HCSL Output Termination Scheme and Waveform Measurement on FemtoClock™ 3 Wireless

Introduction

The FemtoClock™ 3 Wireless (FC3W) family supports HCSL drivers with internal or external terminations. This document describes the termination schemes and the resulting amplitude and cross-voltage measurements.

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1. Termination Scheme

The FC3W family of devices support transmitter internal termination (see Figure 1). Integrating the terminations inside the transmitter simplifies the BOM and the board design.

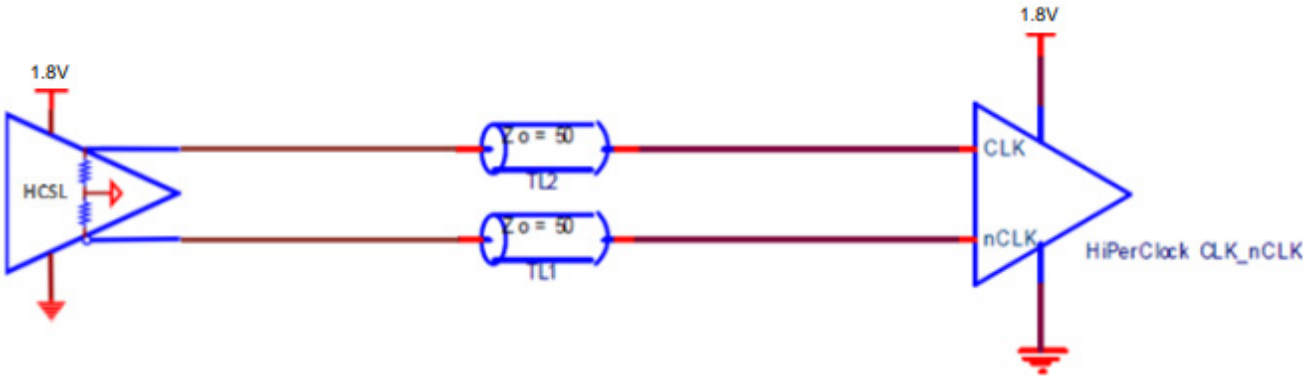


Figure 1. HCSL Transmitter Internal Termination – Simple Topology

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.

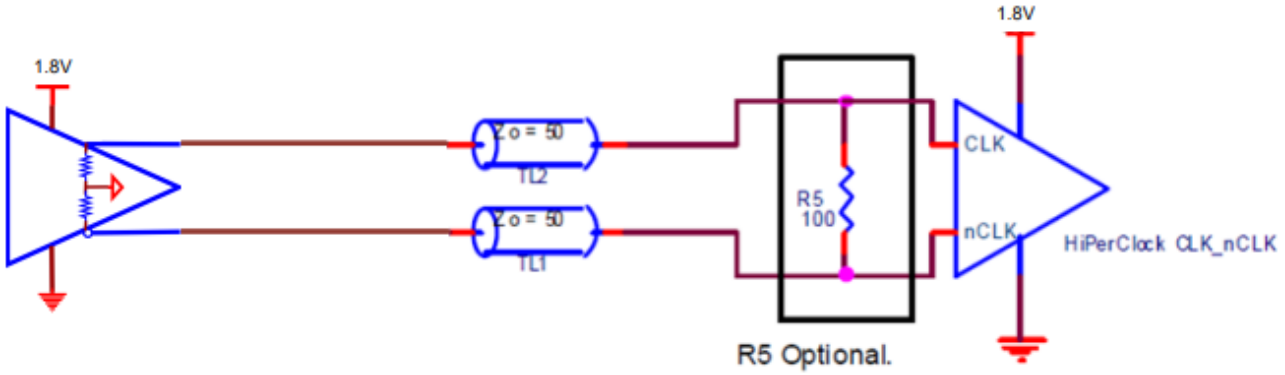


Figure 2. HCSL Internal Transmitter Termination with Optional Resistor

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

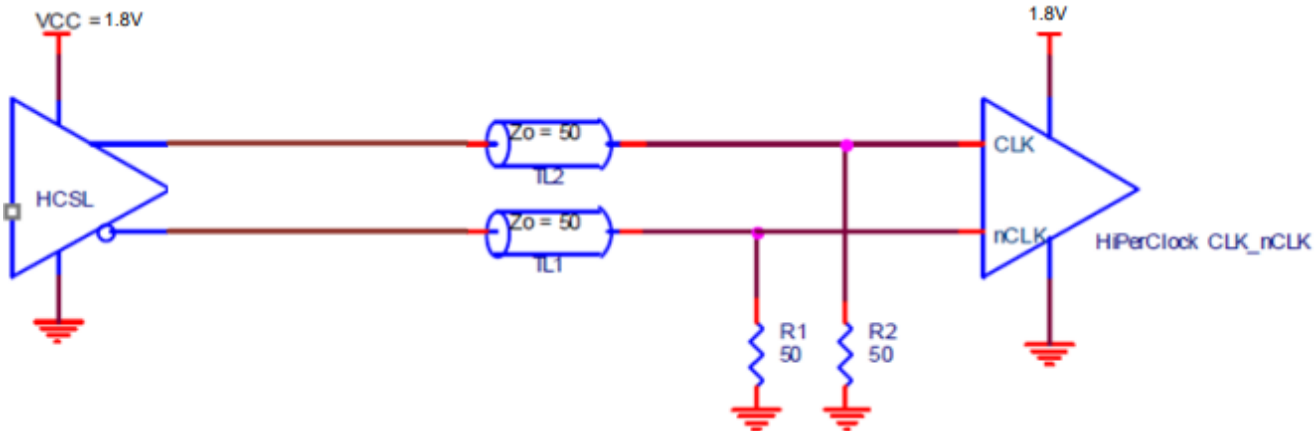


Figure 3. HCSL Common External Termination

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

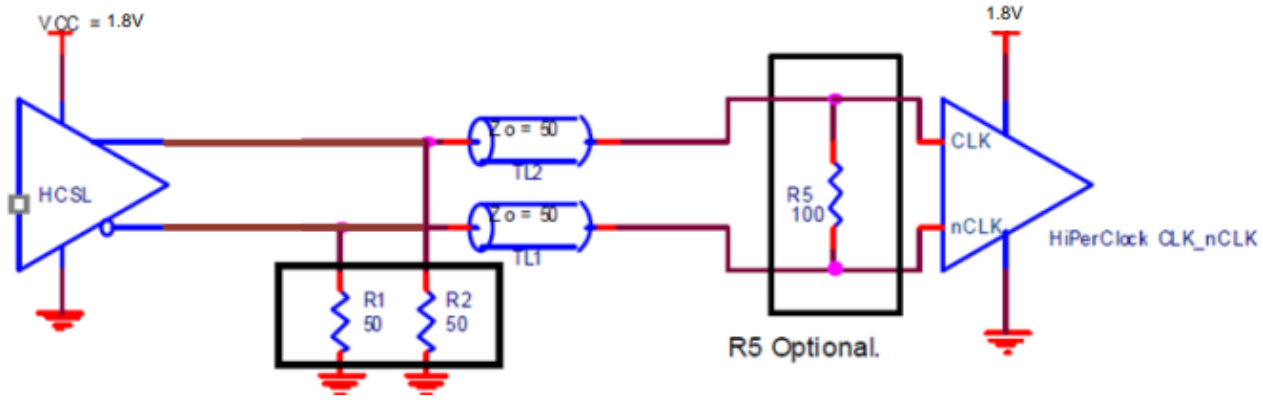


Figure 4. HCSL External Termination Near the Transmitter

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 FC3W's internal terminations. The combination of the FC3W 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 FC3W amplitude should be set to the maximum setting of 30% boost.

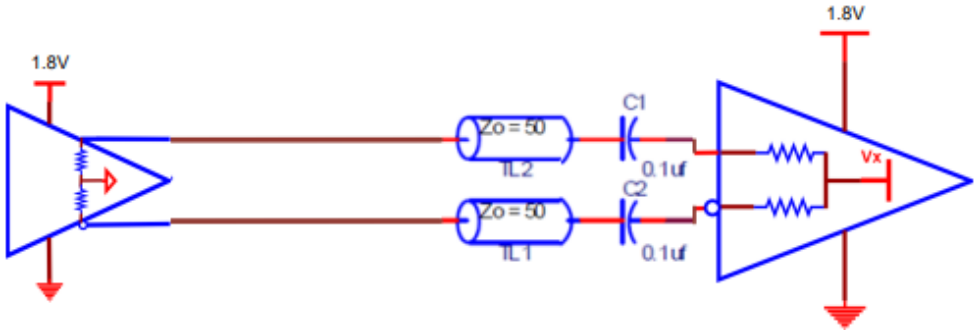


Figure 5. HCSL Dual-Termination for Receivers with Internal Terminations

Figure 6 shows how to interface an FC3W HCSL output to an LVPECL receiver. It uses AC-coupling and a re-bias. R1 and R2 can also be omitted when the FC3W HCSL driver is configured to use internal terminations.

