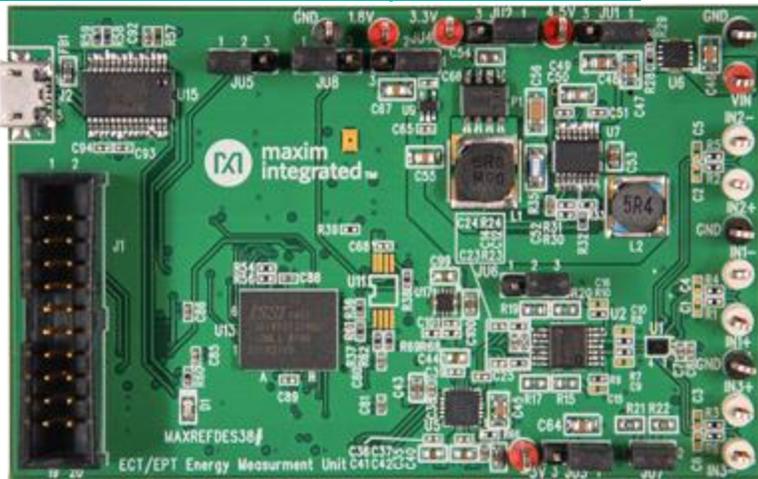


System Board 5979

MAXREFDES38#: ECT/EPT CURRENT FAULT SENSOR

[MAXREFDES38# System Board](#)



Introduction

To realize the vision of a truly smart electricity grid, utilities must find new ways to increase the speed at which they locate, isolate, and fix faults. The electronic current transformer/electronic potential transformer (ECT/EPT), or current fault sensor, fulfills this vision. The ECT/EPT is a low-power sensor that may be placed at many points in the grid thereby increasing the granularity grid health data and fault location. These sensors must be ultra-low power, because they generally receive energy from batteries or nearby fiber

optic lines. Although power is readily present in the lines being measured, converting power from the kilovolts in the distribution lines is not feasible. In addition to low-power operation, these sensors must also maintain accuracy and performance, as they provide valuable grid health information during both faults and normal operation.

The term ECT/EPT refers to a variety of technologies applied to grid measurement applications. MAXREFDES38# specifically provides the low-power, high-speed, high-accuracy analog front-end designed for the ECT/EPT or current fault sensor application.

The MAXREFDES38# features a low-power, 16-bit, high-accuracy, three-channel analog input. Input channels can be configured as $\pm 3V_{P-P}$ single-ended or $\pm 6V_{P-P}$ differential. The MAXREFDES38# design integrates a three-channel analog switch (MAX14531E); a quad precision low-power buffer (MAX44245); a 16-bit fully differential ADC (MAX11901); an ultra-high-precision, 3V voltage reference (MAX6126); a low-noise precision op amp (MAX44241); a STM32L1 microcontroller; a supervisory circuit (MAX16058); a 64kB SRAM, a FTDI USB-UART bridge; a dual-output step-down DC-DC converter (MAX1775); a switched-capacitor voltage converter (MAX1044); and -3V, 1.8V, 3.3V, 3.38V, 4.5V power rails (MAX1735/MAX8891/MAX8881/MAX8902B/MAX16910). The

entire system typically operates at less than 85mW and fits into a space roughly the size of a credit card. The MAXREFDES38# targets for the ECT/EPT and current fault sensor applications that require low-power high-accuracy data conversion. A block diagram of the system is shown in **Figure 1**.

