GMSL2 Channel Specification User Guide

Rev 0

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Abstract

The GMSL2 channel specification user guide defines the hardware system design requirements necessary for the proper operation of GMSL2 devices. Use it in conjunction with the relevant GMSL2 serializer and deserializer data sheets to develop compliant GMSL2 systems.

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Purpose and Scope

The GMSL2 channel specification defines the hardware system design requirements necessary for the proper operation of GMSL2 systems, as specified by the device data sheets. It contains both the *GMSL2 System Channel Specification* and *GMSL2 Module Channel Specifications*. This document collectively refers to both specifications as GMSL2 channel specification.

See this document for important system design considerations, including system development and component evaluation. Relevant system elements include PCB material, PCB layout, passive PCB components, cable(s), and connectors.

Compliant GMSL2 systems meet or exceed the S-parameter curves, crosstalk specifications, and link margin requirements detailed in this document.

A compliant GMSL2 system channel has an expected bit error rate (BER) of 1E-15 or better.

GMSL2 Channel Descriptions and Definitions

GMSL2 Overview

GMSL2 devices use Analog Devices' proprietary second-generation gigabit multimedia serial link (GMSL2) technology to transport high-speed, serialized data over coax or shielded-twisted pair (STP) cables for automotive camera and display applications. GMSL2 links operate at fixed data rates, including 3 Gbps or 6 Gbps on the forward channel, and 187Mbps on the reverse channel, depending on device capabilities and configuration. *Figure 2.A* shows a block diagram of a typical GMSL2 system.

Note: The forward channel is defined as serializer-to-deserializer transmission, and the reverse channel is defined as deserializer-to-serializer transmission.

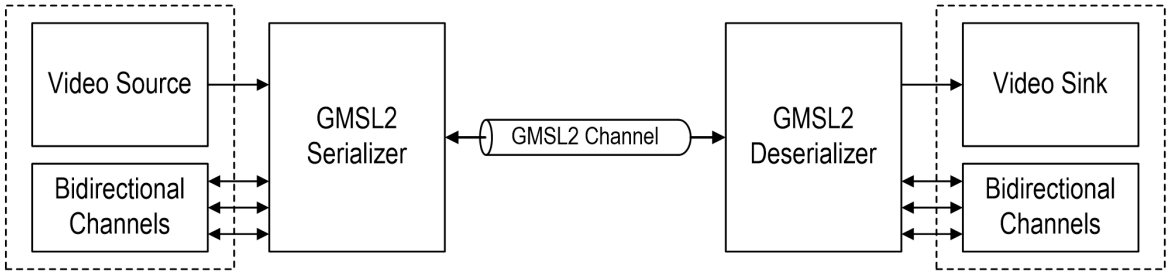

Figure 2.A. GMSL2 System Block Diagram

GMSL2 Channel Definition

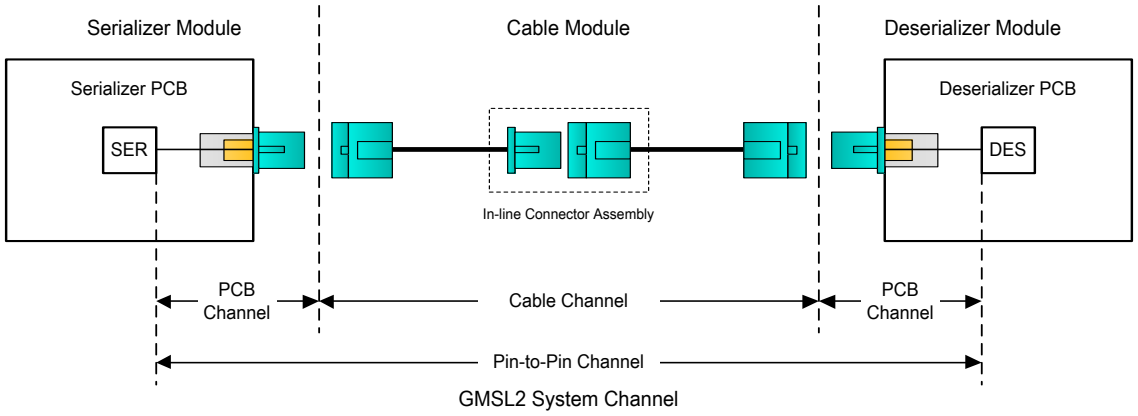

Figure 2.B. GMSL2 Channel Definition

Note: *Figure 2.B* does not depict AC-coupling capacitors and optional power over coax (PoC) or line-fault components are not depicted in.

The “GMSL2 system channel” is defined as the pin-to-pin channel from the SIO pin(s) of the serializer to the SIO pin(s) of the deserializer and consists of the following:

- Serializer PCB channel
- Cable channel
- Deserializer PCB channel

Note: For multilink configurations (i.e., dual link, splitter mode, and reverse splitter mode), each GMSL link is treated as an independent pin-to-pin channel.

The “GMSL2 module channels” are defined as the individual sub-channels within the GMSL2 system channel. The PCB channel is defined as the channel from the device SIO pin to the end of the PCB-mounted connector. It includes the trace itself and any PCB components on the trace (e.g., line-fault resistors, PoC components, electrostatic discharge (ESD) diodes, common-mode chokes, and other passive components). This channel is also referred to as the serializer or deserializer PCB channel module and can be evaluated for GMSL2 module compliance.

The cable channel is defined inclusively as the channel comprising all components from the cable connector on the serializer side to the cable connector on the deserializer side, including the cable(s) and any in-line connector(s). For applications using cable bundles, the cable crosstalk specification must consider the other conductors in the cable harness. This channel is also referred to as the cable module and can be evaluated for GMSL2 module compliance.

Note: Meeting module compliance requirements guarantees GMSL2 system channel compliance when implemented with other compliant modules and cable(s).

GMSL2 Channel Frequency Bands

GMSL2 is a packet-based protocol operating at a fixed-link rate. The GMSL2 forward channel data rate is either 6 Gbps or 3 Gbps; the reverse channel data rate is 187 Mbps. The transmitted/received data rate is a fixed rate based on the data rate setting and is independent of the payload. For example, if a camera or display application requires 5 Gbps, the forward channel data rate on the link must be set to 6 Gbps. Idle data fills the unused link capacity.

