Insertion / Return Losses vs. Temperature Performance of RTPGE Cable Assemblies

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- James Lawlis, Douglas Oliver – Ford
- Kirsten Matheus - BMW

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Introduction:

We focused on the entire communication channel between two Ethernet nodes, which includes the two ECU connectors, cable and, in some cases, inline connectors.

Only frequency response of the channels was measured. The purpose of the study was twofold:

- To investigate IL/RL at certain temperatures;
- To investigate if there is a permanent degradation to IL/RL after exposing assemblies to different temperatures.

Introduction:

Definitions:

IL – Insertion Loss (SDD21)

RL – Return Loss (SDD22)

Frequency measurements were taken at the following temperatures :

- 40 C (required per USCAR-2, GMW3191 – Classes 1, 2 & 3)

+23 C (common temperature for most tests)

+85 C (required per USCAR-2, GMW3191 – Class 1)

+105 C (required per GMW3191; USCAR-2 requires 100 C – Class 2)

+125 C (required per USCAR-2, GMW3191 – Class 3)

Per GMW3191 and USCAR-2:

Class 1 – passenger compartment

Class 2 – under the hood or on chassis

Class 3 – on engine

Test samples were <u>not</u> subjected to mechanical or environmental conditioning prior to this test.

Test Samples Description:

Measurements were taken on entire communication channels 10m and 15m in total length with up to 4 in-lines.

All samples are made with stranded copper wire.

Sample nomenclature:

Sample 1 – 22 awg PP/PVC (0.34mm^2)_15m_no inlines_Cable Type A_Connector Type 1

Sample 2 – 22 awg PP/PVC (0.34mm^2)_15m_five 3m links_4 inlines_Cable A_Connector 1

Sample 5 – 22 awg PP/PVC (0.34mm^2)_15m_no inlines_Cable A_Connector 2

Sample 6 – 22 awg PP/PVC (0.34mm^2)_15m_five 3m links_4 inlines_Cable A_Connector 2/3*

Sample 3 – 28 awg PP Shielded (0.08mm^2)_10m_five 2m links_4 inlines_Cable B_Connector 1

Sample 4 – 25 awg PVC/PVC (0.18mm^2)_10m_five 2m links_4 inlines_Cable C_Connector 1

(* connector type 2 as ECU connectors; connector type 3 as inline connectors)

Test setup:

We have used a cardboard drum 12" diameter (30.5 cm) that allowed each wrap of cable to be ~1m. This allowed us to test up to 15m links in a chamber that is 24"W_21"H_24"D.

Drum with cable assembly and the thermal chamber:

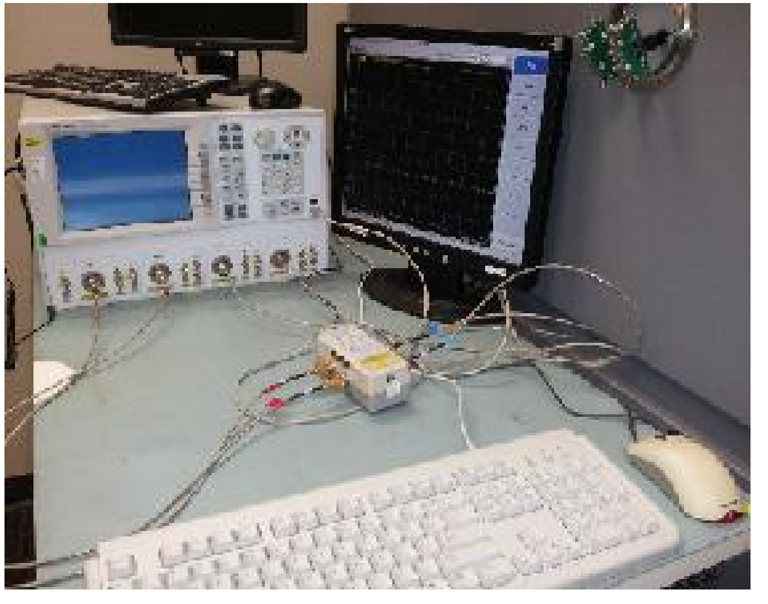
Test setup:

4-port Vector Network Analyzer capable of 300 kHz – 20 GHz was used.

Setup was calibrated to remove the effects of SMA hookup lines.

For simplicity, measurement results include SMA test fixtures with headers and entire communication channels.

VNA test setup:



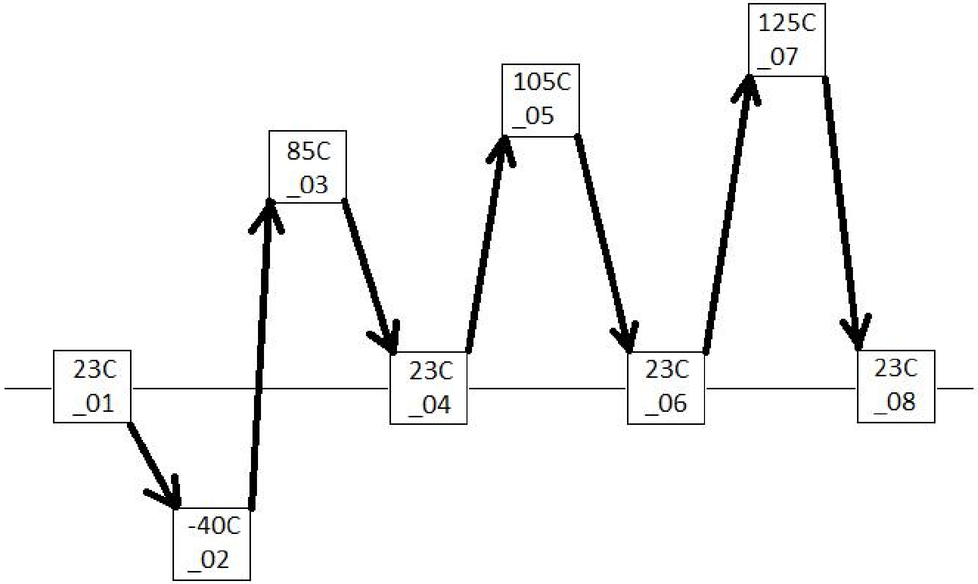
Test setup:

Two test sequences were used.

First sequence had 8 steps as outlined below (_01 through _08) with their respective temperature settings. It was used to ensure that there is no damage to the assemblies by verify that IL/RL values would return back to their original values after each extreme temperature.

Four entire channel assemblies were tested using this sequence.

Data for each step 01 through 08 is identified with “_01 ... _08” for easier tracking of test results.

