Floating Measurement with Isolated Channel Handheld Scope

Application Note

Introduction

Making accurate and safe measurements on power electronics, power semiconductors, and other electronics applications can be challenging when the signal reference is floating rather than referenced to earth ground. Under these conditions, not all oscilloscopes are suitable viewing waveforms. Obtaining floating measurements without the proper instrument and probe can pose safety hazards to the tester. Using the wrong measurement equipment can result in incorrect measurement results, as well as damage the circuit and scope. This application note explains what floating measurements are, the danger floating measurements present, and why it's advisable to use an isolated-channel handheld scope for power electronic applications.

Signal Source and Measurement Systems Basic

Basically, there are two main categories of signal source: ground-referenced and non-ground referenced, which is also called a floating signal. A grounded signal source is one in which the voltage signals are referenced to a system ground, such as earth or building ground. A floating signal source is one in which the voltage signal is not referenced to a system ground.

Similarly, a measurement system can be grouped into one of two categories: ground-referenced and non-ground referenced (floating). A ground-referenced measurement system is similar to a grounded source in that the measurement is made with respect to ground. A floating measurement system has neither of its inputs tied to a fixed reference such as earth or building ground. Handheld, battery-powered instruments are examples of floating measurement systems.

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Most modern power electronics systems such as switching mode power supplies, ballasts, uninterruptible power supplies, motor drives, and industrial equipment require a floating measurement system. This is because these types of electronics systems are commonly designed without a reference to a system ground.

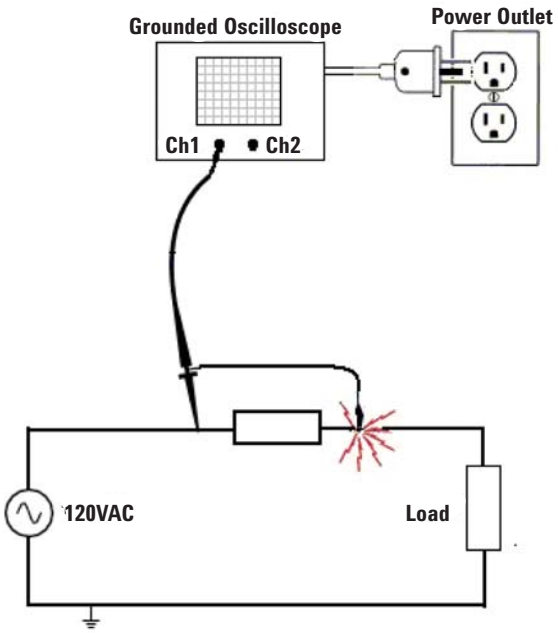

Figure 1. Danger of obtaining floating measurements using a grounded oscilloscope

All voltage measurements are differential since voltage is defined between two points. A voltage at a single point can be measured with respect to earth ground. Oscilloscopes typically are used for these types of measurements.

In many applications, especially power electronics applications, there is a need to measure voltage between two points; neither of which is referenced to ground potential. Connecting a typical oscilloscope input, which is referenced to ground, to the two non-grounded points creates a short circuit between one of the points and ground, possibly damaging the circuit and oscilloscope.

When users float the scope by disconnecting the ground plug or using an isolation transformer for the scope, it also creates another serious hazard (see Figure 1). Most oscilloscopes have their signal ground terminals connected to the protective earth ground system. Placing a probe ground lead to one of the floating test points can put the exposed metal parts of the oscilloscope to the same potential of the test point to which the probe ground lead is connected. This could be a deadly shock hazard if you accidently touch the exposed metal.

In addition to being a very unsafe practice, as well as one that can threaten the safety of those near you, floating the scope is not an accurate method for measuring floating voltage. The safest and most accurate method for making this type of measurement is to use a handheld scope with independently-isolated floating inputs.

Independently-Isolated Input Channel Handheld Scope

Measuring multiple signals is a common requirement in an industrial setting. Engineers and technicians consistently need to measure several independent signals that are simultaneously referenced to different voltages. To address the safety and accuracy concern of a floating measurement, battery-powered handheld scopes can provide separate isolated-input channels. An isolated-input channel scope can avoid all ground loop disturbances and short circuits. The handheld scope is electrically isolated from the input channels including the ground lead. Independent input channels enable two separate and floating measurements to be obtained simultaneously.

The chassis and the controls of an isolated-input channel handheld scope are designed with plastic, rubber, or another type of insulating material.