GMSL2 uses a non-return to zero (NRZ) encoding scheme. A key frequency of NRZ encoding is half-link rate ($f_{½Linkrate}$). For the 6 Gbps forward channel bit rate, $f_{½Linkrate}$ = 3 GHz. Note that the maximum frequency is defined in the channel specification factors in the rise/fall-time dependent signal content above $f_{½Linkrate}$ (*Table 1*). The attenuation, due to insertion loss, of the signal at $f_{½Linkrate}$ is the most critical value to consider when exploring the maximum channel length used in a system. For all NRZ encoding schemes, where bitrate is the serial data rate:

$$f_{½Linkrate} = \frac{bitrate}{2}$$

Equation 1. $f_{1/2Linkrate}$ *equation*

Table 1. Frequency Bandwidth Allocation for GMSL2

GMSL (SPEED)	MINIMUM FREQUENCY	F½LINKRATE	MAXIMUM FREQUENCY IN CHANNEL SPECIFICATION
Forward Channel (3 Gbps)	50 MHz	1.5 GHz	2.0 GHz
Forward Channel (6 Gbps)	100 MHz	3 GHz	3.5 GHz
Reverse Channel (187 Mbps)	2 MHz	93.5 MHz	400 MHz

The bidirectional transmitter/receiver of GMSL2 necessitates emphasis on return loss. The energy of the forward and reverse channel overlaps in frequency. So, reflections in the band of the low-speed transmitter and receiver are especially important considerations when designing the channel. For system optimization, insertion loss must be minimized, and return loss must be optimized.

GMSL2 Channel S-Parameter Definitions

The GMSL2 channel specification defines minimum or maximum values of scattering parameters (S-parameters) across the frequency band of interest. S-parameters are defined for insertion loss, return loss. See *Figure 2.C* and the following corresponding sections. For the GMSL2 channel specification, the serializer is defined as Port 1, and the deserializer is defined as Port 2.

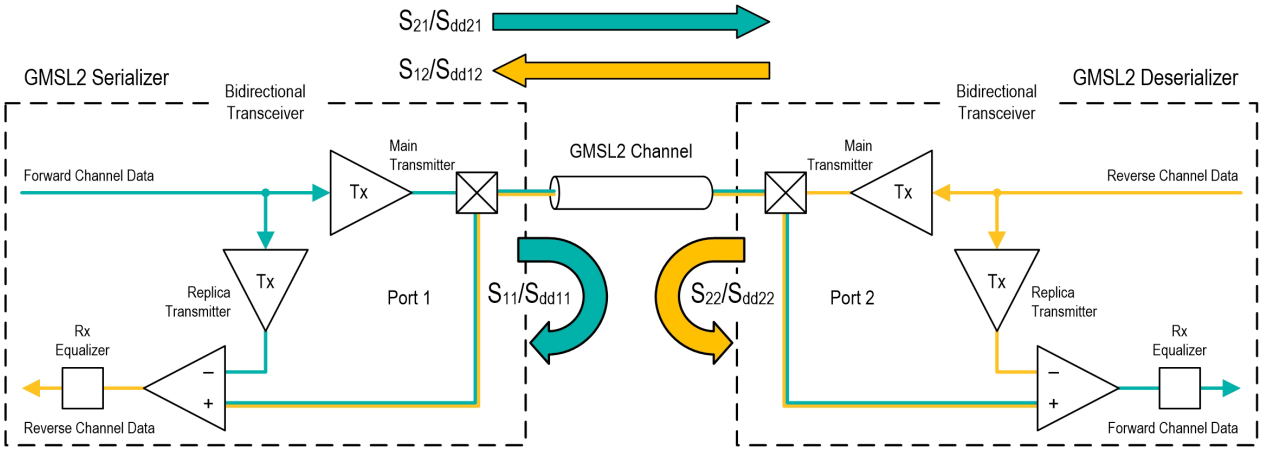

Figure 2.C. GMSL2 Channel S-Parameter Definitions

Insertion Loss (S_{21}/S_{dd21}, S_{12}/S_{dd12})

Insertion loss is the energy loss across the transmission channel.

- S_{21}/S_{dd21} – Forward channel insertion loss
- S_{12}/S_{dd12} – Reverse channel insertion loss

S_{21}/S_{dd21} defines the amount of energy loss for the high-speed channel (forward channel), and S_{12}/S_{dd12} defines the amount of energy loss for the low-speed channel (reverse channel). For typical GMSL2 channels consisting of passive PCB components and cables, S_{21}/S_{dd21} and S_{12}/S_{dd12} are equal.

For differential applications (i.e., STP), use differential S-parameters (S_{dd21} and S_{dd12}).

Return Loss (S_{11}/S_{dd11}, S_{22}/S_{dd22})

Return loss is the reflected energy back to the transmitter.

- S_{11}/S_{dd11} – Forward channel return loss
- S_{22}/S_{dd22} – Reverse channel return loss

S_{11}/S_{dd11} is used to evaluate the high-speed transmitter energy reflected into the low-speed receiver; S_{22}/S_{dd22} is used to evaluate the reflected energy of the low-speed transmitter back into the high-speed receiver.

For differential applications (i.e., STP), use differential S-parameters (S_{dd11} and S_{dd22}).

GMSL2 System Channel Specification

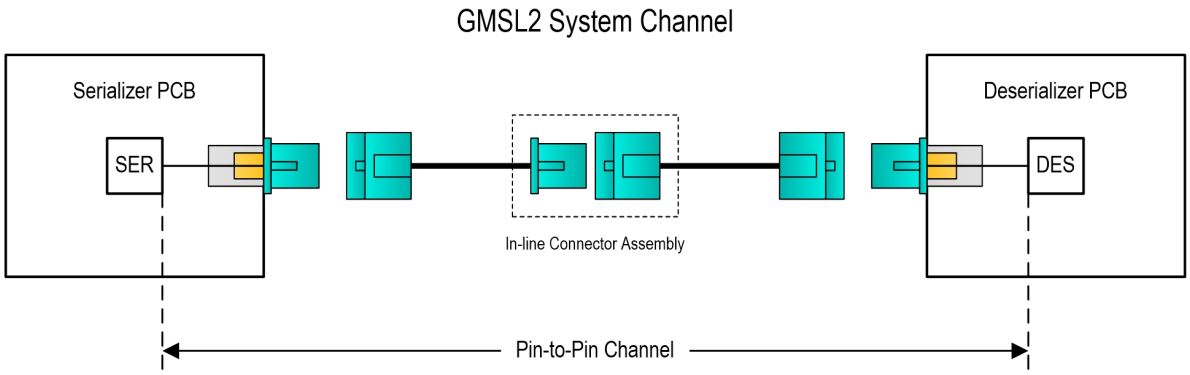

Figure 3.A. GMSL2 System Channel

GMSL2 System Channel Compliance

A compliant GMSL2 system must meet the overall pin-to-pin channel specification, including the S-parameter curves, crosstalk specification, and the link margin requirements under worst-case conditions as defined by the system designer.

Worst-case conditions include longest cable (highest insertion loss), cable aging effects, channel degradation due to temperature, PCB impedance variation, and minimum/maximum system PoC loads. Worst-case conditions can be simulated. Contact the cable manufacturer and PCB designer for technical advice.