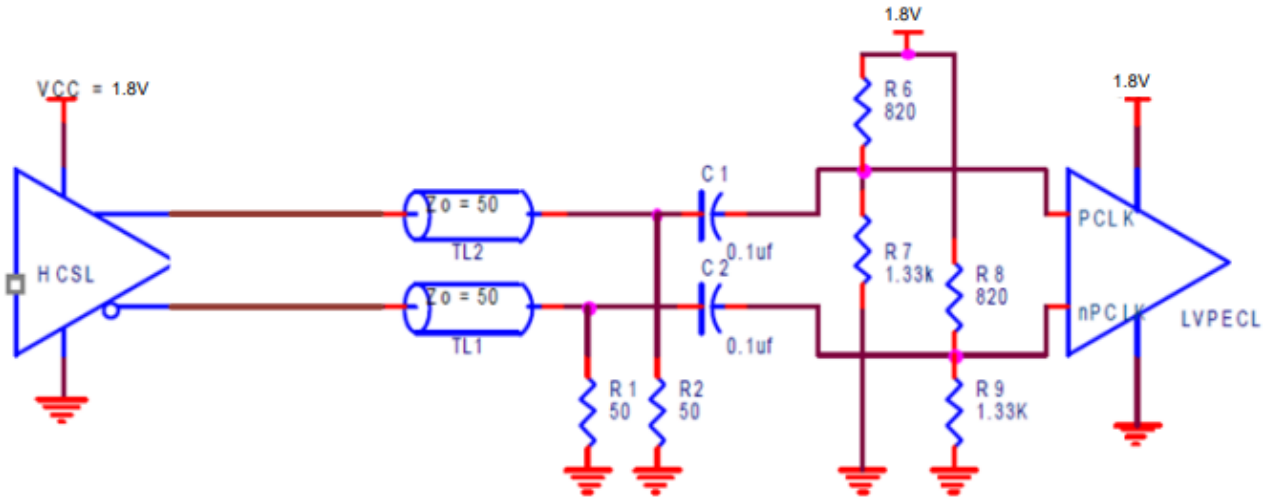


Figure 6. Termination Example of HCSL to LVPECL

2. OUTx Mode Setting in RICBox

The following section and Figure 7 describes how to setup the HCSL configuration using the RICBox GUI.

1. **Output Type** – Select HCSL internally terminated or HCSL externally terminated.
2. **Differential Amplitude Boost** – Enable 0% (no boost), 15%, or 30% boost.

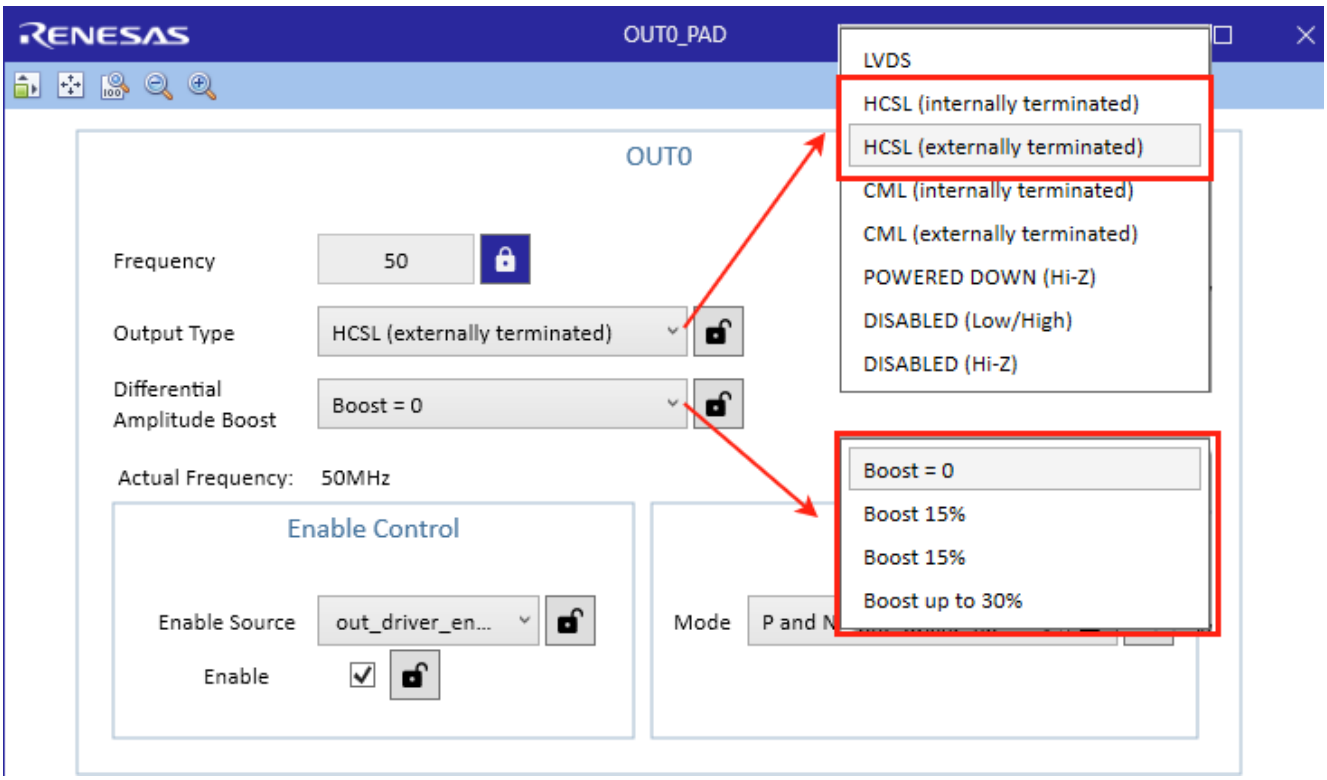


Figure 7. FC3W HCSL Termination and Boost Settings in RICBox

Note: When the **Output Type** selected is **HCSL (externally terminated)**, the GUI automatically sets the internal termination to disabled.

3. FC3W Evaluation Board Waveform Measurement Method

3.1 HCSL Internal Termination

- Scope: Keysight EXR054A. Scope Channels set to high impedance
- 50Ω coaxial cable x2
- FC3W output configured to **HCSL internally terminated**

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

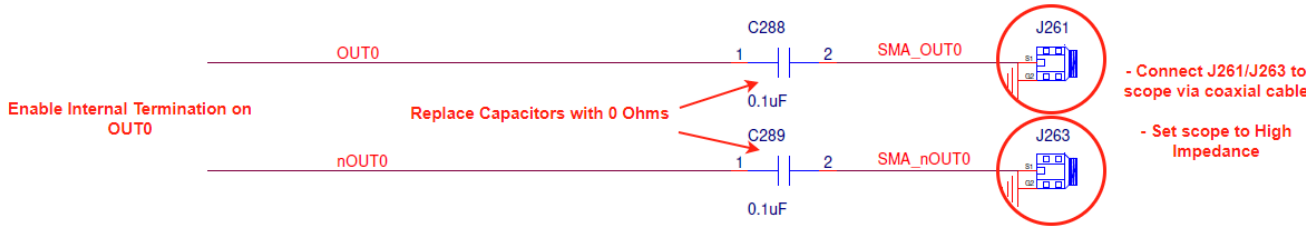


Figure 8. Probe Points of HCSL Internal Termination Mode

3.2 HCSL External Termination

- Scope: Keysight EXR054A. Scope Channels set to 50Ω impedance
- 50Ω coaxial cable x2
- FC3W output configured to **HCSL externally terminated**

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

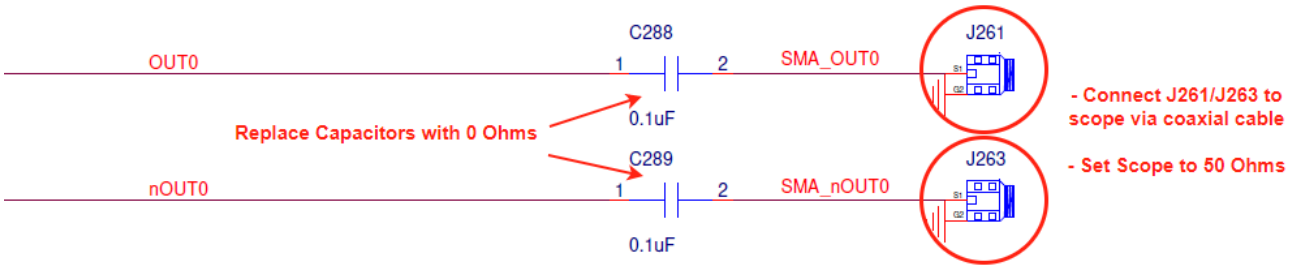


Figure 9. Probe Points of HCSL External Termination Mode

3.3 HCSL Dual Termination

- Scope: Keysight EXR054A. Scope Channels set to 50Ω impedance
- 50Ω coaxial cable x2
- FC3W output configured to **HCSL internally terminated**

