Keywords: Petaluma MAXREFDES30, 16-bit 8-channel simultaneous-sampling analog front end

SUBSYSTEM BOARD 5827

# Petaluma (MAXREFDES30#): 8-Channel Simultaneous-Sampling Analog Front End

Apr 28, 2014

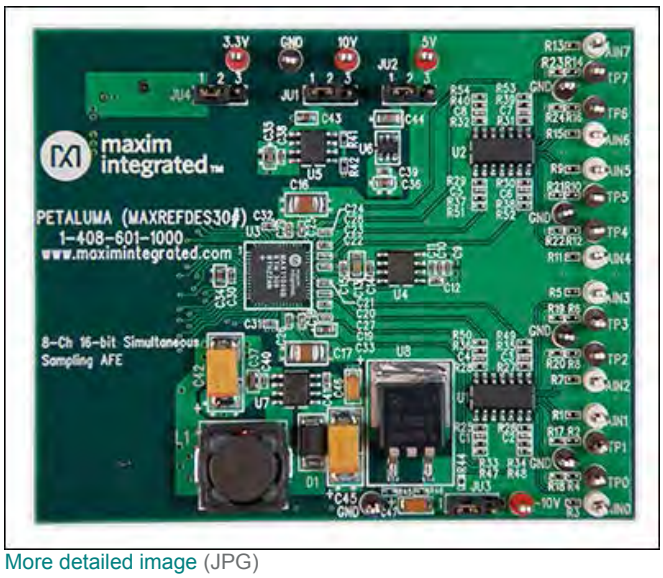
*Abstract: The Petaluma (MAXREFDES30#) subsystem reference design is a cost optimized, high-speed and high-accuracy analog measurement solution for three-phase power monitoring applications. Hardware, firmware, design files, and lab measurements provide complete system information for rapid prototyping and development.*

## Introduction

Three-phase power measurement applications require multiple analog inputs for voltage and current measurements on each line of the three-phase system. A power monitoring system must sample all of the analog inputs simultaneously to accurately calculate the instantaneous power consumption.

The Petaluma (MAXREFDES30#) subsystem reference design provides eight high-speed, 250ksps, 16-bit simultaneous-sampling analog input channels that accept ±10V input signals.

The Petaluma design utilizes two quadruple ultra-precision, ultra-low-noise input buffers (MAX44252); an 8-channel, 16-bit simultaneous-sampling ADC (MAX11046B); an ultra-high precision 4.096V voltage reference (MAX6126); and regulated +10V, -10V, and +5V power rails (MAX1659, MAX765/LM337, MAX8881). In addition to three-phase power measurement applications, this subsystem also performs well in any application that requires multiple simultaneous sampling of analog inputs, such as multiphase motor control and industrial vibration sensing.




More detailed image (JPG)