Note: The PCB and cable channels comprising a compliant GMSL2 system channel may not meet the standards required for GMSL2 module compliance. Modules must be independently evaluated for module compliance. See the *GMSL2 Module Channel Specifications* section for additional information.

GMSL2 Pin-to-Pin Channel Specification

Maximum Insertion Loss Specification (Pin-to-Pin Channel)

This section defines the maximum insertion loss (i.e., energy loss across the transmission channel) for the pin-to-pin channel specification.

- S-parameters: S_{21}/S_{dd21} and S_{12}/S_{dd12}
- Single-ended and differential configurations

Table 2. Maximum System Channel Insertion Loss (Pin-to-Pin Channel)

GMSL2 MAXIMUM CHANNEL INSERTION LOSS PIN-TO-PIN		
	3 Gbps Forward/187 Mbps Reverse	**6 Gbps Forward/187 Mbps Reverse**
APPLIED BAND	2 MHz to 2 GHz	2 MHz to 3.5 GHz
INSERTION LOSS	−19.5 dB at 1.5 GHz	−21 dB at 3 GHz

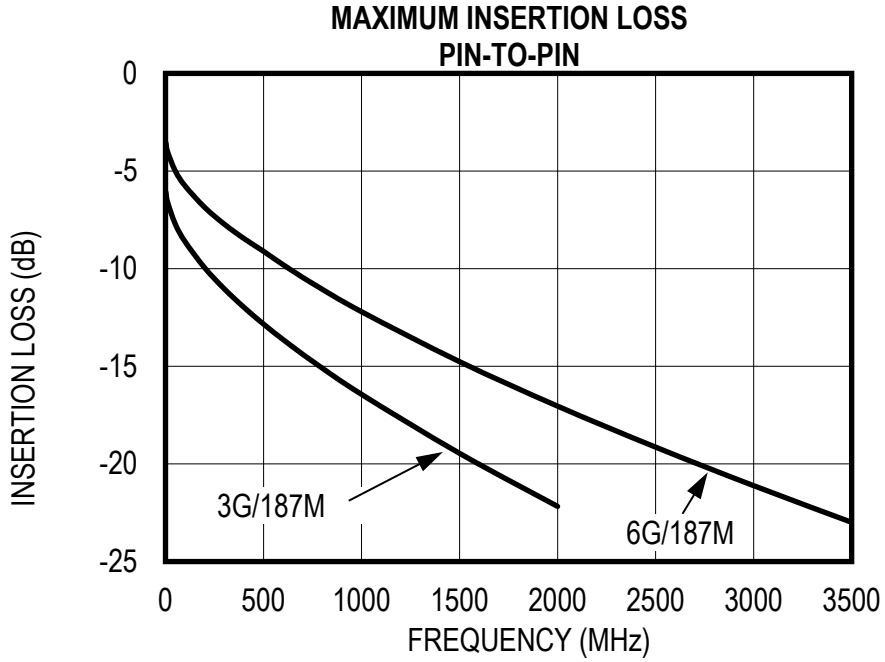

Figure 3.B. GMSL2 System Channel (Pin-to-Pin Maximum Insertion Loss)

Use the following equations to calculate and plot insertion loss profiles of each forward/reverse channel configuration.

3 Gbps Forward/187 Mbps Reverse

$$IL(f[Hz]) = \begin{cases} -\left(7.7 + 0.27\sqrt{(f \times 10^{-6})} + 2.2\,(f \times 10^{-9})\right) & for\ 2\ MHz\ to\ 5\ MHz \\ -\left(5.7 + 0.27\sqrt{(f \times 10^{-6})} + 2.2\,(f \times 10^{-9})\right) & for\ 5\ MHz\ to\ 2\ GHz \end{cases}$$

Equation 2. Insertion Loss 3 Gbps/187 Mbps

6 Gbps Forward/187 Mbps Reverse

$$IL(f[Hz]) = \begin{cases} -\left(3.2 + 0.25\sqrt{(f \times 10^{-6})} + 0.64\,(f \times 10^{-9})\right) & for\ 2\ MHz\ to\ 500\ MHz \\ -\left(2.74 + 0.25\sqrt{(f \times 10^{-6})} + 1.56\,(f \times 10^{-9})\right) & for\ 500\ MHz\ to\ 3.5\ GHz \end{cases}$$

Equation 3. Insertion Loss 6 Gbps/187 Mbps

Maximum Return Loss Specification (Pin-to-Pin Channel)

This section defines the maximum return loss (i.e., reflected energy back to the transmitter) for the pin-to-pin channel specification.

- S-parameters: S_{11}/S_{dd11} and S_{22}/S_{dd22}
- Single-ended and differential configurations

Table 3. Maximum System Channel Return Loss (Pin-to-Pin Channel)

GMSL2 MAXIMUM RETURN LOSS-PIN-TO-PIN CHANNEL		
	3 Gbps Forward/187 Mbps Reverse	6 Gbps Forward/187 Mbps Reverse
APPLIED BAND	2 MHz to 3.5 GHz	2 MHz to 3.5 GHz
INSERTION LOSS	−8 dB at 1.5 GHz	−8 dB at 3 GHz

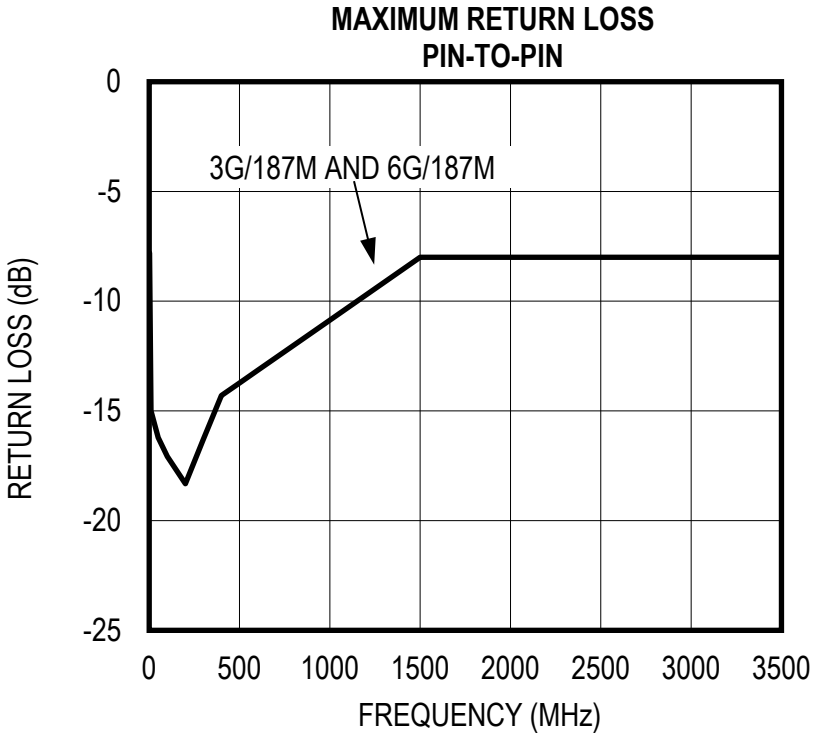

Figure 3.C. GMSL2 System Channel (Pin-to-Pin Maximum Return Loss)

Use the following equations to calculate and plot the return loss profiles of each forward/reverse channel configuration.