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

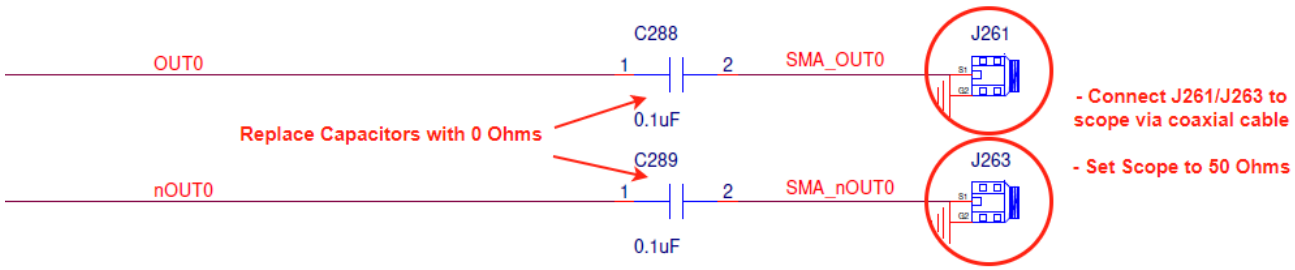


Figure 10. Probe Points of HCSL Dual Termination Mode

4. HCSL Amplitude and Cross-Voltage Measurement

Table 1 lists the HCSL measuring data on the FC3W evaluation board for a variety of termination schemes. Waveforms for each case are shown in Figure 11 to Figure 28. For these figures, the yellow waveform is OUT0 and the blue waveform is nOUT0. For more information on the EVB test method, see FC3 EVB Waveform Measurement Method.

Table 1. Vovs and Vcross Measurement

HCSL Termination Mode	Differential Amplitude Boost	Vovs (mV) [1]		Vcross (mV) [2]	
		OUTx	nOUTx	OUTx Rising/ nOUTx Falling	nOUTx Rising/ OUTx Falling
Internal Termination	0%	749	769	368	372
	15%	913	935	432	444
	30%	1045	1080	480	492
External Termination	0%	785	771	390	345
	15%	925	915	483	429
	30%	993	986	534	483
Dual Termination *Note*: Enable internal HCSL termination and add external termination.	0%	386	387	182	140
	15%	469	459	224	176
	30%	536	535	252	208

1. Vovs = Peak-to-peak output voltage swing on each OUTx and nOUTx pin.
2. Vcross = voltage crossing point. Voltage level where the rising edge of the output p-side waveforms intersects the output n-side waveform and vice-versa.

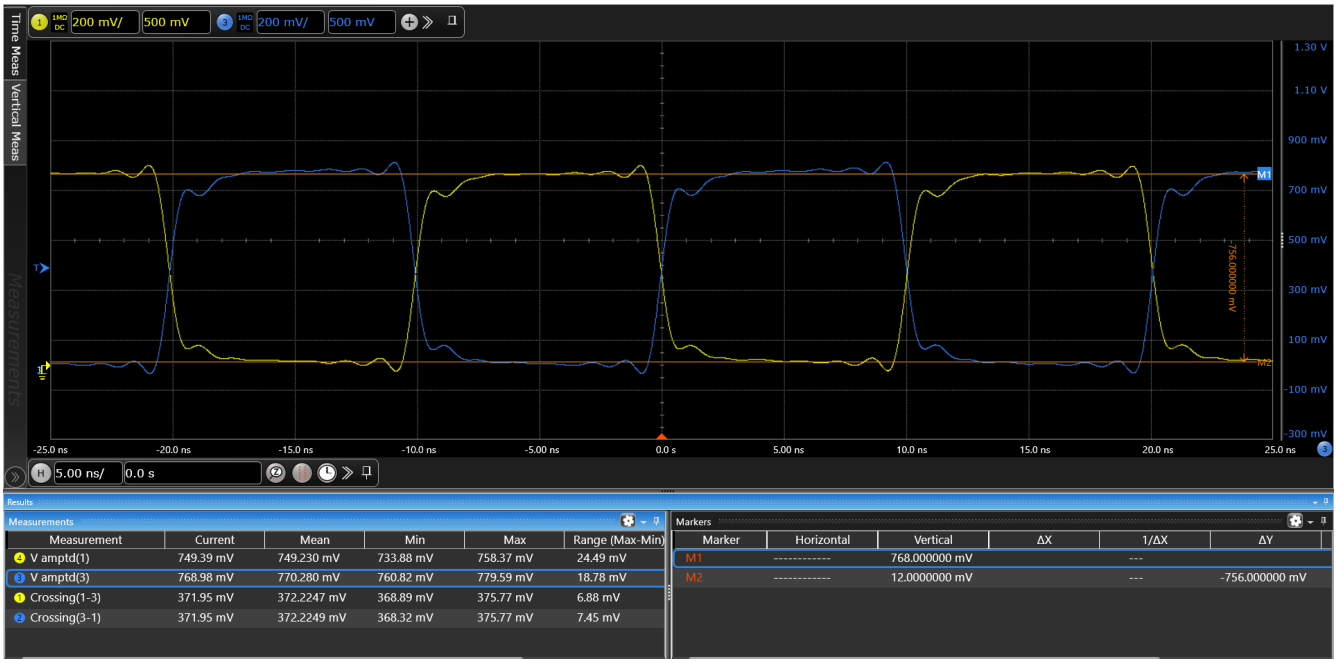


Figure 11. Vovs – HCSL Internal Termination, Boost = 0% on OUT0 (yellow trace) and nOUT0 (blue trace)

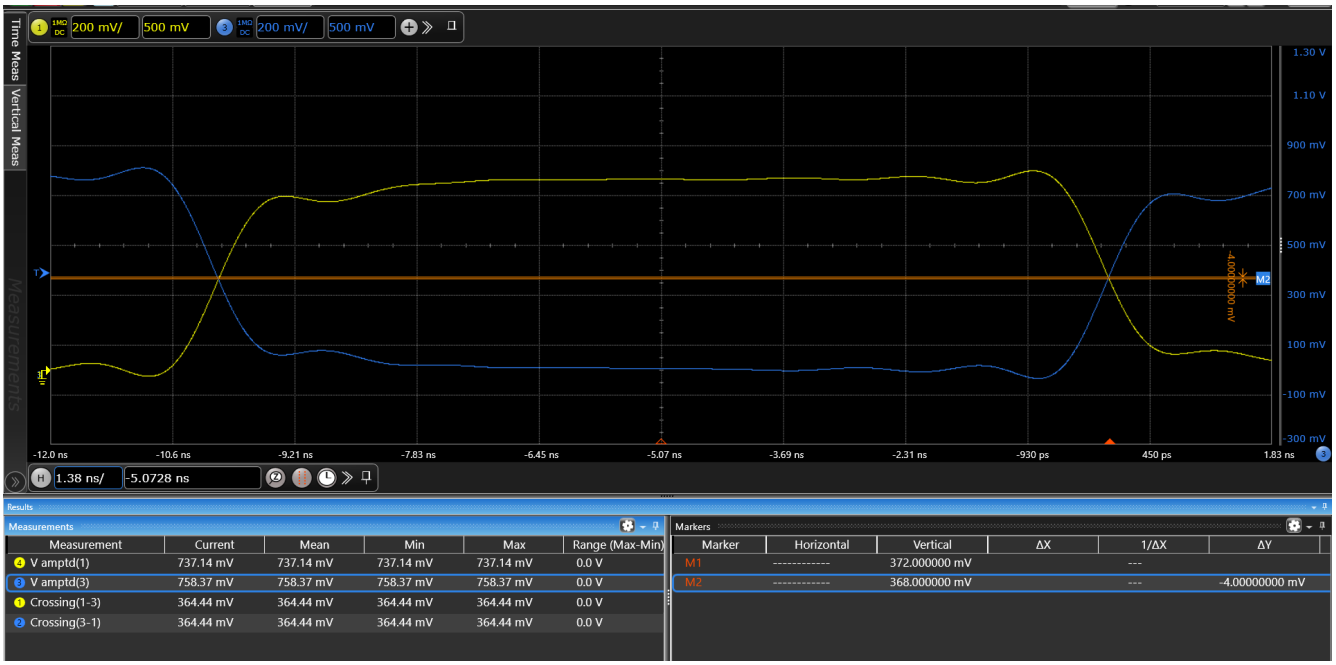


Figure 12. Vcross – HCSL Internal Termination, Boost = 0% on OUT0 (yellow trace) and nOUT0 (blue trace)

