*TI Designs*

# *3G Serial Digital Interface (SDI) Repeater With Reclocking Function Reference Design*

## Description

This SDI repeater signal conditioning solution for a 3G-SDI design includes the LMH0324 3G-SDI Adaptive Equalizer and the LMH0318 3G-SDI Reclocker with an integrated cable driver. It provides a serial interface for connection to a host computer along with a graphic user interface (GUI) program for configuring and monitoring the devices on the board. As shown in Figure 1, the LMH0324 adaptive cable equalizer receives the SDI signal and compensates for the cable losses encountered between the signal source and the input. One copy of the equalized signal is sent to the LMH0318 cable driver and another copy to SMA connectors. The LMH0318 drives AC coupled 75-Ω SDI coaxial cable and 100-Ω differential signals.

## Resources

| | |
|---|---|
| TIDA-03028 | Design Folder |
| LMH0324 | Product Folder |
| LMH0318 | Product Folder |
| Sigcon Architect | Tools Folder |

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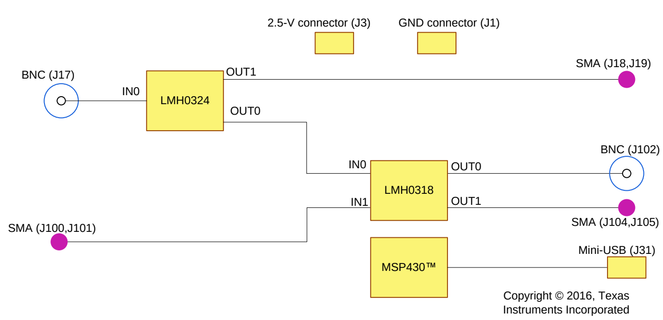
## Features

- 75-Ω and 100-Ω Differential Inputs
- 75-Ω and 100-Ω Differential Outputs
- Low-Power Consumption With Automatic Power Down When No Input Signal is Provided
- Ability to Estimate Coaxial Input Cable Length
- Ability to Diagnose Signal Eye Diagram and Determine incoming Signal Horizontal and Vertical Eye Opening
- GUI Allows User to Control Settings of Each Device and Monitor Status of Each Device
- Single Power Supply, Requires No Firmware, Heatsink, or Reference Clock
- Lab-Tested Hardware Example Including 3G SDI Test Data

## Applications

- SDI Broadcast and Studio
- Communication Equipment
- Video Communication System

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# 1 System Overview

## 1.1 System Description

In a typical studio such as a local news station, what goes on the air is controlled by a SDI video switcher. The switcher receives SDI video signals from different sources such as a live camera or a video server. The system integrator then measures the cable length between the video source and its destination, such as a video monitor. The LMH0324 indicates cable length based on the equalizer gain settings. Based on the cable type used, one can determine the physical length of the cable. System integrators use this type of measurement to verify that the cable length is within the specifications of the SDI video transport equipment. To ensure the cable length is within the manufacturer recommended cable length and there is enough headroom, additional devices are inserted within the SDI signal path to deliver video reliably. System integrators usually use either an equalizing distribution amplifier (DA) or a reclocking DA. These equipment have a 75-Ω input and output.

An equalizing DA attenuates data-dependent jitter or inter-symbol interference (ISI) only. However, this type of DA does not attenuate random jitter and jitter is accumulated when multiple devices are used in tandem. Because of these limitations, this type of DA is normally used for a short distance.

A more reliable approach is to use a re-clocking DA. This type of DA has an onboard equalizer and re-clocker before driving the 75-Ω coax. The onboard reclocker extracts the clock, and this recovered clock is used to output the video data stream. Using this approach, the re-clocker attenuates the jitter above its loop bandwidth and tracks low frequency jitter within its PLL loop bandwidth. Normally, cascaded devices can tolerate more lower frequency jitter, and the SMPTE limit is also much higher for this type of jitter. Figure 1 shows that the TIDA-03028 is a reclocking DA. SDI video signal is equalized by the LMH0324, the LMH0318 extracts the recovered clock, and then this is used to drive a coax cable. The LMH0318 onboard eye opening monitor can measure low-frequency jitter in the form of a horizontal and vertical eye opening measurement. Moreover, the system integrator can use the LMH0324 Cable Length Indicator to measure cable length and the LMH0318 to measure jitter within the channel. This guarantees a highly reliable SDI video DA.

