

# MT1116

## 1-Channel Signal Generator Adapter Module

The MT1116 is a 1-channel, 2.5 GS/s, 16-bit, 1.2 GHz Analog Bandwidth (with no compensation for DAC sinc response) , High-Speed Signal Generator adapter module designed to work in conjunction with your NI FlexRIO™ FPGA module.

The 1-Channel Signal Generator Adapter Module designed to work in conjunction with your NI FlexRIO™ FPGA module. The MT1116 features the following connectors and chips:

- 1 channel, 2.5 GS/s digital-to-analog converter (DAC) with 16-bit accuracy
- Timing chip with clocking options from the backplane and the front panel
- The following front panel connectors:
  - TRIG IN
  - CLK IN
  - AO 0+
  - AO 0-
  - DIO

This document contains signal information and lists the specifications of the MT1116, which is composed of the NI Flex RIO FPGA module and the MT1116. This document also contains tutorial sections that demonstrate how to acquire data using a LabVIEW FPGA Example VI and how to create and run your own LabVIEW project with the MT1116.



**Note** MT1116 refers to the combination of your MT1116 adapter module and your NI FlexRIO FPGA module. MT1116 refers to your MT1116 adapter module only.



**Note** The MT1116 is only compatible with the NI PXIe-796xR FPGA modules.



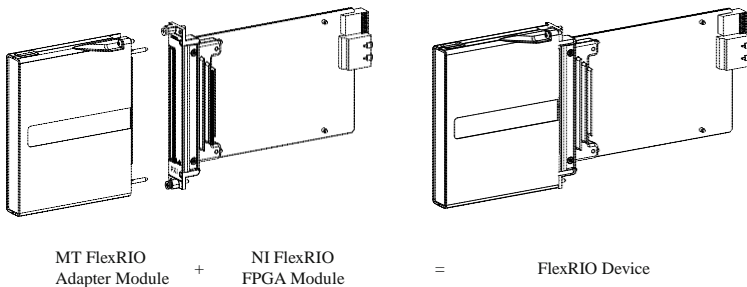
**Note** Before configuring your MT1116, you must install the appropriate software and hardware. Refer to the *NI FlexRIO FPGA Module Installation Guide and Specifications* for installation instructions.



**Note** For EMC compliance, operate this device according to the documentation.

The following figure shows an example of a properly connected FlexRIO device.

**Figure 1.** FlexRIO Device



## Related Information

[MT1116 Specifications](#) on page 17

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## Electromagnetic Compatibility Guidelines

This product was tested and complies with the regulatory requirements and limits for electromagnetic compatibility (EMC) stated in the product specifications. These requirements and limits are designed to provide reasonable protection against harmful interference when the product is operated in the intended operational electromagnetic environment.

This product is intended for use in industrial locations. However, harmful interference may occur in some installations, when the product is connected to a peripheral device or test object, or if the product is used in residential or commercial areas. To minimize interference with radio and television reception and prevent unacceptable performance degradation, install and use this product in strict accordance with the instructions in the product documentation.

Furthermore, any modifications to the product not expressly approved by Mush Technologies could void your authority to operate it under your local regulatory rules.



**Caution** To ensure the specified EMC performance, operate this product only with shielded cables and accessories.



**Caution** To ensure the specified EMC performance, the length of all I/O cables must be no longer than 3 m (10 ft).



**Caution** To ensure the specified EMC performance, you must install PXI EMC Filler Panels (National Instruments part number 778700-1) in adjacent chassis slots.

