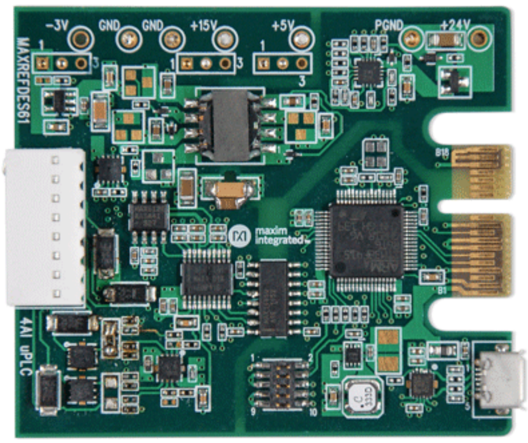
maxim integrated

System Board 5943

MAXREFDES61#: 16-BIT FOUR-CHANNEL ANALOG INPUT MICRO PLC CARD

Details

MAXREFDES61# System Board



Enlarge+

Introduction

Industry 4.0[1] marks the fourth industrial revolution, characterized by distributed, intelligent control systems. Breaking from a past with large, centralized programmable-logic controllers, Industry 4.0 allows for highly configurable, highly modular factories, which accept an ever increasing number of sensor inputs, while operating at a higher output than ever before. The ultra-small PLC, or Micro PLC, lies at the heart of the Industry 4.0 factory, providing high performance with ultra-low power consumption in an ultra-small package. MAXREFDES61# is Maxim's Micro PLC, quad-channel, analog input card.

The MAXREFDES61# features a 16-bit high-accuracy four-channel analog input with isolated power and data. Two of the input channels accept -10V to +10V signals and the other two inputs accept 4mA to 20mA signals. The MAXREFDES61# design integrates a dual low-noise low-distortion buffer (MAX9633); a 16-bit 4-channel multirange input ADC (MAX1301); two high-voltage 4–20mA current protectors (MAX14626) for the current input channels; an ultra-high-precision 4.096V voltage reference (MAX6126); 600VRMS data isolation (MAX14850); a STM32F4 microcontroller; a FTDI USB-UART bridge; a high-efficiency DC-DC converter (MAX15062); and isolated/regulated +15V, +5V, and -3V power rails (MAX17498C/MAX8719/MAX1659/MAX1735). The entire system typically operates at less than 500mW and fits into a space roughly the size of a credit card. While targeted for the industrial, Micro PLC application, MAXREFDES61# may be used in any application that requires high-accuracy analog-to-digital conversion. A block diagram of the system is shown in **Figure 1**.