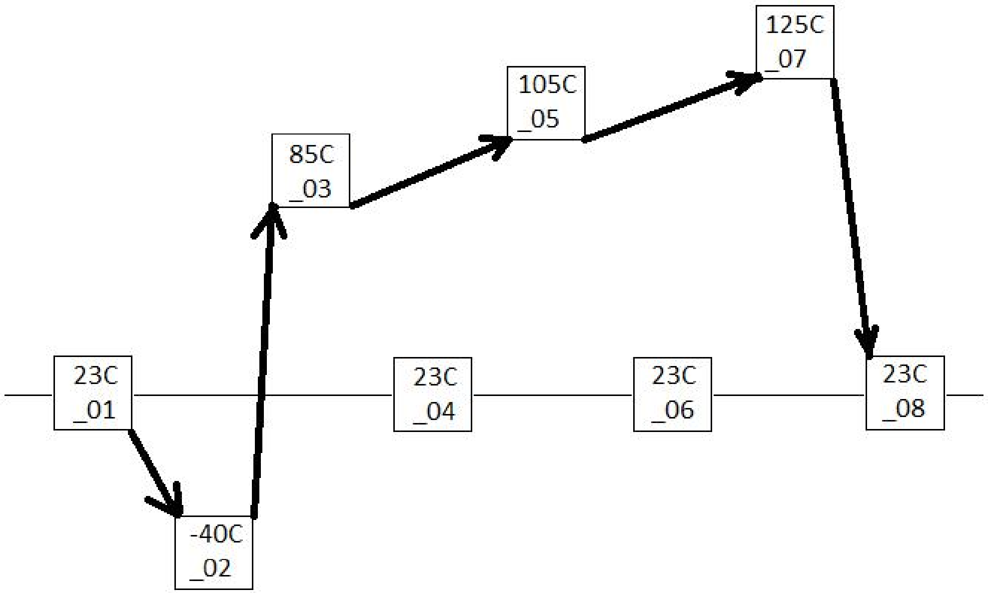


Test setup:

Second sequence had only 6 steps as outlined below (_01, _02, _03, _05, _07, _08) with their respective temperature settings. After it was proven using the first test sequence that extreme temperatures do not permanently degrade the IL/RL, second more streamlined sequence was used where 23C measurements _04 and _06 were skipped.

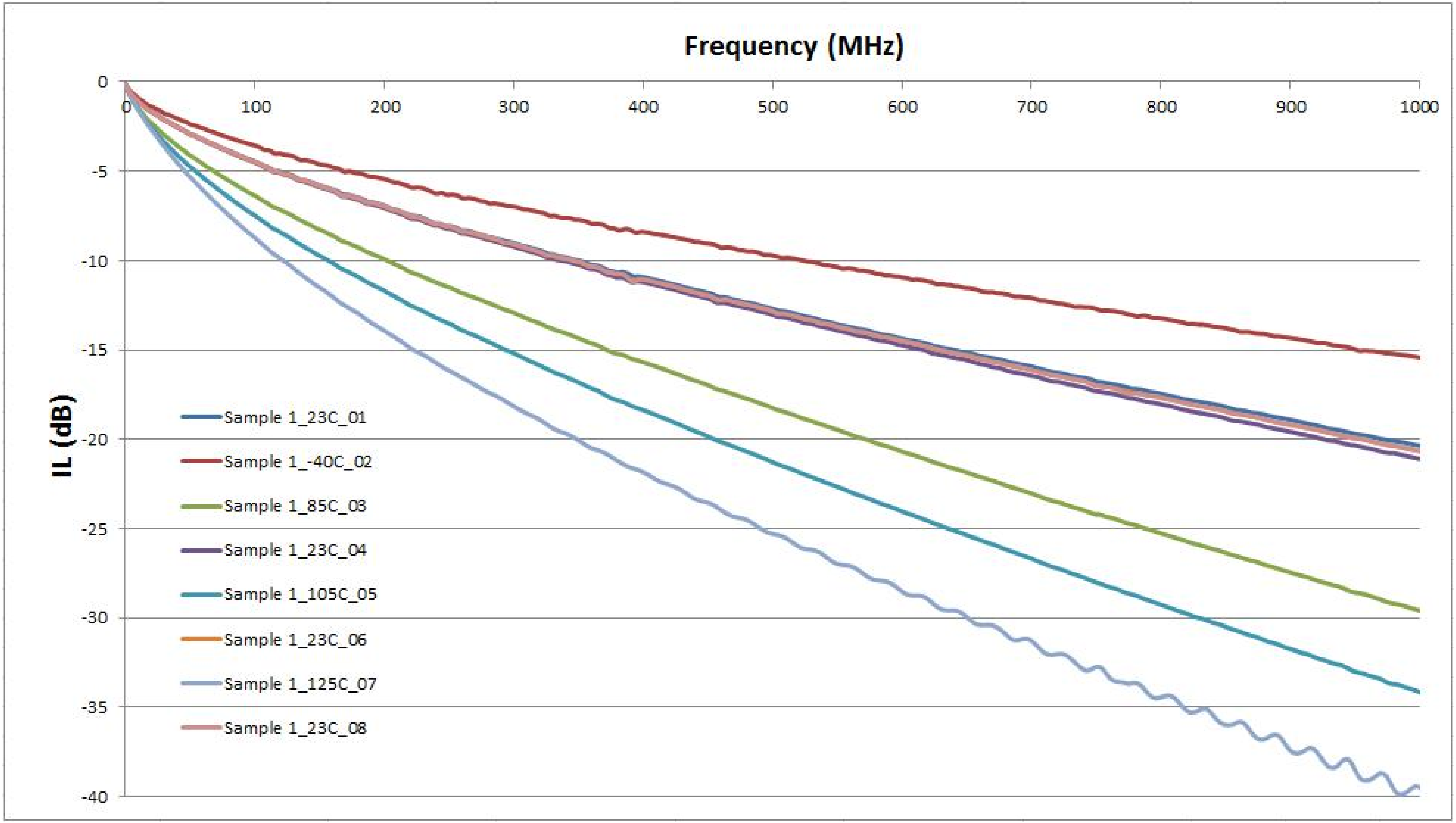
Two entire channel assemblies were tested using this sequence.

Data for each step 01 through 08 is identified with "_01 ... _08" for easier tracking of test results.