## Connecting Cables

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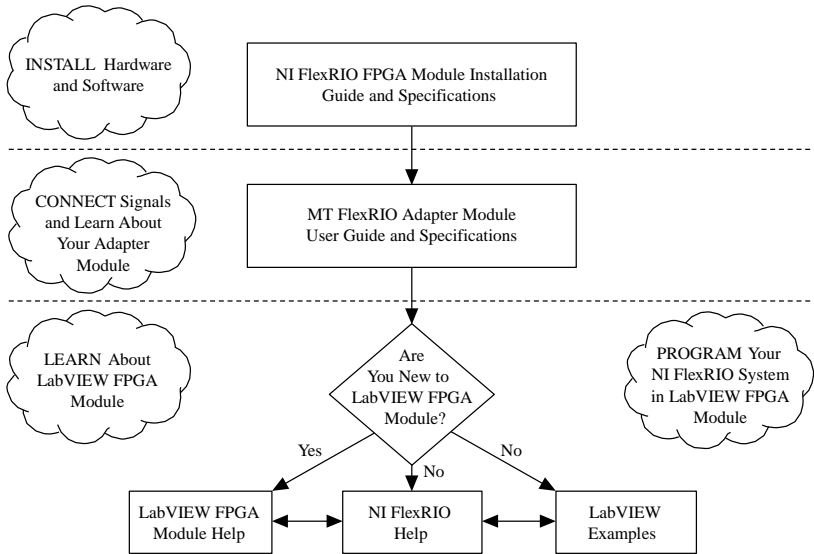
1. Use any shielded 50  $\Omega$  SMB cable to connect signals to the connectors on the front panel of your device.

## How to Use Your NI FlexRIO Documentation Set

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Refer to Figure 2 and Table 1 to learn how to use your FlexRIO documentation set.

**Figure 2.** How to Use Your NI FlexRIO Documentation Set.



**Table 1.** NI FlexRIO Documentation Locations and Descriptions

Document	Location	Description
<i>NI FlexRIO FPGA Module Installation Guide and Specifications</i>	Available from the Start menu and at <a href="http://ni.com/manuals">ni.com/manuals</a> .	Contains installation instructions for your NI FlexRIO system and specifications for your FPGA module.
<i>MT1116 User Manual and Specifications</i> (this document)	Available from at <a href="http://www.mush-tech.com/">www.mush-tech.com/</a>	Contains signal information, examples, CLIP details, and specifications for your adapter module.
<i>LabVIEW FPGA Module Help</i>	Embedded in <i>LabVIEW Help</i> and at <a href="http://ni.com/manuals">ni.com/manuals</a> .	Contains information about the basic functionality of the LabVIEW FPGA Module.
<i>NI FlexRIO Help</i>	Available from the Start menu and at <a href="http://ni.com/manuals">ni.com/manuals</a> .	Contains FPGA Module, adapter module, and CLIP configuration information.
LabVIEW Examples	Available in NI Example Finder.	Contains examples of how to run FPGA VIs and Host VIs on your device.

**Table 1.** NI FlexRIO Documentation Locations and Descriptions (Continued)

<b>Document</b>	<b>Location</b>	<b>Description</b>
IP Net	ni.com/ipnet	Contains LabVIEW FPGA functions and intellectual property to share.
NI FlexRIO product page	ni.com/flexrio	Contains product information and data sheets for NI FlexRIO devices.

## Key Features

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The MT1116 includes the following key features:

Instantaneous bandwidth ..... 1.2 GHz

DAC ..... 16-bit 1 channel at 2.5 GS/s  
(DC coupled Option 01); (AC coupled Option 02)

## Configuration

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You can configure the MT1116 as follows:

- Instantaneous bandwidth up to 1.2 GHz
- Differential transmitter channel, 16-bit, 2.5 GS/s

## Front Panel and Connector Pinouts

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Table 2 shows the front panel connector and signal descriptions for the MT1116.



**Caution** To avoid permanent damage to the MT1116, disconnect all signals connected to the MT1116 before powering down the module, and connect signals only after the adapter module has been powered on by the NI FlexRIO FPGA module




**Caution** Connections that exceed any of the maximum ratings of any connector on the MT1116 can damage the device and the chassis. NI is not liable for any damage resulting from such connections.

