Section 10

Capturing and analyzing waveforms

In this section:

Introduction

This example application demonstrates how to use the Model DMM7510 to capture voltage and current waveforms. In this application, you use both the digitize voltage and digitize current functions to directly interact with the waveforms. The waveforms are acquired from a 5 V buck converter through the front-panel touchscreen interface.

The touchscreen can be helpful in a variety of applications that involve transient signal analysis at a 1 Msample/s sampling rate. You can analyze signals from a microvolt to 1000 V up to 350 kHz, or a microamp to 10 A up to 100 kHz.

Equipment required

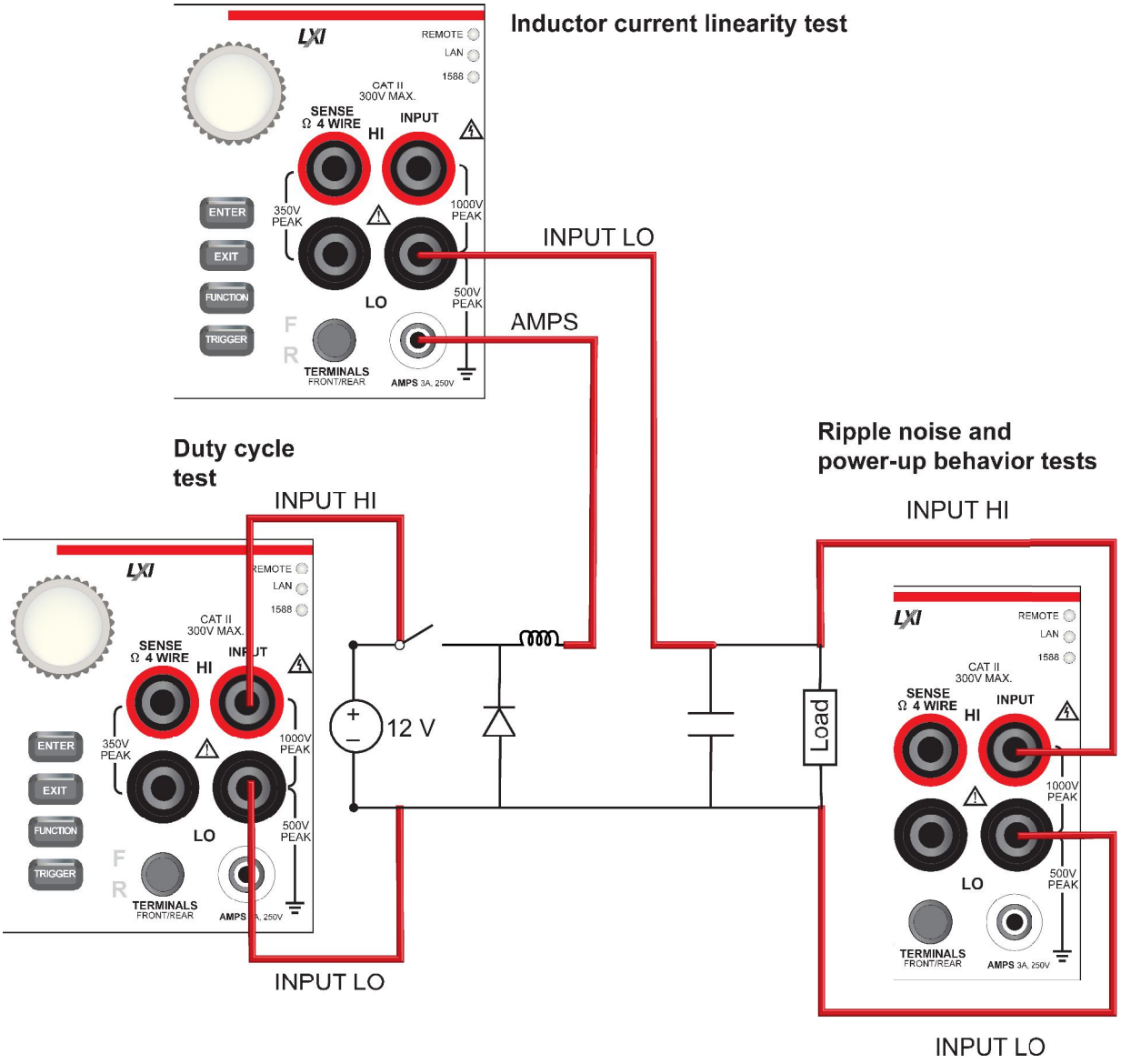
- One Model DMM7510
- A power supply
- Buck controller evaluation board, such as the Texas Instrument LM25088MH-1/NOPB Current Mode Non-Synchronous Buck Controller Evaluation Board
- Four insulated banana cables, such as the Keithley Instruments Model 1756 Standard Test Lead Kit (one set with two cables is provided with the Model DMM7510; you will need another set)
- Resistors for a varying load application; the application shown here uses resistor from 3 Ω to 8 Ω
- One computer set up for remote communication with the Model DMM7510

Device connections

This application example consists of four tests with different connections. An overview of the connections is shown in the figure below.

