*Technical Article*

# *How to monitor automated testers and encoders*

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An analog-to-digital converter (ADC) uses simultaneous sampling to monitor and control voltage and current in systems designed to accurately monitor and control vital electrical parameters, including current, voltage and power. Some of the most important parameters are speed and accuracy, which help maximize signal-chain performance. In addition, ADCs with increased channel density can help reduce board sizes and increase the amount of data going through a given board. In this technical article, I'll explain how higher-precision and higher speed ADCs can enable greater accuracy and faster throughput in systems with higher site counts such as automated semiconductor testers, data acquisition equipment and high-end linear encoders.

### Automated semiconductor testers

Channel density plays a crucial role in semiconductor test equipment, especially automated memory test equipment. A higher channel density enables test equipment to accommodate more test sites and increase throughput for the semiconductor content under examination. Leveraging an ADC with an increased channel count in a smaller package increases the achievable channel densities. However, even with high channel counts, it's important to optimize the bandwidth and settling time of the ADC. Higher bandwidth and reduced settling time reduce signal throughput time, which decreases the overall test time for automated semiconductor test equipment. Memory testers are typically multiplexed systems, creating a need for fast response times for the ADC to quickly capture the data on the multiplexer output.

Figure 1 shows a circuit diagram for the ADC configuration in a memory tester, while Table 1 lists the settling time and bandwidth modes of the ADS9817, an 18-bit eight-channel dual-simultaneous-sampling ADC in a 7mm-by-7mm package.

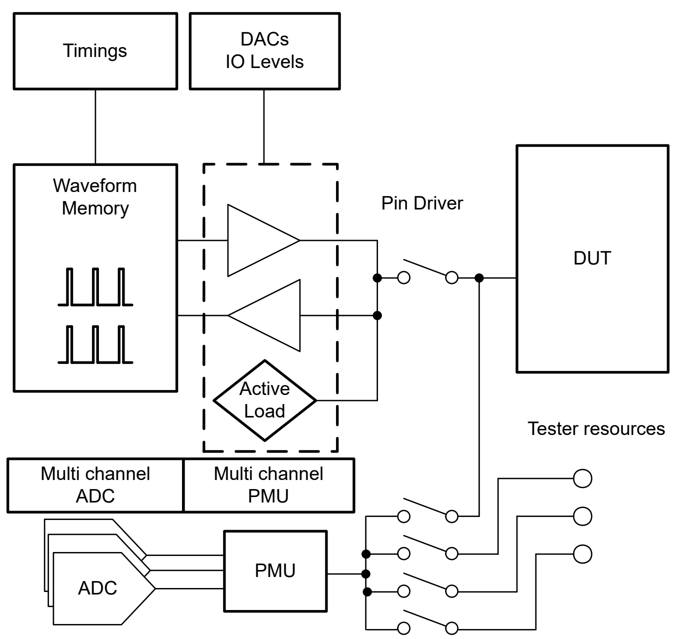


**Figure 1. Circuit diagram ADC configuration for a memory tester**

**Table 1. ADS9817 bandwidth modes**

| Bandwidth mode | Settling time (0.01% of full scale) | Signal-to-noise ratio (typical) |
|---|---|---|
| Low noise (up to 21kHz) | 2.5µs | 92dB |
| Wide bandwidth (up to 400kHz) | 69.42µs | 85.5dB |

An ADC's total unadjusted error (TUE) is another factor that affects test equipment performance and its associated calibration methods. A highly accurate device can increase the overall accuracy of a system design and lower the required calibrations. The ADS9817 has lower integral nonlinearity (INL) and ultra-low temperature with drift 0.5ppm/°C offset and 0.7ppm/°C gain drift. These specifications result in a reduced TUE, translating to reduced calibrations and increased performance for the tester. Table 2 provides insight into the TUE of the ADS9817 device.

**Table 2. Measurement accuracy of the ADS9817 under various operating conditions**

| Total unadjusted error (TUE) at 25°C | | | | | |
|---|---|---|---|---|---|
| | INL (ppm) | Offset error (ppm) | Gain error (ppm) | TUE (ppm) | Error (%) |
| TUE at 25°C | 15.26 | 495.90 | 183.10 | 528.84 | 0.053 |
| TUE at 25°C after calibration | 15.26 | 0 | 0 | 15.26 | 0.0015 |
| TUE at 25°C ±5°C after calibration | 15.26 | 2.5 | 3.5 | 15.85 | 0.0016 |

### Data acquisition equipment

High-speed data acquisition systems require a wide-bandwidth, alias-free precision signal chain to measure the outputs of high-frequency sensors, such as undamped accelerometers or wide-bandwidth current transducers. A high-speed precision ADC is required in order to capture fast transient signals accurately over a wide dynamic range. Data acquisition systems need an ADC around 20MSPS to accurately capture the wide variety of signals they may experience. The ADS9219 offers a 95dB signal-to-noise ratio at 20MSPS.

