

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3

The FemtoClock3 (FC3) family supports HCSL drivers with internal or external terminations. This document describes the termination schemes and shows the resulting amplitude and cross-voltage measurements.

Contents

- 1. Termination Scheme3
- 2. OUTx Mode Setting in RICBox6
- 3. HCSL Amplitude and Cross-Voltage Measurement.....8
- 4. FC3 EVB Waveform Measurement Method28
 - 4.1 HCSL Internally Terminated28
 - 4.2 HCSL Externally Terminated29
 - 4.3 LVDS29
 - 4.4 Measurement Bench.....30
- 5. Revision History31

Figures

- Figure 1. HCSL Internal Termination–Simple Topology3
- Figure 2. HCSL Internal Termination with Optional Resistor3
- Figure 3. HCSL External Termination–Common3
- Figure 4. HCSL External Termination Near the Transmitter.....4
- Figure 5. HCSL Dual-Termination for Receivers with Internal Terminations4
- Figure 6. Termination Example of HCSL to LVPECL5
- Figure 7. Standard LVDS Termination.....5
- Figure 8. HCSL Internal Termination Setting in RICBox.....6
- Figure 9. HCSL External Termination Setting in RICBox.....7
- Figure 10. Vovs–HCSL Internal Termination SWING = 800mV on OUT119
- Figure 11. Vovs–HCSL Internal Termination SWING = 800mV on nOUT119
- Figure 12. Vcross–HCSL Internal Termination SWING = 800mV on OUT1110
- Figure 13. Vovs–HCSL Internal Termination SWING = 850mV on OUT1110
- Figure 14. Vovs–HCSL Internal Termination SWING = 850mV on nOUT1111
- Figure 15. Vcross–HCSL Internal Termination SWING = 850mV on OUT1111
- Figure 16. Vovs–HCSL Internal Termination SWING = 900mV on OUT1112
- Figure 17. Vovs–HCSL Internal Termination SWING = 900mV on nOUT1112
- Figure 18. Vcross–HCSL Internal Termination SWING = 900mV on nOUT13
- Figure 19. Vovs–HCSL Internal Termination SWING = 950mV on OUT1113
- Figure 20. Vovs–HCSL Internal Termination SWING = 950mV on nOUT1114
- Figure 21. Vcross–HCSL Internal Termination SWING = 950mV on OUT1114
- Figure 22. Vovs–HCSL External Termination SWING = 800mV on OUT1115
- Figure 23. Vovs–HCSL External Termination SWING = 800mV on nOUT.....15

Figure 24. Vcross–HCSL External Termination SWING = 800mV on OUT11	16
Figure 25. Vovs–HCSL External Termination SWING = 850mV on OUT11	16
Figure 26. Vovs–HCSL External Termination SWING = 850mV on nOUT11	17
Figure 27. Vcross–HCSL External Termination SWING = 850mV on OUT11	17
Figure 28. Vovs–HCSL External Termination SWING = 900mV on OUT11	18
Figure 29. Vovs–HCSL External Termination SWING = 900mV on nOUT11	18
Figure 30. Vcross–HCSL External Termination SWING = 900mV on OUT11	19
Figure 31. Vovs–HCSL External Termination SWING = 950mV on OUT11	19
Figure 32. Vovs–HCSL External Termination SWING = 950mV on nOUT11	20
Figure 33. Vcross–HCSL External Termination SWING = 950mV on OUT11	20
Figure 34. Vovs–HCSL Dual-Termination SWING = 800mV on OUT11	21
Figure 35. Vovs–HCSL Dual-Termination SWING = 800mV on nOUT11	21
Figure 36. Vcross–HCSL Dual-Termination SWING = 800mV on OUT11	22
Figure 37. Vovs–HCSL Dual-Termination SWING = 850mV on OUT11	22
Figure 38. Vovs–HCSL Dual-Termination SWING = 850mV on nOUT11	23
Figure 39. Vcross–HCSL Dual-Termination SWING = 850mV on nOUT11	23
Figure 40. Vovs–HCSL Dual-Termination SWING = 900mV on OUT11	24
Figure 41. Vovs–HCSL Dual-Termination SWING = 900mV on nOUT11	24
Figure 42. Vcross–HCSL Dual-Termination SWING = 900mV on OUT11	25
Figure 43. Vovs–HCSL Dual-Termination SWING = 950mV on OUT11	25
Figure 44. Vovs–HCSL Dual-Termination SWING = 950mV on nOUT11	26
Figure 45. Vcross–HCSL Dual-Termination SWING = 950mV on OUT11	26
Figure 46. Vovs–HCSL Dual-Termination SWING = 950mV, HCSL Boost = Enabled on OUT11.....	27
Figure 47. Vovs–HCSL Dual-Termination SWING = 950mV, HCSL Boost = Enabled on nOUT11.....	27
Figure 48. Vcross–HCSL Dual-Termination SWING = 950mV, HCSL Boost = Enabled on OUT11.....	28
Figure 49. Probe Points of HCSL Internal Termination Mode.....	28
Figure 50. Probe Points of HCSL External Termination Mode	29
Figure 51. LVDS Waveform Measurement.....	29
Figure 52. Waveform Measurement with Probe	30
Figure 53. Waveform Measurement with Coaxial Cable.....	30
Figure 54. Scope's CH1 and CH2 Need to Set 50Ω Impedance when Connecting with Coaxial Cable	31

1. Termination Scheme

The FC3 devices support transmitter internal termination, as shown in Figure 1. Integrating the terminations inside the transmitter simplifies the BOM and the board design.

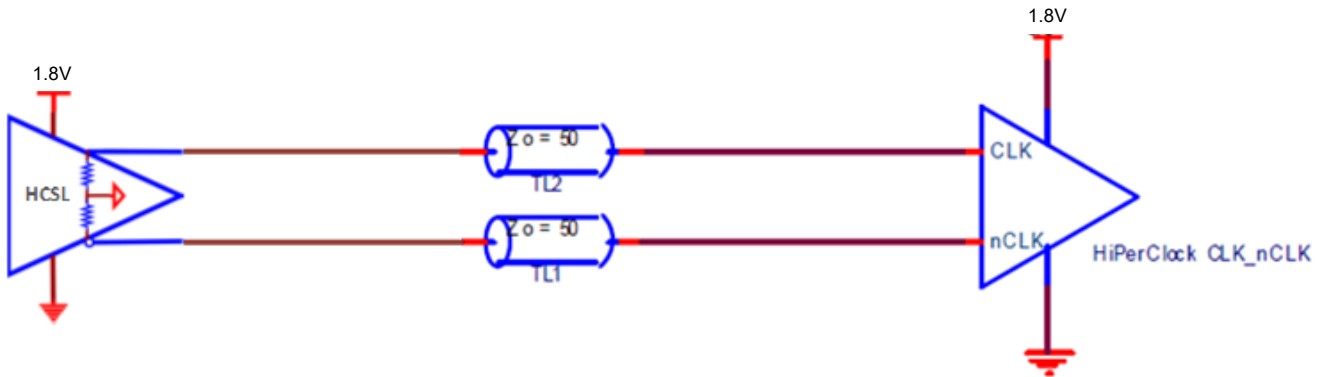


Figure 1. HCSL Internal Termination—Simple Topology

In the case where there may be discontinuities in the traces due to vias, connectors, etc., then a resistor may be added at the receiver to improve signal integrity (see Figure 2). If R5 is used, it improves the signal quality but reduces the signal amplitude by half due to the double termination.

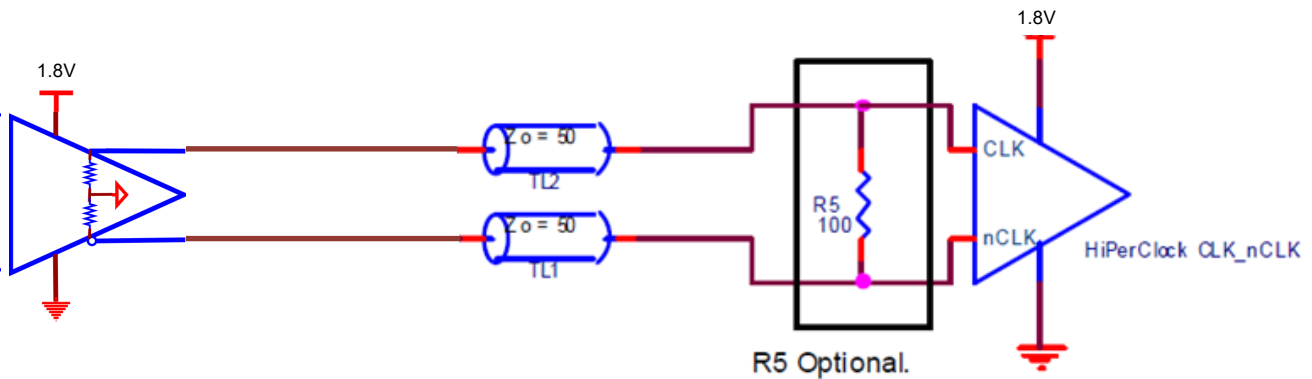


Figure 2. HCSL Internal Termination with Optional Resistor

Figure 3 shows a common standard HCSL external termination scheme. It uses 50Ω pull-down resistors.

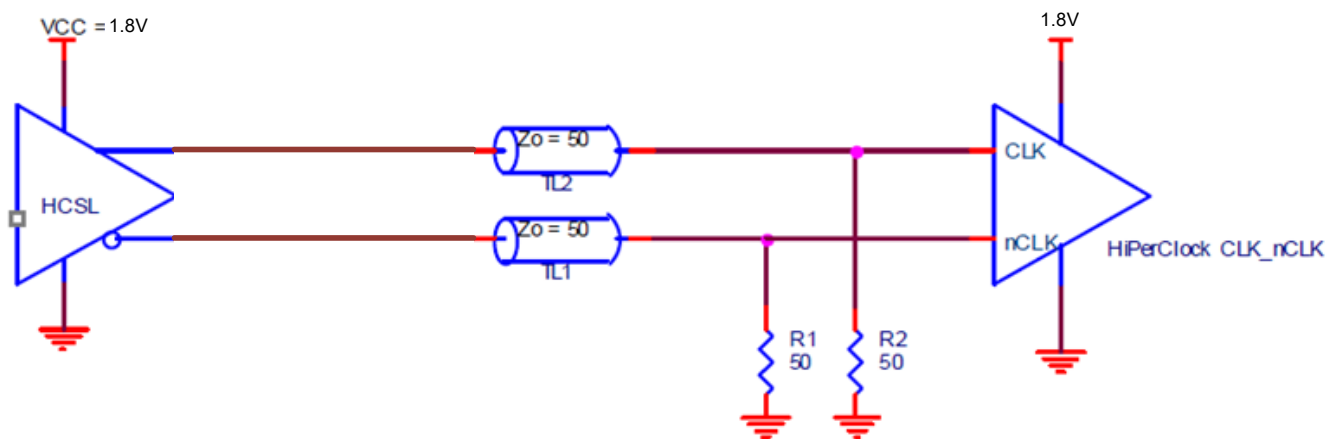


Figure 3. HCSL External Termination—Common

Figure 4 shows another common termination scheme used in PCIe applications with the termination placed close to the transmitter.

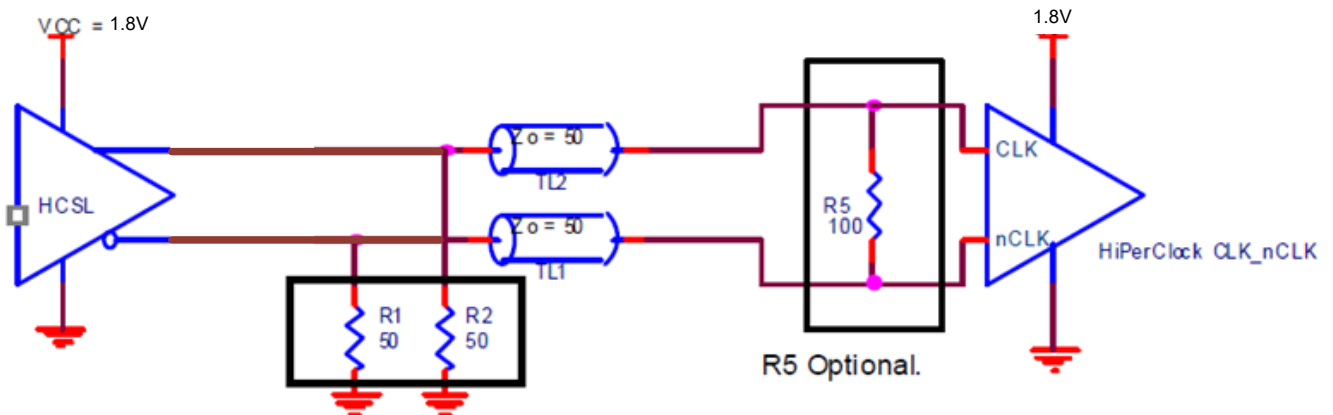


Figure 4. HCSL External Termination Near the Transmitter

Figure 5 shows a common HCSL termination scheme for receivers with internal terminations. Internally, the receiver will have a Thevenin-equivalent termination consisting of two series 50Ω resistors center-tapped to a bias voltage. Due to the receiver’s internal DC-offset, the HCSL driver should not be DC-coupled. This requires that the interface be AC-coupled and that the HCSL terminations be provided at the driver. In this case, the topology is simplified by using the FC3’s internal terminations. The combination of the FC3 internal termination and the receiver’s internal termination creates a dual-termination scheme, which improves the signal quality but reduces the signal amplitude by half. In this case, the FC3 amplitude should be set to the maximum setting of 950mV.

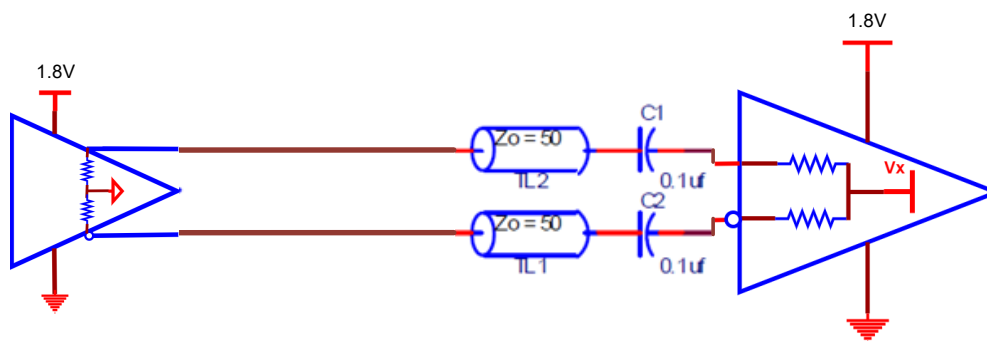


Figure 5. HCSL Dual-Termination for Receivers with Internal Terminations

Figure 6 shows how to interface an FC3 HCSL output to an LVPECL receiver. It uses AC-coupling and a re-bias. R1 and R2 can also be omitted when the FC3 HCSL driver is configured to use internal terminations.