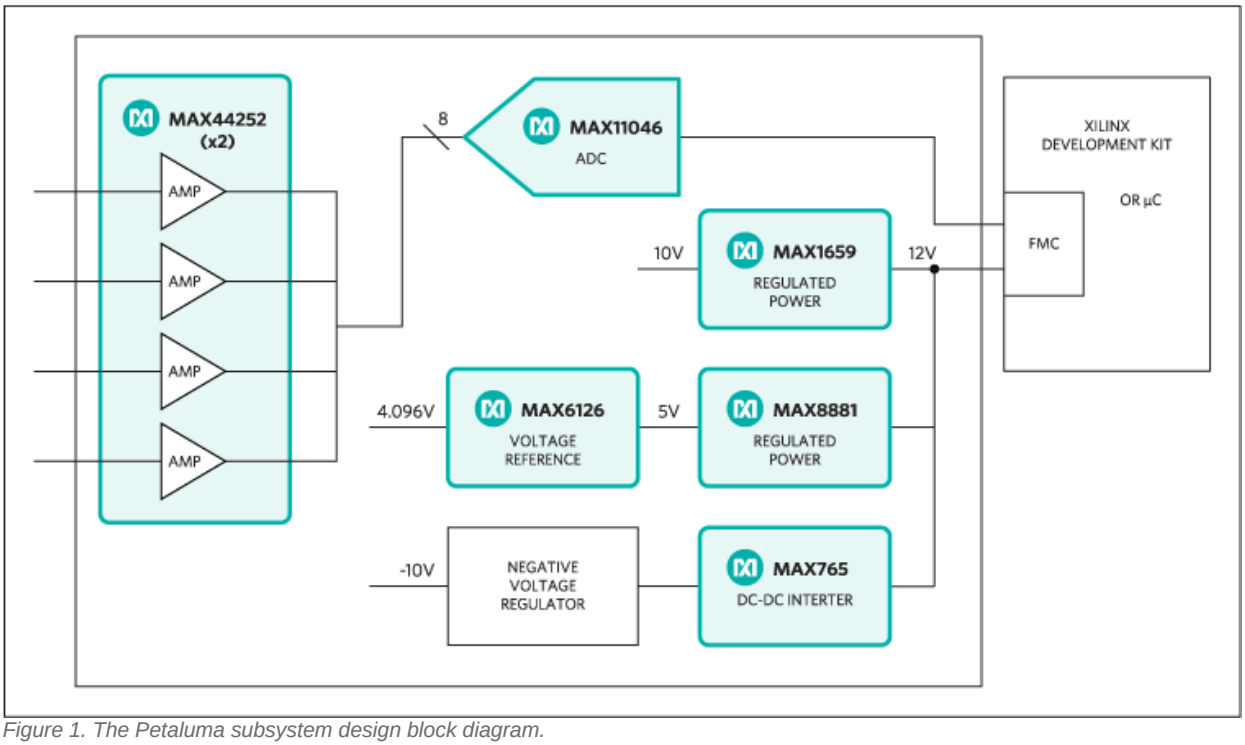



*Figure 1. The Petaluma subsystem design block diagram.*

## Features

- High precision, 8-channel, simultaneous-sampling inputs
- High-speed 250ksps sampling rate
- High-accuracy 16-bit resolution
- Device drivers
- Example C source code
- Configuration files for ZedBoard™ platform
- FMC-compatible

## Competitive Advantages

- High-performance energy measurement subsystem
- Cost optimized
- Energy efficient

## Applications

- Three-phase power measurement
- Power grid protection
- Multiphase motor control
- Vibration and waveform analysis

## Detailed Description of Hardware

The Petaluma subsystem is optimized for applications that use multiple high-speed, high-accuracy, simultaneous-sampling analog inputs. **Figure 1** shows the block diagram of the Petaluma reference design.

The MAX44252 devices (U1 and U2) are quadruple ultra-precision, low-noise op amps. The op amps attenuate and buffer the ±10V input signals to match the input range of the ADC (MAX11046). The MAX44252 devices are set up in the inverting configuration, so the polarity of the signal is reversed at the input of the ADC. The formula to convert the ADC code to voltage is: 10-CODE/65536*20.

The MAX11046 (U3) is a low-cost, 8-channel, 250ksps, 16-bit, single-supply, bipolar, simultaneous-sampling ADC.

Although the MAX11046 ADC has an internal 4.096V voltage reference, Petaluma uses an external MAX6126 (U4) voltage reference to provide the highest possible accuracy. The MAX6126 has an initial accuracy of 0.02% and a 3ppm/°C maximum temperature coefficient (tempco).

By default, the Petaluma is powered from the 12V and 3.3V outputs of the FMC connector on the ZedBoard, if all shunts are installed in the 1–2 position. The MAX1659 (U5) and MAX8881 (U6) provide post-regulated 5V and 10V rails. The MAX765 DC-DC inverter and LM337 negative LDO produce the -10V rail. To use external power supplies, move the shunts on all jumpers to the 2–3 position. Connect the ground terminal of the external power supplies to the GND connector. Connect the 3.3V, 5V, 10V, and -10V supplies to the corresponding connectors on the board.

Petaluma connects to FMC-compatible field-programmable gate array (FPGA)/microcontroller development boards. Petaluma requires supply voltages of 3.3V and 12V from the FMC connector and uses the pin assignments illustrated in **Figure 2**.