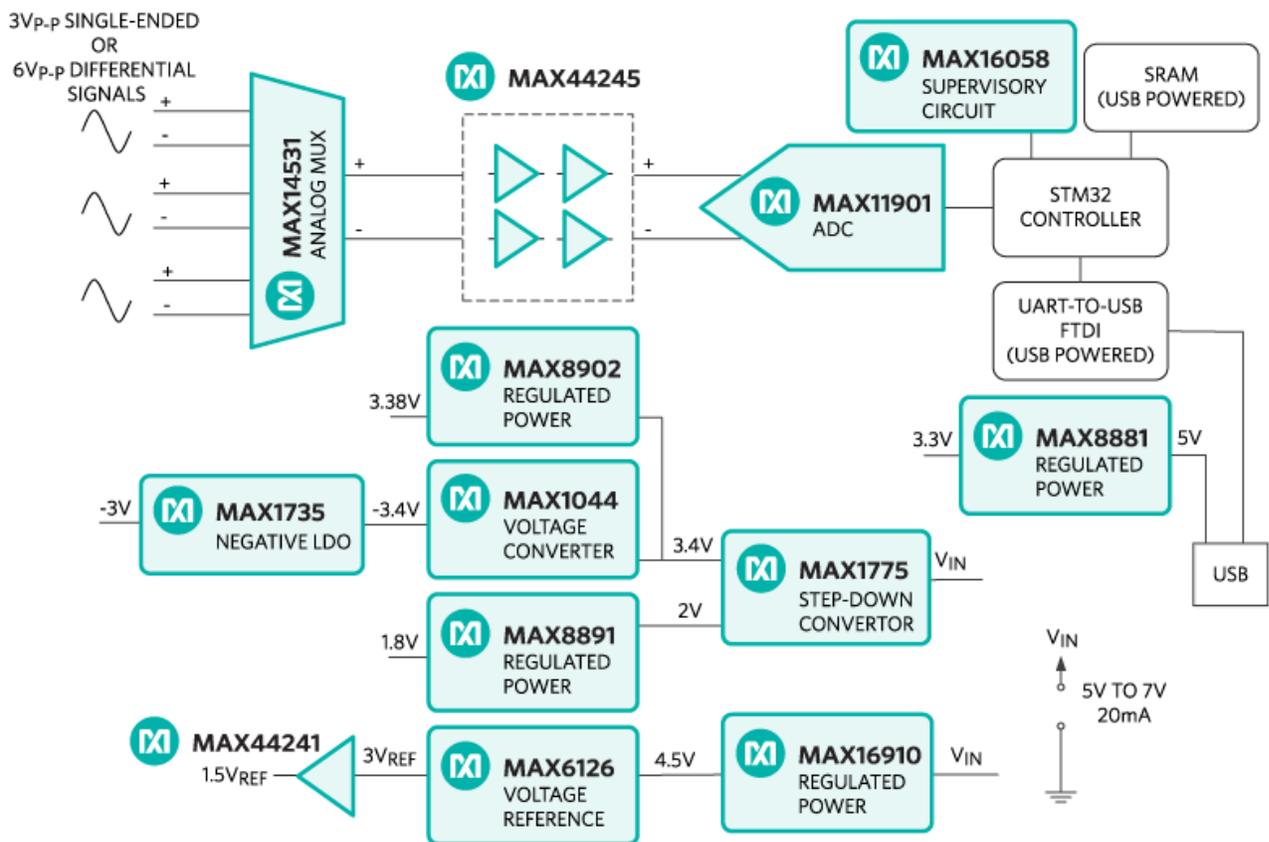


Figure 1. The MAXREFDES38# reference design block diagram.

Features

- High accuracy

- Low power
- Accepts $3V_{P-P}$ single-ended signal or $6V_{P-P}$ differential signal
- Optimized layout and size
- Device drivers
- Example C source code
- Test data

Applications

- ECT/EPT
- Current fault sensors

Competitive Advantages

- Ultra-low power
- Small size

Detailed Description of Hardware

The power requirement is shown in **Table 1**, replicating the power typically available from a photovoltaic power converter used in fiber optic applications. An example of such a converter is the PPC-6E from JDSU, where the power provided is at 5V with a typical power of 100mW.

Table 1. Power Requirement for the MAXREFDES38#
Reference Design

Power Type

Input Voltage (V)

Note: SRAM and FTDI are powered by USB separately.

The MAX11901 (U5) is a 16-bit, low-power, fully differential ADC. The ADC's reference input is driven by an ultra-high-precision 3V voltage reference, the MAX6126 (U3), with 0.02% initial accuracy and a 3ppm/°C maximum temperature coefficient (tempco).

The input circuit consists of a MAX14531E (U1) three-channel analog switch, a MAX44245 (U2) quad precision low-power op amp, and a MAX44241 low-noise op amp. The STM32L1 microcontroller controls the MAX14531E to select the input channel. The MAX44245 op amps convert the single-ended or differential input signal to match the input range of the MAX11901 ADC. Because the analog inputs of the MAX11901 ADC only accept positive signals, an accurate offset voltage has to be applied to the MAX44245 op amps to shift up the user input signal. The MAX44241 low-noise op amp provides 1.5V offset voltage to the MAX44245.

By default, the MAXREFDES38# is powered by a 5V supply, and creates the -3V, 1.8V, 3.3V, 3.38V, and 4.5V power rails. It uses the DC-DC step-down converter, voltage converter, and LDOs

(MAX1775/MAX1044/MAX1735/MAX8891/MAX8881/MAX890

2B/MAX16910). To use external power supplies for all power rails, move the shunts on jumpers JU1–JU4 to the 2-3 position, and connect the appropriate power supply to the corresponding power input connectors. See **Table 2** for more details.

To use the single-ended signal, connect the positive terminal of the signal source to the INx+ connector, and connect the negative terminal of the signal source to the GND connector. Move the shunt on JU6 to the 1-2 position and remove the shunt on JU7.

To use the differential signal, connect the positive terminal of the signal source to the INx+ connector, and connect the negative terminal of the signal source to the INx- connector. Move the shunt on JU6 to the 2-3 position and install the shunt on JU7.

The MAX15062 (U14) step-down DC-DC converter converts the +5V supply from the USB to +3.3V and powers the SRAM (U13) and FTDI (U15) USB-UART bridge.

