



APPLICATION NOTE 3972

## MAX1452/MAX1455 FAQs

*Abstract: The MAX1452/MAX1455 are high-performance signal conditioners with analog output that have been widely accepted and used in a variety of industrial and automotive applications. This application note presents and answers the questions frequently asked while designing-in these signal conditioners.*

**Note: In this document, the term *signal conditioner* refers to the MAX1452 and MAX1455. All questions, answers, and comments below apply equally to both parts, unless a specific part is referenced.**

- [1. What is the difference between the MAX1452 and the MAX1455?](#)
- [2. What is the sensor-excitation mode of these signal conditioners?](#)
- [3. Can the MAX1452 be used in voltage-bridge-drive mode?](#)
- [4. Can the MAX1455 be used in voltage-bridge drive mode?](#)
- [5. Can the MAX1452 be used in 4-20mA applications?](#)
- [6. Can the MAX1455 be used in 4-20mA applications?](#)
- [7. What is the smallest sensor output that can produce 4V of span \(VDD = 5V\) without requiring external amplification?](#)
- [8. What is the largest sensor output that can produce 4V of span \(VDD = 5V\), without requiring an external circuit?](#)
- [9. Can I use the uncommitted op amp to provide additional gain for the output voltage?](#)
- [10. When operating in digital mode and the output MUX is activated for "infinite" output duration, communication is blocked for nine seconds before it is released to accept digital commands. This is unacceptable in a production environment. How can I get around the unnecessary wait after I finish reading the output from a DMM?](#)
- [11. Do I need a pull-down resistor on the UNLOCK pin?](#)
- [12. What are the limits for the bridge-excitation voltage?](#)
- [13. What are the limits for the analog output voltage?](#)
- [14. My sensor may be at a different temperature than the signal conditioner. Can I still compensate the sensor?](#)
- [15. Do I have to use the offset TC DAC and FSOTC DAC in my compensation algorithm?](#)
- [16. Is there any advantage in using the offset TC DAC and FSOTC DAC in addition to the lookup tables?](#)
- [17. What are the recommended values for the offset TC DAC and FSOTC DAC, if they are not used for first-order temperature compensation?](#)
- [18. Can the coefficients in the OFF lookup table have different signs?](#)
- [19. Must I use the Serial.dll provided with the EV kit software to operate in digital mode?](#)
- [20. Must I use the KEY \(interface adapter\) provided by Maxim to communicate with the signal conditioner?](#)
- [21. Must I use the same power source for the signal conditioner and the KEY?](#)
- [22. During the compensation process, can I connect the +5V of the power supply directly to the VDD of the signal conditioner?](#)
- [23. I see a very low-frequency noise, 2Hz to 3Hz for example, on the output. What causes this?](#)
- [24. I cannot see the internal oscillator signal at the CLK1M pin. What is the problem?](#)
- [25. My signal conditioner does not start in analog mode. What is the problem?](#)
- [26. What is the VDD voltage level which indicates that the signal conditioner is completely turned off?](#)

27. [What is the minimum startup VDD voltage for the signal conditioner?](#)
28. [What is the factory setting for the flash memory content?](#)
29. [Is the signal conditioner's default operating mode digital or analog?](#)
30. [What is the factory setting of the Configuration register?](#)
31. [I have mistakenly overwritten the oscillator bits in the Configuration register. Can I recover the factory setting?](#)
32. [The EV kit software does not allow writing to the oscillator bits in the Configuration register. How can I write to these bits?](#)
33. [How critical are the oscillator trim bits in the configuration register?](#)
34. [How do I trim the oscillator frequency to 1MHz?](#)
35. [What is included in the EV kit package?](#)
36. [I see a 1kHz ripple at the output signal. How can I eliminate it?](#)
37. [The current drawn by the KEY, approximately 40mA, is interfering with the 4-20mA current loop calibration. How can I fix this?](#)
38. [There was a multichannel sensor calibration station available on your website, but I can not find it now. Is it still available?](#)
39. [What are the voltage threshold \(logic\) levels for the DIO signal?](#)
40. [Do I have to use a Wheatstone bridge-type sensor to utilize these signal conditioners?](#)
41. [My sensor has very low impedance. Can I still use the MAX1452 as a signal conditioner?](#)
42. [My sensor has very high impedance. Can I still use the MAX1452 as a signal conditioner?](#)
43. [My sensor has more than 68mV/V sensitivity. Can I still use these signal conditioners?](#)
44. [I get the "divide by zero" error when I launch the EV kit software. What is the problem?](#)
45. [I have downloaded and installed the latest EV kit software from the website, but when I run the software I get the message, "missing DIPortIO.dll." What is the problem and what should I do?](#)
46. [Where on the Maxim website can I find the EV kit software?](#)
47. [Is there any software stored in flash memory?](#)
48. [Can the signal conditioner be operated beyond the product's operating temperature range?](#)
49. [Can I read the signal conditioner's output digitally?](#)
50. [What are the differences between the –NS and –CS EV kits?](#)
51. [Should the serial cable required between the PC and KEY be a null modem \(straight through\) or cross cable?](#)
52. [When I call the DLLs from Visual Basic, I get the error. What do I need to do?](#)