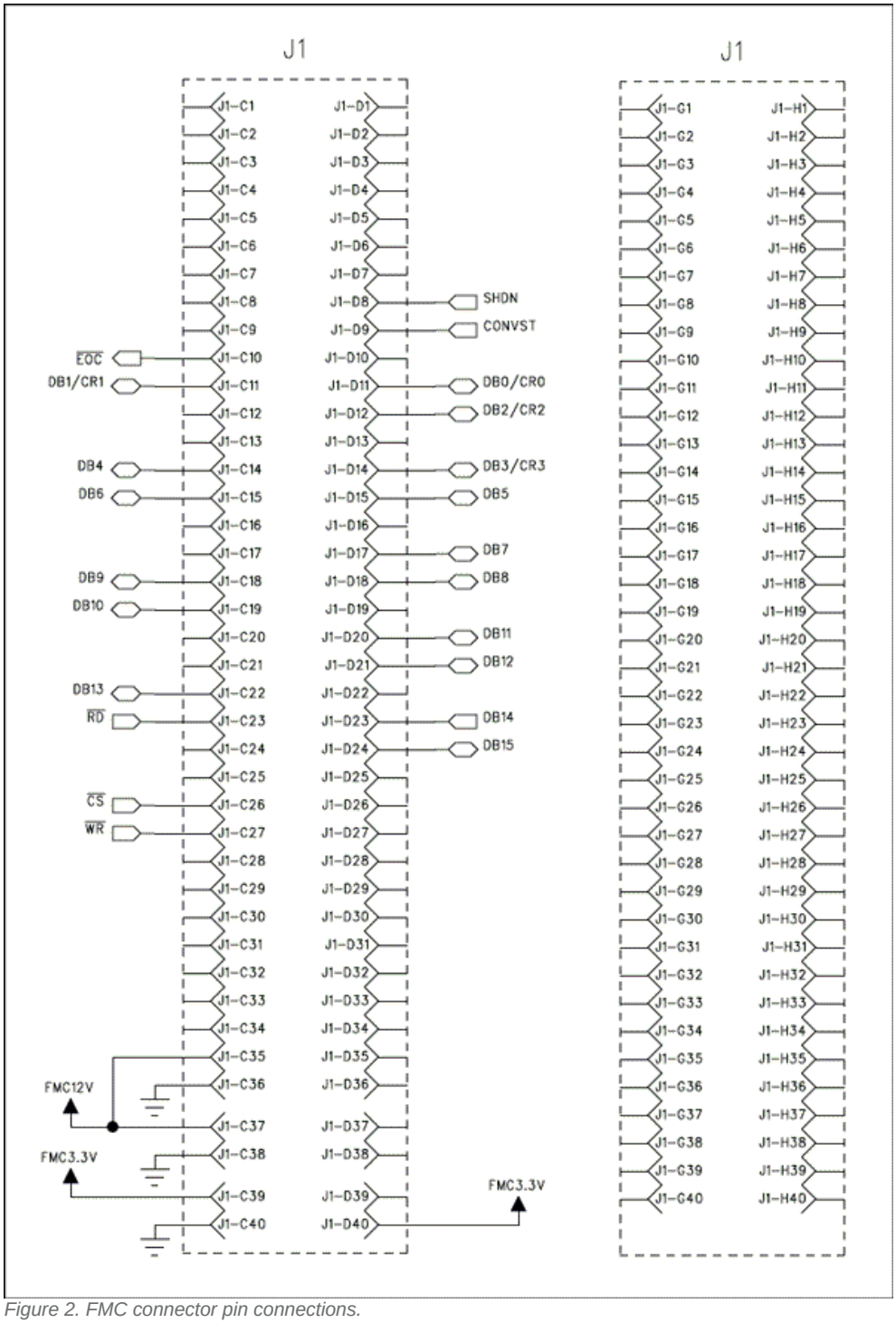



*Figure 2. FMC connector pin connections.*

**Table 1** shows the power requirements. **Table 2** shows currently supported platforms and ports.

| Table 1. Power Requirement for the Petaluma Subsystem Reference Design | | | |
|---|---|---|---|
| **Power Type** | **Jumper Shunt** | **Input Voltage (V)** | **Input Current (mA, typ)** |
| On-board power | JU1–JU4: 1–2 | 3.3 | 6.2 |
| | | 12 | 70 |
| External power | JU1–JU4: 2–3 | 3.3 | 6.2 |
| | | 5 | 41.4 |
| | | 10 | 9.4 |
| | | -10 | 9.4 |

| Table 2. Supported Platforms and Ports | |
|---|---|
| **Supported Platforms** | **Ports** |
| ZedBoard platform (Zynq®-7020) | J1 |

## Detailed Description of ZedBoard Firmware

Table 2 shows the currently supported platforms and ports. Support for additional platforms may be added periodically under Firmware Files in the All Design Files section.