Figure 2 shows the circuit block diagram for a data acquisition system. An integrated ADC driver eases the bandwidth requirement of the front-end amplifier. This enhancement enables data acquisition systems to deliver both precision and wide bandwidth. After the ADC takes in the analog information, the data acquisition software processes the digitized data and outputs it to the user.

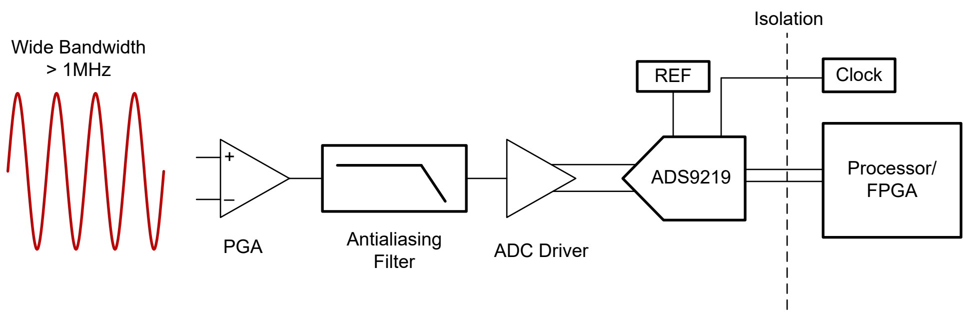


**Figure 2. Circuit diagram of an ADC configuration for data acquisition**

### Linear encoders

Analog incremental encoders output 1Vpp sine and cosine signals that an ADC digitizes in the servo drive. Interpolation of the sine and cosine signals gives the servo drive the position and speed of the motor. Two simultaneous sampling channels are required to accurately interpolate these signals. Motor-control end equipment with high accuracy requirements such as laser interferometers or high-end linear encoders can measure fast-moving motors and perform precise movements by leveraging the sine and cosine motor method. The output signal frequency of the encoder is directly related to the speed of the motor, so high-end linear encoders require a high-sampling-rate ADC.

The ADS9219 and ADS9218 are two-channel simultaneous sampling ADCs with 20MSPS or 10MSPS, respectively, perfect for measuring encoders' sine and cosine outputs. The THS4541 is a high-speed fully differential amplifier that acts as a low-power, high-performance ADC driver. These devices are good options for sine and cosine motor control, because the ADCs can capture both signals simultaneously with high bandwidth, enabling tighter control and more accurate movements. The motor controller can accurately and precisely control the electric motor using both signals in the control algorithm. Since sine and cosine signals are 90 degrees out of phase, the control algorithm can detect where the motor position is and how fast it rotates. Figure 3 shows an encoder block diagram for an incremental encoder system.

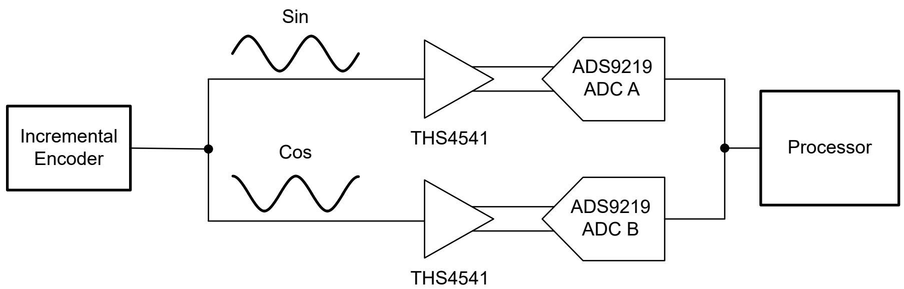


**Figure 3. Encoder block diagram with THS device**

## Conclusion

I've explained how automated semiconductor testers need high-channel density with high speed at a certain level of accuracy. Data acquisition equipment requires very high speeds to capture the signals, and high-end linear encoders that use sine and cosine control require accurate simultaneous sampling ADCs to enable precise control. The ADS9219 and ADS9817 can help you build top-tier systems with reduced size and improved operating accuracy, minimizing the required calibrations and downtime in end equipment.

## Additional resource

- Read the application note, "Simplify Antialiasing Filters with ADS9218."
- Check out the product overview, "Precision ADCs for Motor Encoders and Position Sensing."
- Learn more in the application brief, "Low Latency Signal-Chain for Measurement Unit in Digital Control Loop."
- Watch the video, "ADS9817 and ADS9813 Family of Precision ADCs."

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