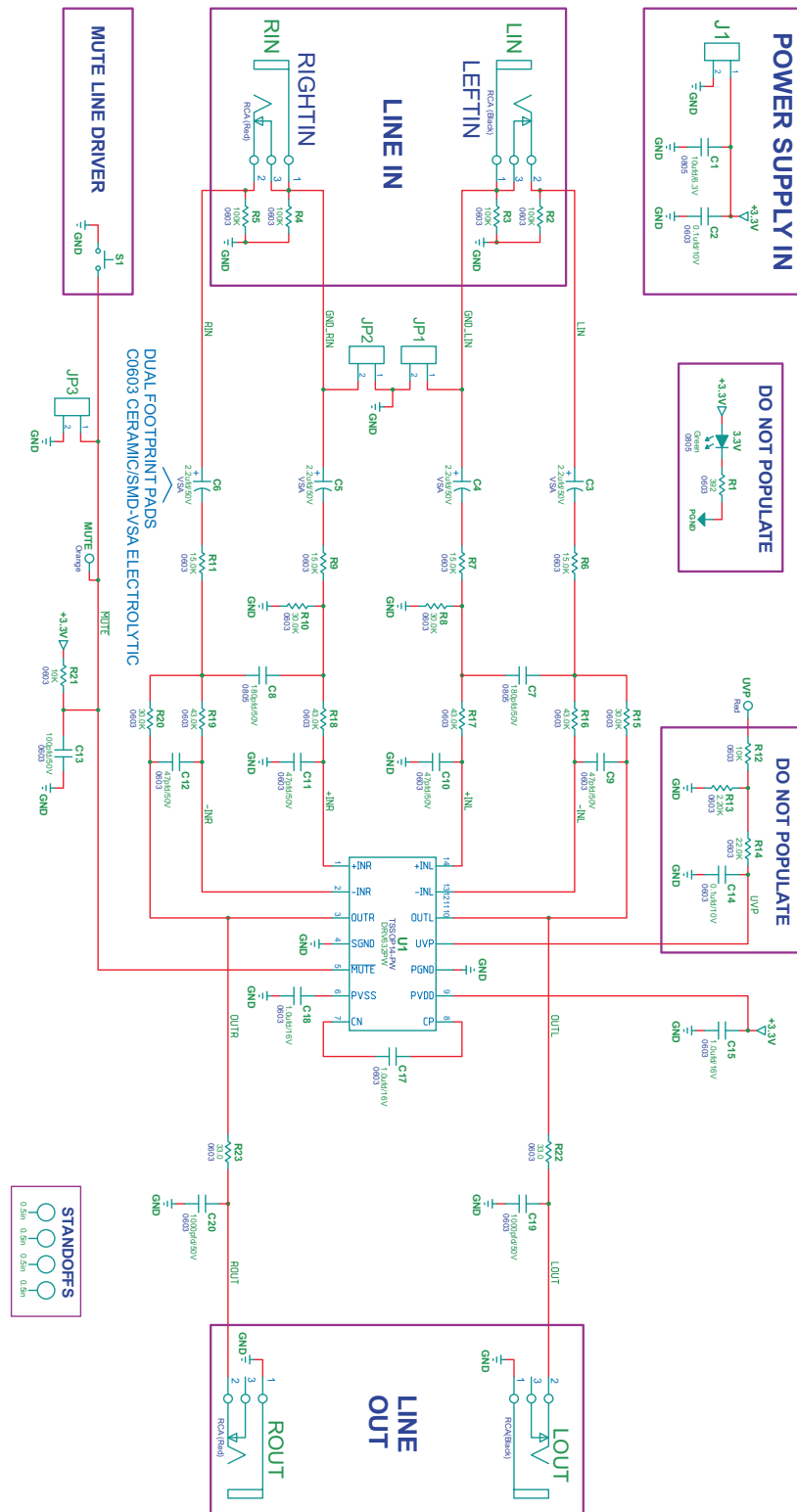


Figure 7. DRV632EVM Schematic



## 7.2 Bill of Materials

The bill of materials (BOM) for the DRV632EVM is listed in [Table 5](#).

