Application Brief

Precision ADC for Measuring Analog Outputs of Parametric Measurement Unit (PMU)

Rahul Kulkarni

Precision ADC

Introduction

An automated test equipment (ATE) rack contains a variety of instrumentation cards to enable testing of semiconductors. One example is a voltage-current (VI) source card. The function of the VI card is to provide precise and stable voltage and current sources, which are essential for testing the electrical properties of semiconductor devices. During testing, the VI card is typically connected to the device under test (DUT), and the voltage and current supplied by the card are used to stimulate the DUT and measure the response with an analog- to-digital converter (ADC). The results of these measurements can then be analyzed to determine the electrical performance of the device, and to identify any potential defects.

VI cards are designed for a wide range of applications, and include features such as high accuracy, high resolution, fast response time, with programmable voltage and current ranges. Some VI cards also include additional functions, such as data acquisition and processing capabilities, for more advanced testing and analysis.

The VI card contains several channels of the subsystem shown in Figure 1. A higher number of VI channels allows parallel testing of DUTs while reducing test-time and cost.

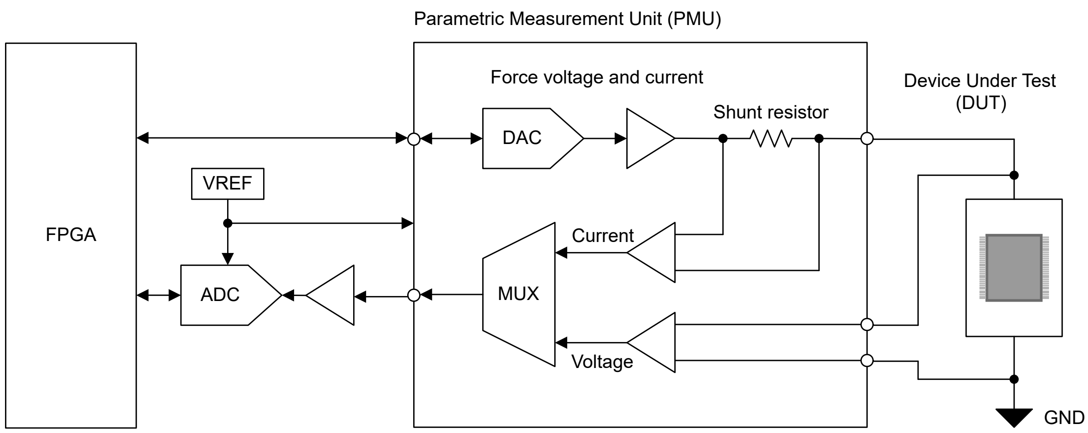

Figure 1. Pin-Electronics Subsystem in an ATE Simplified Block Diagram

ADC for Pin Electronics

A parametric measurement unit (PMU) generates the stimulus (voltage and current) for the DUT and has an analog signal-chain to sense voltage and current from the DUT. The PMU can be a separate component or integrated in an application-specific integrated circuit (ASIC). A precision ADC digitizes the analog measurement output of the PMU to make sure that the test results are repeatable and consistent, which is important for the quality control and manufacturing processes in the semiconductor industry.

The ADS9817 is an eight-channel data acquisition (DAQ) system based on an 18-bit successive-approximation register (SAR) architecture. The ADS9817 features a complete analog front end for each channel with an overvoltage input clamp, 1-MΩ input impedance, independently programmable gain amplifier (PGA), programmable low-pass filter (LPF), and an ADC input driver. The ADC also features a low-drift, precision reference with a buffer to drive the ADCs.

The user-programmable analog input ranges of ADS9817 enable direct interface with the analog measurement output of a PMU. This reduces the error contribution from additional amplifiers between the PMU output and ADC input.