## 1.2 System Block Diagram

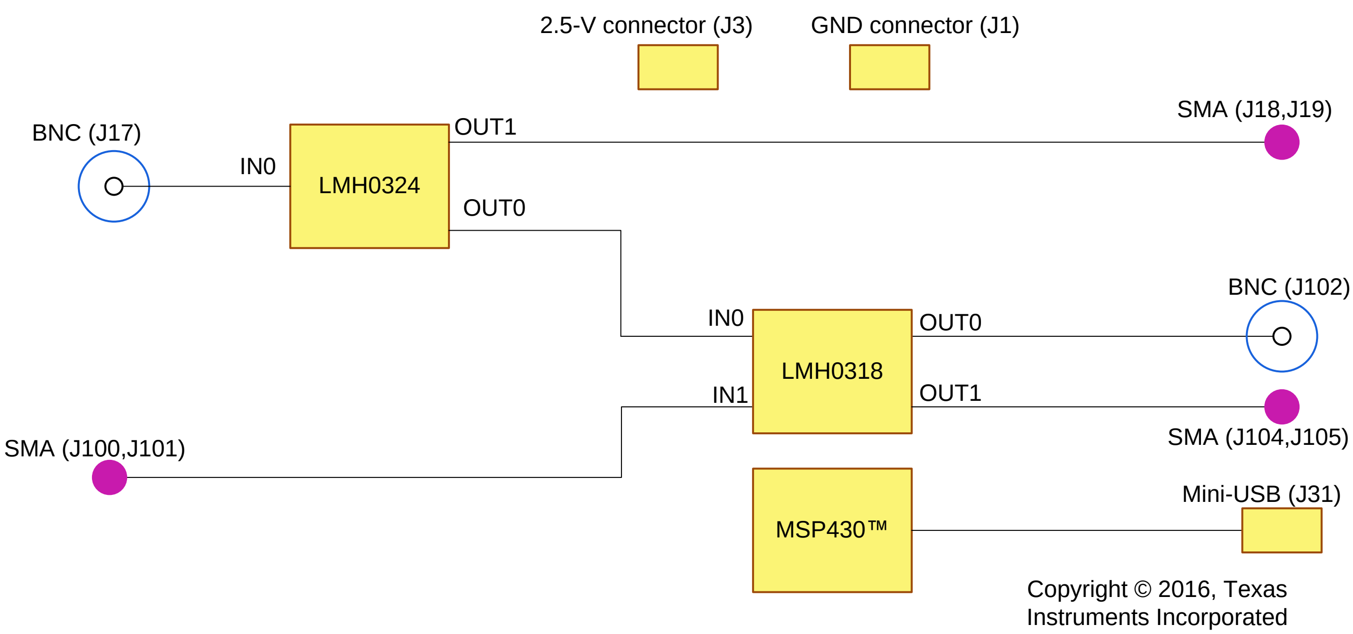


**Figure 1. TIDA-03028 Reclocking Distribution Amplifier**

## 1.3 Highlighted Products

### 1.3.1 LMH0318

The data path of the LMH0318 device includes several key blocks as shown in Figure 2.

- Loss-of-signal detection
- Continuous time linear equalizer (CTLE) for FR4 compensation
- 2:1 multiplexer at a fanout rate of 1:2
- CDR
- Eye monitor
- Differential output selection
- 75-Ω and 100-Ω output drivers
- SMBus and SPI configuration

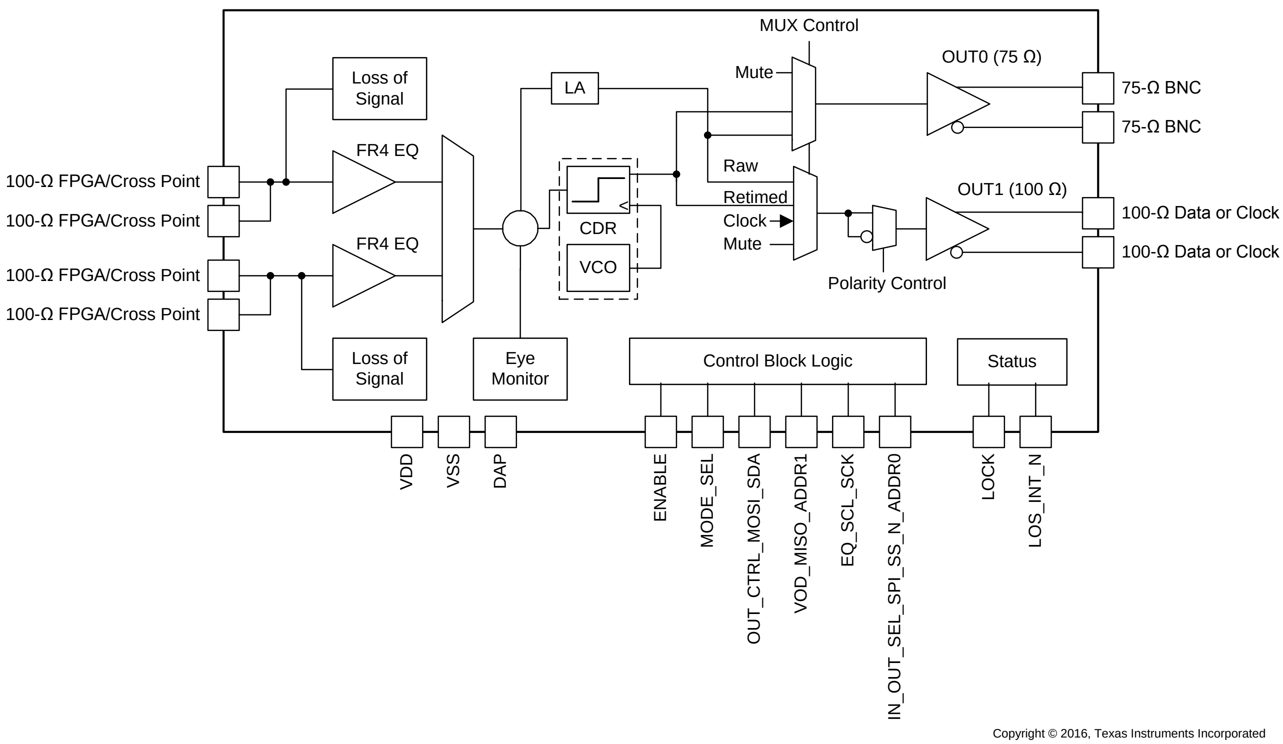


**Figure 2. LMH0318 Functional Block Diagram**

### 1.3.2 LMH0324

The LMH0324 includes of several key blocks as shown in Figure 3:

- 4-level input configuration pins
- Carrier detection
- Adaptive cable equalizer
- Launch amplitude
- Input/output multiplexer selection
- Output function control
- Output driver amplitude and de-emphasis control