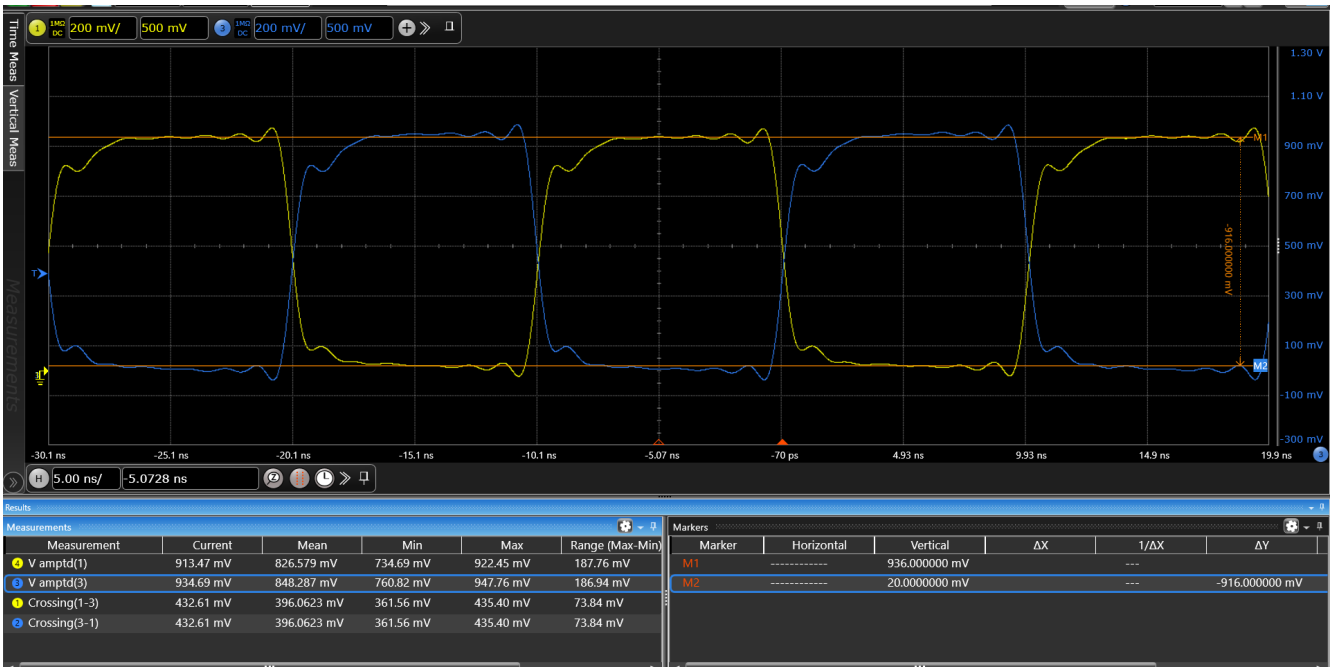


Figure 13. Vovs – HCSL Internal Termination, Boost = 15% on OUT0 (yellow trace) and nOUT0 (blue trace)

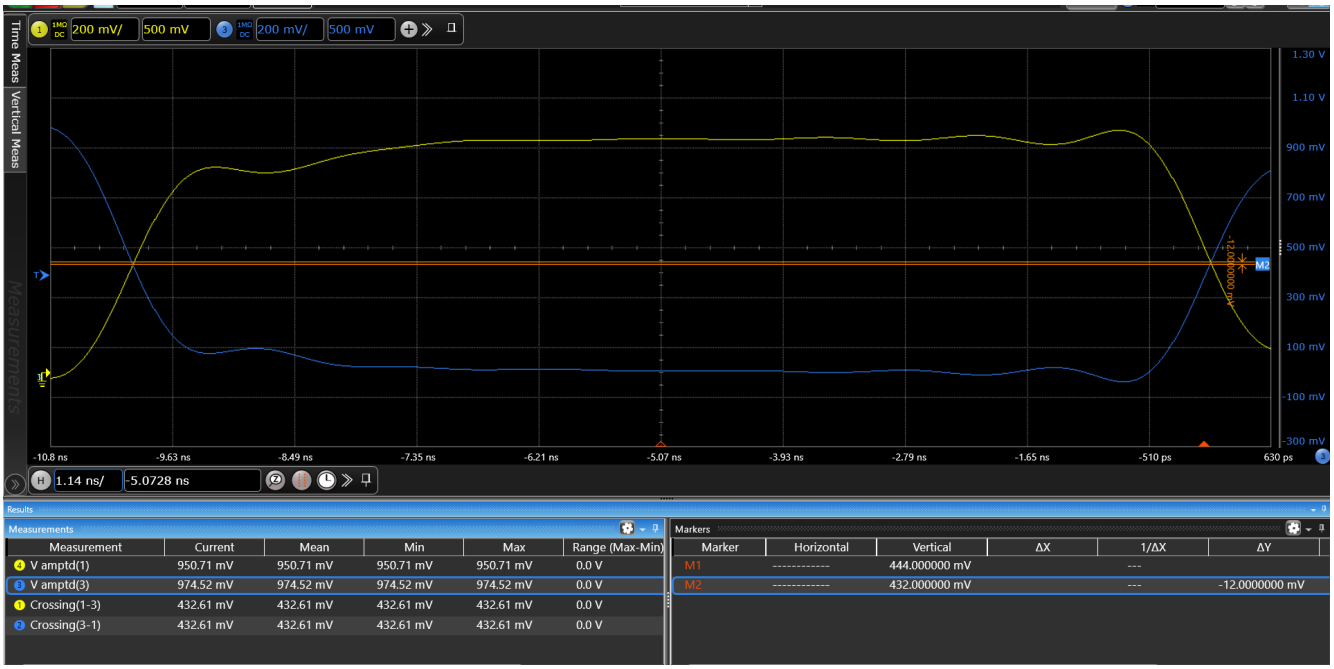


Figure 14. Vcross – HCSL Internal Termination, Boost = 15% on OUT0 (yellow trace) and nOUT0 (blue trace)

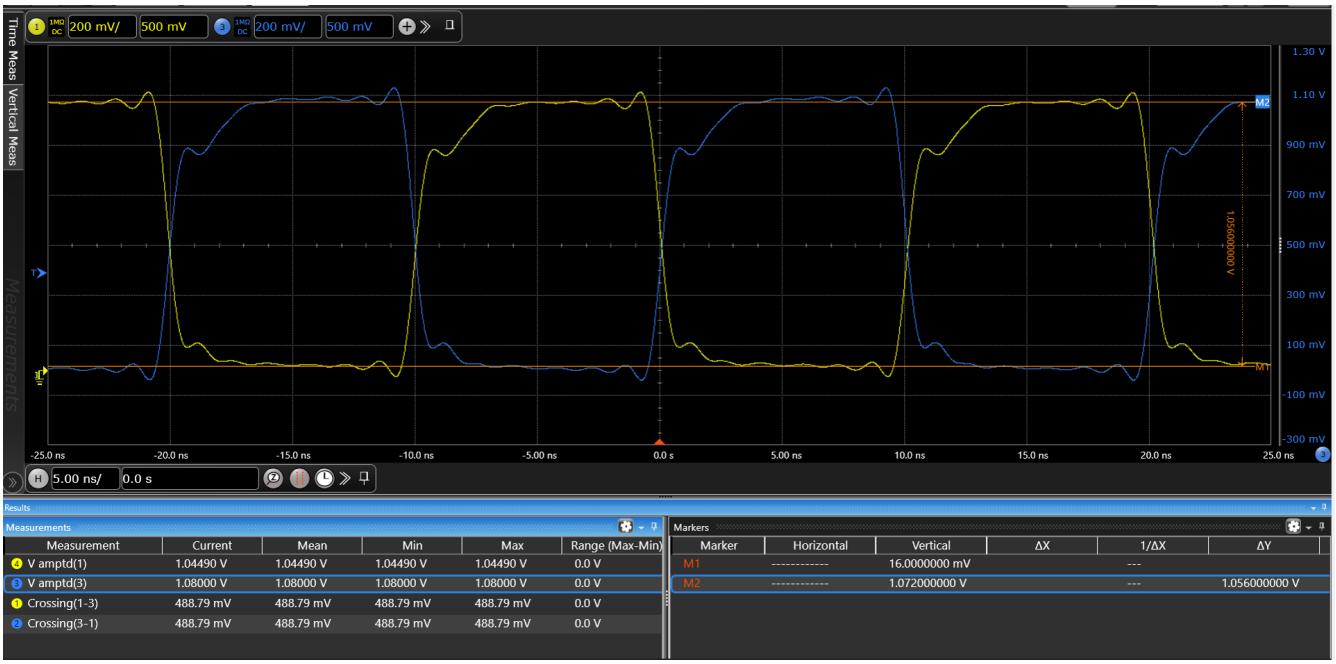


Figure 15. Vovs – HCSL Internal Termination, Boost = 30% on OUT0 (yellow trace) and nOUT0 (blue trace)