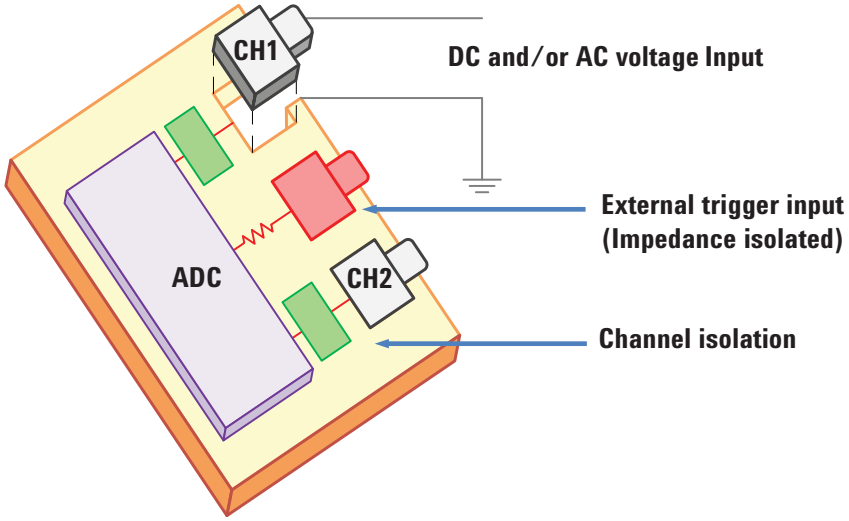

Figure 2. Isolated channel scope block diagram.

Each input channel is isolated either with an opto-coupler or a transformer, depending on the design. Since there is no direct connection between the measurement probes and the inputs to the scope, the scope's operator is protected from the voltages being measured.

When selecting an isolated-input channel handheld scope, it is important to note that not all isolated-input channels handheld scopes are fully isolated. A fully-isolated channel input handheld scope provides channel-to-power line isolation and channel-to-USB connectivity isolation. This allows users to connect to signals of widely differing voltage reference levels with complete safety and obtain accu-

rate measurements. Figures 3 and 4 show a fully-isolated input channel scope monitoring output voltage of a PWM inverter drive and the gate control signals of an insulated gate bipolar transistor (IGBT). Channel 1 is used to monitor the output voltage of the PWM AC drive and Channel 2 is used to monitor low level signals from the control board. The IGBT is used for fast switching of electric power in many modern appliances.

