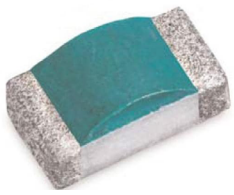
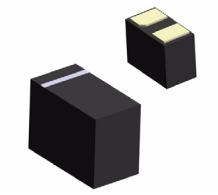
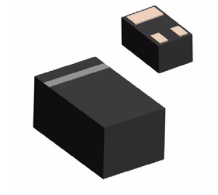
Eaton ESD suppression in high-speed data lines







Overview

With increasing data speeds and ever-shrinking sizes of electronic components, devices and equipment are becoming more susceptible to electrostatic discharge (ESD) than ever. Human contact, dielectric breakdown, circuit component proximity, switching events, and electric shorts are some common causes of ESD, and it can adversely impact the operation and longevity of electrical and electronic systems, resulting in latent or catastrophic failures in solid-state components. Engineers can incorporate ESD suppression devices into high-speed circuits to prevent ESD-induced damage.

This application note covers the root causes of ESD in electrical circuits, how ESD suppression devices work, selection considerations for ESD devices, and guidelines for integrating ESD suppressors in high-speed data applications. It concludes with an appendix containing extensive test information and data on the insertion loss performance of Eaton's ESD offerings.

Emerging trends in high-speed data

A key parameter for finding the performance of a device is the number of bits transferred per second (i.e., data rate). Engineers have made significant improvements to electronic interface data rates, going from kilobits per second to megabits per second, with the most recent development being gigabits per second (Gb/s). These improvements ensure more rapid and efficient data transfer in electronic applications, such as telecommunication networks and data centers. However, with higher data rates comes greater susceptibility to ESD.

Some of the most common effects of ESD in high-speed circuits include leakage current, gate oxide breakdown/punch-through, burnout of metal junctions, and metallization/resistor fusing. As designers meet the increasing need for higher speed in data transfer applications, there is a corresponding need for ESD suppression in high-speed data interfaces, such as PCI-E, USB, HDMI, and V-by-One. For example, PCI-E 4.0 offers data rate capabilities of up to 16 Gbps for motherboard applications. This high-speed interface is prone to sudden ESD strikes. Thus, designers must select an appropriate ESD suppression device that prevents circuit damage and maintains the signal quality.

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ESD in high-speed datalines

Generally, the higher the speed, the lower the required parasitic capacitance of the ESD suppression device for constant signal integrity. In other words, high-speed interfaces require ESD suppression devices with capacitance as low as 0.08 pF, depending on the application data rate. This is because higher capacitance can filter out data and produce distortion in high-speed signals, leading to lower signal quality. Similarly, USB 3.2 type C (widely adopted in most consumer electronics with a data rate of up to 10 Gbps) also requires low-capacitance ESD suppression to ensure high-quality signal during data transfer.

Key applications of ESD suppressors include ESD event protection in high-speed circuits (HDMI, USB, PCI-E), protection of consumer electronics (phones, laptops, television, etc.), electrical fast transient (EFT) protection, as well as induced lightning protection. Keypads or push buttons in electronics are also common sources of ESD events.

Incorporating ESD suppressors between keypads and I/O controllers helps protect electronics from ESD-induced damage. Engineers can also install ESD suppressors between antenna elements and RF amplifiers modules to mitigate ESD in RF applications. Similarly, ESD suppressors can be integrated between HDMI ports and HDMI transmitters/receivers.

Moreover, ESD suppressors offer protection to several IoT applications, including positioning sensors, Near Field Communication (NFC), wearable and implantable devices, smart homes, and industry 4.0. However, suppressor specifications and the choice of test methods and models are essential for ensuring high ESD robustness ideal for a wide range of IoT applications. For instance, positioning sensors, which offer up to 8.5 GHz wireless interface for utilization at several locations, require up to 2 kV ESD protection level due to their vulnerability and operational areas. Conversely, many Industry 4.0 applications require up to 15 kV ESD protection due to their high susceptibility to air discharge. Thus, designers must first consider specific IoT applications or processes to determine the ideal ESD suppressor to incorporate into their design.

Eaton ESD Suppressor products suited for high-speed data applications

Eaton offers a broad range of ESD suppressors across multiple industry footprints and technologies to help end-users protect high-speed data circuits. Due to their ultra-low capacitance, Eaton's ESD suppressors provide virtually no signal distortion in high-speed data lines.