Jumper	Shunt Position	Description
JU1	1-2*	On-board LDO provides a 4.5V output
	2-3	Connect the external 4.5V supply to the 4.5V connector

JU2	1-2*	On-board DC-DC converter provides a 3.4V output
	2-3	Connect the external 3.4V supply to the 3.4V connector
JU3	1-2*	On-board voltage converter and negative LDO provides a
	2-3	Connect the external -3V supply to the -3V connector
JU4	1-2*	On-board LDO provides a 1.8V output
	2-3	Connect the external 1.8V supply to the 1.8V connector
JU5	1-2*	Firmware loaded from the STM32 internal flash
	2-3	For other boot load options, see STM32 user manual
JU6	1-2*	For single-ended input signal
	2-3	For differential input signal
JU7	Open*	For single-ended input signal
	Installed	For differential input signal
JU8	1-2*	Firmware loaded from the STM32 internal flash

*Default position.

Detailed Description of Firmware

The MAXREFDES38# uses the on-board STM32L1 microcontroller to communicate with the ADC and save the samples in the on-board 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 μ Vision5 tool.

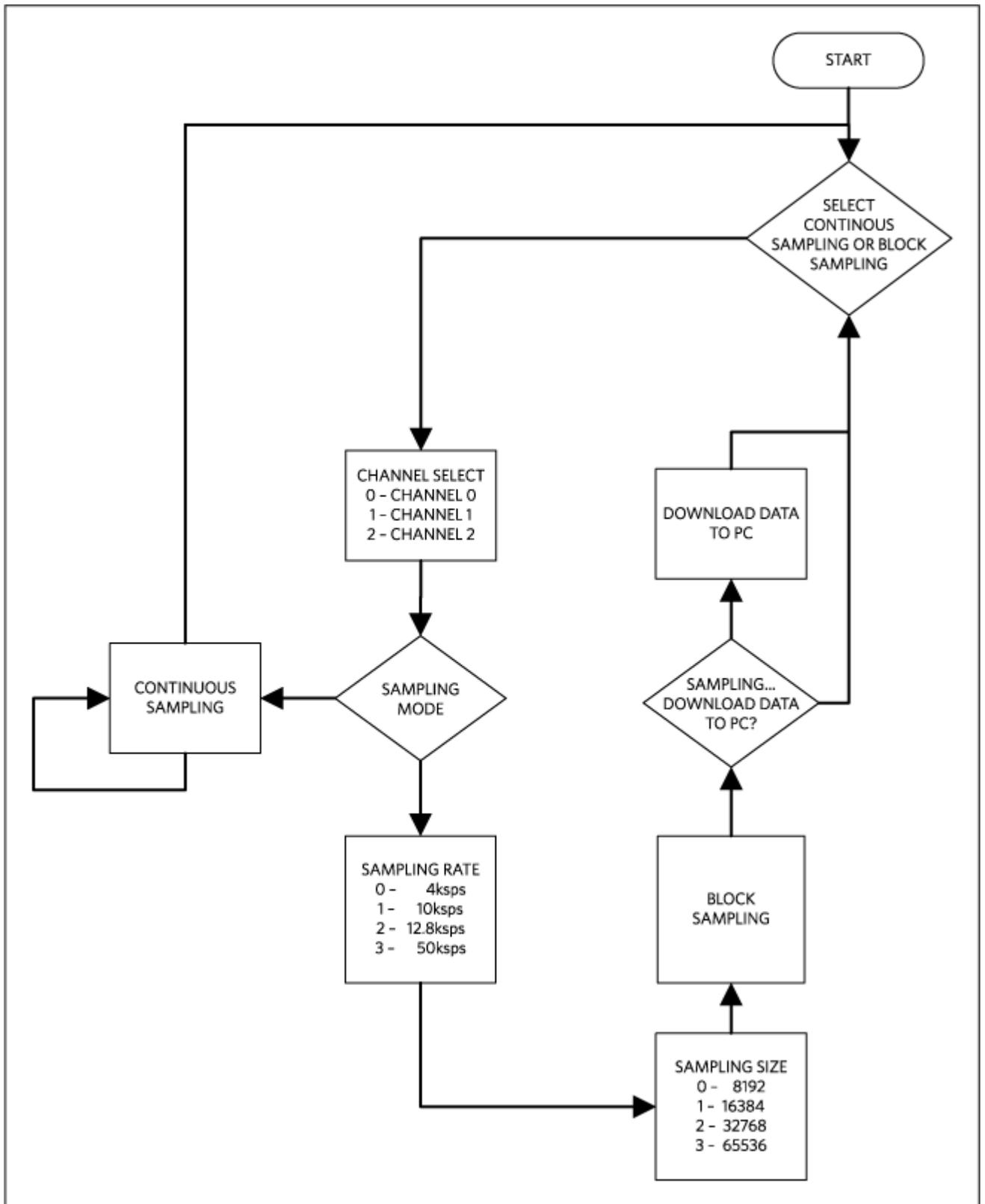


Figure 2. The MAXREFDES38# firmware flowchart.