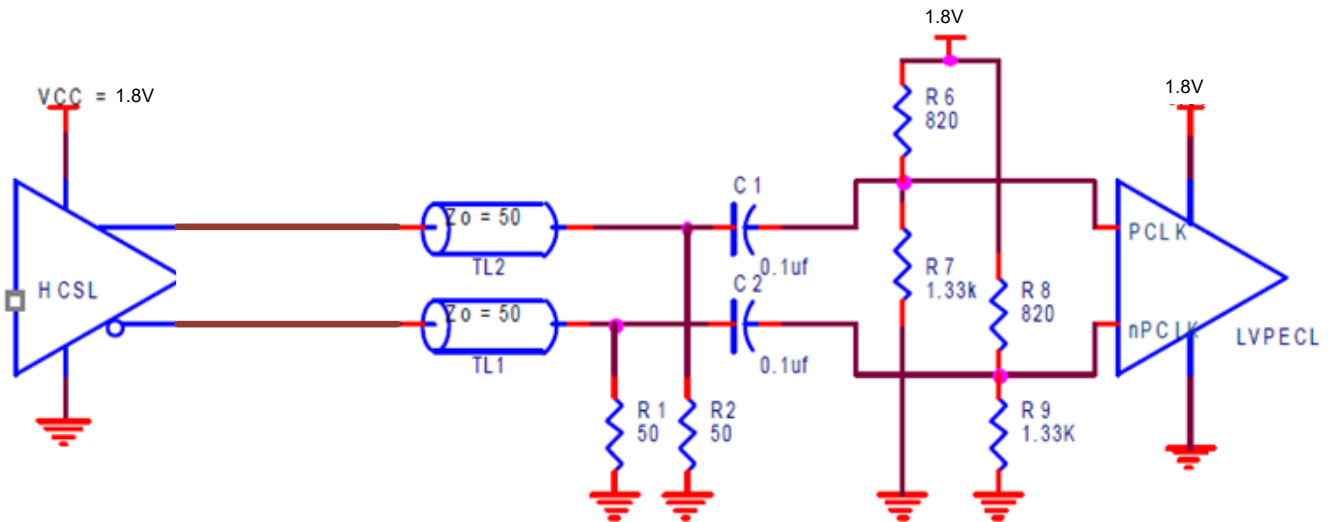


Figure 6. Termination Example of HCSL to LVPECL

Figure 7 shows how to interface an FC3 LVDS output to an LVDS receiver.

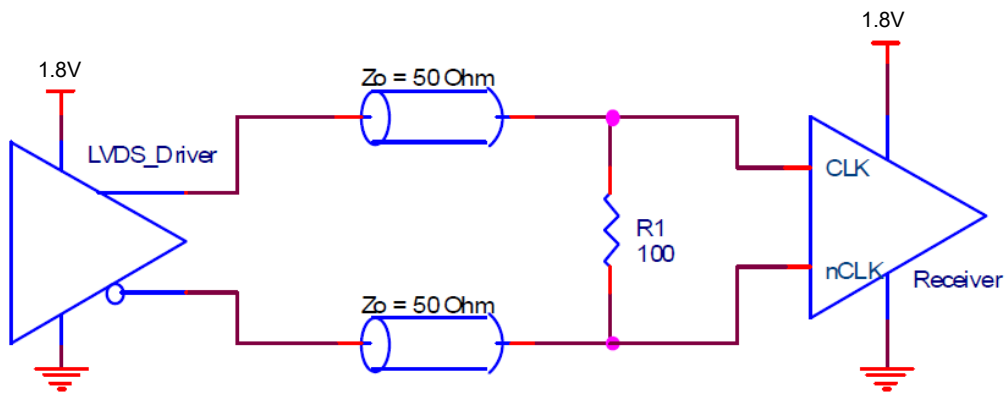


Figure 7. Standard LVDS Termination

2. OUTx Mode Setting in RICBox

The following section describes how to setup the HCSL configuration using the RICBox GUI.

1. **Output type**—Select HCSL internally terminated or HCSL externally terminated.
2. **Swing**—Select HCSL output swing, for example, 800mV, 850mV, 900mV, 950mV (use 950mV for double-termination schemes).
3. **Enable Boost:** Enable/disable HCSL Boost. HCSL boost is only supported for Swing = 950mV (see Figure 8).

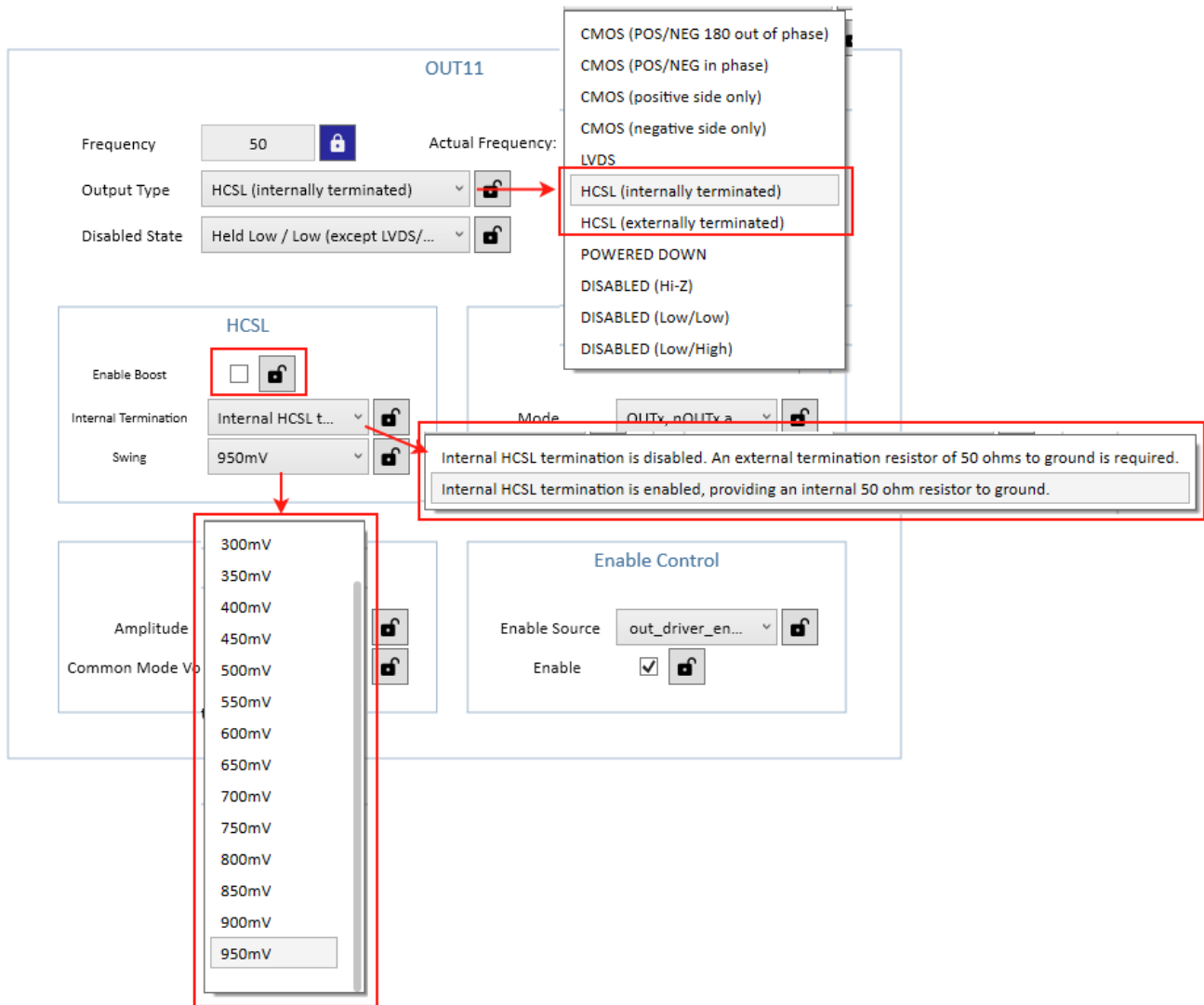


Figure 8. HCSL Internal Termination Setting in RICBox

- When the **Output Type** selected is *HCSL (externally terminated)*, the GUI automatically sets the **Internal Termination** to disabled (see Figure 9).

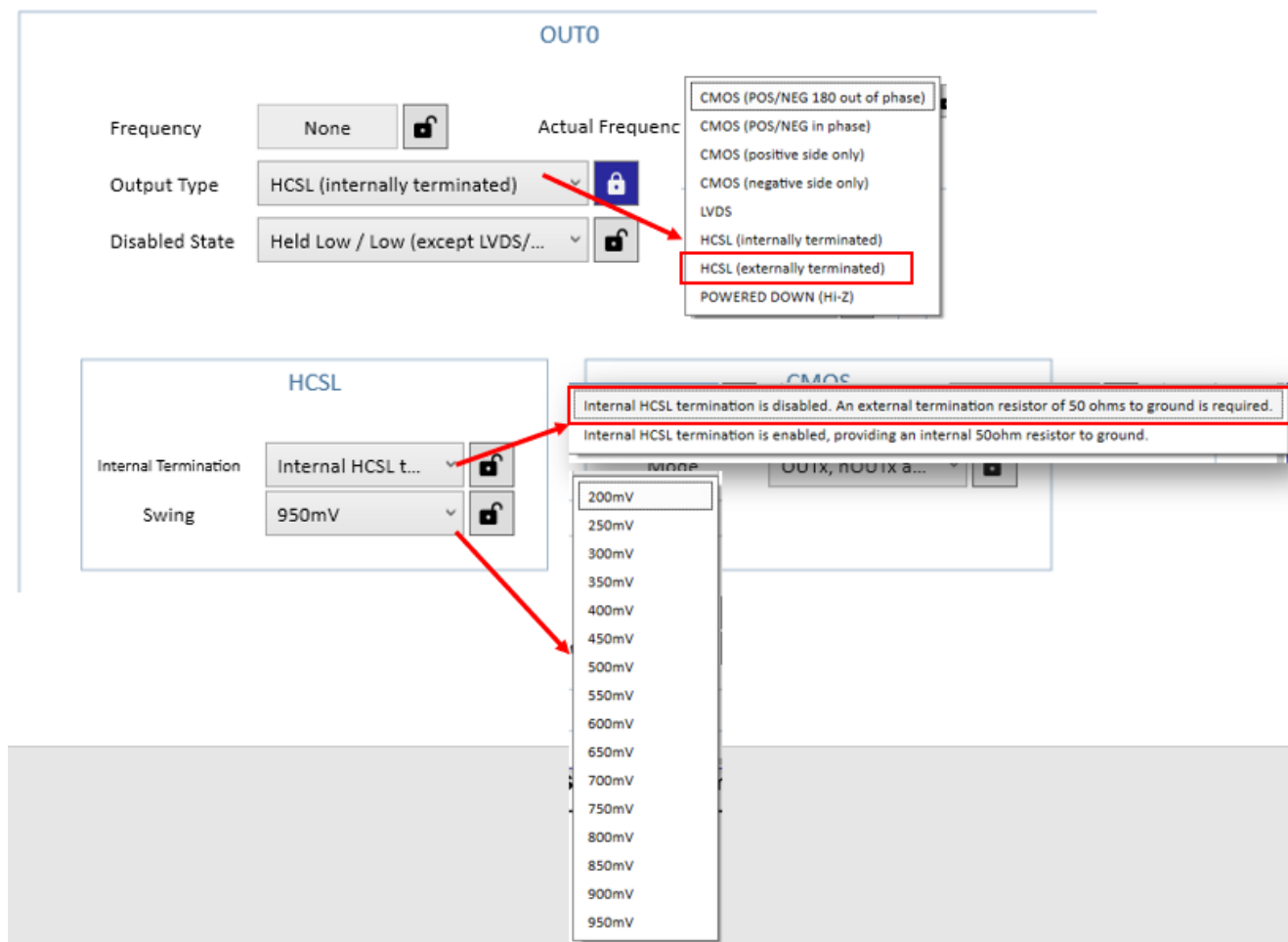


Figure 9. HCSL External Termination Setting in RICBox

3. HCSL Amplitude and Cross-Voltage Measurement

Table 1 lists the HCSL measuring data on the FC3 EVB for a variety of termination schemes. Waveforms for each case are shown in Figure 10 to Figure 48. For more information on the EVB test method, see FC3 EVB Waveform Measurement Method.

Table 1. Vovs and Vcross Measurement

HCSL Termination Mode	HCSL_SWING Register Field Setting	HCSL Boost	Vovs (mV)		Vcross (mV)	
Internal Termination	HCSL_SWING = 800	Disabled	875	976	505	517
	HCSL_SWING = 850	Disabled	946	915	459	478
	HCSL_SWING = 900	Disabled	980	948	506	475
	HCSL_SWING = 950	Disabled	1096	1079	503	537
External Termination	HCSL_SWING = 800	Disabled	870	870	415	456
	HCSL_SWING = 850	Disabled	907	914	487	446
	HCSL_SWING = 900	Disabled	937	942	462	503
	HCSL_SWING = 950	Disabled	960	969	515	475
Dual Termination <i>Note: Enable internal HCSL termination and add external termination.</i>	HCSL_SWING = 800	Disabled	436	437	203	194
	HCSL_SWING = 850	Disabled	463	464	216	209
	HCSL_SWING = 900	Disabled	488	488	221	232
	HCSL_SWING = 950	Disabled	514	512	243	235
	HCSL_SWING = 950	Enabled	656	657	328	306

