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

Figures

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.

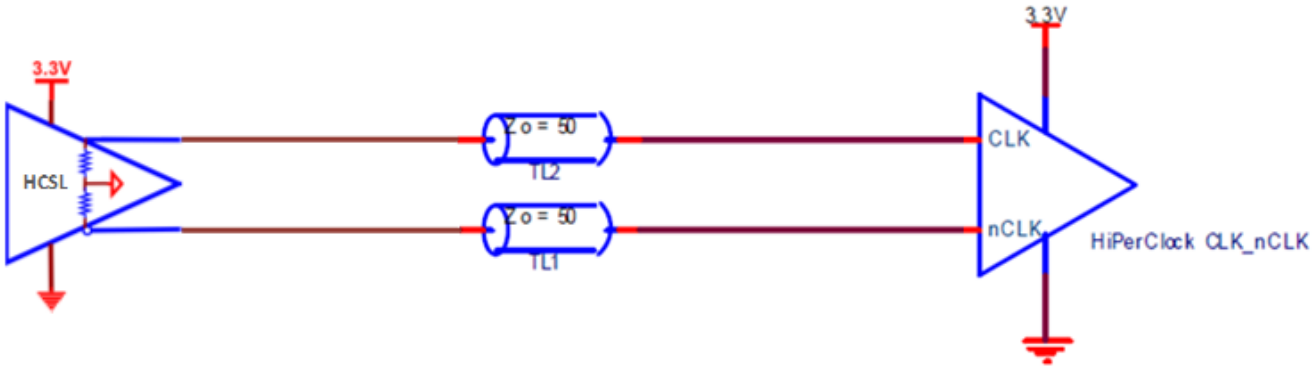

Figure 1. HCSL Internal Termination–Simple Topology

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.

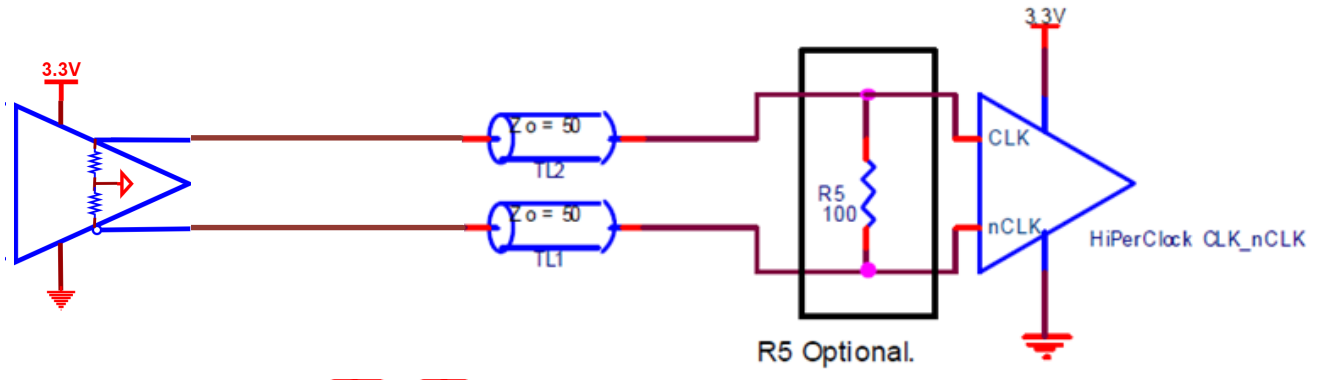

Figure 2. HCSL Internal Termination with Optional Resistor

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

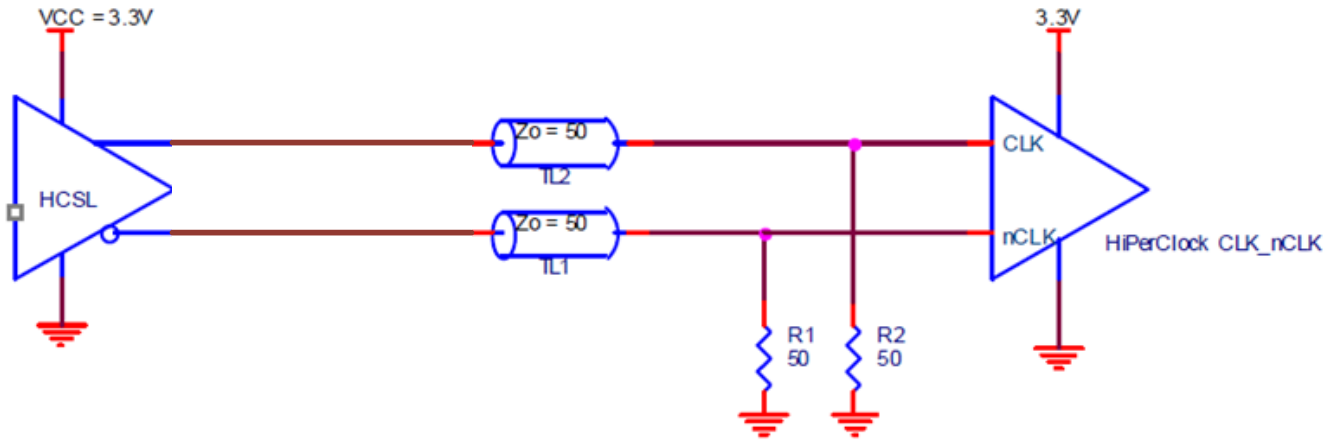

Figure 3. HCSL External Termination–Common

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

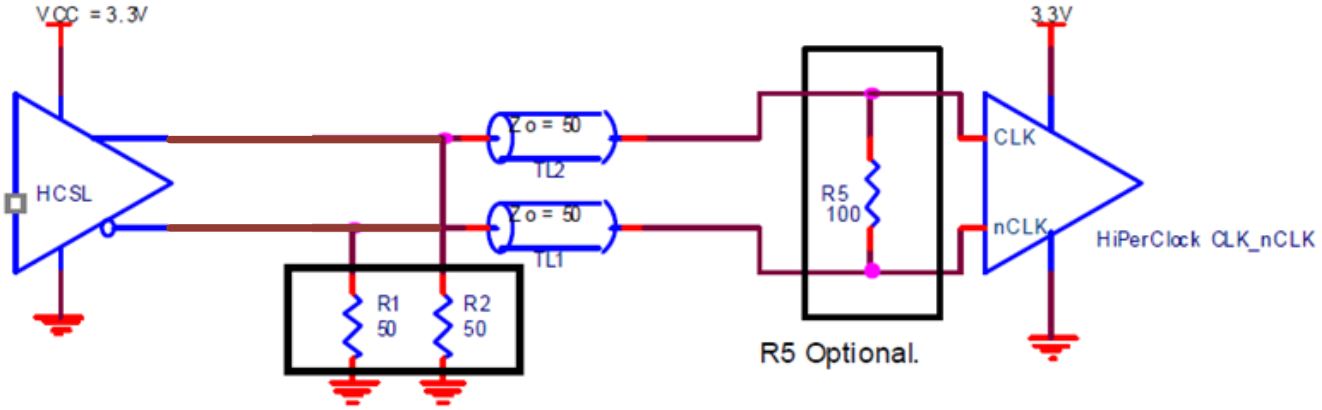

Figure 4. HCSL External Termination Near the Transmitter

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.

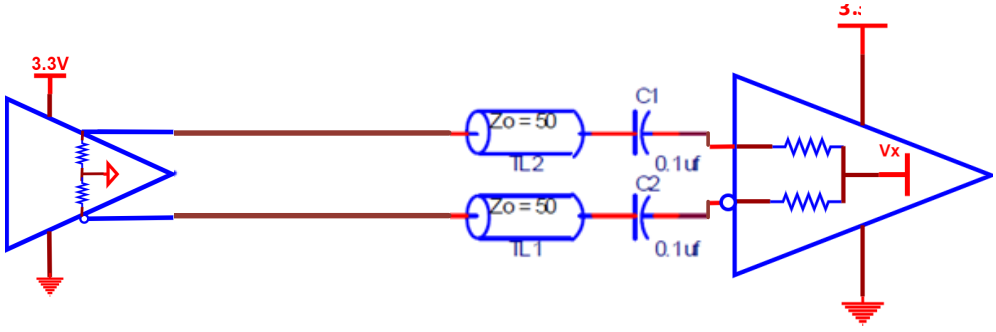

Figure 5. HCSL Dual-Termination for Receivers with Internal Terminations

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.

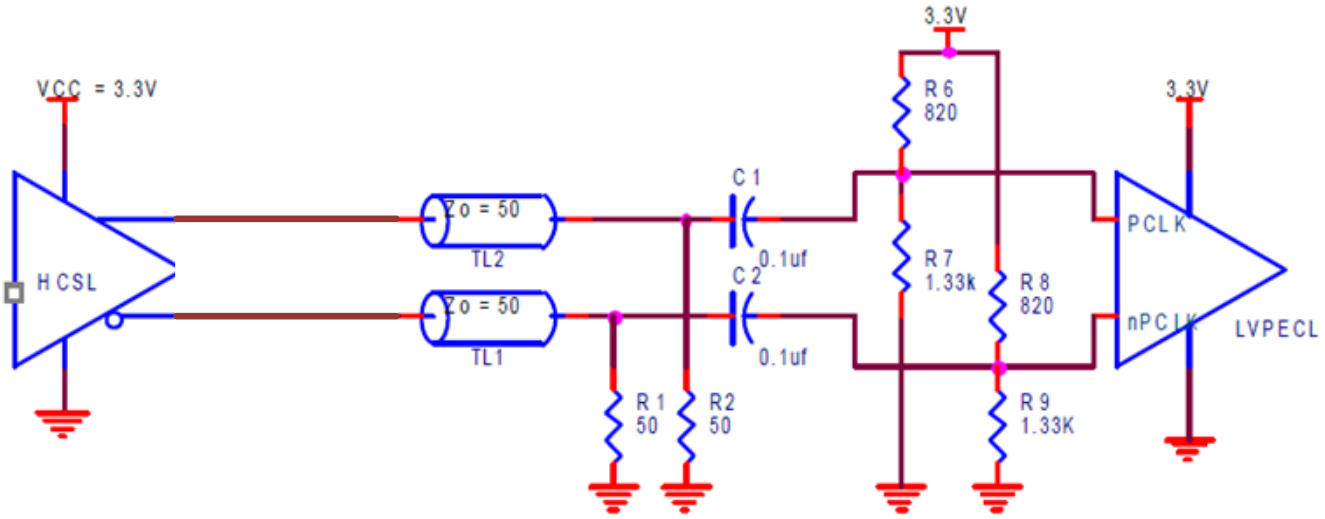

Figure 6. Termination Example of HCSL to LVPECL

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

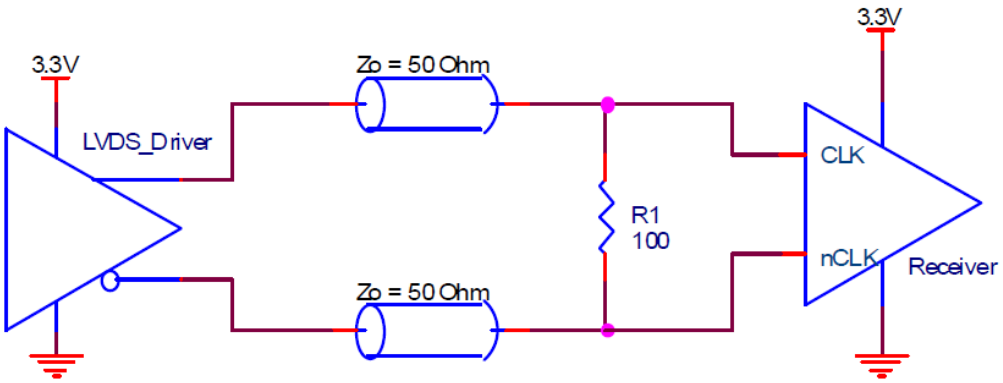

Figure 7. Standard LVDS Termination

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).

