



APPLICATION NOTE 3852

Frequently Asked Questions (FAQs) on the MAX1464 Digital Sensor Signal Conditioner

Abstract: The MAX1464 is a high-performance, low-cost, low-power, multichannel, microprocessor-based, digital sensor signal conditioner that integrates flash memory and a temperature sensor. This document presents a comprehensive list of questions and issues that may be raised by a user and provides a brief answer to each. For more in-depth answers, users should consult the [MAX1464 data sheet](#) and other publications relevant to this product. In addition, Maxim's technical support group is a valuable resource for obtaining answers to questions that cannot be found in here or other mentioned documents.

1) Q. What is the MAX1464?

A. The MAX1464 is a high-performance, low-cost, low-power, multichannel, microprocessor-based, digital sensor signal conditioner that integrates flash memory and a temperature sensor.

2) Q. What is an example application of the MAX1464 signal conditioner?

A. The typical application of the MAX1464 is to perform compensation, amplification, and linearization of the sensor's low-level signal output. Sensor types include PRTs, RTDs, thermocouples, strain gauges, etc.

3) Q. What types of support are available for the MAX1464?

A. Various forms and levels of supports are available evaluation kit, software tools, programming examples, application notes, online/call-in [technical support](#), etc.

4) Q. What is included in the MAX1464 evaluation kit?

A. The evaluation kit includes an evaluation board (which contains a MAX1464 signal conditioner with a typical application circuit and potentiometers that act as sensor inputs to the MAX1464), the MAX1464KEY to interface to a PC, a few MAX1464 samples, and interconnection cables.

5) Q. What software tools are available for using the MAX1464?

A. The software tools include:

- 1) an assembler for programming the on-chip microcontroller,
- 2) a hardware debugger that allows interactive control of the internal functions and modules,
- 3) and a control program written in LabVIEW®, which has a built-in 2nd-order compensation function and allows higher level of interaction with the MAX1464.

6) Q. Are there any programming examples available for the MAX1464?

A. Yes. Example codes are part of the EV kit software available on the Maxim website. Assembly language examples include 2nd-order compensation algorithm, LED-blinking program, and a typical loop function.

7) Q. Are there any application notes available for the MAX1464?

A. Yes, below is a list of published application notes. Application notes on additional subjects are under development and more will be generated in the future.

- 1) Second-order compensation (application note 3649): [MAX1464 Signal Conditioner, Sensor Compensation Algorithm](#)
- 2) Ratiometric current source (application note 3364): [Creating a Ratiometric Current Excitation in Sensors Using the MAX1464 Signal Conditioner](#)
- 3) Temperature sensor (application note 3650): [The MAX1464's On-Chip Temperature Sensor](#)

For the most part, application notes for the MAX1463 also apply to the MAX1464.

8) Q. When starting an ADC cycle, how long does it take before sampling starts?

A. The ADC sampling begins immediately with the execution of an ADC command and lasts for the entire duration of the ADC cycle.

9) Q. What is the sequence of events that take place to complete one ADC conversion?

A. The sampling is continuous throughout the conversion time, according to the ADC clock setting (ADC Clock table on page 32 of the MAX1464 data sheet). The sigma-delta converter generates a bit-stream output of the signal over the conversion time. This bit-stream is digitally processed to form a 16-bit output result. Then the sampling of that input channel stops. If the input signal changes during an ADC conversion, the result would be an average of the input values over time.

10) Q. When the ADC is sampling does it start with LSB or MSB?

A. The sigma-delta converter does not convert LSB or MSB first as a traditional SAR or integrating converter does. The bit stream output is filtered throughout the conversion cycle. Application note 1870, [Demystifying Sigma-Delta ADCs](#), provides an overview of sigma-delta converters and can be used as supplemental reading material.

11) Q. What is the maximum supply voltage at which the MAX1464 can operate without damaging the part?

A. Applying 6.0V on the MAX1464 does not seem problematic. There have been instances that we supplied this level of voltage on the ASIC and did not observe any adverse effects when returned to normal supply levels after few minutes, though no official data was recorded. Of course, the part will not operate per data-sheet specifications at supply levels higher than 5.5V.

12) Q. Can the MAX1464 be used to measure the RTDs or K-type thermocouples?

A. Yes. The user must always ensure that the voltage levels at INM and INP are above V_{SS} and below V_{DD} . If extra gain is necessary, the op amps in the DOP can be used to implement an analog gain stage, which will result in converting a differential signal to a single-ended signal. The output of this gain stage can then be fed into the ADC for conversion, or the op-amp output can be directly converted using one of the ADC-loopback conversion modes.

13) Q. What are the differences between the MAX1463 and the MAX1464?