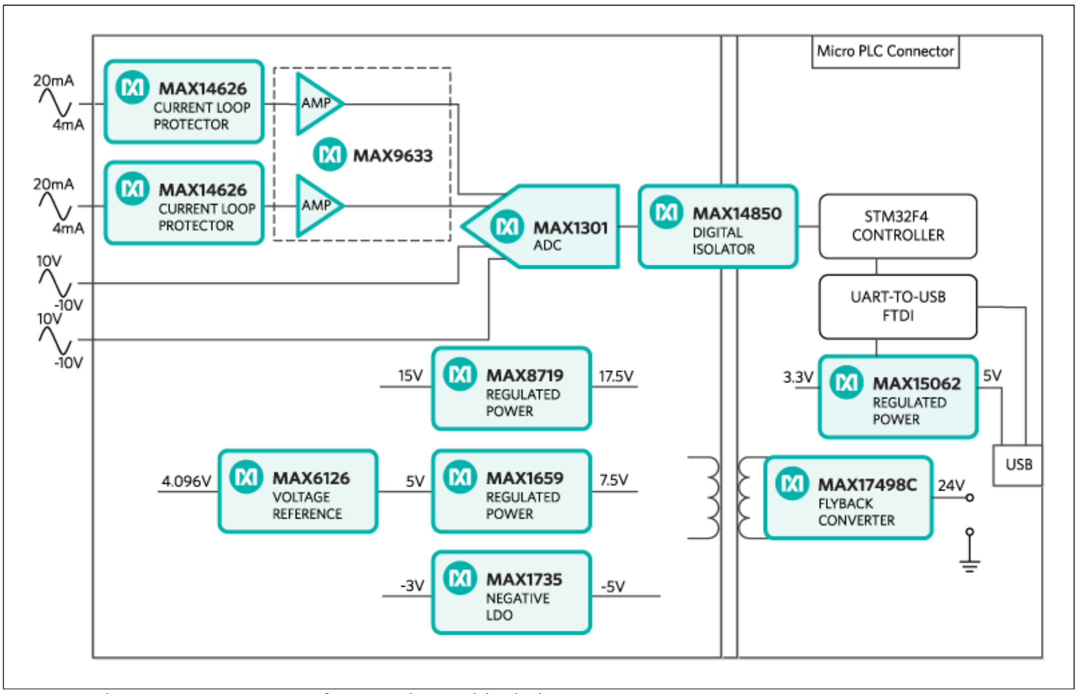


Figure 1. The MAXREFDES61# reference design block diagram.

Features

- High accuracy
- -10 to +10V ±20% voltage inputs
- 4 to 20mA +20% current inputs
- Isolated power and data
- Micro PLC form factor
- Device drivers
- Example C source code
- Test data

Applications

- Industrial control and automation
- Process control
- PLC

Detailed Description of Hardware

The power requirement is shown in **Table 1**.

Table 1. Power Requirement for the MAXREFDES61# Reference Design

Power Type	Input Voltage (V)	Input Current (mA, typ)
On-board isolated power	24	20

Note: STM32 and FTDI are powered by USB separately.

The MAX1301 (U1) is a highly integrated, 16-bit, 4-channel ADC with a selectable multirange input feature. The ADC also has integrated analog input buffers with a 17kΩ input. The ADC's reference input is driven by an ultra-high-precision 4.096V voltage reference, the MAX6126 (U3), with 0.02% initial accuracy and a 3ppm/°C maximum temperature coefficient (tempco). Channel 0 and channel 1 are used for the 4–20mA current loop input, and channel 2 and channel 3 are used for the ±10V voltage input.

The current input circuit consists of two MAX14626 (U4, U5) high-voltage current protectors and a MAX9633 (U2) dual low-noise low-distortion op amp. The MAX14626 protects the current input circuit from high input current. The MAX9633 and the 499Ω sensing resistors convert the 4–20mA signals to 0V to 10V signals to match the input range of channel 0 and channel 1 of the ADC.

MAXREFDES61# uses the ultra-efficient MAX17498C (U13) to generate the isolated +17.5V, +7.5V, and -5V rails from a 24V supply. The MAX8719 (U10), MAX1659 (U11), and MAX1735 (U12) provide post-regulated +15V, +5V, and -3V rails. The MAX14850 (U6) digital data isolators provide data isolation. The combined power and data isolation achieved is $600V_{RMS}$.

The MAX15062 (U9) step-down DC-DC converter converts the +5V supply from the USB to +3.3V and powers the STM32 (U7) microcontroller and FTDI (U8) USB-UART bridge.

Detailed Description of Firmware

The MAXREFDES61# uses the on-board STM32F4 microcontroller to communicate with the ADC and save the samples in the on-chip SRAM. User reads the sampled data through a terminal program, allowing analysis on any 3rd party software. The simple process flow is shown in **Figure 2**. The firmware is written in C using the Keil µVision5 tool.