These solutions range from 3.3 V up to 70 V, offering capacitances down to 0.08 pF, ideal for high-speed circuits. They come in various package sizes and can protect against ESD of up to 30 kV ESD according to IEC 61000-4-2 standards. Eaton's ESD suppressors include the 0402ESDA-AEC, 0603ESDA-MLP, 0603ESDA2-TR2, STN061033BL15, STN061050BL15, STN101050BL25, and STN101050BL30. Moreover, with Eaton's PolySurg™ and TVS Diode solutions, customers can ensure industry-leading ESD protection for each of their electronic applications.

Insertion loss data

Eaton's design team carried out a series of performance tests on our ESD suppression devices with the aid of a test setup using a piece of test equipment, a 1.92 mm adapter, and two pieces of RF cables. The test equipment includes a Keysight ENA Network Analyzer E5071C, while the adapter and cables have SF1521-60070-1S and PT26 MPNs, respectively.

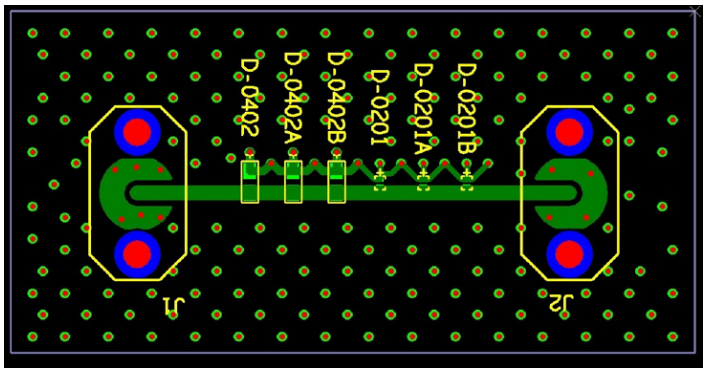

Figure 1. Test board

Figures 1 and 2 represent the typical test board and device under test-incorporated test board relevant to the performance test.

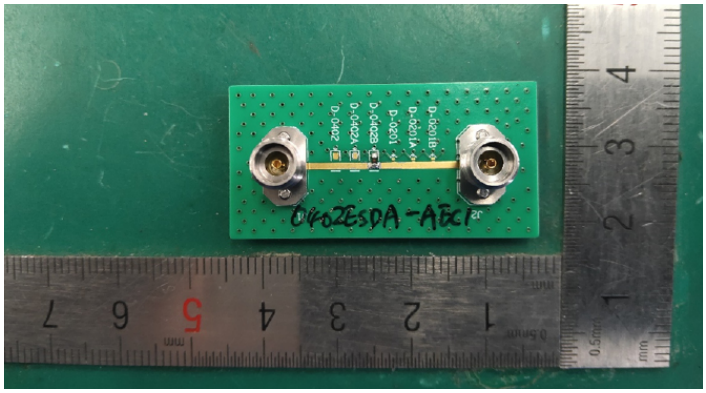

Figure 2. Test board with adapter and device under test (DUT)

Figures 3 through 9 are screen shot views of the network analyzer equipment which has measured the resulting of insertion loss contribution of respective ultra-low capacitance ESD Suppressors from Eaton. The data speeds vary from 1 MHz all the way up to 20 GHz (or 20,000 MHz), which support even the latest high speed data protocols. Furthermore, the testing data was replotted for another view of the insertion loss results in Figures 10 through 16. From these figures, it is evident that Eaton's ultra-low capacitance ESD suppressors exhibit excellent performance and low signal loss in even the highest speed data circuits. By ensuring ultra-low capacitance in both TVS Diodes and PolySurg™ technologies, Eaton's solutions achieve industry leading results for ESD suppressors with virtually no distortion of high speed protocols.