A. The major differences are:

- 1) The ISRC pin is not available in the MAX1464.
- 2) The VB pin is not available in the MAX1464
- 3) In the MAX1464, the external reference voltage is limited to 2.5V (1/2 of V_{DD}) only.
- 4) PGA gain setting can be applied on the temperature conversion in the MAX1464.
- 5) In the MAX1464, the temperature sensor has a positive slope (it is negative in the MAX1463) and it can be gained.
- 6) For other minor differences, refer to the MAX1464 data sheet.

14) Q. What are the register definition differences between MAX1463 and MAX1464?

A. Three changes have been made to the register definitions:

- 1) Register 08h, "ADC_Config_TA", have been redefined to include PGA gain (PGAT[4:0]=ADC_Config_TA [15:11]) setting for temperature conversion. Other bits remain unchanged.
- 2) Register 31h, "Power-On Control", PWRWFL bit (bit-12) is no longer needed, and it is "don't-care" in the MAX1464.
- 3) Register 33h, "Current Source Control", has been eliminated.

15) Q. Is the internal temperature sensor of the MAX1463 the same as on the MAX1464?

A. No. The slope of the temperature-sensor output in the MAX1464 is positive with temperature, opposite to that of the MAX1463. In addition, the PGA-gain function can be applied to the MAX1464 temperature-sensor output, but this is not the case in the MAX1463.

16) Q. My setup is correct but cannot communicate with the MAX1464. What is the problem?

A. Some possibilities are:

- 1) The jumpers on the evaluation board are not properly set.
- 2) The MAX1464KEY, the jumper setting, and the configuration settings are not consistent for 3-wire or 4-wire communication.
- 3) The computer serial port has a problem.

- 4) The evaluation board is damaged.
- 5) The MAX1464 chip on the evaluation board is damaged.
- 6) The MAX1464KEY is damaged.

17) Q. What are the differences between 3-wire and 4-wire interfaces?

A. The MAX1464 serial interface can operate in 4-wire SPI™-compatible mode or in a 3-wire mode (default on power-up). In 3-wire mode, the DI and DO lines should be connected together, forming a bidirectional data line.

18) Q. Can I use the Hardware Debugger program in both 3-wire and 4-wire communication?

A. Yes.

19) Q. Can I use the Control program in both 3-wire and 4-wire communication?

A. Yes.

20) Q. How can I switch the EV board from 3-wire to 4-wire communication, and vice versa?

A. 3-wire or 4-wire communication is possible by connecting the DI and DO pins together or keeping them separate, respectively. This is accomplished by inserting or removing the shunt on JU4. The 3-wire mode allows the user to use a single line, DIO, for communication with the MAX1464 by shorting the DI and DO pins together.

21) Q. Is the temperature sensor output ratiometric to V_{DD}?

A. Yes. The temperature sensor reading is ratiometric V_{DD}, meaning that the correct temperature is reported regardless of the V_{DD} voltage, provided that V_{DD} is consistent with the MAX1464 data sheet specification.

22) Q. What is the allowed common-mode voltage range for the INP_x and INM_x input voltages?

A. The common mode of input voltages can be in the range of GND to V_{DD}, provided that GND and V_{DD} signals are consistent with the MAX1464 data sheet specification.

23) Q. Is the common-mode range specification the same for all PGA gain settings?

A. Yes.

24) Q. Does input impedance of the MAX1464 change with different PGA gain settings? How?

A. Yes. The input impedance as a function of PGA setting can be calculated by the expressions below, where "f" is the ADC clock frequency, and "Gain" is the PGA gain. A partial list of input impedance vs. PGA setting for both differential and single-ended inputs is given in the Electrical Characteristics (EC) table on pages 2 to 7 of the MAX1464 data sheet.

For Gains = 1 ... 64, use $R_{IN} = (4 \times 10_{12}) / (f \times \text{Gain})$

For Gains = 80 ... 128, use $R_{IN} = (8 \times 10_{12}) / (f \times \text{Gain})$

For Gains = 160 ... 256, use $R_{IN} = (16 \times 10_{12}) / (f \times \text{Gain})$

25) Q. What should be the relationship between the output impedance of the sensor and input impedance of the MAX1464? How are they affecting each other?

A. The input stage of the MAX1464 is switched capacitor. That is, during ADC sampling, the current flows into the ADC input terminals in periodic charge packets. In effect, at the beginning of each sample interval, the input impedance starts out small (large current flows into the caps) and, at the end of each sample interval, the input impedance is very large (capacitors are almost fully charged and zero current flows). This can be achieved by choosing proper filtering elements (RC-filter) on INM-INP, or by reducing the ADC clock rate.

26) Q. How is the conversion resolution affected by changing conversion rate?

