*User's Guide*
*SBOU088–August 2010*

# *Multi-Cal-Test PCA Evaluation Module*

This user's guide describes the characteristics, operation, and the use of the Multi-Cal-Test PCA evaluation module (EVM). It covers all pertinent areas involved to properly use this printed circuit assembly (PCA). The document includes the physical printed circuit board (PCB) layout, schematic diagrams, and circuit descriptions.

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# 1 Overview

The Multi-Cal-Test PCA Evaluation Module is a set of EVMs that is used to calibrate multiple PGA308 sensor modules. The PGA308 is a programmable analog sensor signal conditioner. All components in the Multi-Cal-Test can be expanded to calibrate up to 64 sensors simultaneously. For a more detailed description of the PGA308, refer to the product data sheet (SBOS440) available from the Texas Instruments web site at http://www.ti.com. Additional support documents are listed in the section of this guide entitled *Related Documentation from Texas Instruments* .

The Multi-Cal-Test PCA Evaluation Module consists of a single PCB. The complete Multi-Cal-System contains a series of PCAs, and can be expanded to meet your specific system requirements.

Throughout this document, the abbreviation *EVM* and the term *evaluation module* are synonymous with the Multi-Cal-Test PCA Evaluation Module.

## *1.1 Multi-Cal-Test PCA Hardware Options*

Figure 1 shows the hardware included with the Multi-Cal-Test PCA. Contact the factory if any component is missing.

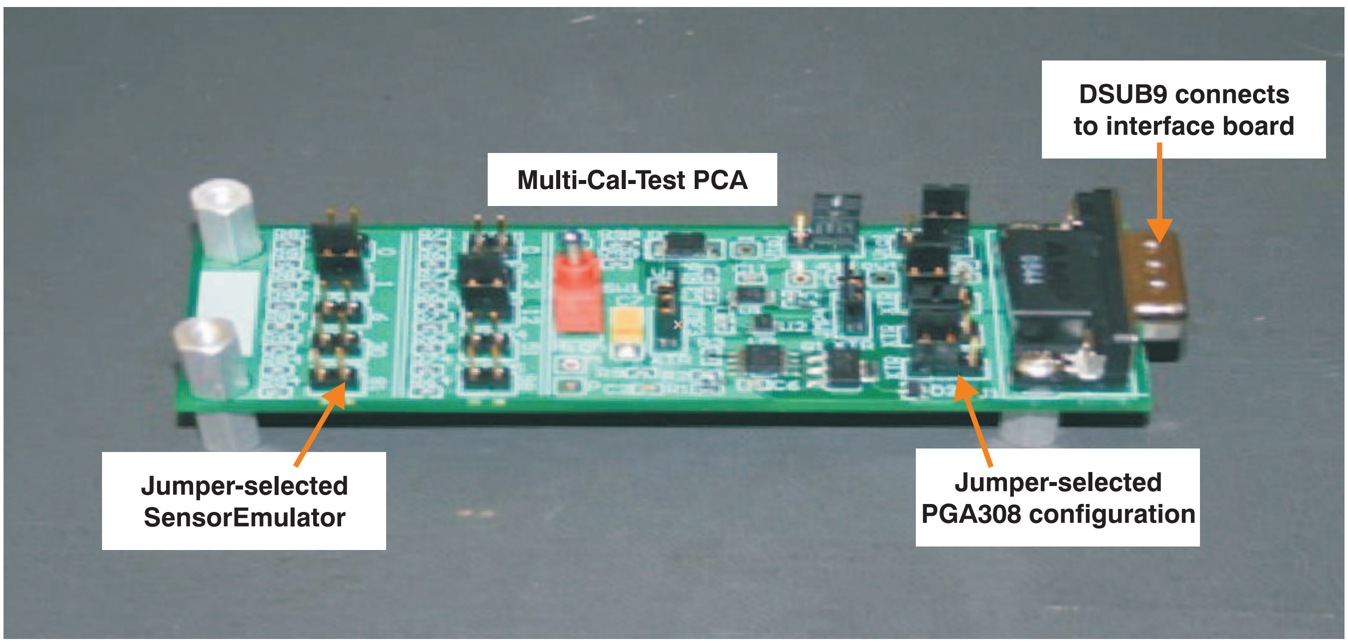


**Figure 1. Hardware Included with the Multi-Cal-Test PCA EVM Kit**

The Multi-Cal-Test PCA has several purposes. First, the test board can be used to learn how to use the Multi-Cal-System EVM before connecting a real sensor. It can be also used as the system hardware verification. In other words, you can test the system functionality before connecting your actual sensors to ensure that the system works properly.

Another reason for the test board is to demonstrate the accuracy capability of a given system. The Multi-Cal-Test PCA has an onboard signal source that emulates the sensor. This sensor emulator is very stable (low drift). Many real-world sensors typically have temperature drift, non-repeatability, and hysteresis issues. Because the Multi-Cal-Test PCA does not have these issues, it effectively demonstrates the system capability. As a result, for example, if you are able to achieve 0.05% accuracy with the Multi-Cal-Test PCA and you cannot achieve this level of accuracy with an actual sensor, you should investigate the repeatability of your sensor. Note that you should select the sensor emulator range to be as close as possible to your real-world sensor.