### Related Information

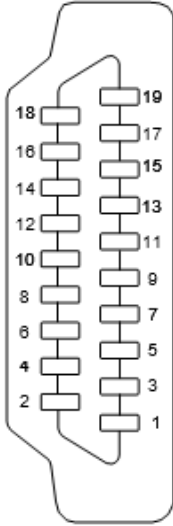
[MT1116 Specifications](#) on page 17

**Table 2.** Front panel connector and signal descriptions for the MT1116

Device Front Panel	Connector	Signal Description
 <p>The image shows the front panel of the MT1116 device. It features five connectors arranged vertically: a TRIG IN connector, a CLK IN connector, an AO 0+ connector, an AO 0- connector, and a DIO connector. The device is white with a vertical slot for the connectors.</p>	TRIG IN	Input connector for Trigger IN, 50 $\Omega$ single-ended, +20 dBm maximum
	CLK IN	Reference Clock input, 50 $\Omega$ single-ended, +20 dBm maximum
	AO 0+	Analog Output Channel 0, single-ended analog output channel
	AO 0-	Analog Output Channel 1, single-ended analog output channel
	DIO	Refer to Table 3 for the signal list and descriptions.

# DIO Connector

**Table 3.** MT1116 DIO Connector Pin Assignments

DIO Connector	Pin	Signal	Signal Description
	1	Port 0 (DIO 0)	Bidirectional single-ended (SE) digital I/O (DIO) data channel.
	2	GND	Ground reference for signals.
	3	Port 0 (DIO 1)	Bidirectional SE DIO data channel.
	4	Port 0 (DIO 2)	Bidirectional SE DIO data channel.
	5	GND	Ground reference for signals.
	6	Port 0 (DIO 3)	Bidirectional SE DIO data channel.
	7	Port 1 (DIO 0)	Bidirectional SE DIO data channel.
	8	GND	Ground reference for signals.
	9	Port 1 (DIO 1)	Bidirectional SE DIO data channel.
	10	Port 1 (DIO 2)	Bidirectional SE DIO data channel.
	11	GND	Ground reference for signals.
	12	Port 1 (DIO 3)	Bidirectional SE DIO data channel.
	13	Port 2 (DIO 0)	Bidirectional SE DIO data channel.
	14	+3.3 V	+3.3 V power (50 mA maximum).
	15	Port 2 (DIO 1)	Bidirectional SE DIO data channel.
	16	Port 2 (DIO 2)	Bidirectional SE DIO data channel.
	17	GND	Ground reference for signals.
	18	+3.3 V	+3.3 V power (50 mA maximum).
	19	Port 2 (DIO 3)	Bidirectional SE DIO data channel.



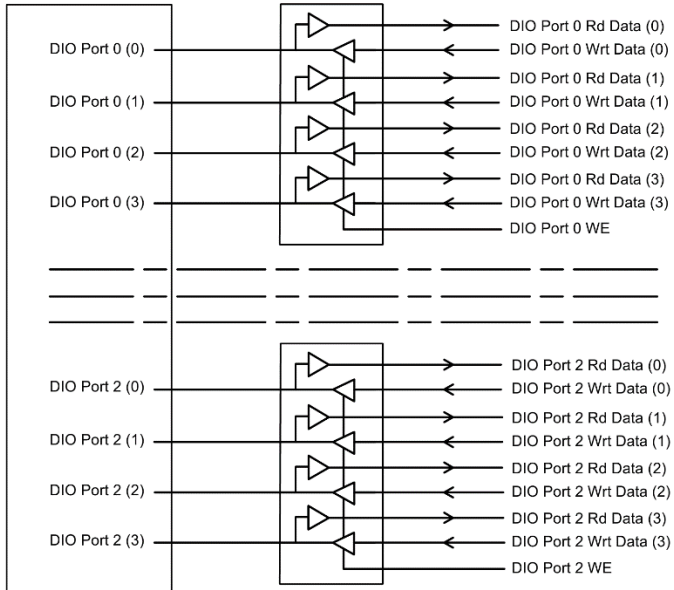
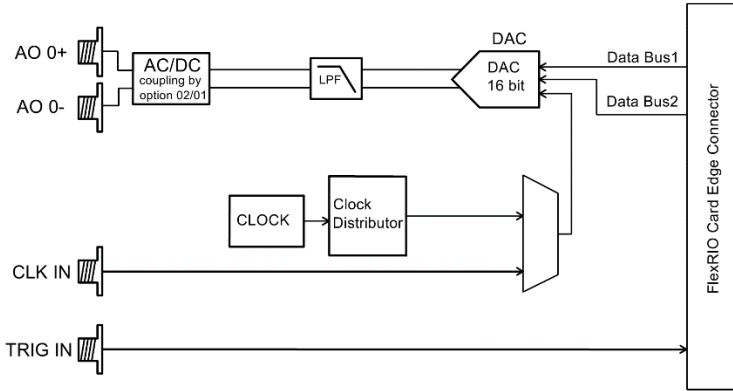
**Caution** The AUX I/O connector accepts a standard, third-party HDMI cable, but the AUX I/O port is not an HDMI interface. Do not connect the AUX I/O port on the MT1116 to the HDMI port of another device. MT is not liable for any damage resulting from such signal connections.