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
- MAXREFDES38# board
- 5V power supply
- 1V 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 5V power supply.
2. The MAXREFDES38# 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. Verify that all jumpers are in their default positions, as shown in Table 2.
4. Connect the negative terminal of the 5V power supply to the GND connector on the MAXREFDES38# board. Connect the positive terminal of the 5V power supply to the VIN connector on the MAXREFDES38# board.
5. Turn on the 5V power supply.
6. Connect the USB cable from the PC to the MAXREFDES38# board.
7. 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 115200, n, 8, 1, none (flow control).
8. The MAXREFDES38# software will display a menu (**Figure 3**)
9. For immediate signal testing, connect the negative terminal of the 1V DC voltage source to the GND connector. Connect the positive terminal of the 1V voltage source to the IN1+ connector.
10. Press 0 in the terminal program to start the continuous sampling.
11. Press 1 to select channel 1.
12. Verify the ADC output code is around 54613.

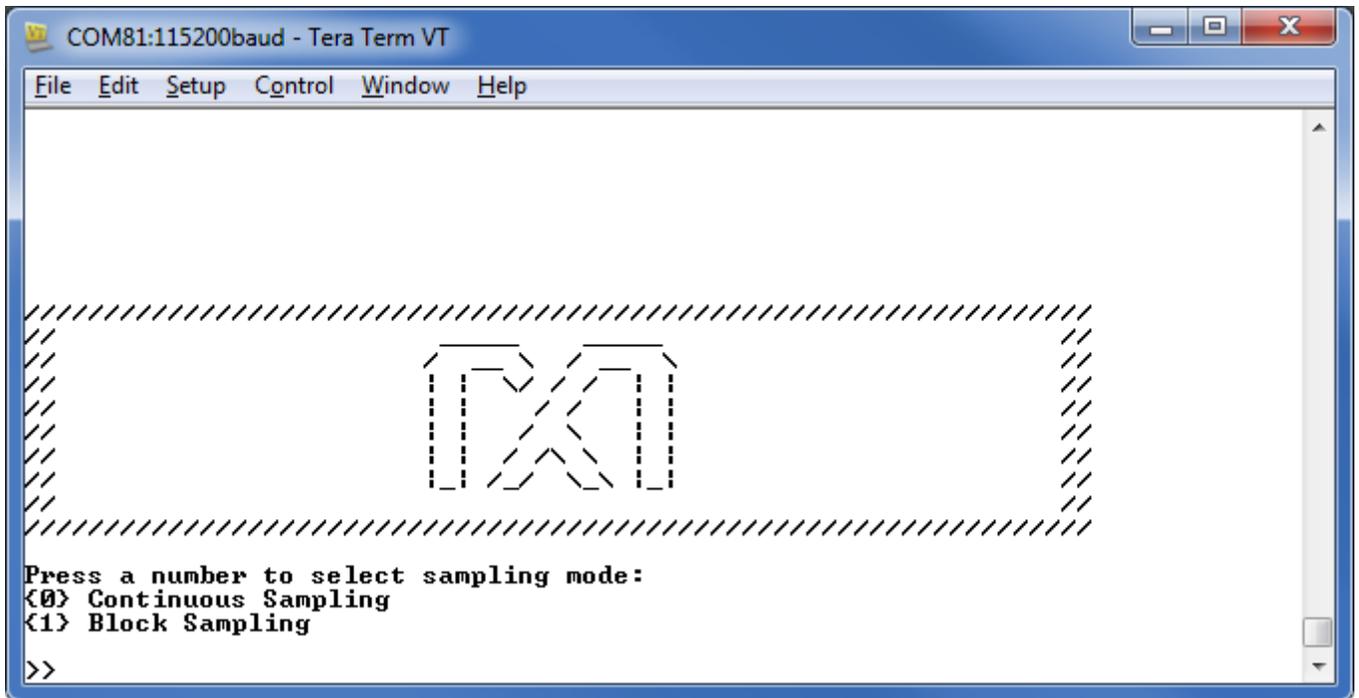


Figure 3. Terminal program main menu.

Lab Measurements

Equipment used:

- Audio Precision® SYS-2722 signal source or equivalent
- Voltage calibrator DVC-8500
- Windows PC, a USB port
- MAXREFDES38# board
- +5V power supply

Special care must be taken and the proper equipment must be used when testing the MAXREFDES38# 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, Figure 8** show the FFT and histogram test results.

