

Overview

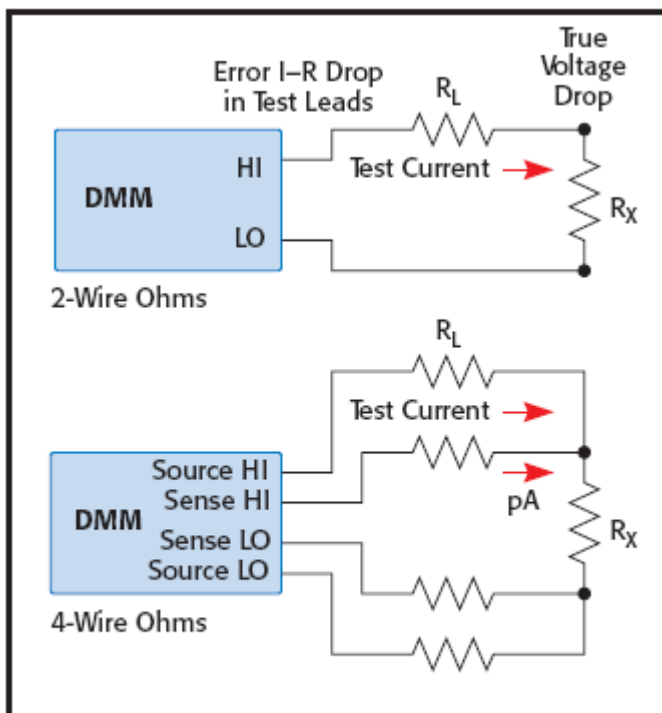
The basic circuits and electronics devices lab is one of the first electrical engineering lab courses students will take. In this lab, students become familiar with making basic electrical measurements using laboratory instruments such as digital multimeters (DMMs), power supplies, function generators, and oscilloscopes. Once they've developed some competence in the use of these tools, students begin learning how basic components such as resistors, diodes, transistors, and operational amplifiers function. By the end of their lab coursework, students should be able to design, assemble, and use basic electronic circuits and have the skills necessary to measure and characterize their designs.

Keithley offers a variety of educational lab instruments designed to speed and simplify this lab experience. As a leading manufacturer of electronics laboratory instrumentation, Keithley understands the importance of a solid understanding of measurement science, particularly for engineering students. To make the lab experience as instructive as possible, Keithley offers a variety of lab instruments, such as our Series 2000 DMMs and Series 2400 and 2600A SourceMeter® instruments, that are well suited for student use in circuits and basic electronics labs.

Measurement Example

Example 1:

2-wire resistance measurements vs. 4-wire resistance measurements using a DMM



2-Wire vs. 4-Wire Ohms

Ohms law relates voltage V across a circuit component to current I through a circuit component and resistance R of that component: $R = V/I$.

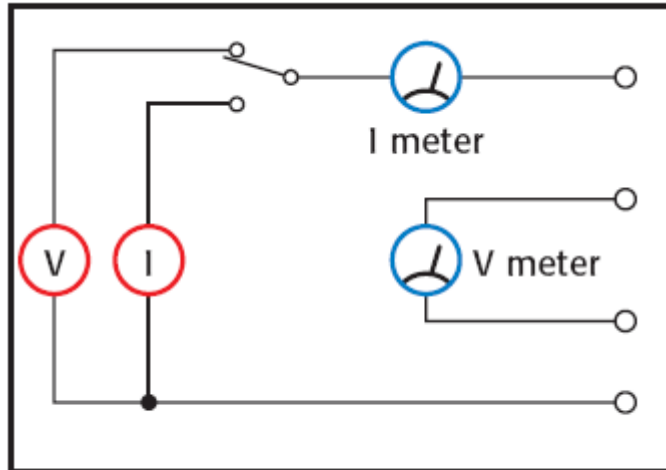
Two-terminal DMMs source test current through the measuring test leads, terminating at the HI-LO inputs of the DMM. This two-wire ohms system works fine for most resistance measurements applications. However, the I-R drop in the test leads (R_L) can cause inaccuracies that become apparent in lower resistance measurements. See the figure to the left.

Four-wire ohms or Kelvin measurements bypass the voltage drop across R_L by bringing two high

impedance voltage sense leads out to the unknown R_X . There is very little current in the sense circuit because of the high input impedance, so there's effectively no I-R drop in the leads, and the voltage seen by the sense terminals is the same as the voltage developed across R_X .