The measurement accuracy of the pin-electronics subsystem, in a given temperature range, depends on the thermal drift of errors of the PMU and the ADC. A heat sink can be used to reduce the temperature variation of the PMU and ADC. The measurement accuracy of the ADC can be calculated using total unadjusted error (TUE) as shown in Table 1. For increased accuracy, the PMU and ADC can share a common reference voltage as shown in Figure 2. The offset and gain errors in the measurement can be calibrated using a calibration circuit on the VI card to increase accuracy.

Table 1. Measurement Accuracy of ADS9817 Under Various Operating Conditions

Condition	INL (ppm)	Offset Error (ppm)	Gain Error (ppm)	TUE (ppm)	Accuracy
TUE at 25°C	9.5	25	305	306	0.0306%
TUE at 25°C after calibration	9.5	0	0	9.5	0.0009%
TUE at 25°C ±5°C after calibration	9.5	2.5	5	11	0.0011%

The pin-electronics subsystem can have either multiplexer or switches to connect multiple PMU outputs to one ADC channel as shown in Figure 2. This allows higher channel count of pin-electronics on the VI card. The sampling rate and analog input bandwidth must be high enough to accurately capture the fast-changing signals produced by PMUs, which can result in significant errors in the measurement.

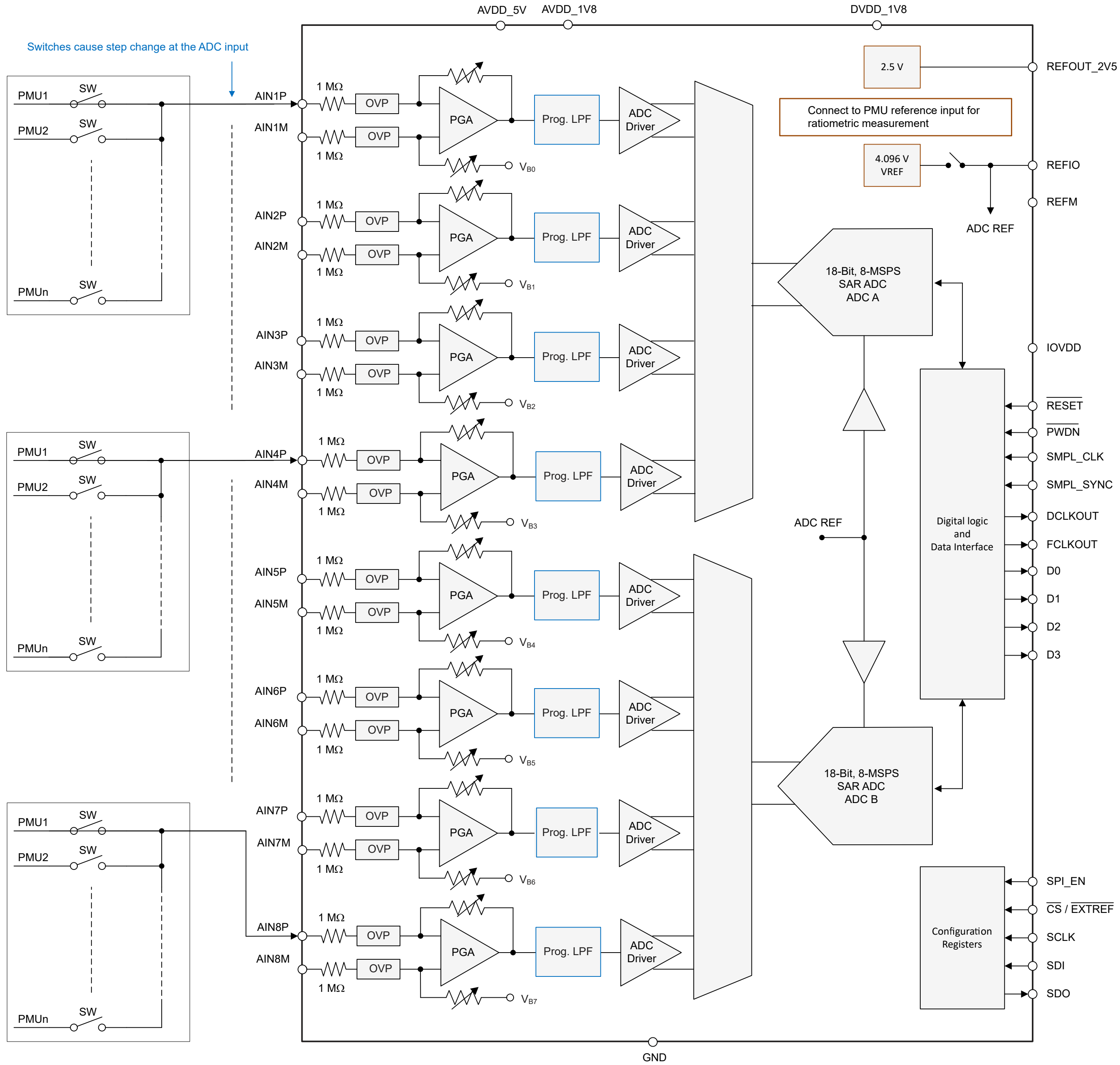

Figure 2. Multiplexed PMU Outputs in Pin Electronics

The ADS9817 features 2 MSPS / channel sampling rate with user-selectable analog input bandwidth up to 400 kHz as shown in Figure 3 and Figure 4. Wide analog input bandwidth allows the ADS9817 to sample fast-changing signals at the analog inputs of the ADC as shown in Figure 5 and Figure 6.