**Table 5. Bill of Materials**

Qty	Part Reference	Description	Manufacturer	Mfr Part No
2	C19, C20	CAP SMD0603 CERM 1000PF 50V 5% COG ROHS	TDK	C1608C0G1H102J
4	C9–C12	CAP SMD0603 CERM 47PFD 50V 5% COG ROHS	MURATA	GRM1885C1H470JA01D
1	C13	CAP SMD0603 CERM 100PFD 50V 5% COG ROHS	MURATA	GRM1885C1H101JA01D
2	C7, C8	CAP SMD0805 CERM 180PFD 50V 5% NPO ROHS	YAGEO	CC0805JRN09BN181
1	C2	CAP SMD0603 CERM 0.1UFD 10V 5% X7R ROHS	KEMET	C0603C104K8RACTU
3	C15, C17, C18	CAP ALUM-ELECT SMD-VSA 10UFD 16V 20% ROHS	TDK	C1608X7R1C105K
4	C3,C4,C5,C6	CAP ALUM-ELECT SMD-VSA 2.2uF 50V 20% ROHS	PANASONIC	EEE-1HS2R2SR
1	C1	CAP SMD0805 CERM 10UFD 6.3V X7R 10% ROHS	AVX	08056C106KAT2A
2	R22, R23	RESISTOR SMD0603 33 Ω 1% 1/10W ROHS	PANASONIC	ERJ-3EKF33R0V
1	R21	RESISTOR SMD0603 10K 5% 1/10W ROHS	PANASONIC	ERJ-3GEYJ103V
4	R6, R7, R9, R11	RESISTOR SMD0603 15.0KΩ 1% 1/10W ROHS	STACKPOLE ELECTRONICS	RMCF0603FT15K0
4	R16–R19	RESISTOR SDM0603 20.0KΩ 1% THICK FILM 1/16W ROHS	YAGEO	RC0603FR-0743KL
4	R8, R10, R15, R20	RESISTOR SMD0603 THICK FILM 30.0K 1% 1/10W ROHS	YAGEO	RC0603FR-0730KL
4	R2–R5	RESISTOR SMD0603 100KΩ 5% 1/10W ROHS	STACKPOLE ELECTRONICS	RMCF0603JT100K
4	J1 ,JP1–JP3	HEADER THRU MALE 2 PIN 100LS GOLD ROHS	SULLINS	PBC02SAAN
2	LIN, LOU	JACK, RCA 3-PIN PCB-RA BLACK ROHS	SWITCHCRAFT	PJ1RAN1X1U01X
2	RIN ,ROUT	JACK, RCA 3-PIN PCB-RA RED ROHS	SWITCHCRAFT	PJ1RAN1X1U03X
1	UVP	PC TESTPOINT, RED, ROHS	KEYSTONE ELECTRONICS	5000
1	MUTE	PC TESTPOINT, ORANGE, ROHS	KEYSTONE ELECTRONICS	5003
1	S1	SWITCH, MOM, 160G SMT 4X3MM ROHS	E-SWITCH	TL1015AF160QG
3	JP1–JP3	SHUNT, BLACK AU FLASH 0.100LS	SULLINS	SPC02SYAN
4	N/A	4-40 SCREW, STEEL 0.250 IN	BUILDING FASTENERS	PMS 440 0025 PH
4	N/A	STANDOF ,4-40 0.5IN 3/16IN DIA ALUM RND F-F	KEYSTONE ELECTRONICS	2027

### 7.3 PCB Layers

Gerber files are available for download at the DRV632EVM product folder page on the TI Web site. Component placement and board layout are illustrated in [Figure 8](#), [Figure 9](#), and [Figure 10](#), respectively.

**NOTE:** Board layouts are not to scale. These figures are intended to show how the board is laid out; they are not intended to be used for manufacturing DRV632EVM PCBs.