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3

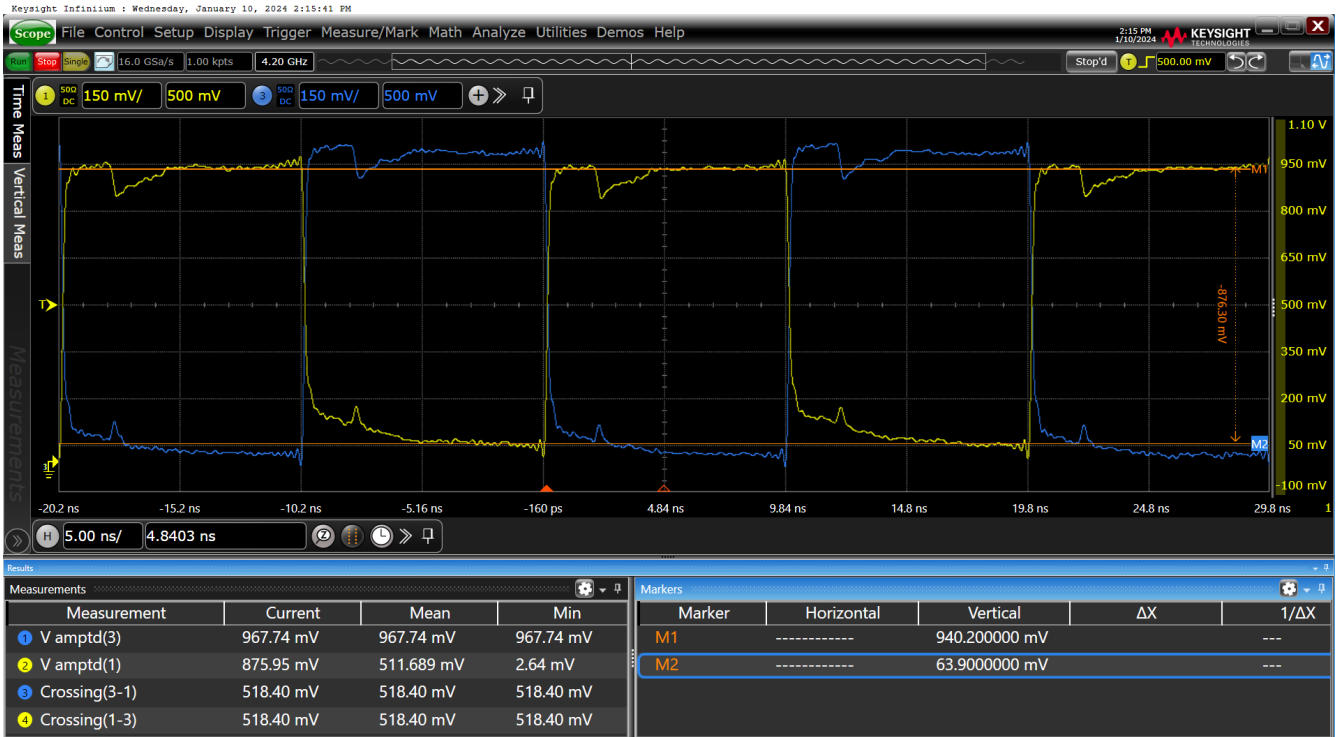


Figure 10. Vovs–HCSL Internal Termination SWING = 800mV on OUT11

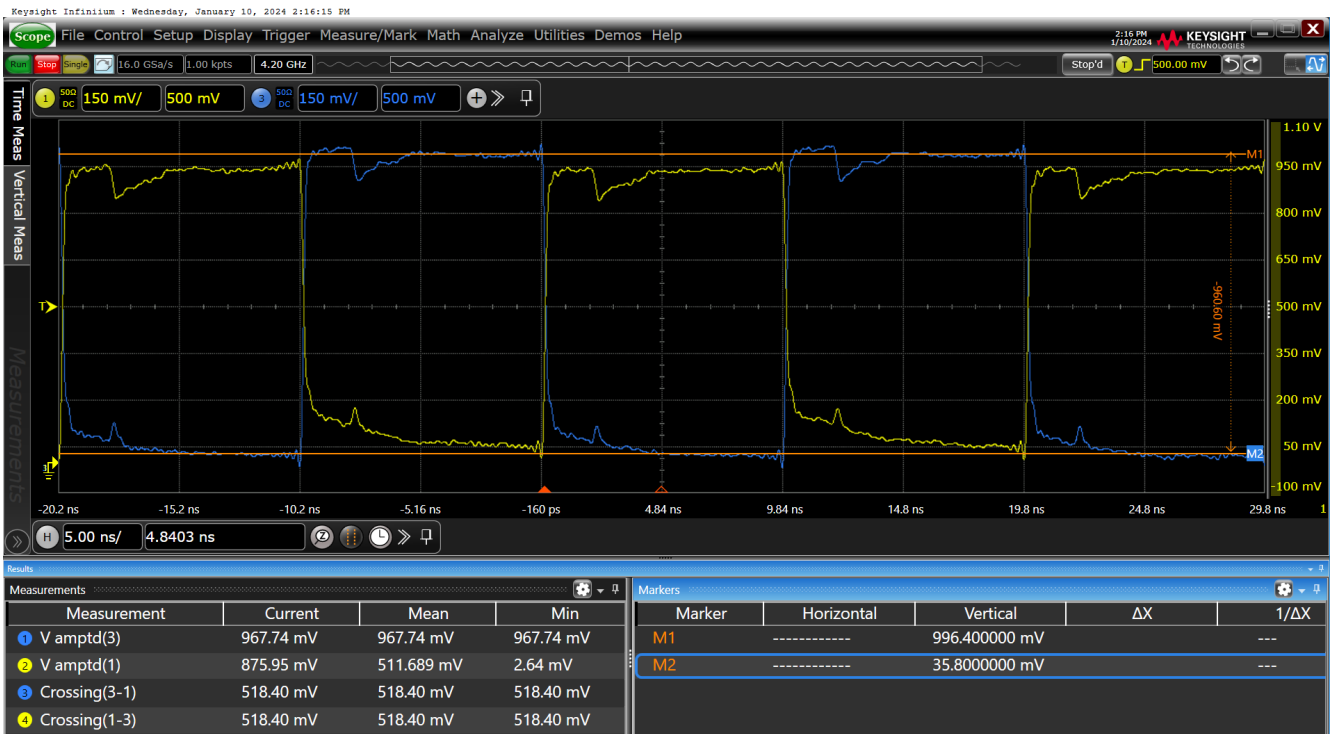


Figure 11. Vovs–HCSL Internal Termination SWING = 800mV on nOUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3

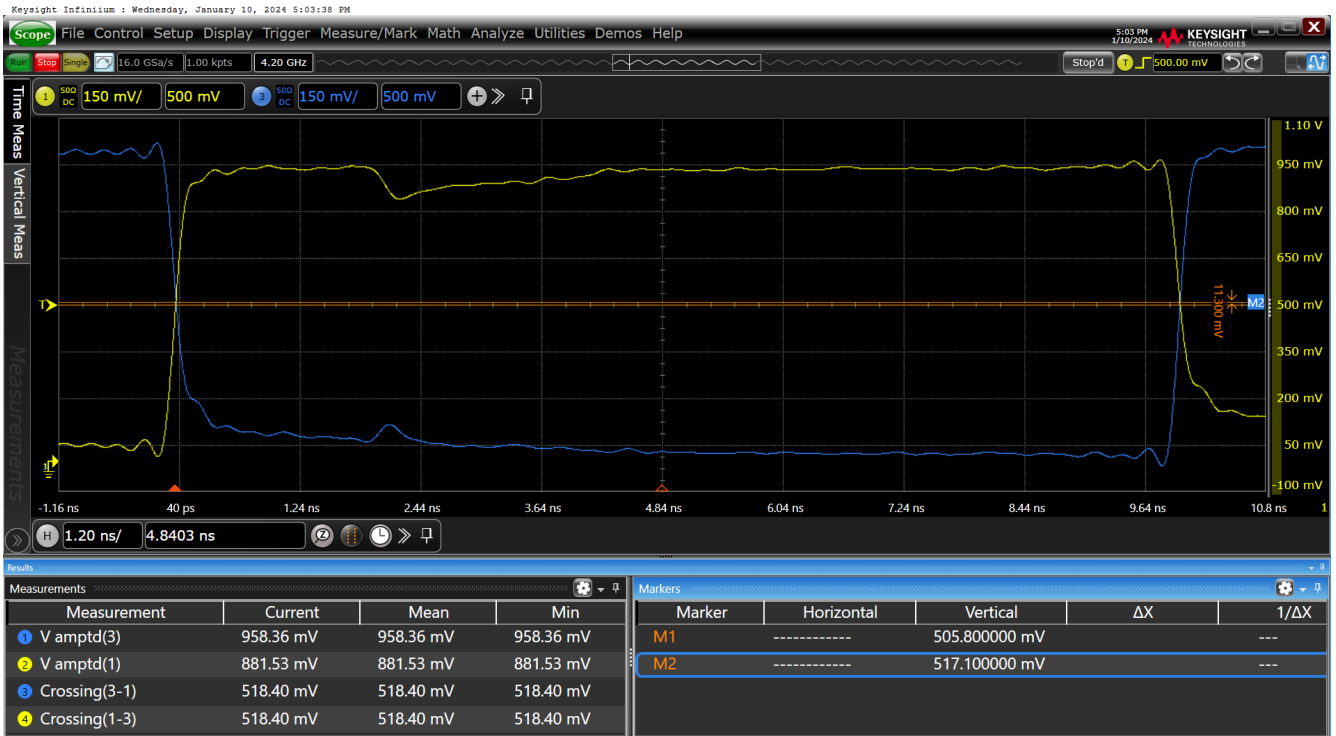


Figure 12. Vcross–HCSL Internal Termination SWING = 800mV on OUT11

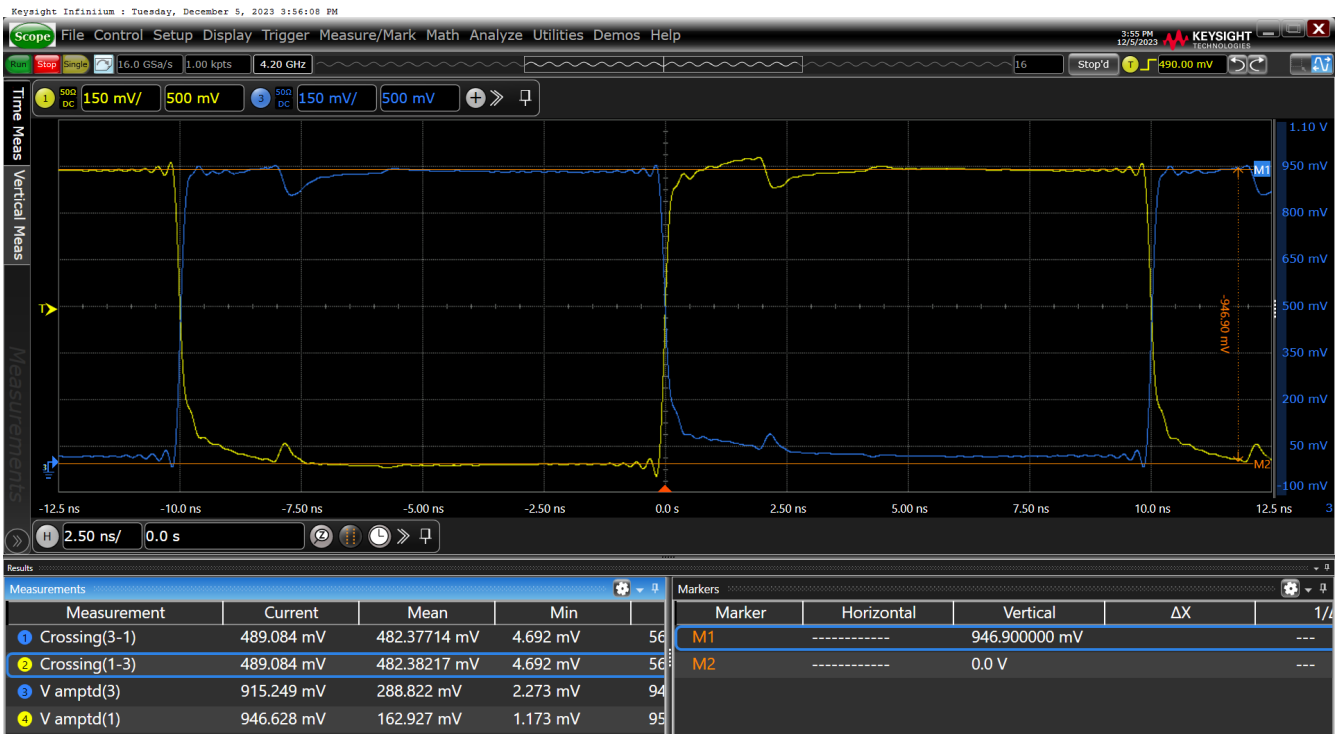


Figure 13. Vovs–HCSL Internal Termination SWING = 850mV on OUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3

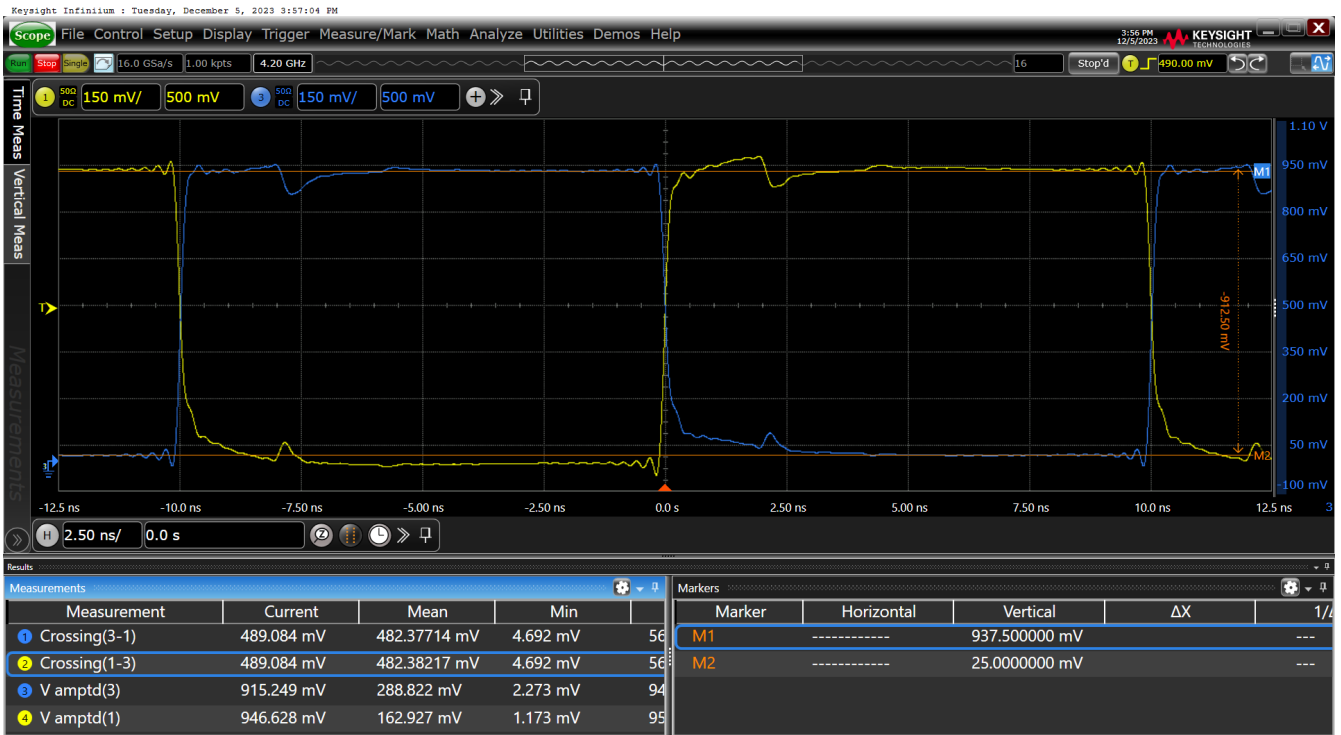


Figure 14. Vovs–HCSL Internal Termination SWING = 850mV on nOUT11



Figure 15. Vcross–HCSL Internal Termination SWING = 850mV on OUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3