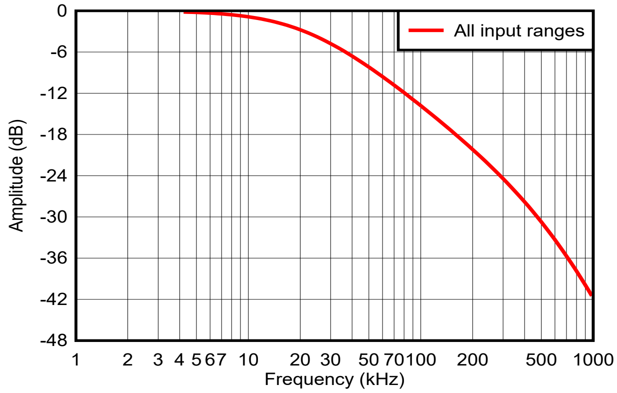

Figure 3. Low-Noise LPF Frequency Response Across Input Ranges

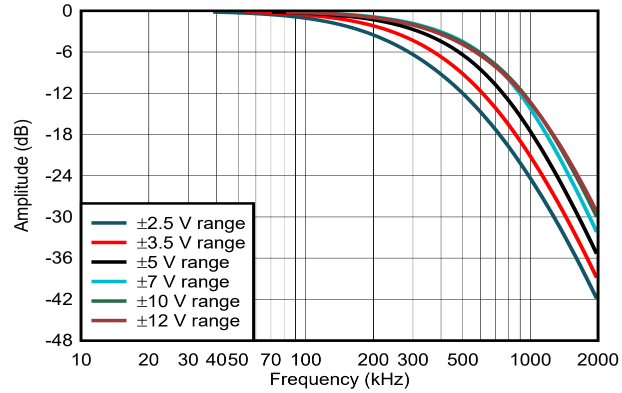

Figure 4. Wide-Bandwidth LPF Frequency Response Across Input Ranges

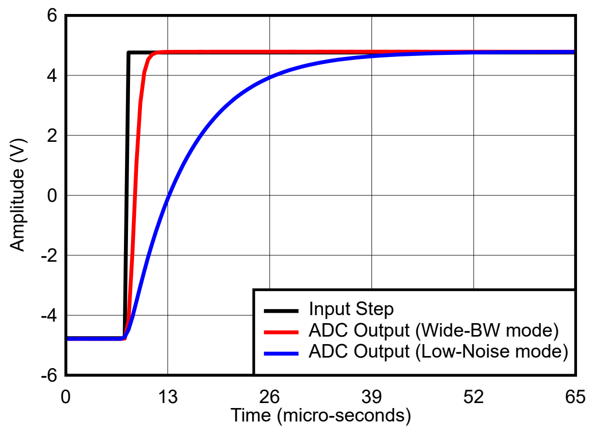

Figure 5. Settling Time for Bipolar Step at ADS9817 Analog Inputs in ±5-V Range

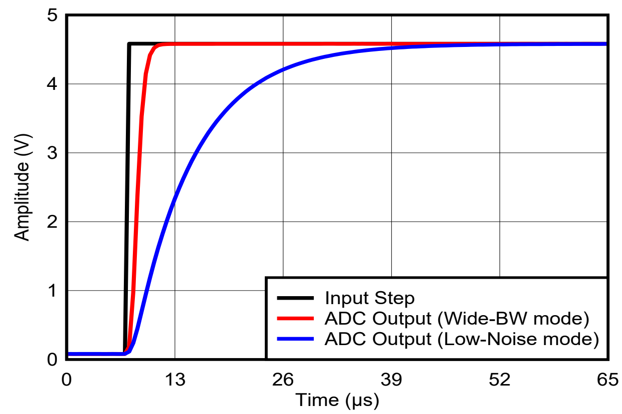

Figure 6. Settling Time for Unipolar Step at ADS9817 Analog Inputs in ±5-V Range

The data transmission must be fast and reliable, with low-latency to transmit the measured data to the field-programmable grid array (FPGA) in real time to minimize delays in testing the DUT. The ADS9817 features a source-synchronous