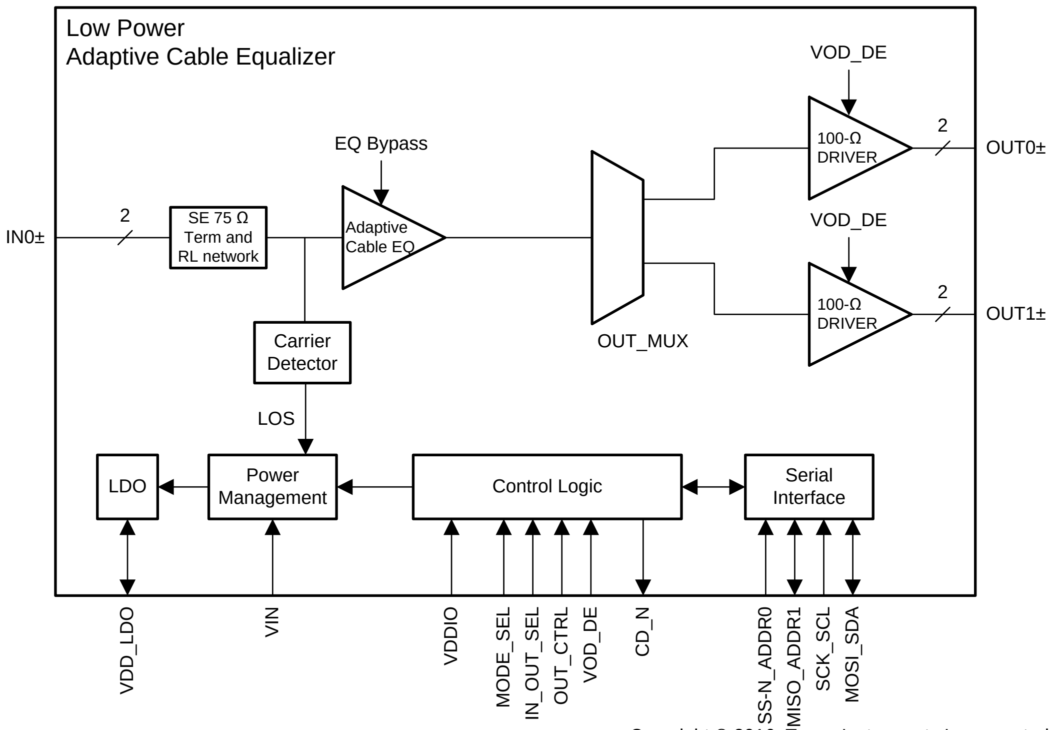


**Figure 3. LMH0324 Functional Block Diagram**

### 1.3.3 MSP430™

The TI MSP430 family of ultra-low-power microcontrollers consists of several devices featuring peripheral sets targeted for a variety of applications. The architecture, combined with extensive low-power modes, is optimized to achieve extended battery life in portable measurement applications. The microcontroller features a powerful 16-bit RISC CPU, 16-bit registers, and constant generators that contribute to maximum code efficiency. The digitally controlled oscillator (DCO) allows the devices to wake up from low-power modes to active mode in 3.5 µs (typical).

The MSP430F5529 microcontroller has integrated USB and PHY supporting USB 2.0, four 16-bit timers, a high-performance 12-bit analog-to-digital converter (ADC), two universal serial communication interfaces (USCI), a hardware multiplier, DMA, a real-time clock (RTC) module with alarm capabilities, and 63 I/O pins.

Typical applications include analog and digital sensor systems, data loggers, and others that require connectivity to various USB hosts. In this s reference design, the MSP430 is used as a communication tool to interface a PC GUI with the device through SMBus protocol.

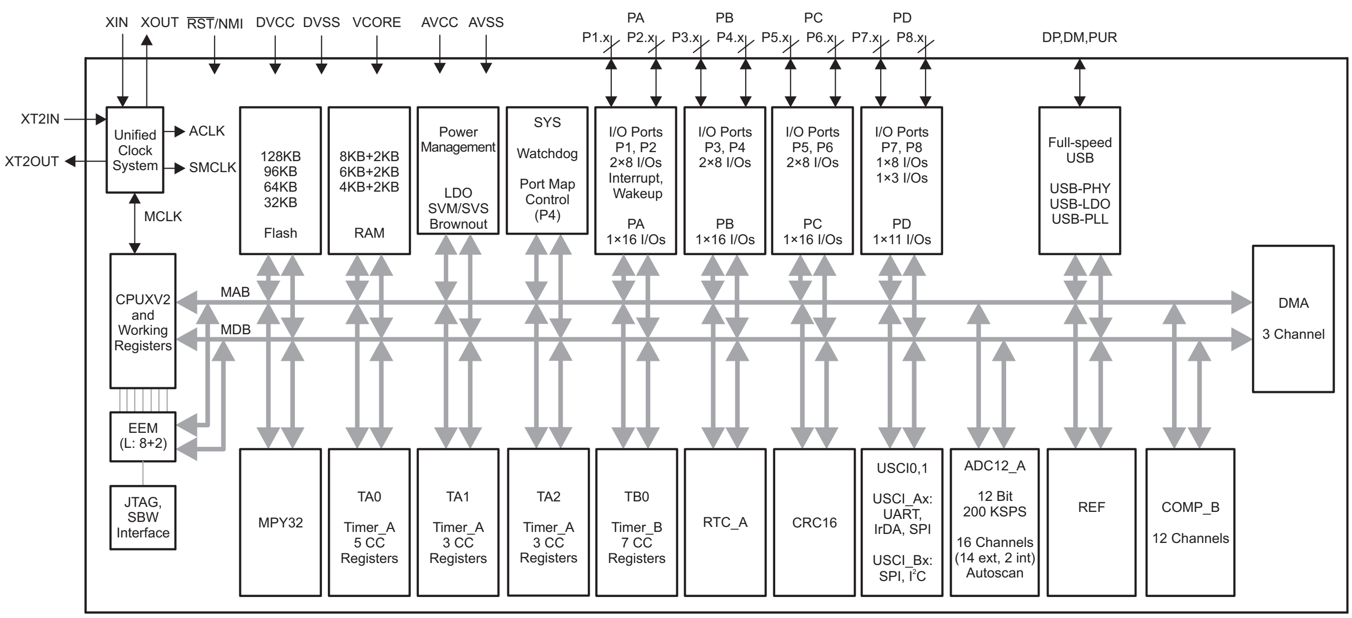


**Figure 4. MSP430 Functional Block Diagram**

# 2 Getting Started Hardware and Software

## 2.1 Hardware

### 2.1.1 Jumper Settings

Verify the following jumpers are installed:

- J9: Tie pin 1 to pin 2.
- J21: Tie pin 1 to pin 2.
- J20, J33: Ensure there are no jumpers on this header.

