Application Brief

How to Select Precision Amplifiers for Semiconductor Testers

Brendan Hess and Soufiane Bendaoud

Precision Amplifiers

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 1. Power Amplifiers Specifications

Device	Drift (µV/°C, max)	Settling Time (µs)	Slew Rate (V/µs)
OPA462	20	5 (120-V step)	32 (80-V step)
OPA454	10	10 (80-V step)	13 (80-V step)
OPA455	20	5.2 (120-V step)	32 (80-V step)

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.

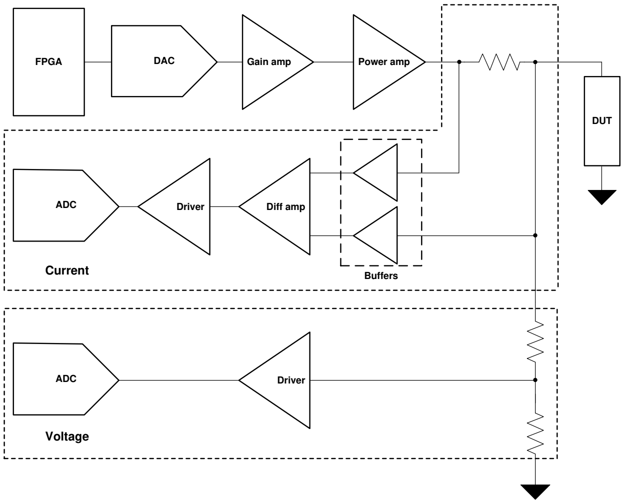

Figure 1. Typical Block Diagram for Semiconductor Testers

To measure the current, an IA must be implemented. A discrete solution can be used to increase signal bandwidth or supply, which can be done using the power amplifiers as buffers to feed into a difference amplifier, like the INA149. A monolithic IA such as the INA818 with 120-V input protection can be used instead of a discrete solution to decrease board size and design complexity. The output signal can then be fed into an ADC so that the feedback data can be read by the test interface.

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 2. Summary of Precision Op Amps for Semiconductor Testers

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

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATA SHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

TI objects to and rejects any additional or different terms you may have proposed.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2022, Texas Instruments Incorporated