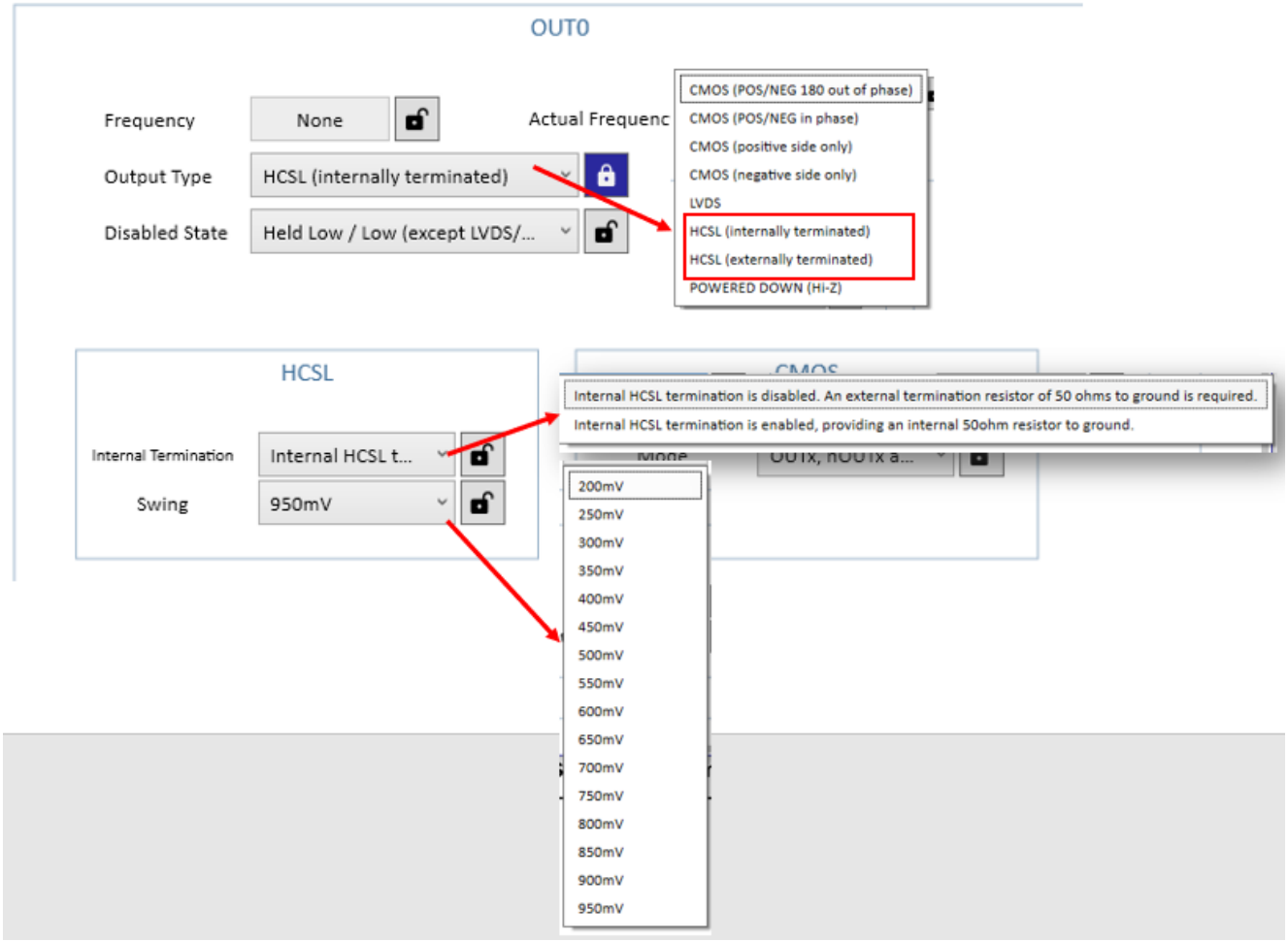

Figure 8. HCSL Internal Termination Setting in RICBox

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

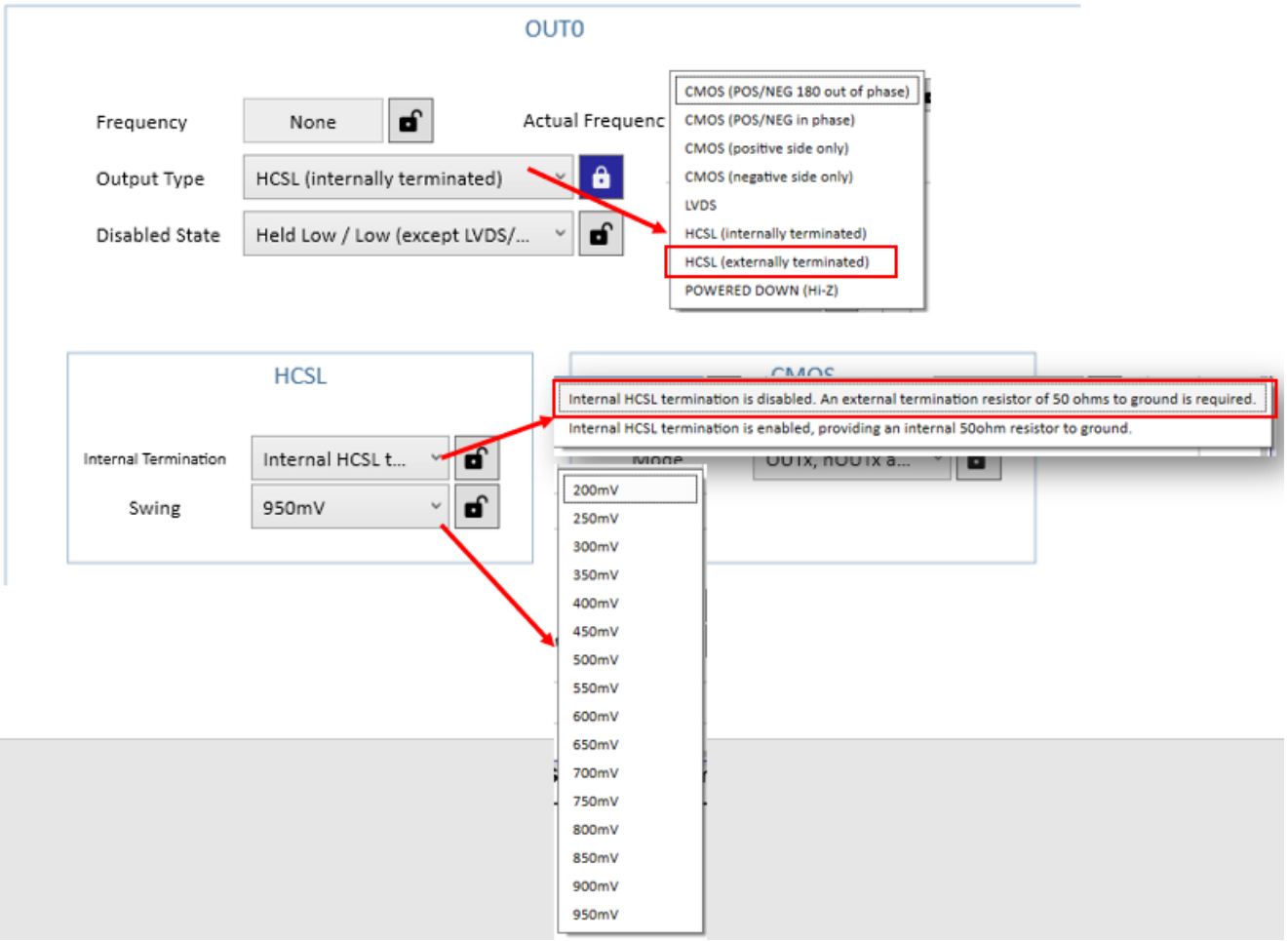

Figure 9. HCSL External Termination Setting in RICBox

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 44. 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	Vovs (mV)		Vcross (mV)	
Internal Termination	HCSL_SWING = 800	875	976	505	517
	HCSL_SWING = 850	946	915	459	478
	HCSL_SWING = 900	980	948	506	475
	HCSL_SWING = 950	1008	973	503	537
External Termination	HCSL_SWING = 800	870	870	415	456
	HCSL_SWING = 850	907	914	487	446
	HCSL_SWING = 900	937	942	462	503
	HCSL_SWING = 950	960	969	515	475
Dual Termination *Note*: Enable internal HCSL termination and add external termination.	HCSL_SWING = 800	436	437	203	194
	HCSL_SWING = 850	463	464	216	209
	HCSL_SWING = 900	488	488	221	232
	HCSL_SWING = 950	514	512	243	235