Figure 16. Vovs–HCSL Internal Termination SWING = 900mV on OUT11

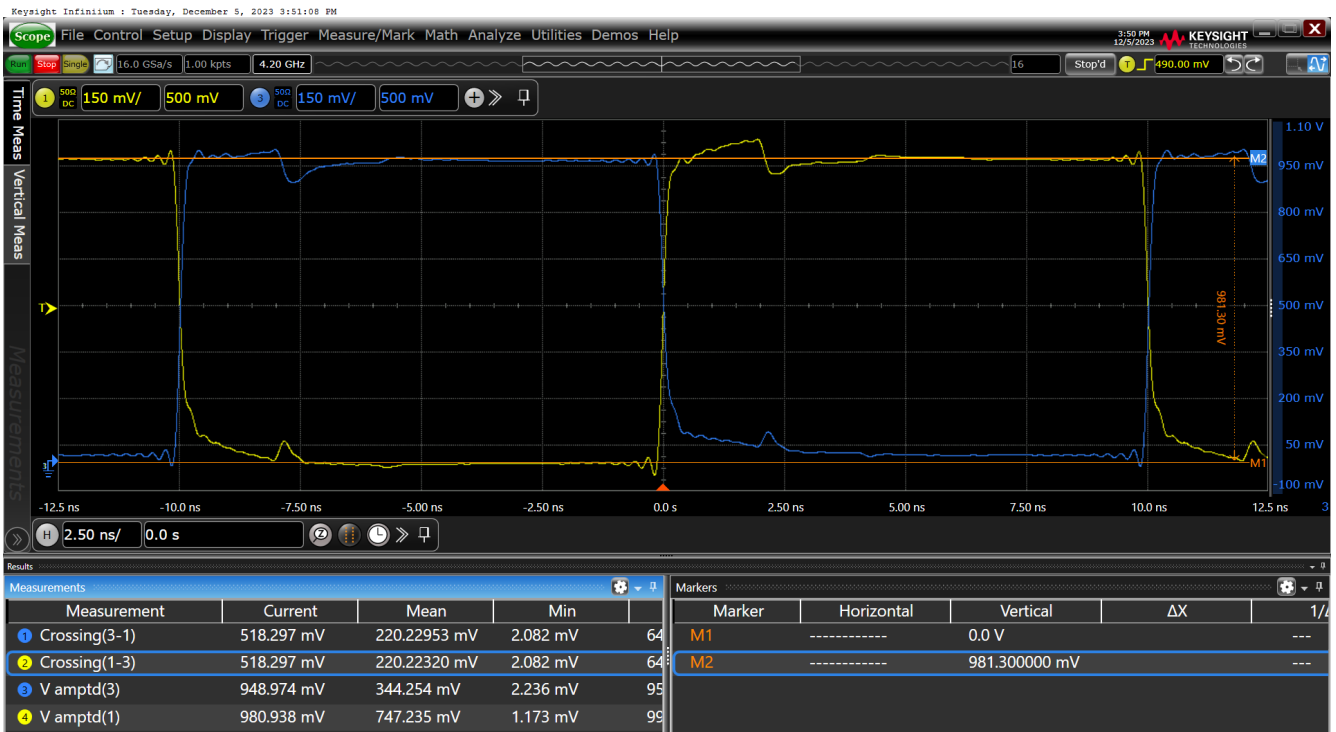


Figure 17. Vovs–HCSL Internal Termination SWING = 900mV on nOUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3



Figure 18. Vcross–HCSL Internal Termination SWING = 900mV on nOUT



Figure 19. Vovs–HCSL Internal Termination SWING = 950mV on OUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3

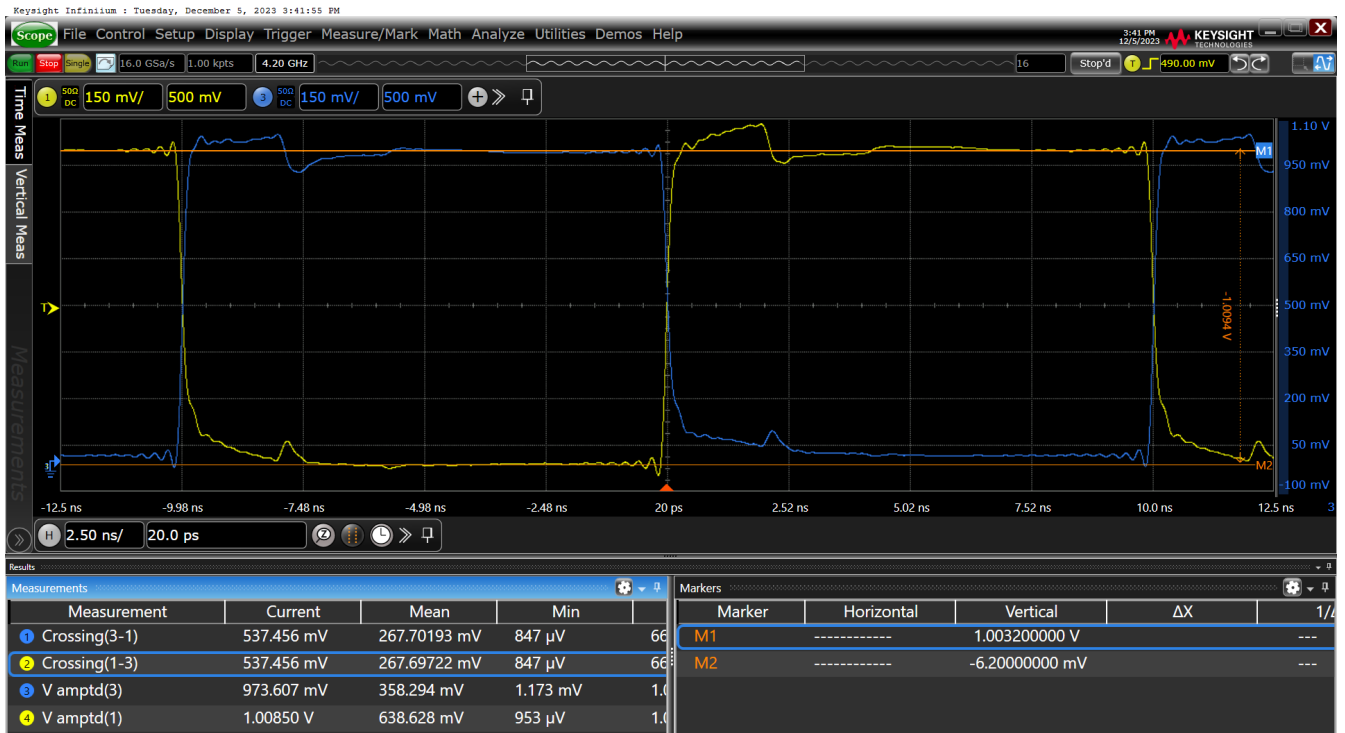


Figure 20. Vovs-HCSL Internal Termination SWING = 950mV on nOUT11



Figure 21. Vcross-HCSL Internal Termination SWING = 950mV on OUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3