You can use either the front or rear panel connections for these tests. Check the front panel TERMINALS switch to verify that the instrument is set to read the correct set of terminals (F is lit for front terminals; R is lit for rear terminals). Note that you must use either the front terminals or rear terminals — you cannot mix connections.

Figure 33: Buck converter evaluation board connections - overview



⚠ WARNING

To prevent electric shock, test connections must be configured such that the user cannot come in contact with test leads or any device under test (DUT) that is in contact with the conductors. It is good practice to disconnect DUTs from the instrument before powering the instrument. Safe installation requires proper shields, barriers, and grounding to prevent contact with test leads.

There is no internal connection between protective earth (safety ground) and the LO terminals of the Model DMM7510. Therefore, hazardous voltages (more than 30 V_{rms}) can appear on LO terminals. This can occur when the instrument is operating in any mode. To prevent hazardous voltage from appearing on the LO terminals, connect the LO terminal to protective earth if your application allows it. You can connect the LO terminal to the chassis ground terminal on the front panel or the chassis ground screw terminal on the rear panel. Note that the front-panel terminals are isolated from the rear-panel terminals. Therefore, if you are using the front-panel terminals, ground to the front-panel LO terminal. If using the rear-panel terminals, ground to the rear panel LO terminal.

Testing a buck converter

A buck converter is a highly efficient switch mode DC-to-DC voltage step-down converter. It stores energy in the form of a magnetic field on an inductor. In the on state, the switch is closed and the input voltage charges the inductor. In the off state, the switch is open and the inductor discharges the stored energy as current flow through the load. Some of the key measurements involved in testing a buck converter are:

- Ripple noise on the output voltage
- Duty cycle from switch node voltage
- Inductor current linearity with varying load
- Power-up behavior

The following test will use the Texas Instruments LM25088 evaluation board (EVM) to demonstrate the digitizing capabilities of the Model DMM7510. Modifications were made to the LM25088 evaluation board to realize a 50 kHz switching frequency. An input voltage of 12 V is used on all subsequent tests.

Since the maximum output current of the LM25088 is 3 A, different resistive loads can be used to achieve a variety of loading effects, as shown in the following tests.

Ripple noise on the output voltage

This test measures the ripple voltage captured on the output terminal of the buck converter evaluation board.

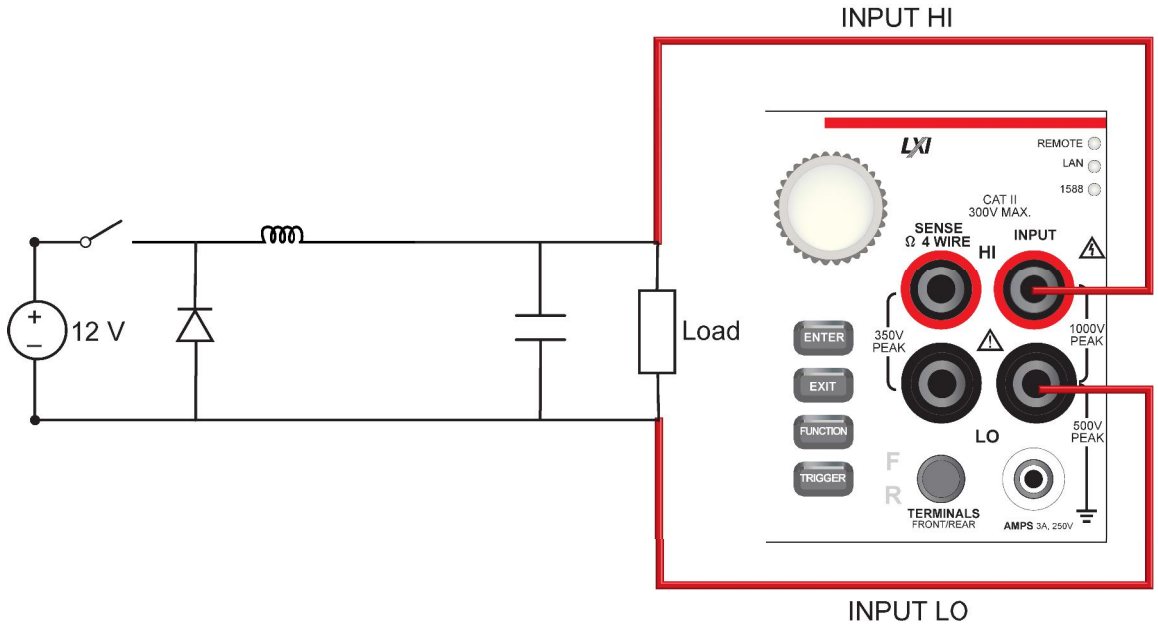
For this test, you will:

- Connect the 3 Ω load resistor to the output terminals of the buck converter
- Connect test leads to the output terminals of the buck converter
- Supply 12 V to the input terminals of the buck converter
- Reset the instrument
- Select the digitize voltage function and set sample rate to 1 Msamples per second with a sample count of 100
- View the data the graph
- Turn on horizontal cursors to measure voltage ripple magnitude

Device connections

The connections for the ripple noise test are shown in the figure below.