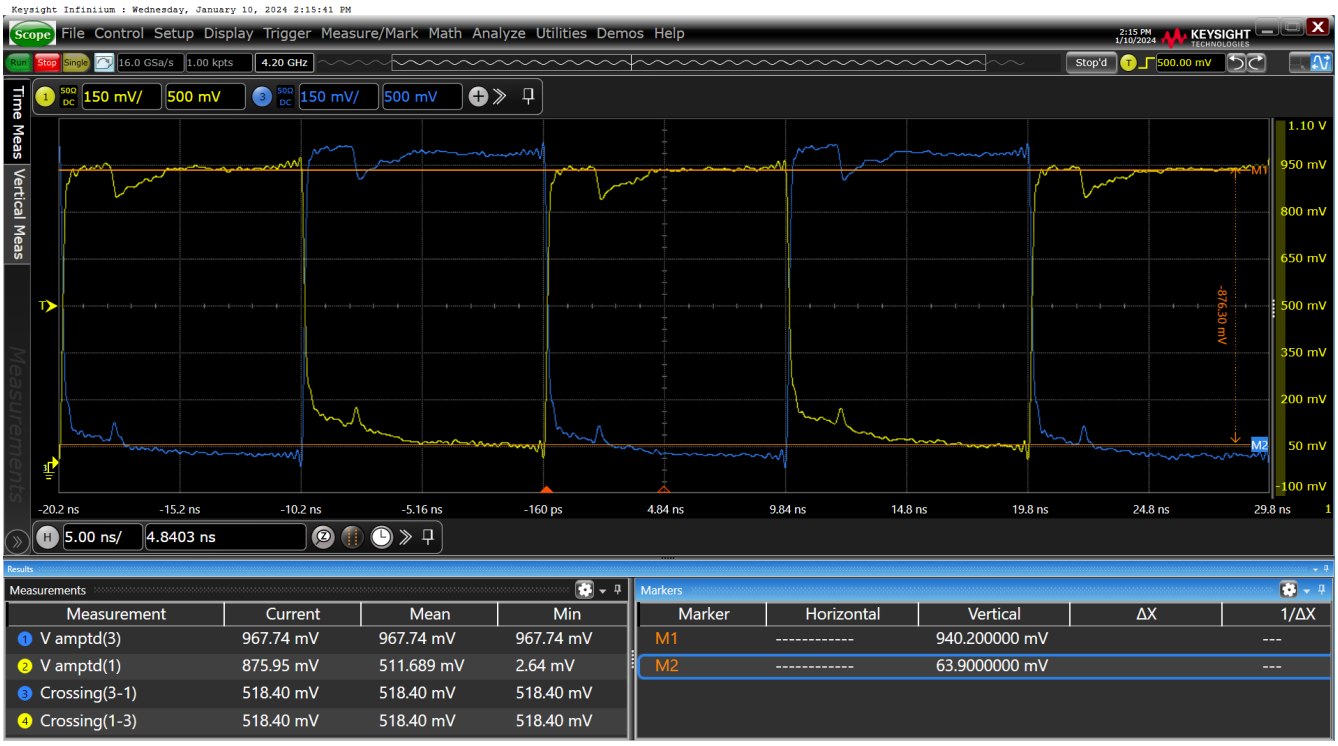

Figure 10. Vovs–HCSL Internal Termination SWING = 800mV on OUT11

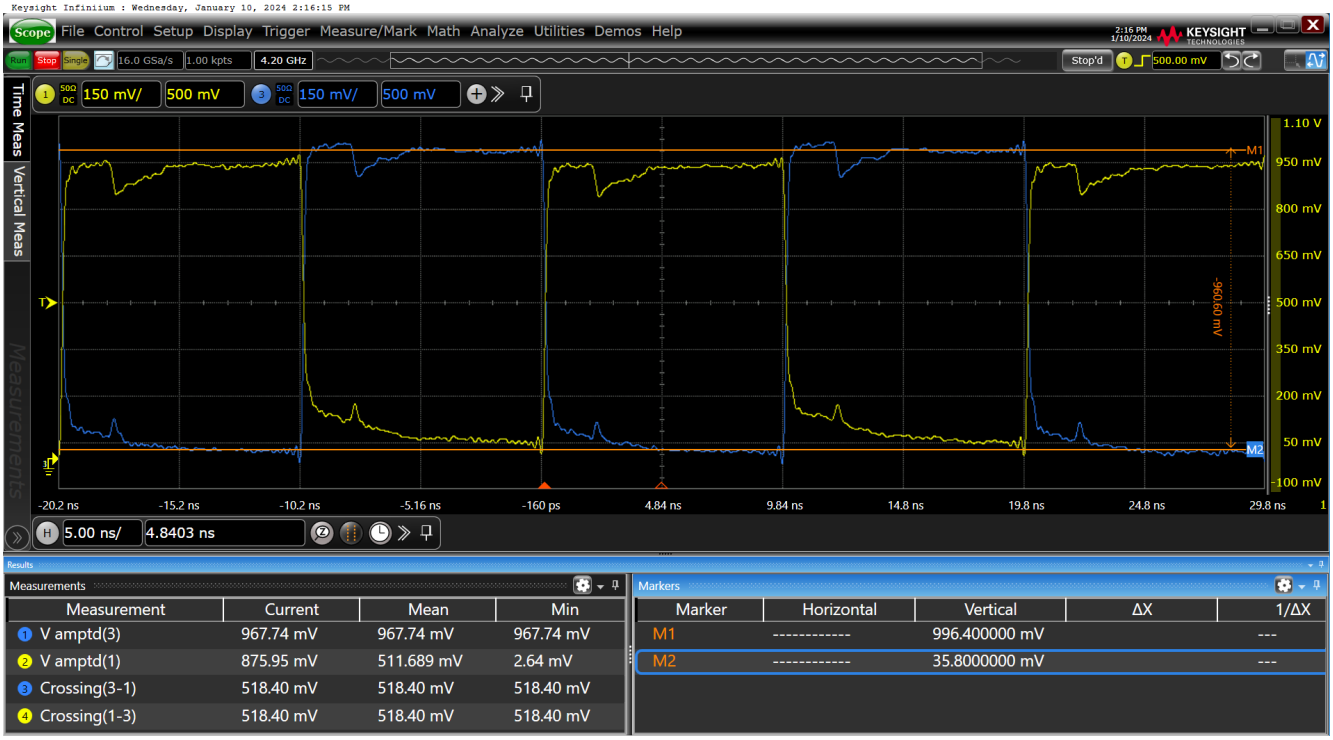

Figure 11. Vovs–HCSL Internal Termination SWING = 800mV on nOUT11

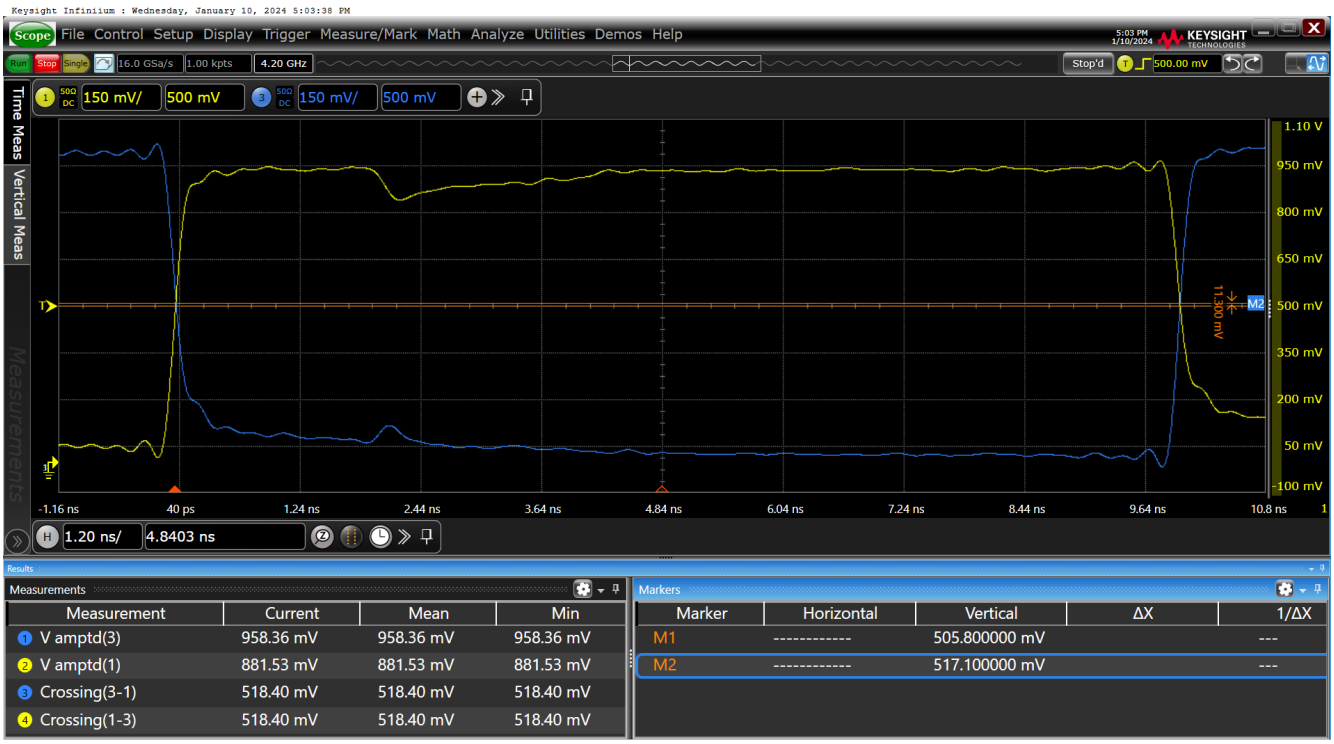

Figure 12. Vcross–HCSL Internal Termination SWING = 800mV on OUT11

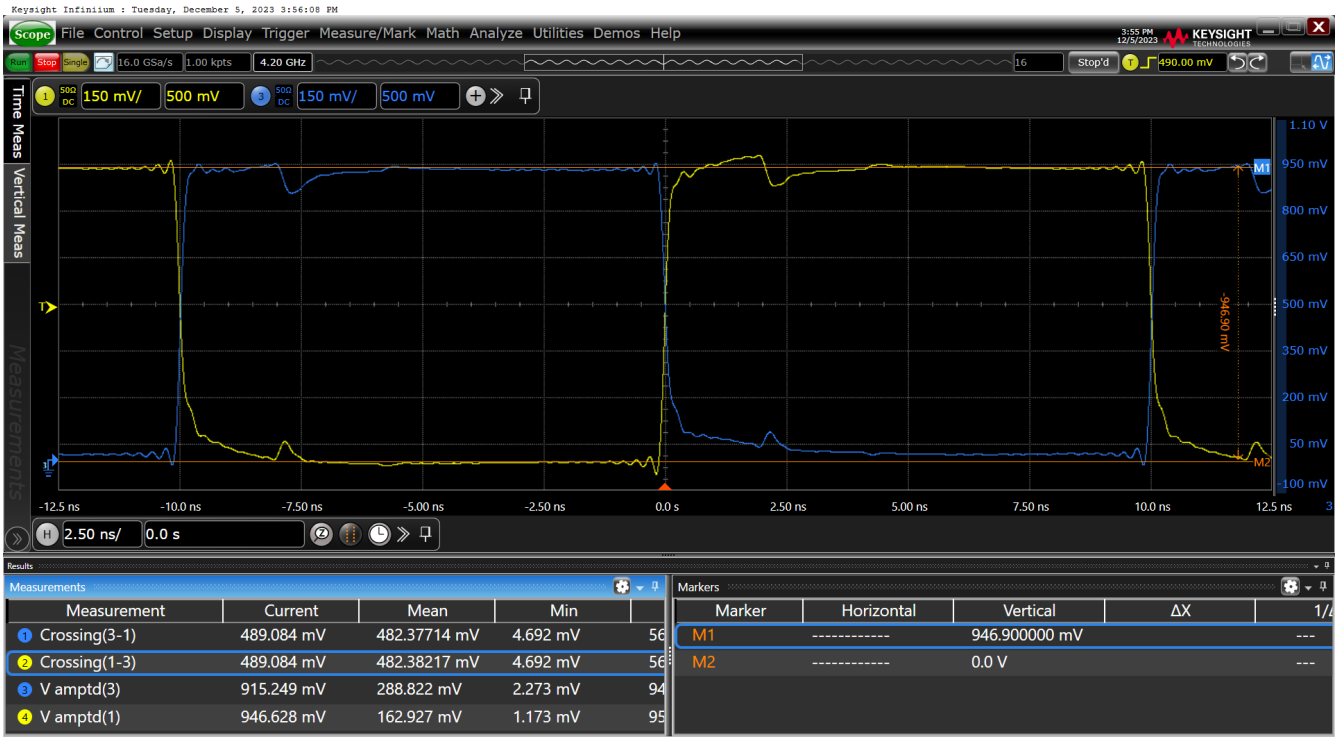

Figure 13. Vovs–HCSL Internal Termination SWING = 850mV on OUT11

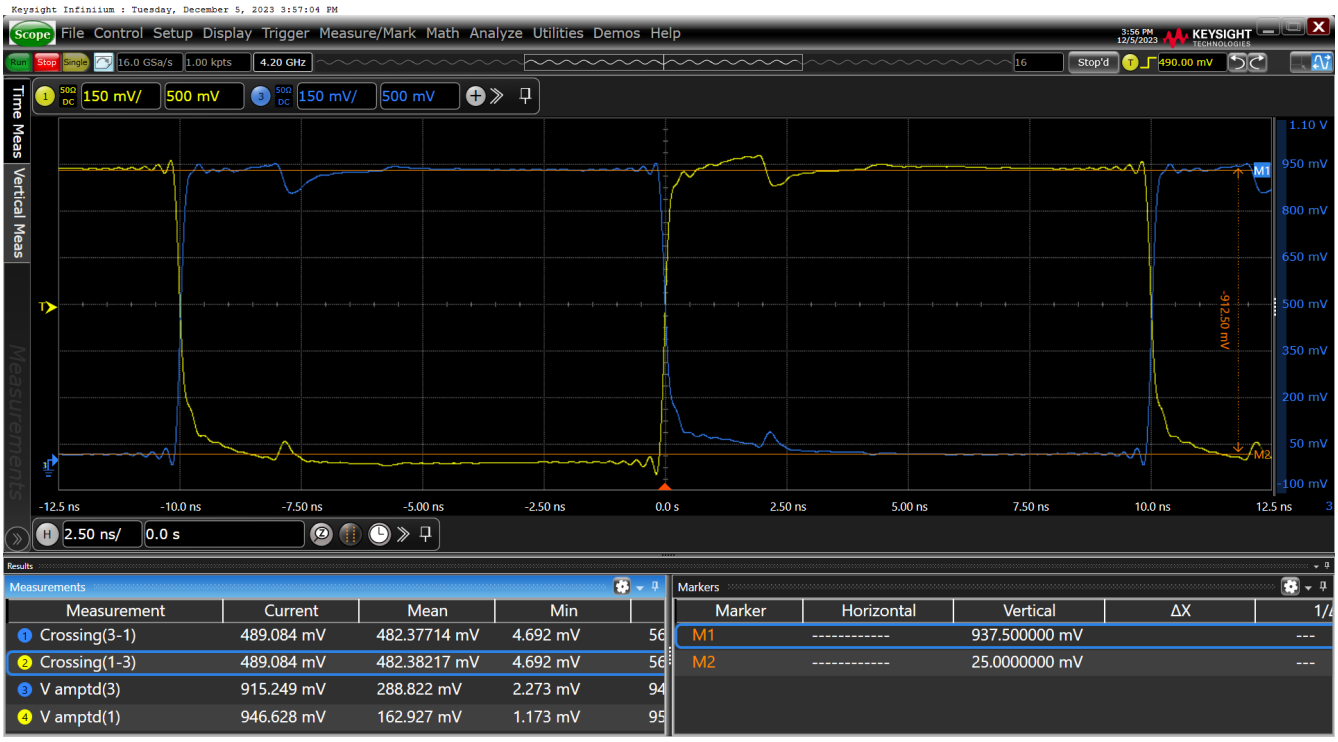

Figure 14. Vovs–HCSL Internal Termination SWING = 850mV on nOUT11

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

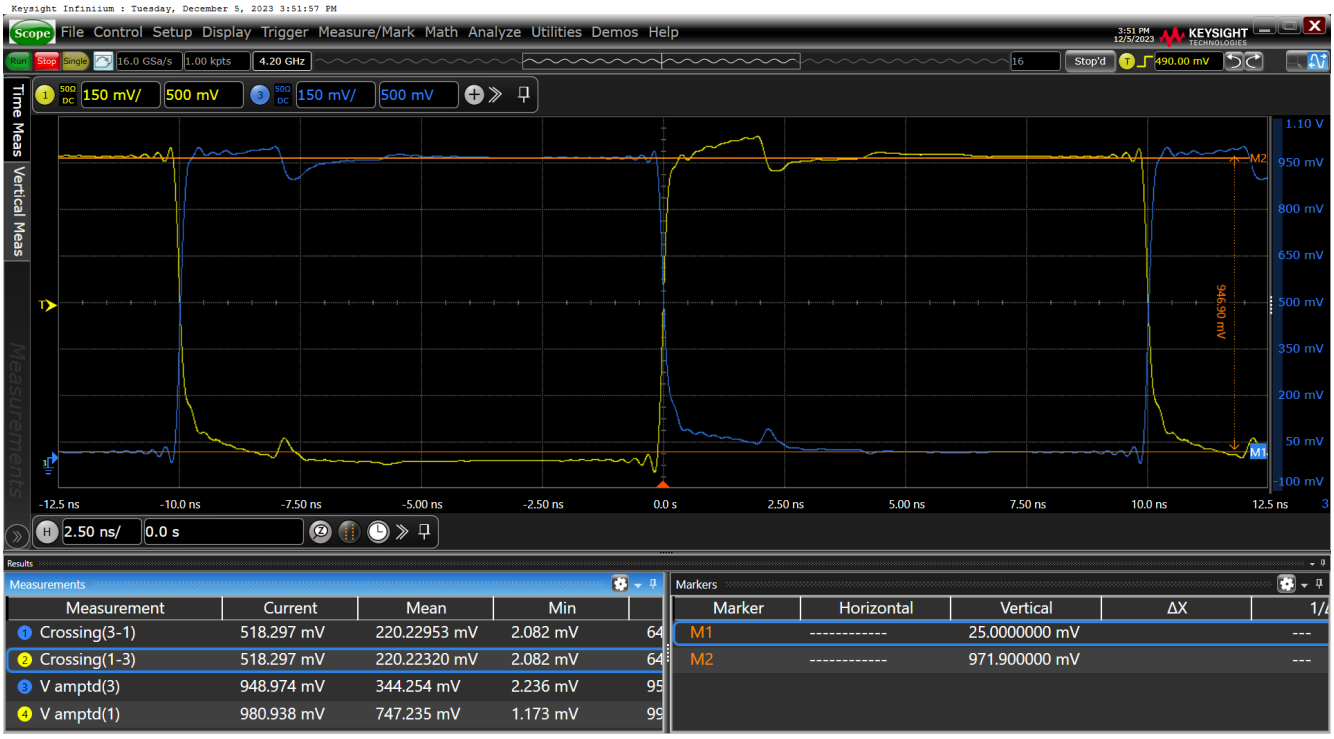