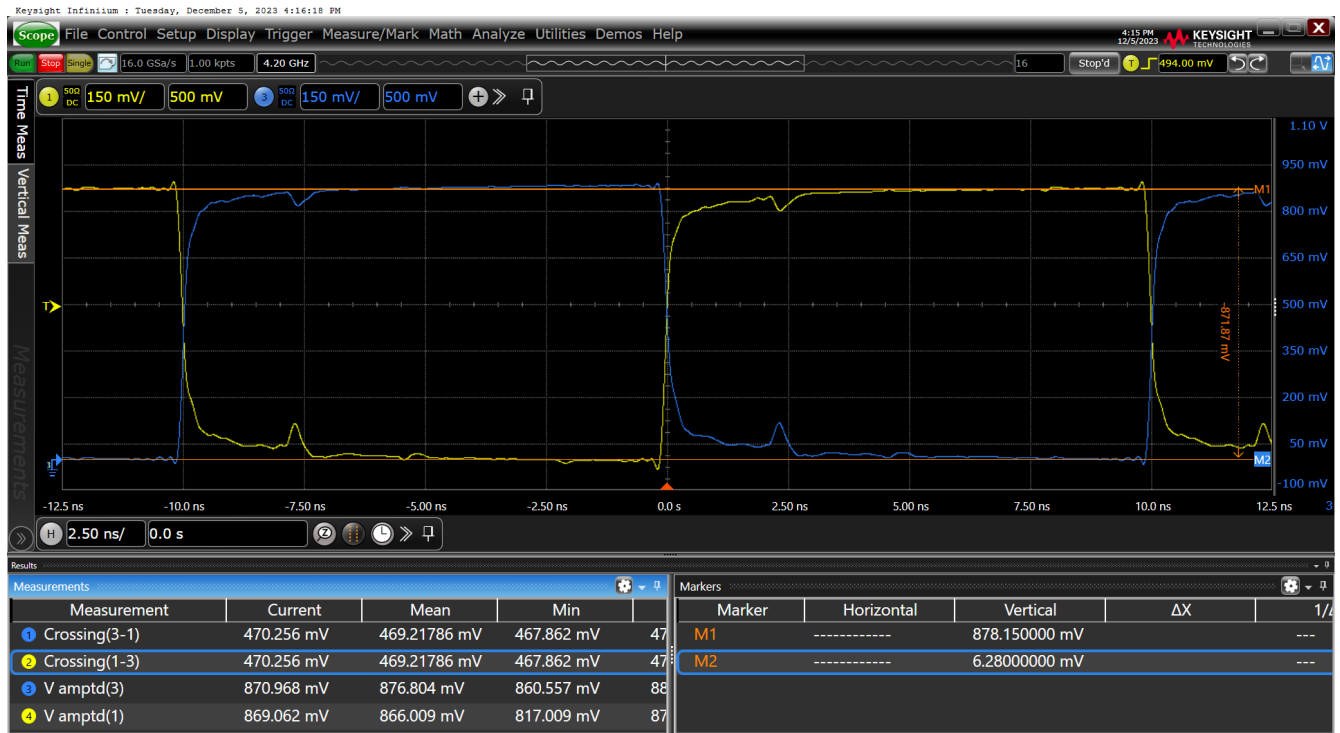


Figure 22. Vovs–HCSL External Termination SWING = 800mV on OUT11

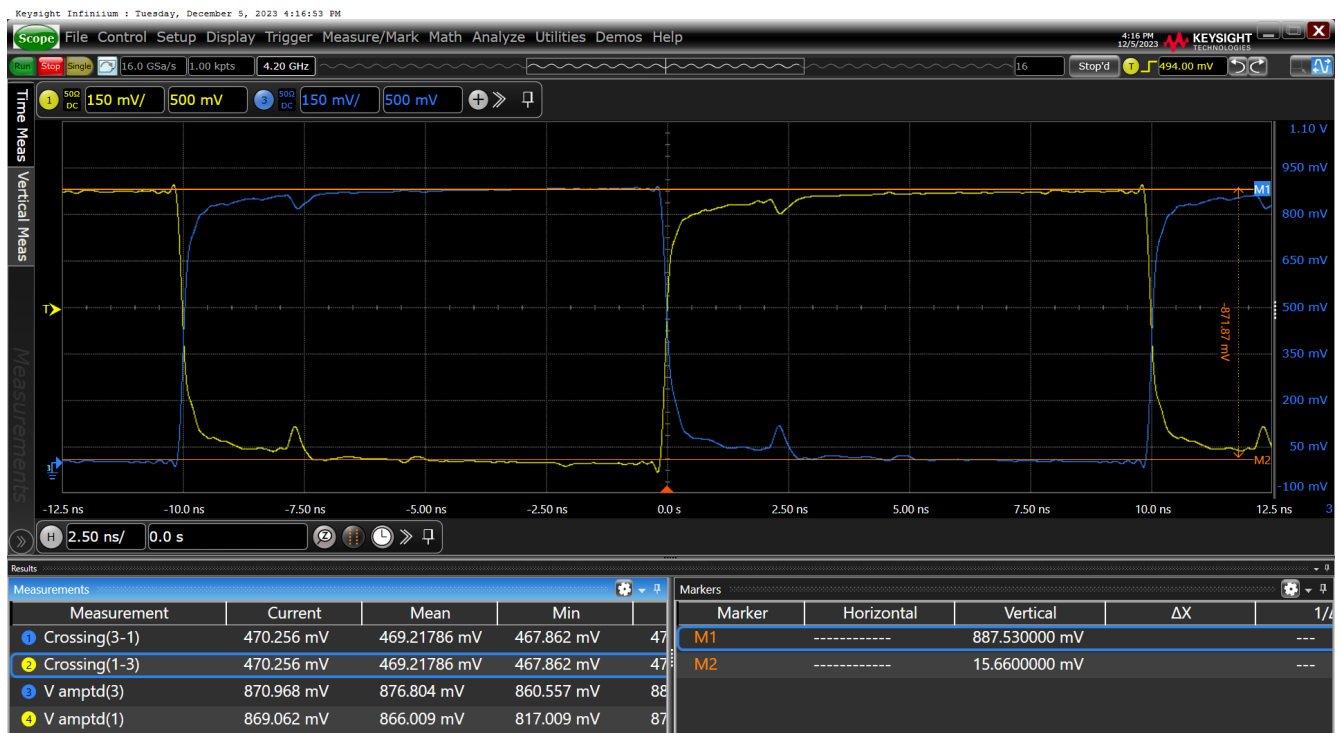


Figure 23. Vovs–HCSL External Termination SWING = 800mV on nOUT

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3



Figure 24. Vcross-HCSL External Termination SWING = 800mV on OUT11

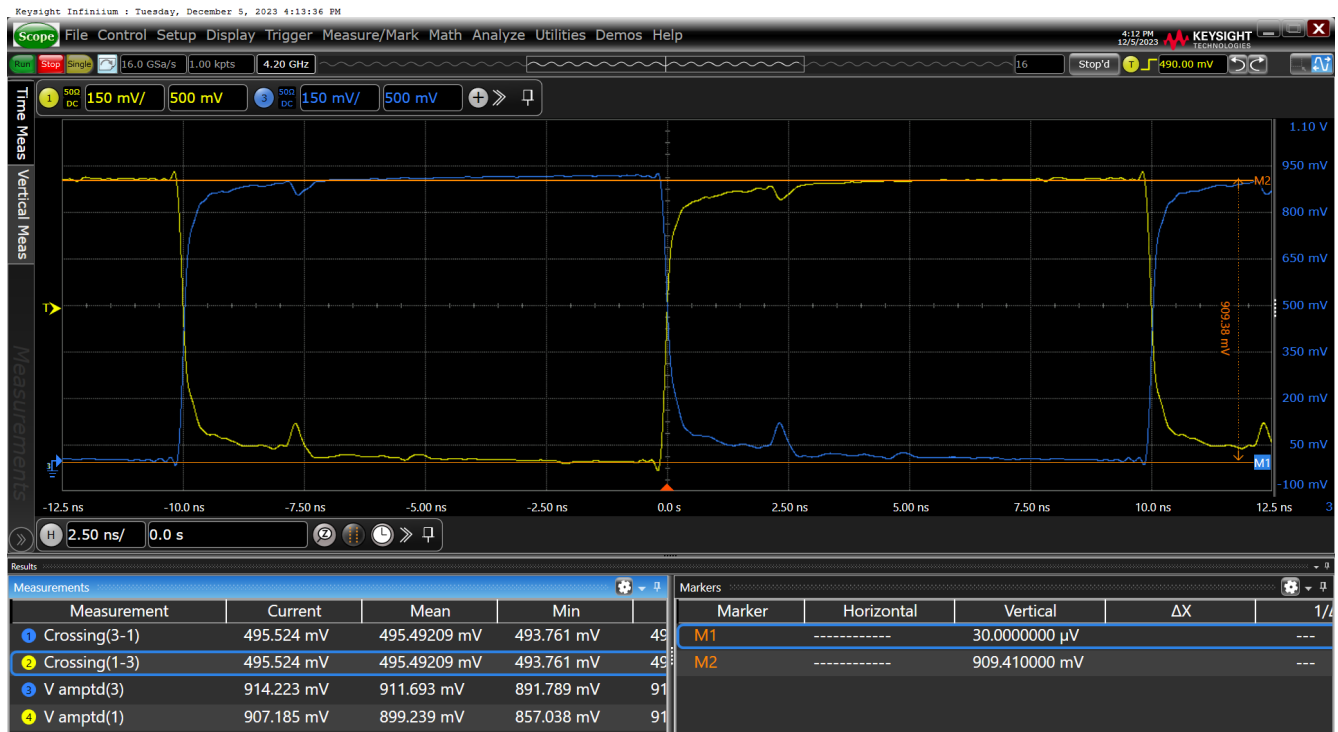


Figure 25. Vovs-HCSL External Termination SWING = 850mV on OUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3

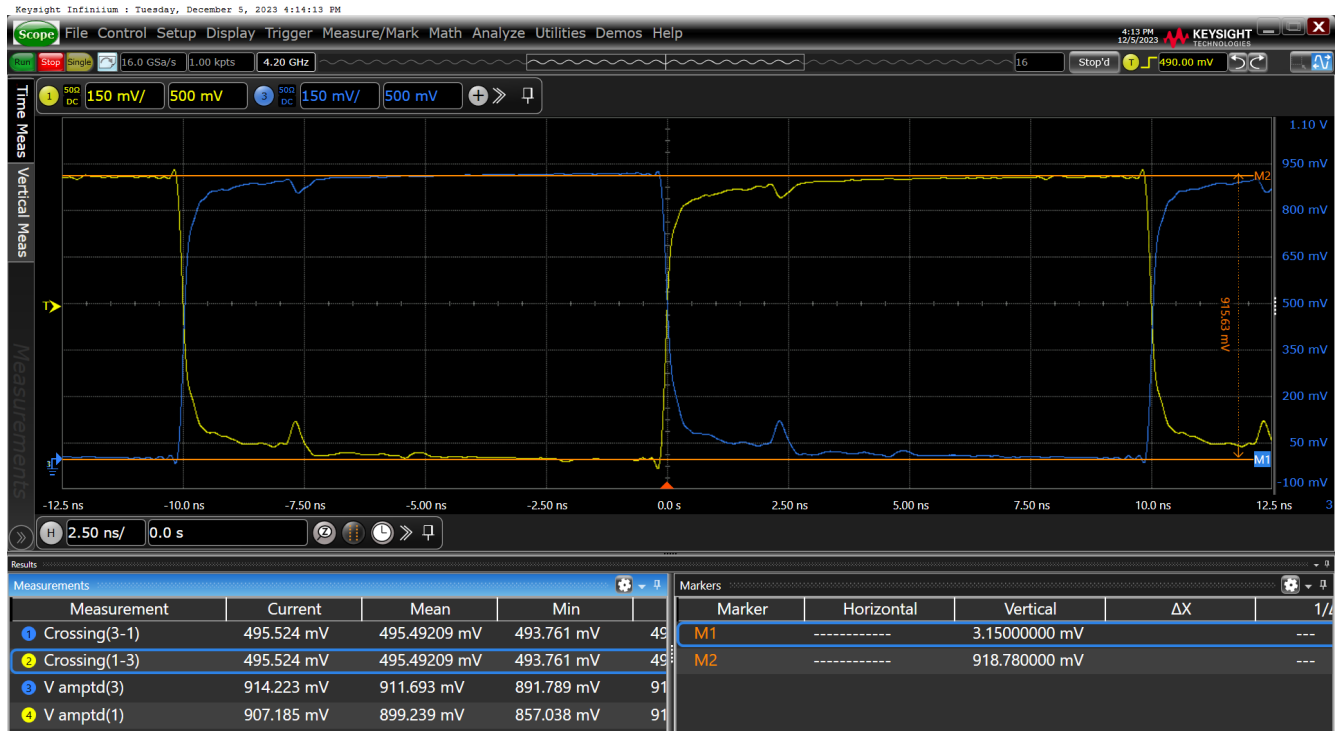


Figure 26. VoVs-HCSL External Termination SWING = 850mV on nOUT11



Figure 27. Vcross-HCSL External Termination SWING = 850mV on OUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3



Figure 28. Vovs–HCSL External Termination SWING = 900mV on OUT11

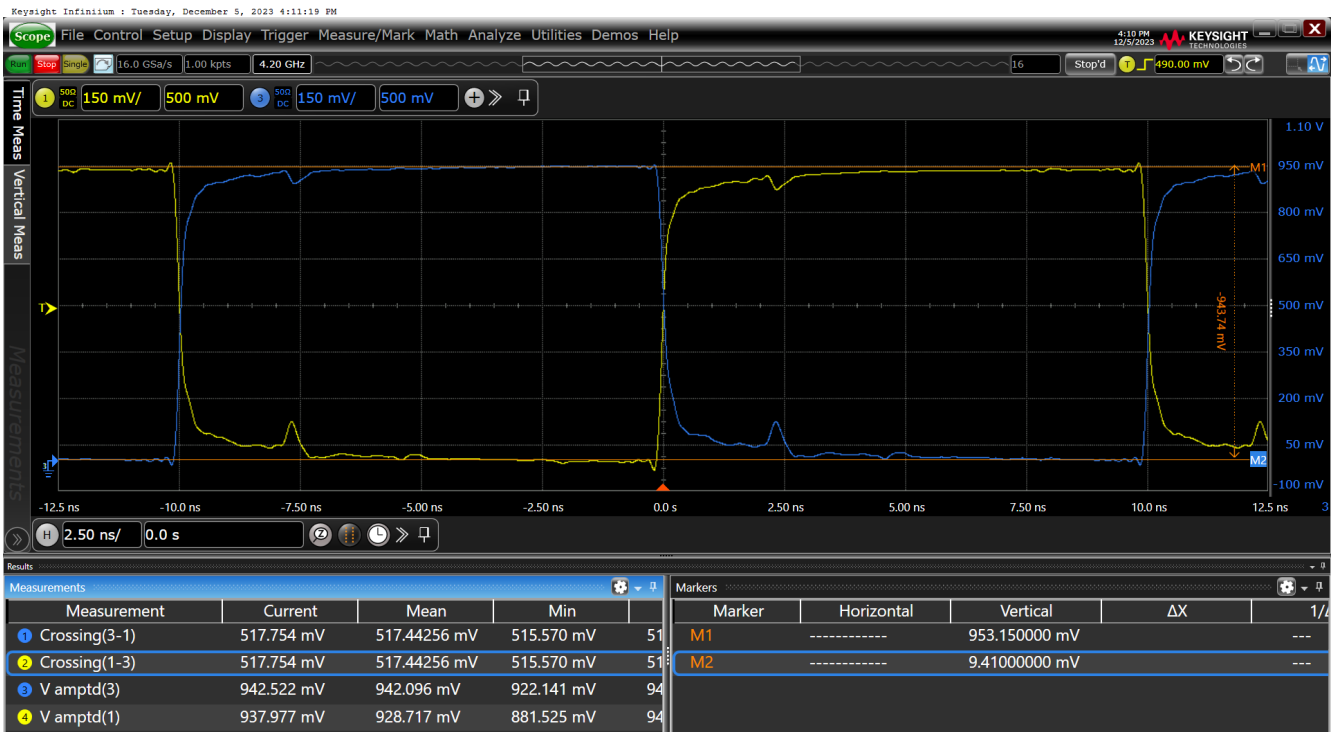


Figure 29. Vovs–HCSL External Termination SWING = 900mV on nOUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3



Figure 30. Vcross–HCSL External Termination SWING = 900mV on OUT11



Figure 31. Vovs–HCSL External Termination SWING = 950mV on OUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3

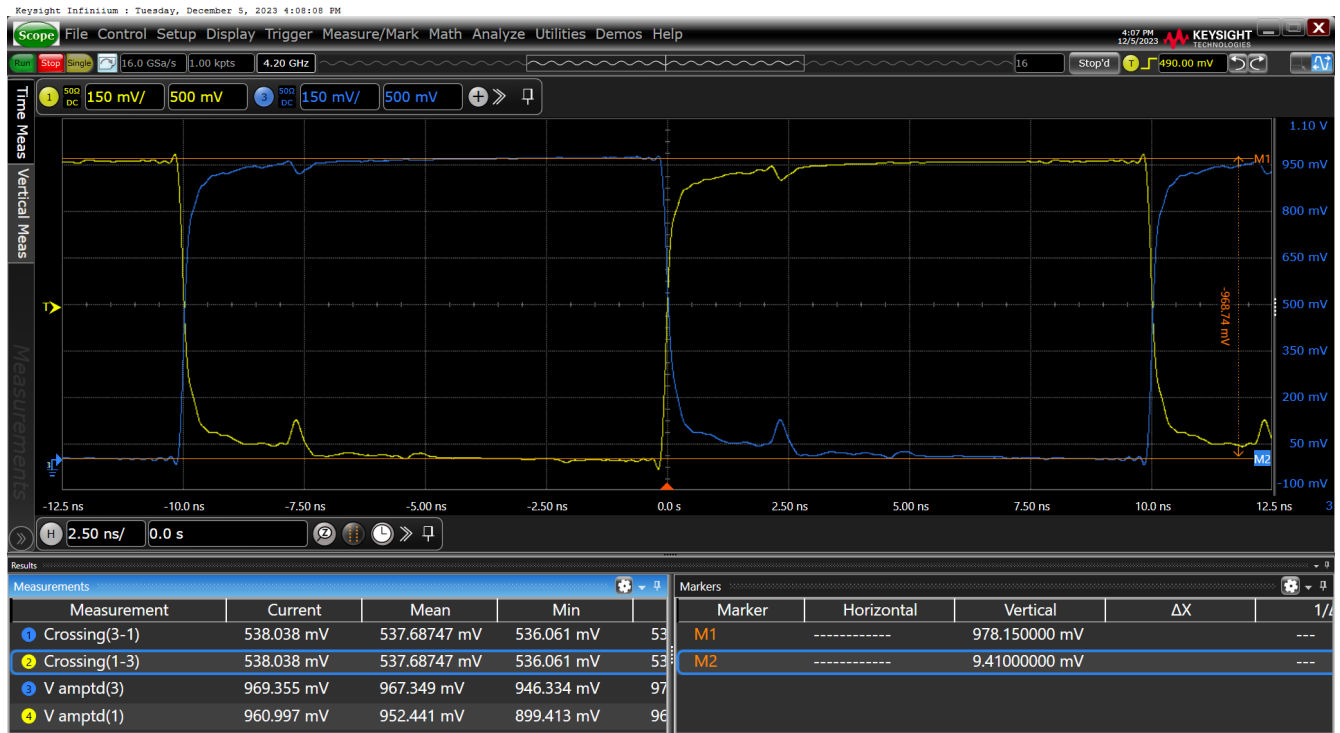


Figure 32. Vovs-HCSL External Termination SWING = 950mV on nOUT11



Figure 33. Vcross-HCSL External Termination SWING = 950mV on OUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3