The Petaluma firmware released for the ZedBoard kit targets an ARM® Cortex®-A9 processor placed inside a Xilinx Zynq system-on-chip (SoC).

The firmware is a working example of how to interface to the hardware, collect samples, and save them to memory. **Figure 3** shows the process flow. The firmware is written in C using the Xilinx SDK tool, which is based on the Eclipse open source standard. Custom Petaluma-specific design functions were created utilizing the AXI MAX11046 custom IP core. The firmware supports the maximum ADC sampling rate at 250ksps.

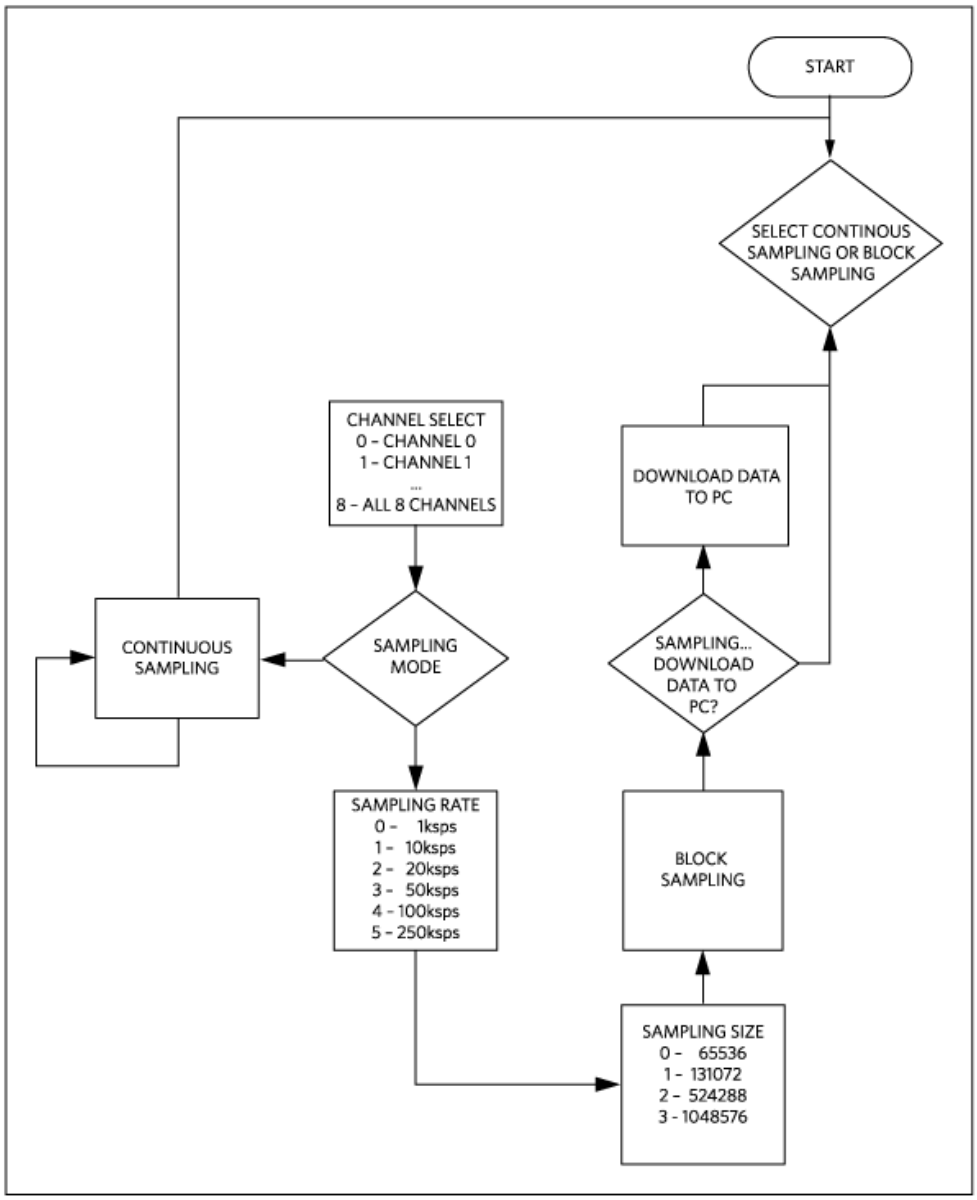



*Figure 3. The Petaluma firmware flowchart.*

The firmware accepts commands, configures the ADC, and is capable of downloading blocks of sampled data to a standard terminal program through a virtual COM port. The complete source code is provided to speed up customer development. The corresponding firmware platform files contain code documentation.

## Quick Start

Required equipment:

- Windows® PC with two USB ports
- Petaluma (MAXREFDES30#) board
- Petaluma-supported platform (i.e., ZedBoard kit)
- Industrial signal source

Download, read, and carefully follow each step in the appropriate Petaluma (MAXREFDES30#) ZedBoard Quick Start Guide.

## Lab Measurements

Equipment used:

- Audio Precision® SYS-2722 signal source or equivalent
- Voltage calibrator DVC-8500
- Windows PC with two USB ports
- Petaluma (MAXREFDES30#) board
- ZedBoard kit

Take special care and use proper equipment when testing the Petaluma design. Duplication of the presented test data requires a signal source with higher accuracy than the design being tested. 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.