Figure 16. Vovs–HCSL Internal Termination SWING = 900mV on OUT11

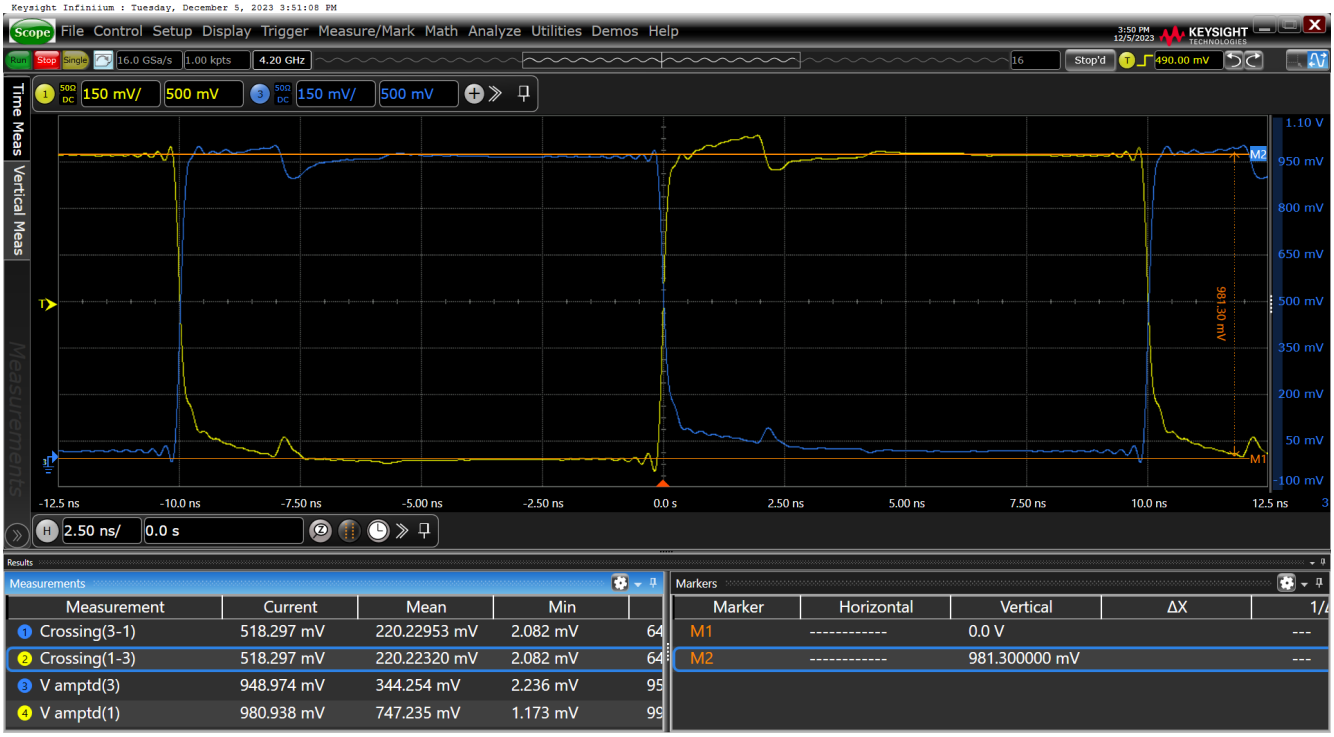

Figure 17. Vovs–HCSL Internal Termination SWING = 900mV on nOUT11

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

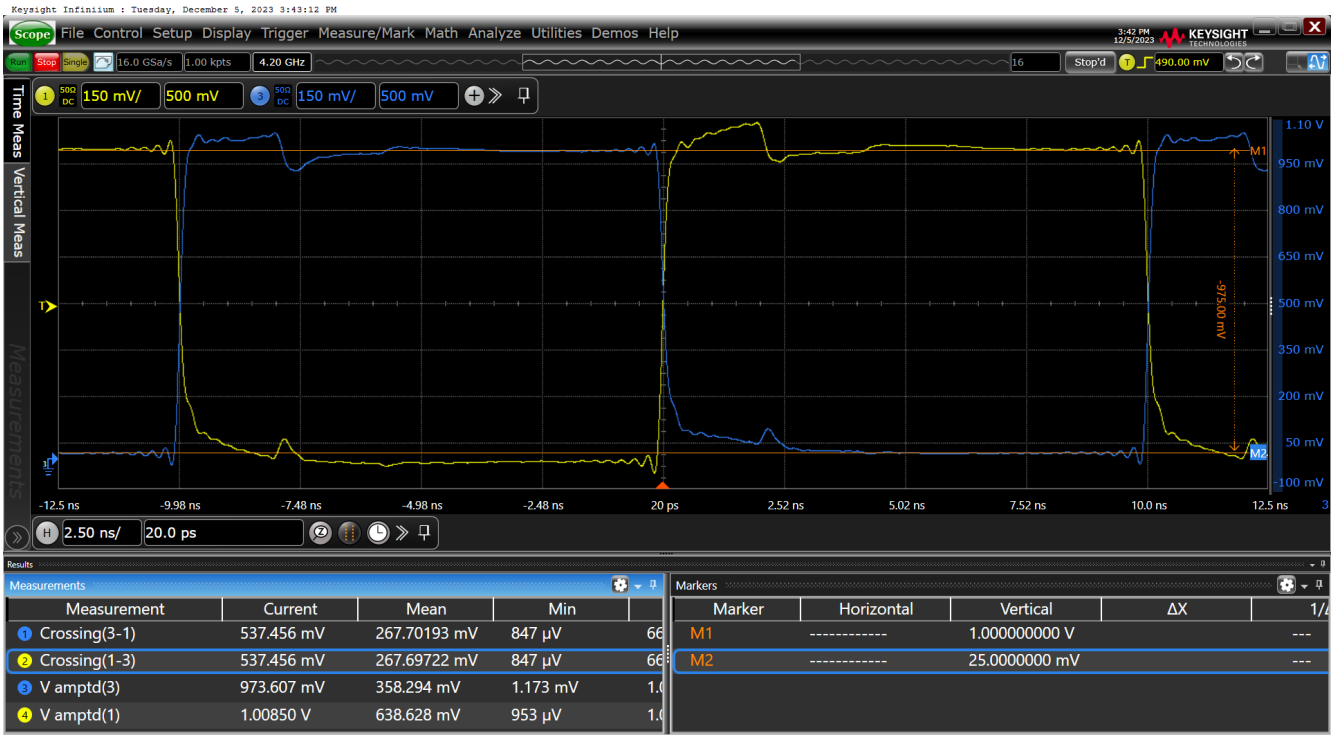

Figure 19. Vovs–HCSL Internal Termination SWING = 950mV on OUT11

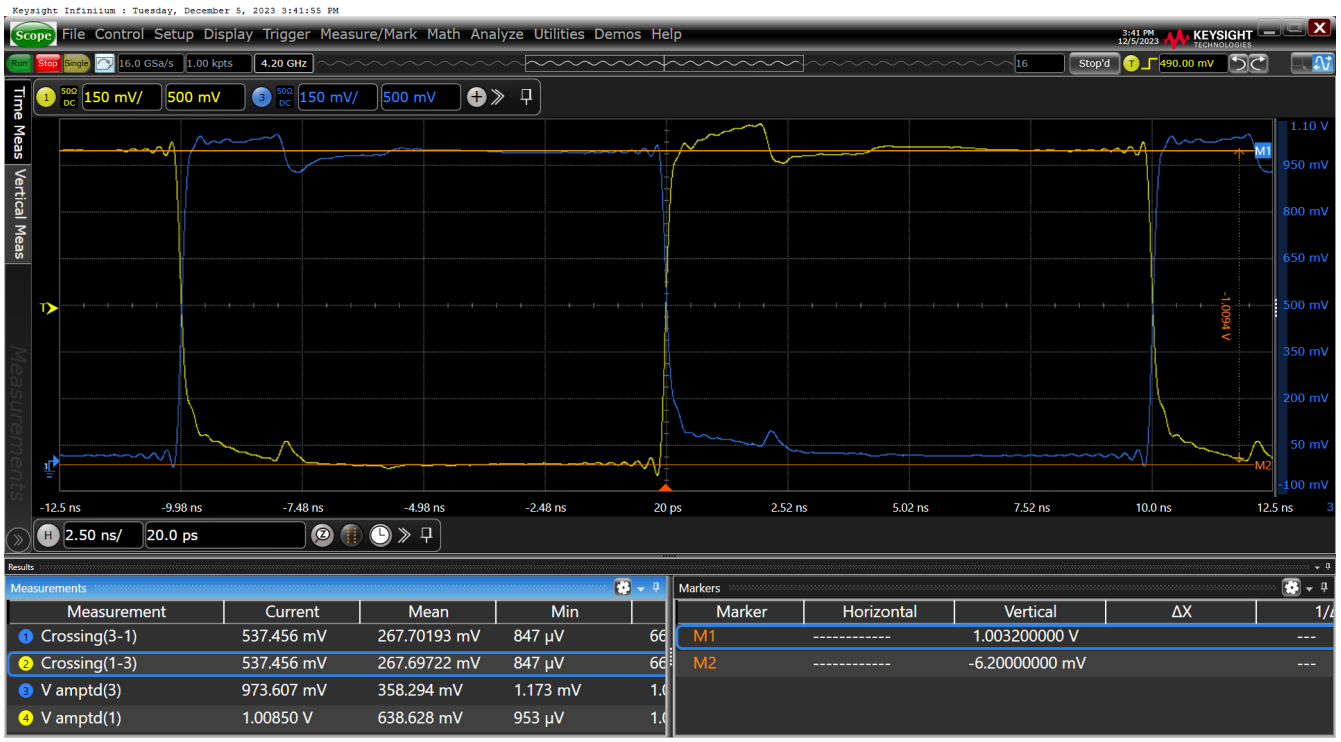

Figure 20. Vovs–HCSL Internal Termination SWING = 950mV on nOUT11

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

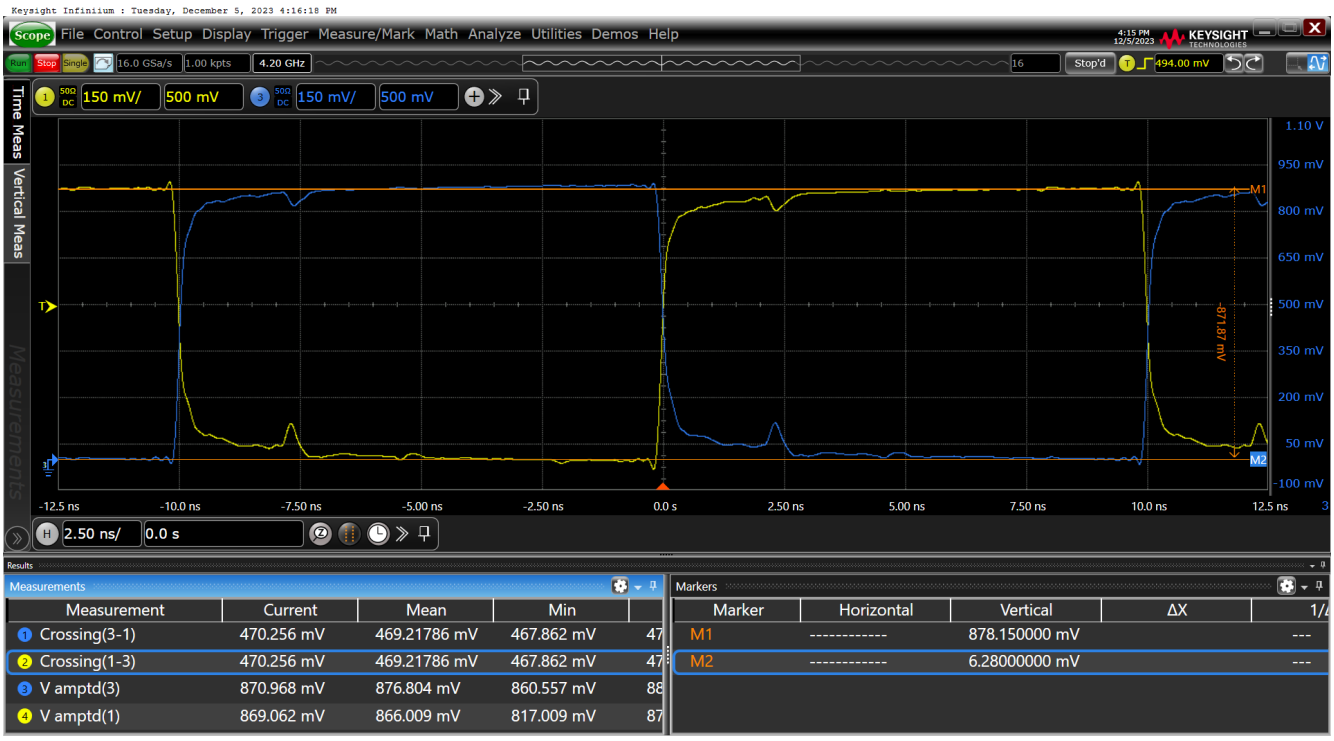

Figure 22. Vovs–HCSL External Termination SWING = 800mV on OUT11

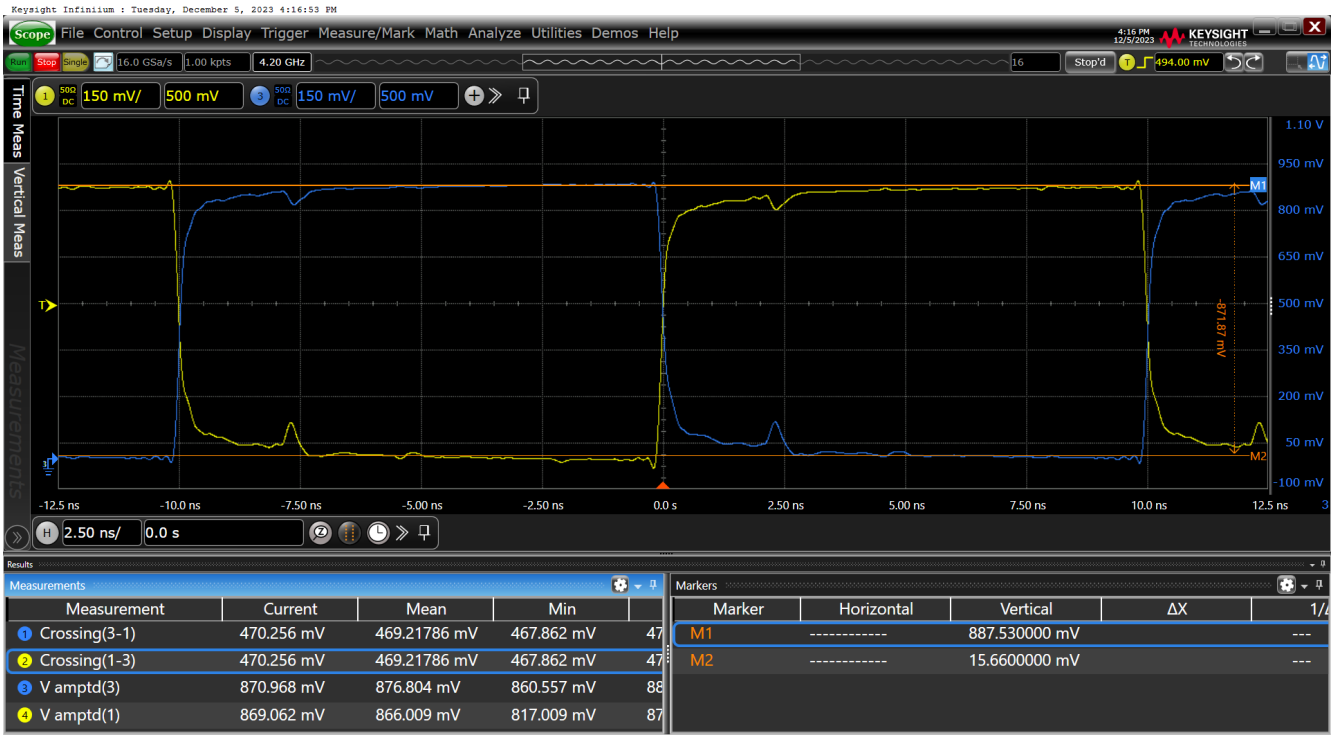