A. Conversion resolution is independent of conversion rate. Any conversion rate ranging from 0.256ms to 262.14ms can be used with any possible resolution from 9-bit to 16-bit. Refer to the ADC Resolution and ADC Conversion Time tables on page 33 of the MAX1464 data sheet.

27) Q. Can the ADC-clock be set independent of the microcontroller clock?

A. Yes. For a given system clock (internal or external), the ADC clock can be set according to the ADC Clock table in the MAX1464 data sheet.

28) Q. What is the relationship between ADC clock rates and power consumption?

A. Power consumption is approximately linear with respect to the ADC clock rate. The lower the ADC clock rate, the lower the power consumption. The ADC current consumption for an ADC clock of 1MHz and an ADC clock of 7kHz is given in the EC table of the MAX1464 data sheet. A linear approximation between these two data points can be used for reference.

29) Q. What are the trade-offs between power consumption and conversion speed?

A. Systems operating with very low power consumption benefit from the reduced ADC clock rate, F_{ADC} . Slower clock speeds require less operating current. Systems operating from a larger power consumption budget can use the highest F_{ADC} clock rate to improve speed performance over power performance. The ADC conversion times for various resolution and clock rate settings are summarized in the ADC Conversion Time table in the MAX1464 data sheet. The conversion time is calculated by the formula:

$$T_{CONVERT} = (\text{number of } F_{ADC} \text{ clocks per conversion}) / F_{ADC}$$

"Number of clocks per conversion" is a function of desired conversion resolution.

30) Q. What is MAX1464 data-retention rating as function of temperature?

A. The device is rated for data retention of 100 years at room temperature. It has been qualified for 10 years for the rated operating temperature range.

31) Q. What is the flash-memory capacity in the MAX1464?

A. The MAX1464 flash memory consists of two partitions. Partition-0 is 4kB and is for storing the program to be executed by the CPU for correction, amplification, and linearization of the input signal. Partition-1 is 128B in length and is used to hold user information. Partition-1 is not accessible by the CPU.

32) Q. What extent of programming can be realized with the available 4kB of flash memory?

A. 4kB of flash memory is significant memory space for a sensor application. As an example, one can store a program performing the following functions in less than 4kB of flash memory:

- 1) Measure one differential input
- 2) Measure two single-ended inputs
- 3) Read a non-chip temperature sensor
- 4) Read V_{DD}
- 5) Set two analog outputs
- 6) Set alarm trip points using GPIO pins
- 7) Implement a 2nd-order compensation function.

Of course, programming expertise is always a factor in how efficiently the memory space is used.

33) Q. What instructions are available for the MAX1464 microprocessor?

A. The MAX1464 has 16 instructions to perform all calculations for sensor compensation, amplification, and linearization of the sensor signal output. These are explained in detail in the MAX1464 data sheet.

MAX1464 Instruction Set

OP-CODE (HEX)	MNEMONIC	OPERATION
0X	LDX	Load register X from program memory.
1X	CLX	Clear X-reg
2X	ANX	A-reg = A-reg AND X-reg
3X	ORX	A-reg = A-reg OR X-reg
4X	ADX	A-reg = A-reg ADD X-reg
5X	STX	X-reg = A-reg
6X	SLX	Shift left X-reg
7X	SRX	Shift right X-reg propagating sign bit
8X	INX	X-reg = X-reg + 1
9X	DEX	X-reg = X-reg - 1
AX	NGX	X-reg = NOT X-reg
BX	BPX	Branch positive I-reg by amount in X-reg
CX	BNX	Branch not zero I-reg by amount in X-reg
DX	RDX	A-reg = CPU port-X
EX	WRX	CPU port-X = A-reg
F3	MLT	A-reg M-reg = M-reg multiplied by N-reg; register op code must be 3h

34) Q. How do I program the MAX1464?

A. The assembler provided as part of the MAX1464 EV kit software tools can be used to develop the assembly language program and compile it. Then the assembly language program is compiled running the assembler. The assembler generates a .hex file, which should be downloaded into the MAX1464's internal flash memory using one of the provided tools (Hardware Debugger or the Control Program).

35) Q. With which Windows platform is the Hardware Debugger compatible?

A. The Hardware Debugger can run on Windows® 95/98/2000/NT/XP.

36) Q. With which Windows platforms are the MAX1464 DLLs compatible?

A. The MAX1464 DLLs can run on Windows 95/98/2000/NT/XP.

37) Q. On what platform are the MAX1464 DLLs developed?

A. The MAX1464 DLLs were developed on C++ platform using standard calls.

38) Q. Is it possible to call the MAX1464 DLL functions from Visual Basic?