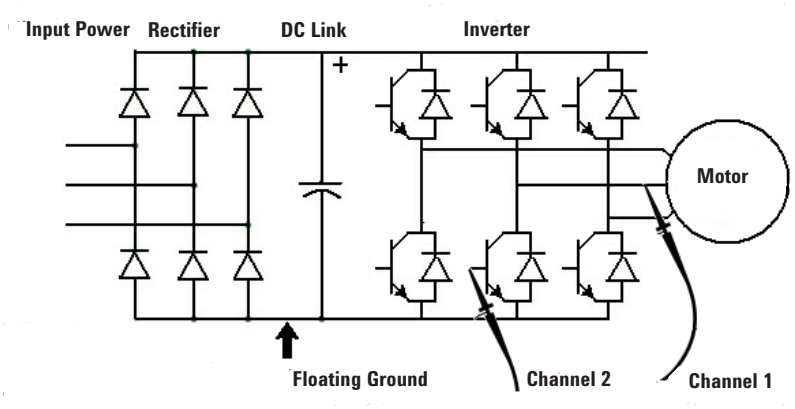

Figure 3. Probing at VFD IGBT control signal and IGBT output

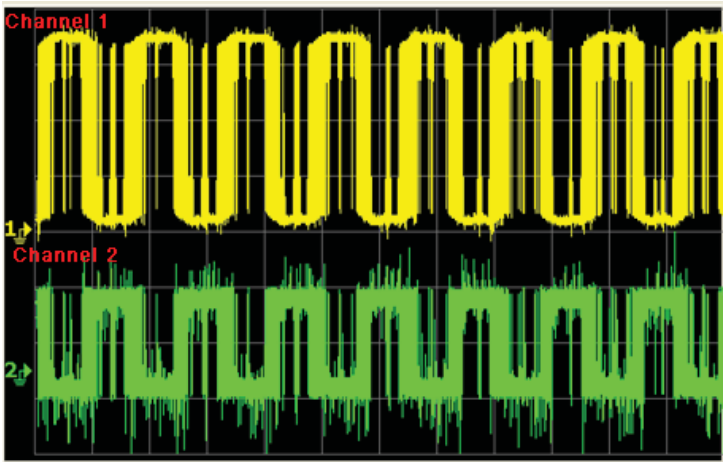

Figure 4. Waveform of the IGBT control signal and IGBT output

Input Terminal and Scope Probe Rating

An isolated-input channel oscilloscope is designed with operator safety in mind. However, getting a fully-isolated channel oscilloscope does not ensure user safety. Taking on challenges of testing industrial equipment and power conversion systems, requires a handheld scope that's safety-rated for measurements in CAT III environments. Distribution boards, three-phase motors, variable speed drives, building installations, or equipment for industrial use are examples of CAT III environments. Most handheld oscilloscopes display this rating near the BNC input terminals. This marking is a convenient way for users to identify the maximum transient voltage that the meter can safely withstand. Before starting to measure with a handheld scope, the tester must know the input ratings of all terminals, ratings such as the maximum BNC input voltage with a 10:1 probe or 1:1 probe and the maximum floating voltage from any terminal-to-earth ground.

In addition to the safety rating of the scope, consideration should also be given to the probe's rating. Different types of probes have different voltage ratings. Make sure the signal being measured is within the voltage range specified by the probe's manufacturer (see Figure 5).

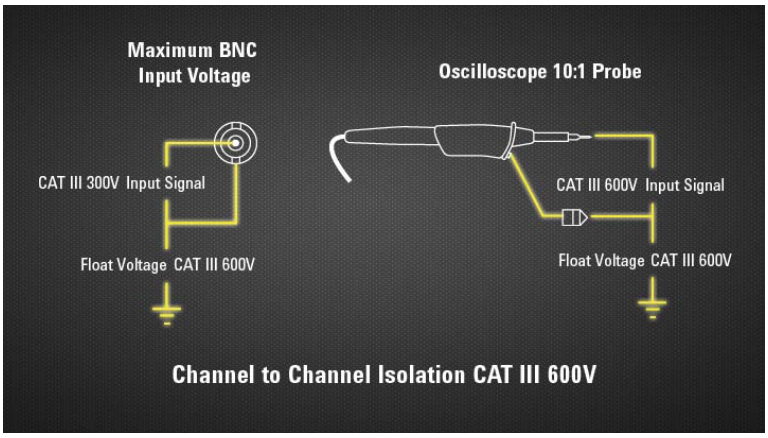

Figure 5. Maximum BNC input voltage of Agilent U1610A/U1620A and the scope probe rating.

Agilent U1610A/U1620A Isolated Input Channel Handheld Scope

Agilent's U1600 Series handheld oscilloscopes include the 100 MHz U1610A and the 200 MHz U1620A. Each is a fully-isolated input channel oscilloscope and provides three viewing modes on a VGA TFT LCD display. The display ensures that it is easy to see and analyze waveforms effortlessly, whether working in a poorly-lit environment or under the glaring sun, or even in dark environments.

With up to two mega points of memory depth, the U1610A and U1620A handheld scopes display detailed waveforms without sacrificing the 2 GSa/s sampling rate, even in zoom mode. The dual-window zoom function also allows users to view the original signal and the selected area on a single screen simultaneously.

The U1610A and U1620A are a CAT III 600 volts-rated to work in harsh industrial environments. The fully-isolated input channels also allow technicians to make easy, safe and accurate measurements on motor drives, switched-mode power supplies and other power electronics applications.

The data logger function allows the handheld scope to monitor signals over long periods of time even when unattended. This helps users identify waveform anomalies. Each Agilent U1610A and U1620A comes with a USB port, which allows users to save waveforms on a memory stick and connect to a PC to transfer waveforms for reporting.

The graphical user interface supports ten languages, allowing users to easily choose their desired interface for scope operation.

Summary

Engineers and technicians often need to make floating measurements in the power control circuits, such as motor controllers and uninterruptible power supplies, and industrial equipment. This need has made choosing a proper handheld scope for electrical service, repair, and installation increasingly complex. A fully-isolated input channel is highly recommended to make an accurate and safe measurement in a demanding environment. Agilent U1610A and U1620A handheld scopes are each an integrated test tool designed for industrial troubleshooting needs. They allow technicians of any skill level to easily troubleshoot all types of electrical and power electronic circuit.

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Revised: January 6, 2012

Product specifications and descriptions in this document subject to change without notice.

Published in USA, January 24, 2012
5990-9777EN

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