## 1.2 Related Documentation from Texas Instruments

The following document provides information regarding Texas Instruments integrated circuits used in the assembly of the Multi-Cal-Test PCA EVM. This user's guide is available from the TI website under literature number SBOU088. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions may be available from the TI web site at http://www.ti.com/, or call the Texas Instruments Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number.

| Document | Literature Number |
|---|---|
| PGA308 Product Data Sheet | SBOS440 |
| XTR115 Product Data Sheet | SBOS124A |
| USB DAQ Platform User's Guide | SBOU056 |
| Multi-Cal-System EVM User's Guide | SBOU087 |
| Multi-Cal-Master EVM User's Guide | SBOU089 |
| Multi-Cal-Slave EVM User's Guide | SBOU094 |
| Multi-Cal-Cable User's Guide | SBOU092 |
| Multi-Cal-Interface User's Guide | SBOU093 |

## 1.3 Information About Cautions and Warnings

This document contains caution statements.

**CAUTION**

This is an example of a caution statement. A caution statement describes a situation that could potentially damage your software or equipment.

The information in a caution or a warning is provided for your protection. Please read each caution carefully.

## 1.4 Applications Questions

If you have questions about this or other Texas Instruments evaluation modules, post a question in the *Amplifiers* forum at http://e2e.ti.com. Include in the subject heading the product in which you are interested.

# 2 Multi-Cal-Test PCA Setup

## 2.1 Electrostatic Discharge Warning

Many of the components on the Multi-Cal-Test PCA 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.

**CAUTION**

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

## 2.2 Multi-Cal-Test PCA Configuration

The Multi-Cal-Test PCA has several different configuration options, including current output mode, three-wire mode, and four-wire mode.

Figure 2 shows the test board configured for the current output mode. Note that the SensorEmulator jumpers can be set in any position according to the sensor output voltage (that is, the PGA308 input voltage) desired. In this example, the sensor output at low stimulus (that is, low pressure) is set to 1mV, and the output at high stimulus is 3mV.

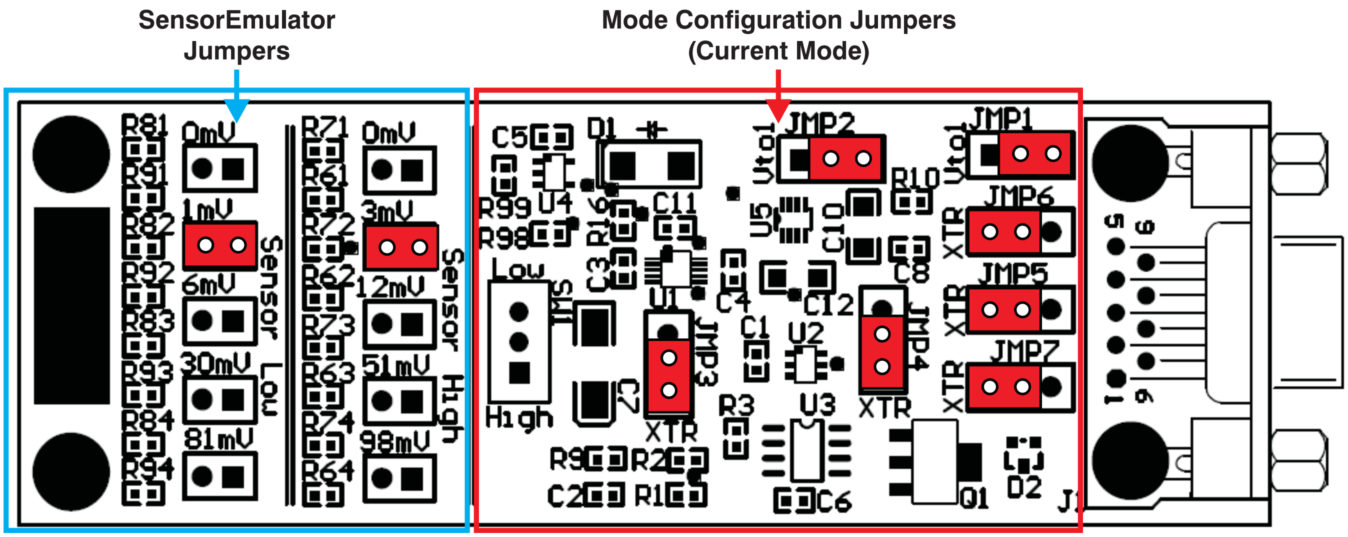


**Figure 2. Jumper Settings for Current Output Mode**

Figure 3 shows the test board configured for the voltage output four-wire mode. Again, note that the SensorEmulator jumpers can be set in any position according to the sensor output voltage (that is, the PGA308 input voltage) desired. In this example, we have set the sensor output at low stimulus (that is, low pressure) to 1mV, and the output at high stimulus to 3mV.