# Block Diagram

The following figure shows the MT1116 block diagram.

**Figure 3. MT1116 Block Diagram**



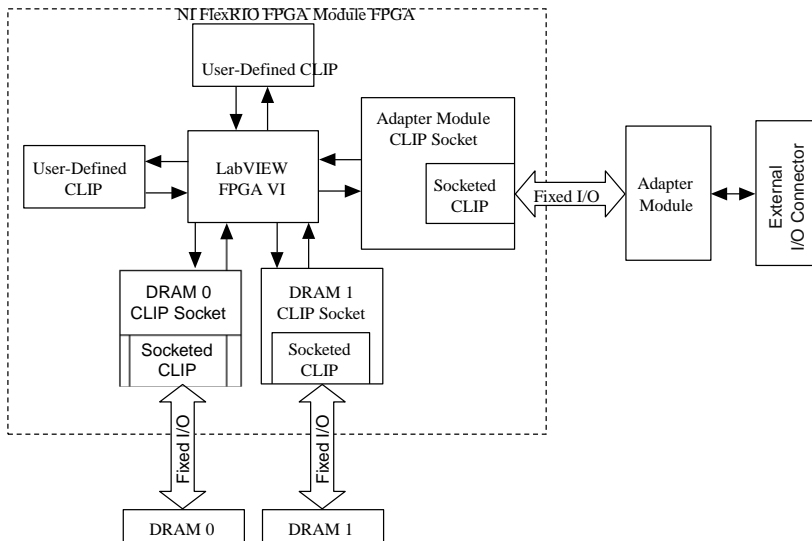
# MT1116 Component-Level Intellectual Property (CLIP)

The LabVIEW FPGA Module includes component-level intellectual property (CLIP) for HDL IP integration. NI FlexRIO devices support two types of CLIP: user-defined and socketed.

- *User-defined CLIP* allows you to insert HDL IP into an FPGA target, enabling VHDL code to communicate directly with an FPGA VI.
- *Socketed CLIP* provides the same IP integration of the user-defined CLIP, but also allows the CLIP to communicate directly with circuitry external to the FPGA. Adapter module socketed CLIP allows your IP to communicate directly with both the FPGA VI and the external adapter module connector interface.

The following figure shows the relationship between an FPGA VI and the CLIP.

**Figure 4. CLIP and FPGA VI Relationship**



The MT1116 ships with socketed CLIP items that add module I/O to the LabVIEW project.

# MT1116 CLIP

The MT1116 CLIP provides access to two receive channels and four transmit channels. The CLIP also provides a User Command interface for common configurations of the baseband clocking.

Configure the baseband clocking using one of the following settings:

- Internal Sample Clock
- Internal Sample Clock locked to an external Reference Clock through the CLK IN connector
- External Sample Clock through the CLK IN connector
- Internal Sample Clock locked to an external Reference Clock through the Sync Clock

This CLIP also contains a SPI interface, which directly programs registers on all programmable devices, such as the digital-to-analog converter (DAC). Programming registers on these devices allows for more advanced configuration.

# Using Your MT1116 with a LabVIEW FPGA

## Example VI

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**Note** You must install the software before running this example. Refer to the *NI FlexRIO FPGA Installation Guide and Specifications* for more information about installing your software.