3 Gbps Forward/187 Mbps Reverse and 6 Gbps Forward/187 Mbps Reverse

$$RL(f[Hz]) = \begin{cases} -6 - \left(0.9\,(f \times 10^{-6})\right) & for\ 2\ MHz\ to\ 10\ MHz \\ -\left(14.2 + 0.28\sqrt{(f \times 10^{-6})} + 0.8\,(f \times 10^{-9})\right) & for\ 10\ MHz\ to\ 200\ MHz \\ -18.3 + 0.02\,\left((f \times 10^{-6}) - 200\right) & for\ 200\ MHz\ to\ 400\ MHz \\ 5.7 \times 10^{-3}\,(f * 10^{-6}) - 16.6 & for\ 400\ MHz\ to\ 1500\ MHz \\ -8 & for\ 1500\ MHz\ to\ 3500\ MHz \end{cases}$$

Equation 4. Return Loss (3 Gbps/187 Mbps and 6 Gbps/187 Mbps)

GMSL2 Crosstalk Specification

The GMSL2 crosstalk specification places limits on the permissible parasitic coupling from GMSL2, other high-speed links (aggressors), and/or noise sources onto a GMSL2 link. Separate specification items for the PCB module at the end of a link and cable bundle allow system components to be individually developed and evaluated for crosstalk.

Crosstalk Specification for the PCB Module

Crosstalk between multiple ports on a PCB (e.g., an electronic control unit (ECU)) can be characterized in different ways depending on the source of the crosstalk and whether the interfering signals are narrowband or broadband.

Crosstalk from GMSL or Other Broadband Signals

The setup shown in *Figure 3.E* is used to measure crosstalk between the different ports (connectors) on a PCB. The data traffic causing interference is running on Ports 1..N, and crosstalk is measured on Port M of the PCB. The worst-case crosstalk condition occurs when using cables with minimum insertion loss. This maximizes the received signal power on Port M. Crosstalk is measured as peak amplitude on Port M using an oscilloscope. The GMSL2 device on Port M should be configured in squelch mode. *Table 5* presents the broadband crosstalk limits.

Table 5. Broadband Crosstalk Limits

FORWARD DATA RATE [GB/S]	REVERSE DATA RATE [MB/S]	MEASUREMENT FREQUENCY RANGE [MHz]	MAXIMUM CROSSTALK	CONDITIONS
3 Gbps or 6 Gbps	187.5 Mbps	1 MHz to 4000 MHz	<4 mV(p-p)	Interferers are any combination of high-speed links

In *Figure 3.E*, links from devices 1..N are active. Crosstalk is measured on Port M with device M in the squelch mode.

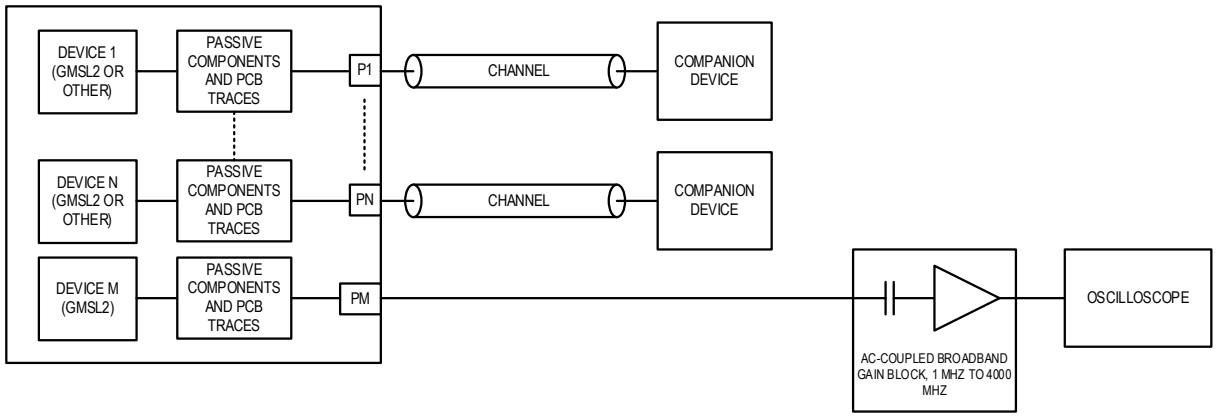

Figure 3.E. Broadband Crosstalk Characterization Method

Crosstalk from Narrowband Signals

If the interfering signal is a continuous wave or narrowband signal (e.g., a clock or switching frequency from a voltage regulator or a PoC circuit), the crosstalk into the GMSL port is measured in mV, as shown in *Figure 3.F*. If the measured signal is a continuous wave, use an oscilloscope or a spectrum analyzer to measure the crosstalk voltage on the disturbed port (convert from dBm to mV). If the interfering signal is a complex waveform (e.g., a modulated waveform), use an oscilloscope. A low-noise amplifier and bandpass filter may be required to obtain a clean measurement.

The limits in *Table 6* are frequency-dependent because the GMSL receiver input amplifier adaptively compensates for the frequency-dependent loss of the cable by boosting high-frequency gain. The higher the frequency-dependent attenuation

of the cable, the more the high-frequency portion of the received signal is boosted by the serial link receiver. An unwanted side effect of this high-frequency boost is increased sensitivity to high-frequency crosstalk.

Table 6. Narrowband Crosstalk Limits

FORWARD DATA RATE	REVERSE DATA RATE	MEASUREMENT FREQUENCY RANGE [MHz]	PEAK-TO-PEAK VOLTAGE LIMIT [mV] (f = FREQUENCY [MHz])
3 Gbps or 6 Gbps	187.5 Mbps	1 MHz to 10 MHz	40
		10 MHz to 100 MHz	$40 - 20 \times log_{10}\left(\frac{f}{10}\right)$
		100 MHz to 400 MHz	20
		400 MHz to 4000 MHz	$20 - 18 \times log_{10}\left(\frac{f}{400}\right)$
		4000 MHz to 10000 MHz	$2 + 80 \times log_{10}\left(\frac{f}{4000}\right)$

Note: These limits include ripple injected by the PoC circuit.