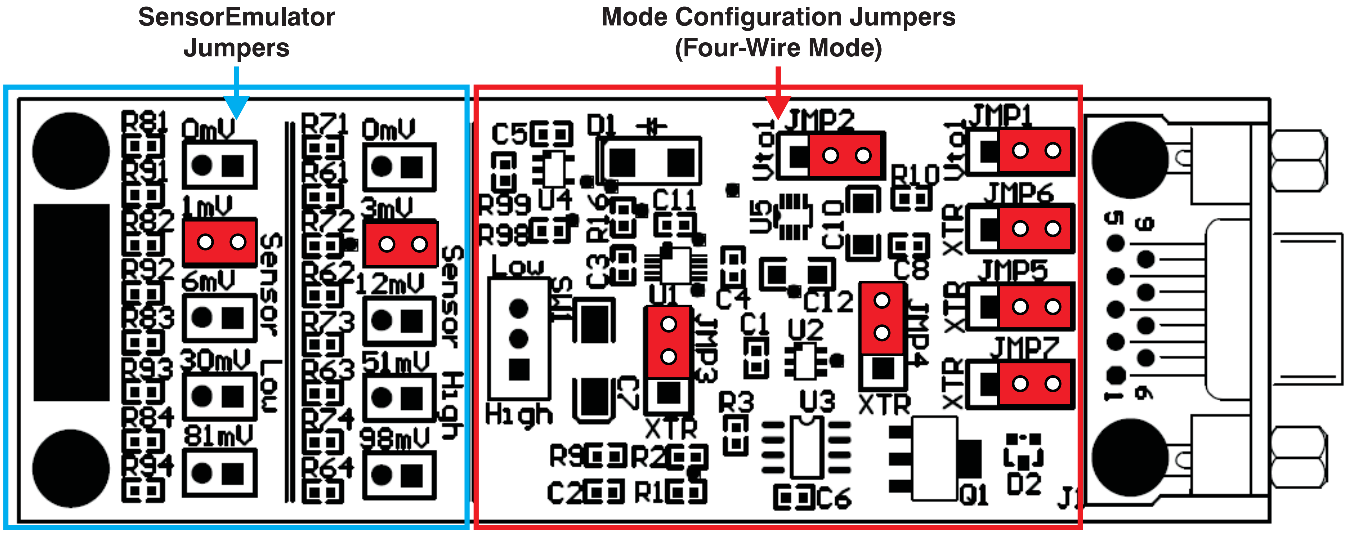


**Figure 3. Jumper Setting for Voltage Output Four-Wire Mode**

Figure 4 illustrates the test board configured for the voltage output three-wire mode. In three-wire mode, the communications line is connected to the output voltage pin ($V_{OUT}$). As with the other configurations, note that the SensorEmulator jumpers can be set in any position according to the sensor output voltage (that is, the PGA308 input voltage) desired. In this example, we have set the sensor output at low stimulus (that is, at low pressure) to 1mV, and the output at high stimulus to 3mV.

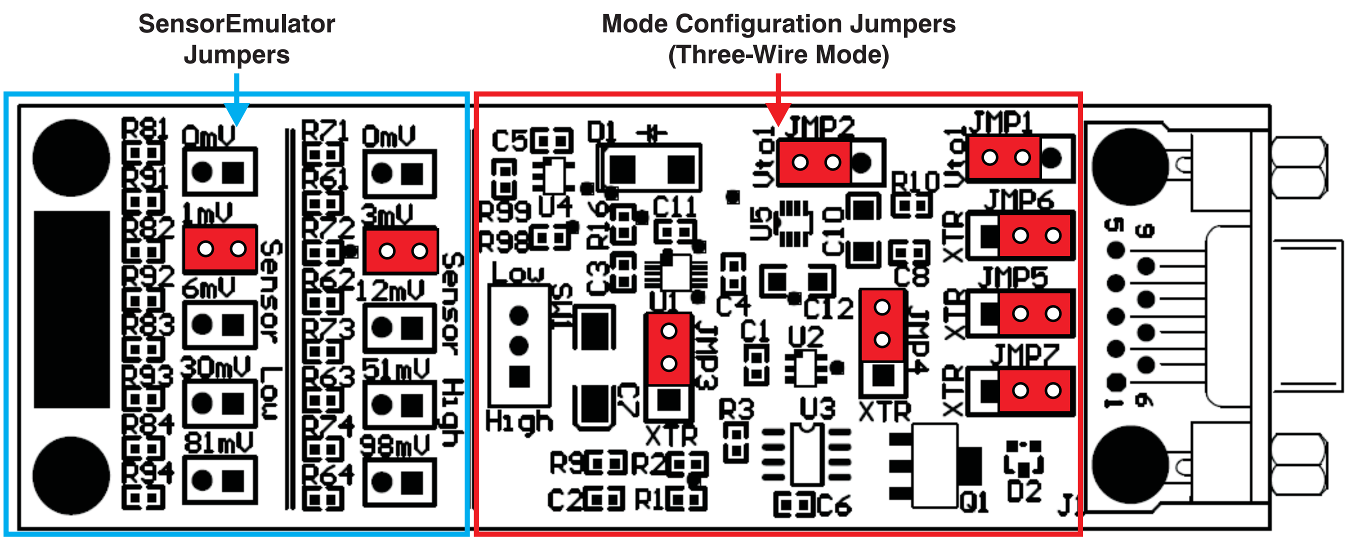


**Figure 4. Jumper Setting for Voltage Output Three-Wire Mode**

Table 1 and Table 2 show how to set the jumpers on the Multi-Cal-Test-PCA. The test board allows all for the operation of the three modes of the PGA308 device. The test board also has a jumper-selected SensorEmulator. The SensorEmulator creates an input signal for the PGA308 so that you can perform an example calibration.