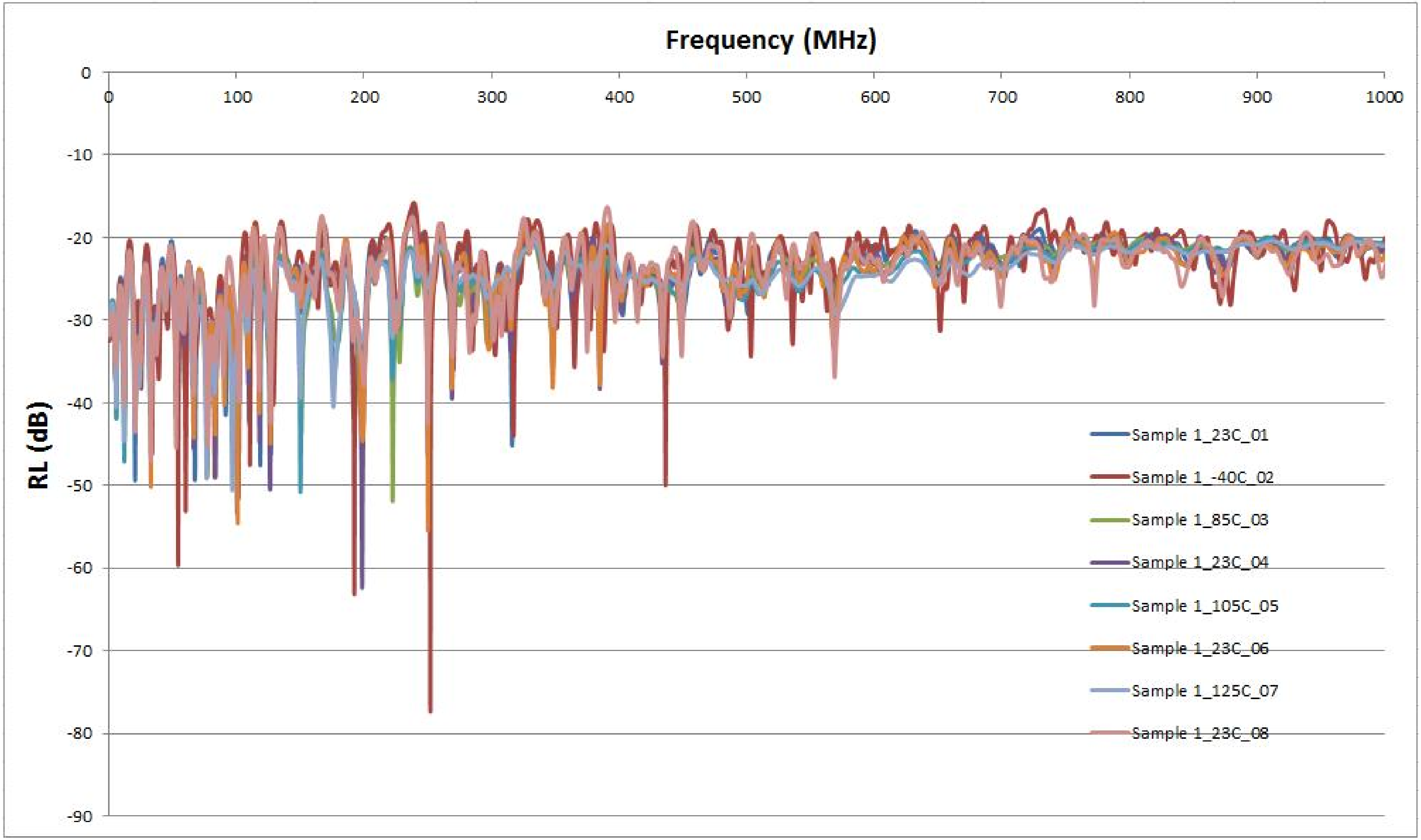
Test Results:

Sample 1 – 22 awg PP/PVC (0.34mm²)_15m_no inlines_Cable Type A_Connector Type 1



Test Results:

Sample 1 – 22 awg PP/PVC ($0.34mm^2$)_15m_no inlines_Cable Type A_Connector Type 1



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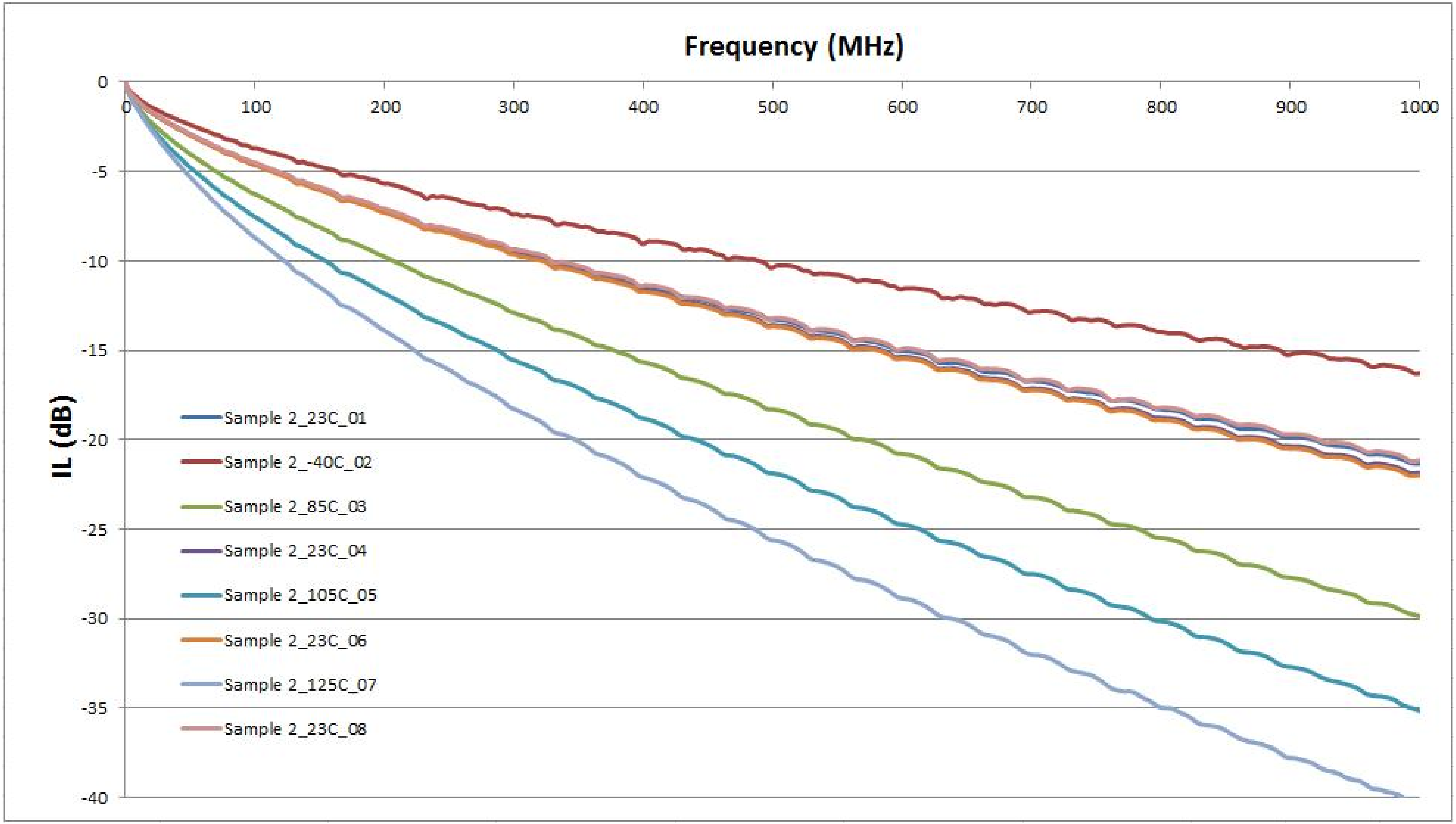
Test Results:

Sample 2 – 22 awg PP/PVC ($0.34mm^2$)_15m_five 3m links_4 inlines_Cable A_Connector 1