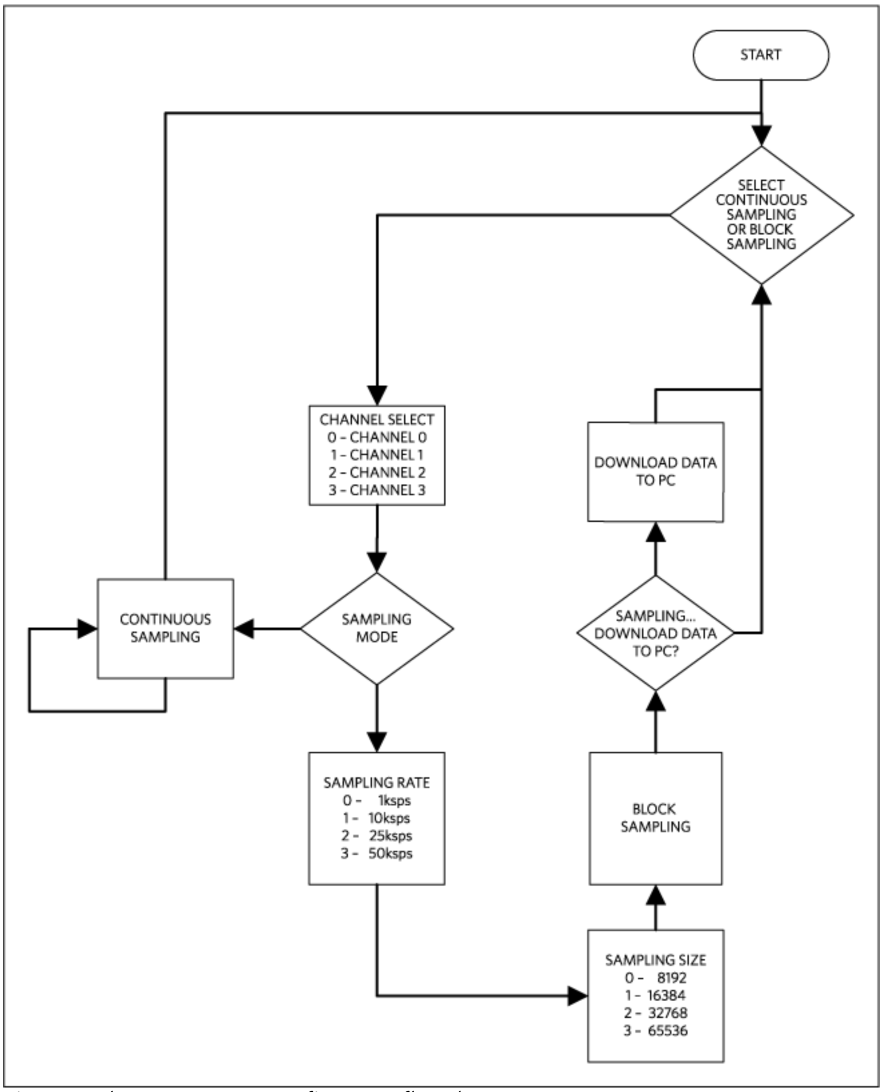


Figure 2. The MAXREFDES61# firmware flowchart.

The firmware accepts commands, writes status, and is capable of downloading blocks of sampled data to a standard terminal program via a virtual COM port. The complete source code is provided to speed up customer development. Code documentation can be found in the corresponding firmware platform files.

Quick Start

Required equipment:

- Windows® PC with a USB port
- MAXREFDES61# board
- 24V power supply
- 5V DC voltage source

Procedure

The reference design is fully assembled and tested. Follow the steps below to verify board operation:

1. Turn off or keep off the 24V power supply.
2. The MAXREFDES61# utilizes the FTDI USB-UART bridge IC. If Windows cannot automatically install the driver for the FTDI USB-UART bridge IC, the driver is available for download from www.ftdichip.com/Drivers/VCP.htm.
3. Connect the negative terminal of the 24V power supply to the PGND connector on the MAXREFDES61# board. Connect the positive terminal of the 24V power supply to the +24V connector on the MAXREFDES61# board.
4. Turn on the 24V power supply.
5. Connect the USB cable from the PC to the MAXREFDES61# board.
6. Open Hyperterminal or similar terminal program on the PC. Find the appropriate COM port, usually a higher number port, such as

COM4, or COM6, and configure the connection for 921600, n, 8, 1, none (flow control).

7. The MAXREFDES61# software will display a menu (**Figure 3**)
8. For immediate signal testing, connect the negative terminal of the 5V DC voltage source to the GND terminal of the J3 terminal block. Connect the positive terminal of the 5V voltage source to the V1 terminal of the J3 terminal block. The inputs are labeled on the bottom side of the board.
9. Press 0 in the terminal program to start the continuous sampling.
10. Press 2 to select channel 2.
11. Verify the ADC output code is around 46100.