**Table 1. Mode Jumpers on the Multi-Cal-Test PCA**

| Mode | Jumper Positions |
|---|---|
| Current Output | JMP1 = Position without label<br>JMP2 = Position without label<br>JMP3 = XTR<br>JMP4 = XTR<br>JMP5 = XTR<br>JMP6 = XTR<br>JMP7 = XTR |
| 4-Wire Voltage Output | JMP1 = Position without label<br>JMP2 = Position without label<br>JMP3 = Position without label<br>JMP4 = Position without label<br>JMP5 = Position without label<br>JMP6 = Position without label<br>JMP7 = Position without label |
| 3-Wire Voltage Output | JMP1 = Vto1<br>JMP2 = Vto1<br>JMP3 = Position without label<br>JMP4 = Position without label<br>JMP5 = Position without label<br>JMP6 = Position without label<br>JMP7 = Position without label |

**Table 2. Mode Jumpers on the Multi-Cal-Test-PCA**

| Jumper Banks | Function |
|---|---|
| **Sensor High:**<br>• 0mV<br>• 3mV<br>• 12mV<br>• 51mV<br>• 98mV | Place the jumper shorting unit on one of these five positions. This jumperbank will determine the sensor emulator output when the switch (SW1) is in the HIGH position. The output of the sensor emulator is the input to the PGA308. For example: When the shorting unit is in the “HIGH2” position, the PGA308 input signal is 3mV. |
| **Sensor Low:**<br>• 0mV<br>• 1mV<br>• 6mV<br>• 30mV<br>• 81mV | Place the jumper shorting unit on one of these five positions. This jumper bank will determine the sensor emulator output when the switch (SW1) is in the LOW position. The output of the sensor emulator is the input to the PGA308. For example: When the shorting unit is in the “LOW3” position, the PGA308 input signal is 6mV. |

# 3 Theory of Operation for Multi-Cal-Test PCA Board Hardware

This section discusses the operation of the Multi-Cal-Test PCA EVM hardware.

## 3.1 Current Mode Circuit

Figure 5 shows the voltage-to-current mode section. The jumper selections shown configure the output for current output mode. Table 3 summarizes the function of each component in the circuit.