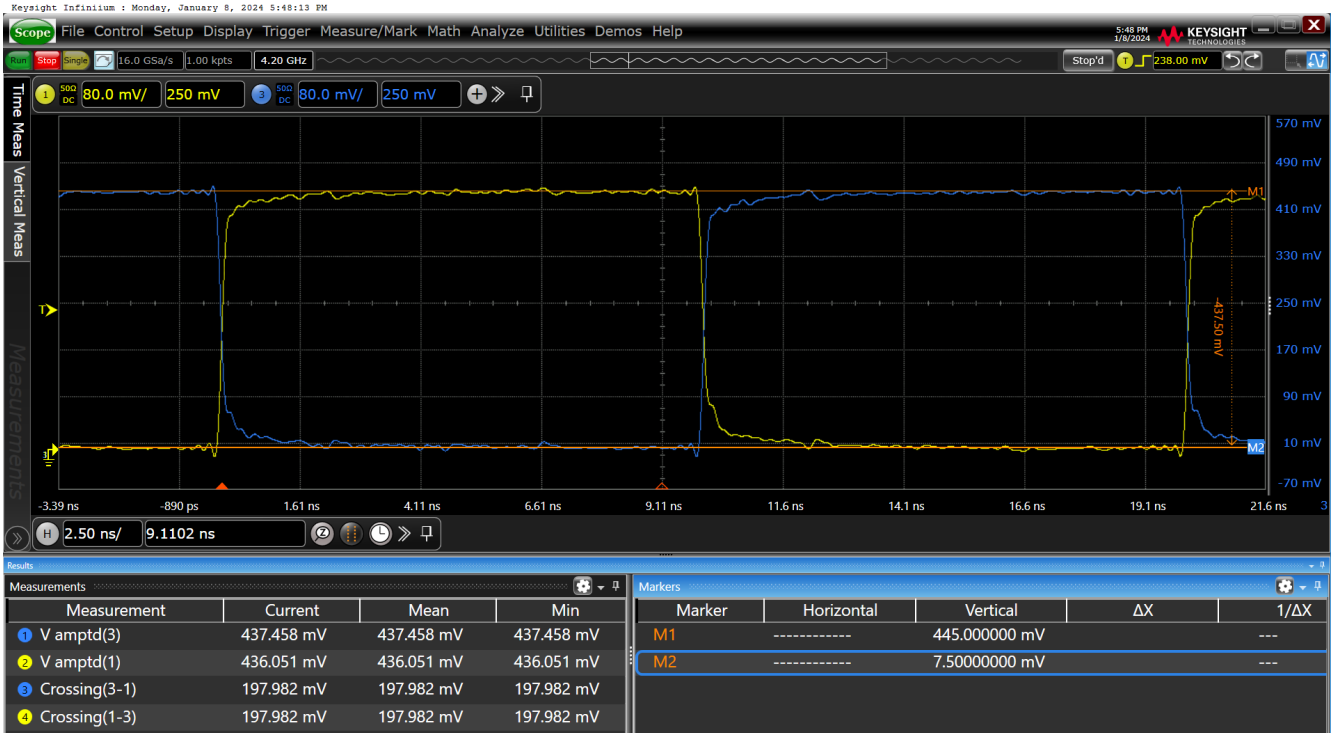


Figure 34. Vovs–HCSL Dual-Termination SWING = 800mV on OUT11

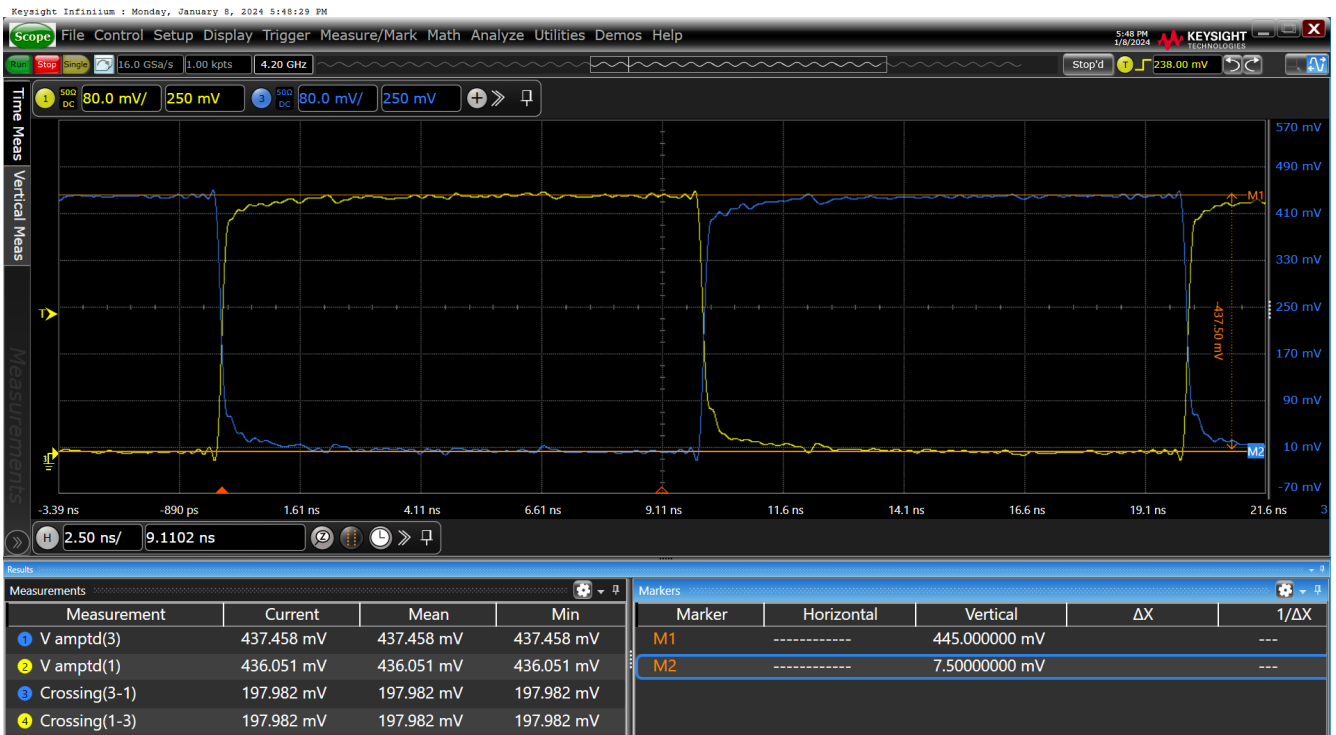


Figure 35. Vovs–HCSL Dual-Termination SWING = 800mV on nOUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3



Figure 36. Vcross-HCSL Dual-Termination SWING = 800mV on OUT11



Figure 37. Vovs-HCSL Dual-Termination SWING = 850mV on OUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3

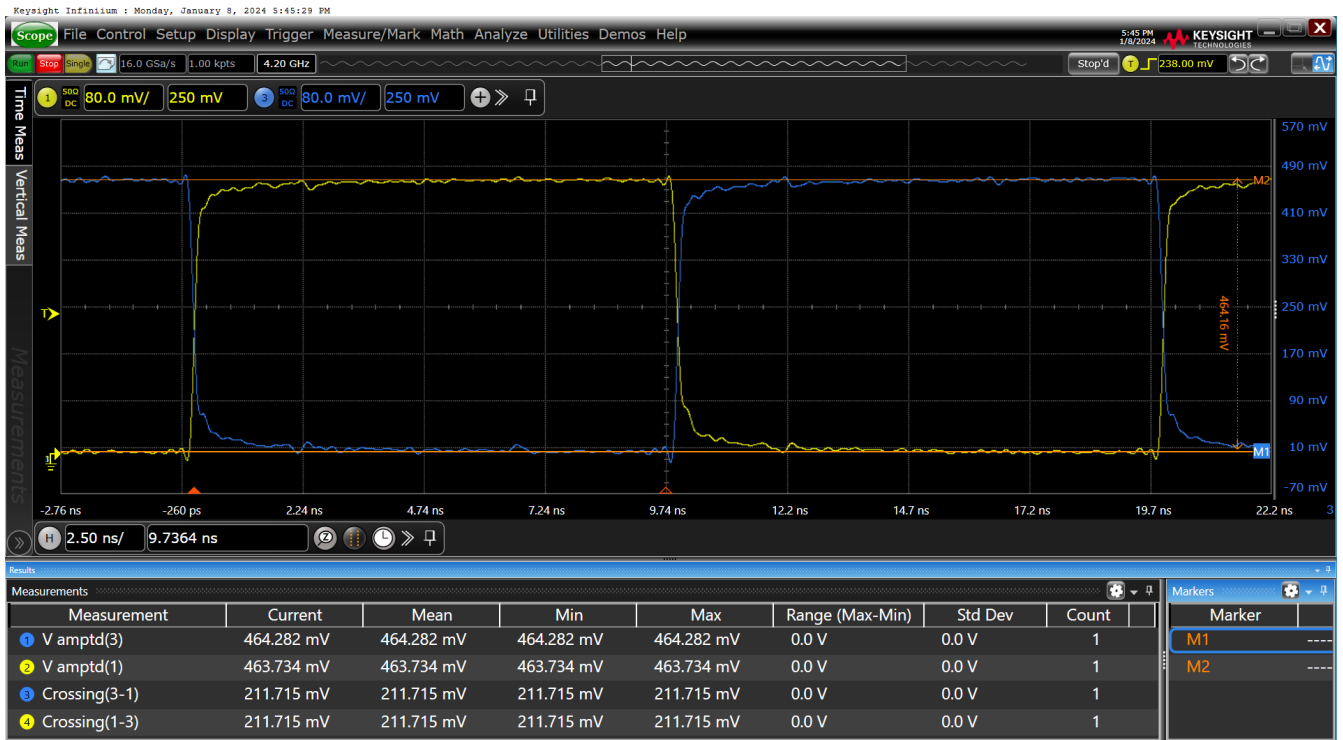


Figure 38. Vovs-HCSL Dual-Termination SWING = 850mV on nOUT11



Figure 39. Vcross-HCSL Dual-Termination SWING = 850mV on nOUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3

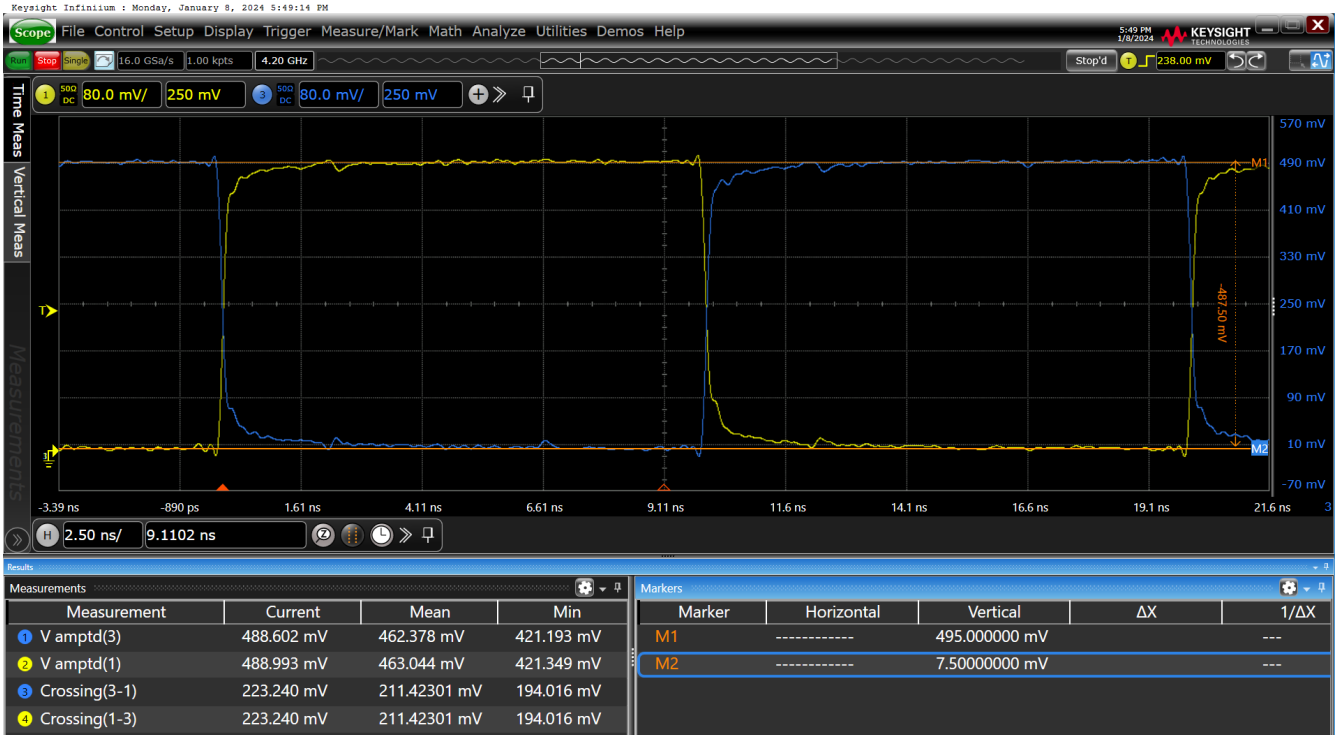


Figure 40. Vovs-HCSL Dual-Termination SWING = 900mV on OUT11

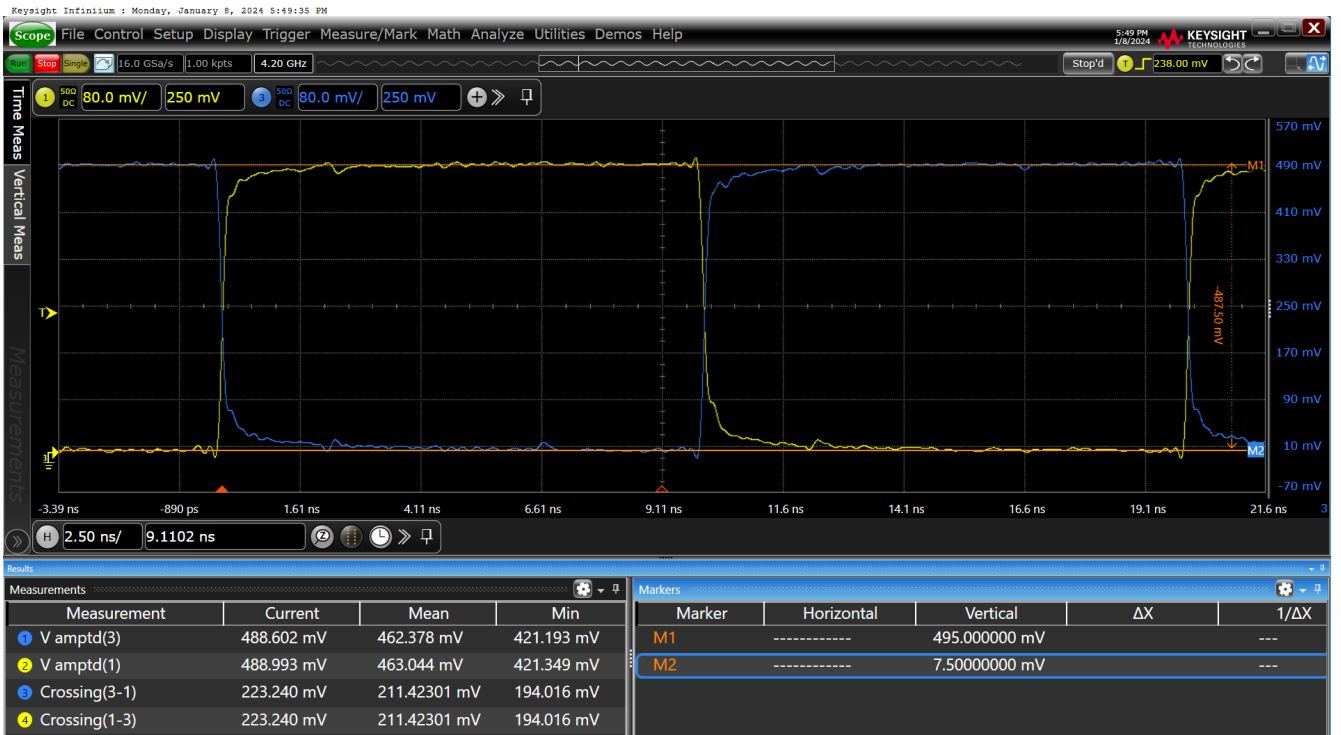


Figure 41. Vovs-HCSL Dual-Termination SWING = 900mV on nOUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3



