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DATA SHEET

Aero Software Package

for InfiniiVision X-Series Oscilloscopes

The Aero Software Package for Keysight's InfiniiVision oscilloscopes enables protocol triggering and decode for the MIL-STD 1553 and ARINC 429 serial buses. This package also enables other advanced analysis capabilities including eye-diagram mask testing and frequency response analysis (FRA) to help test and debug electronic systems found in the aerospace & defense industries.

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Introduction

The primary reason engineers use oscilloscopes to debug and characterize serial buses, such as MIL-STD 1553 and ARINC 429 is because of an oscilloscope's inherent ability to characterize the analog quality of these signals. Performing analog characterization using an oscilloscope is often referred to as "physical layer" measurements. Table 1 lists the specific measurement capabilities that are enabled on each series with the Aero Software Package for Keysight Technologies InfiniiVision X-Series oscilloscopes.

Table 1. Aero Software Packages for InfiniiVision Oscilloscopes

InfiniiVision X-Series		3000A	3000T	4000A	6000A	P9240	M9240
Aero Package Model Number		D3000AERB	D3000AERB	D4000AERB	D6000AERB	P9240AERC	M9240AERB
Serial Trigger & Decode	MIL-STD 1553	✓	✓	✓	✓	✓	✓
	ARINC 429	✓	✓	✓	✓	✓	✓
Advanced Analysis	Mask Limit Test	✓	✓	✓	✓	✓	✓
	Measurement Limit Test		✓	✓	✓	✓	✓
	Frequency Response Analysis (Bode plots)		✓	✓	✓	✓	✓
	Enhanced HDTV Video Triggering & Analysis	✓	✓	✓	✓	✓	✓
	Advanced Math	✓	Std	Std	Std	Std	Std

Although there are many oscilloscopes on the market today from multiple vendors that offer aero-focused options, Keysight's InfiniiVision X-Series oscilloscopes offer some unique measurement capabilities for debugging and characterizing the physical layer of aerospace/defense serial buses including:

- MIL-STD 1553 trigger and decode
- MIL-STD 1553 eye-diagram mask testing
- ARINC 429 trigger and decode
- ARINC 429 eye-diagram mask testing
- Dual-bus time-interleaved protocol lister display
- Hardware-based decoding for responsiveness
- Decoding of all frames captured using segmented memory

To learn more about these advanced measurement capabilities, refer to the list of Keysight aero-focused application notes listed at the end of this document.

Figure 1 shows an example of triggering on and decoding two lanes of Manchester-encoded MIL-STD 1553 bus traffic consisting of command words from the bus controller and status and data word responses from remote terminals.

Figure 1. Capturing and decoding two lanes of MIL-STD 1553 bus traffic.

MIL-STD 1553 Trigger and Decode

Table 2. MIL-STD 1553 Performance Characteristics

MIL-STD 1553 input source	Analog channels 1, 2, 3 or 4 (using a differential active probe)
Triggering	Data word start
	Data word stop
	Command/status word start
	Command/status word stop
	Remote terminal address (hex)
	Remote terminal address (hex) + 11 bits (binary)
	Parity error
	Sync error
	Manchester error
Color-coded, hardware-accelerated decode	Base: HEX or binary
	Command or status word (“C/S” in green)
	Remote terminal address (hex or binary digits in green)
	11 Bits following RTA (hex or binary digits in green)
	Data word (“D” in white)
	Data word bits (hex or binary digits in white)
	Parity error (all decoded text in red)
	Synchronization error (“Sync” in red)
	Manchester error (“Manch“ in red)
Eye-diagram mask testing (downloadable mask files available at no charge)	System xfmr-coupled input
	System direct-coupled input
	BC xfmr-coupled input
	BC direct-coupled input
	RT xfmr-coupled input
MIL-STD 1553 input source	MIL-STD 1553 plus one other serial bus, (including another MIL-STD 1553 bus)