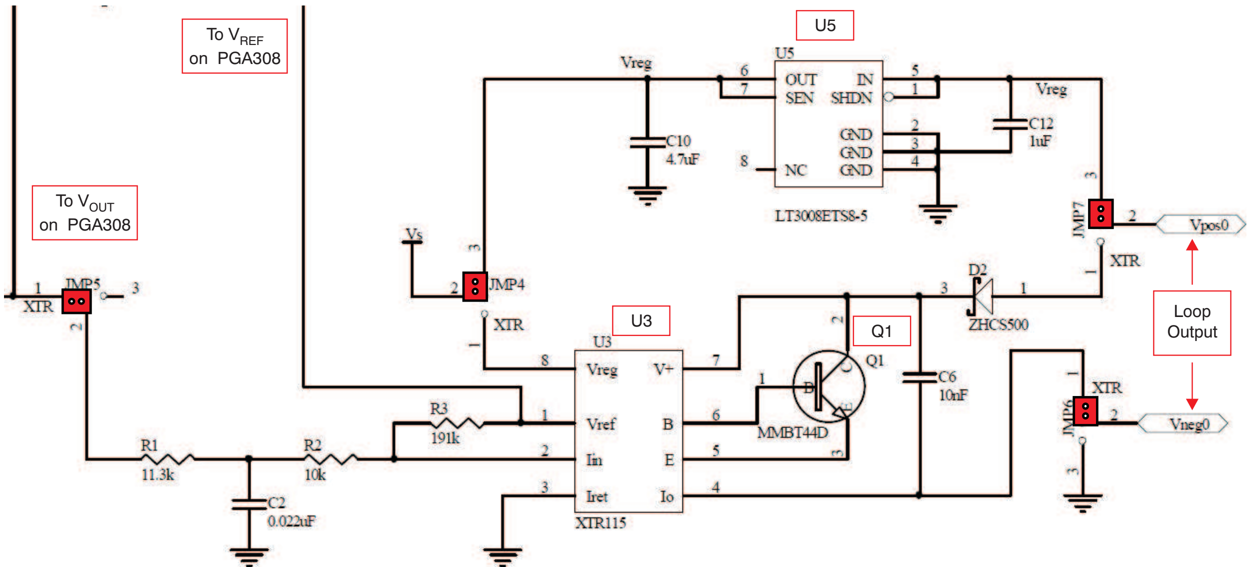


**Figure 5. Current Mode Circuit (Configured for Current Mode)**

**Table 3. Function of Components in the Voltage-to-Current Section (in Current Mode)**

| Component | Description |
|---|---|
| U5 | U5 is a regulator used for voltage mode. The input of U5 can range from 5V to 45V. The output is 5V. The jumpers are set in Figure 5 for current mode, so U5 is disconnected. |
| U3 | U3 converts the voltage output of the PGA308 to a 4mA to 20mA current output. In voltage mode, this circuit is disconnected. |
| Q1 | The transistor Q1 dissipates the majority of the current loop power, so that U3 does not have excessive self heating. In voltage mode this circuit is disconnected. |
| JMP4 | JMP4 connects the $V_{REG}$ to the PGA308 power supply. JMP7 connects the power to V+ on the XTR115. In Figure 5, U5 is disconnected. |
| JMP5 | JMP5 connects the voltage output from the PGA308 to the input of U3. In voltage, the jumper is set so that U3 is disconnected. |
| JMP6 | JMP6 connects the XTR115 $I_{OUT}$ output to the negative supply. |
| JMP7 | JMP7 connects the power to V+ on the XTR115. |
| C6 | Decoupling/filtering for the output of the current loop. |
| R1, R2, R3 | These resistors scale the voltage to current function. See the XTR115 data sheet for information on how to scale these resistors. |
| C2 | R1 and C2 form a low-pass filter for additional filtering. |

### 3.2 Reference Configuration Circuit

The power supply and reference connections are illustrated in Figure 6. The jumper selections shown here configure the device for current output mode. See Table 4 for a complete description of each component in the circuit.

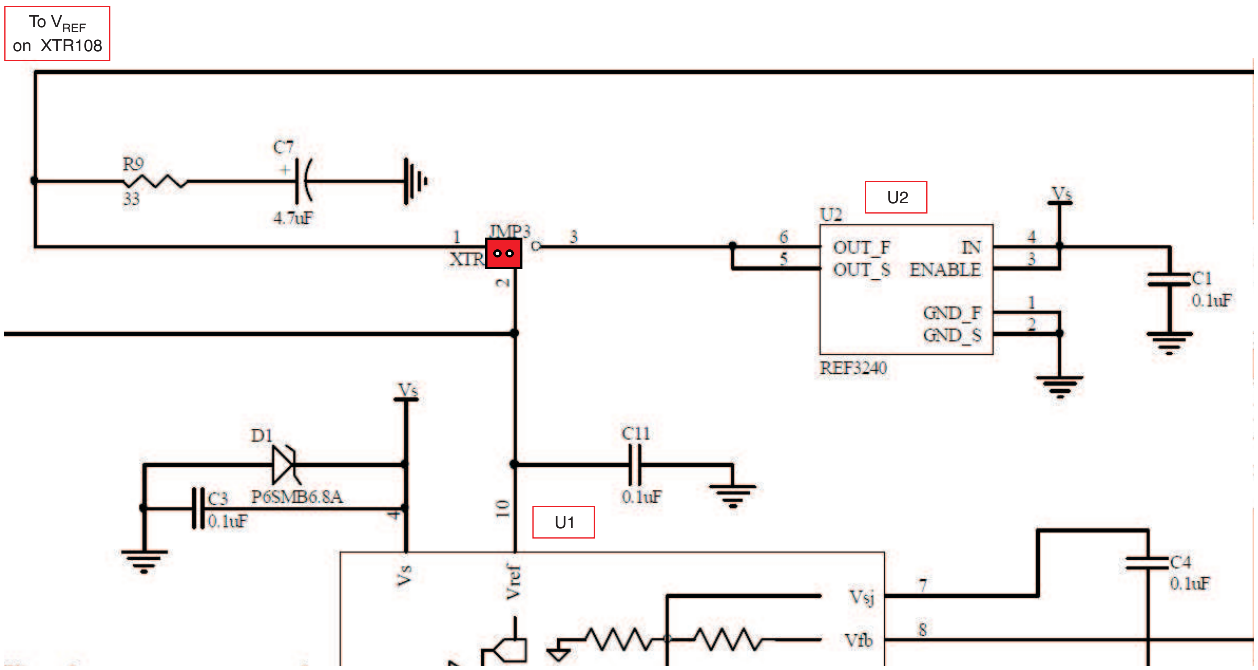


**Figure 6. Reference Circuit (Configured for Current Mode)**

**Table 4. Reference Circuit Description (Configured for Voltage Mode)**

| Component | Description |
|---|---|
| U1 | This component is the PGA308. Figure 6 focuses on the $V_{REF}$ and $V_S$ pins. |
| U2 | Voltage reference device. This device is only used in voltage mode. It provides a 4.096V reference. In Figure 6, U2 is disconnected by JMP3. |
| C1 | Decoupling for U2. |
| JMP3 | This jumper connects the reference pin of the PGA308 to either U2 (voltage mode) or to U3 current mode. As shown here, the reference is connected to U3. |
| D1 | D1 is a transient voltage suppressor. This component protects the device from electrical overvoltage conditions. |
| C3 | Decoupling for the PGA308. |
| C11 | Filtering for the $V_{REF}$ pin. |
| R9, C7 | These components form a snubbing network for the XTR116 regulator output to ensure stability when connecting to a capacitance (such as 0.1µF C11). |

### 3.3 SensorEmulator/Input Circuit

Figure 7 shows the SensorEmulator connection to the PCA308 input. The SensorEmulator generates dc voltages that are comparable to typical bridge sensor outputs. The switch allows you to select between two different sensor output levels (Sensor High or Sensor Low). The sensor high or sensor low level is selected by two different banks of jumpers. The jumpers select different voltage dividers that set the input signal.