1. **Q. What is the difference between the MAX1452 and the MAX1455?**

A. The MAX1452 and MAX1455 are based on the same internal architecture with similar functions and performance. The MAX1455 is intended for automotive applications because it includes output-clip voltage limits. The MAX1452 can support 4-20mA applications.

2. **Q. What is the sensor-excitation mode of these signal conditioners?**

A. The default mode is current-bridge drive. However, the MAX1452 can also be configured as voltage-bridge drive. This configuration is accomplished by shorting the ISRC and BDR pins together. Voltage-bridge drive is not possible with the MAX1455.

3. **Q. Can the MAX1452 be used in voltage-bridge-drive mode?**

A. Yes, the MAX1452 can be configured as voltage-bridge drive by shorting the ISRC and BDR pins together.

4. **Q. Can the MAX1455 be used in voltage-bridge drive mode?**

A. No.

5. **Q. Can the MAX1452 be used in 4-20mA applications?**

A. Yes. The maximum current drawn by the MAX1452 in normal operation is less than 4mA, and therefore, it can be used in 4-20mA applications.

6. **Q. Can the MAX1455 be used in 4-20mA applications?**  
 A. No. The MAX1455 draws more than 4mA in normal operation, so it cannot be used in 4-20mA applications.
7. **Q. What is the smallest sensor output that can produce 4V of span (VDD = 5V) without requiring external amplification?**  
 A. The smallest sensor output can be determined when the largest excitation voltage setting of 4.5V (VDD = 5V) and the largest PGA gain (234x) are applied. The applying equation is:  

$$\text{sensor output (mV/V)} = \text{span (V)} / [\text{VBDR (V)} * \text{PGA-Gain (V/V)}] * 1000$$
 The smallest possible sensor output is 4mV/V.
8. **Q. What is the largest sensor output that can produce 4V of span (VDD = 5V), without requiring an external circuit?**  
 A. The largest sensor output can be determined when the smallest excitation voltage setting of 1.5V (VDD = 5V) and smallest PGA gain (39x) are applied. The applying equation is:  

$$\text{sensor output (mV/V)} = \text{Span (V)} / [\text{VBDR (V)} * \text{PGA-Gain (V/V)}] * 1000$$
 The largest possible sensor output is 68mV/V.
9. **Q. Can I use the uncommitted op amp to provide additional gain for the output voltage?**  
 A. Yes.
10. **Q. When operating in digital mode and the output MUX is activated for "infinite" output duration, communication is blocked for nine seconds before it is released to accept digital commands. This is unacceptable in a production environment. How can I get around the unnecessary wait after I finish reading the output from a DMM?**  
 A. The power to the signal conditioner, VDD, must be cycled. If the supplied KEY and Evaluation Kit (EV kit) software are used, the hard\_init (mode = 1) function included in the serial.dll must be executed to cycle power. In this mode (mode = 1) the prepower-cycle contents of the DACs will be automatically restored, so the power cycle operation will be transparent to the compensation process.
11. **Q. Do I need a pull-down resistor on the UNLOCK pin?**  
 A. A pull-down resistor on the UNLOCK pin is recommended for manufacturability. This resistor will allow the switch to digital mode (set UNLOCK = VDD) without having to rewire the board.
12. **Q. What are the limits for the bridge-excitation voltage?**  
 A. The bridge-excitation limits are dictated by the limits in setting the FSO DAC. This limit is specified in the data sheet as 0x4000 to 0xC000, which corresponds to approximately 1.25V to 3.75V from the FSO DAC, for VDD = 5V. In practice, the bridge-excitation voltage can be as high as 4.5V.
13. **Q. What are the limits for the analog output voltage?**  
 A. According to the data sheet, the analog output voltage can swing between 0.2V and 4.75V. In typical applications, the output is calibrated for 0.5V to 4.5V. As the calibrated output limits approach the data sheet limits, the compensation process can become more difficult as more iteration will be required, mainly because the output runs into the saturation region.
14. **Q. My sensor may be at a different temperature than the signal conditioner. Can I still compensate the sensor?**  
 A. Yes. The FSOTC DAC and offset TC DAC provide first-order temperature compensation. This is possible because the reference voltage to FSOTC DAC and offset TC DAC is the BDR (sensor-excitation) voltage, which is temperature dependent. In this case, the internal lookup tables must be filled with a constant value. The compensation process is the same as for the MAX1458/MAX1478. Consult the factory for more details.
15. **Q. Do I have to use the offset TC DAC and FSOTC DAC in my compensation algorithm?**  
 A. Not necessarily. In a typical application, the offset TC DAC and FSOTC DAC are set to arbitrary values; the OFF and FSO lookup tables are used for total temperature compensation. It is recommended that the FSOTC DAC and offset TC DAC be set to non-zero values, e.g., 0x0200.
16. **Q. Is there any advantage in using the offset TC DAC and FSOTC DAC in addition to the lookup**