A. Yes. The DLLs can be called from any Windows-based OS. The Control Program developed by Maxim uses the c-calls DLLs. To call the DLLs from Visual Basic or others, the stdCall DLLs must be used. The MAX1464 DLLs supplied with the EV kit is the c-call. For stdCall, contact the Maxim technical support group.

39) Q. What input voltage range can the MAX1464 accommodate?

A. Theoretically, the MAX1464 can accommodate input ranges from 1mV to 5V. But in reality, the input range depends on the desired full-scale output and resolution. The MAX1464 can provide analog amplification of up to 244 in 17 steps. Higher amplification can be achieved digitally. Output resolution is compromised when amplifying a signal digitally.

40) Q. How can the Hardware Debugger be used?

A. The Hardware Debugger program includes multiple tabs for accessing the relevant registers and ports loading flash memory contents into a file, etc. Use the Hardware Debugger program to learn the MAX1464 functions, registers, and ports.

41) Q. How can the Control Program be used?

A. The main purpose of the Control Program is to provide the user with a tool to easily compensate a sensor. The Control Program includes functional buttons to have the MAX1464 perform a series of lower level and predefined operations such as "Read the ADC", loading a file into the MAX1464 internal flash memory, etc. The

Control Program can be used to perform 2nd-order temperature compensation.

42) Q. Can the op amps on the MAX1464 be used as uncommitted op amps?

A. Yes. There are two op amps associated with each output channel of the MAX1464. At any given time, only one of the two op amps can be connected to an output terminal, and the unused op amp can be used as a buffer or to provide additional gain.

43) Q. What is the function of the partition-1 of the flash memory in the MAX1464?

A. The partition-1 of the flash memory is intended to hold the user information such as serial number, device history, manufacturing information, date codes, etc. Partition-1 cannot be accessed by the CPU. It can only be written to or be read through the SPI interface.

44) Q. Can the partition-1 (user portion) of the MAX1464 flash memory be accessed by the CPU program?

A. No. Partition-1 can be accessed through the SPI interface only. Partition-1 cannot be used to control the MAX1464 operation.

45) Q. How many input channels does the MAX1464 have?

A. Two differential inputs or four single-ended inputs and nine loopback inputs.

46) Q. How can the ADC range be maximized during compensation?

A. The ADC range is maximized when the coarse offset and the PGA-gain setting for the ADC input are properly set. Refer to page 7 of the [MAX1460 data sheet](#) for the procedure to set proper coarse offset and PGA.

47) Q. How can the temperature sensor resolution be maximized during compensation?

A. The temperature-sensor resolution is maximized when the coarse offset and the PGA-gain setting for temperature-sensor conversion are properly set. Refer to page 7 of the MAX1460 data sheet for the procedure to set proper coarse offset and PGA.

48) Q. Can the second-order compensation algorithm built into the Control Program be used for real compensation in production?

A. Yes. The coefficients in the template file must be replaced with the coefficients specific to the sensor production module.

49) Q. The 'DUT?' button on the Control Program window does not turn green when I start the program. What is wrong?

A. The MAX1464 cannot be found by the PC. There are many possibilities, including:

- 1) The setup is not correct. Verify that the setup and connections are consistent with that given in the MAX1464 EV kit data sheet. Also make sure the supply voltage is correct and it is applied on the correct terminal block on the evaluation board.
- 2) The jumpers on the evaluation board are not properly set. Verify that the jumpers are consistent with specifications in the MAX1464 EV kit data sheet.
- 3) The MAX1464KEY, the jumper setting, and the configuration settings are not consistent for 3-wire or 4-wire communication.
- 4) The computer parallel port has a problem.
- 5) The evaluation board is damaged. Visually check the evaluation board and make sure there are no broken or missing components. 100% of all evaluation boards are tested before they leave the factory floor.
- 6) The MAX1464 chip on the evaluation board is damaged. Replace the MAX1464 ASIC.
- 7) The MAX1464KEY is damaged.

50) Q. I get 'file operation' failure error when launching the Control Program. What is the problem?

A. One or more of the files the controller attempts to launch at the startup cannot be found. Two of the possibilities are:

- 1) The "MAX1464.ini" is missing from the folder from which the "MAX1464 Main.exe" is launched.
- 2) The files listed in the "MAX1464.ini" file are not present in the folder.

51) Q. Turning the potentiometers on the EV board does not change the input to the MAX1464. What is the problem?

A. Two likely reasons are:

- 1) The jumpers JU11 and JU12 are not installed.
- 2) The potentiometers are not good. This is a less likely possibility. The integrity of the potentiometers can be checked by performing an ohmic measurement at the potentiometer's terminals.

Additional Resources

- 1) [MAX1464 Data Sheet](#)
- 2) [MAX1460 Data Sheet](#)
- 3) [MAX1464 and MAX1463 Application Notes](#)

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