interface that is optimized for high-speed data transfer with FPGAs. The ADS9817 outputs data and data-clock thereby eliminating the delays associated with SPI. This simplifies timing closure on FPGA for the high-speed ADC data interface. The ADS9817 supports a digital interface compatible with 1.2-V to 1.8-V IO levels that eliminates the need for external logic-level translators and associated propagation delays.

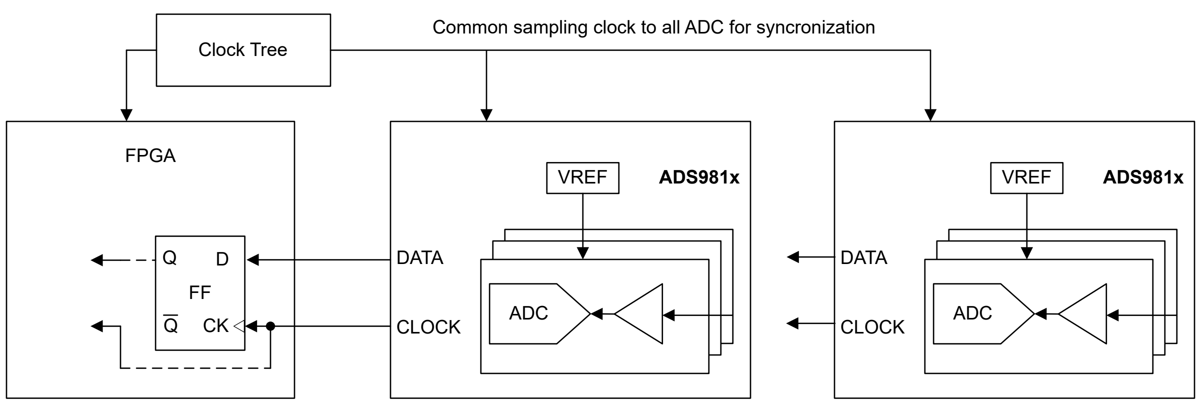

Figure 7. Source-Synchronous High-Speed Data Interface with FPGA

A high channel count VI card can be realized using the 8-channel ADS9817 that interfaces directly with analog outputs of a PMU and digital inputs of an FPGA.