## tables?

A. Yes. First-order temperature error can be corrected by loading proper values into the offset TC DAC and FSOTC DAC. Then, only the higher order temperature errors remain to be corrected by the OFF and FSO lookup tables. This will result in a significantly higher temperature compensation resolution. However, in most applications, using only the FSO and OFF lookup tables does yield the expected results.

17. **Q. What are the recommended values for the offset TC DAC and FSOTC DAC, if they are not used for first-order temperature compensation?**

A. The offset TC DAC and FSOTC DAC can be set to any arbitrary values. However, it is recommended that they be set to non-zero values, e.g., 0x0200.

18. **Q. Can the coefficients in the OFF lookup table have different signs?**

A. No. The sign of all entries in the OFF lookup table is specified by a single bit in the Configuration register. Therefore, before starting the compensation process, necessary precautions must be taken to ensure that the offset compensation coefficients will all have the same polarity, positive or negative.

19. **Q. Must I use the Serial.dll provided with the EV kit software to operate in digital mode?**

A. Not necessarily, but it is **highly** recommended. Every function in the Serial.dll has been optimized and verified for correctness, and there are built-in traps and tests for special circumstances to ensure reliable communication.

20. **Q. Must I use the KEY (interface adapter) provided by Maxim to communicate with the signal conditioner?**

A. Not necessarily, but it is **highly** recommended. The KEY has been designed to provide reliable communication by ensuring correct timing and correct signal levels. The KEY has proven to be reliable in many applications.

21. **Q. Must I use the same power source for the signal conditioner and the KEY?**

A. Not necessarily. The KEY can be powered by a supply other than the VDD supplied to the signal conditioner. The GND line of the KEY and the VSS of the signal conditioner must be shorted together.

22. **Q. During the compensation process, can I connect the +5V of the power supply directly to the VDD of the signal conditioner?**

A. No. The signal conditioner's VDD must be connected through the KEY so that power to the signal conditioner can be controlled by software. This connection is required for synchronization and to speed up the compensation process by avoiding the nine seconds wait time for every voltage read through a DMM.

23. **Q. I see a very low-frequency noise, 2Hz to 3Hz for example, on the output. What causes this?**

A. The low-frequency noise could be associated with the ODAC and/or OTCDAC outputs. Sigma-delta DACs use pseudorandom sequencing of capacitor charge "dumps" to keep the DAC output at the desired voltage level. Sometimes the DAC sequencing can fall into a pattern. A very long sequencing pattern could repeat and produce output "tones" which can show up on a spectrum analyzer as very low frequencies. Since ODAC and OTCDAC sum directly into the output OUT, these tones could appear on the output. A quick test would be to set up the signal conditioner and monitor the output to see the low-frequency noise, then change the DAC digital value by one or two bits and see if the low-frequency noise disappears or moves to some other frequency. To avoid the low-frequency noise, find the DAC settings that produce them, and avoid those settings in the final calibration of the ODAC table by adding 1 to any "tone value." Being off by 1 bit will make no measurable difference in sensor performance. Please note that Maxim has not been able to produce these tones, but it is a known artifact in sigma-delta DACs.

24. **Q. I cannot see the internal oscillator signal at the CLK1M pin. What is the problem?**

A. The CLK1M bit in the Configuration register must be set to "1" and the TEST pin must be set to VDD. Contact the factory if the problem persists.

25. **Q. My signal conditioner does not start in analog mode. What is the problem?**

A. One or more of the followings can be the problem:

– Evaluation board, KEY, etc., not connected correctly.

– Signal conditioner not configured correctly for analog mode:

a) Low byte of the Control register must contain a non-zero value, e.g., 0xFFFF.

b) The UNLOCK pin must be pulled low or connected to VSS.