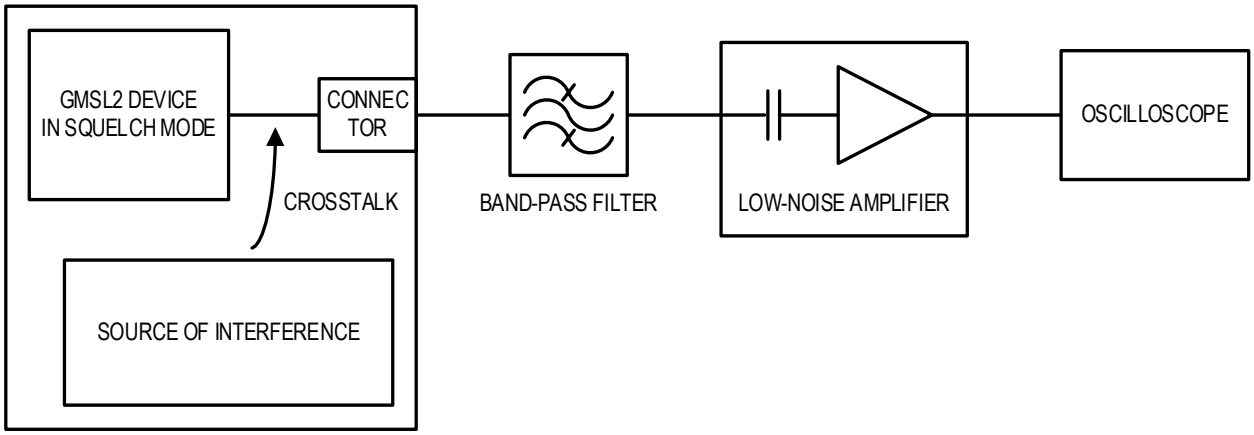

Figure 3.F. Measurement Setup for Narrowband Crosstalk

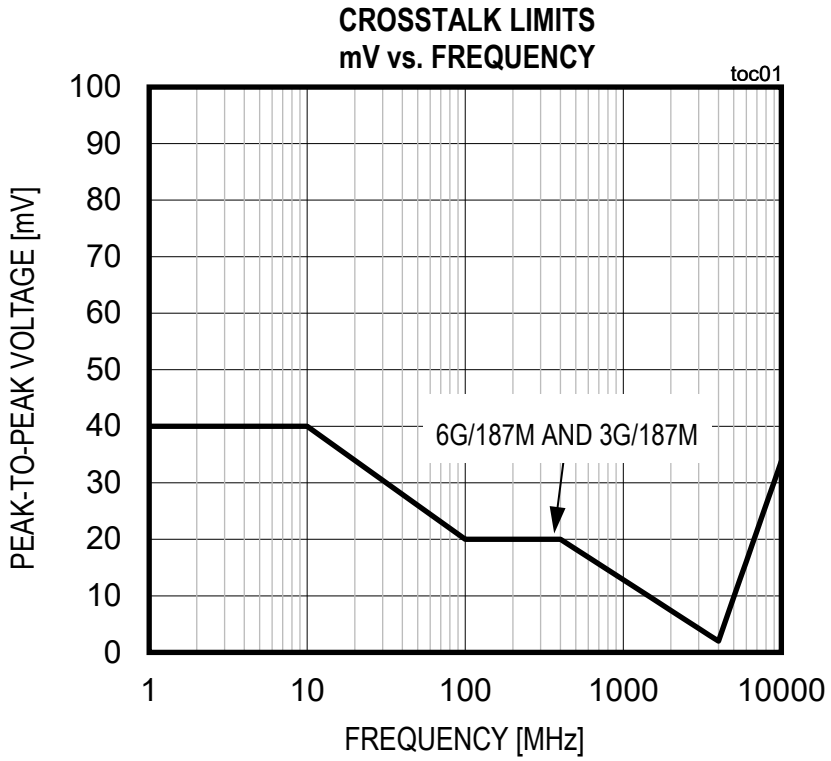

Figure 3.G. Narrowband Crosstalk Limits

Crosstalk Specification for the Cable Bundle

Crosstalk occurs when multiple cables are routed together in a harness. Analog Devices specifies both near-end crosstalk (NEXT) and far-end crosstalk (FEXT) in case GMSL2 links are routed in the same harness.

Note: The metric for FEXT is Power-Sum Adjusted Crosstalk Ratio – Far End (PS_ACR_F). See *Figure 3.I* for additional information.

Table 7. Maximum System Channel Crosstalk Limits for Cable Bundles

DATA RATE	FREQUENCY RANGE [MHz]	SPECIFICATION LIMIT
3 Gbps or 6 Gbps forward, 187.5 Mbps reverse	1 MHz to 4000 MHz	NEXT < −50 dB PS_ACR_F < −50 dB

Near-End Cable Bundle Crosstalk

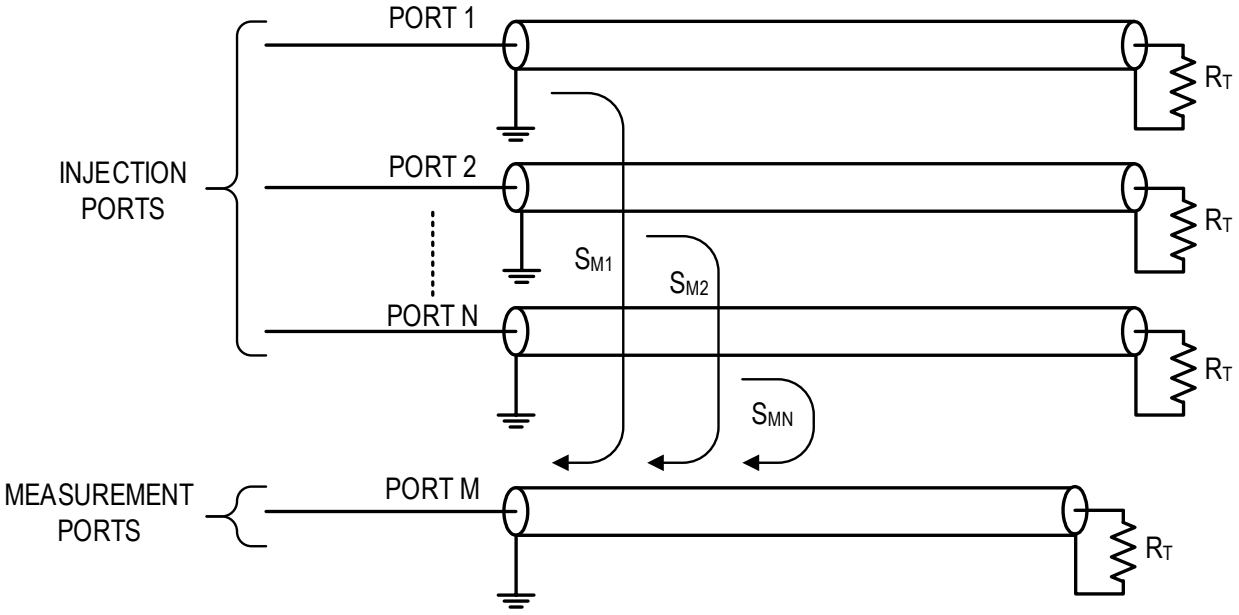

Figure 3.H. Near-End Crosstalk (NEXT)