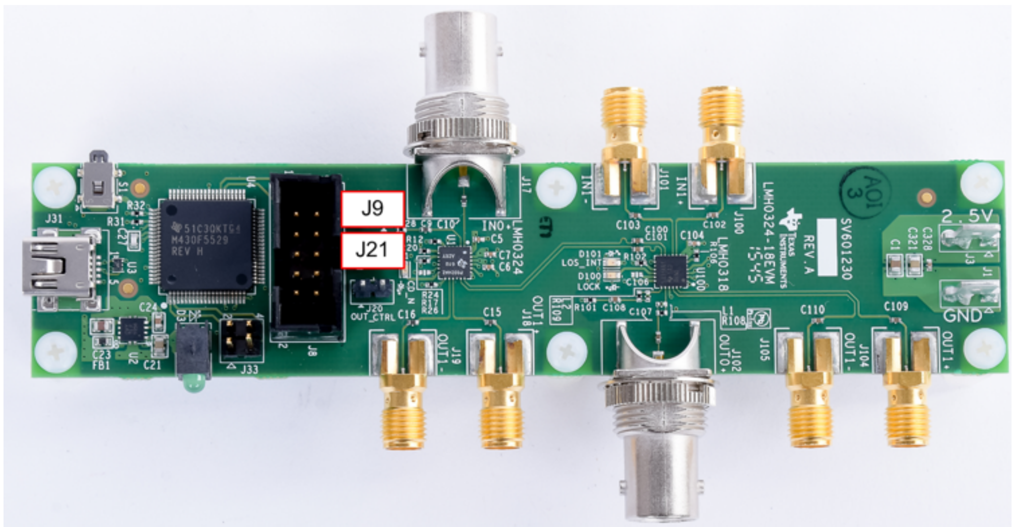


**Figure 5. Jumper Settings**

### 2.1.2 Power Supply Connection

1. Connect a 2.5-V DC power supply (900 mA maximum) between J3 (2.5 V) and J1 (GND).
2. Connect the TIDA-03028 to a PC using USB cable on J31.

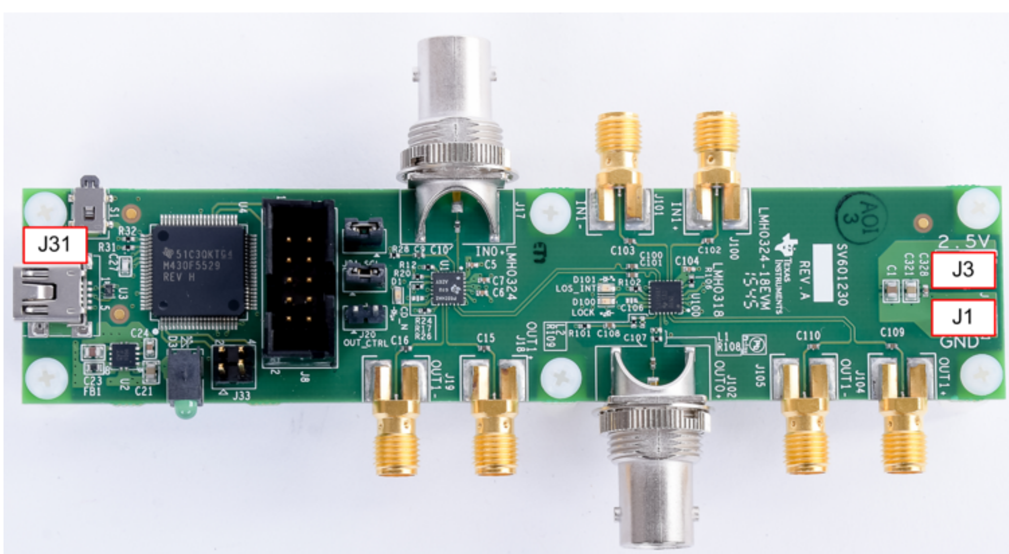


**Figure 6. 2.5-V Power Supply Connections**

## 2.2 Software

### 2.2.1 Installation

1. (One-time step) Install USB2ANY Explorer.
2. Connect to a PC with a USB-to-Mini USB cable via the mini USB Port located on J31. Open USB2ANY Explorer. To the *Update Firmware* prompt, click *Yes* and proceed to update the EVM firmware, or contact TI Sales to get a copy of this GUI.
3. (One-time step) Download a copy of the SigCon Architect tool from the following two options for installing this software:
   - SigCon Architect Installer (Run-time engine not embedded): For users who have access to LabVIEW RTE installed or for users that do not have access to LabVIEW RTE but are installing SigCon Architect software on a PC with an active Internet connection.
   - SigCon Architect Installer wRTE (Run-time engine embedded): For users without access to LabVIEW RTE and are installing SigCon Architect software on a PC without an active internet connection.

   Refer to the SigCon Architect User's Guide software.
4. Contact TI Application Support to obtain the software profile for the LMH0318. Double-click this file and follow the pop-up instructions. Click the *Finish* button at the end of the installation to open the Sigcon Architect tool automatically.

### 2.2.2 Configuration

1. Highlight the configuration tab of the LMH0318 as shown in Figure 7.
2. Set the slave address to *0x1A* and click *Apply*.