The NI FlexRIO Adapter Module Support software includes an example project to help you get started creating your LabVIEW FPGA application. This section explains how to use an existing LabVIEW FPGA example project to generate and acquire samples with the MT1116. This example requires at least one SMA cable for connecting signals to your MT1116.



**Note** The examples available for your device are dependent on the version of the software and driver you are using. For more information about which software versions are compatible with your device, visit [ni.com/info](http://ni.com/info), enter `rdsoftwareversionin` in the text field, and click the NI FlexRIO link in the results.

The MT1116 example project includes the following components:

- A LabVIEW FPGA VI that can be compiled and run on the FPGA embedded in the hardware
- At least one VI that runs on Windows and interacts with the LabVIEW FPGA VI



**Note** In the LabVIEW FPGA Module software, NI FlexRIO adapter modules are referred to as *IO Modules*.

## Using the Included Streaming Example

Complete the following steps to run an example that acquires a waveform using the MT1116.

1. Connect a scope to the AO 0+ connector on the front panel of the MT1116.
2. Launch LabVIEW.
3. Select **File»Open Project**.
4. Navigate to <labview>\examples\instore\MT1116\Getting Started.
5. Select **MT1116 Getting Started.lvproj**.
6. In the **Project Explorer** window, select **MT1116 Getting Started (Host).vi** under **My Computer** to open the host VI. The Open FPGA VI Reference function in this VI uses the NI 7965R as the FPGA target by default. If you are using an NI FlexRIO FPGA module other than the NI 7965R, complete the following steps to change to the FPGA VI to support your target.
  - a) On the block diagram, right-click the Open FPGA VI Reference (PXI-7965R) function and select **Configure Open FPGA VI Reference**.
  - b) In the **Configure Open FPGA VI Reference** dialog box, click the **Browse** button next to the **Bitfile** button.
  - c) In the **Select Bitfile** dialog box that opens, select the bitfile for your desired target. The bitfile name is based on the adapter module, example type, and FPGA module.
  - d) Click the **Select** button.
  - e) Click **OK** in the **Configure Open FPGA VI Reference** dialog box.
  - f) Save the VI.
7. On the front panel, in the **RIO Device** pull-down menu, select an MT1116 resource that corresponds with the target configured in step 6.
8. Click the **Run** button to run the VI.
9. The VI acquires data and displays the captured waveform on the **Timing Diagram and Power Spectrum** graphs.
10. Click the **STOP** button to stop the VI.
11. Close the VI.

## Creating a LabVIEW Project

This section explains how to set up your target and create an FPGA VI and host VI for data communication. This section focuses on proper project configuration, proper CLIP configuration, and how to access MT1116 I/O nodes.

### Creating a Project

1. Launch LabVIEW, or if LabVIEW is already running, select **File»Create Project**.
2. In the **Create Project** dialog box, select **LabVIEW FPGA Project** and click **Finish**.
3. Select **FlexRIO on My Computer** and click **Next**.

4. Either discover a LabVIEW FPGA target in your system or create a new system and specify an FPGA target for which to construct a project.
5. Click **Finish** in the **Project Preview** dialog box.
6. Click **File»Save** and specify a name for the project.

## Creating an FPGA Target VI

1. In the **Project Explorer** window, expand **FPGA Target**.
2. Right-click **IO Module** in the **Project Explorer** window and select **Properties**.
3. Select **Enable IO Module**.
4. Select the MT1116 from the **IO Module** list. The available CLIP for the MT1116 is displayed in the **Component Level IP** pane.
5. Select MT1116 in the **Name** list of the **Component Level IP** pane.
6. Right-click **FPGA Target** and select **New»FPGA Base Clock**.
7. In the **Resource** pull-down menu, select **IO Module Clock 0** and click **OK**.
8. Right-click **FPGA Target** and select **New»FPGA Base Clock**.
9. In the **Resource** pull-down menu, select **IO Module Clock 1** and click **OK**.