The near-end crosstalk is usually dominant. NEXT is based on the injection and measurement ports shown in *Figure 3.H* and is specified as the power sum of the coupling from Ports 1..N into Port M (*Equation 10*).

$$NEXT = 10 * log\left(\sum_{i=1}^{N} S_{Mi}^2\right)[dB]$$

Equation 5. Near-End Crosstalk Equation

The NEXT measurement is performed as a sequence of multiport S-parameter measurements using a vector network analyzer (VNA). The transfer functions from the injection port to measurement port are added in the power domain.

Note: During measurement, all unused ports must be terminated in 50 Ω for coax or 100 Ω for STP.

As an example, assume two interferers with transfer functions S_{M1} = −60 dB and S_{M2} = −66 dB. The power sum of S_{M1} and S_{M2} is found by converting both parameters from dB to power and converting the sum of power back to dB. NEXT is calculated as:

$$NEXT = 10 \times log\left(10^{\left(-\frac{60\ dB}{10}\right)} + 10^{\left(-\frac{66\ dB}{10}\right)}\right) = -59\ dB$$

The resulting NEXT = −59 dB satisfies the requirement for NEXT in *Table 7*.

Far-End Cable Bundle Crosstalk

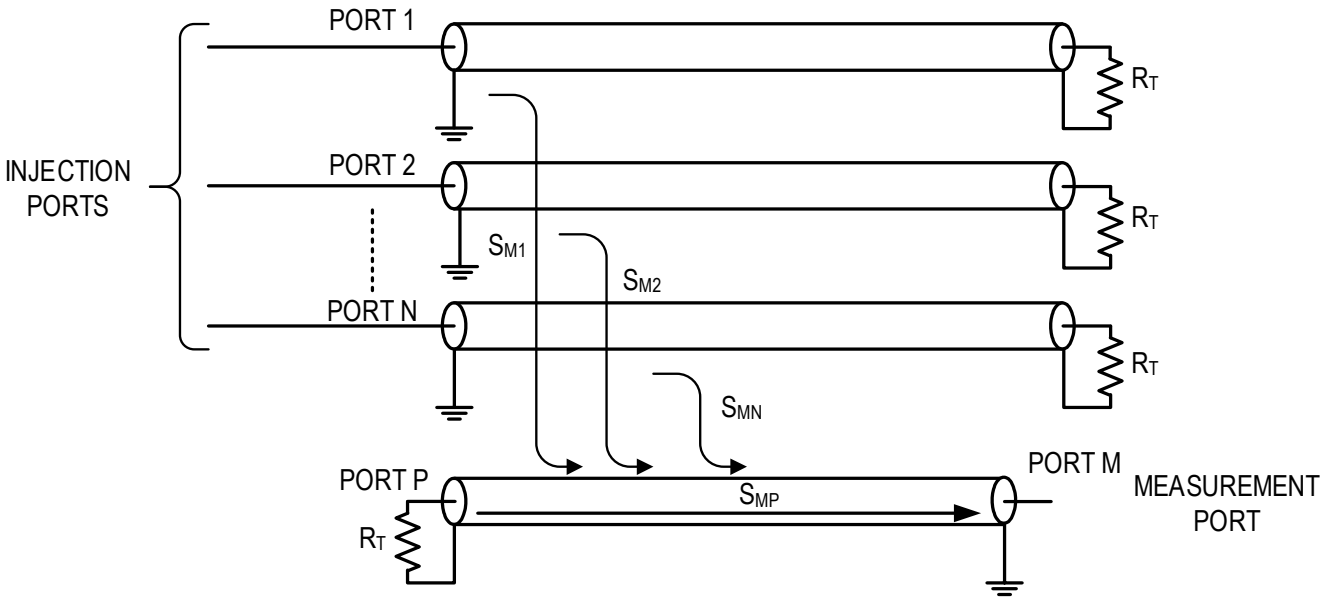

Figure 3.I. Far-End Crosstalk (FEXT)

Far-end crosstalk (FEXT) is a measure of the crosstalk received at the far end of the cable with the disturbance applied at the near-end of the cable (*Figure 3.I*). The metric for FEXT is power-sum adjusted crosstalk ratio – far end (PS_ACR_F). The received amplitude on the measurement Port M of each interferer is attenuated by the transfer function S_{Mi}. Similarly, the wanted signal received at Port M is attenuated by the insertion loss S_{MP} of the disturbed cable. Assuming that the transmitted amplitude of all the interfering signals is the same, the far-end crosstalk measure, PS_ACR_F, represents the ratio of the interferers to the received wanted signal, providing a measure of interference-to-signal ratio in the disturbed cable. In the dB domain, this becomes a simple subtraction (*Equation 11*).

$$\text{PS\_ACR\_F} = 10 * log\left(\sum_{i=1}^{N} S_{Mi}^2\right)\ [\text{dB}] - S_{MP}[\text{dB}]$$

Equation 6. Power-Sum Adjusted Crosstalk Ratio – Far-End Crosstalk Equation

The PS_ACR_F measurement is performed as a sequence of two-port measurements using a vector network analyzer (VNA). The results are added in the power domain, as shown above.

Note: During measurement, all unused ports must be terminated in 50 Ω for coax or 100 Ω for STP.

As an example, assume two interferers with transfer functions S_{M1} = −70 dB and S_{M2} = −70 dB. S_{MP} = −11 dB. The power sum (calculated in the same manner as NEXT above) of S_{M1} and S_{M2} is −67 dB. The resulting far-end crosstalk is PS_ACR_F = -67dB – (−11 dB) = −56 dB, which meets the requirement for FEXT in *Table 7*.

GMSL2 Link Margin Specification

Link margin is specifically used to quantitatively test the signal integrity of the GMSL link. The link margin test starts at the default transmit voltage amplitude for both the forward and reverse channels. The test decreases the transmit amplitude in 10 mV steps and performs an error check before proceeding to the next test amplitude. The test ends at any point an error is detected. The link margin is reported as the difference between the default transmitter amplitude and the amplitude at which the error is detected. *Table 8* contains the required minimum link margin for both the forward and reverse channels.