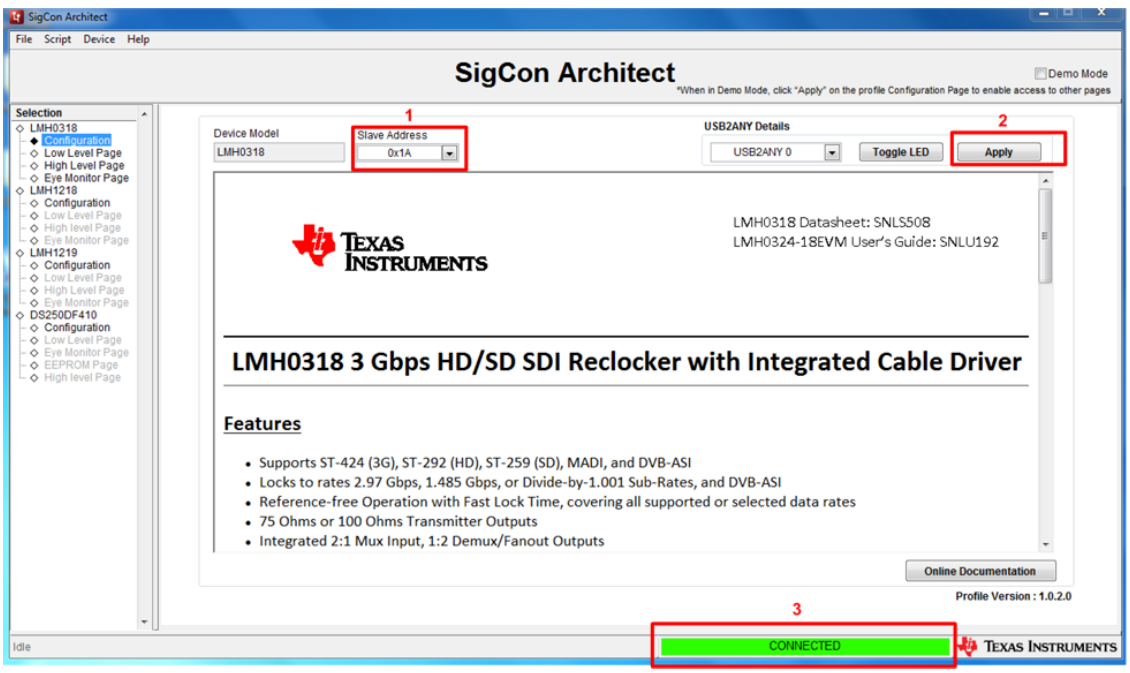


**Figure 7. SigCon Architect LMH0318 Configuration**

Once the GUI communicates with the reference design, *Low Level Page*, *High Level Page*, and *Eye Monitor Page* are highlighted (see Figure 8).

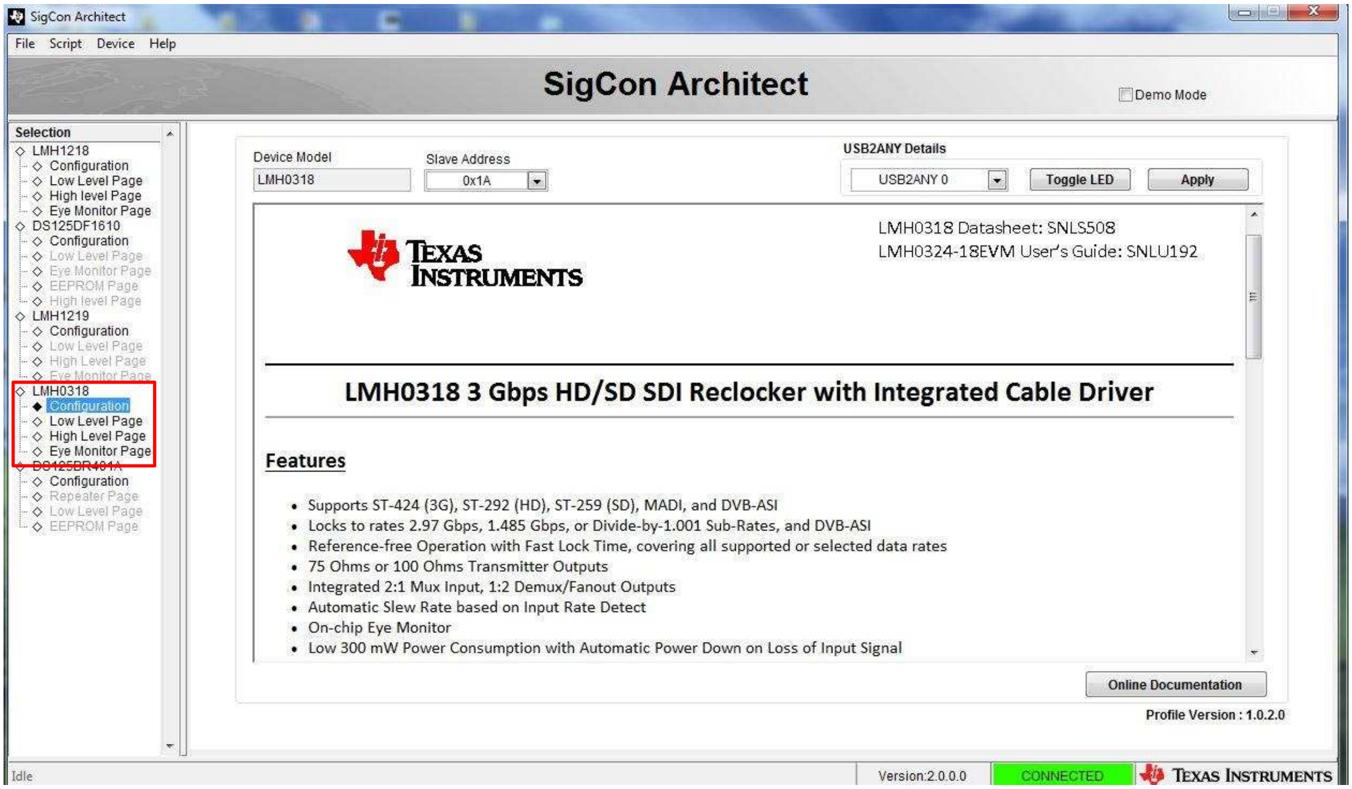


**Figure 8. LMH0318 Configuration Complete**

3. After successfully establishing communication between the SigCon Architect software and the device, select the LMH0318 *High Level Page* tab for the LMH0318 (see Figure 9 ) . By default, the channel CTLE stage 0 gain has been set to 2 to compensate for a long PCB trace. In some cases, set stage 0 of the CTLE to 0 as shown in Figure 9. See the LMH0318 Programming Guide for additional information.