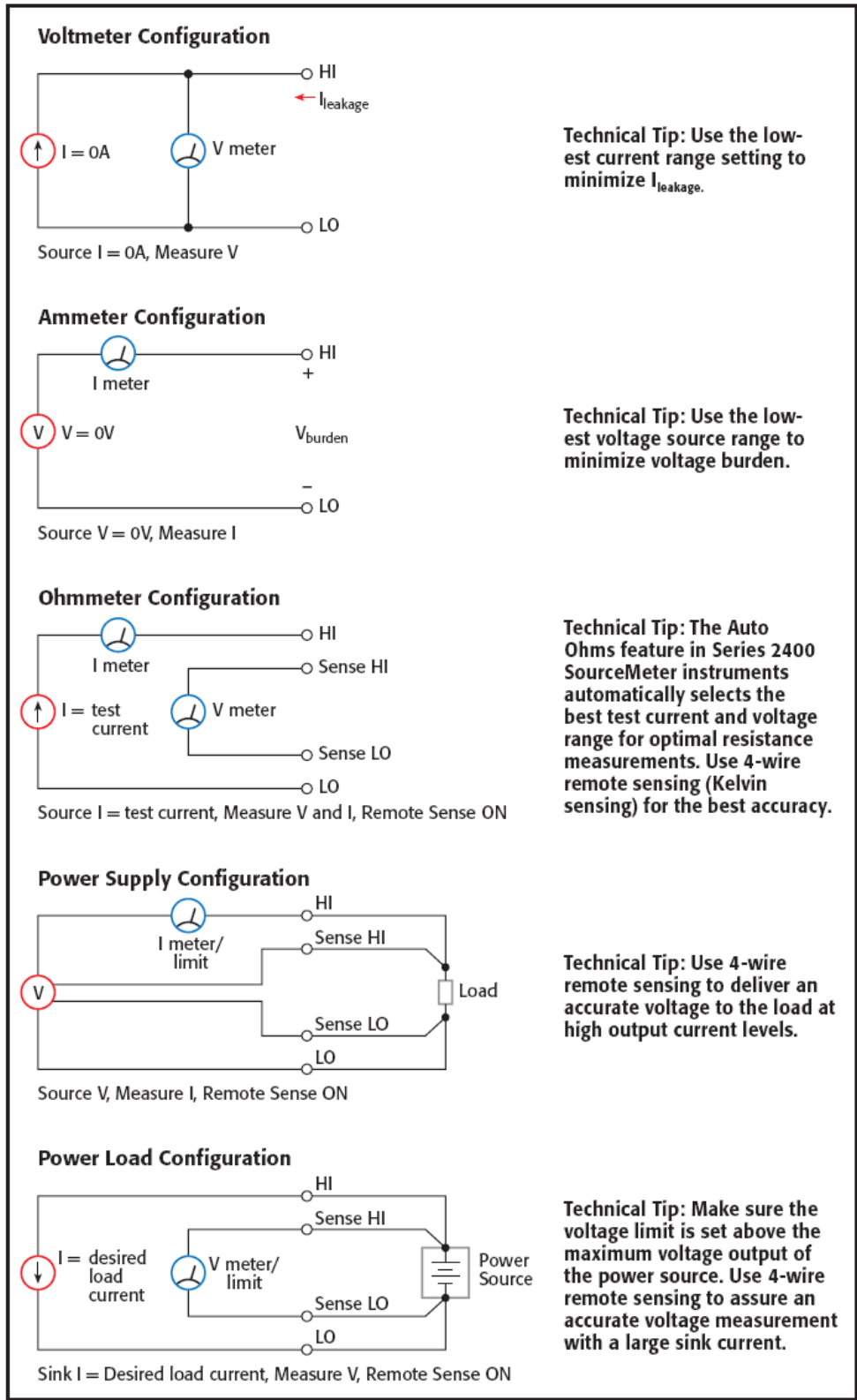
Example 2:

Using a source-measure unit as voltmeter, ammeter, ohmmeter, power supply, or a power load to measure volts, current, resistances, as well as I-V characterization and curve tracing.



