Application Brief
How to Select Precision Amplifiers for Semiconductor Testers

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Introduction
Semiconductor test equipment is an important and ever-evolving industry. As semiconductors and integrated circuits continue to become more advanced and stretch the limits on electronics, test equipment must continue to improve. Texas Instruments offers a wide variety of precision amplifiers that provide the best results for testing integrated circuits.

Voltage forcing, otherwise known as device under test (DUT) or load excitation, is a key subsystem. Forcing certain voltage conditions on the semiconductor device and observing how the semiconductor reacts is important to make sure the device responds correctly. Voltage forcing must be done accurately to provide the best end results. To get accurate results, the current and voltage being applied to the DUT is measured for feedback.

DUT or Load Excitation
When a voltage or signal is applied to a pin of a semiconductor device, the digital signal from the field-programmable gate array (FPGA) controls the digital-to-analog converter (DAC). The DAC output is delivered to the power amplifier, or a gain and power amplifier combination, to be gained. The power amplifier output is then applied to the semiconductor device pins.

Depending on the application of the semiconductor test equipment, a gain stage may be necessary. Using the power amplifier in a high-gain configuration limits bandwidth; therefore, the gain must be split between a gain amplifier and the power amplifier. This split allows for a wider bandwidth while still applying a high gain to the DAC output. Splitting the gain also helps offload some of the required precision. By taking some of the gain off the power amplifier, the offset voltage and noise are not amplified, which allows for better precision.

The power amplifier is the part of the circuit that drives the test voltage. One of the most important specifications of a power amplifier is the power supply range. Depending on the type of tester being designed, different power supply ranges may be required. Automated test equipment (ATE) requires a high supply range to test a broader variety of devices. For example, the OPA462 offers a supply voltage of up to 180 V. Memory test equipment requires a specified range of –10 V to +32 V, which the OPA454 op amp can accommodate with a supply voltage range of ±50 V.

Depending on the process technology, some amplifiers may exhibit long thermal tails where settling time suffers a great deal. This phenomenon is attributed to the offset voltage drift of the amplifier. Selecting a low offset drift amplifier helps reduce the settling time significantly, and is particularly true for JFETs.

Test signals are tightly controlled to provide accurate results; therefore, a low offset drift is required to meet tolerance requirements. In addition, fast settling and high slew rate are needed for quick results because test time has a major impact in device cost. Table 1 shows the OPA454, OPA455, and OPA462 precision specifications, as well as settling time and slew rate.

<table>
<thead>
<tr>
<th>Device</th>
<th>Drift (µV/°C, max)</th>
<th>Settling Time (µs)</th>
<th>Slew Rate (V/µs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPA462</td>
<td>20</td>
<td>5 (120-V step)</td>
<td>32 (80-V step)</td>
</tr>
<tr>
<td>OPA454</td>
<td>10</td>
<td>10 (80-V step)</td>
<td>13 (80-V step)</td>
</tr>
<tr>
<td>OPA455</td>
<td>20</td>
<td>5.2 (120-V step)</td>
<td>32 (80-V step)</td>
</tr>
</tbody>
</table>

In addition to wide power supply ranges, precision, and fast settling, other features are necessary to maintain a robust output stage capable of driving a variety of loads. Features such as high output load drives, thermal protection, current limit protection, and an independent output disable can not only protect the circuit from overloads, but interface with low-voltage circuitry without compromising the input signal or power budgets.
Voltage and Current Feedback

Voltage and current feedback measurements are necessary to make sure the correct conditions are forced on the device. Figure 1 shows that current measurement is implemented using an instrumentation amplifier (IA), and voltage measurement is implemented using a voltage divider, both feeding into separate analog-to-digital converters (ADCs) with a driver.

![Figure 1. Typical Block Diagram for Semiconductor Testers](image)

Before the differential signal can be sent to the ADC; however, the ADC must be driven by a precision amplifier to attain acceptable system accuracy. This requirement is mostly because most difference amplifiers, or IAs, are not optimized for low noise, and cannot settle the signal during the ADC acquisition time. An exception is the INA849, which offers an ultra-low noise floor and a fast settling time.

For accurate results, an ultra-low noise amplifier must be used to drive the ADC. The OPA2210 offers a low 1/f and broadband noise with sufficiently high bandwidth to avoid compromising signal processing.

The feedback difference amplifier and ADC driver can be combined using the industry’s first 36-V, precision, fully-differential amplifier, the THP210. The THP210 has a wide supply range of 3 V to 36 V, which provides a wider dynamic range. These features not only save board space, but also maintain signal integrity and achieve accurate results.

For voltage measurements, a voltage divider is applied close to the DUT. The output of the voltage divider is sent to an ADC using a driver that must also buffer the signal. The OPA2182 offers excellent offset drift using the zero-drift technology from TI. The device low offset drift eliminates the need for calibration for temperature and can be used as a buffer and driver combination, which decreases board size and circuit complexity.

Conclusion

Texas Instruments offers a wide variety of precision amplifiers that can be used across multiple platforms for ATE and memory testers. In DUT excitation, precision amplifiers are used to apply the correct voltage and measure the forced voltage for feedback.

Table 2 shows a summary of related devices.

<table>
<thead>
<tr>
<th>Device</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>INA849</td>
<td>Ultra-low noise (1 nV/√Hz), high-speed (28 MHz, 35 V/μs), precision (35 μV), instrumentation amplifier</td>
</tr>
<tr>
<td>INA149</td>
<td>550-V, high common-mode voltage, difference amplifier</td>
</tr>
<tr>
<td>INA818</td>
<td>Low-power (350 μA), high-precision (35 μV), low-noise, instrumentation amplifier with overvoltage protection</td>
</tr>
<tr>
<td>OPA2210</td>
<td>Ultra-low noise (2.2 nV/√Hz), high-precision (35 μV), wide bandwidth amplifier (18 MHz)</td>
</tr>
<tr>
<td>THP210</td>
<td>Industry’s first high-voltage, fully differential, low-noise (3.7 nV/√Hz) amplifier and ADC driver</td>
</tr>
<tr>
<td>OPA2182</td>
<td>Industry’s lowest offset drift (0.012 μV/˚C, max) chopper-stabilized op amp</td>
</tr>
</tbody>
</table>
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