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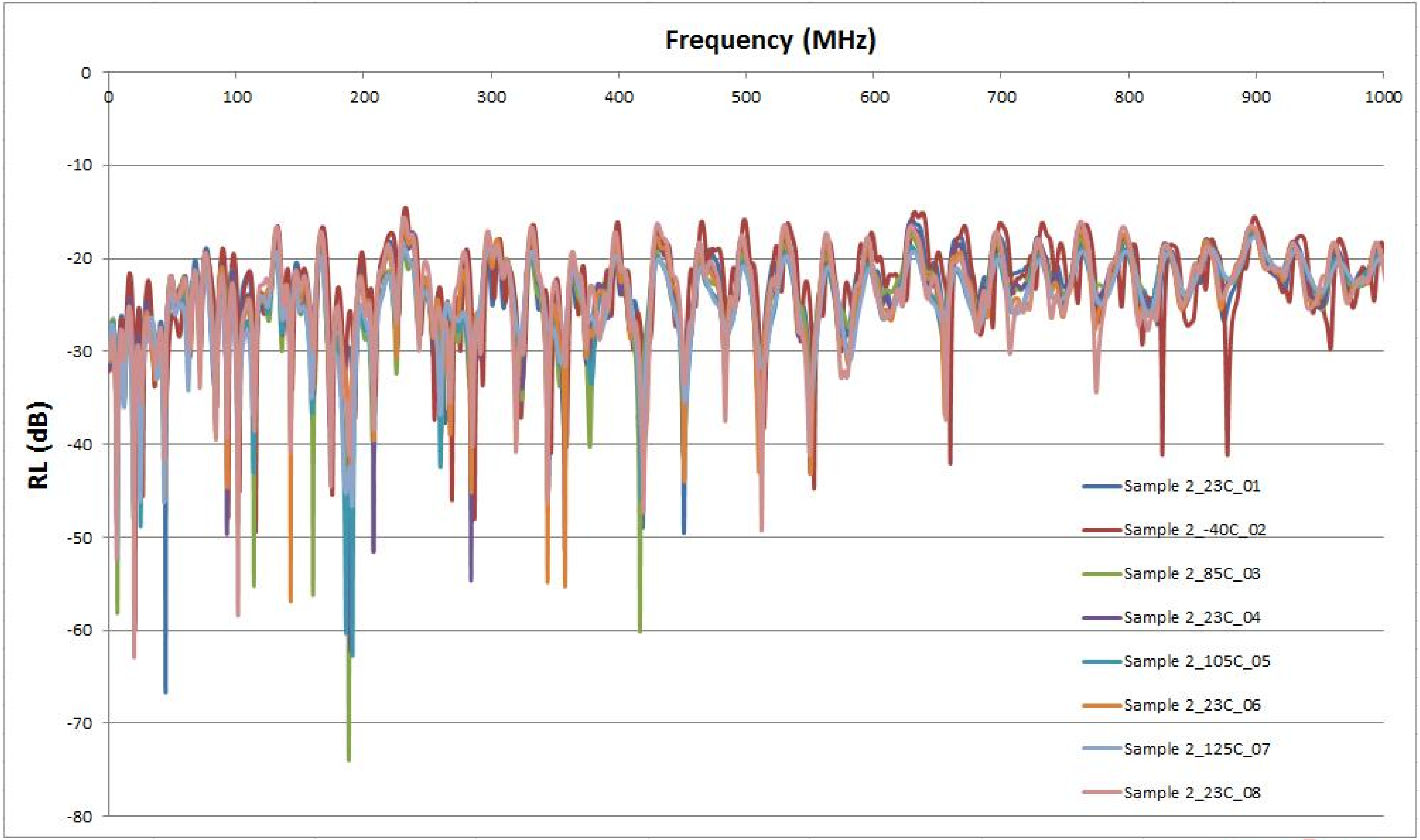
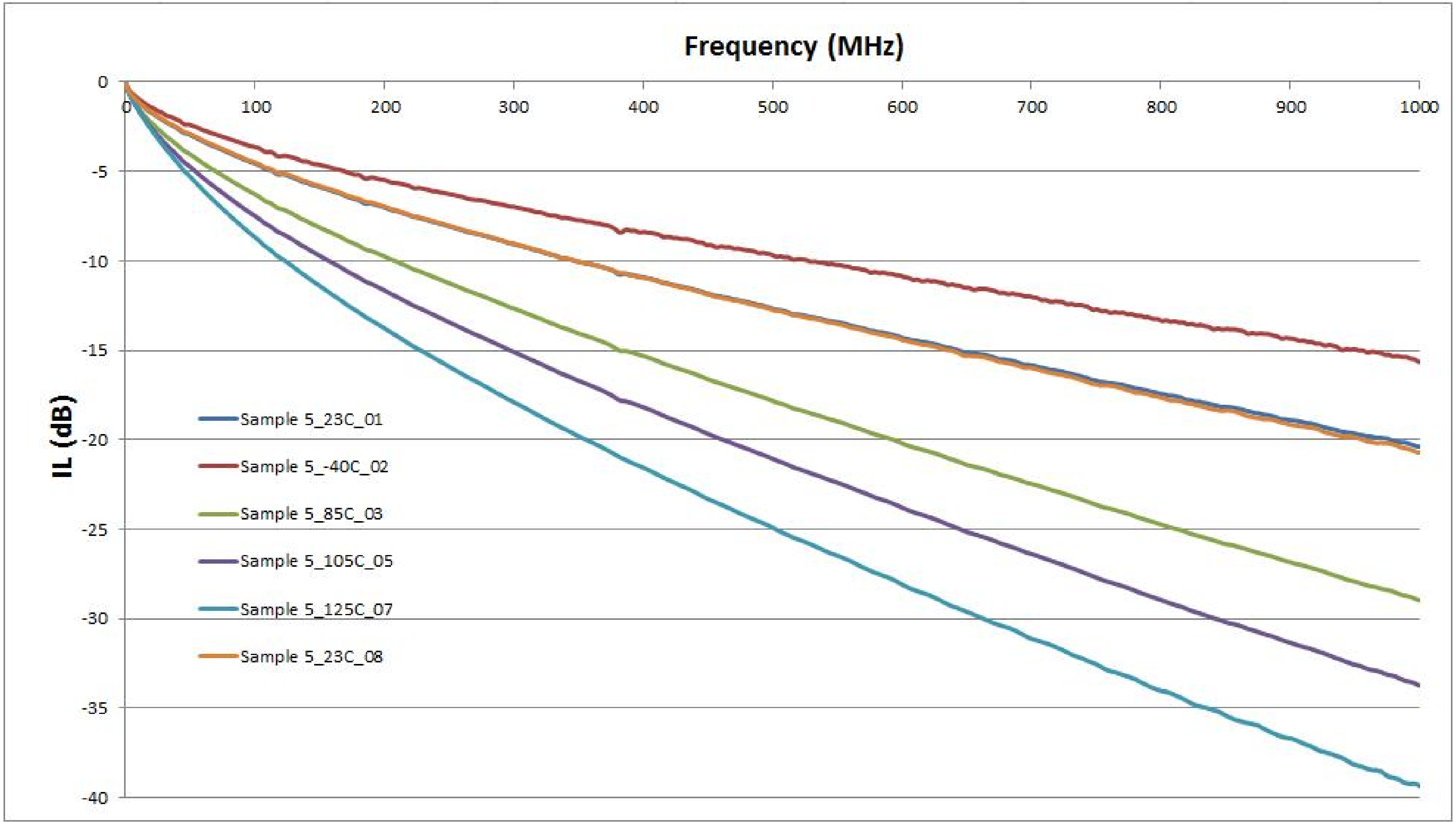
Test Results:

Sample 2 – 22 awg PP/PVC (0.34mm²)_15m_five 3m links_4 inlines_Cable A_Connector 1