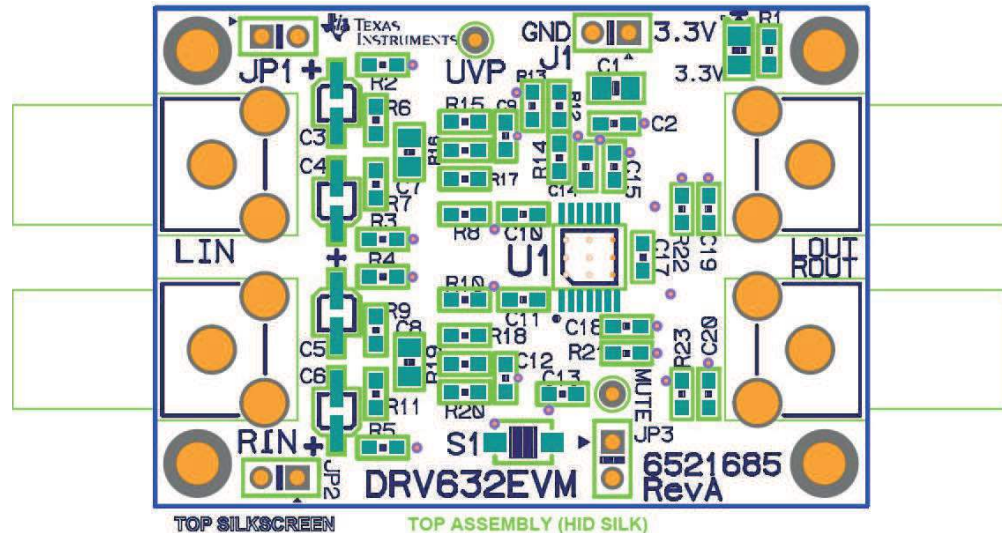


Figure 8. DRV632EVM PCB Component Placement

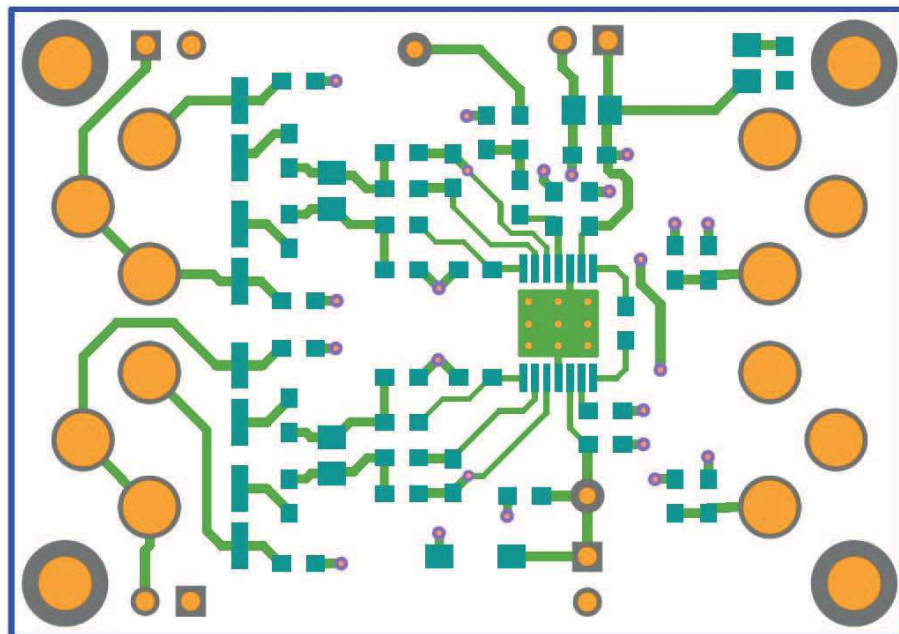


Figure 9. DRV632EVM PCB Top Layer

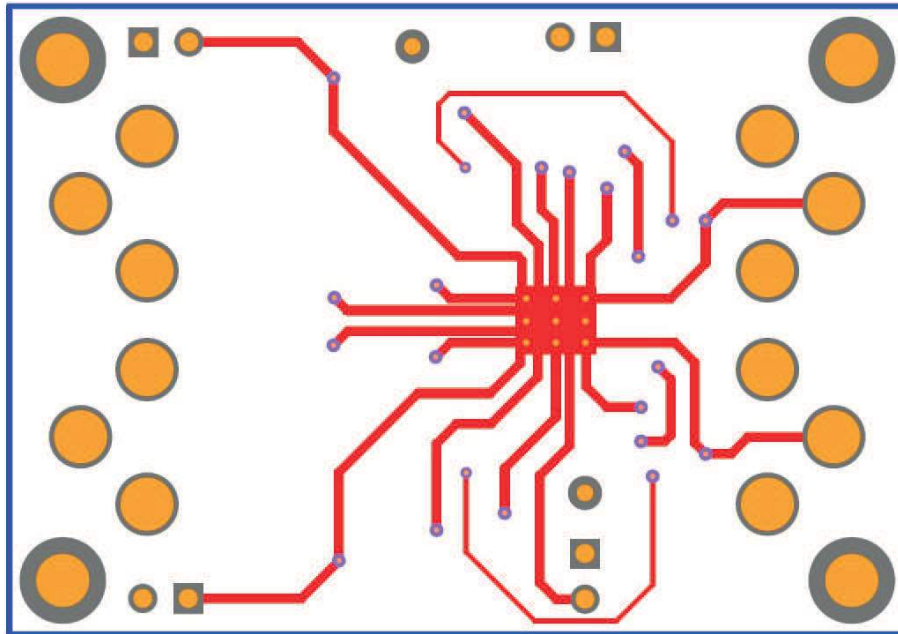


Figure 10. DRV632EVM PCB Bottom Layer

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## EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 0 V to 3 V and the output voltage range of 0 V to 3.3 V .

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than 60°C. The EVM is designed to operate properly with certain components above 40°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>	Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>	Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>	Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>	Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>	Energy	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>	Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>	Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>	Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>	Space, Avionics & Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>	Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
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