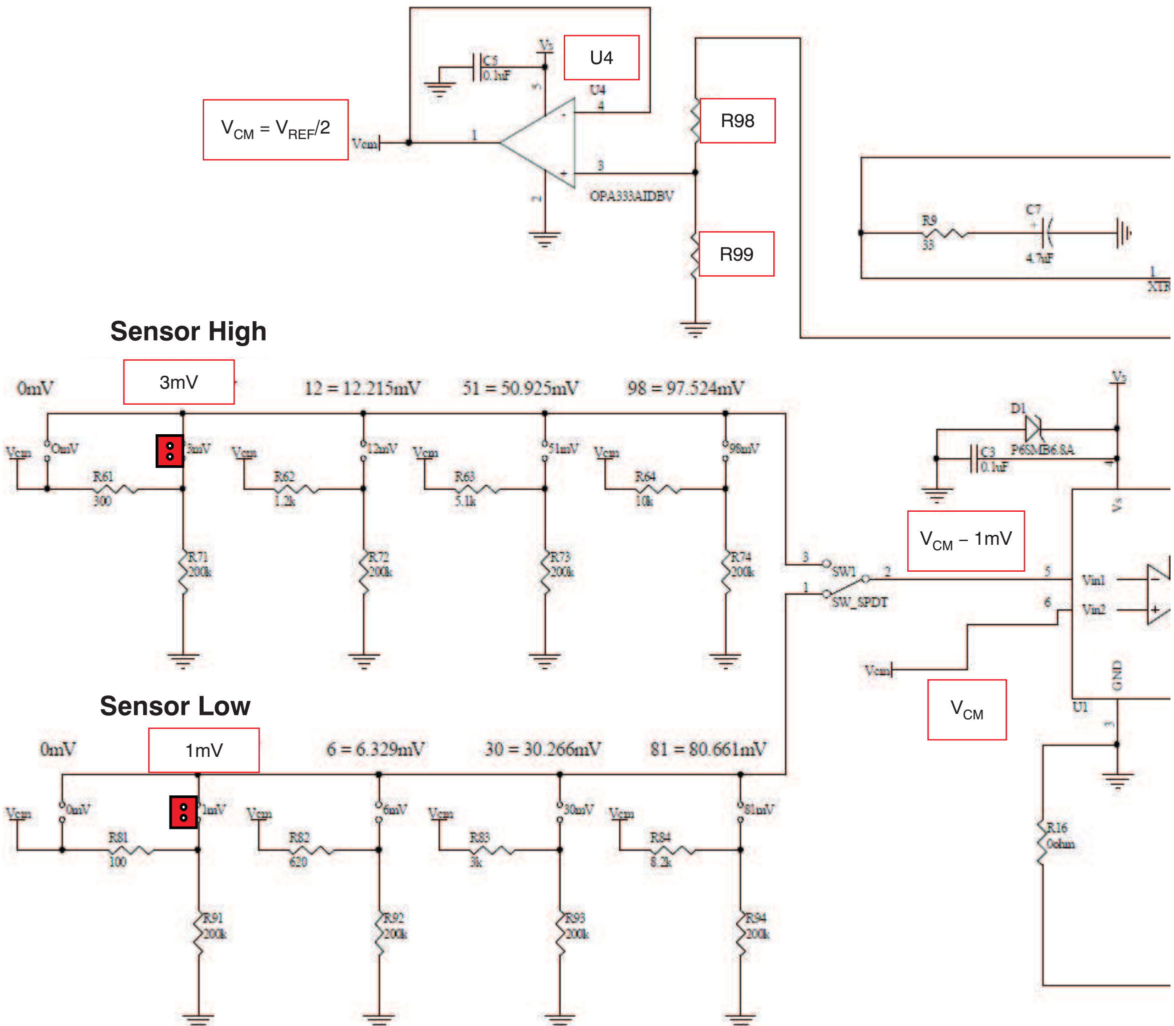


**Figure 7. SensorEmulator Section (PGA308 Input)**

In the circuit, the *Sensor Low* jumper is selected for 1mV, and the *Sensor High* jumper is selected for 3mV. Changing the position of SW1 changes the differential input of the PGA308 from 1mV to 3mV. This configuration simulates a sensor with a 1mV offset and a 3mV full-scale range. Note that the resistors in the sensor high and sensor low bank were selected to have low temperature coefficients (that is, 20ppm/°C or less).