**Note** Configuring these clocks is required for proper CLIP operation. Refer to the MT1116 CLIP topics in the *NI FlexRIO Help* for more information about configuring your clocks.

10. Select **File»Open** and select <labview>\examples\instr\MT1116\Getting Started\MT1116 FPGA.vi.
11. Select **File»Save As**.
12. Select **Copy»Open Additional Copy** and check **Add Copy to <your project name>.lvproj**.
13. Select the destination folder for the new file, specify a file name, and click **OK**. Use this FPGA VI with the MT1116 Configuration Design Library.
14. Add any FPGA code, controls, and indicators that you need. Refer to MT1116 Getting Started.lvproj for example FPGA code, controls, and indicators.
15. Click the **Run** button. LabVIEW creates a default build specification and begins compiling the VI. The **Generating Intermediate Files** window displays the code generation process. The **Compilation Status** window displays the progress of the compilation. The compilation takes several minutes.
16. Click **Close** in the **Compilation Status** window.
17. Save and close the VI.
18. Save the project.

## Creating a Host VI

1. In the **Project Explorer** window, right-click **My Computer** and select **New»VI** to open a blank VI.
2. Select **Window»Show Block Diagram** to open the VI block diagram.
3. Add the Open FPGA VI Reference function from the FPGA Interface palette to the block diagram.
4. Right-click the Open FPGA VI Reference function and select **Configure Open FPGA VI Reference**.
5. In the **Configure Open FPGA VI Reference** dialog box, select **VI** in the **Open** section.
6. In the **Select VI** dialog box, select your project under your device and click **OK**.
7. Click **OK** in the **Configure Open FPGA VI Reference** dialog box. The target name appears under the Open FPGA VI Reference function in the block diagram.
8. Select **File»Open** and select <labview>\instr.lib\MT1116\
9. Add any VIs from this folder that you need.
10. Open the FPGA Interface palette.
11. Add any Read/Write Control or Invoke Method nodes necessary to configure and communicate with your FPGA VI.
12. Add the Close FPGA VI Reference function to your block diagram.
13. Wire the FPGA VI Reference function to the Close FPGA VI Reference function.
14. Save and close the VI.
15. Save the project.

## Run the Host VI

1. Open the front panel of your host VI.
2. Click the **Run** button to run the VI.

# MT1116 Configuration Design Library

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The MT1116 Configuration Design Library consists of host and FPGA VIs that provide an interface to configure the hardware on the MT1116.

The library allows you to perform the following actions:

- Configure the RF signal path
- Read from and write to the EEPROM
- Configure the clocks
- Reinitialize the CLIP
- Query for CLIP errors

The MT1116 Configuration Design Library relies on the Register Bus Design Library. The Register Bus provides a packet-based configuration interface which exposes all of the address spaces of the configurable chips and subsystems of the adapter module, without requiring hundreds of controls and indicators on your FPGA VI front panel.

The MT1116 Configuration Design Library host VIs all require a register bus object for the device you want to configure.

## FPGA VI Requirements

Copy all the controls, indicators, and FPGA logic required to use the MT1116 Configuration Design Library from the following VI: <labview>\instr.lib\MT1116\MT1116 Open .vi. The FAM Support installer installs this VI on your system.

Configure your FPGA target to contain a memories with the following configuration.

- Names: DAC Memory - CH0 / DAC Memory – CH1 / DAC Memory – CH2 / DAC Memory – CH3
- Requested number of elements: 65536
- Data type: U16
- Interface A Arbitration: Arbitrate if multiple requestors only
- Interface B Method: Write
- Interface B Arbitration: Arbitrate if multiple requestors only

## Host VI Requirements

Configure your host VI to use the MT1116 Configuration Design Library using the following configuration:

1. Create a Register Bus object for your device and initialize the session using MT1116 Open.vi.
2. Use any of the MT1116 Configuration Design Library Host VIs using the Register Bus object returned by the MT1116 Open VI.
3. To access the Host VIs, select **Functions» Instrument I/O» Instrument Drivers» MT1116**.
4. Close the session using the MT1116 Close VI.