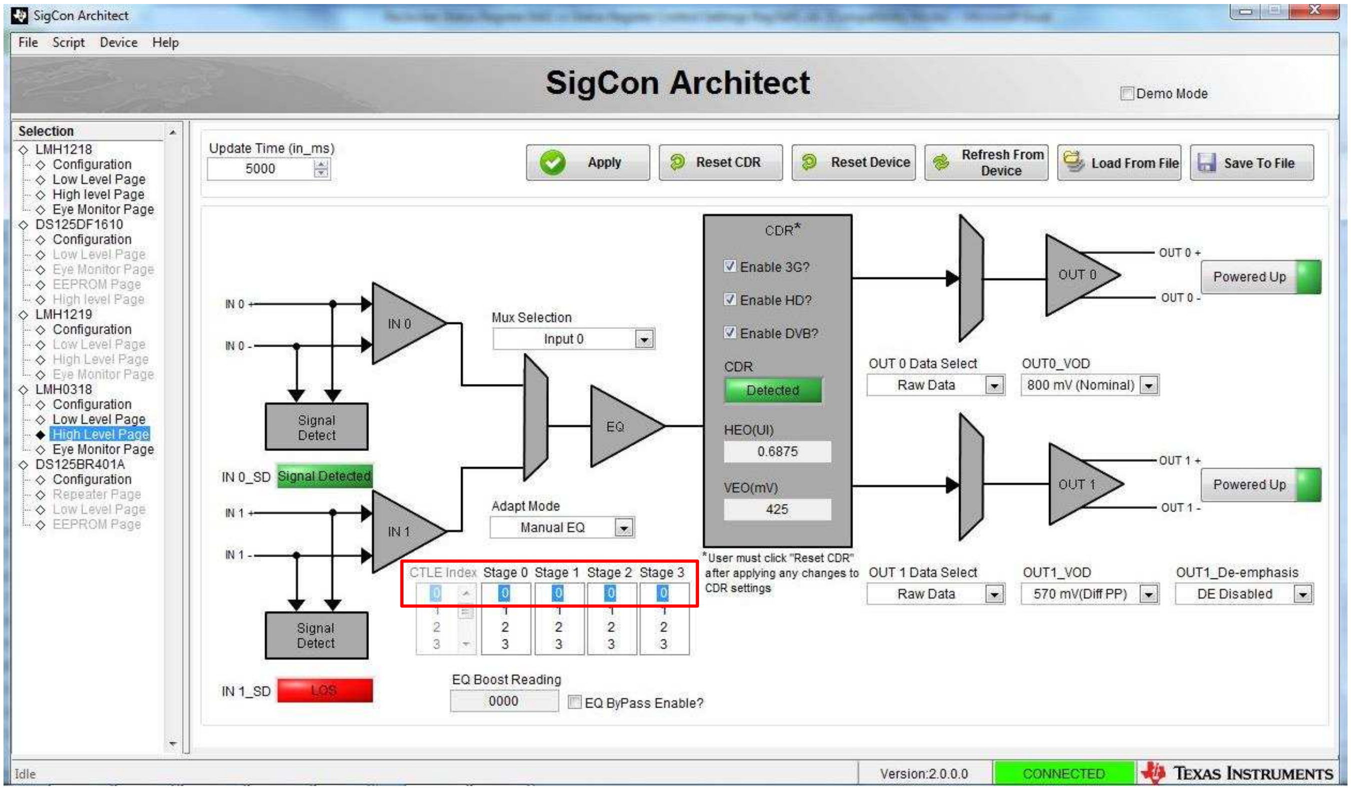


**Figure 9. LMH0318 High Level GUI**

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**NOTE:** The LMH0318 CTLE gain settings are set to 0x80 to equalize long traces. In some cases, this must be forced to 0x00. See the LMH0318 High Level GUI.

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### 2.3 Connectors and Recommended Settings

Table 1 lists the available connectors, their functions, recommended default settings, and comments.

The board is powered by a 2.5-V power supply and the jumper settings must appear identical to the setup in Figure 6.

**Table 1. Jumper Settings**

| CONNECTOR | PIN CONNECTION | | FUNCTION | RECOMMENDED DEFAULT SETTINGS | COMMENTS |
|---|---|---|---|---|---|
| | FROM | TO | | | |
| J1 | — | — | Power Ground | Connect to the ground of the external power supply | — |
| J3 | — | — | 2.5-V Power supply | Connect to the external 2.5-V power supply | — |
| J8 | — | — | USB2ANY Connector | Do not connect | Reserved for debug purpose |
| J9 | 1 | 2 | SDA Pullup resistor | Install this jumper | — |
| J17 | — | — | LMH0324 IN0+ BNC | Connect to 75-Ω SDI coax input | SDI input signal |
| J18 | — | — | LMH0324 OUT1+ | LMH0324 OUT1+ SMA | Connect to scope or other monitoring instrument |
| J19 | — | — | LMH0324 OUT1- | LMH0324 OUT1- SMA | Connect to scope or other monitoring instrument |
| J20 | 1 | 2 | LMH0324 OUT_CTRL | Do not install | LMH0324 Equalizer enabled |
| J21 | 1 | 2 | SCL Pullup resistor | Install this jumper | — |
| J31 | — | — | Mini USB connector | Connect to PC USB port | — |
| J33 | — | — | MSP430 Settings | Do not install this jumper | Reserved for debug purpose |
| J100 | — | — | LMH0318 IN1+ | LMH0318 IN1+ SMA | Connects to pattern generator |
| J101 | — | — | LMH0318 IN- | LMH0318 IN1- SMA | Connects to pattern generator |
| J102 | — | — | LMH0318 OUT0+ BNC | Connect to 75-Ω SDI coax | SDI output signal |
| J104 | — | — | LMH0318 OUT1+ | LMH0318 OUT1+ SMA | Connect to scope or other monitoring instrument |
| J105 | — | — | LMH0318 OUT1- | LMH0318 OUT1- SMA | Connect to scope or other monitoring instrument |

# 3 Testing and Results

## 3.1 LMH0324 Cable Length Indicator versus B1694A

The LMH0324 is a low-power, dual output, extended reach adaptive cable equalizer. It is designed to equalize SDI data transmitted over 75-Ω coax cable. The equalizer operates over a wide range of data rates ranging from 125 Mbps to 2.97 Gbps.

The LMH0324 Cable Length Indicator (CLI) indicates the length of the coaxial cable attached to IN0+. The CLI is accessible through the LMH0324 CableEQ/Driver Page Reg 0x25[5:0]. The 6-bit setting ranges in decimal value from 0 to 55 (000000'b to 110111'b binary), corresponding to 0 to 600 m of a Belden 1694A coax cable.

The TIDA-03028 was connected as shown in Figure 10. The pattern generator and checker transmits PRBS10 data pattern at different data rates. Using different B1694A cable lengths, the LMH0324 Reg 0x25[5:0] were recorded.