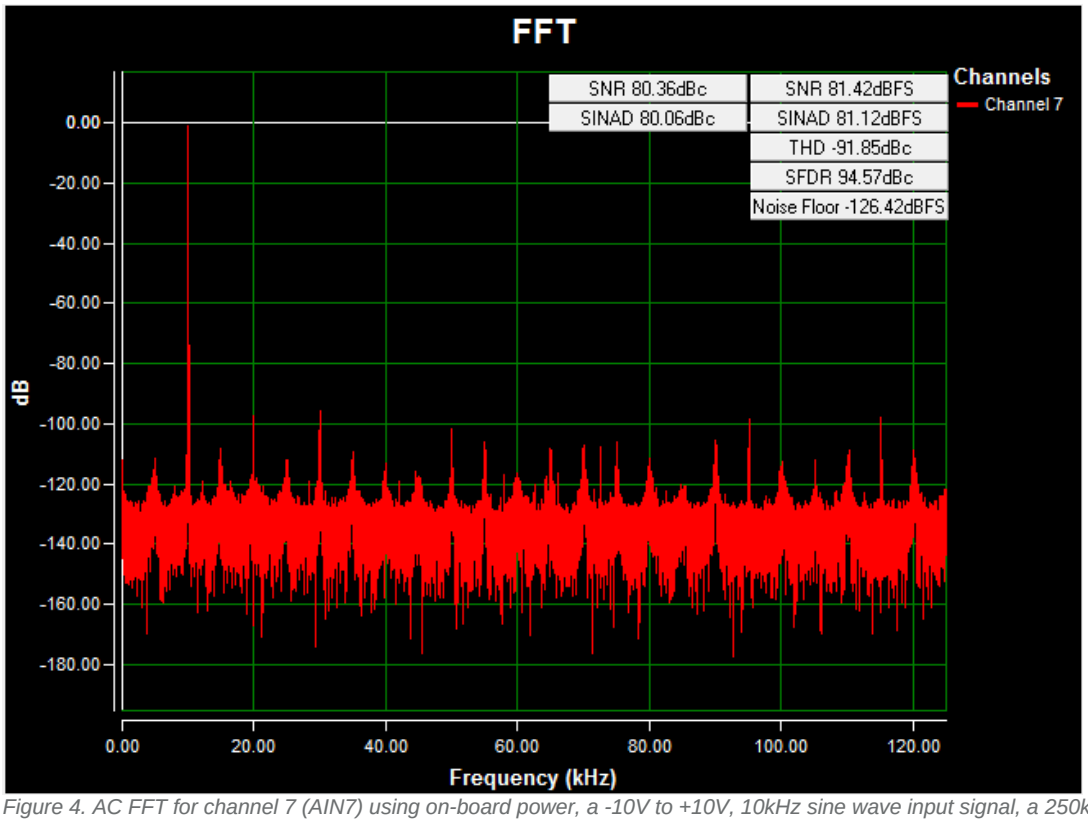



*Figure 4. AC FFT for channel 7 (AIN7) using on-board power, a -10V to +10V, 10kHz sine wave input signal, a 250ksps sample rate, and a Blackman-Harris window at room temperature.*

