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

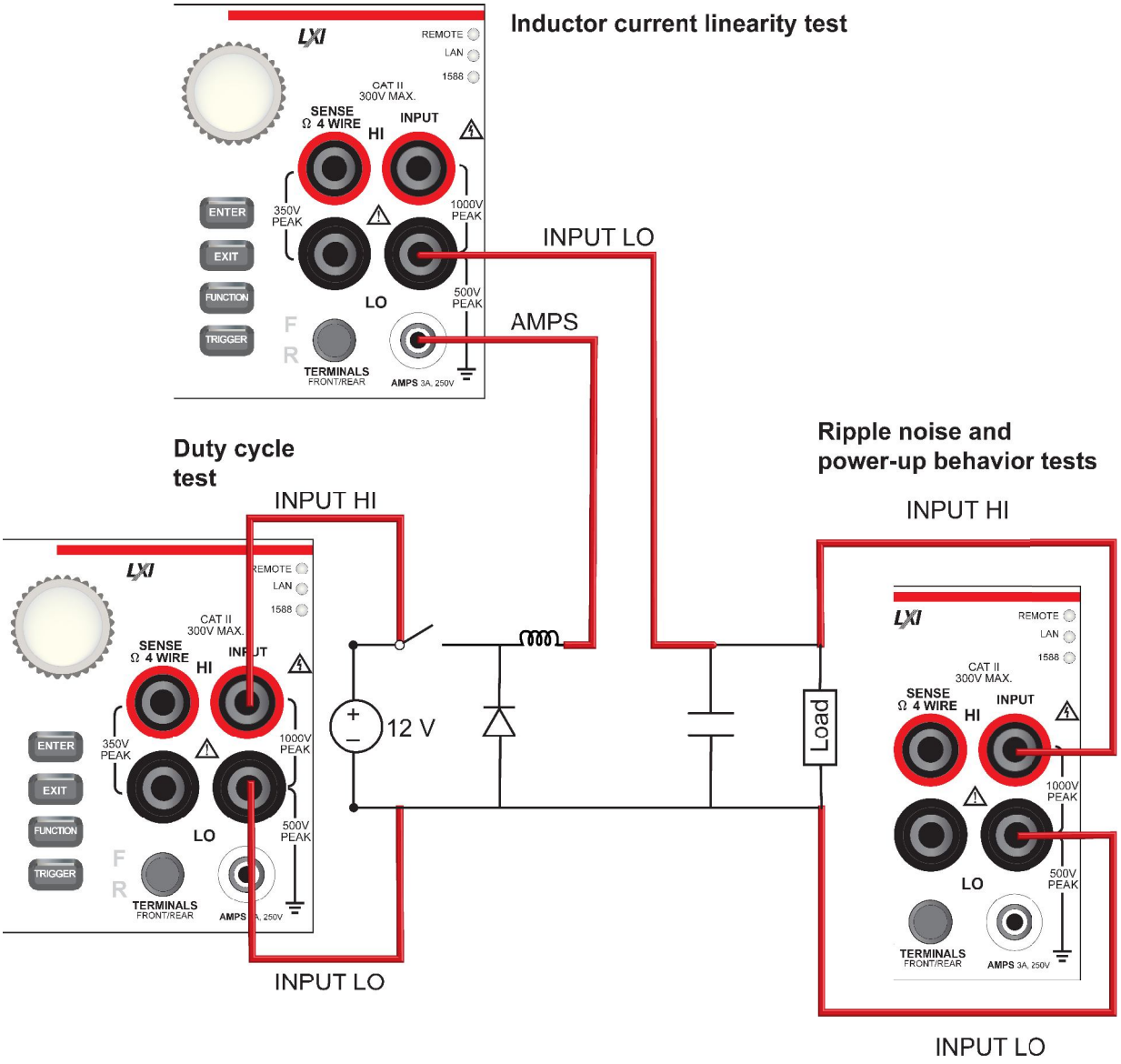
- One Model DMM7510
- A power supply
- Buck controller evaluation board, such as the Texas Instrument LM25088MH-1/NOPB Current Mode Non-Synchronous Buck Controller Evaluation Board
- Four insulated banana cables, such as the Keithley Instruments Model 1756 Standard Test Lead Kit (one set with two cables 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.

Send the following commands:

```
--Reset the instrument to default settings
reset()
--Create a local variable to store the number of samples
numofsamples=50
--Set DMM function to digitize current to capture the inductor current
dmm.digitize.func = dmm.FUNC_DIGITIZE_CURRENT
--Current range must be fixed when using digitize current
dmm.digitize.range = 1
--Set the sample rate to 500 ksamples per second to sample a 50 kHz current
   waveform
dmm.digitize.samplerate = 500e3
--Set the aperture to auto to get the highest accuracy measurement for the sampling
   rate configured
dmm.digitize.aperture = dmm.APERTURE_AUTO
--Set the sample count to the number of samples to capture about 5 ripples
dmm.digitize.count = numofsamples
--Clear buffer
defbuffer1.clear()
--Make sure your signal is connected to the DMM. Digitize now...
dmm.digitize.read()

if defbuffer1.n > 0 then
   print("Digitize Current:")
   print("Total Number of readings:", defbuffer1.n)
   printbuffer(1, defbuffer1.n, defbuffer1)
   print("Timestamps:")
   printbuffer(1, defbuffer1.n, defbuffer1.relativetimestamps)
else
   print("No data collected")
end
print("Test Ended")
```

Power-up behavior

You can use the Model DMM7510 to capture the start-up behavior of the buck converter. The start-up inspection can ensure that the device turns on in a reasonable amount of time without any unexpected glitches or pulses. You can capture the asynchronous power-up event by using the analog trigger feature on the Model DMM7510.