Figure 23. Vovs–HCSL External Termination SWING = 800mV on nOUT

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

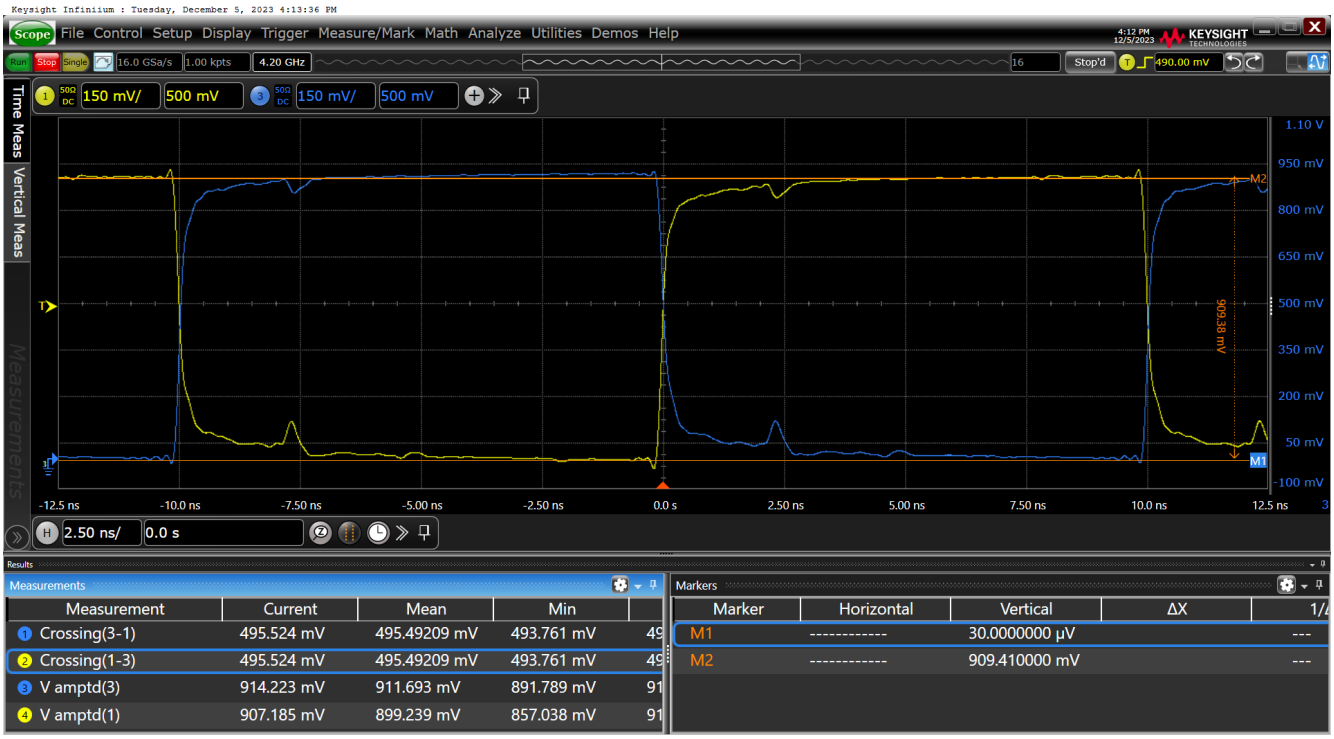

Figure 25. Vovs–HCSL External Termination SWING = 850mV on OUT11

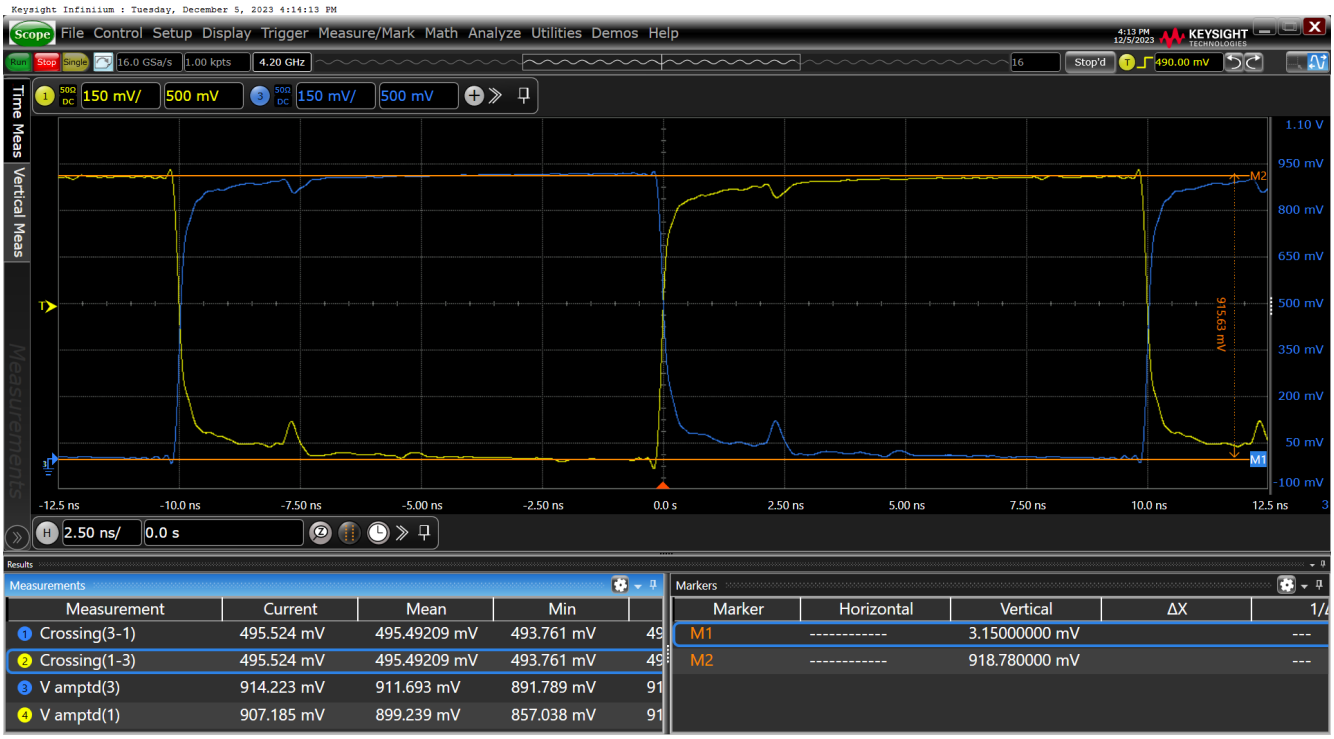

Figure 26. Vovs–HCSL External Termination SWING = 850mV on nOUT11

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

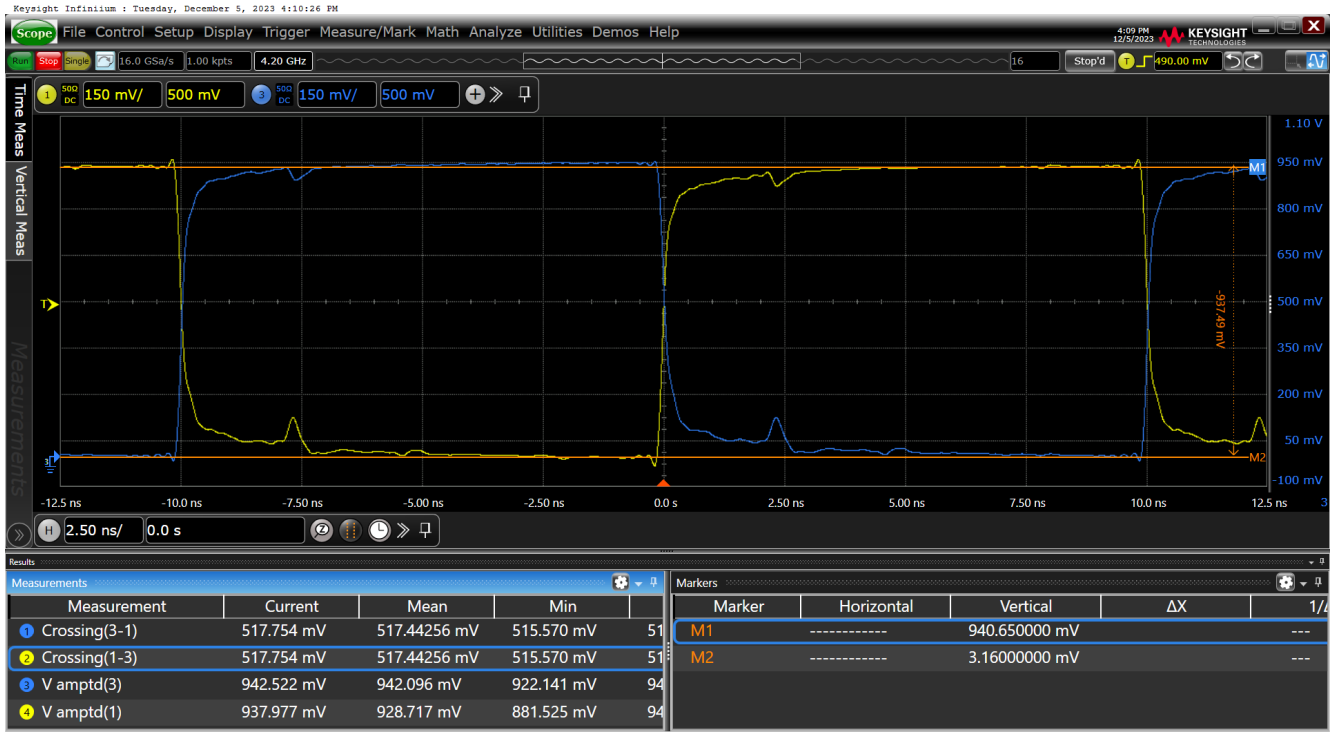

Figure 28. Vovs–HCSL External Termination SWING = 900mV on OUT11

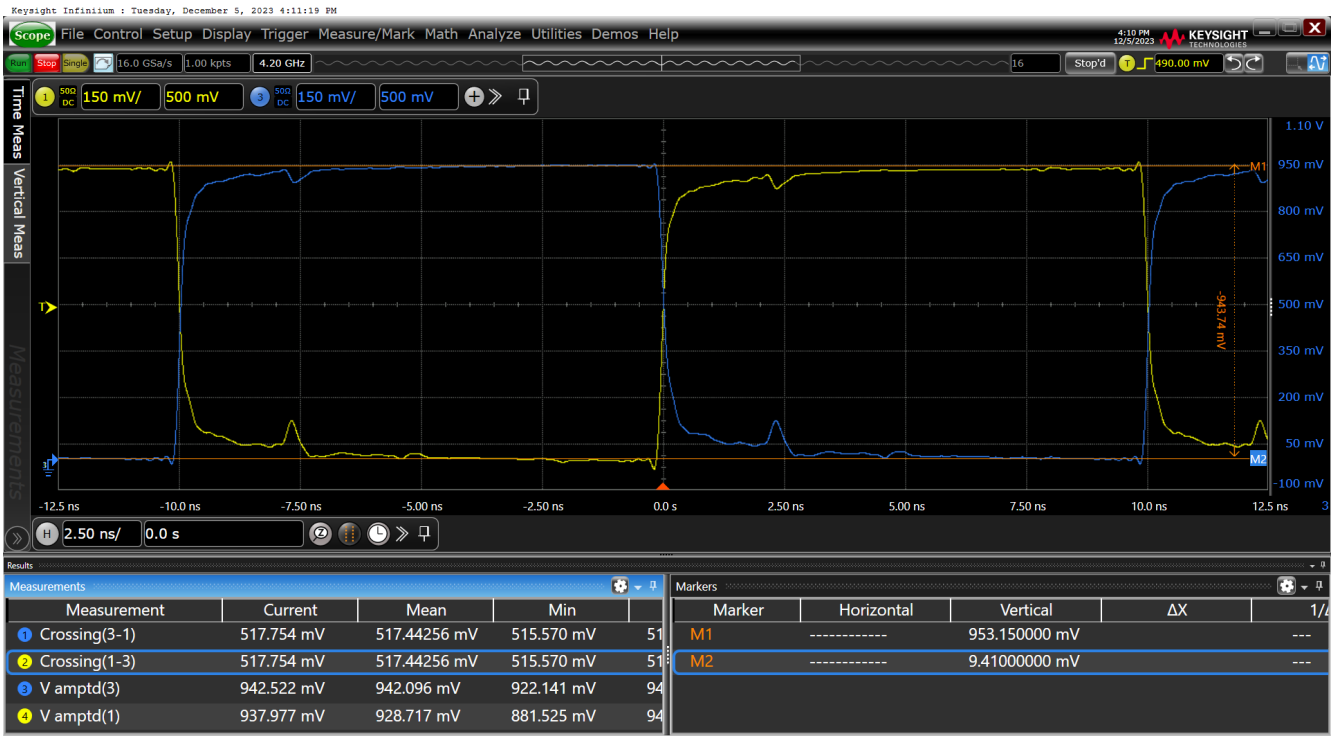

Figure 29. Vovs–HCSL External Termination SWING = 900mV on nOUT11

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