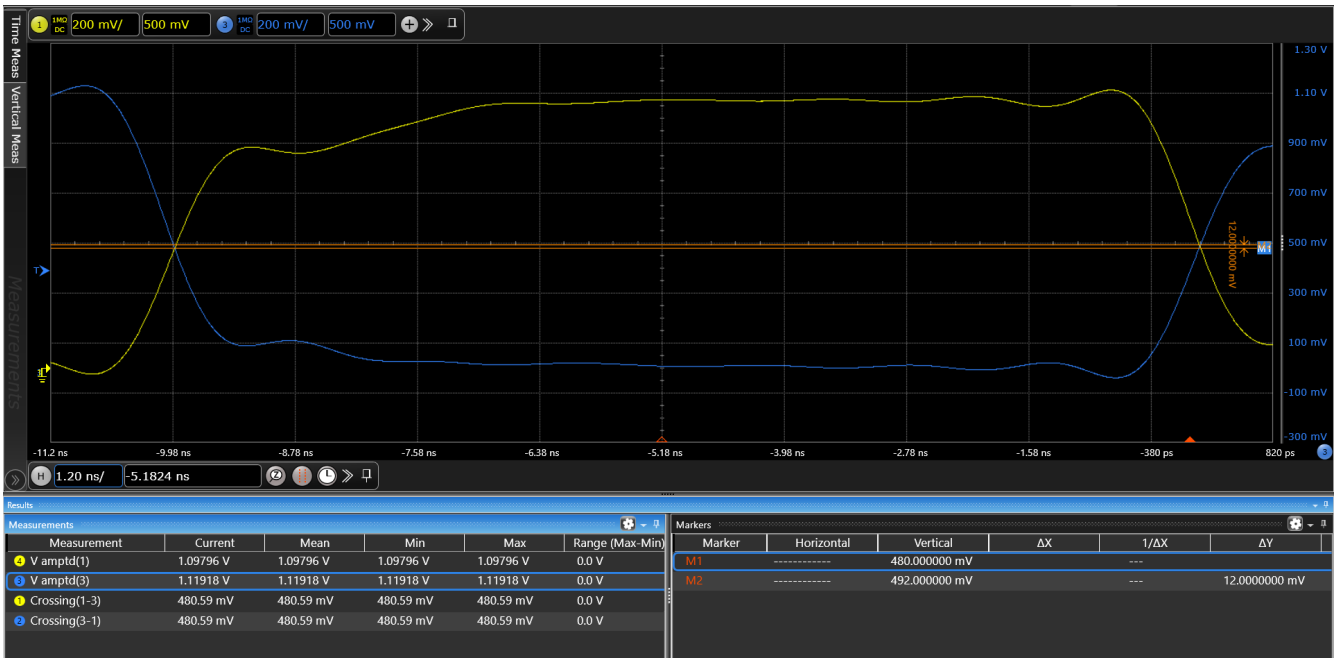


Figure 16. Vcross – HCSL Internal Termination, Boost = 30% on OUT0 (yellow trace) and nOUT0 (blue trace)

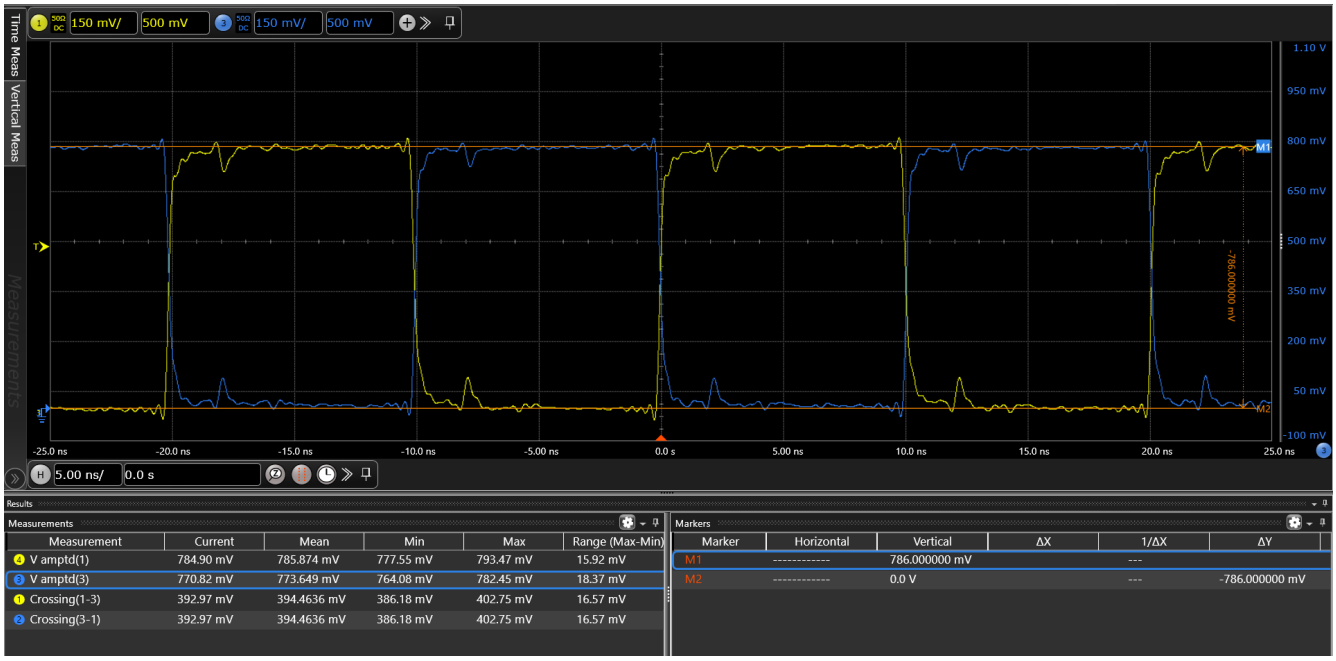


Figure 17. Vovs – HCSL External Termination, Boost = 0% on OUT0 (yellow trace) and nOUT0 (blue trace)

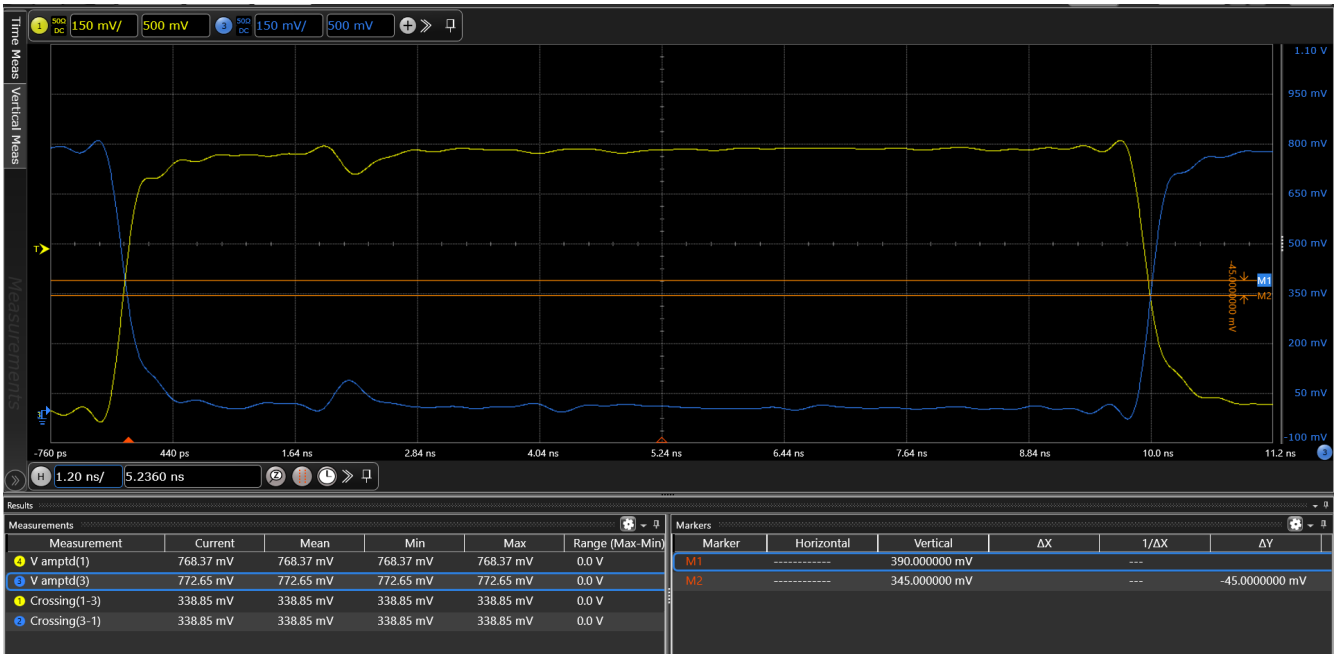


Figure 18. Vcross – HCSL External Termination, Boost = 0% on OUT0 (yellow trace) and nOUT0 (blue trace)