Basic SMU topology

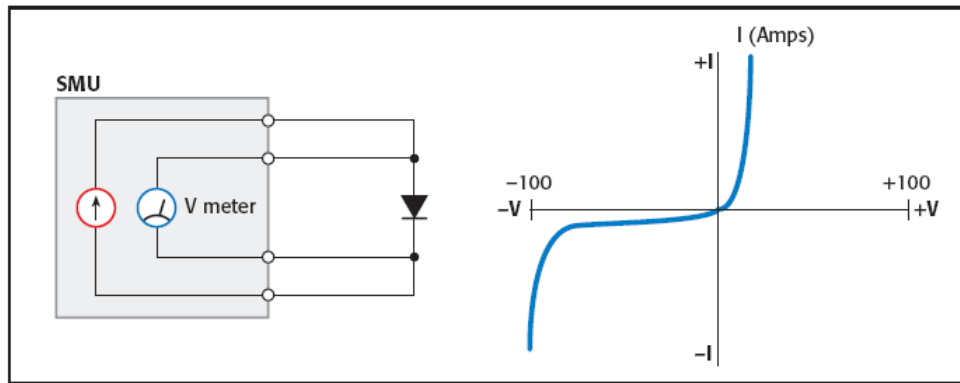
Source-measure units or SMU's can be used as stand-alone constant voltage or constant currents sources and as stand alone voltmeters or ammeters. However, their real strength is their ability to simultaneously source and measure – applying voltage to a device under test (load) and measuring the current through it, or supplying current to a load and measuring the voltage drop across it, such as in measuring resistance. The basic SMU topology is shown to the left along with a variety of SMU configurations.



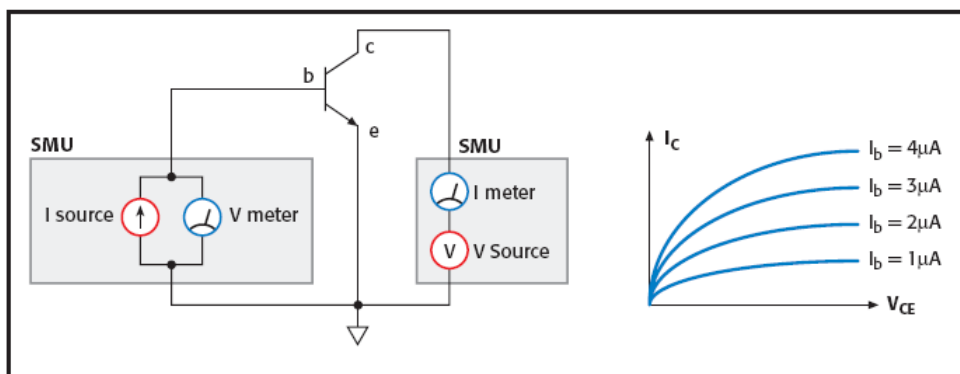
SMU configurations

SMU's are core instruments for I-V characterization tests, for example, to explore the fundamental principles of diodes and transistors. SMU's allow you to perform measurements such as forward voltage, reverse leakage, and reverse breakdown voltage on diodes. Combining two SMU's allows the student to understand the principles of transistors, such as making threshold voltage, beta, and

transconductance parametric tests as well as the generating a family of semiconductor curves, as shown below.