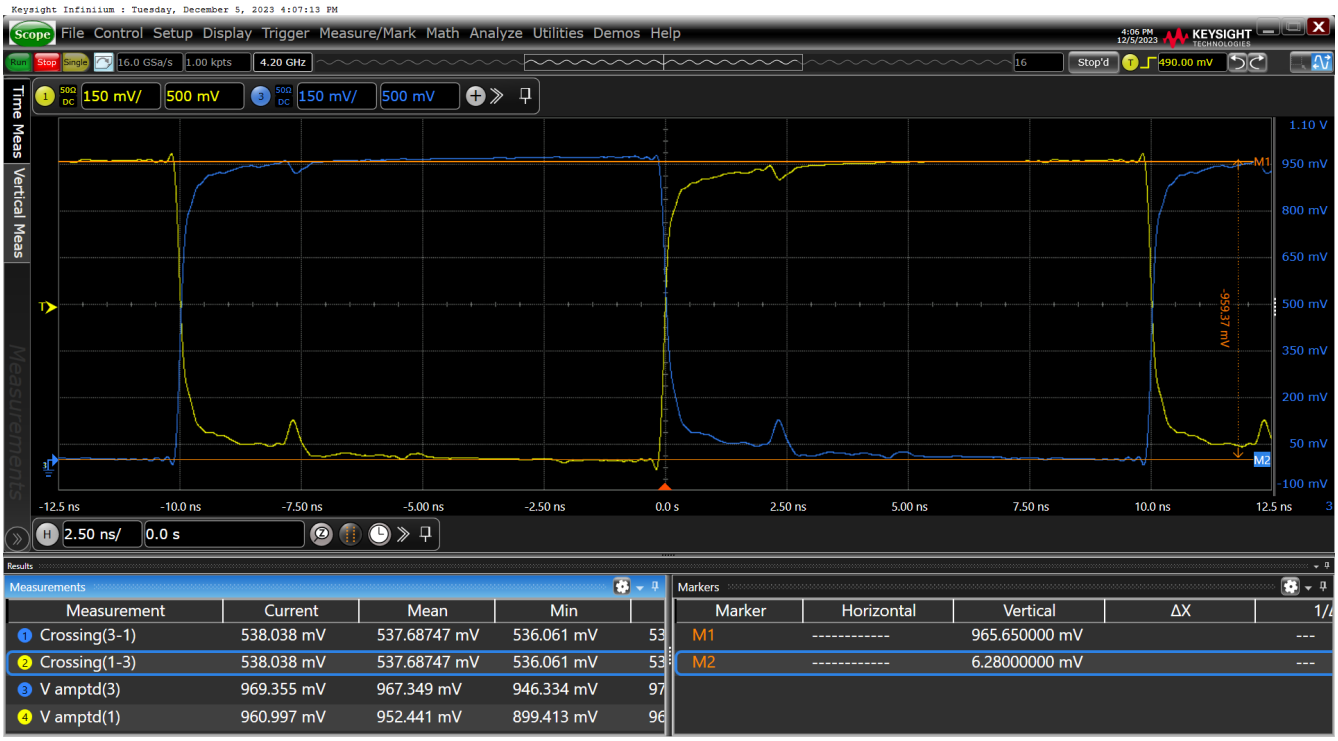

Figure 31. Vovs–HCSL External Termination SWING = 950mV on OUT11

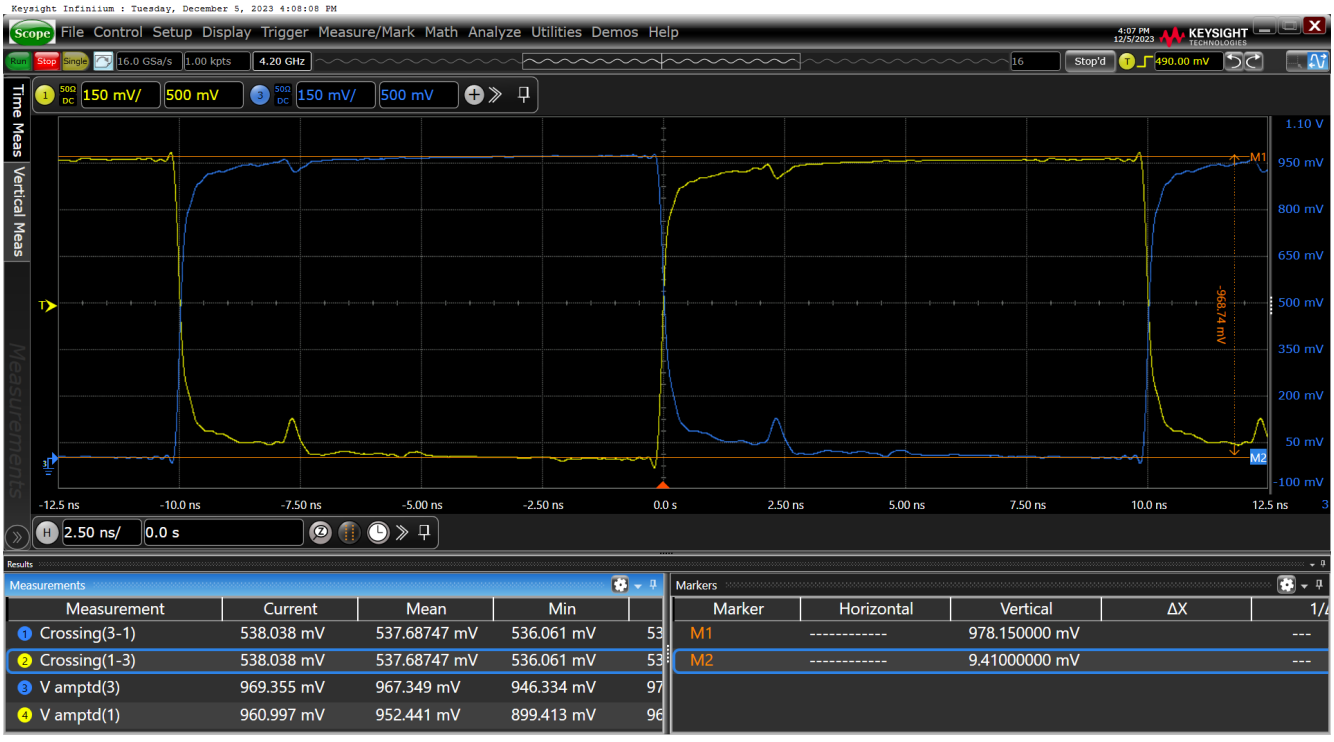

Figure 32. Vovs–HCSL External Termination SWING = 950mV on nOUT11

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

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

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

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

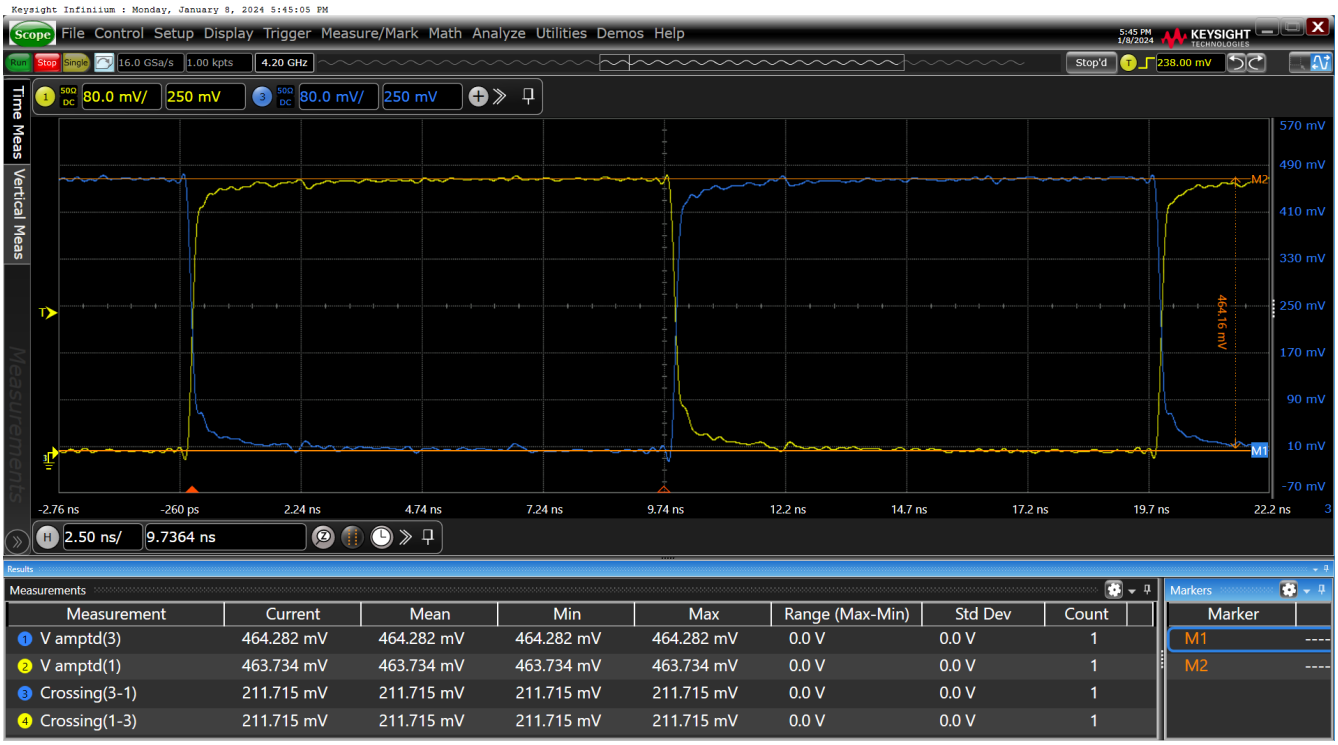

Figure 37. Vovs–HCSL Dual-Termination SWING = 850mV on OUT11

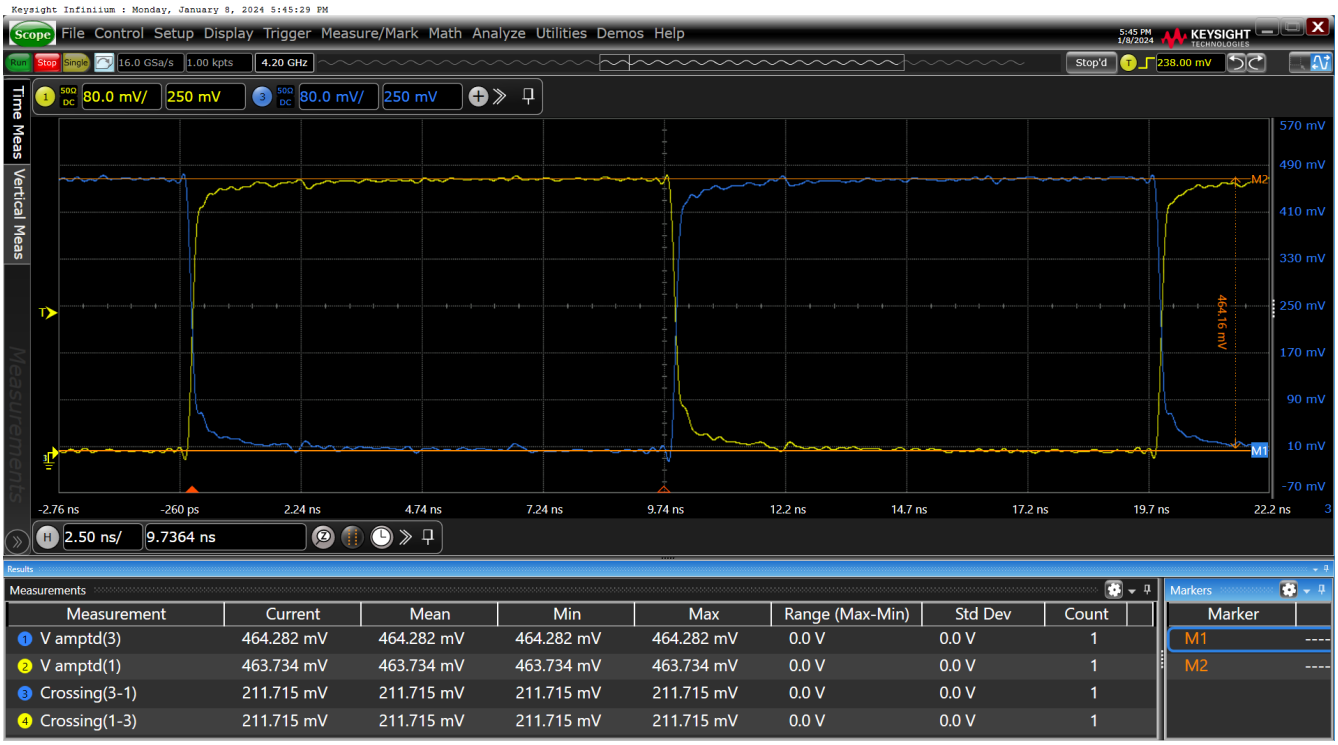

Figure 38. Vovs–HCSL Dual-Termination SWING = 850mV on nOUT11