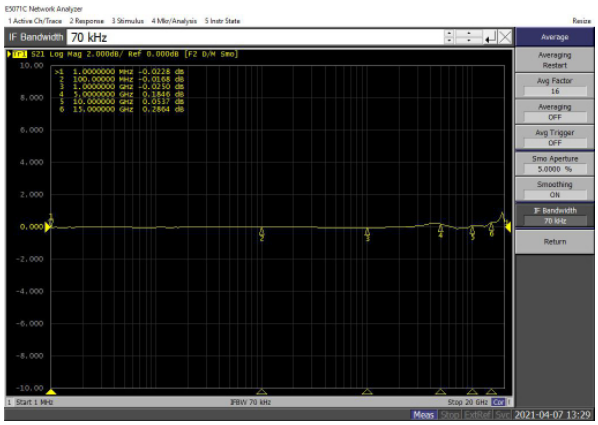

Figure 3: 0402ESDA-AEC

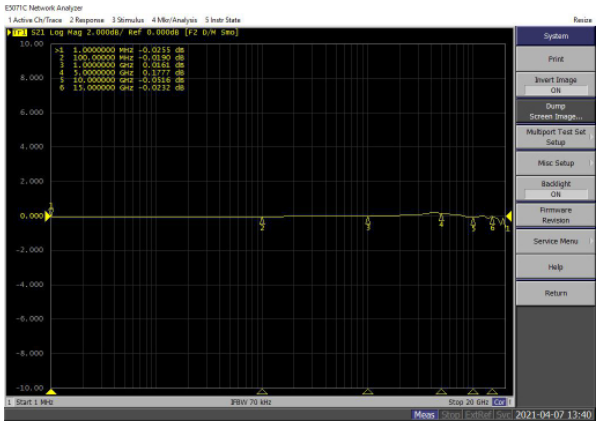

Figure 4: 0603ESDA-MLP

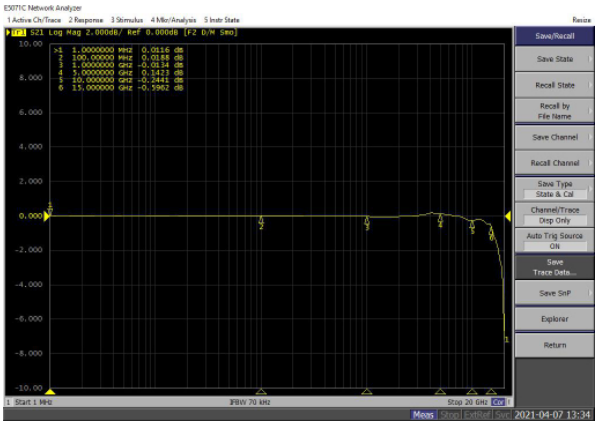

Figure 5: 0603ESDA2-TR2

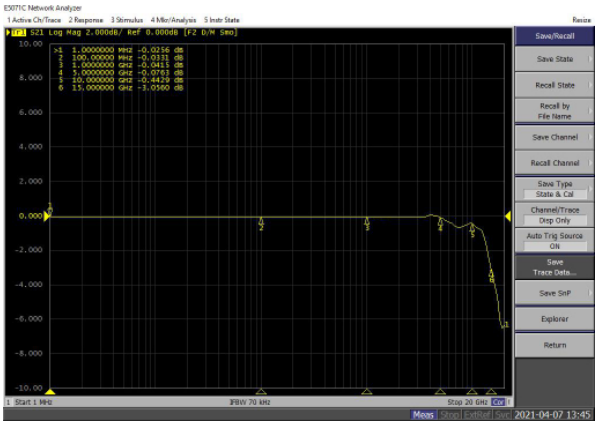

Figure 6: STN061033BL15