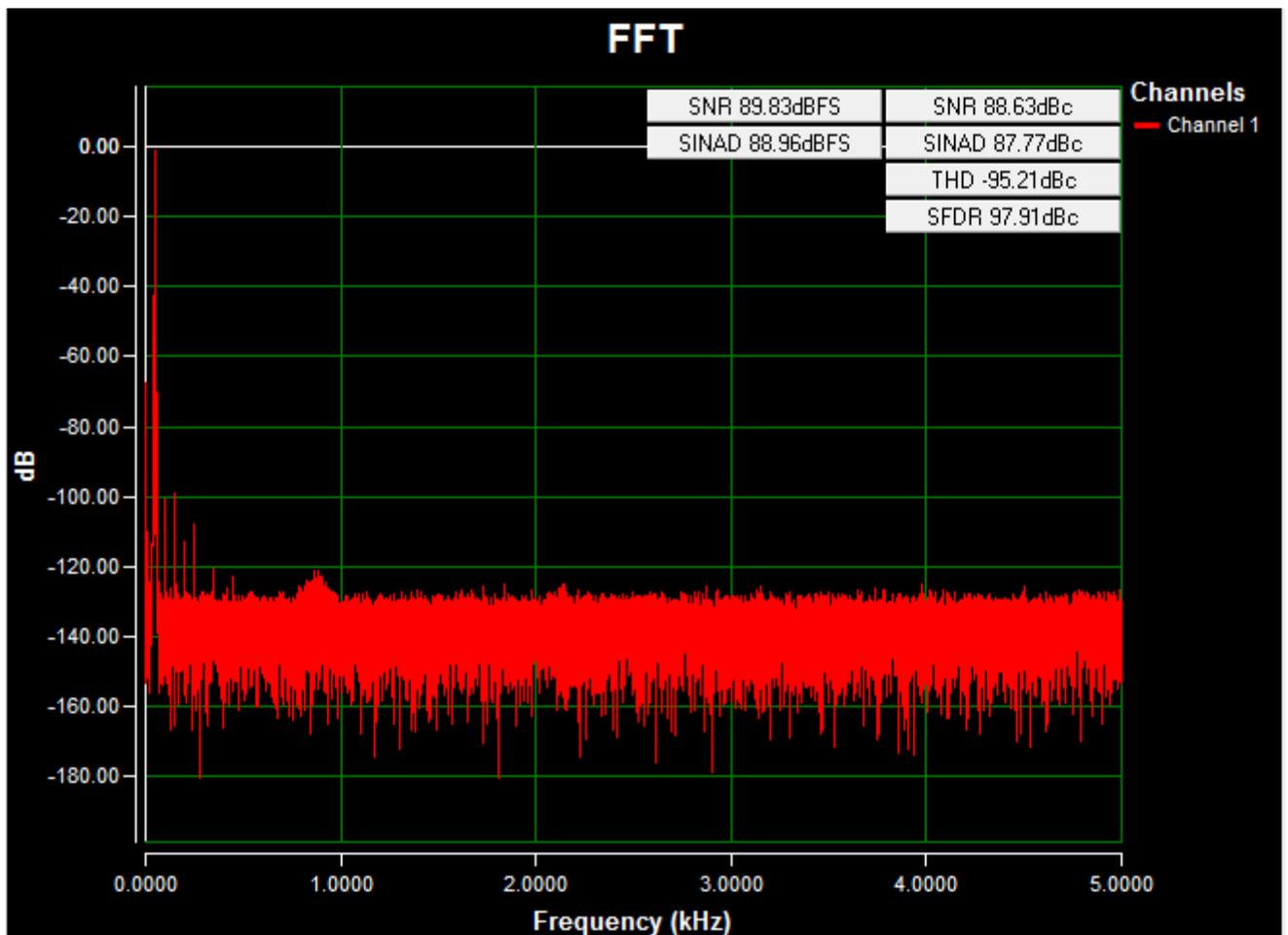


Figure 4. AC FFT using on-board power, a -1.5V to +1.5V 50Hz sine wave single-ended input signal on channel 1, a 10ksps sample rate, and a Blackman-Harris window at room temperature.