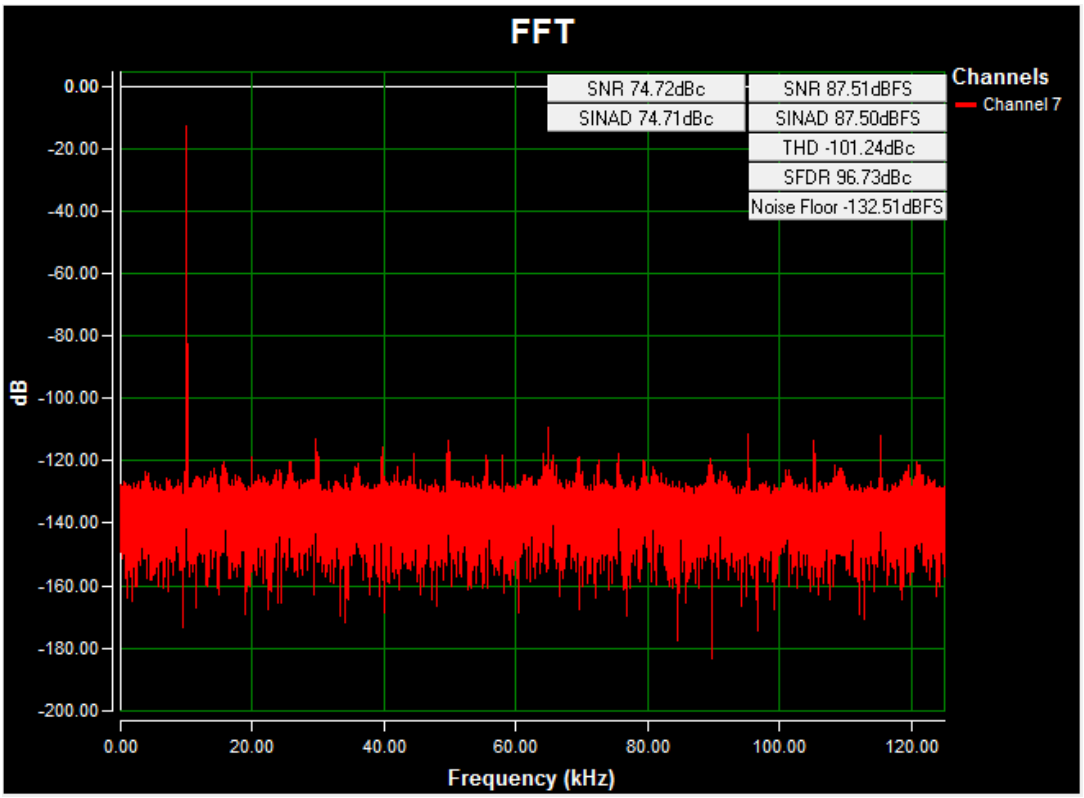



*Figure 5. AC FFT for channel 7 (AIN7) using on-board power, a -2.5V to +2.5V, 10kHz sine wave input signal, a 250ksps sample rate, and a Blackman-Harris window at room temperature.*

