

SL41N-M

Ethernet Switcher Isolation Test

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EXECUTIVE SUMMARY

High Sec Labs' 4-Port Ethernet Switcher allows a device to be shared among multiple sources by an ethernet connection without introducing latency or lapse in security. To prevent any leakage or electrical crosstalk, it must ensure that it completely disconnects all inactive ports.

This document summarizes a structured RF isolation test of HSL's SL41N-M 4-Port Secure Ethernet Switcher. The test exercised every possible idle-port/active-port pairing, at every pair combination relevant to 10BASE-T, 100BASE-TX, 1000BASE-T, and 2.5GBASE-T, across a 90 kHz–200 MHz sweep, resulting in 192 unique measurements. Every single measurement showed isolation exceeding 60 dB, with several channels exceeding 70 dB. No measurement approached a level that would represent a meaningful risk of cross-port signal coupling for any of the four Ethernet standards evaluated.

WHY PORT ISOLATION MATTERS

When several independent systems are connected to the same ethernet switch, the isolation between the switch's idle and active ports acts as a physical security boundary. If an idle port could pick up even a fraction of the signal energy from the active port, a system connected to that idle port might be able to reconstruct fragments of traffic, risking information leakage.

This is why isolation must be tested with the same rigor as connection switching, if not more: a switch can meet every functional and performance requirement and still be unsuitable for shared or multi-domain use if its port-to-port isolation is inadequate. The test program described here was designed to characterize that boundary directly, using calibrated RF instrumentation rather than protocol-level tools that cannot detect analog leakage.

SCOPE OF TESTING

The test evaluated port-to-port isolation only. For each of the Switcher's four positions, one input port is active (connected to the output) while the remaining three are idle. A single wire pair on the active port is stimulated, and isolation is measured on every pair of every idle port. Isolation between pairs within the same port, switching speed, insertion loss, and return loss were outside the scope of this test and are not addressed in this document.

The switch's isolation was characterized against the four twisted-pair Ethernet standards it needs to support:

Standard	Speed	Lanes (Pairs)	Modulation	Max Frequency	Max Reach
10BASE-T	10 Mbps	1 (1 pair TX, 1 pair RX)	Manchester	10 MHz	100 m
100BASE-TX	100 Mbps	2 (1 pair TX, 1 pair RX)	MLT-3 + 4B5B	31.25 MHz	100 m
1000BASE-T	1 Gbps	4 (all pairs, full duplex)	PAM-5	125 MHz	100 m
2.5BASE-T	2.6 Gbps	4 (all pairs, full duplex)	PAM-16	200 MHz	100 m

MODULATION NOTES:

- **Manchester (10BASE-T):** self-clocking and simple, but bandwidth-inefficient — 1 bit per symbol at 50% efficiency.
- **MLT-3 + 4B5B (100BASE-TX):** a 3-level line code (-1, 0, +1); FDDI-derived 4B5B encoding raises the symbol rate to 31.25 MHz for a 100 Mbps payload.
- **PAM-5 (1000BASE-T):** 5 amplitude levels, 2 bits per symbol, running simultaneously on all four pairs in both directions.
- **PAM-16 (2.5GBASE-T and above):** 16 amplitude levels, 4 bits per symbol, paired with LDPC forward error correction to manage the higher noise floor at elevated frequencies.

TEST METHODOLOGY

EQUIPMENT

Isolation was measured using a spectrum analyzer with tracking generator (DC–3 GHz minimum), configured as follows:

Two 50 Ω single-ended-to-100 Ω differential adapters with RJ-45 breakout/patch cables (one on the tracking generator output, one on the spectrum analyzer input) for direct access to individual wire pairs.

50 Ω single-ended termination resistors on every pair not actively being stimulated or measured, to prevent reflections from confounding the isolation reading.

Fixed test conditions were held constant across all 192 measurements:

Parameter	Value
Sweep range	90 kHz–200MHz (covers all four standards)
Stimulus impedance	100 Ω differential
Measurement impedance	100 Ω differential
Non-measured pairs	Terminated with 100 Ω differential load (50 Ω single-ended)
Recorded result	Peak (worst-case) isolation across the full sweep, in dB

PROCEDURE

1. Set the analog switch to the active port indicated in the test table heading.
2. Connect the tracking generator, via a 100 Ω differential adapter, to the stimulated pair on the active port.
3. Terminate all other pairs on all ports with 50 Ω single-ended loads, except the pair currently being measured.
4. Connect the spectrum analyzer, via a 100 Ω differential adapter, to the measured pair on the idle port.
5. Sweep 90 kHz–200 MHz and record the peak leakage level relative to the tracking generator output, in dB.
6. Repeat for each row in the test table, moving the analyzer to the next pair.