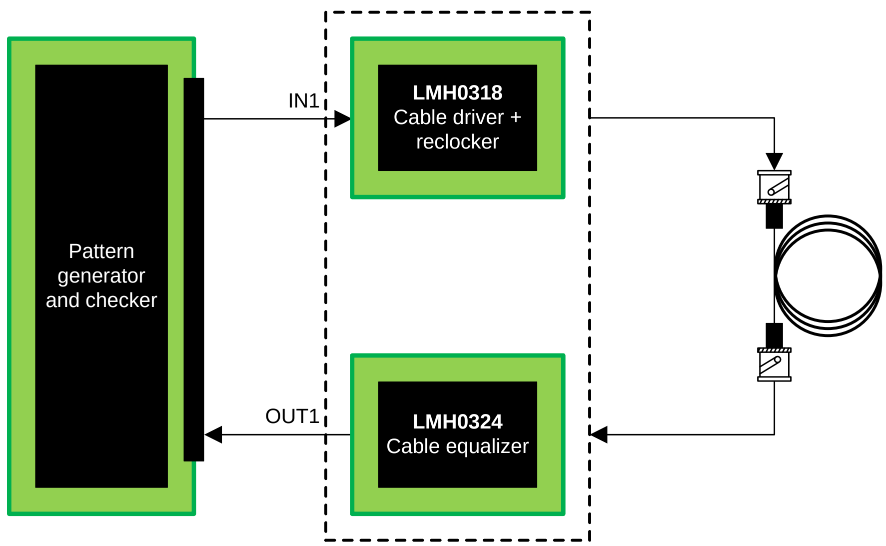




**Figure 10. SDI SMPTE 75-Ω Coax Media Setup**

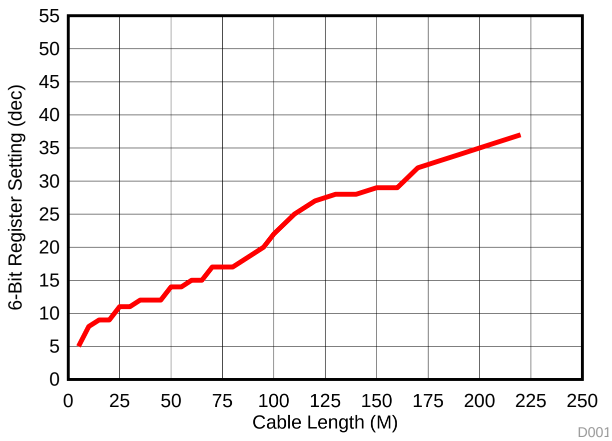


**Figure 11. LMH0324 3G Reg 0x25 versus B1694A Cable Length**

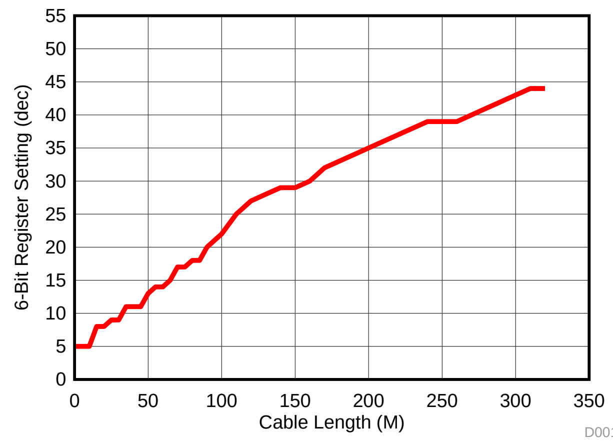


**Figure 12. LMH0324 HD Reg 0x25 versus B1694A Cable Length**

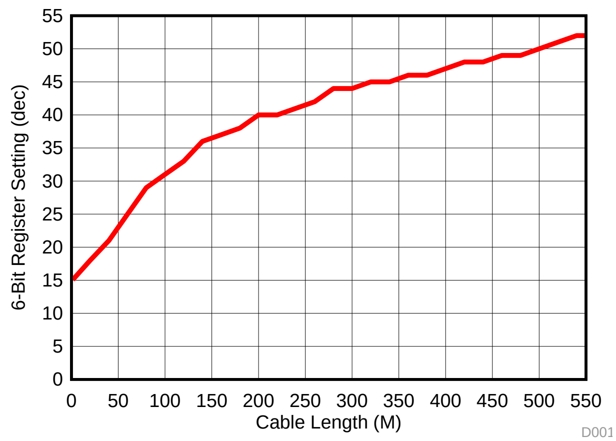


**Figure 13. LMH0324 SD Reg 0x25 versus B1694A Cable Length**

## *3.2 LMH0324 Return Loss Margin versus Rise and Fall Time*

SMPTE specifies the requirements for the SDI to transport digital video at SD, HD, 3G, and higher data rates over coaxial cables. One of the requirements is meeting the required return loss. This requirement specifies how closely the port resembles 75-Ω impedance across a specified frequency band.

The impedance looking into a 75-Ω port must resemble a 75-Ω impedance as closely as possible to minimize signal reflection and degradation when driving a 75-Ω media. Thus more signal energy content is delivered to the load. At frequencies above 1 GHz, parasitic due to the passive components play a major role and can greatly affect return loss performance.

Figure 14 shows LMH0318 typical application schematic, showing a return loss network, using a 3.3-nH inductor and 75-Ω resistor.