Typical diode curve trace tests

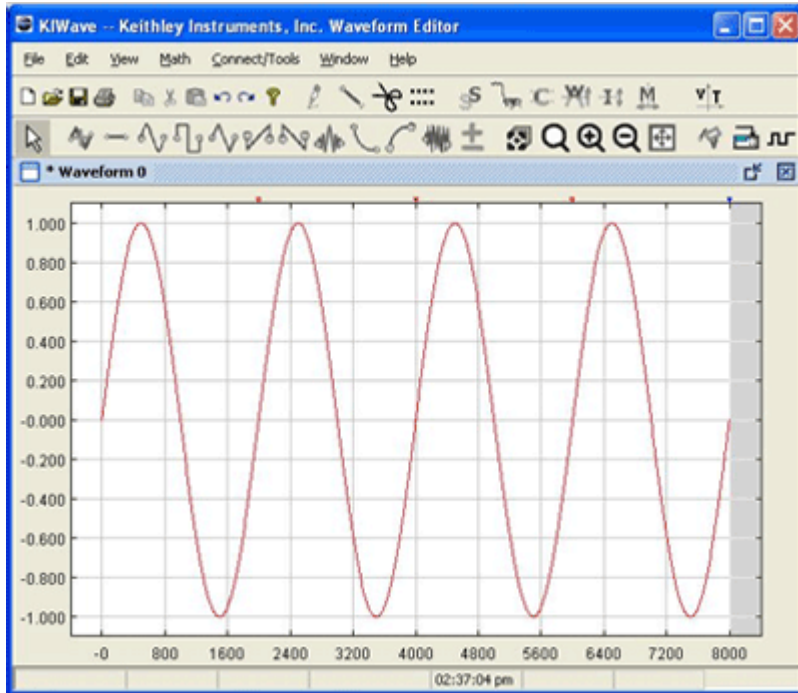


Typical curve trace test for transistors

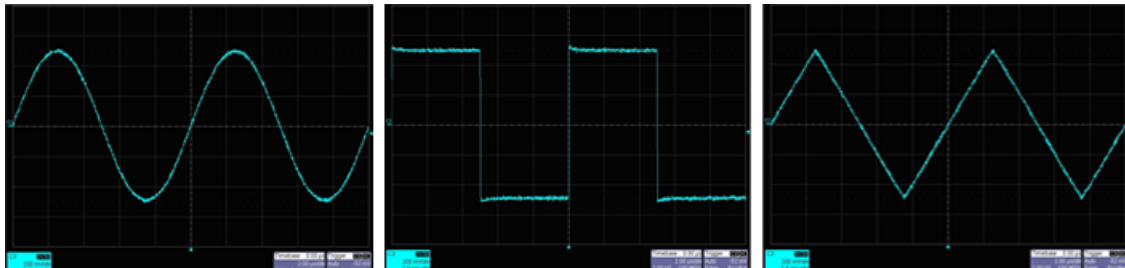
Example 3:

Generating basic electrical signals or waveforms to test electronic circuits

All electrical engineering students must work with signals or waveforms. In the basic circuits and electronics lab, students study how signals such as sine, square, ramp, pulse, and even noise waveforms pass through electronic circuits. The basic tool for generating these signals is the function generator. These instruments produce signals where parameters such as magnitude, frequency and shape are easily controlled. Combined with powerful waveform generation software, the student can experiment on electronic circuits with speed and simplicity.



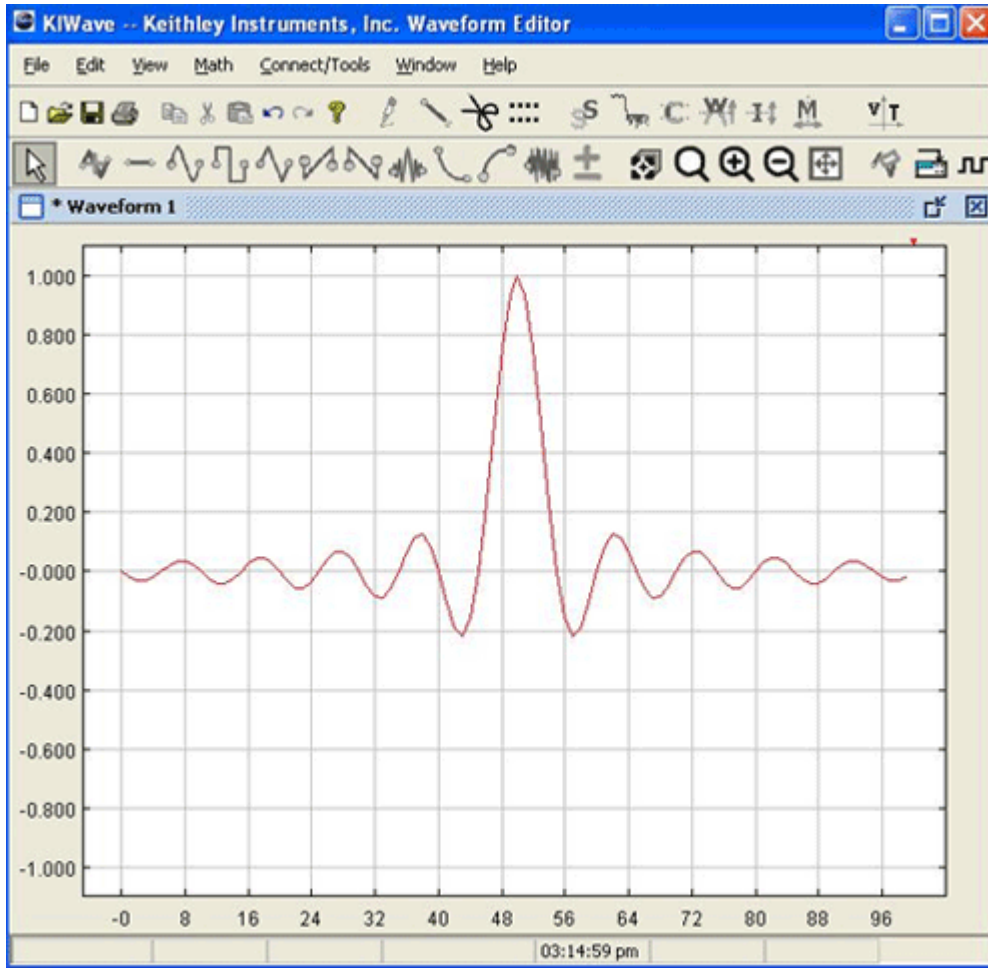
KiWAVE Software. This waveform utility software allows the student to create standard waveforms such as sine, square, ramp, pulse, and noise as well as managing waveform memory. KiWAVE lets users view waveforms in real units and perform editing. Waveforms can then be uploaded to Keithley's arbitrary waveform/function generator.