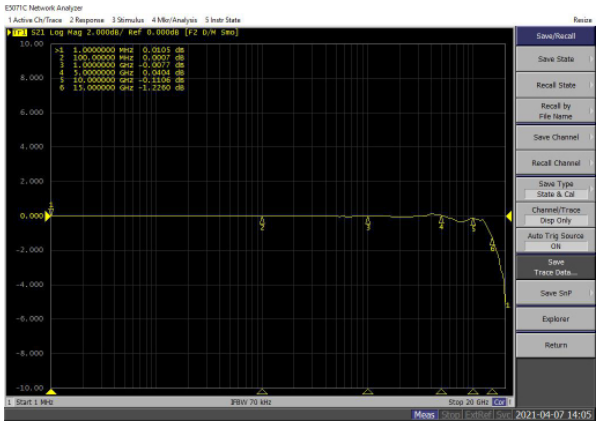

Figure 7: STN061050BL15

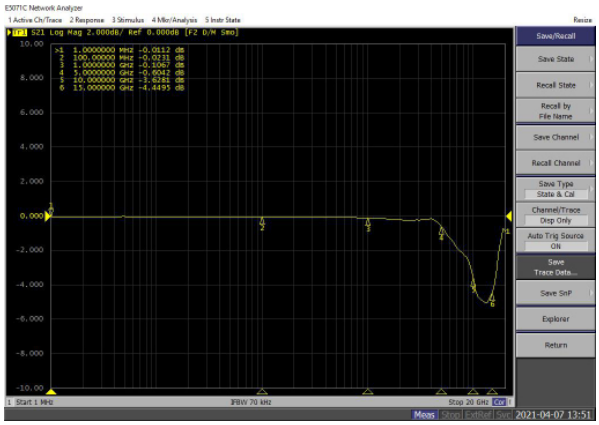

Figure 8: STN101050BL25

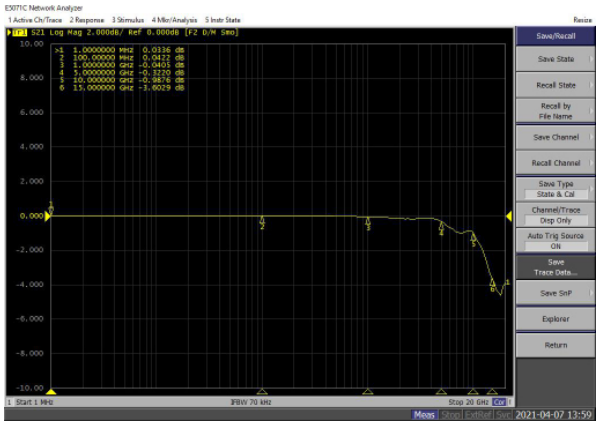

Figure 9: STN101050BL30

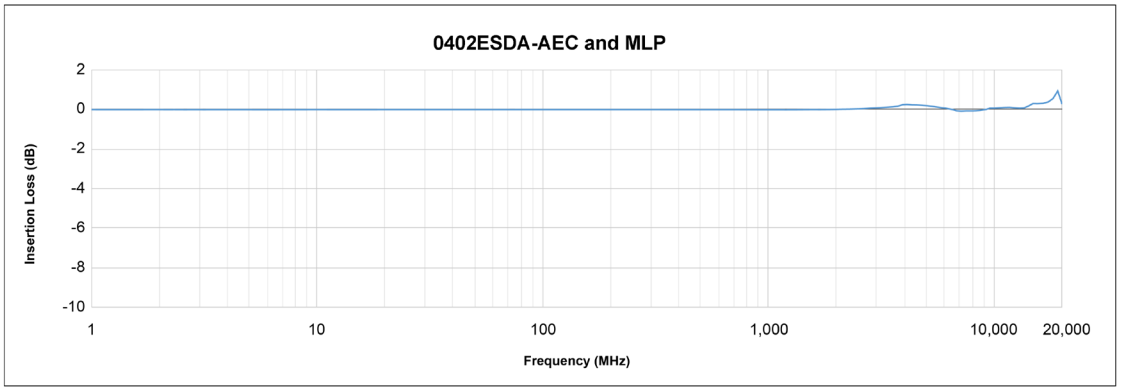

Figure 10: 0402ESDA-AEC and MLP