The common-mode voltage is one-half of the reverence voltage ($V_{REF}/2$); this voltage is developed with the R98, R99 voltage divider. Amplifier U4 buffers the output of the voltage divider. The common-mode signal is applied to one input of the PGA308 ($V_{IN}2$, pin 6). The other input ($V_{IN}1$, pin 5) is from the voltage divider banks. The voltage divider banks output is slightly lower then the common-mode voltage. The difference between $V_{IN}1$ and $V_{IN}2$ is the differential input signal.

### 3.4 PGA308 Output

The connection to the output and communications pin on the PGA308 is illustrated in Figure 8. The jumper selection shown here is for current output modules. Table 5 summarizes the purpose of each component.

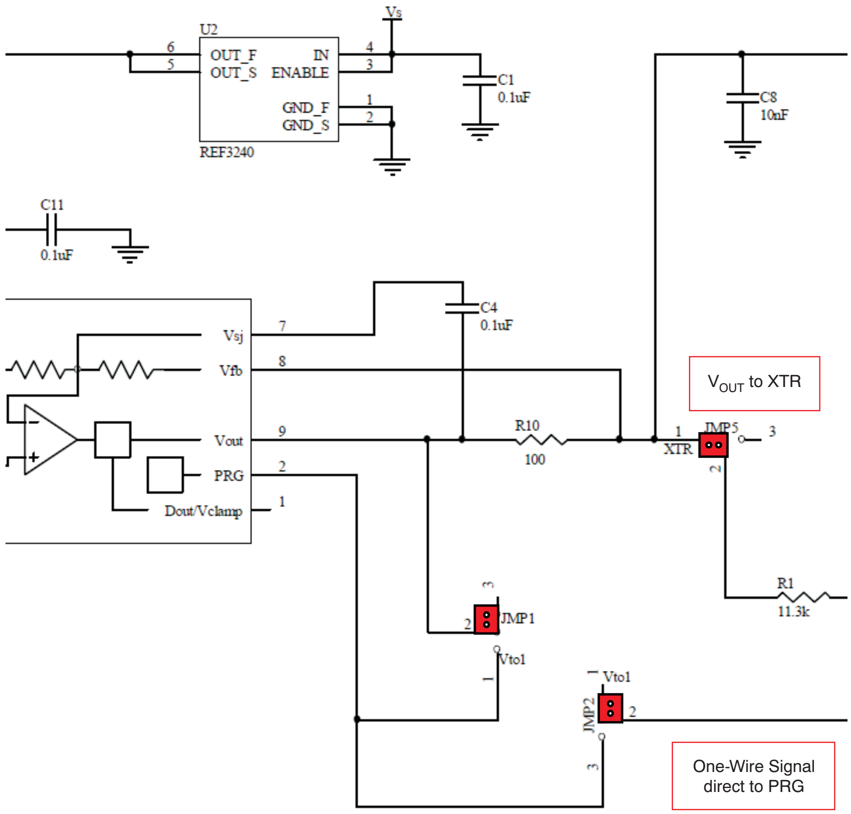


**Figure 8. PGA308 Output (Configured for Current Mode)**

**Table 5. Function of PGA308 Output (Configured for Current Mode)**

| Component | |
|---|---|
| U1 | This component is the PGA308. Figure 8 focuses on the output and communications connections. |
| R10 | R10 is used for overvoltage protection on $V_{OUT}$. |
| C4 | C4 limits the output bandwidth. Lower bandwidth decreases noise. |
| C8 | C8 is an RFI / EMI filter. |
| JMP1 | JMP1 connects or disconnects $V_{OUT}$ to the one-wire communications line. Three-wire modules connect $V_{OUT}$ and a one-wire signal. Four-wire modules (or current module) have the output and one-wire signals separated. As shown here, it is connected as a four-wire module (or current module). |
| JMP2 | Connects or disconnects the one-wire communications line to the PGA308. |
| | Three-wire modules connect one-wire signal via the $V_{OUT}$ connection. Four=wire modules (or current module) have the output and One-Wire signals separated. As shown it is connected as a four wire module (or current module). |
| JMP5 | Connects or disconnects the voltage output to the XTR115. It is connected fo rcurrent output modules, and disconnected for voltage output modules. As shown here, it is connected as a current module. |

## 4 Bill of Materials

Table 6 shows the parts list for the Multi-Cal-Test PCA EVM.