WIRE PAIR REFERENCE (TIA-568B, RJ-45)

All pair identifications in the results below follow the standard TIA-568B RJ-45 pinout:

Pair	RJ-45 Pins	Color (T568B)	Used by Standard
Pair 1	4 & 5	Blue / Blue-white	1000BASE-T, 2.5GBASE-T
Pair 2	3 & 6	Orange / Orange-white	All standards
Pair 3	1 & 2	Green / Green-white	All standards
Pair 4	7 & 8	Brown / Brown-white	1000BASE-T, 2.5GBASE-T

RESULTS

The full test matrix covers all four switch positions, each with four possible stimulated pairs, each measured against the twelve available combinations of pairs and idle ports (3 idle ports $\times$ 4 pairs), resulting in a total of 16 test configurations and 192 individual measurements. Across every single measurement, isolation exceeded 60 dB relative to the tracking generator output; several channels, as captured directly on the spectrum analyzer, exceeded 70 dB.

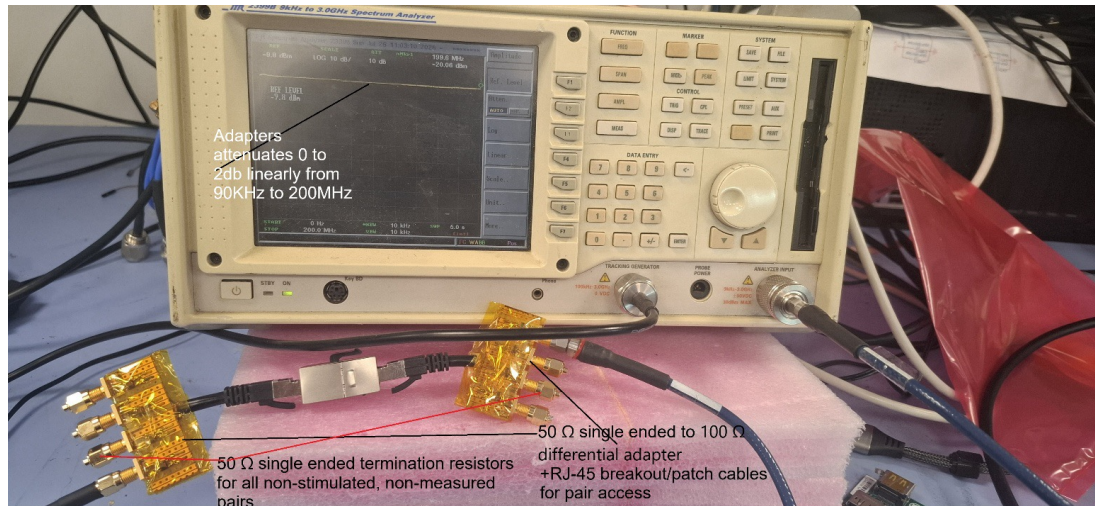


Figure 1. Swept isolation trace, active-port pair (0 dB reference) versus a representative idle-port pair.



Figure 2. Non-selected channel measurement showing isolation of more than 60 dB; a second channel (not shown) exceeded 70 dB.

The table below summarizes the peak isolation result for each of the 16 test configurations. In every case, all twelve measurements within that configuration cleared the 60 dB threshold; no configuration or standard showed degraded performance relative to the others.