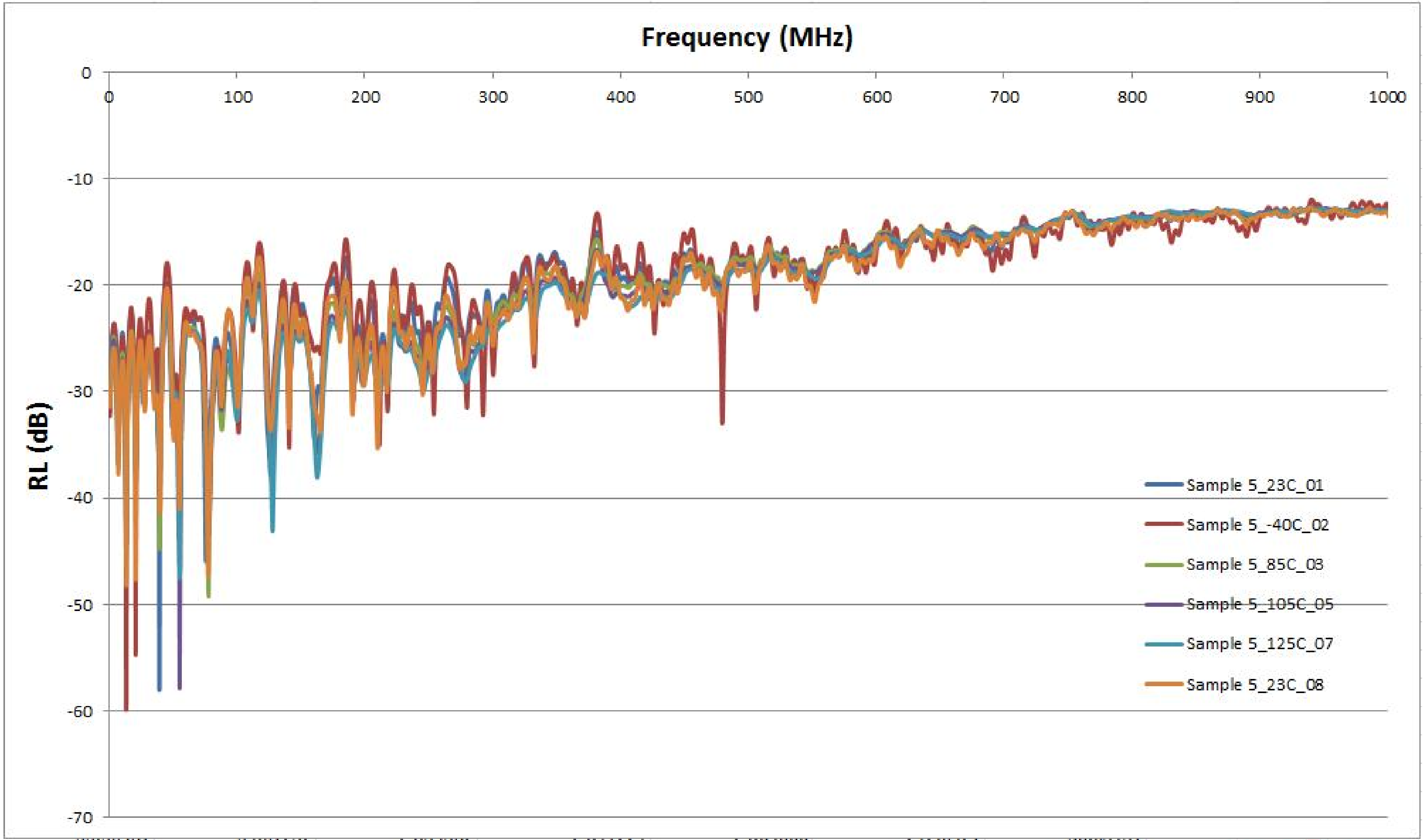
Test Results:

Sample 5 – 22 awg PP/PVC (0.34mm²)_15m_no inlines_Cable A_Connector 2



Test Results:

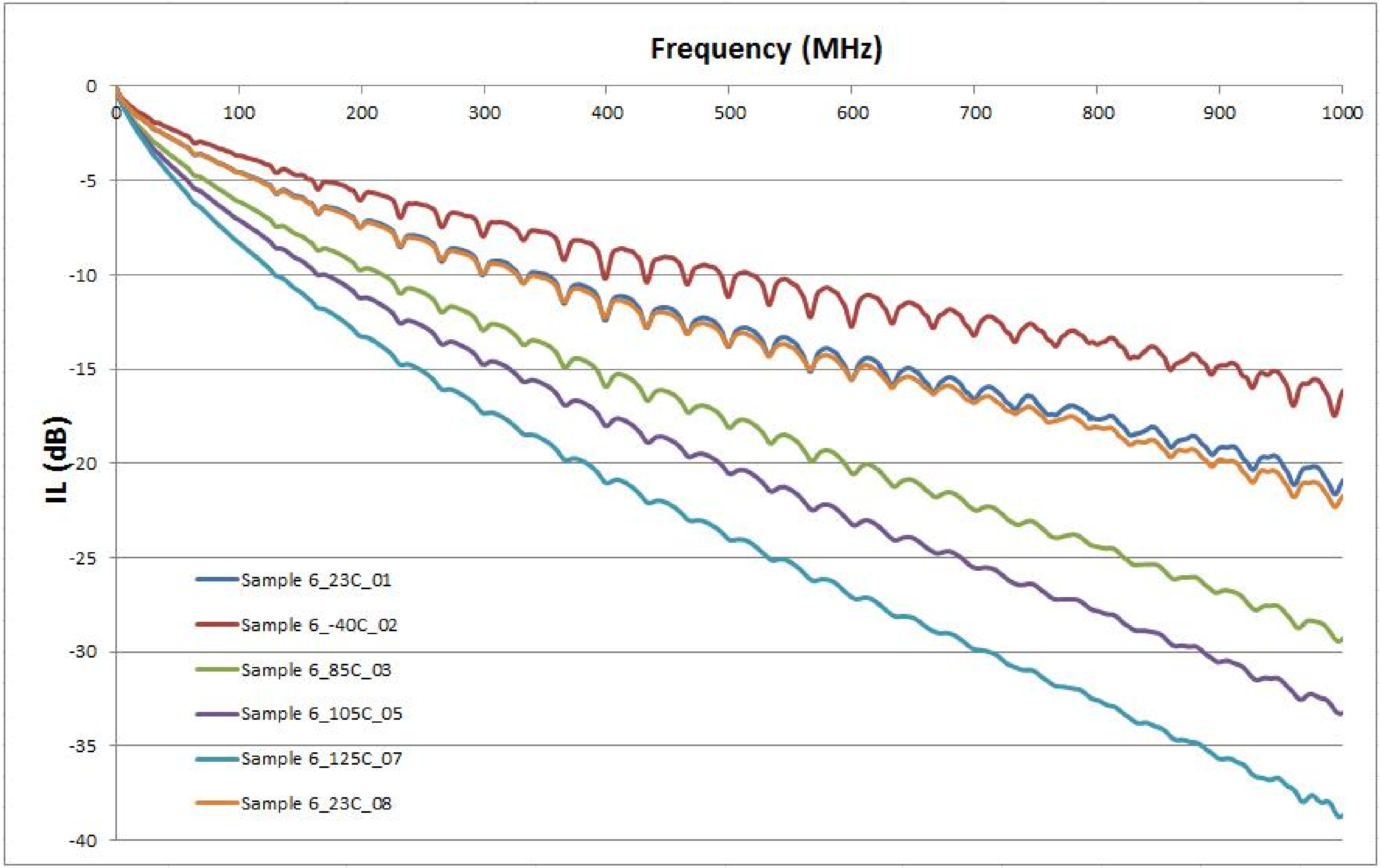
Sample 5 – 22 awg PP/PVC (0.34mm²)_15m_no inlines_Cable A_Connector 2