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

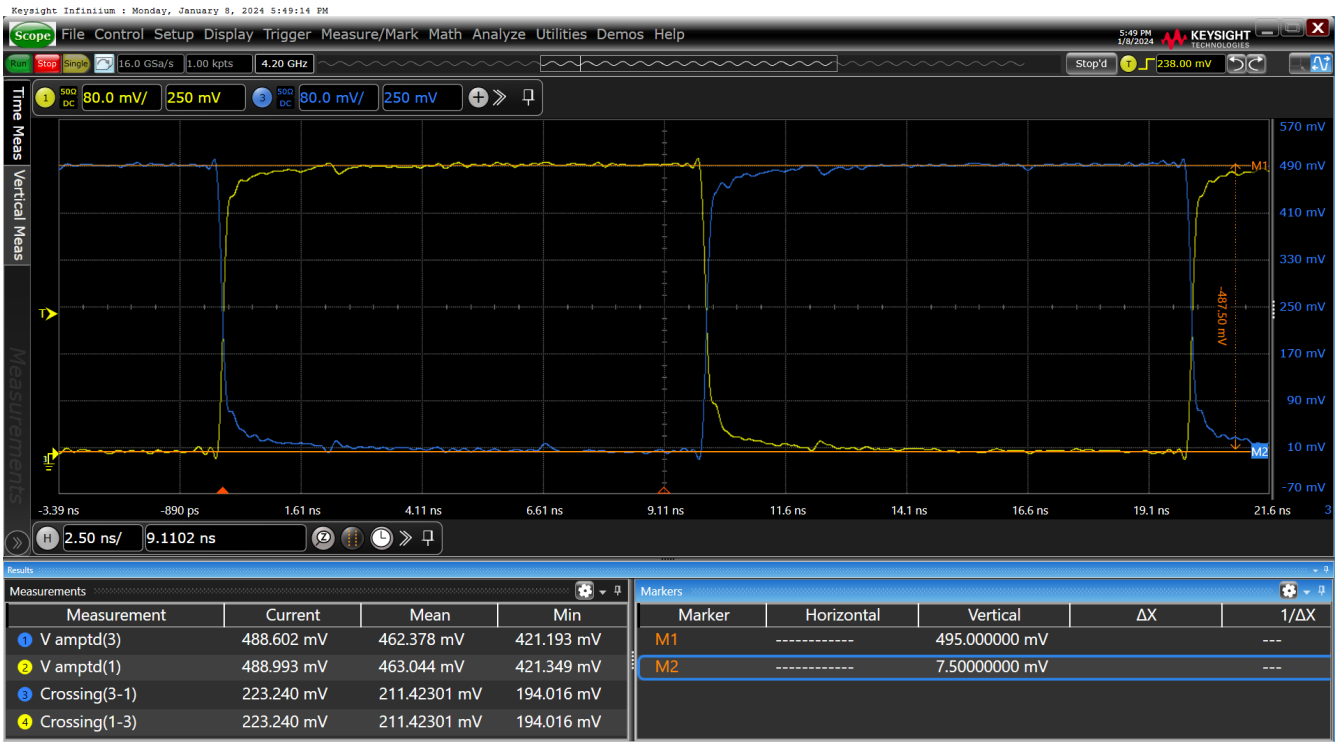

Figure 40. Vovs–HCSL Dual-Termination SWING = 900mV on OUT11

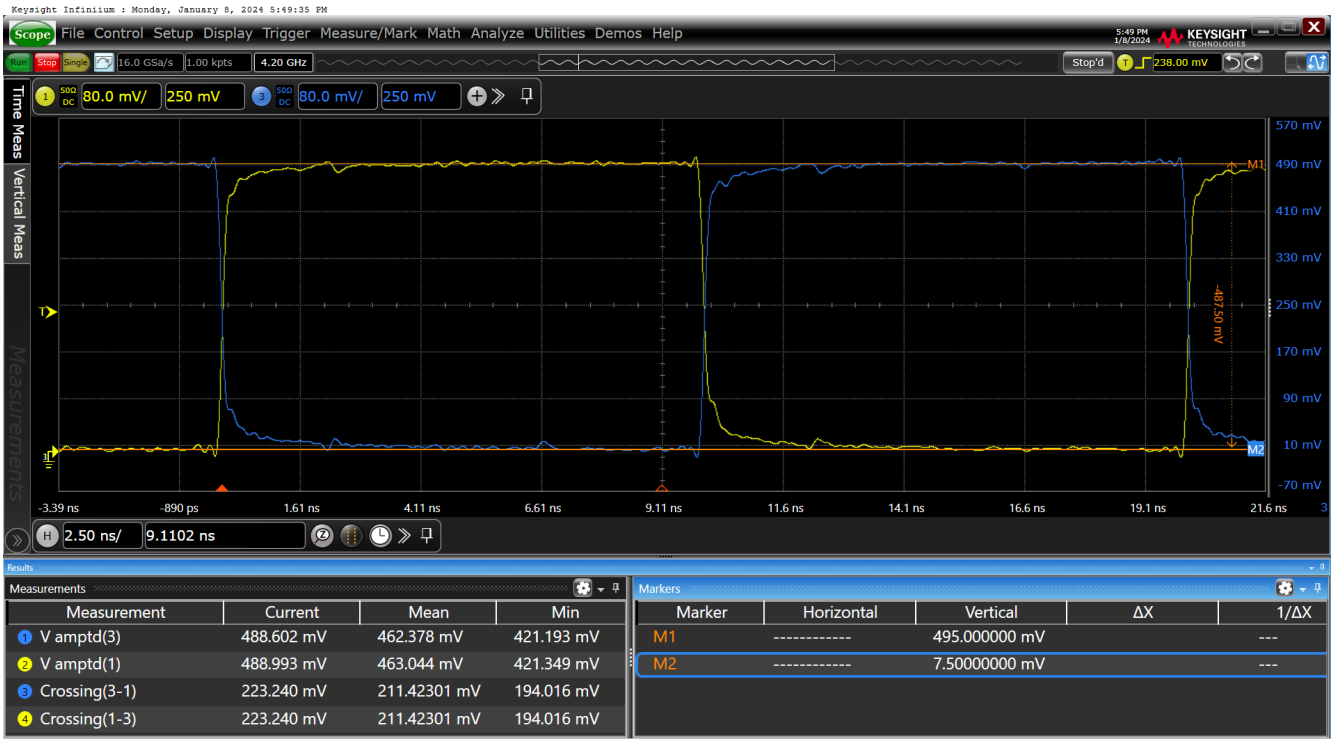

Figure 41. Vovs–HCSL Dual-Termination SWING = 900mV on nOUT11

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

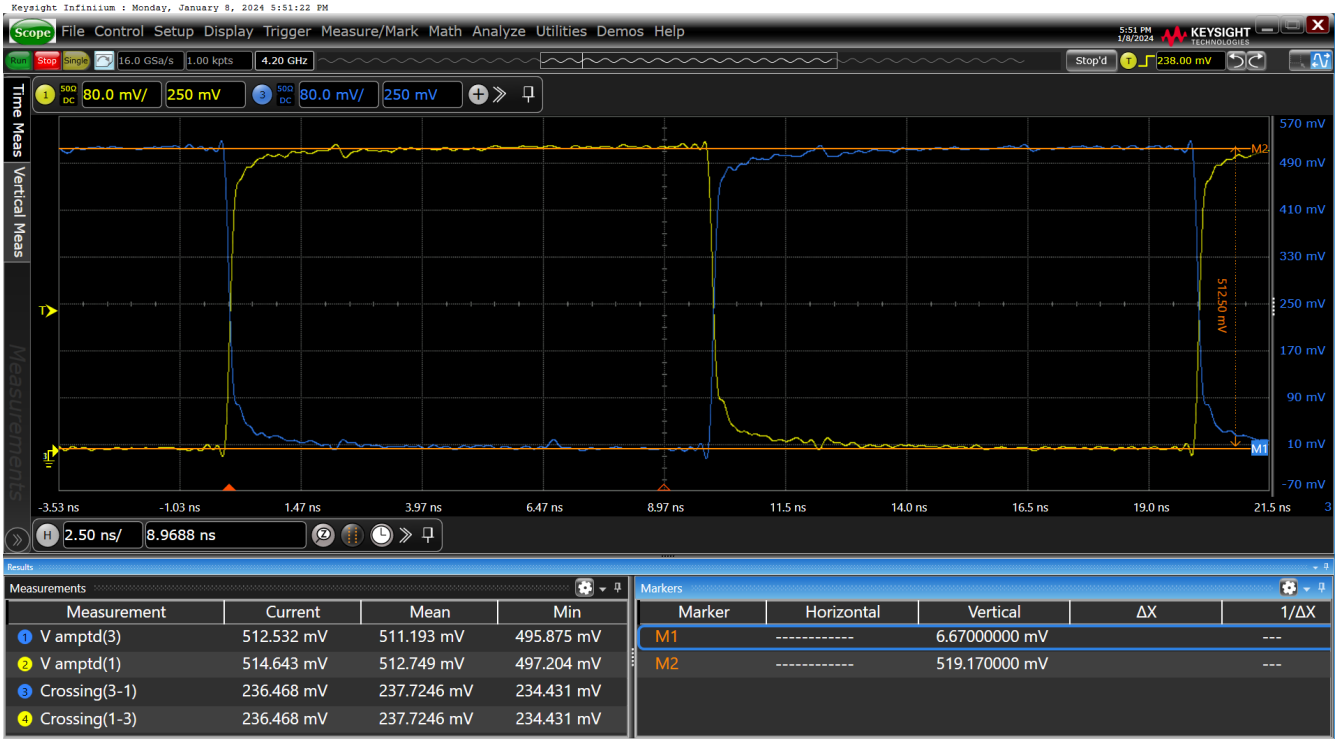

Figure 43. Vovs–HCSL Dual Termination SWING = 950mV on OUT11

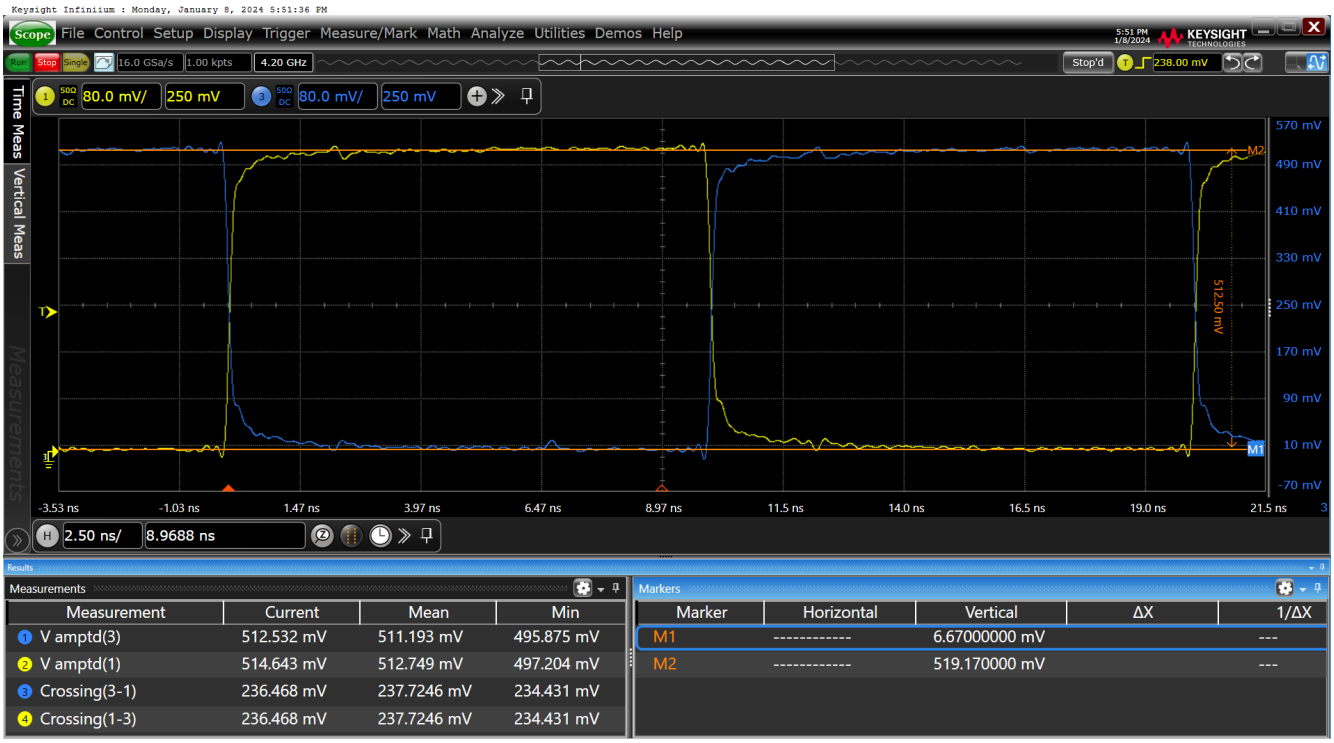

Figure 44. Vovs–HCSL Dual-Termination SWING = 950mV on nOUT11

Figure 45. Vcross–HCSL External Termination SWING = 950mV 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.