Table 8. Minimum Required Link Margin

CABLE	DATA RATE (FORWARD/REVERSE)	MINIMUM REQUIRED FORWARD CHANNEL LINK MARGIN [mV]	MINIMUM REQUIRED REVERSE LINK MARGIN [mV]
COAX/STP	6 Gbps/187 Mbps	150 mV	90 mV
COAX/STP	3 Gbps/187 Mbps	150 mV	90 mV

Note: A link margin tool is available through the Analog Devices GMSL GUI. Alternatively, software support is available for customers to develop their own implementation of these tools in their software.

GMSL2 Module Channel Specifications

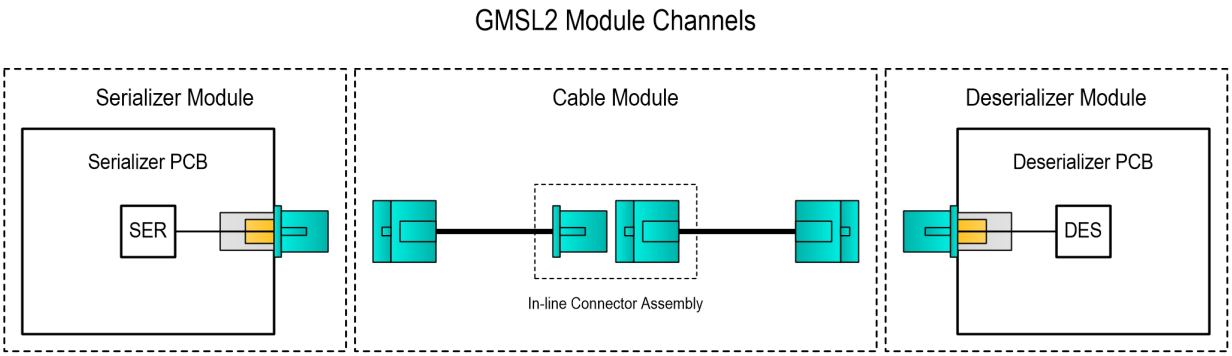

Figure 4.A. GMSL2 Module Channels

GMSL2 Module Compliance

Meeting module compliance requirements guarantees GMSL2 system channel compliance when implemented with other compliant modules and cable(s).

For GMSL2 module compliance:

- Serializer/deserializer module channels must meet the PCB insertion loss and return loss requirements under worst-case conditions, as defined by the system designer.
- Cable module channels must meet the cable insertion loss and return loss requirements under worst-case conditions, as defined by the system designer.

Worst-case conditions include longest cable (highest insertion loss), cable aging effects, channel degradation due to temperature, PCB impedance variation, or minimum/maximum system PoC loads. Worst-case conditions can be simulated. Contact the cable manufacturer and PCB designer for technical advice.

Notes:

- A module meeting the GMSL2 module compliance specification is interoperable with other compliant modules. The cable module specification is allocated such that a 15 m LD302 cable under worst-case operating conditions meets the specification.
- The PCB and cable channels comprising a compliant GMSL2 system channel may not meet the standards required for GMSL2 module compliance. Modules must be independently evaluated for GMSL2 module compliance.

Maximum Insertion Loss Specification (PCB and Cable Channels)

This section defines the maximum insertion loss (i.e., energy loss across the transmission channel) for the module channel specifications.

- S-parameters: S_{21}/S_{dd21} and S_{12}/S_{dd12}
- Single-ended and differential configurations

Table 9. Maximum Insertion Loss (PCB and Cable Channels)

GMSL2 MAXIMUM INSERTION LOSS PCB AND CABLE CHANNELS		
	3 Gbps Forward/187 Mbps Reverse	**6 Gbps Forward/187 Mbps Reverse**
APPLIED BAND	**2 MHz to 2 GHz**	**2 MHz to 3.5 GHz**
SERIALIZER PCB MODULE	−2 dB at 1.5 GHz	−2 dB at 3 GHz
CABLE MODULE	−15.5 dB at 1.5 GHz	−17 dB at 3 GHz
DESERIALIZER PCB MODULE	−2 dB at 1.5 GHz	−2 dB at 3 GHz

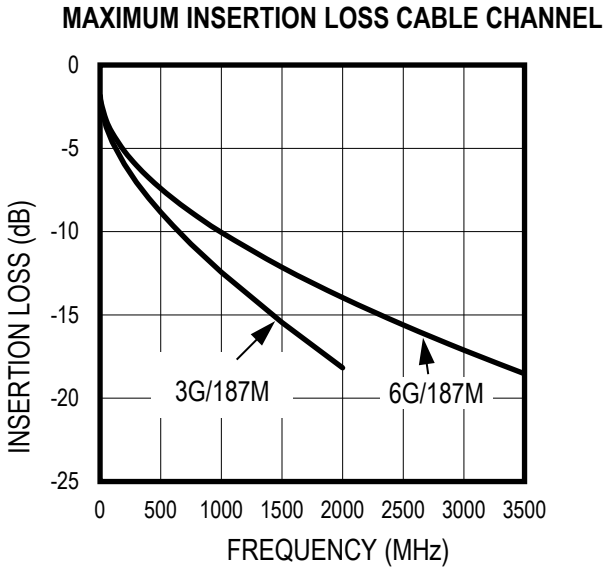

Figure 4.B. GMSL2 Cable Channel Insertion Loss

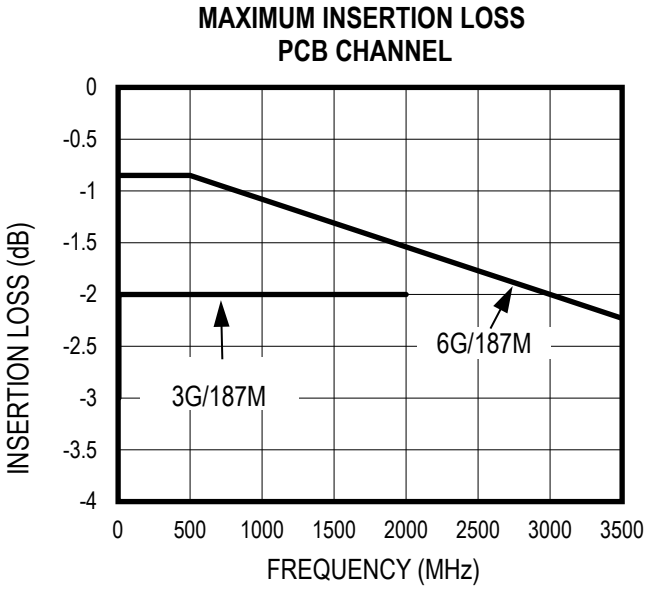

Figure 4.C. GMSL2 PCB Channel Insertion Loss

Use the following equations to calculate and plot the insertion loss profiles for both the PCB and cable system segments of each forward/reverse channel configuration.