**Table 6. Multi-Cal-Test PCA EVM Parts List**

| Qty | Ref Des | Description | Vendor | Part Number |
|---|---|---|---|---|
| 1 | U1 | IC, Prog Sensor Signal Conditioner 10-MSOP | Texas Instruments | PGA308AIDGST |
| 1 | U2 | IC, LDO volt ref 4.096V SOT23-6 | Texas Instruments | REF3240AIDBVT |
| 1 | U3 | IC, 4 to 20mA transmitter 8-SOIC | Texas Instruments | XTR116UA |
| 1 | U4 | IC, Op amp CHOP R-R 350KHZ SOT23-5 | Texas Instruments | OPA333AIDBVT |
| 1 | U5 | IC, Regulator, LDO 5.0V 20MA TSOT23-8 | Linear Technology | LT3008ETS8-5#TRMPBF |
| 1 | J1 | Connector, D-SUB plug R/A 9POS 30GOLD | Tyco Electronics | 5747250-4 |
| 1 | D2 | SOT-23 Schottky Diode, 500mA, 40V | Zetex Semiconductors | ZHCS500 |
| 1 | D1 | Diode, TVS 6.0V 400W UNI 5% SMA | Littelfuse Inc | SMAJ6.0A |
| 1 | Q1 | IC, Trans, NPN SS GP 1.5A SOT223-4 | Fairchild Semiconductor | BCP55 |
| 1 | R1 | Resistor, 11.3kΩ 1/16W .5% 0603 SMD | Susumu Co Ltd | RR0816P-1132-D-06C |
| 1 | R3 | Resistor, 191kΩ 1/10W 1% 0603 SMD | Yageo Corporation | ERJ-3EKF1913V |
| 1 | R9 | Resistor, 33.0Ω 1/10W 1% 0603 SMD | Yageo Corporation | RC0603FR-0733RL |
| 1 | R16 | Resistor, 0.0Ω 1/10W 5% 0603 SMD | Yageo | RC0603JR-070RL |
| 1 | R61 | Resistor, 300Ω 1/16W .5% 0603 SMD | Susumu Co Ltd | RR0816P-301-D |
| 1 | R62 | Resistor, 1.2kΩ 1/16W .5% 0603 SMD | Susumu Co Ltd | RR0816P-122-D |
| 1 | R63 | Resistor, 5.1kΩ 1/16W .5% 0603 SMD | Susumu Co Ltd | RR0816P-512-D |
| 2 | R64, R2 | Resistor, 10.0kΩ 1/16W .5% 0603 SMD | Susumu Co Ltd | RR0816P-103-D |
| 2 | R81, R10 | Resistor, 100Ω 1/16W .5% 0603 SMD | Susumu Co Ltd | RR0816P-101-D |
| 1 | R82 | Resistor, 620Ω 1/16W .5% 0603 SMD | Susumu Co Ltd | RR0816P-621-D |
| 1 | R83 | Resistor, 3.0kΩ 1/16W .5% 0603 SMD | Susumu Co Ltd | RR0816P-302-D |
| 1 | R84 | Resistor, 8.2kΩ 1/16W .5% 0603 SMD | Susumu Co Ltd | RR0816P-822-D |
| 10 | R71, R72, R73, R74, R91, R92, R93, R94, R98, R99 | Resistor, 200K OHM 1/16W .5% 0603 SMD | Susumu Co Ltd | RR0816P-204-D |
| 1 | C7 | Capacitor, tant, 4.7µF 25V 10% SMD 6032-28 (EIA) | Kemet | T491C475K025AT |
| 2 | C6, C8 | Capacitor, 10000pF 50V ceramic X7R 0603 | Kemet | C0603C103K5RACTU |
| 5 | C1, C3, C4, C5, C11 | Capacitor, .10µF 25V ceramic Y5V 0603 | KEMET | C0603C104M3VACTU |
| | C10 | Capacitor, ceramic 4.7µF 16V X5R 20% 1206 | TDK Corporation | C3216X5R1C475M/1.60 |
| | C12 | Capacitor, ceramic 1.0µF 50V X7R 1206 | Taiyo Yuden | UMK316B7105KL-T |
| 1 | C2 | Capacitor, .022µF 50V ceramic X7R 0603 | Kemet | C0603C223K5RACTU |
| 1 | S1 | Switch, toggle SPDT .4VA PC mnt | E-Switch | 200AWMSP1T1A1M2RE |
| 5 | HIGH1, HIGH2, HIGH3, HIGH4, HIGH5 | Connector, header 2-pos .100" Sgl Gold | Samtec Inc | SW-102-07-G-S |
| 5 | LOW1, LOW2, LOW3, LOW4, LOW5 | Connector, header 2-pos .100" Sgl Gold | Samtec Inc | SW-102-07-G-S |
| 7 | JMP1, JMP2, JMP3, JMP4, JMP5, JMP6, JMP7 | Connector, header 3-pos .100" Sgl Gold | Samtec Inc | SW-103-07-G-S |
| 0 | n, p, one, Vout, Vs, Vref, GND | Omit | — | — |
| 9 | Jumper shorting units for jumpers | Jumper Shorting Units | AMP/Tyco Electronics | 881545-2 |
| 2 | None | SI 4-40THR ALUM .500" Male/Female | Keystone Electronics | 8401 |
| 4 | None | Standoff hex 4-40THR ALUM .500" Female/Female | Keystone Electronics | 2203 |

**Table 6. Multi-Cal-Test PCA EVM Parts List (continued)**

| Qty | Ref Des | Description | Vendor | Part Number |
|---|---|---|---|---|
| 2 | None | Screw, machine Phillips 4-40X1/2 SS | Building Fasteners | PMSSS 440 0050 PH |

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## EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 5.7V to 9V and the output voltage range of 0V to 5V.

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 +25°C. The EVM is designed to operate properly with certain components above +25°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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