Figure 42. Vcross–HCSL Dual-Termination SWING = 900mV on OUT11

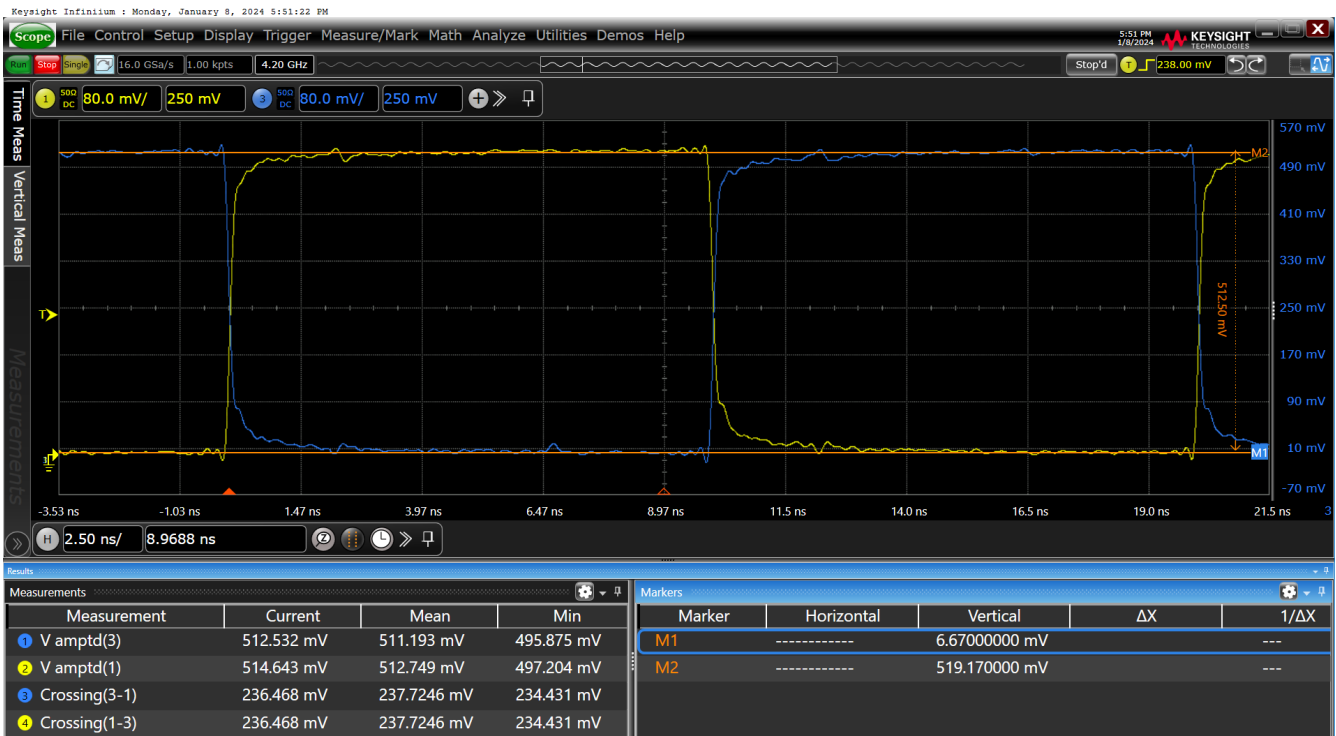


Figure 43. Vovs–HCSL Dual-Termination SWING = 950mV on OUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3

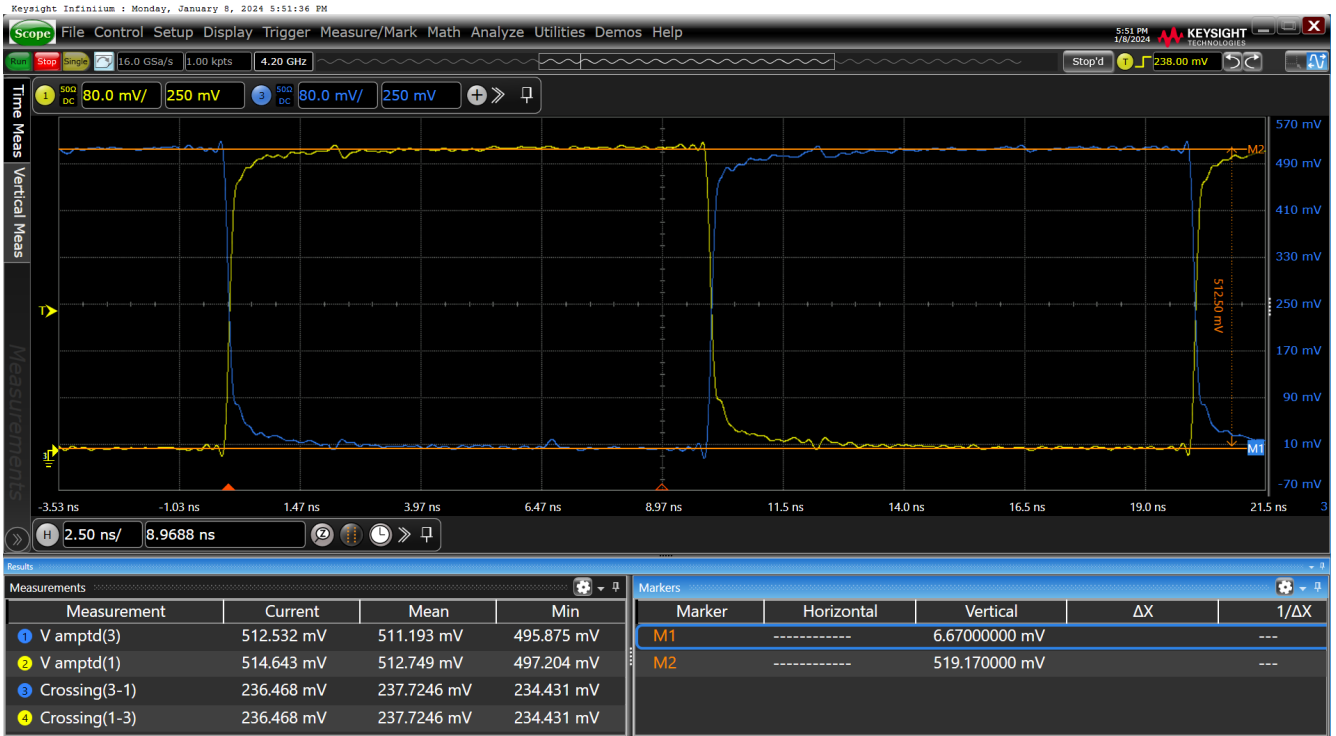


Figure 44. Vovs-HCSL Dual-Termination SWING = 950mV on nOUT11



Figure 45. Vcross-HCSL Dual-Termination SWING = 950mV on OUT11

HCSL Output Termination Scheme and Waveform Measurement on FemtoClock3

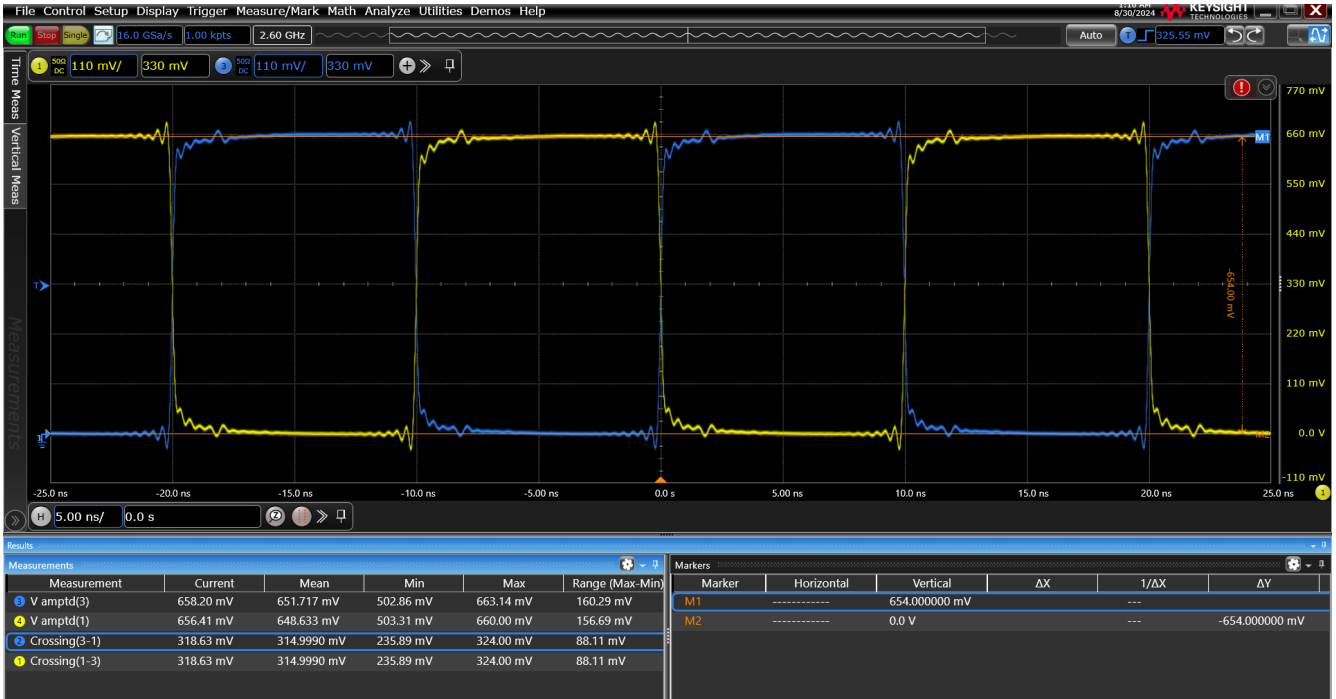


Figure 46. Vovs-HCSL Dual-Termination SWING = 950mV, HCSL Boost = Enabled on OUT11

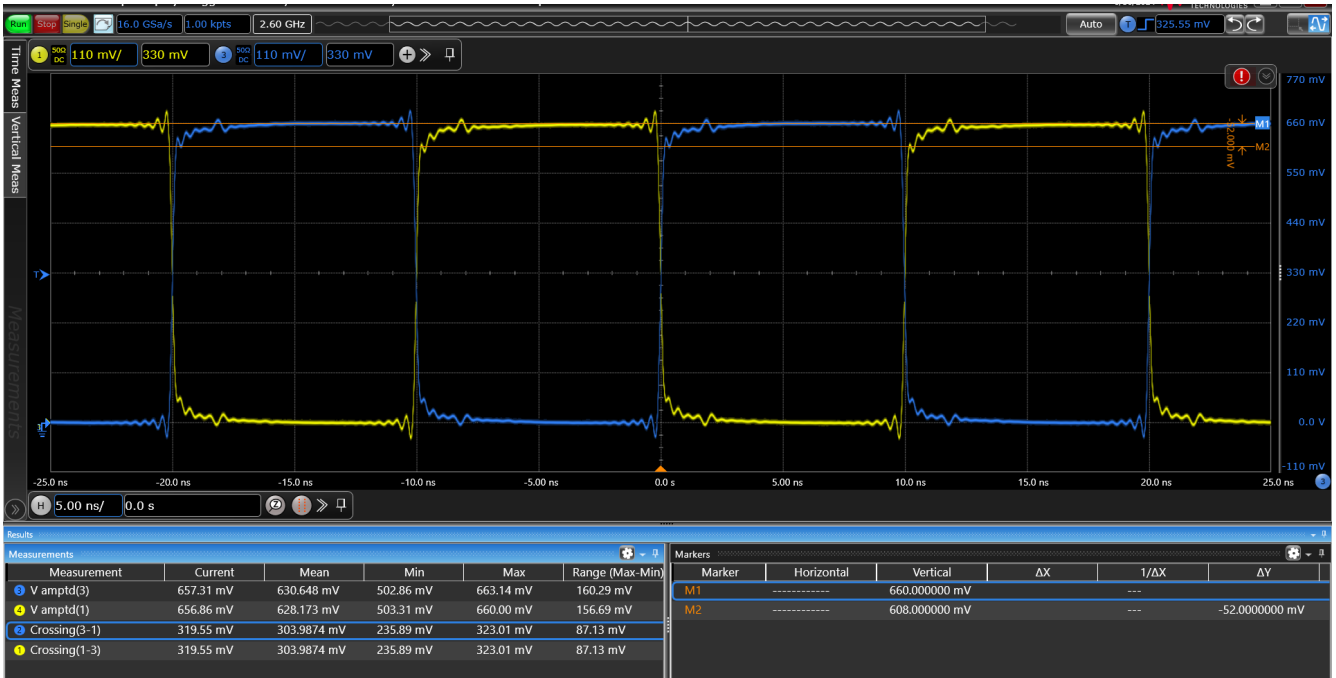


Figure 47. Vovs-HCSL Dual-Termination SWING = 950mV, HCSL Boost = Enabled on nOUT11

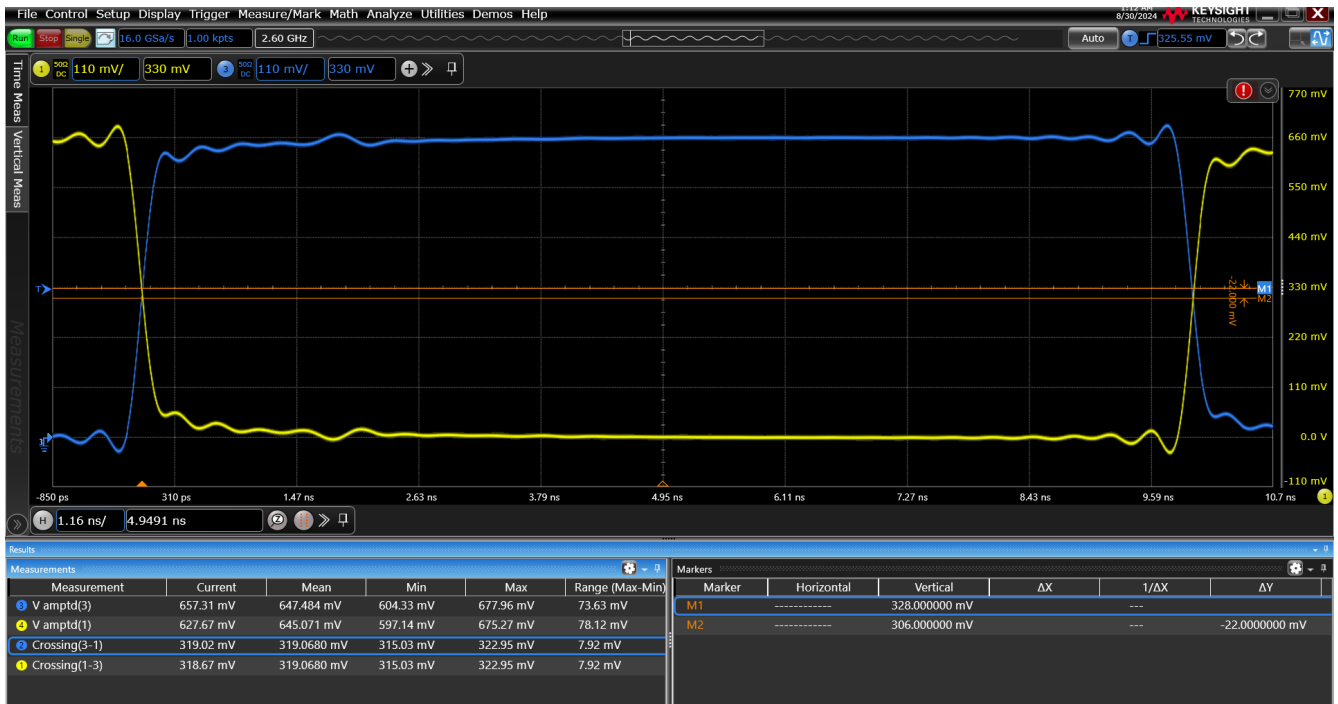


Figure 48. Vcross–HCSL Dual-Termination SWING = 950mV, HCSL Boost = Enabled on OUT11

4. FC3 EVB Waveform Measurement Method

4.1 HCSL Internally Terminated

- **Scope:** Keysight MAX404A
- **Probe:** Keysight 1131B x2

Probe HCSL positive signal on R140 pin1 (OUT11) and probe HCSL negative signal on R145 pin1 (nOUT11). Ensure the probe's ground connection is as short as possible during the measurement.