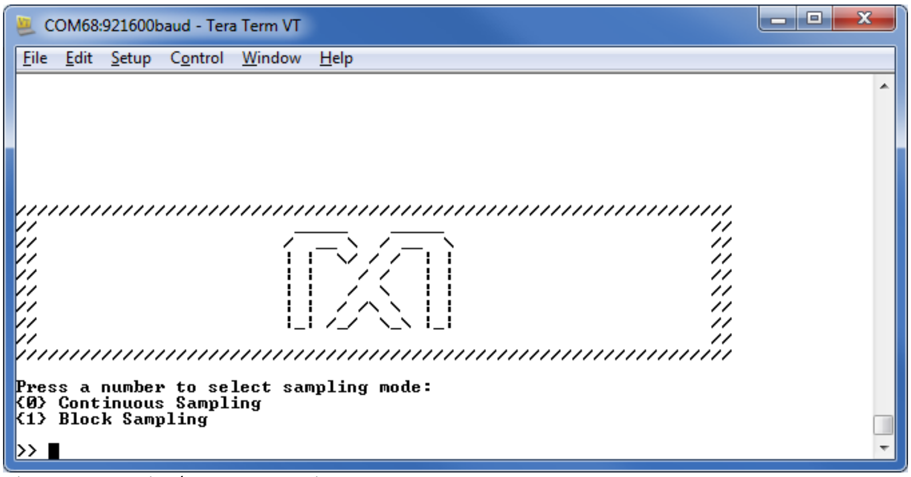


Figure 3. Terminal program main menu.

Lab Measurements

Equipment used:

- Audio Precision® SYS-2722 signal source or equivalent
- Voltage calibrator DVC-8500
- Windows PC, a USB port
- MAXREFDES61# board
- +24V power supply

Special care must be taken and the proper equipment must be used when testing the MAXREFDES61# design. The key to testing any high-accuracy design is to use sources and measurement equipment that are of higher accuracy than the design under test. A low-distortion signal source is absolutely required to duplicate the presented results. The input signal was generated using the Audio Precision SYS-2722. The FFTs were created using the FFT control in SignalLab from Mitov Software. **Figure 4**, **Figure 5**, **Figure 6**, **Figure 7** show the FFT and histogram test results.

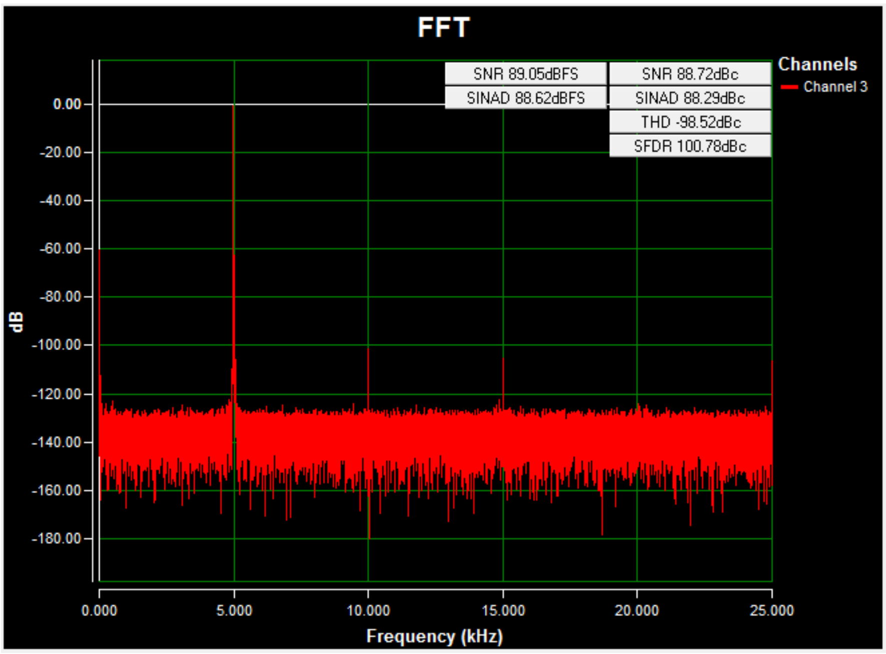


Figure 4. AC FFT, on channel V2, using on-board isolated power, a -12V to +12V 5kHz sine wave voltage input signal, 17kΩ input impedance, a 50ksps sample rate, at room temperature, and a Blackman-Harris window.