Figure 34: Ripple noise on output voltage device connections

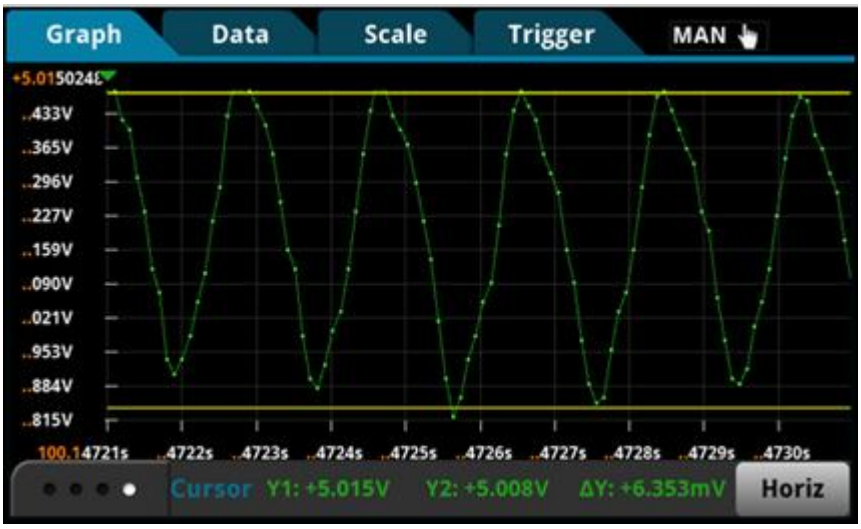


Run the test using the front panel

To run the test using the front panel:

1. Press the **POWER** button on the front panel to turn on the instrument.
2. On the FUNCTIONS swipe screen, select **Digi V** to select the Digitize Voltage measure function.
3. Swipe to display the **SETTINGS** swipe screen.
4. Set the Sample Rate to **1,000,000**.
5. Set the Count to **100**.
6. Swipe to display the **GRAPH** swipe screen.
7. Select the graph icon on the upper right of the swipe screen to open the **Graph** screen.
8. To analyze the voltage ripple peak-to-peak value, swipe the bottom of the graph screen until the Cursor Enable button is displayed.
9. Select the Cursor Enable button until **Horiz** is displayed. The horizontal cursors are displayed.
10. Touch the yellow horizontal cursor lines on the graph and move them to measure the peak-to-peak ripple amplitude.
11. The ΔY value is shown on the graph swipe bar.

Figure 35: Results of the ripple noise test



Using SCPI commands

You may need to make changes so that this code will run in your programming environment.

Send the following commands:

Command	Description

`*RST`
`:SENS:DIG:FUNC "VOLT"`
`:SENS:DIG:VOLT:RANG 10`
`:SENS:DIG:VOLT:INP AUTO`
`:SENS:DIG:VOLT:SRATE 1000000`
`:SENS:DIG:VOLT:APER AUTO`
`:SENS:DIG:COUN 100`
`:TRAC:POIN 100`
`:TRAC:CLE`
`:TRAC:TRIG:DIG`
`:TRAC:DATA? 1, 100, "defbuffer1", READ`
`:TRAC:DATA? 1, 100, "defbuffer1", REL`
	• Reset the Model DMM7510.
	• Set the instrument to measure digitize voltage.
	• Set range to 10 V.
	• Set the input impedance to 10 GΩ.
	• Set the sample rate to 1e6.
	• Enable automatic aperture.
	• Set the sample count to 100.
	• Set `defbuffer1` to store 100 points.
	• Clear `defbuffer1`.
	• Digitize the signal.
	• Read the first 100 measurement and relative timestamp values from `defbuffer1`.

Using TSP commands

NOTE

The following TSP code is designed to be run from Keithley Instruments Test Script Builder (TSB). TSB is a software tool that is available from the Keithley Instruments website. You can install and use TSB to write code and develop scripts for TSP-enabled instruments. Information about how to use TSB is in the online help for TSB and in the "Introduction to TSP operation" section of the *Model DMM7510 Reference Manual*.

To use other programming environments, you may need to make changes to the example TSP code.

By default, the Model DMM7510 is configured to use the SCPI command set. You must select the TSP command set before sending TSP commands to the instrument.

To enable TSP commands:

1. Press the **MENU** key.
2. Under System, select **Settings**.
3. For Command Set, select **TSP**.
4. At the prompt to reboot, select **Yes**.