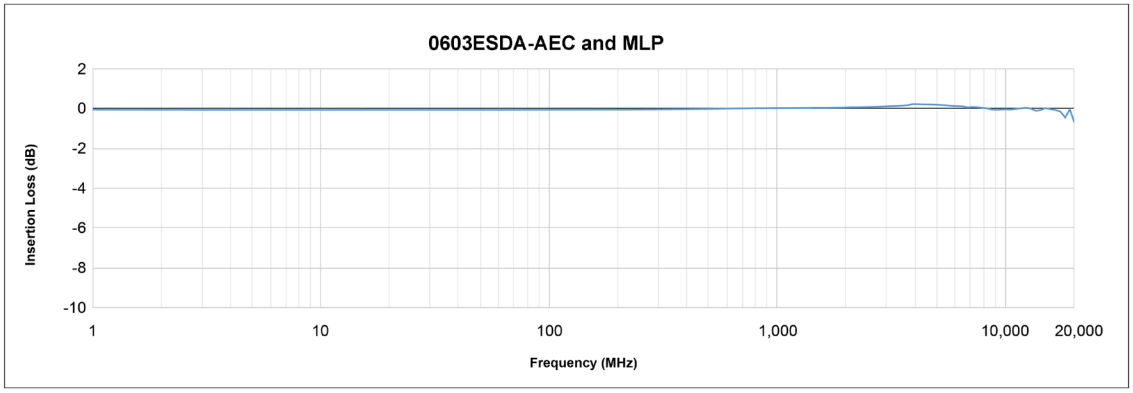

Figure 11: 0603ESDA-AEC and MLP

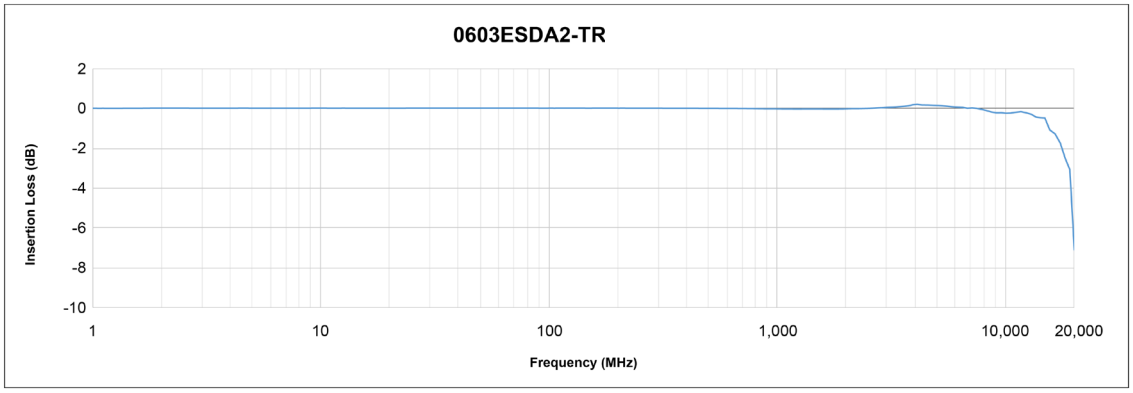

Figure 12: 0603ESDA2-TR

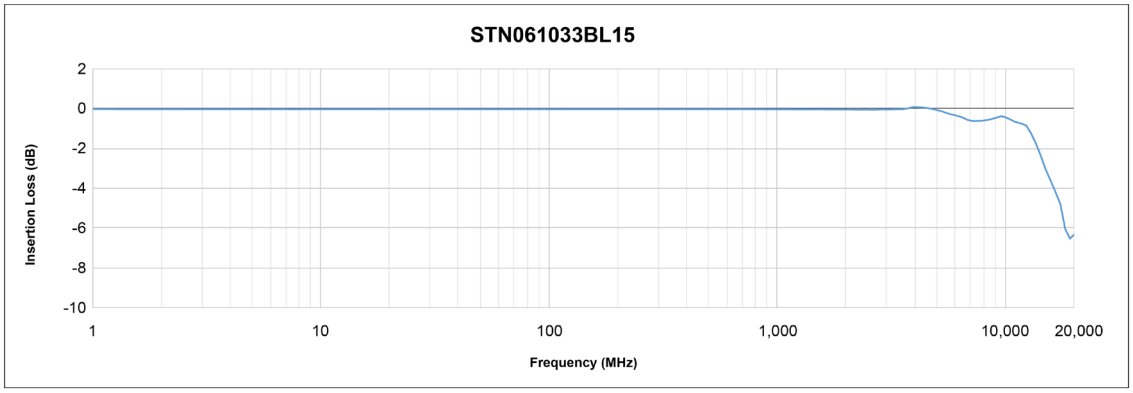

Figure 14: STN061033BL15

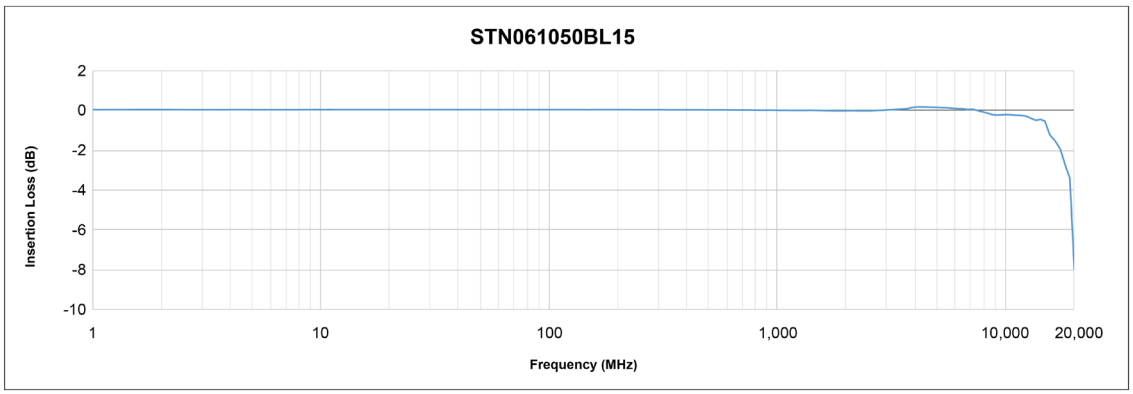