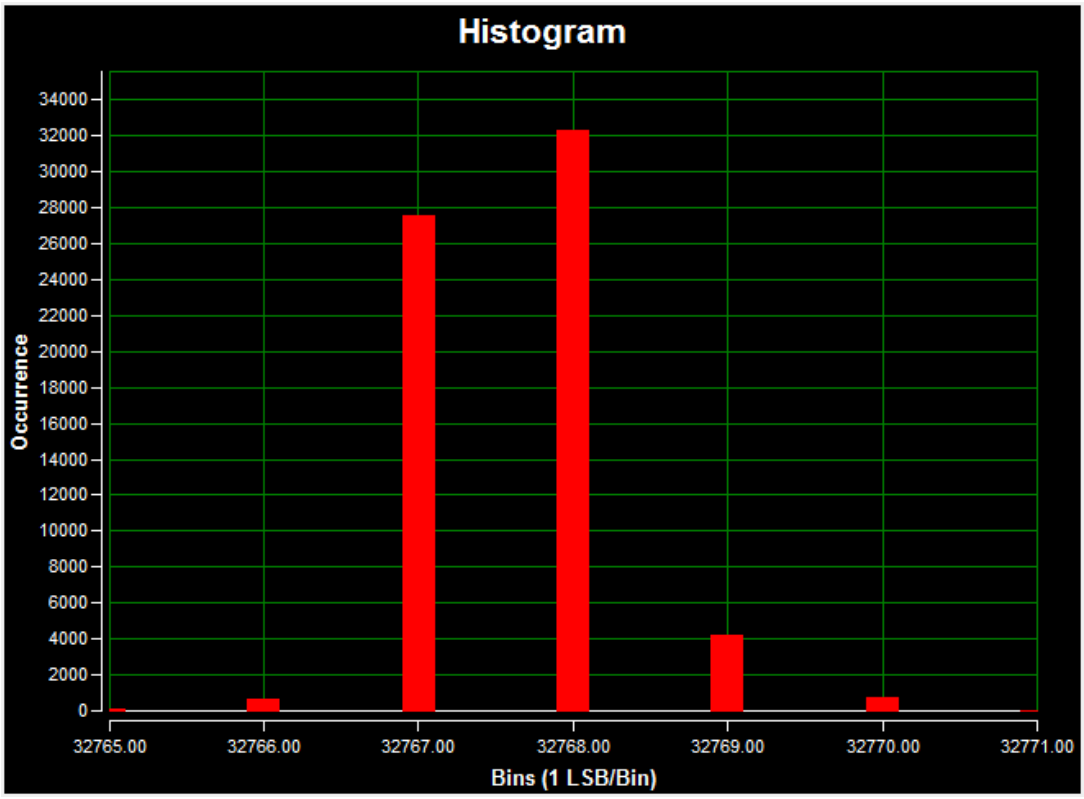



*Figure 6. DC histogram for channel 7 (AIN7) using on-board pwer; a 0V DC input signal; a 250ksps sample rate; 65536 samples; a code spread of 21 LSBs with 97.7% of the codes falling within the three center LSBs; and a standard deviation of 0.711 at room temperature.*

## All Design Files

Download All Design Files

### Hardware Files

Schematic
Bill of materials (BOM)
PCB layout
PCB Gerber
PCB CAD (PADS 9.0)

### Firmware Files

ZedBoard Platform (Zynq-7000)

## Buy Reference Design

Buy Direct: Petaluma (MAXREFDES30#)

Or

Order the Petaluma reference design (MAXREFDES30#) from your local Maxim representative.

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| Related Parts | | |
|---|---|---|
| MAX11046B | 4-/6-/8-Channel, 16-/14-Bit, Simultaneous-Sampling ADCs | Free Samples |
| MAX1659 | 350mA, 16.5V Input, Low-Dropout Linear Regulators | Free Samples |
| MAX44252 | 20V, Ultra-Precision, Low-Noise Op Amps | Free Samples |
| MAX6126 | Ultra-High-Precision, Ultra-Low-Noise, Series Voltage Reference | Free Samples |
| MAX765 | -5V/-12V/-15V or Adjustable, High-Efficiency, Low-$I_Q$ DC-DC Inverters | Free Samples |
| MAX8881 | 12V, Ultra-Low-$I_Q$, Low-Dropout Linear Regulators with POK | Free Samples |

**More Information**
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Application Note 5827: http://www.maximintegrated.com/an5827
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