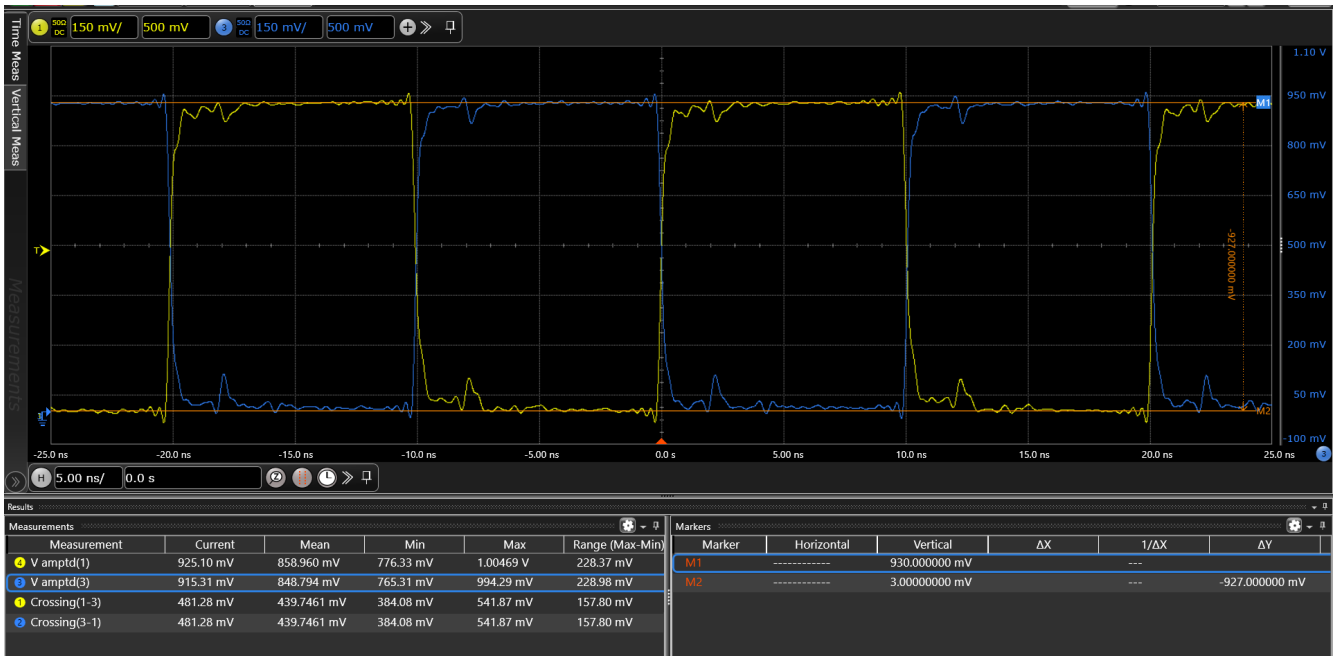


Figure 19. Vovs – HCSL External Termination, Boost = 15% on OUT0 (yellow trace) and nOUT0 (blue trace)

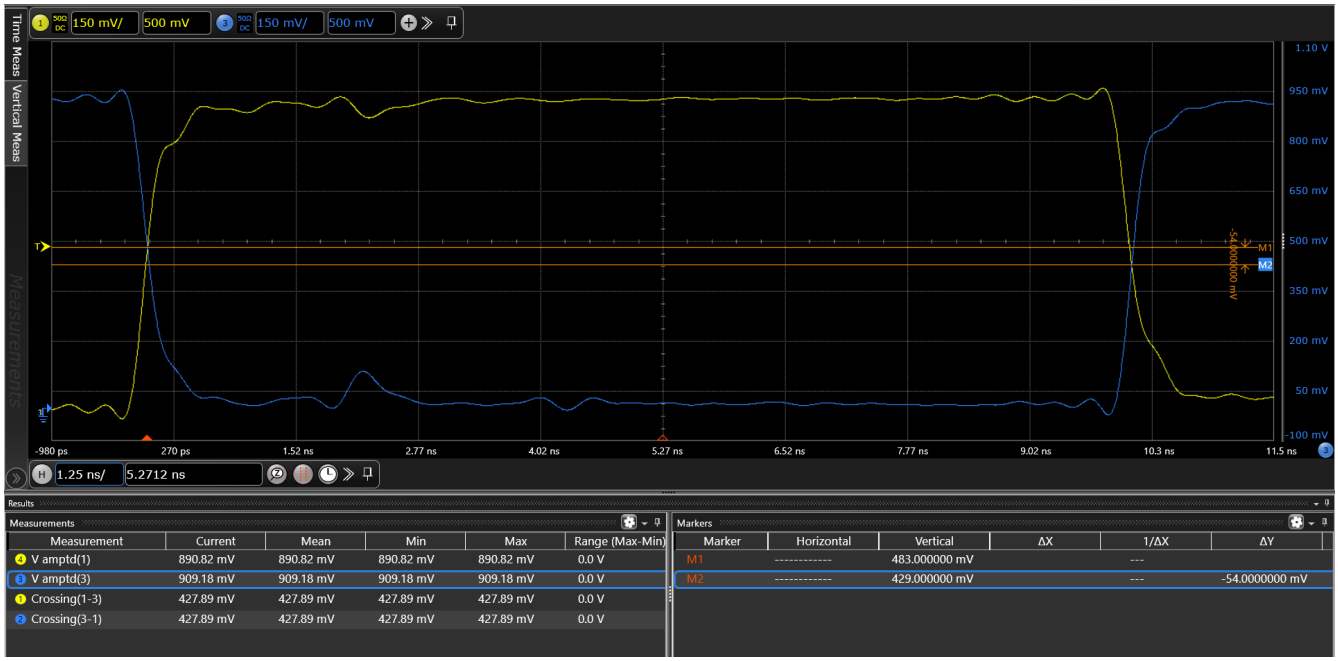


Figure 20. Vcross – HCSL External Termination, Boost = 15% on OUT0 (yellow trace) and nOUT0 (blue trace)

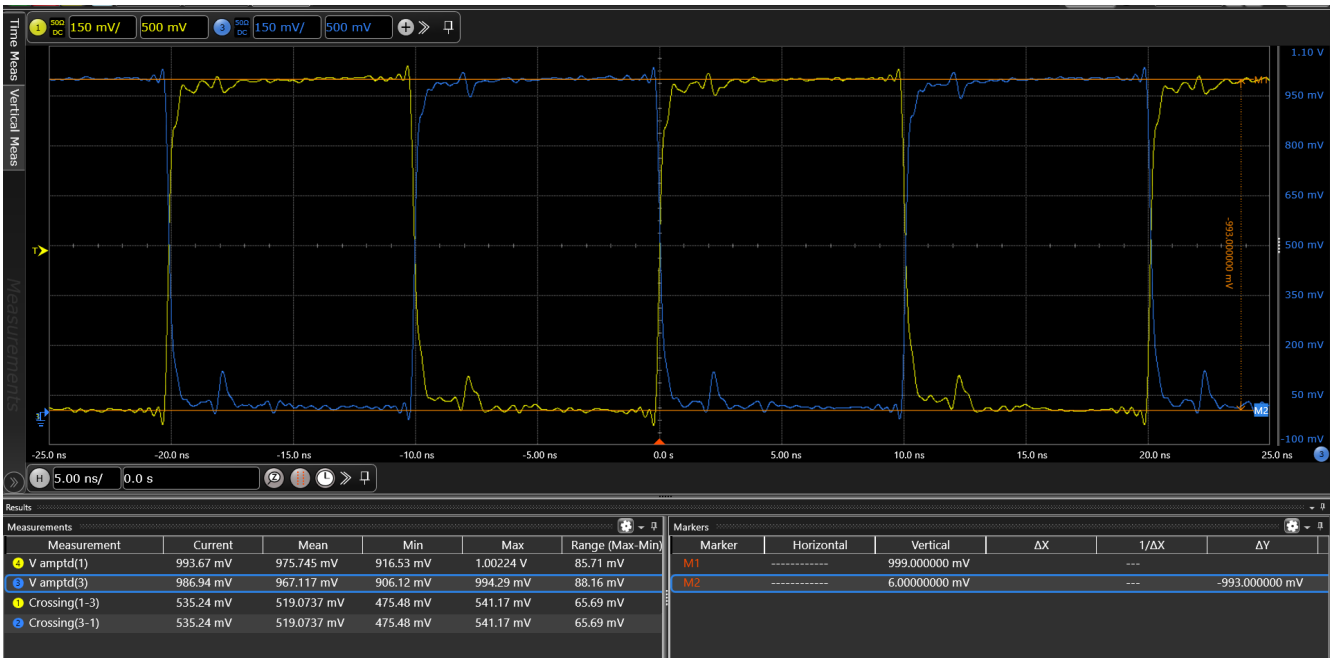
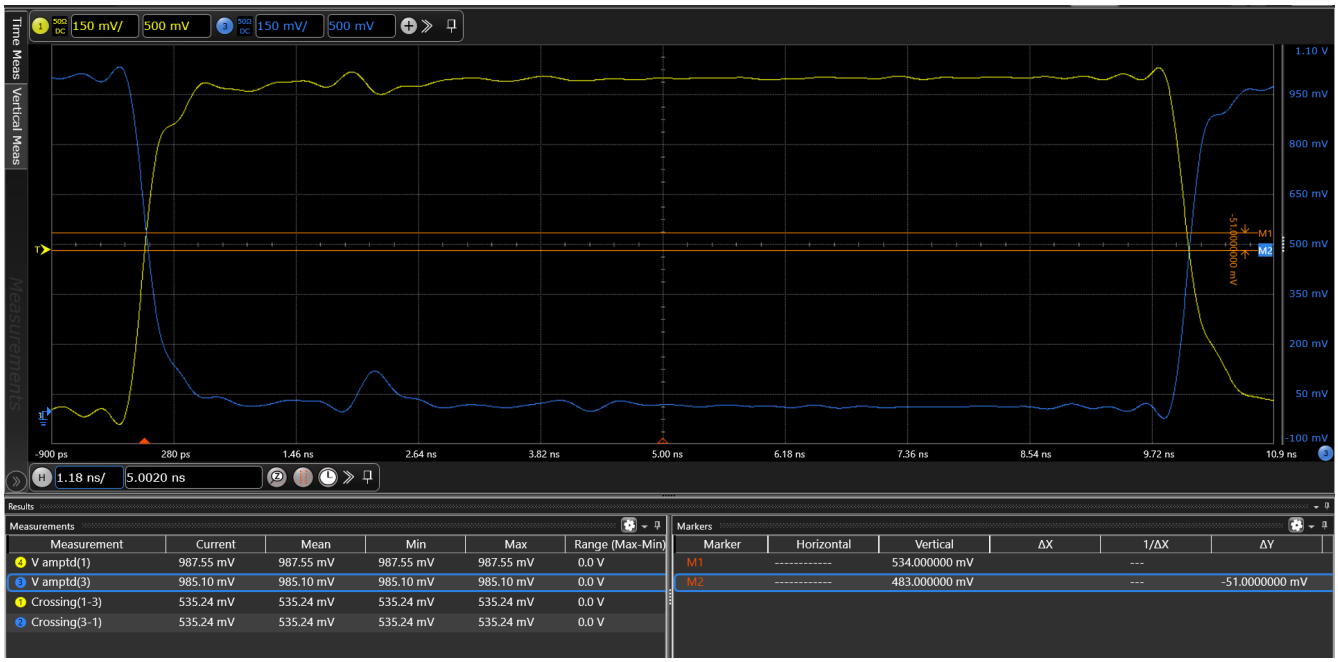