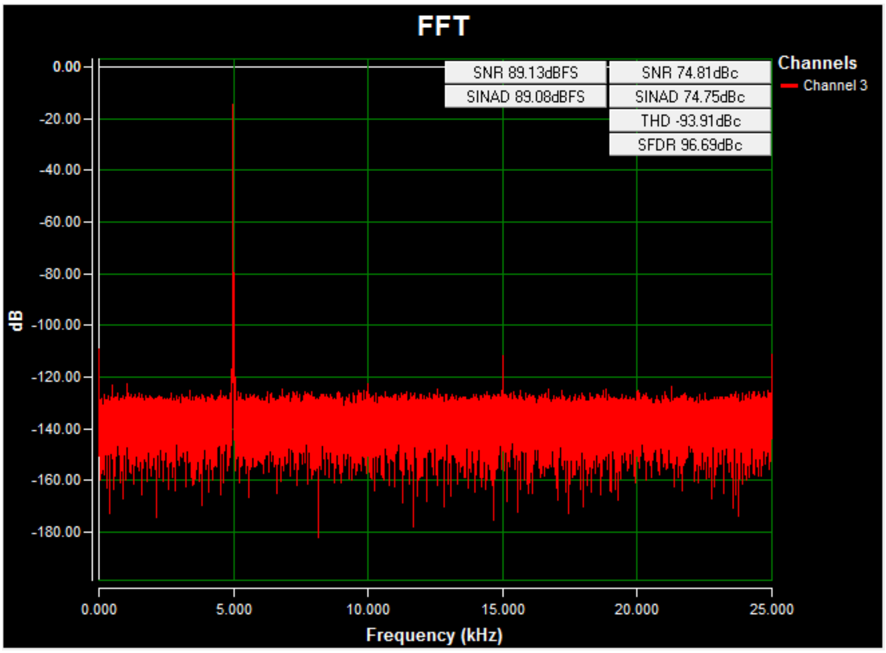


Figure 5. AC FFT, on channel 3 (AIN3), using on-board isolated power, a -2.5V to +2.5V 5kHz sine wave voltage input signal, 17kΩ input impedance, a 50ksps sample rate, at room temperature, and a Blackman-Harris window.

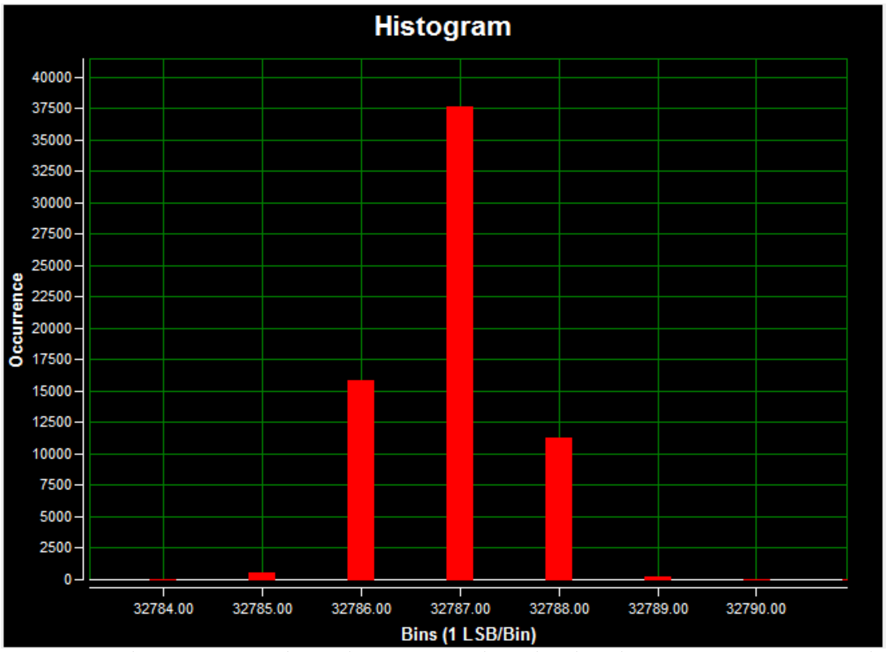


Figure 6. DC histogram, on channel I2, using on-board isolated power; a 0V input signal; a 50ksps sample rate; 65,536 samples; at room temperature; a code spread of 7 LSBs with 98.7% of the codes falling within the three center LSBs; and a standard deviation of 0.677.