Test Results:

Sample 6 – 22 awg PP/PVC (0.34mm²)_15m_five 3m links_4 inlines_Cable A_Connector 2/3*

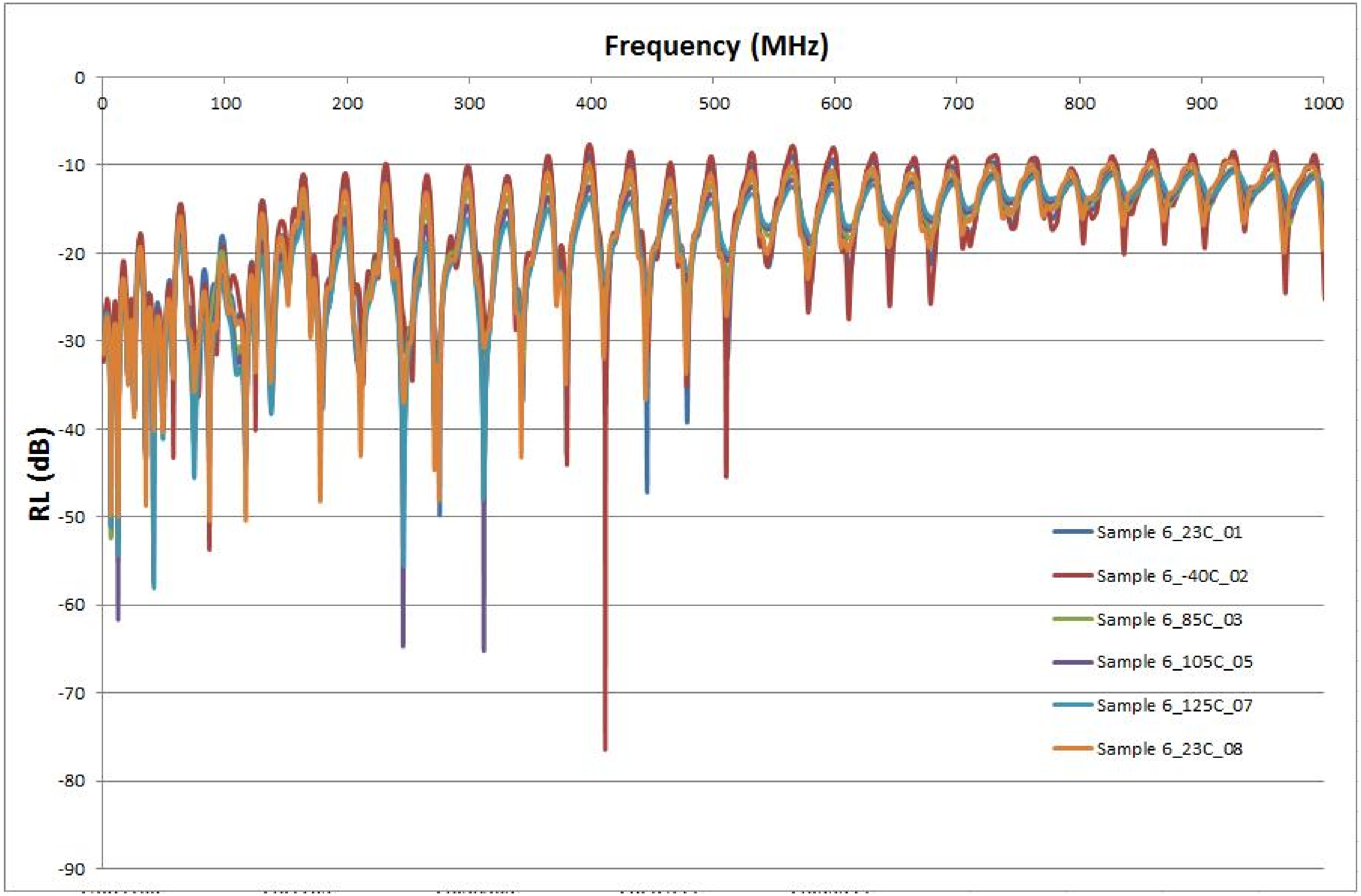
(* connector type 2 as ECU connectors; connector type 3 as inline connectors)



Test Results:

Sample 6 – 22 awg PP/PVC (0.34mm²)_15m_five 3m links_4 inlines_Cable A_Connector 2/3*

(* connector type 2 as ECU connectors; connector type 3 as inline connectors)