Test #	Active Port	Stimulated Pair	Measurements Taken	Isolation Result
Test 1	Port 1	Pair 1 (Pins 4 & 5)	12 (3 idle ports × 4 pairs)	> 60 dB
Test 2	Port 1	Pair 2 (Pins 3 & 6)	12 (3 idle ports × 4 pairs)	> 60 dB
Test 3	Port 1	Pair 3 (Pins 1 & 2)	12 (3 idle ports × 4 pairs)	> 60 dB
Test 4	Port 1	Pair 4 (Pins 7 & 8)	12 (3 idle ports × 4 pairs)	> 60 dB
Test 5	Port 2	Pair 1 (Pins 4 & 5)	12 (3 idle ports × 4 pairs)	> 60 dB
Test 6	Port 2	Pair 2 (Pins 3 & 6)	12 (3 idle ports × 4 pairs)	> 60 dB
Test 7	Port 2	Pair 3 (Pins 1 & 2)	12 (3 idle ports × 4 pairs)	> 60 dB
Test 8	Port 2	Pair 4 (Pins 7 & 8)	12 (3 idle ports × 4 pairs)	> 60 dB
Test 9	Port 3	Pair 1 (Pins 4 & 5)	12 (3 idle ports × 4 pairs)	> 60 dB
Test 10	Port 3	Pair 2 (Pins 3 & 6)	12 (3 idle ports × 4 pairs)	> 60 dB
Test 11	Port 3	Pair 3 (Pins 1 & 2)	12 (3 idle ports × 4 pairs)	> 60 dB
Test 12	Port 3	Pair 4 (Pins 7 & 8)	12 (3 idle ports × 4 pairs)	> 60 dB
Test 13	Port 4	Pair 1 (Pins 4 & 5)	12 (3 idle ports × 4 pairs)	> 60 dB
Test 14	Port 4	Pair 2 (Pins 3 & 6)	12 (3 idle ports × 4 pairs)	> 60 dB
Test 15	Port 4	Pair 3 (Pins 1 & 2)	12 (3 idle ports × 4 pairs)	> 60 dB
Test 16	Port 4	Pair 4 (Pins 7 & 8)	12 (3 idle ports × 4 pairs)	> 60 dB

As a representative example, the full 12-row detail for Test 1 (Port 1 active, Pair 1 stimulated) is shown below; the remaining 15 test configurations followed the identical pattern and are available in the underlying test record on request.

Test 1 - Active Port: 1 | Stimulus: Pair 1 (Pins 4 & 5)

#	Idle Port	Measured Pair	Isolation Result
1	Port 2	Pair 1 (Pins 4 & 5)	> 60 dB
2	Port 2	Pair 2 (Pins 3 & 6)	> 60 dB
3	Port 2	Pair 3 (Pins 1 & 2)	> 60 dB
4	Port 2	Pair 4 (Pins 7 & 8)	> 60 dB
5	Port 3	Pair 1 (Pins 4 & 5)	> 60 dB
6	Port 3	Pair 2 (Pins 3 & 6)	> 60 dB
7	Port 3	Pair 3 (Pins 1 & 2)	> 60 dB
8	Port 3	Pair 4 (Pins 7 & 8)	> 60 dB
9	Port 4	Pair 1 (Pins 4 & 5)	> 60 dB
10	Port 4	Pair 2 (Pins 3 & 6)	> 60 dB
11	Port 4	Pair 3 (Pins 1 & 2)	> 60 dB
12	Port 4	Pair 4 (Pins 7 & 8)	> 60 dB

DISCUSSION

A minimum of 60 dB isolation corresponds to an idle port receiving, at most, roughly one-millionth of the signal power present on the active port, a level far below what could be meaningfully recovered by any device connected to that idle port. This margin held consistently across the full 90 kHz–200 MHz sweep, meaning it applies equally to the low-frequency Manchester encoding of 10BASE-T and the 200 MHz PAM-16 signaling used by 2.5GBASE-T, despite the different modulation schemes and noise sensitivities involved.

Because the test covers all four switch positions and every stimulated-pair/idle-pair combination, the results indicate that the SL41N-M consistently maintains this level of isolation. The absence of any outlier demonstrates that secure isolation is structural to the Ethernet Switcher's design rather than dependent on a particular port, pair, or signaling standard.

CONCLUSION

This test program demonstrates that the SL41N-M Secure Ethernet Switcher maintains more than 60 dB of port-to-port isolation across all input combinations, all idle-port pairings, and all twisted-pair Ethernet standards from 10BASE-T through 2.5GBASE-T. For environments where physical separation between connected systems is a security requirement, this level of isolation provides direct, instrument-verified evidence that the Switcher's idle ports do not present a meaningful risk of signal leakage from the active port.

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High Sec Labs (HSL) develops high-quality cyber-defense solutions in the field of network and peripheral isolation for protecting national assets and infrastructure.

The company, headquartered in Or Akiva, Israel, was founded in 2008 and has a second manufacturing site in the United States.

High Sec Lab's roots are deeply embedded in the defense and commercial industries developing cyber protection solutions. Among its customers are some of the world's leading governments and defense organizations as well as commercial companies such as banks, healthcare providers, and national infrastructure companies.



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