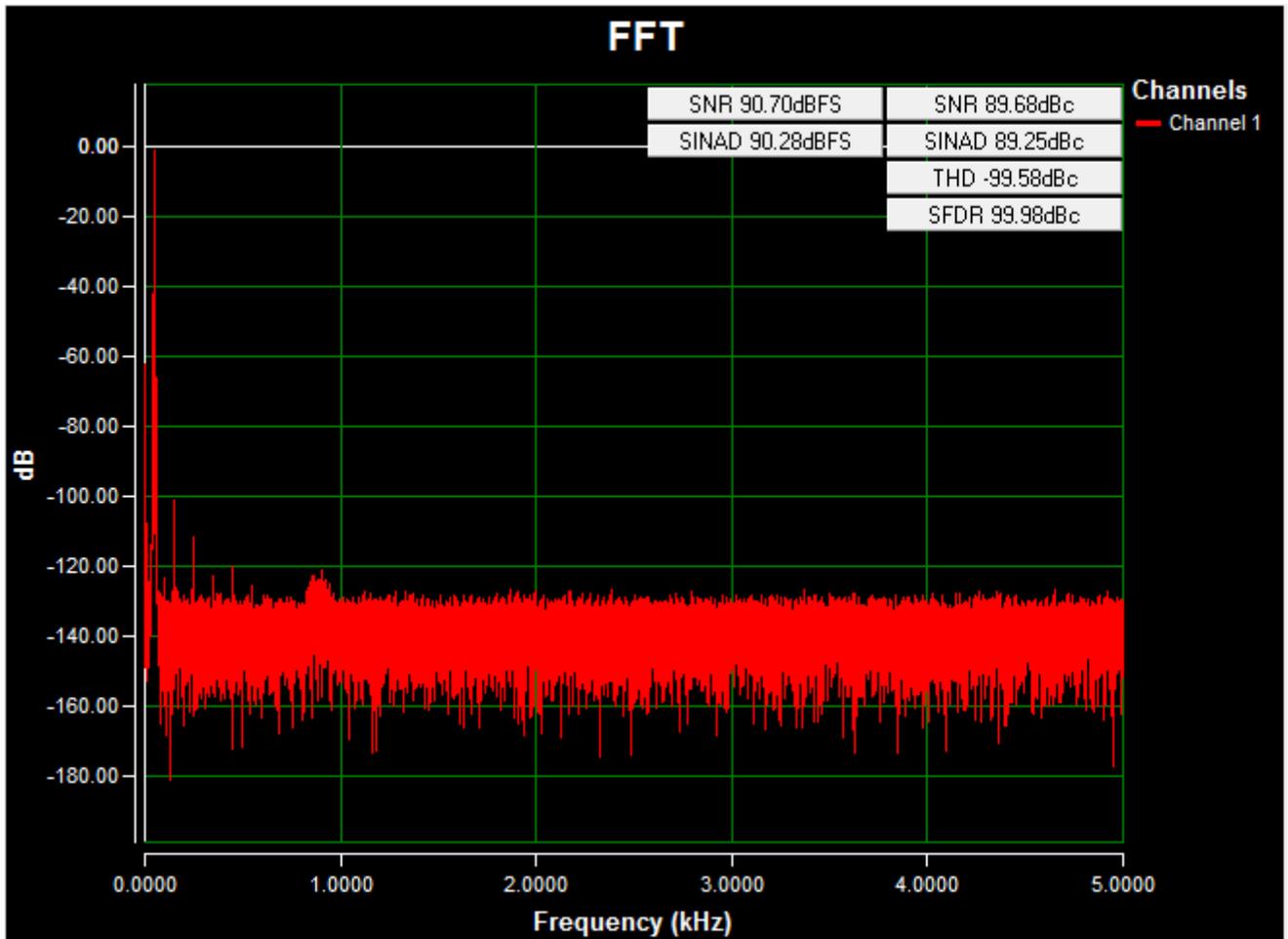


Figure 5. AC FFT using on-board power, a -3V to +3V 50Hz sine wave differential input signal on channel 1, a 10ksps sample rate, and a Blackman-Harris window at room temperature.