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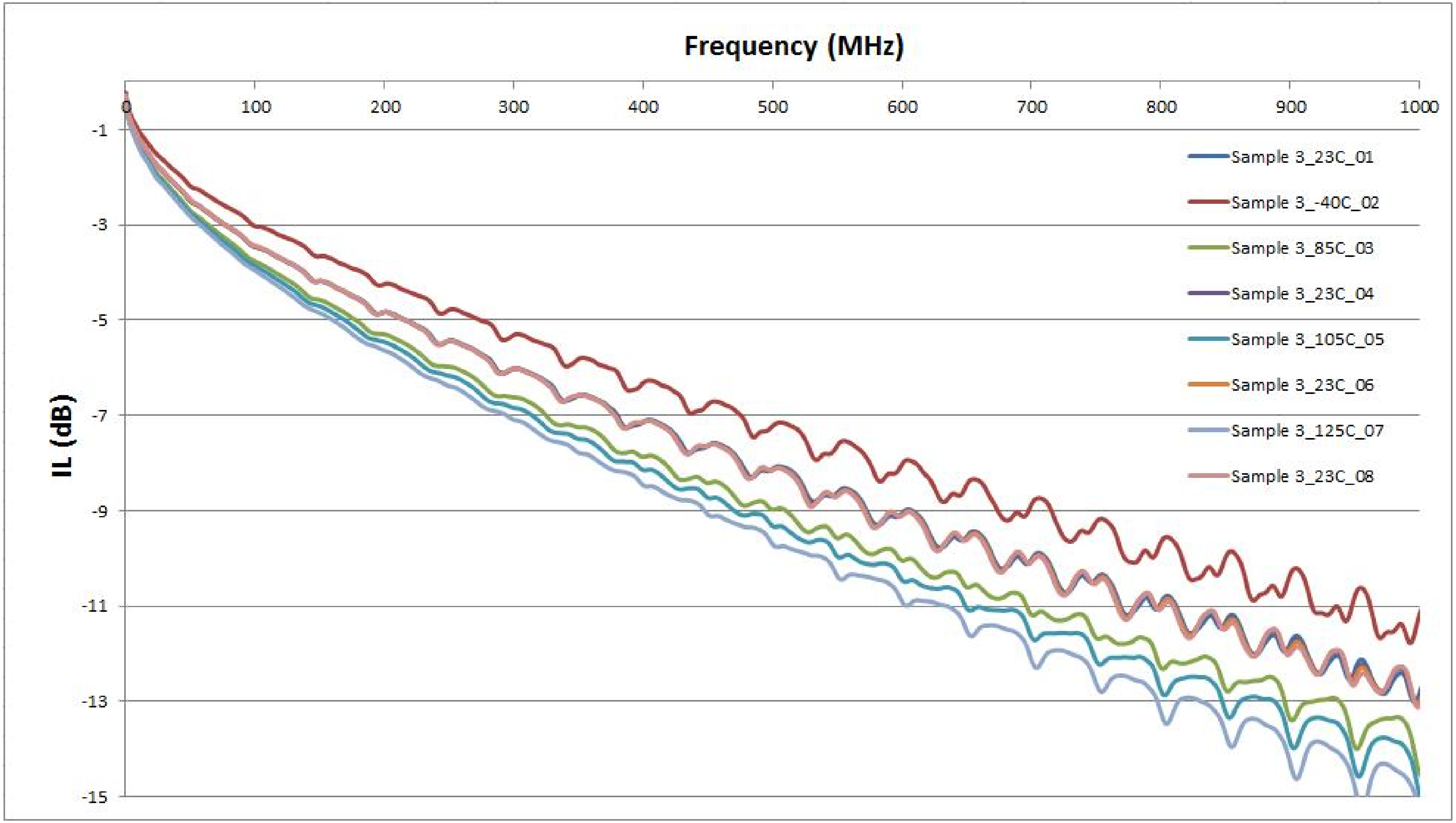
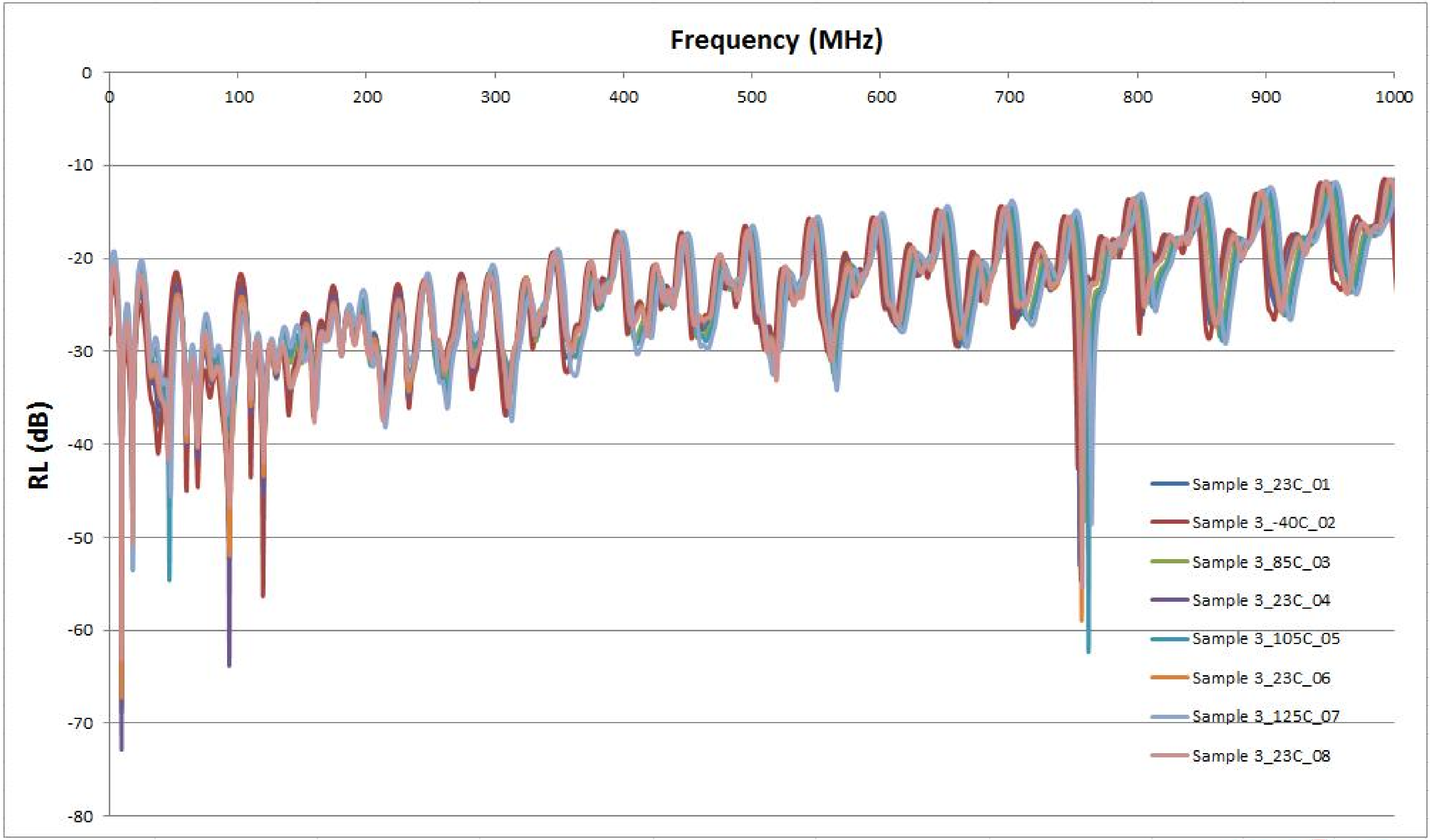
Test Results:

Sample 3 – 28 awg PP Shielded ($0.08mm^2$)_10m_five 2m links_4 inlines_Cable B_Connector 1