3 Gbps Forward/187 Mbps Reverse

$$IL_{PCB}(f[Hz]) = \begin{cases} -3\ dB & for\ 2\ MHz\ to\ 5\ MHz \\ -2\ dB & for\ 5\ MHz\ to\ 2\ GHz \end{cases}$$

Equation 7. PCB Insertion Loss (3 Gbps/187 Mbps)

$$IL_{Cable}(f[Hz]) = -\left(1.7 + 0.27\sqrt{(f \times 10^{-6})} + 2.2\ (f \times 10^{-9})\right) \quad for\ 2\ MHz\ to\ 2\ GHz$$

Equation 8. Cable Insertion Loss (3 Gbps/187 Mbps)

6 Gbps Forward/187 Mbps Reverse

$$IL_{PCB}(f[Hz]) = \begin{cases} -0.85 & for\ 2\ MHz\ to\ 500\ MHz \\ -0.62 - 0.46\ (f \times 10^{-9}) & for\ 500\ MHz\ to\ 3.5\ GHz \end{cases}$$

Equation 9. PCB Insertion Loss (6 Gbps/1.87 Mbps)

$$IL_{Cable}(f[Hz]) = -\left(1.5 + 0.25\sqrt{(f \times 10^{-6})} + 0.64\ (f \times 10^{-9})\right) \quad for\ 2\ MHz\ to\ 3.5\ GHz$$

Equation 10. Cable Insertion Loss (6 Gbps/187 Mbps)

Maximum Return Loss Specification (PCB and Cable Channels)

This section defines the maximum return loss (i.e., reflected energy back to the transmitter) for the module channel specifications.

- S-parameters: S_{11}/S_{dd11} and S_{22}/S_{dd22}
- Single-ended and differential configurations

Table 10. Maximum Return Loss (PCB and Cable Channels)

GMSL2 MAXIMUM CHANNEL RETURN LOSS PCB AND CABLE ALLOCATION		
	3 Gbps FORWARD/187 Mbps REVERSE	**6 Gbps FORWARD/187 Mbps REVERSE**
APPLIED BAND	**2 MHz to 3.5 GHz**	**2 MHz to 3.5 GHz**
SERIALIZER PCB MODULE	−8 dB at 1.5 GHz	−8 dB at 3 GHz
CABLE MODULE	−8 dB at 1.5 GHz	−8 dB at 3 GHz
DESERIALIZER PCB MODULE	−8 dB at 1.5 GHz	−8 dB at 3 GHz

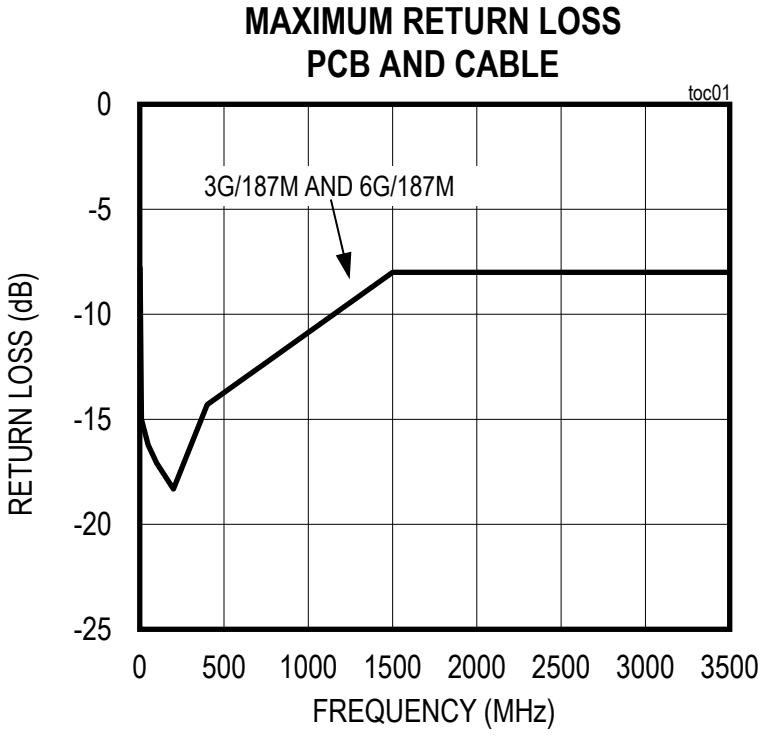

Figure 4.D. Maximum GMSL2 PCB and Cable Channel Return Loss

Note: Return loss is not additive. Thus, there is not an allowable dB value of return loss for each section of the GMSL2 link (i.e., PCBs and cable). The full link (i.e., pin-to-pin) must meet the above specified return loss allocation.

Use the following equations to calculate and plot the return loss profiles for both the PCB and cable system segments of each forward/reverse channel configuration.

3 Gbps Forward/187 Mbps Reverse and 6 Gbps Forward/187 Mbps Reverse

$$RL(f[Hz]) = \begin{cases} -6 - \left(0.9\ (f \times 10^{-6})\right) & for\ 2\ MHz\ to\ 10\ MHz \\ -\left(14.2 + 0.28\sqrt{(f \times 10^{-6})} + 0.8\ (f \times 10^{-9})\right) & for\ 10\ MHz\ to\ 200\ MHz \\ -18.3 + 0.02\ \left((f \times 10^{-6}) - 200\right) & for\ 200\ MHz\ to\ 400\ MHz \\ 5.7 \times 10^{-3}\ (f \times 10^{-6}) - 16.6 & for\ 400\ MHz\ to\ 1500\ MHz \\ -8 & for\ 1500\ MHz\ to\ 3500 MHz \end{cases}$$

Equation 11. PCB Return Loss (3 Gbps/187 Mbps and 6 Gbps/187 Mbps)

$$RL(f[Hz]) = \begin{cases} -6 - \left(0.9\ (f \times 10^{-6})\right) & for\ 2\ MHz\ to\ 10\ MHz \\ -\left(14.2 + 0.28\sqrt{(f \times 10^{-6})} + 0.8\ (f \times 10^{-9})\right) & for\ 10\ MHz\ to\ 200\ MHz \\ -18.3 + 0.02\ \left((f \times 10^{-6}) - 200\right) & for\ 200\ MHz\ to\ 400\ MHz \\ 5.7 \times 10^{-3}\ (f * 10^{-6}) - 16.6 & for\ 400\ MHz\ to\ 1500\ MHz \\ -8 & for\ 1500\ MHz\ to\ 3500\ MHz \end{cases}$$

Equation 12. Cable Return Loss (3 Gbps/187 Mbps and 6 Gbps/187 Mbps)

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION/CHANGE(S)	PAGES CHANGED
0	05/23	Initial release	—