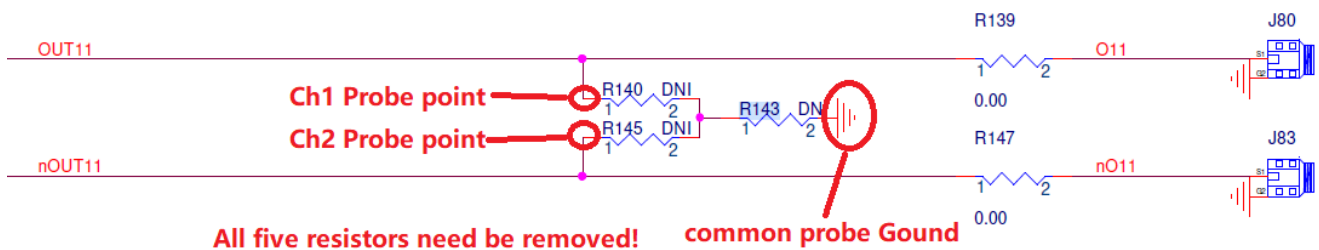


Figure 49. Probe Points of HCSL Internal Termination Mode

4.2 HCSL Externally Terminated

- **Scope:** Keysight MAX404A. Scope Channels select 50Ω impedance.
- **Scope:** Keysight EXR054A. Scope Channels select 50Ω impedance. (HCSL boost enabled measurements only)
- 50Ω coaxial cable x2

Use two pieces of coaxial cable (SMA< -- >BNC) and connect HCSL pairs to scope for measurement.

Note: See Figure 34 for HCSL dual-termination waveform measurement.

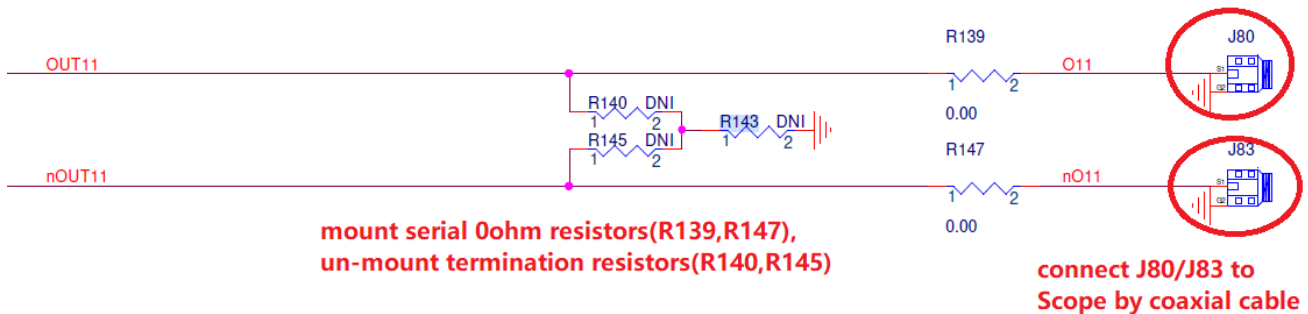


Figure 50. Probe Points of HCSL External Termination Mode

4.3 LVDS

- **Scope:** Keysight MAX404A
- **Probe:** Keysight 1131B x2

Probe LVDS positive signal on R140 pin1(OUT11) and probe LVDS negative signal on R145 pin1(nOUT11). Ensure the probe's ground connection as short as possible during the measurement.

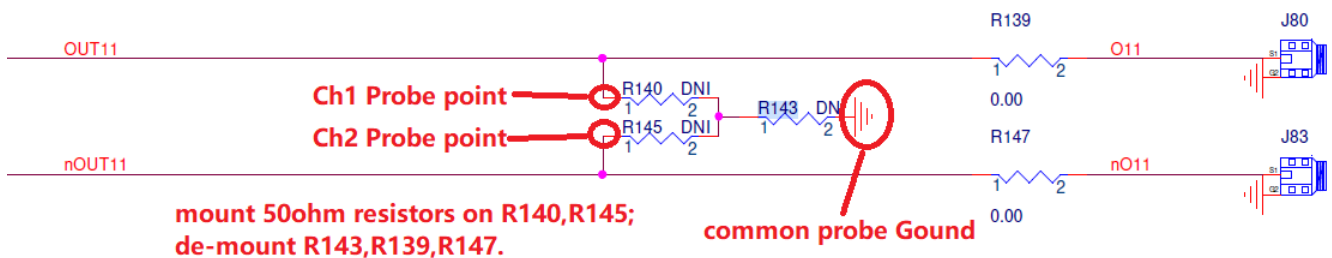


Figure 51. LVDS Waveform Measurement

4.4 Measurement Bench

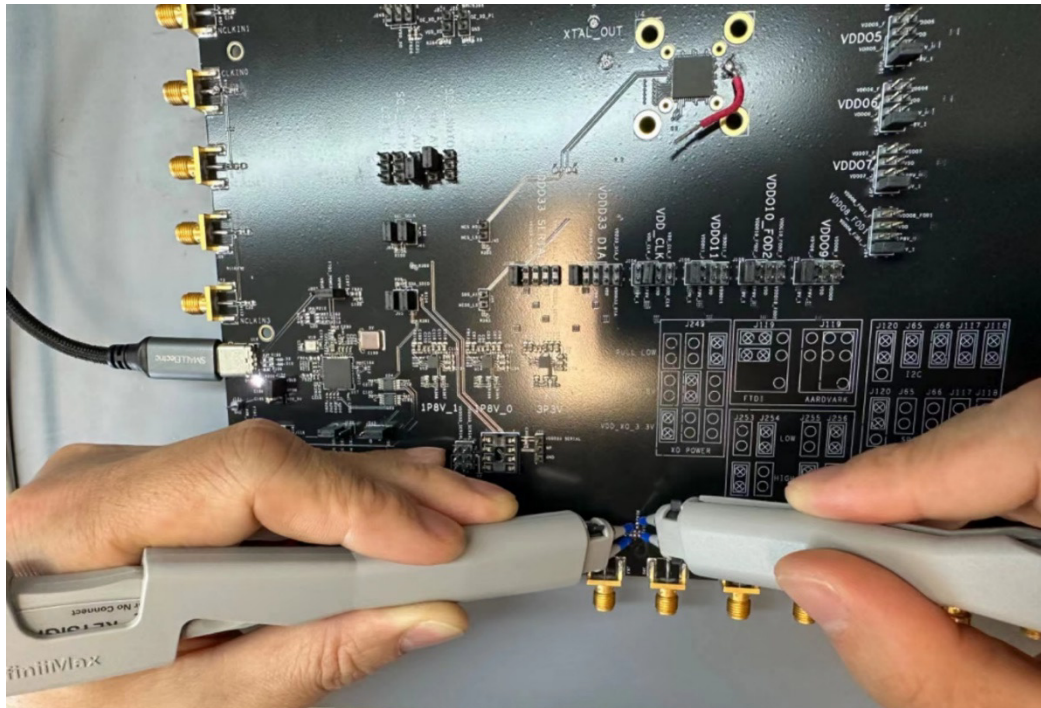


Figure 52. Waveform Measurement with Probe

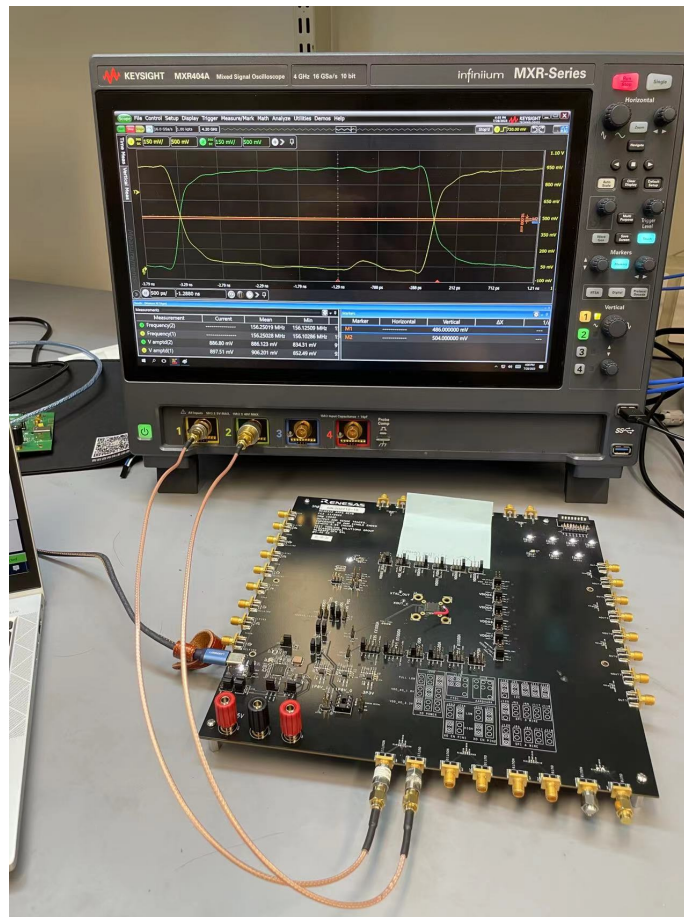


Figure 53. Waveform Measurement with Coaxial Cable

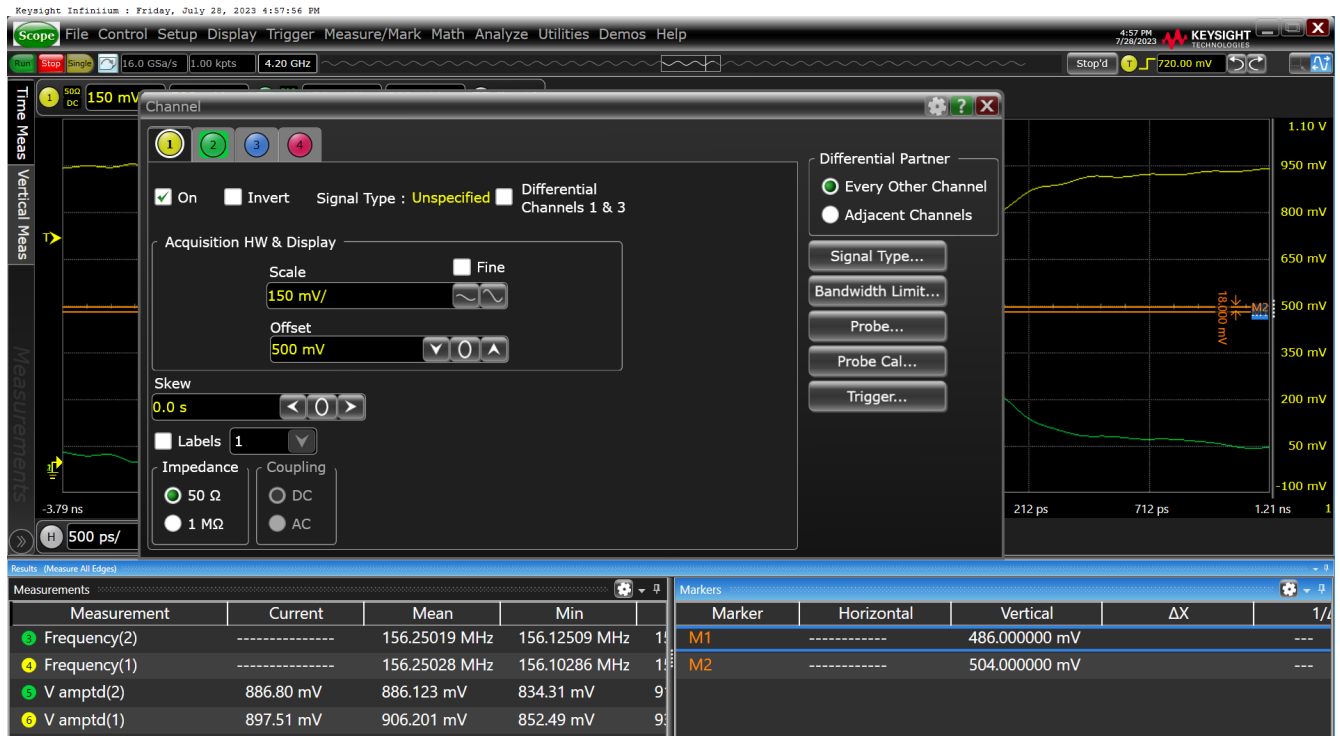


Figure 54. Scope's CH1 and CH2 Need to Set 50Ω Impedance when Connecting with Coaxial Cable

5. Revision History

Revision	Date	Description
1.02	Sep 17, 2024	<ul style="list-style-type: none"> Added list item 3 (Enable Boost) to section 2. Updated Figure 8. Added Figure 46, Figure 47 and Figure 48.
1.01	Jun 18, 2024	Updated power rails to 1.8V from 3.3V in Figure 1 through Figure 7.
1.00	Feb 1, 2024	Initial release.

IMPORTANT NOTICE AND DISCLAIMER

RENESAS ELECTRONICS CORPORATION AND ITS SUBSIDIARIES (“RENESAS”) PROVIDES TECHNICAL SPECIFICATIONS AND RELIABILITY DATA (INCLUDING DATASHEETS), 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 OR 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 developers who are designing with Renesas products. You are solely responsible for (1) selecting the appropriate products for your application, (2) designing, validating, and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. Renesas grants you permission to use these resources only to develop an application that uses Renesas products. Other reproduction or use of these resources is strictly prohibited. No license is granted to any other Renesas intellectual property or to any third-party intellectual property. Renesas disclaims responsibility for, and you will fully indemnify Renesas and its representatives against, any claims, damages, costs, losses, or liabilities arising from your use of these resources. Renesas' products are provided only subject to Renesas' Terms and Conditions of Sale or other applicable terms agreed to in writing. No use of any Renesas resources expands or otherwise alters any applicable warranties or warranty disclaimers for these products.

(Disclaimer Rev.1.01)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit www.renesas.com/contact-us/.