Figure 21. Vovs – HCSL External Termination, Boost = 30% on OUT0 (yellow trace) and nOUT0 (blue trace)


150 mV/
500 mV
150 mV/
500 mV
1.10 V
950 mV
800 mV
650 mV
500 mV
350 mV
200 mV
50 mV
-100 mV
-900 ps
280 ps
1.46 ns
2.64 ns
3.82 ns
5.00 ns
6.18 ns
7.36 ns
8.54 ns
9.72 ns
10.9 ns
1.18 ns/
5.0020 ns
Measurements
Measurement | Current | Mean | Min | Max | Range (Max-Min)
V amptd(1) | 987.55 mV | 987.55 mV | 987.55 mV | 987.55 mV | 0.0 V
V amptd(3) | 985.10 mV | 985.10 mV | 985.10 mV | 985.10 mV | 0.0 V
Crossing(1-3) | 535.24 mV | 535.24 mV | 535.24 mV | 535.24 mV | 0.0 V
Crossing(3-1) | 535.24 mV | 535.24 mV | 535.24 mV | 535.24 mV | 0.0 V
Markers
Marker | Horizontal | Vertical | ΔX | 1/ΔX | ΔY
M1 | 534.000000 mV | | |

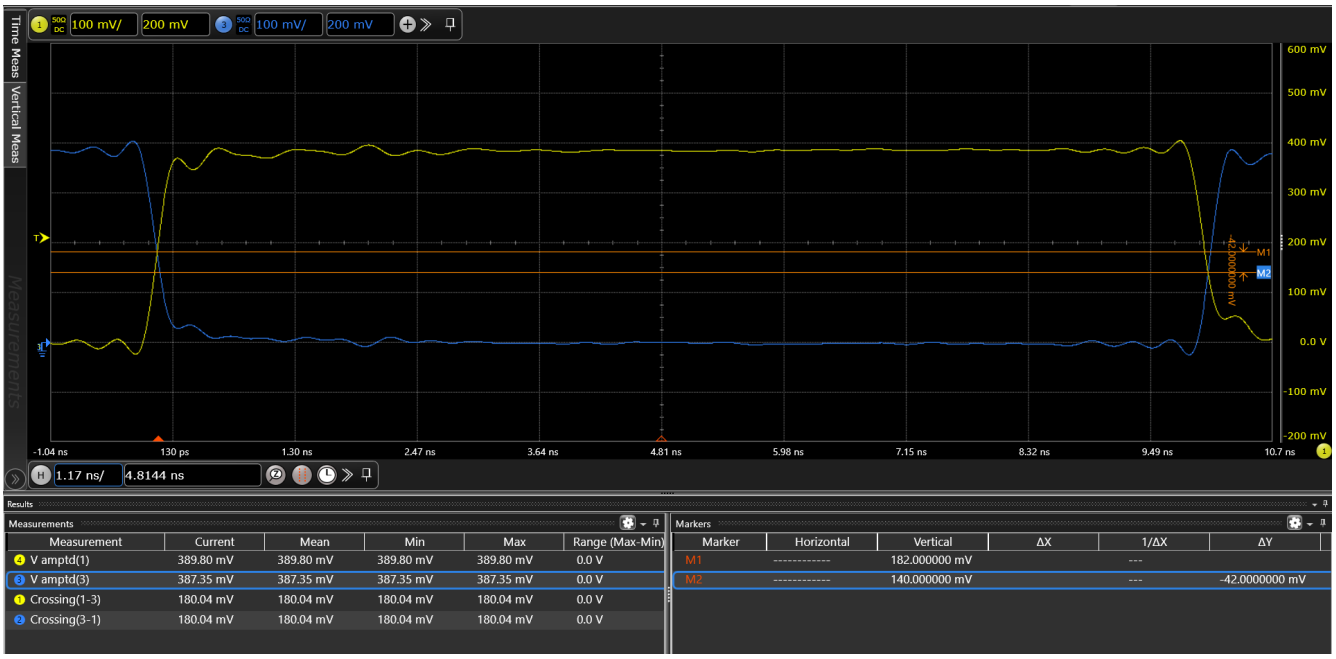


Figure 24. Vcross – HCSL Dual Termination, Boost = 0% on OUT0 (yellow trace) and nOUT0 (blue trace)

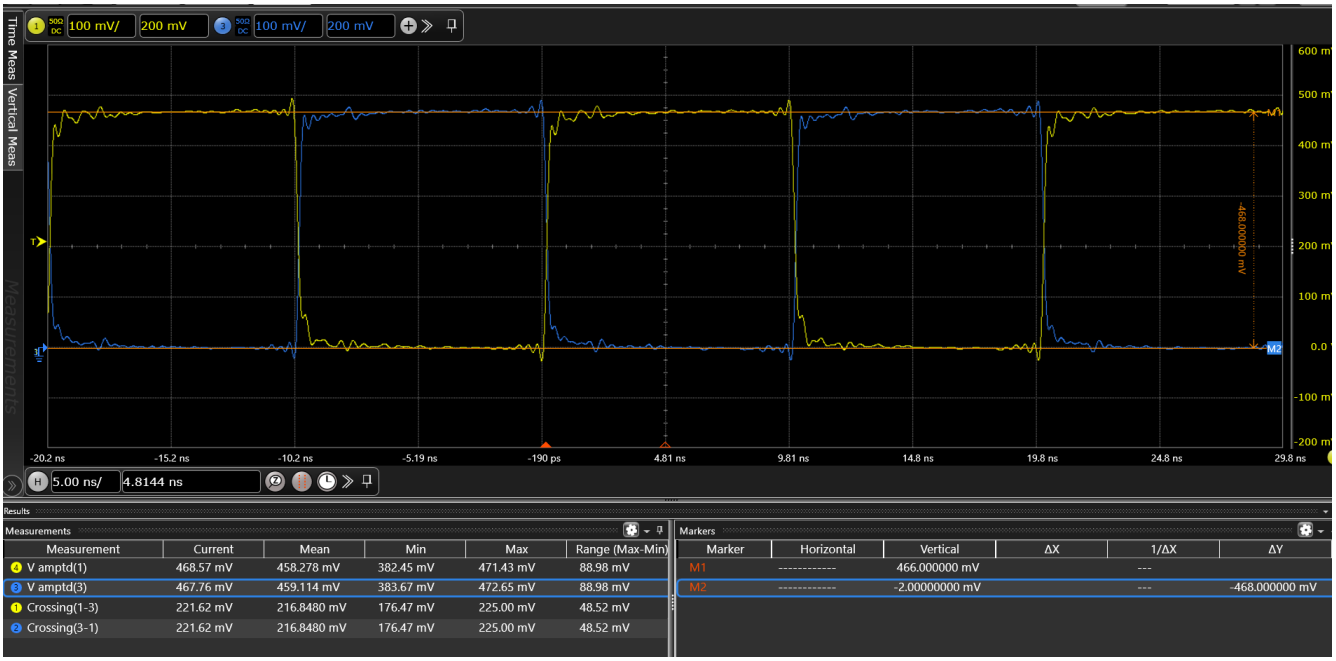


Figure 25. Vovs – HCSL Dual Termination, Boost = 15% on OUT0 (yellow trace) and nOUT0 (blue trace)