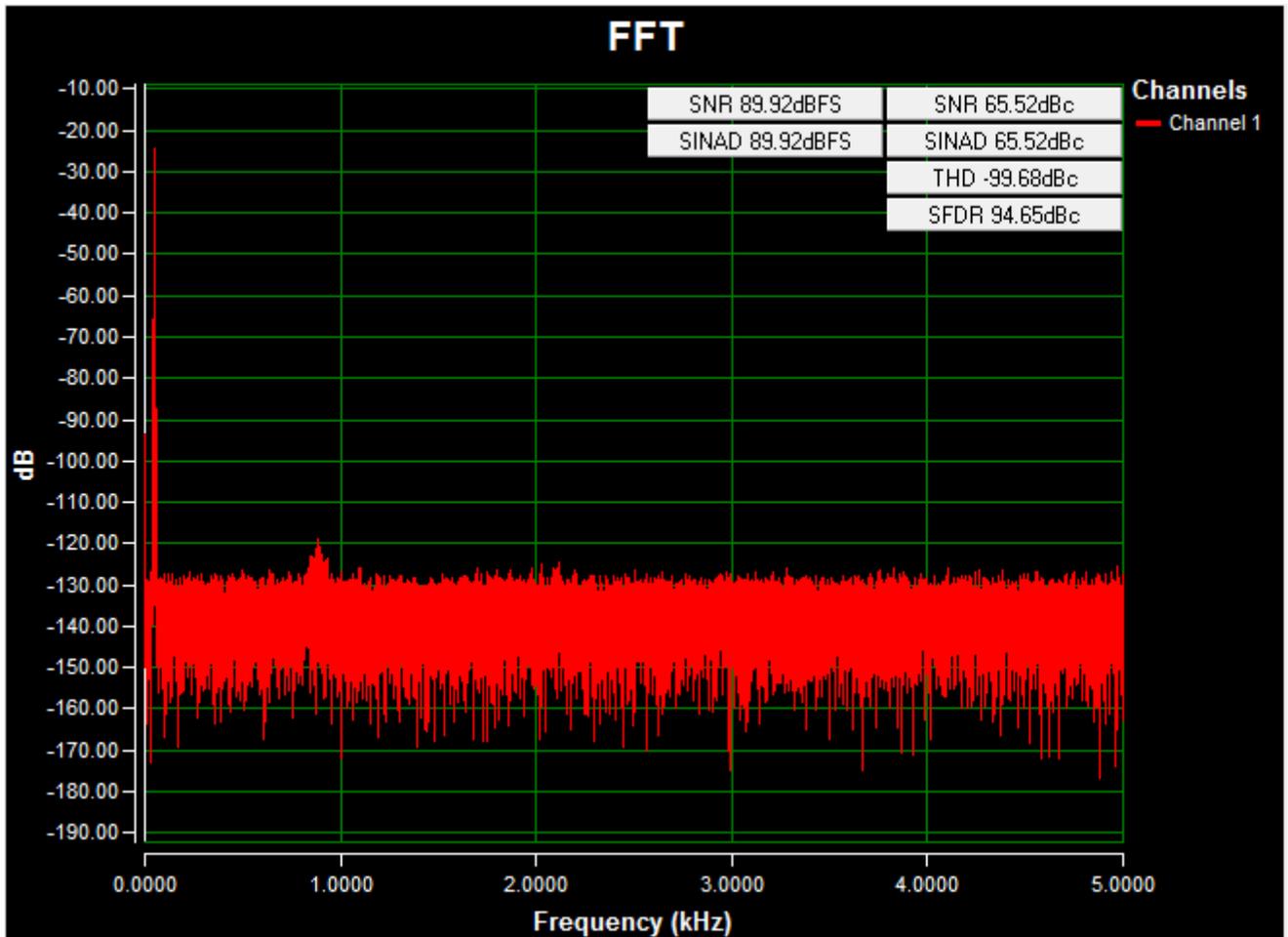


Figure 6. AC FFT using on-board power, a -100mV to +100mV 50Hz sine wave single-ended input signal on channel 1, a 10ksps sample rate, and a Blackman-Harris window at room temperature.