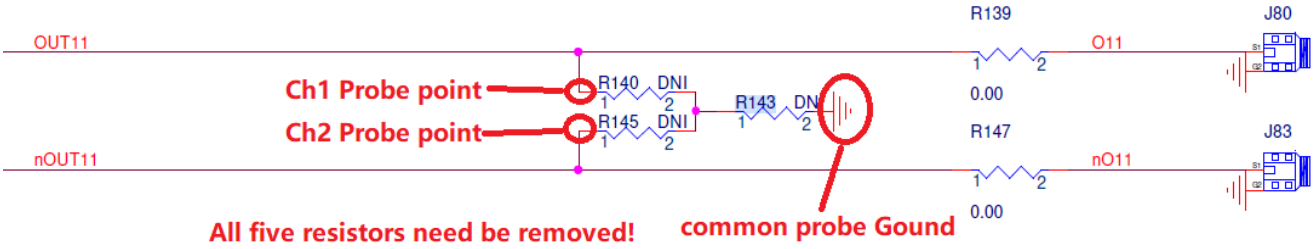

Figure 46. Probe Points of HCSL Internal Termination Mode

4.2 HCSL Externally Terminated

- **Scope**: Keysight MAX404A. Scope Channels select 50Ω impedance.
- 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.

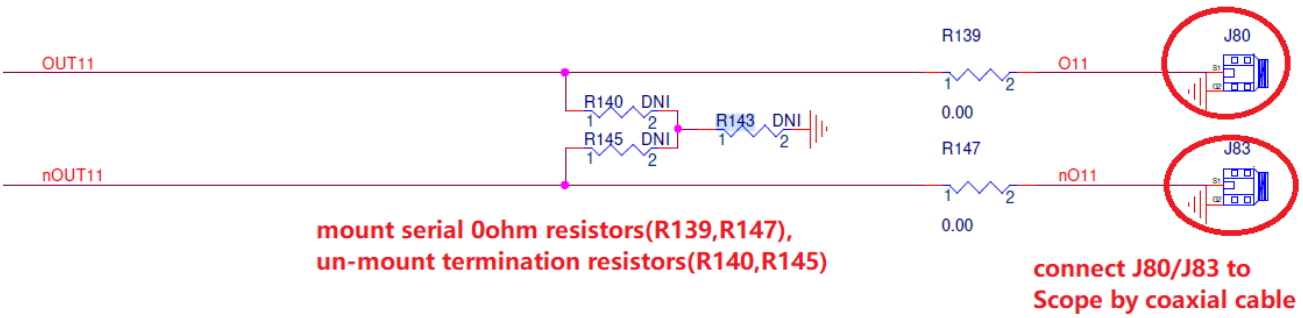

Figure 47. Probe Points of HCSL External Termination Mode

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.

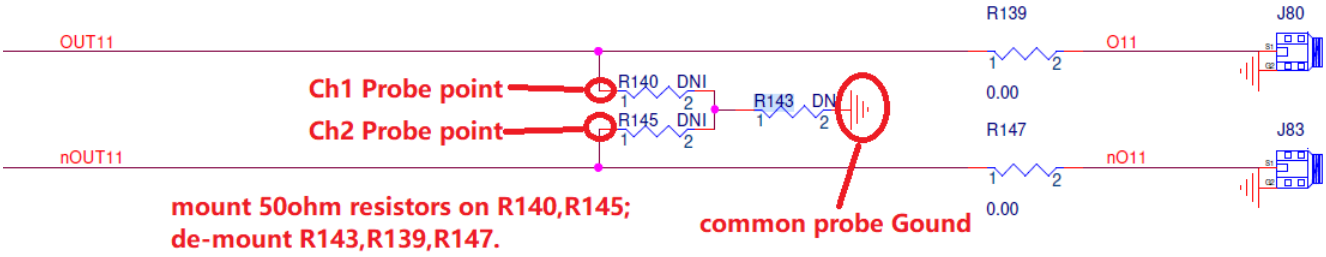

Figure 48. LVDS Waveform Measurement

4.4 Measurement Bench

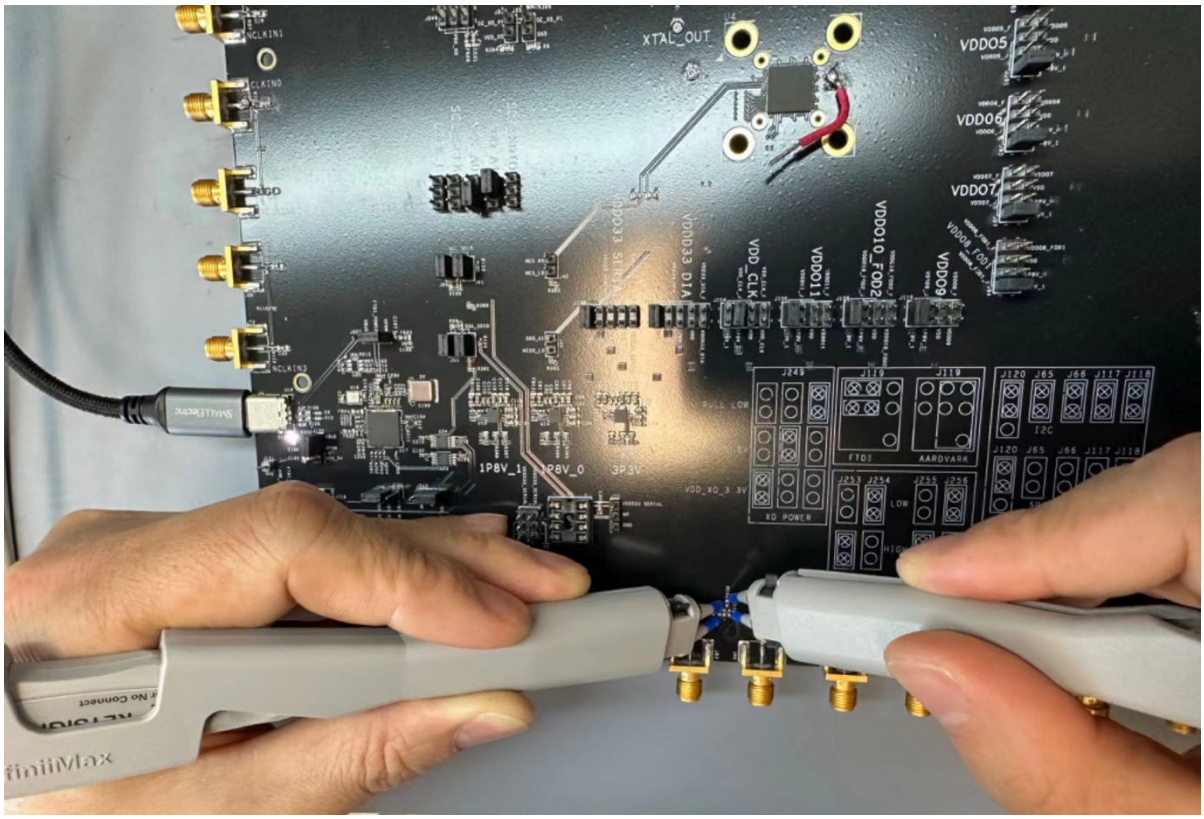

Figure 49. Waveform Measurement with Probe

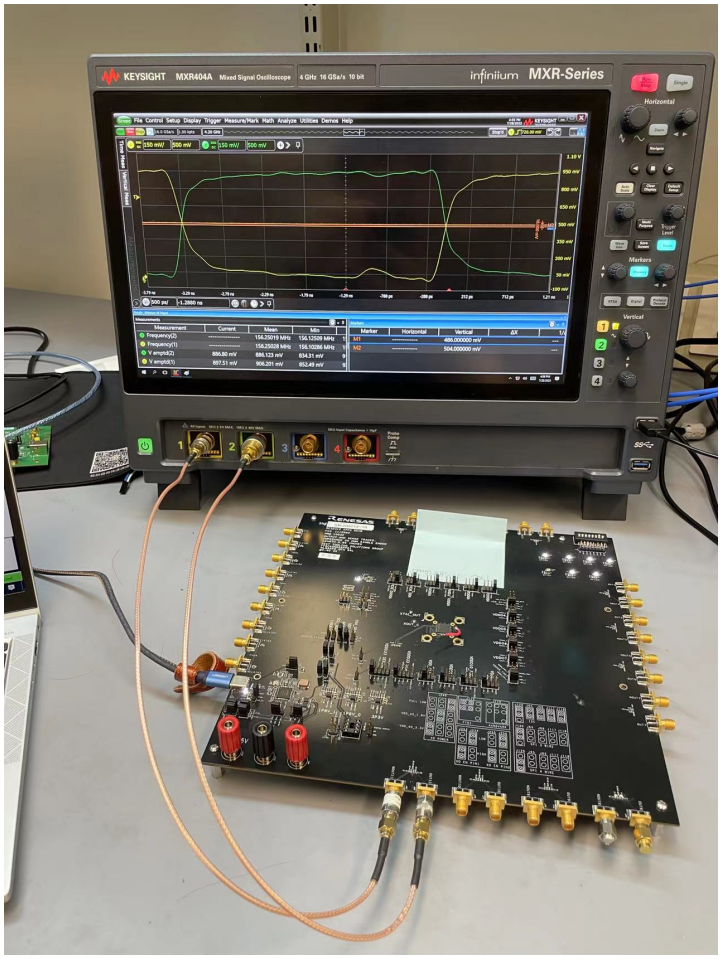

Figure 50. Waveform Measurement with Coaxial Cable

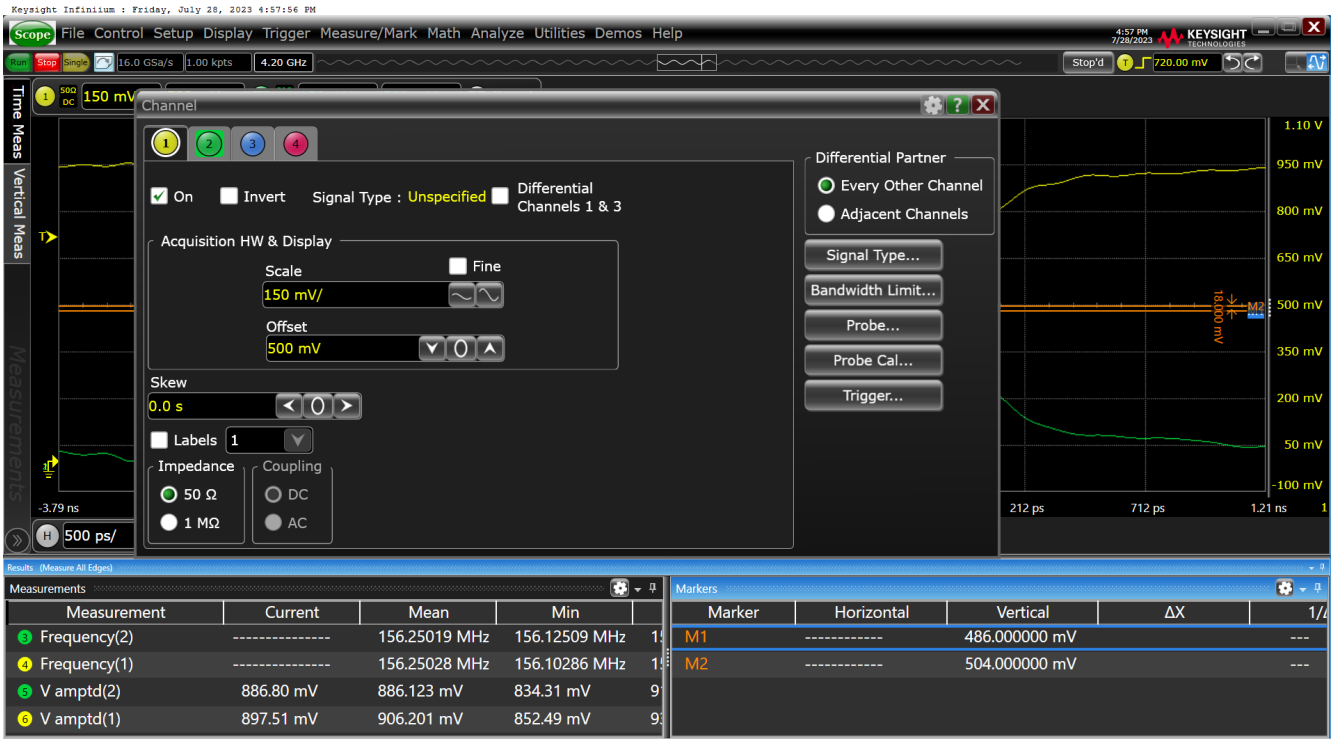

Figure 51. Scope's CH1 and CH2 Need to Set 50Ω Impedance when Connecting with Coaxial Cable

5. Revision History

Revision	Date	Description
1.00	Feb 1, 2024	Initial release.

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