# Clocking

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The MT1116 clock source controls the sample rate and other timing functions on the device. The following table contains information about the possible MT1116 clock sources.

**Table 5.** MT1116 Clock Sources

Clock	Frequency	Source Options
Sample Clock	2.5 GHz	• Free-running and internally sourced
Reference Clock	2.5 GHz	• External through the CLK IN front panel connector

## MT1116 Specifications

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Specifications are warranted by design and under the following conditions unless otherwise noted:

- Chassis fan speed is set to High. In addition, NI recommends using slot blockers and EMC filler panels in empty module slots to minimize temperature drift.
- The MT1116 uses NI LabVIEW and LabVIEW FPGA software.

*Specifications* describe the warranted product performance over ambient temperature ranges of 0 °C to 55 °C, unless otherwise noted.

Specifications are subject to change without notice.

*Typical* values describe useful product performance beyond specifications that are not covered by warranty and do not include guard bands for measurement uncertainty or drift. Typical values may not be verified on all units shipped from the factory. Unless otherwise noted, typical values cover the expected performance of units over ambient temperature ranges of 23 °C ± 5 °C with a 90% confidence level, based on measurements taken during development or production.

*Nominal* values (or supplemental information) describe additional information about the product that may be useful, including expected performance that is not covered under *Specifications* or *Typical* values. Nominal values are not covered by warranty.

### Related Information

[Front Panel and Connector Pinouts](#) on page 6

[Connecting Cables](#) on page 4

[MT1116 User Manual and Specifications](#) on page 1

# AO Front Panel Connectors

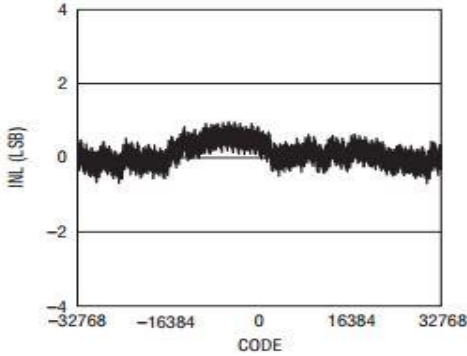
## Amplitude Range

AO output range .....2 Vp-p differential or 1 Vp-p single ended, DC coupled

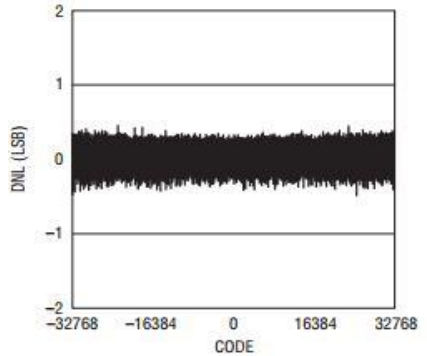
## Typical Characteristics



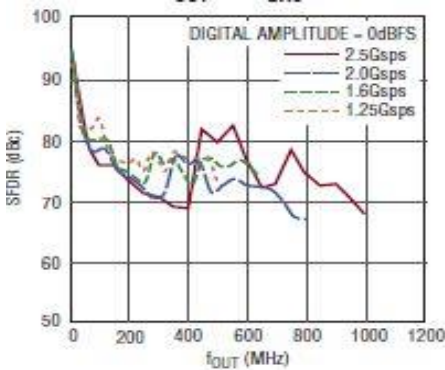
**Note** All values are typical.