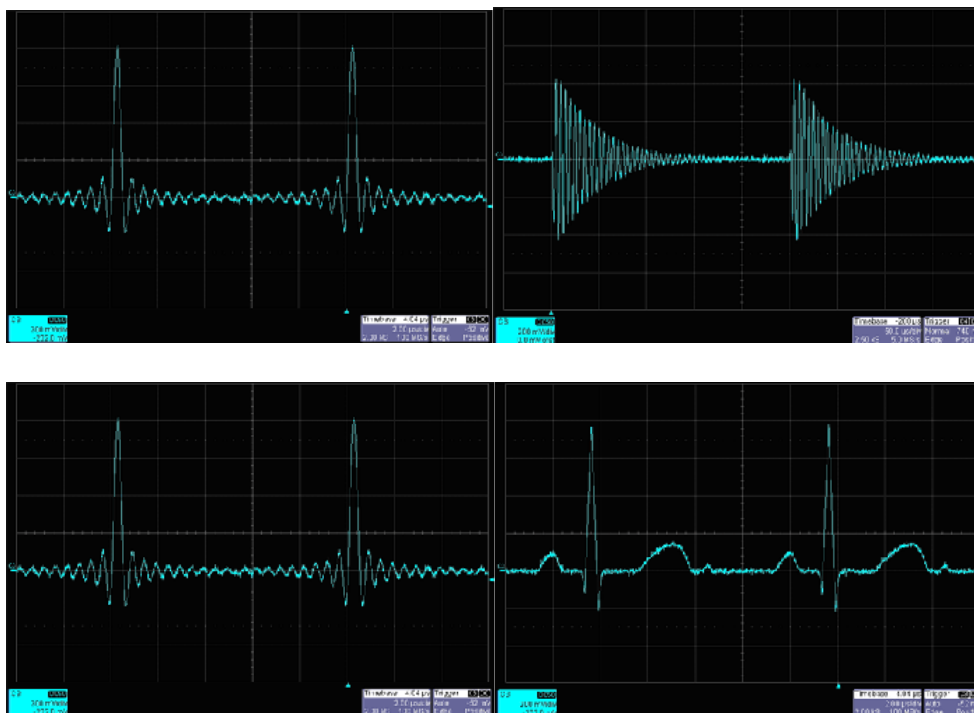
Example 4:

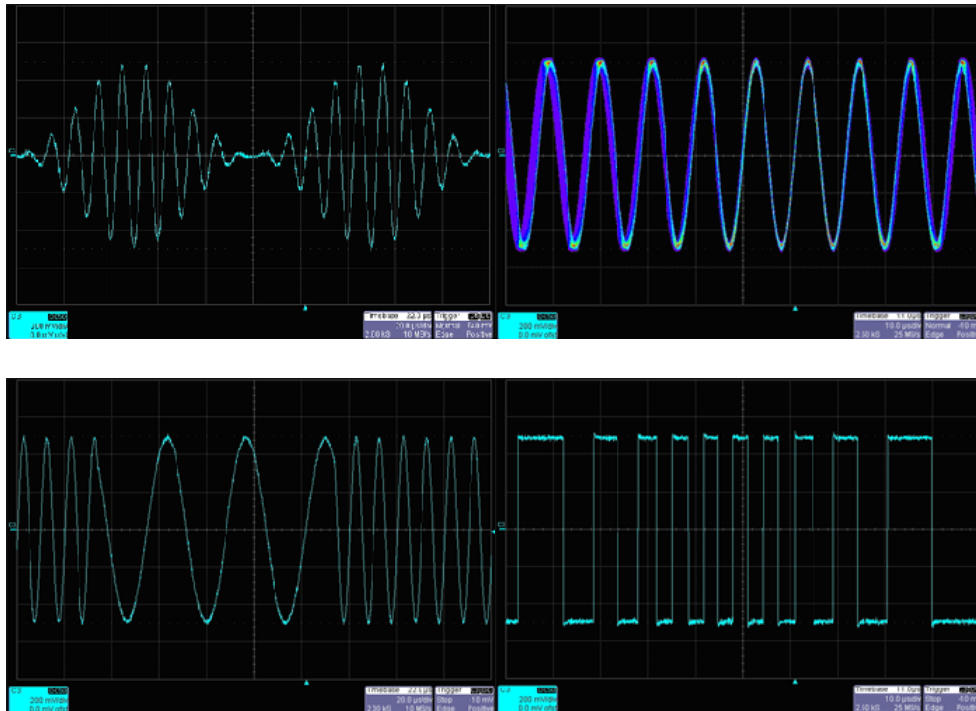
Using a high performance 50 MHz arbitrary waveform/function generator to generate unique waveforms and basic radio carriers and modulations.