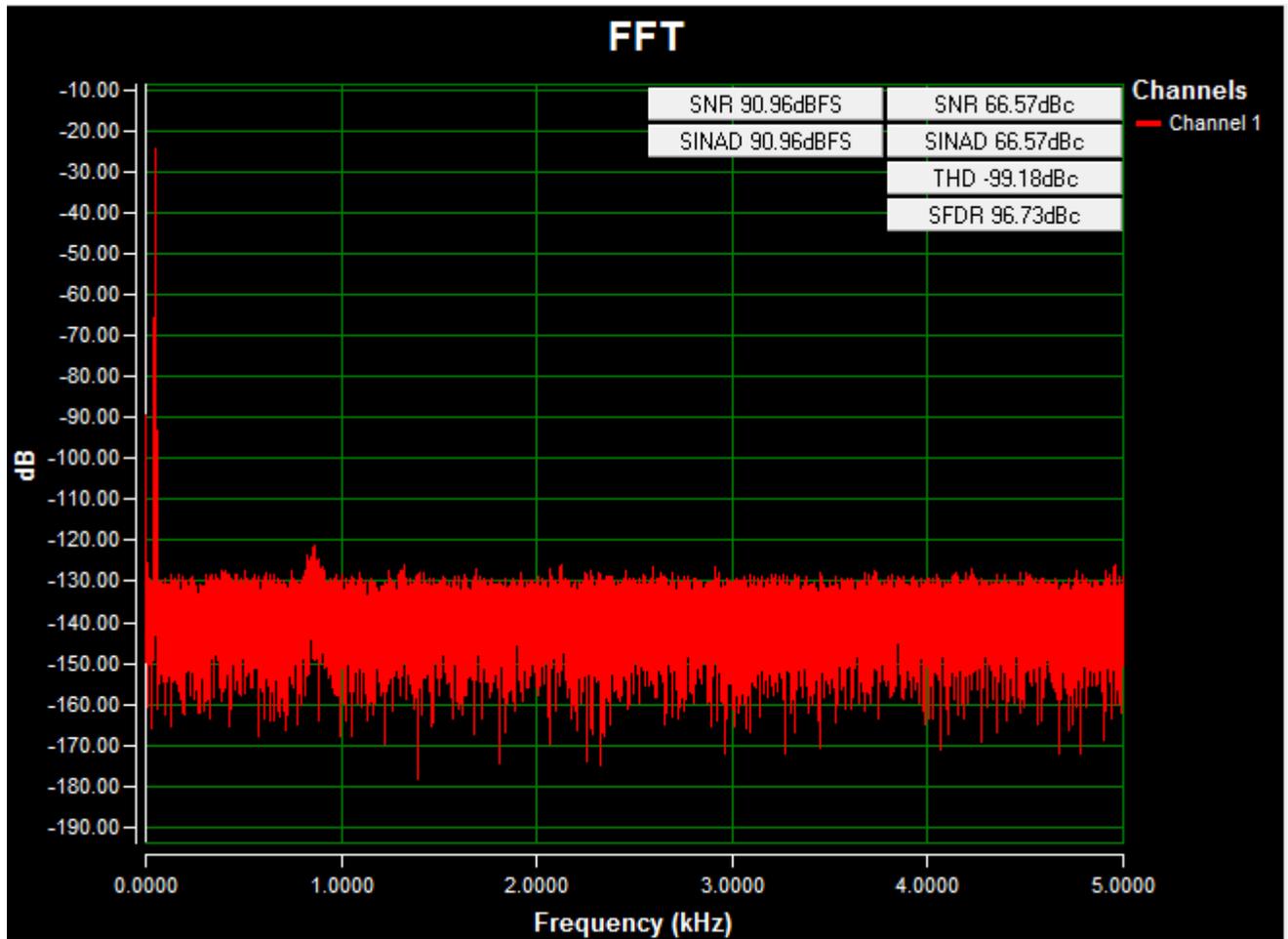


Figure 7. AC FFT using on-board power, a -200mV to +200mV 50Hz sine wave differential input signal on channel 1, a 10ksps sample rate, and a Blackman-Harris window at room temperature.

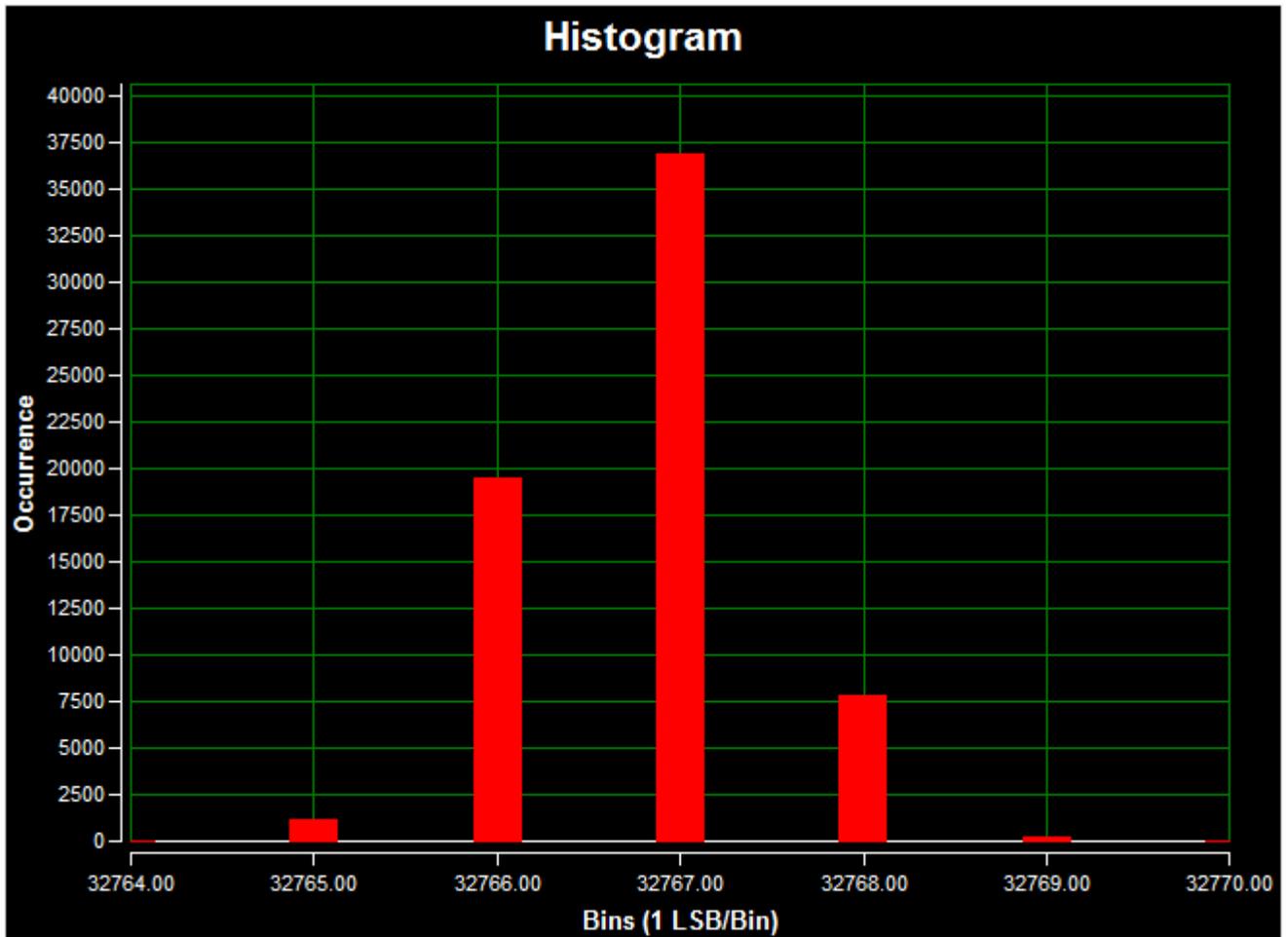


Figure 8. DC histogram using on-board isolated power; a 0V input signal on channel 1; a 50ksps sample rate; 65,536 samples; a code spread of 7 LSBs with 98% of the codes falling within the three center LSBs; and a standard deviation of 0.678 at room temperature.