– The VDD supply requirement is not met. See Application Note 3733, [Startup Requirements for the](#)

[MAX1452/MAX1455 Signal Conditioners](#).

– The VDDF supply requirement is not met. See Application Note 3733, [Startup Requirements for the MAX1452/MAX1455 Signal Conditioners](#).

26. **Q. What is the VDD voltage level which indicates that the signal conditioner is completely turned off?**  
A. 0.5V. This voltage will guarantee that all transistors are turned off. Reapplying VDD will cause a power-on-reset sequence.
27. **Q. What is the minimum startup VDD voltage for the signal conditioner?**  
A. The signal conditioner will start with VDD as low as 2.5V. However, the operation is guaranteed with a minimum VDD of 4.5V. See Application Note 3733, [Startup Requirements for the MAX1452/MAX1455 Signal Conditioners](#).
28. **Q. What is the factory setting for the flash memory content?**  
A. The signal conditioner is shipped with the flash memory ERASED (0xFFFF in all memory locations), except for the Control and Configuration registers. The Control register content is 0xFF00 to place the part in digital mode; the Configuration register content is xxx0000011111111b (or X0FFhex). The xxx (3 MSBs) are the oscillator trim setting.
29. **Q. Is the signal conditioner's default operating mode digital or analog?**  
A. The signal conditioner normally ships in digital mode from the factory, i.e. the Control register is set to 0xFF00.
30. **Q. What is the factory setting of the Configuration register?**  
A. The Configuration register normally contains xxx0000011111111b (or X0FFhex). The xxx (3 MSBs) are the oscillator bits to trim the oscillator frequency as close to 1MHz as possible.
31. **Q. I have mistakenly overwritten the oscillator bits in the Configuration register. Can I recover the factory setting?**  
A. No. If necessary, one should re-trim the oscillator frequency.
32. **Q. The EV kit software does not allow writing to the oscillator bits in the Configuration register. How can I write to these bits?**  
A. The only way to write to these bits with the EVKIT software is to generate a flash file with the oscillator bits set to the desired value. Then, using the EV kit software, perform the "Load Flash from File" operation to write the file into flash.
33. **Q. How critical are the oscillator trim bits in the configuration register?**  
A. The oscillator frequency is not critical for the signal conditioner's operation. However, the signal conditioner operating speed is a direct function of the oscillator frequency. During the manufacturing process, the oscillator bits in the Configuration register are set so the oscillator frequency is closest to the 1MHz. The default value for the oscillator bits is 000b.
34. **Q. How do I trim the oscillator frequency to 1MHz?**  
A. Using the EV kit software, enable the CLK1M and drive the TEST pin high with VDD. Then connect an oscilloscope to the CLK1M pin and change the OSC[2:0] bits in the Configuration register until the frequency of the signal on the CLK1M pin is closest to 1MHz.
- Note that the EV kit software does not allow for direct modification of the oscillator bits. Instead, a flash file with the desired oscillator bits setting must be created, and then uploaded to the flash memory using the EV kit software. Here is the sequence of steps:
1. "Save Flash to File"
  2. Open the file and modify the oscillator bits
  3. "Load Flash from File"
35. **Q. What is included in the EV kit package?**  
A. The EV kit package includes:  
–Evaluation board  
–Interface box or KEY for communication with the signal conditioner  
–RS-232 cable to connect the KEY to the computer

- 10-pin ribbon cable to connect the evaluation board to the KEY
- Samples

The latest version of the EV kit software can be [downloaded](#) from the Maxim website.

36. **Q. I see a 1kHz ripple at the output signal. How can I eliminate it?**

A. The 1kHz ripple is probably due to reading the flash memory to update the DACs. DACs are updated every 1ms, hence the 1kHz. A flash read operation draws peak current of approximately 20mA for approximately 1 $\mu$ s. The ripple may not be totally eliminated, but it can be minimized by selecting an optimal RC filter between the VDD and VDDF supplies, as well as by selecting a power supply that has higher current sourcing capability. See Application Note 3733, [Startup Requirements for the MAX1452/MAX1455 Signal Conditioners](#).

37. **Q. The current drawn by the KEY, approximately 40mA, is interfering with the 4-20mA current loop calibration. How can I fix this?**

A. In the 4-20mA applications the KEY **must** be isolated from the 4-20mA circuit when making a current measurement, so that current drawn by the KEY will not interfere with the 4-20mA current loop. There is a simple and most effective way to achieve this: use a separate 5V power supply to power the KEY, and use relays (not ICs) to isolate the KEY from the 4-20mA current loop when measuring the 4-20mA current. The GND of the KEY power supply and VSS of the signal conditioner must be shorted together (through a relay). The KEY's GND and DIO lines must be switched to isolate the KEY from the 4-20mA circuit.