Quite often, it is necessary to create electrical waveforms that are not of the typical sine, square, or ramp types. To accomplish this, an arbitrary waveform/function generator is used. To simplify the waveform generation effort in a student teaching lab, waveform generation software is recommended, such as Keithley's KiWAVE utility.



KiWAVE Waveform Generation Software. This is an example of using the KiWAVE software to generate a simple sync waveform





Test Solution

[DMMs](#) are the most commonly used type of test equipment for basic measurements of voltage, current, and resistance. Keithley's Series 2000 high performance, precision DMMs meet all of the measurement requirements for circuits and basic electronics labs. The entry-level [Model 2100](#) provides eleven measurement functions that cover the most commonly measured parameters, including standard DMM functions such as volts, ohm, amps, and RTD temperature measurements, as well as $mX+B$, dB, and dBm math modifiers for more specialized measurement applications.



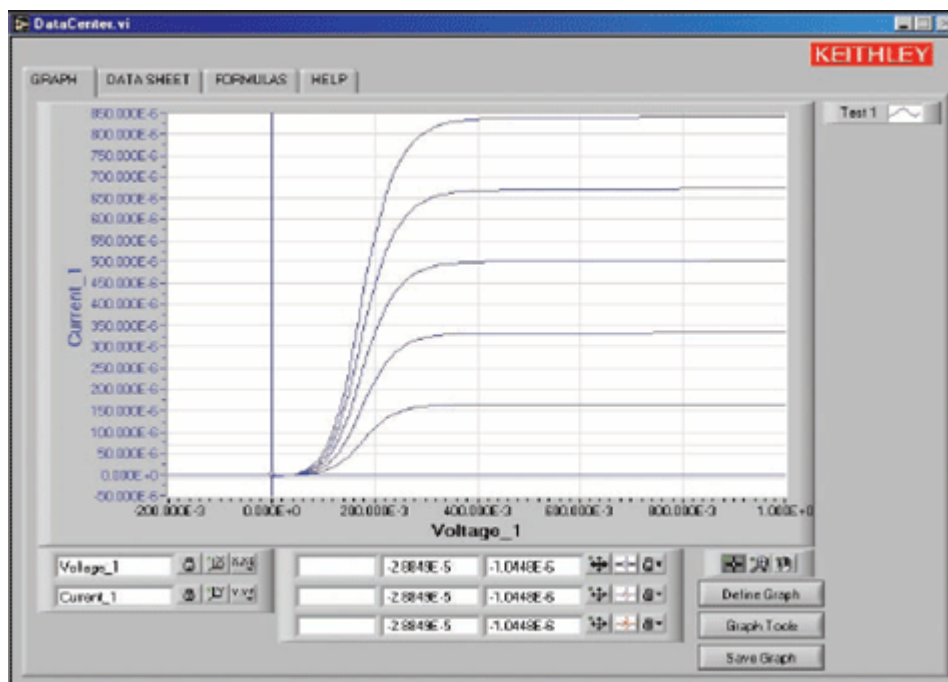
Model 2100 Digital Multimeter

For making measurements on active components such as diodes, transistors, and op-amps, Keithley's [Series 2400 SourceMeter Instruments](#) and [Series 2600A System SourceMeter Instruments](#) combine multiple test instruments in one enclosure.



Model 2602A Dual-Channel System SourceMeter Instrument

These instruments combine the functions of a precision power supply, a true current source, and a DMM. Series 2600A also incorporate an arbitrary waveform generator, a V or I pulse generator with measurement, an electronic load, and a trigger controller. This built-in functionality eliminates the need for many of the lab instruments that were previously required, which took up a large amount of bench space. By using these instruments in conjunction with Keithley's LabTracer software, as shown below, students can make measurements that once required the use of expensive curve tracers with just the click of a mouse.



For signal or waveform generation on a student lab bench, Keithley has paired the best-in-class performance of the Model 3390 Arbitrary Waveform/Function Generator with the best price in the industry to provide student labs with superior wave-form generation functionality and flexibility at an unparalleled price.