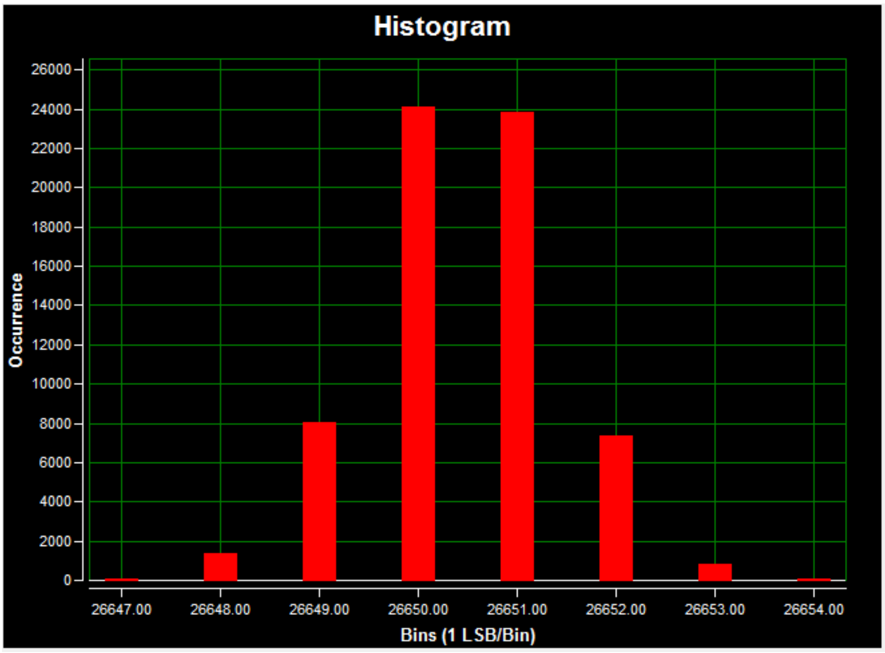


Figure 7. DC histogram, on channel I2, using on-board isolated power; a 10mA input signal; a 50ksps sample rate; 65,536 samples; at room temperature; a code spread of 8 LSBs with 96.5% of the codes falling within the four center LSBs; and a standard deviation of 0.968.

Reference

1. The new generation of manufacturing production is called Industry 4.0 in Germany and Smart Manufacturing System elsewhere. See, **Securing the future of German manufacturing industry, Recommendations for implementing the strategic initiative INDUSTRIE 4.0, Final report of the Industrie 4.0 Working Group**, Industry 4.0 Working Group, Acatech National Academy of Science and Engineering, April 2013, www.acatech.de/fileadmin/user_upload/Baumstruktur_nach_Website/Acatech/root/de/Material_fuer_Sonderseiten/Industrie_4 Henceforth cited as **Industrie 4.0**. Although the Industrie 4.0 report is focused on Germany, the implications of the German research and findings are recognized for industry in other countries. See also Ferber, Stefan, "Industry 4.0 – Germany takes the first steps toward the next industrial revolution," Bosch Software Group, **Blogging the Internet of Things**, October 16, 2013, http://blog.bosch-si.com/industry-4-0-germany-takes-first-steps-toward-the-next-industrial-revolution/.

   There are many sources for Smart Manufacturing Leadership. An interesting summary report of issues and topics can be found at the **Smart Manufacturing Leadership Coalition Committee Working Meeting**, Minneapolis, MN, U.S., Thursday, October 20, 2011, https://smart-process-manufacturing.ucla.edu/workshops/2011-workshop/presentations/SMLC%2010-20-11v3.pdf. Also see, **Implementing 21st Century Smart Manufacturing, Workshop Summary Report**, Smart Manufacturing Leadership Coalition, June 24, 2011, https://smart-process-manufacturing.ucla.edu/about/news/Smart%20Manufacturing%206_24_11.pdf. A simple web search on the topic will reveal considerably more references.