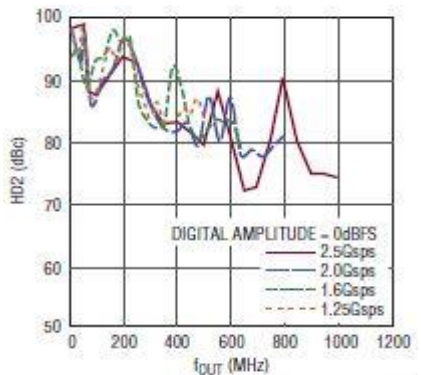
**Figure 5.** Integral Nonlinearity



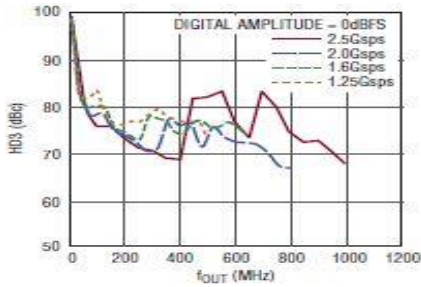
**Figure 6.** Differential Nonlinearity



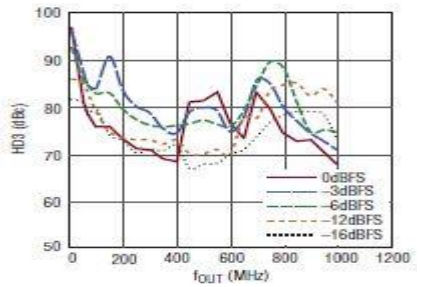
**Figure 7.** SFDR vs Output Frequency Over Input Scale



**Figure 8.** Second Harmonic Distortion vs Output Frequency Over Input Scale



**Figure 9.** Third Harmonic Distortion vs Output Frequency Over Input Scale



**Figure 10.** IMD3 vs Output Frequency Over Input Scale

## CLK IN Front Panel Connector

### Frequency

Reference Clock ..... 2.5 GHz

Sample Clock ..... 2.5 GHz

### Amplitude

Square ..... 0.7 V<sub>pk-pk</sub> to 5.0 V<sub>pk-pk</sub> into 50 Ω, typical

Sine ..... 1.4 V<sub>pk-pk</sub> to 5.0 V<sub>pk-pk</sub> (1 V<sub>RMS</sub> to 3.5 V<sub>RMS</sub>)  
into 50 Ω, typical

Input impedance ..... 50 Ω, nominal

Coupling ..... AC

## Baseband Characteristics

### DAC

Resolution ..... 16 bits

Data rate ..... 2.5 GS/s

Samples per cycle ..... 1

## Dimensions and Weight

Dimensions ..... 12.9 × 2.0 × 12.1 cm (5.1 × 0.8 × 4.7 in)

Weight ..... 413 g (14.6 oz)

I/O ..... AO 0+, AO 0-, CLK IN

Power ..... 3 W, nominal

# DIO (DIO <0..11>, and +3.3 V power)

## General Characteristics

Number of channels .....	12 bidirectional (12 DIO and 2 Pw)
Connector type .....	HDMI
Interface standard .....	3.3 LVCMOS
Interface logic	
Maximum $V_{IL}$ .....	0.8 V
Minimum $V_{IH}$ .....	2.0 V
Maximum $V_{OL}$ .....	0.4 V
Minimum $V_{OH}$ .....	2.7 V
Maximum $V_{OH}$ .....	3.6 V
$Z_{OUT}$ .....	50 $\Omega \pm 20\%$
$I_{OUT}$ (DC) .....	$\pm 2$ mA
Pull-down resistor .....	150 k $\Omega$
Recommended operating voltage .....	-0.3 V to 3.6 V Overvoltage protection .....
	$\pm 10$ V
Maximum toggle frequency .....	6.6 MHz
+3.3 V maximum cur.....	100 mA
+3.3 V voltage tolerance .....	3.2 V to 3.4 V

## Operating Environment

Ambient temperature range .....0 °C to 55 °

Relative humidity range .....10% to 90%, noncondensing

## Storage Environment

Ambient temperature range .....-40 °C to 70 °C

Relative humidity range .....5% to 95%, noncondensing

Operational shock .....30 g peak, half-sine, 11 ms pulse

Random vibration

    Operating .....5 Hz to 500 Hz, 0.3 g<sub>rms</sub>

    Nonoperating .....5 Hz to 500 Hz, 2.4

## Where to Go for Support

The Mush Technologies Web site is your complete resource for technical support. At <http://MUSH-TECH.com/> you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from MT Application Engineers.

Mush Technologies corporate headquarters is located at 123 Hovsep Emin Street, EIF entrance, Yerevan, 0051, Armenia, Phone: +37410 21 97 26.