The Model 3390 generates highly stable and accurate waveforms that allow students to create almost any desired shape. It uses direct digital synthesis (DDS) techniques to achieve this level of performance and functionality. The exceptional signal quality of the Model 3390 is a result of its high resolution, fast rise and fall times, and deep memory. This combined with its low price makes it the ideal solution for applications that use the 50MHz bandwidth and below. This instrument is easy to use. In most cases, pressing one button on the front panel or performing one or two mouse clicks on your PC is all that is necessary to generate or modify a waveform.



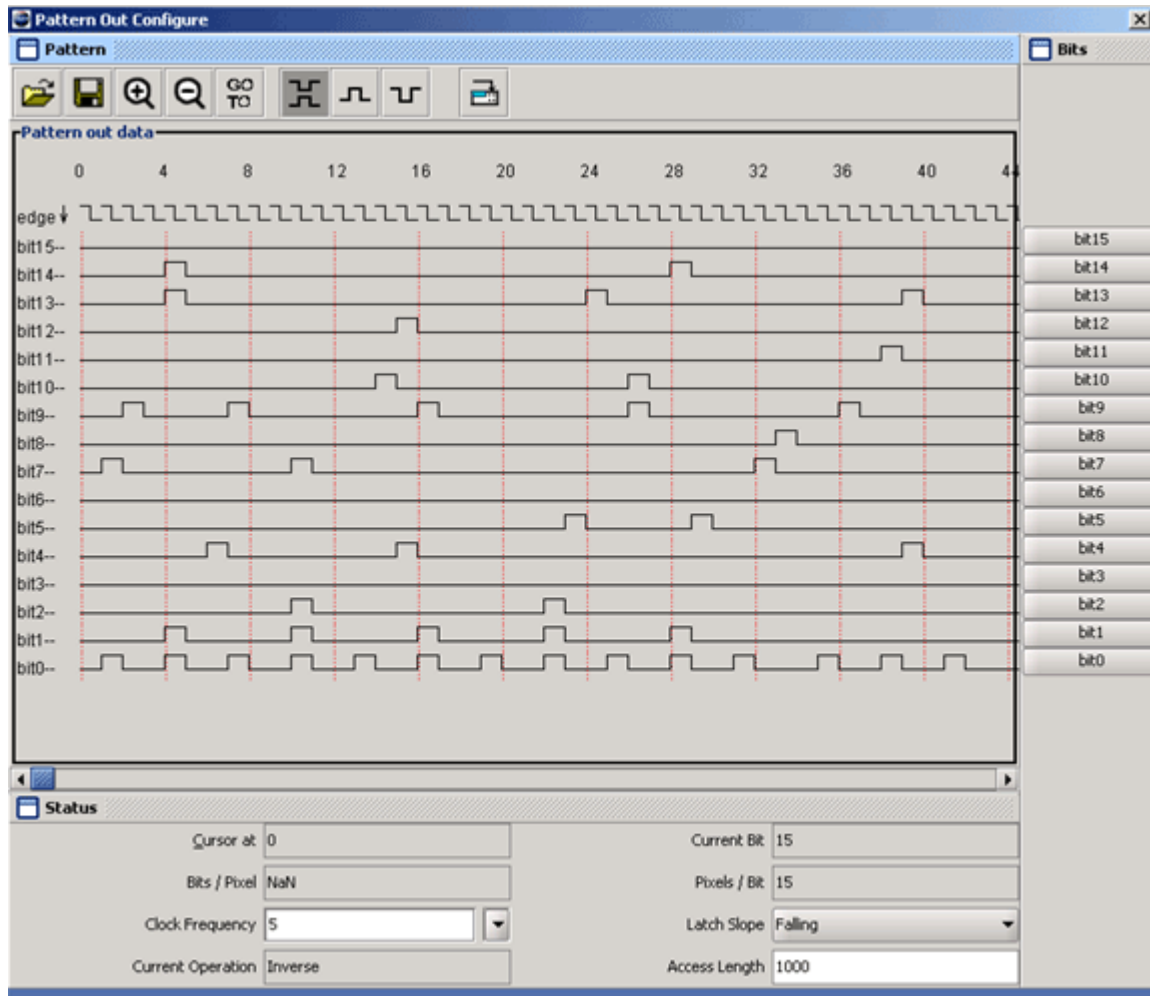
Model 3390 Arbitrary Waveform/Function Generator

The Model 3390's best-in-class performance and features include:

- 50MHz maximum sine wave frequency
- 25MHz pulse frequency with 10ns minimum width
- Arbitrary waveform generator with 256k-point, 14-bit resolution
- Built-in function generator capability including sine, square, triangle, noise, DC, etc.
- Precision pulses and square waves with fast (<10ns) rise/fall times
- Built-in 10MHz external time base for multiple unit synchronization
- Built-in AM, FM, PM, FSK, PWM modulation
- Frequency sweep and burst capability
- LXI Class C compliant Ethernet, TMC compliant USB and standard GPIB interfaces
- Digital pattern output port and control capabilities

The Model 3390 is the only instrument in its class with a digital pattern mode. It provides the ability to transmit arbitrary 16-bit patterns via a multi-pin connector located on the rear panel of the instrument. This feature can be used for applications such as testing clock and data signals directly, sending simple protocols to devices under test, and simulating simple control functions.

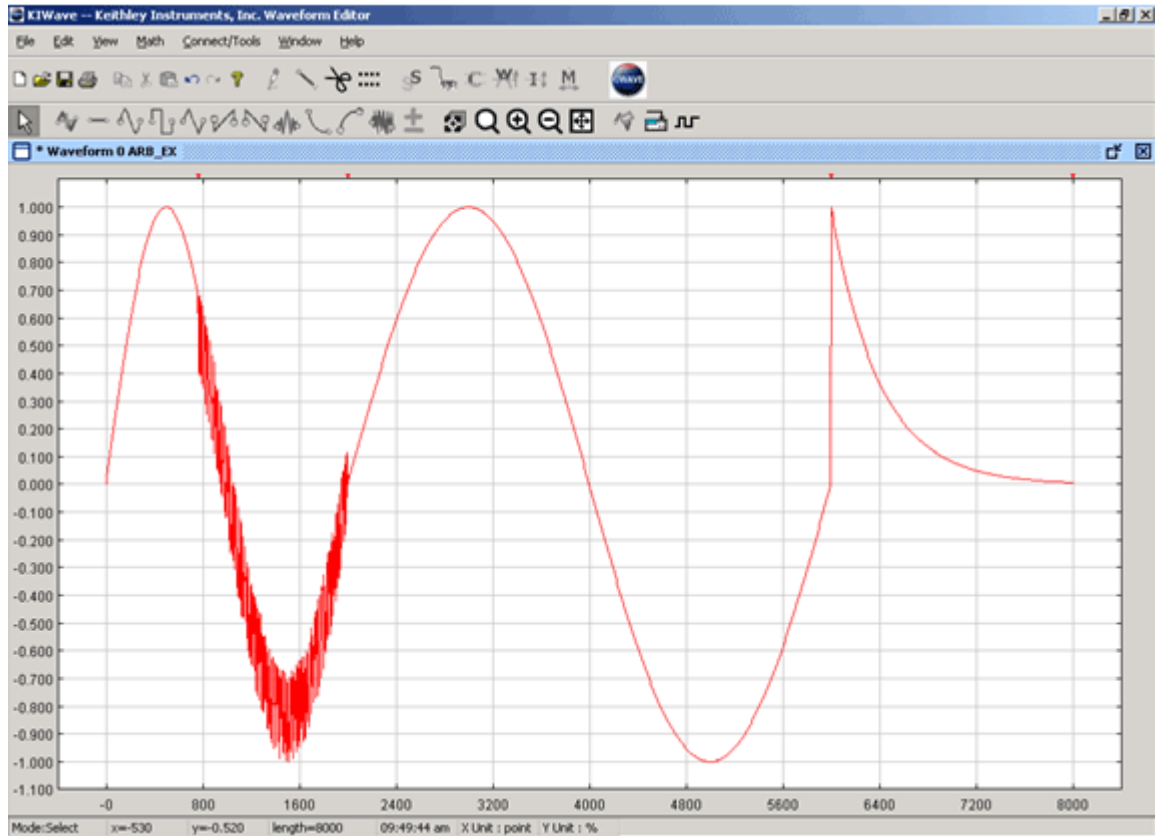
With Keithley's KiWAVE software package, you can easily create complex and long patterns, which the Model 3390 can generate at varying speeds and amplitudes.



Digital Pattern Generation Using Kiwave



The KiWAVE software package, included with the model 3390, helps you or your students define and create custom arbitrary waveforms, manage waveform memory, apply filters to waveforms, and display waveforms on a PC



KiWAVE Waveform Generation Software

To learn more about selecting the best voltage measurement tool for your circuits and electronics lab, check out our new:

[Interactive Voltage Measurement Guide](#)

Quickly find the right solution for your application