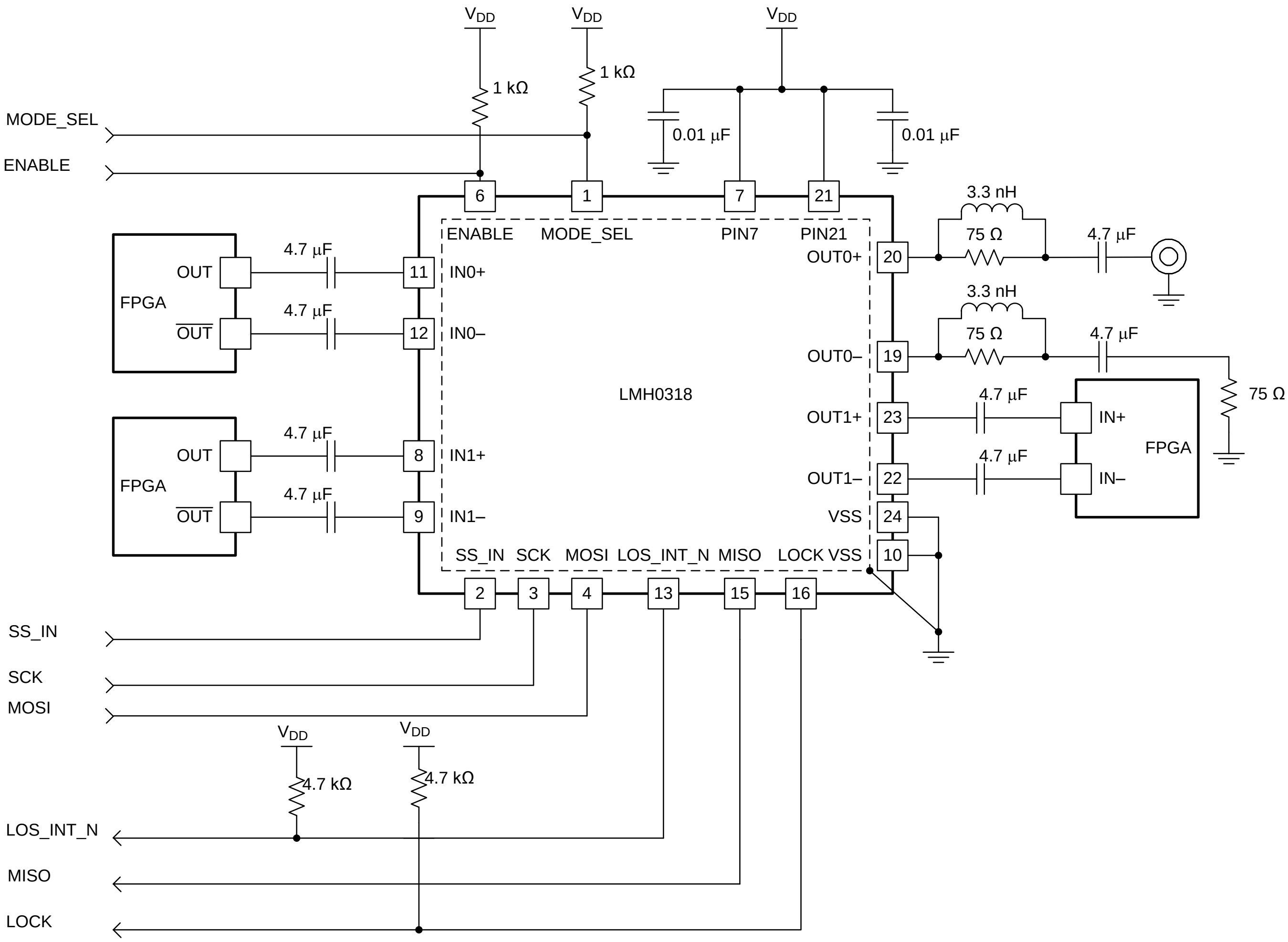


**Figure 14. LMH0318 Typical Application Block Diagram**

Figure 15 shows how the output return loss varies with frequency for different inductor values and rise and fall time trade-off. This shows a higher inductor value provides more return loss margin, but it causes a lower slew rate.

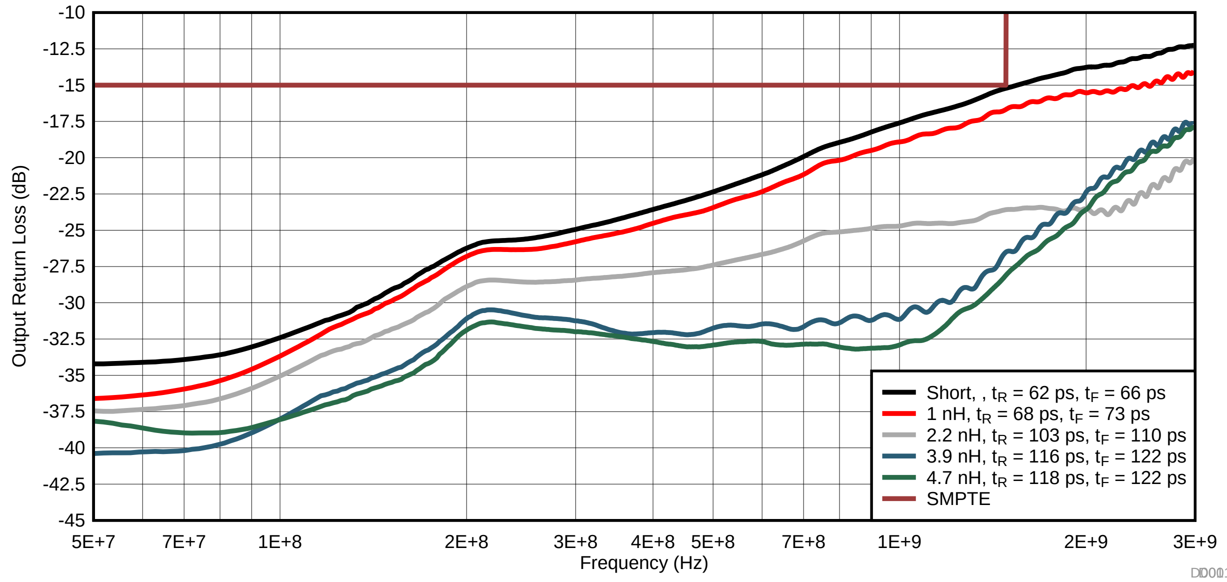


**Figure 15. LMH0318 Output Return Loss versus Frequency**

# 4 Design Files

## 4.1 Schematics

To download the schematics, see the design files at TIDA-03028.

## 4.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDA-03028.

## 4.3 PCB Layout Recommendations

### 4.3.1 Layout Prints

To download the layer plots, see the design files at TIDA-03028.

## 4.4 CAD Project

To download the CAD project files, see the design files at TIDA-03028.

## 4.5 Gerber Files

To download the Gerber files, see the design files at TIDA-03028.

# 5 Software Files

To download the software files, see the design files at TIDA-03028.

# 6 References

1. Texas Instruments, *LMH0318 3 Gbps HD/SD SDI Reclocker with Integrated Cable Driver*, LMH0318 Datasheet (SNLS508)
2. Texas Instruments, *LMH0324 3G/HD/SD SDI Dual Output Adaptive Cable Equalizer*, LMH0324 Datasheet (SNLS516)

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