For this test, you:

- Connect the 4 Ω load resistor to the output terminals of the buck converter
- Connect test leads to the output terminals of the buck converter
- Reset the instrument
- Select the digitize voltage function and set the sample rate to 1 Msample per second
- Set sample count to 10,000 to monitor the power-up event for 10 ms
- On the front panel of the instrument, open the Graph screen and set the graph scale option X-axis Method to All
- Set up the edge trigger level and position
- Run the trigger model to capture the voltage waveform
- Turn on 12 of input voltage to the input terminals of the buck converter

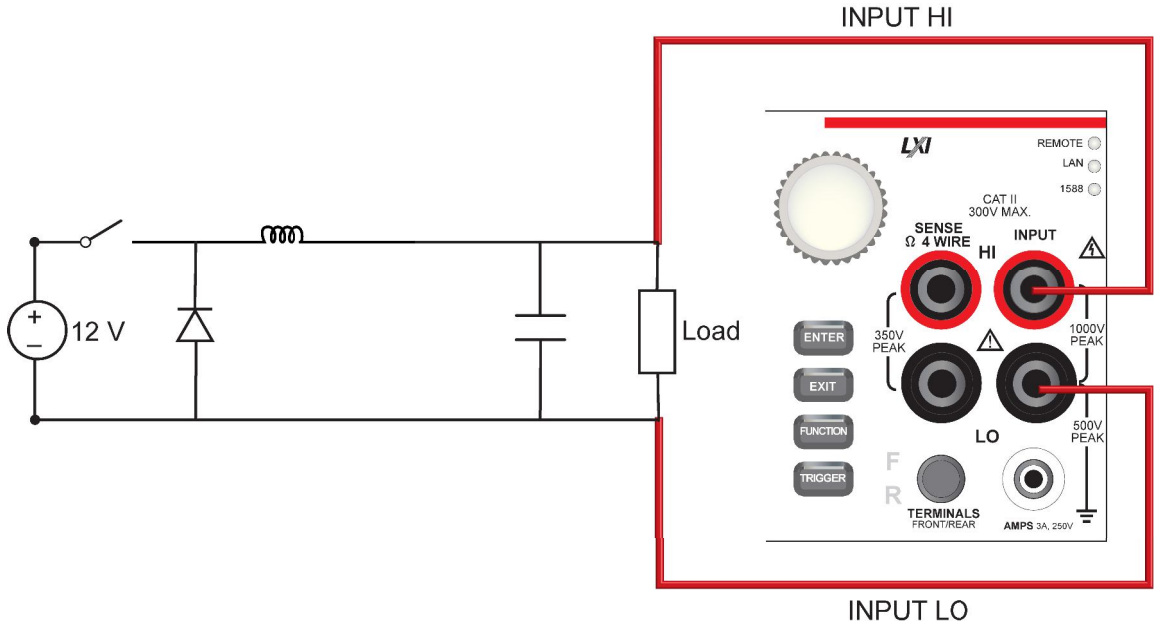
Device connections

Connect the test leads as shown in the following figure.

You can use either the front or rear inputs. Ensure that the front-panel TERMINALS button is set correctly (**F** displayed for front; **R** displayed for rear). Note that you must use either the front terminals or rear terminals — you cannot mix connections.

Both front-panel and rear-panel connections are safety banana jacks. You can make these connections with two insulated banana cables (for example, the leads included with the Keithley Instruments Model 1756 Standard Test Lead Kit).

Figure 44: Power-up behavior test connections



Run the test using the front panel

Set up the digitize function:

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 function.
3. Swipe to display the **SETTINGS** swipe screen.
4. Set the Sample Rate to **1,000,000**.
5. Set the Count to **1**.
6. Press the **MENU** key.
7. Select **Reading Buffers**.
8. Set the Capacity to **10,000**.

Set up triggering:

1. Press the **MENU** key.
2. Select **Graph**.
3. Select the **Scale** tab.
4. Set the X-Axis Method to **All**.
5. Select the **Trigger** tab.
6. Set Source Event to **Waveform**.
7. Select **Analog Edge**.
8. Set Level to **3V**.
9. Set Position to **50%** for the pretrigger position.
10. Select the **Graph** tab to view the graph.
11. To start capturing the buck converter power-up behavior, press the **TRIGGER** key on the front panel. The pretrigger data is shown on the graph.
12. Turn on the 12 V output from the power supply.

Test results

The front-panel graph will show results that are similar to the following.

Figure 45: Power-up test results

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 1e6`
`:SENS:DIG:VOLT:APER AUTO`
`:SENS:DIG:COUN 1`
`:TRAC:POIN 10000`
`:TRAC:CLE`
`:SENS:DIG:VOLT:ATR:MODE EDGE`
`:SENS:DIG:VOLT:ATR:EDGE:SLOPe RIS`
`:SENS:DIG:VOLT:ATR:EDGE:LEV 3`
`:TRIG:BLOC:DIG 1, "defbuffer1", INF`
`:TRIG:BLOC:WAIT 2, ATR`
`:TRIG:BLOC:DIG 3, "defbuffer1", 5000`
`INIT`
`*WAI`
`: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 at 10 V.
	• Set the sample rate to 1,000,000.
	• Enable automatic aperture.
	• Set the sample count to 1 (optional).
	• Set `defbuffer1` to store 10,000 points.
	• Clear `defbuffer1`.
	• Enable analog edge trigger.
	• Set the edge trigger to rising slope.
	• Set the edge trigger level to 3 V.
	• Set up a trigger model that digitizes voltage indefinitely while waiting for the edge trigger event and digitizes 50% post trigger readings.
	• Start the trigger model.
	• Wait for the trigger model to complete.
	• Retrieve the readings from the buffer.
	• Retrieve the relative timestamps from the buffer.

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**.