The system will work in the following manner. During calibration, when communicating with the signal conditioner for writing to DACs or flash memory, close the relays for the KEY to communicate. Open the relays when measuring 4-20mA current so that the KEY is completely isolated from the circuit. Remember that the KEY must always be powered, and the VDDIN and VDDOUT lines from the KEY to the 4-20mA circuit must always be connected.

38. **Q. There was a multichannel sensor calibration station available on your website, but I can not find it now. Is it still available?**

A. The multichannel sensor calibration station is no longer available.

39. **Q. What are the voltage threshold (logic) levels for the DIO signal?**

A. The recommended levels are: 1V = low, and 4V = high. However, the real limits are  $VDD/2 \pm 0.5V$ . Restated, that is, 2V and 3V for  $VDD = 5V$ .

40. **Q. Do I have to use a Wheatstone bridge-type sensor to utilize these signal conditioners?**

A. Any type of sensor can be used, as long as the sensor excitation and sensor output comply with the signal conditioner's requirement. These signal conditioners operate on the differential input between the INP and INM pins. For example, the MAX1452 has been utilized in applications using 350 $\Omega$  strain gauge.

41. **Q. My sensor has very low impedance. Can I still use the MAX1452 as a signal conditioner?**

A. Yes. This can be achieved in more than one way. See Application Note 3396, [Driving Strain-Gauge Bridge Sensors with Signal-Conditioning ICs](#) as a reference. Contact the factory for assistance.

42. **Q. My sensor has very high impedance. Can I still use the MAX1452 as a signal conditioner?**

A. Yes. The MAX1452 can be used in voltage-bridge-drive mode for this type of application. Contact the factory for assistance.

43. **Q. My sensor has more than 68mV/V sensitivity. Can I still use these signal conditioners?**

A. Yes. There are multiple options. A simple approach is to insert a resistor in series (or parallel) with the sensor to reduce the sensor excitation. Contact the factory for other possible solutions.

44. **Q. I get the "divide by zero" error when I launch the EV kit software. What is the problem?**

A. Most probably, you are not running the latest version of the EV kit software. This problem has been resolved in the latest version, which can be [downloaded](#) from the Maxim website. Contact the factory if the problem persists.

45. **Q. I have downloaded and installed the latest EV kit software from the website, but when I run the software I get the message, "missing DIPortIO.dll." What is the problem and what**

**should I do?**

A. You are missing drivers required for operating systems newer than Windows® 95. Run the Port98nt.exe supplied with the EVKIT software to install the missing drivers. You need to run the Port98nt.exe only one time.

**46. Q. Where on the Maxim website can I find the EV kit software?**

A. The EV kit software can be [downloaded](#).

**47. Q. Is there any software stored in flash memory?**

A. No. These signal conditioners do not have a built-in microprocessor, and there is no software stored in the flash memory. Only the compensation coefficients are stored in the flash memory.

**48. Q. Can the signal conditioner be operated beyond the product's operating temperature range?**

A. The data sheet performance specification is guaranteed only when the product is operated within its specified operating range. However, the product will continue to operate as long as the Maximum Operating condition is not violated.

**49. Q. Can I read the signal conditioner's output digitally?**

A. No. The only output from the signal conditioner is analog voltage.

**50. Q. What are the differences between the –NS and –CS EV kits?**

A. The –CS EV kit includes a 100KPAG pressure sensor and the EV board has been compensated over temperature (-40°C to +125°C) and pressure (0KPAG to 100 KPAG). The –NS EVKit does not include the pressure sensor. However, to evaluate the signal conditioner, the –NS EV kit must be used.

**51. Q. Should the serial cable required between the PC and KEY be a null modem (straight through) or cross cable?**

A. The cable is a straight-through connection (basically an extension cable). One is included in the EV kit package.

**52. Q. When I call the DLLs from Visual Basic, I get the error. What do I need to do?**

A. The Serial.dll included in the EV kit software package is c-call. You must use the std-call if you are using VB. To obtain a copy of the Serial.dll std-call, contact the factory.

**References:**

MAX1452: [data sheet](#), [application notes](#)

MAX1455: [data sheet](#), [application notes](#)

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Application Note 3972: [www.maxim-ic.com/an3972](http://www.maxim-ic.com/an3972)

**More Information**

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For samples: [www.maxim-ic.com/samples](http://www.maxim-ic.com/samples)

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