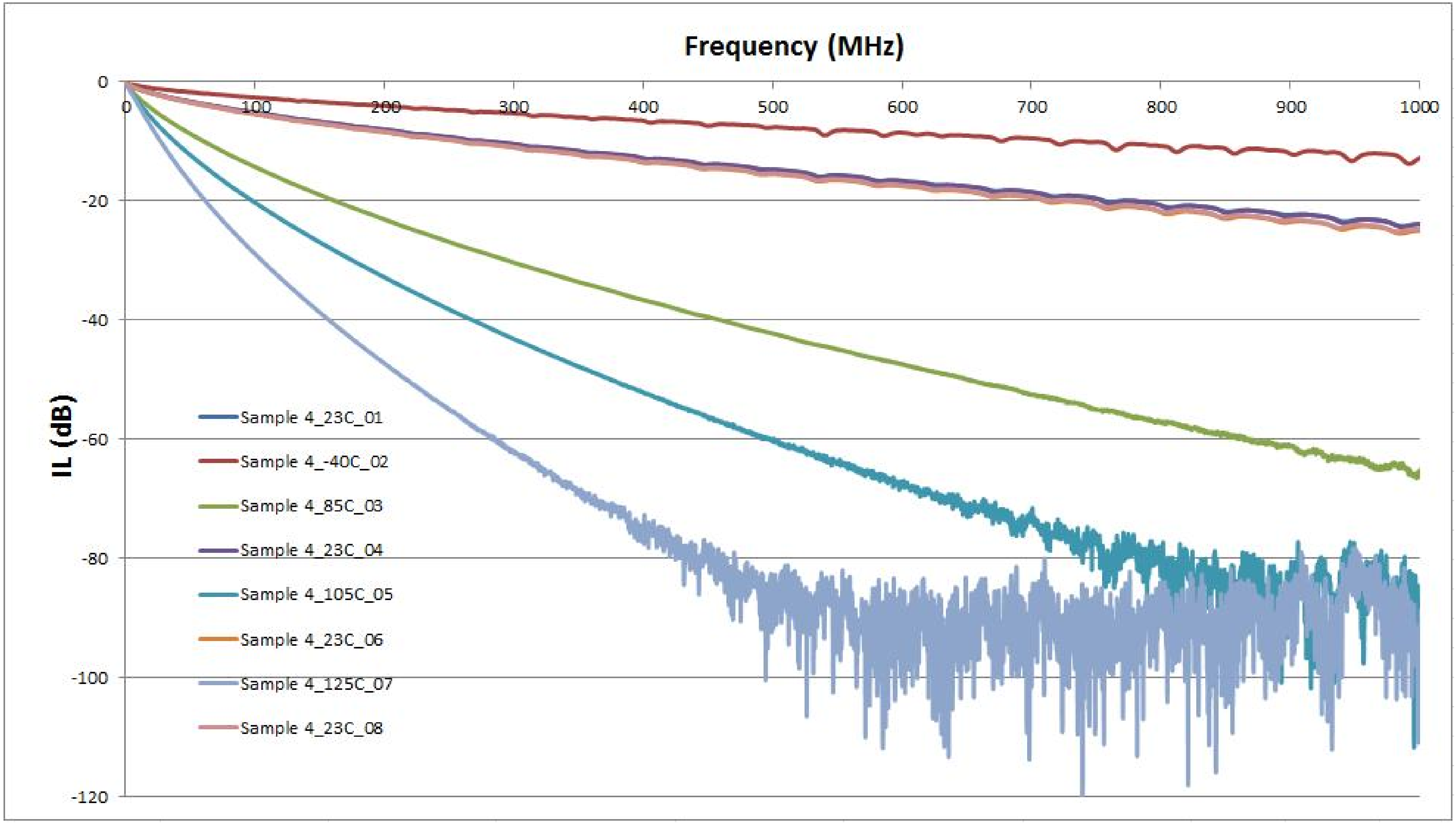
Test Results:

Sample 3 – 28 awg PP Shielded (0.08mm²)_10m_five 2m links_4 inlines_Cable B_Connector 1



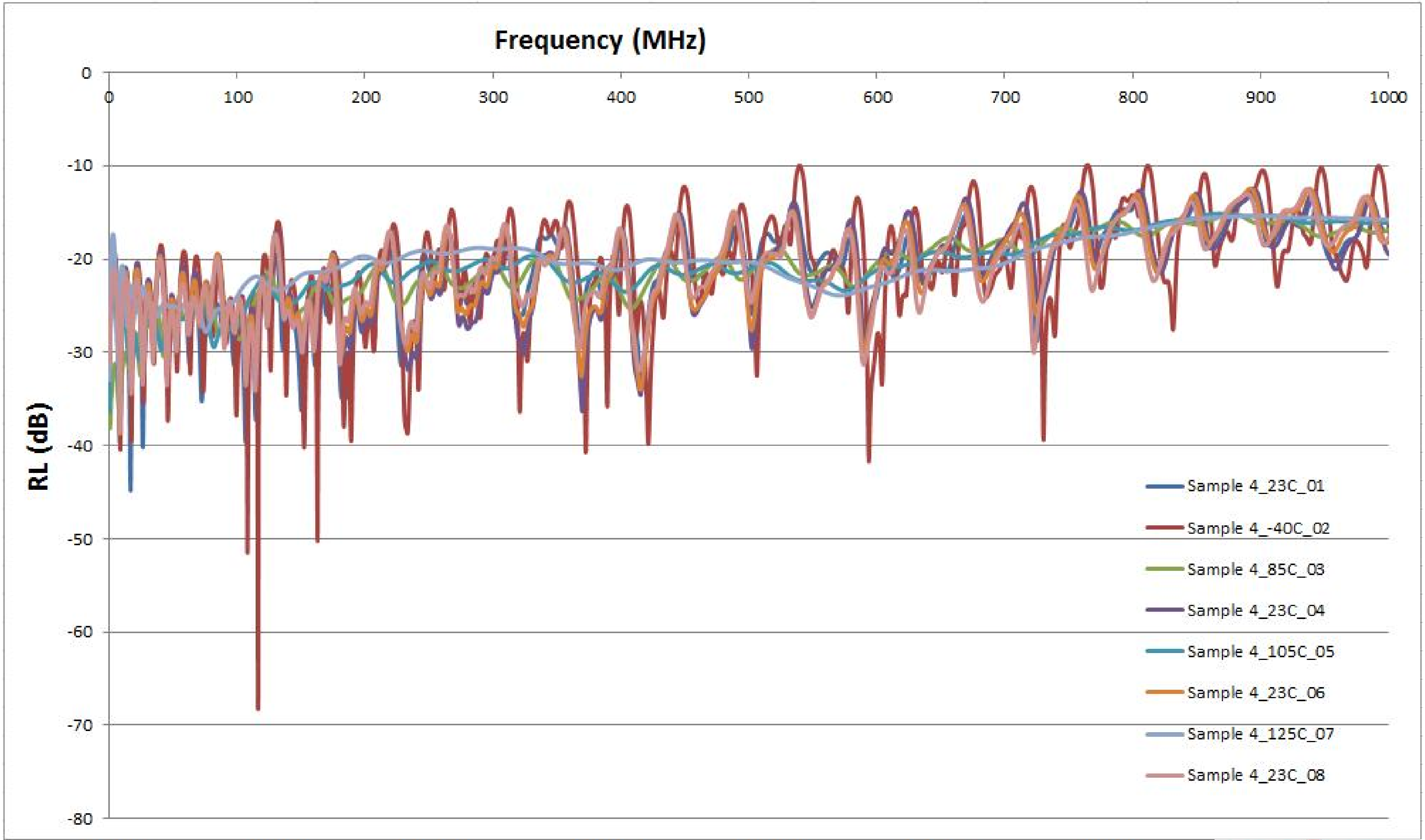
Test Results:

Sample 4 – 25 awg PVC/PVC (0.18mm²)_10m_five 2m links_4 inlines_Cable C_Connector 1



Test Results:

Sample 4 – 25 awg PVC/PVC (0.18mm²)_10m_five 2m links_4 inlines_Cable C_Connector 1



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Conclusions:

- There appears to be no permanent degradation of IL/RL after extreme temperature exposure (long-term thermal cycling / shock studies would be needed to fully verify this)
- Higher temperatures definitely degrade IL/RL performance and this must be taken into account during limit selection and later during production and system implementation
- Special attention must be paid to raw cable performance (dielectric material properties play a big role in assembly performance)
- In-line connections and untwist of diff pairs around end connectors and in-line connectors may create noticeable resonances (periodic IL suck outs / dips)