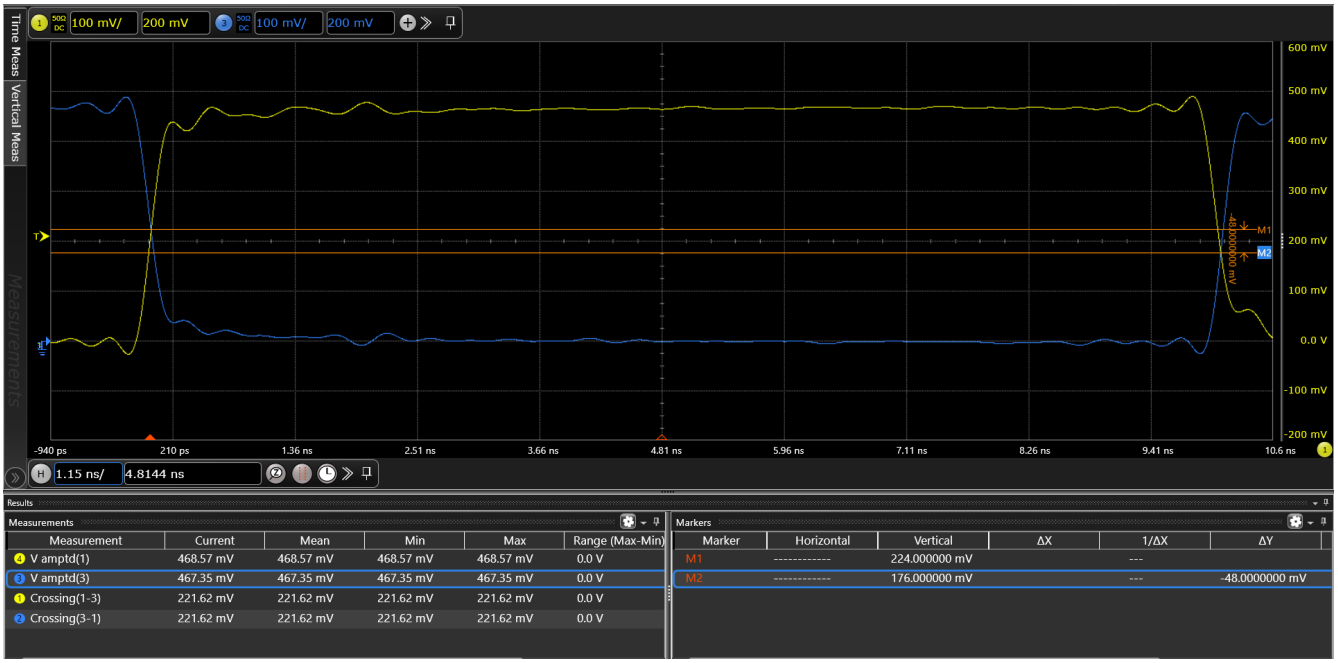


Figure 26. Vcross – HCSL Dual Termination, Boost = 15% on OUT0 (yellow trace) and nOUT0 (blue trace)

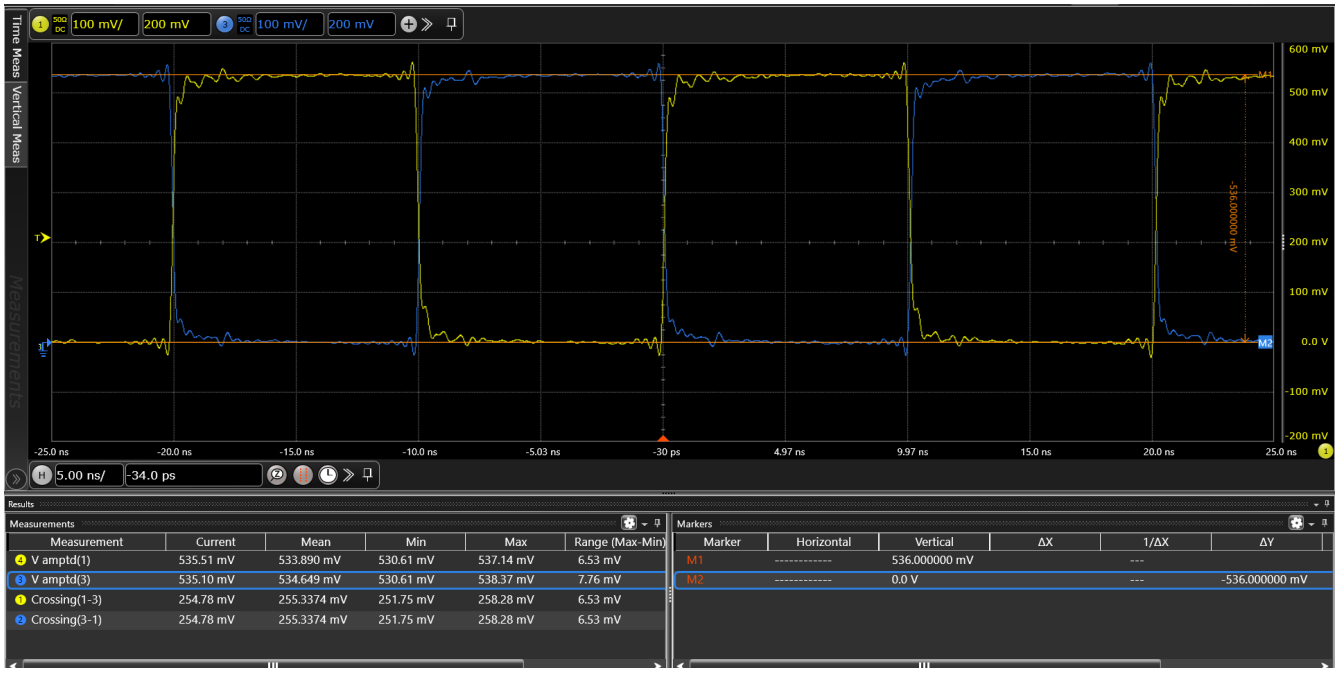


Figure 27. Vovs – HCSL Dual Termination, Boost = 30% on OUT0 (yellow trace) and nOUT0 (blue trace)

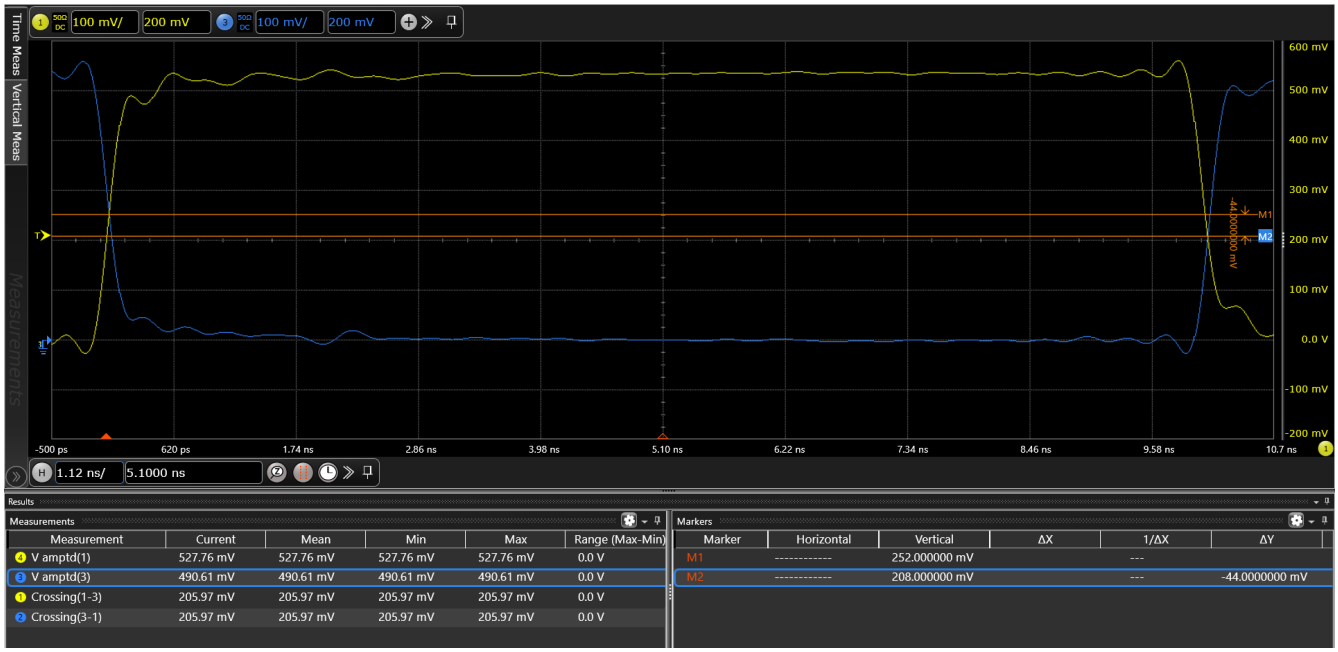


Figure 28. Vcross – HCSL Dual Termination, Boost = 30% on OUT0 (yellow trace) and nOUT0 (blue trace)

5. Revision History

Revision	Date	Description
1.00	Aug 1, 2025	Initial release.