Figure 15: STN061050BL15

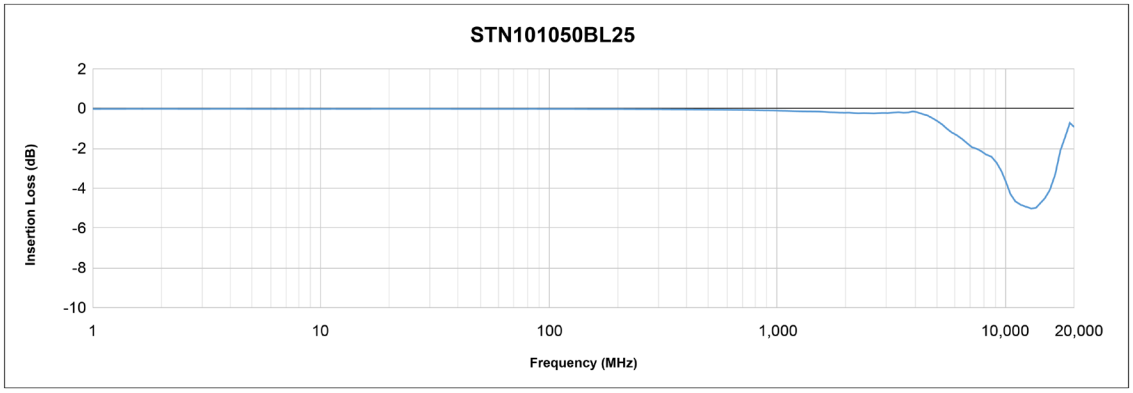

Figure 16: STN101050BL25

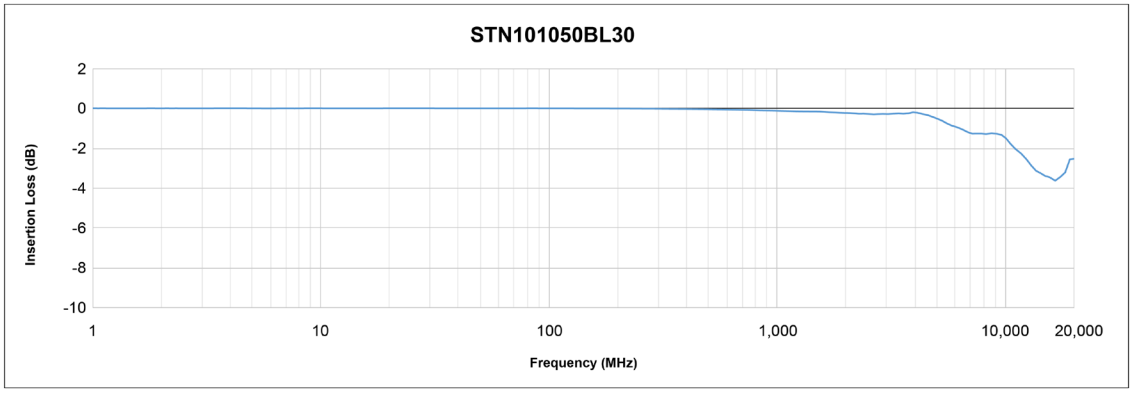

Figure 17: STN101050BL30

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Printed in USA
Publication No. ELX1194 BU-ELX22054
April 2022