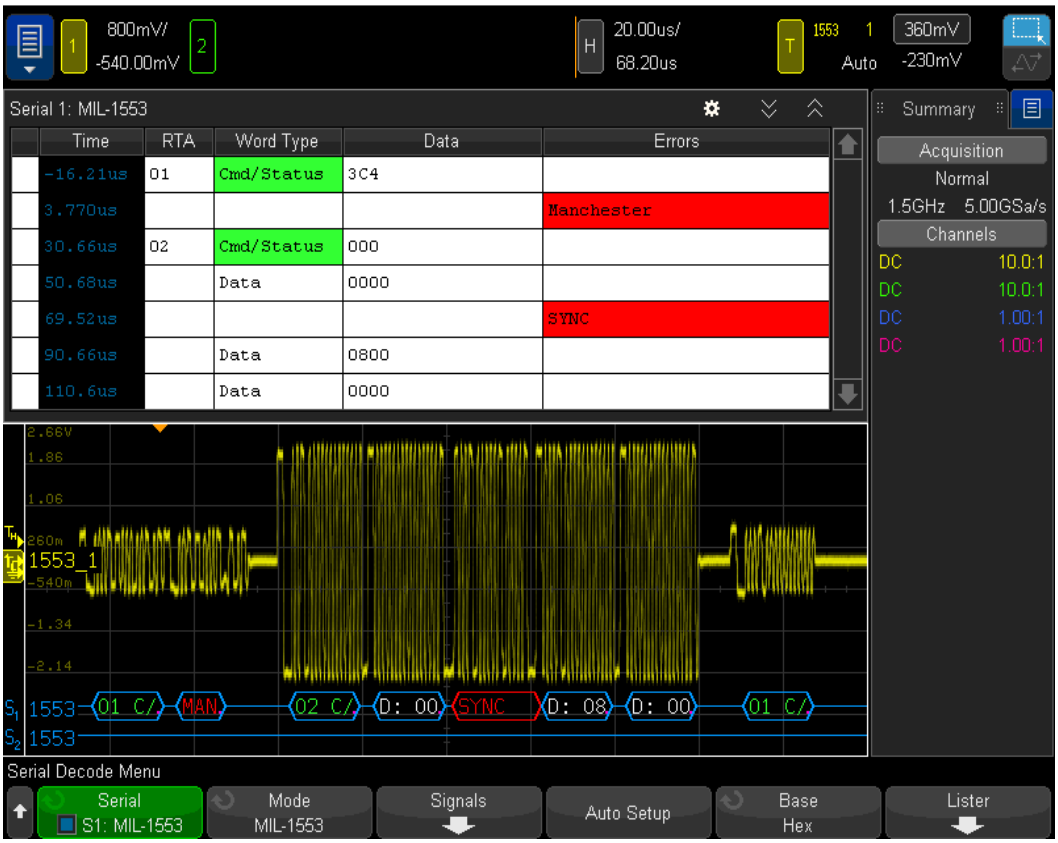

Figure 2. MIL-STD 1553 decode on an InfiniiVision X-Series oscilloscope.

ARINC 429 Trigger and Decode

Table 3. ARINC 429 Performance Characteristics

ARINC 429 input source	Analog channels 1, 2, 3 or 4 (using a differential active probe)
Baud rates	High (100 kbps)
	Low (12.5 kbps)
Triggering	Word start
	Word stop
	Label (octal)
	Label (octal) + bits (binary)
	Label range (octal)
	Parity error
	Word error
	Gap error
	Word or gap error
	All errors
	All bits (useful for eye-diagram testing)
	All 0 bits
	All 1 bits
Color-coded, hardware-accelerated decode	Word format: Label/SDI/data/SSM or label/data/SSM or label/data
	Label (octal digits in yellow)
	SDI (binary digits in blue)
	Data (hex or binary digits in white)
	SSM (binary digits in green)
	Errors (text in red)
Totalize function	Total errors
	Total words
	100 kbps eye test
Eye-diagram and pulse mask testing (requires DSOX3MASK plus downloadable mask files)	100 kbps 1's test
	100 kbps 0's test
	100 kbps null test
	12.5 kbps eye test
	12.5 kbps 1's test
	12.5 kbps 0's test
	12.5 kbps null test
Multi-bus analysis	ARINC 429 plus one other bus (including another ARINC 429 bus)

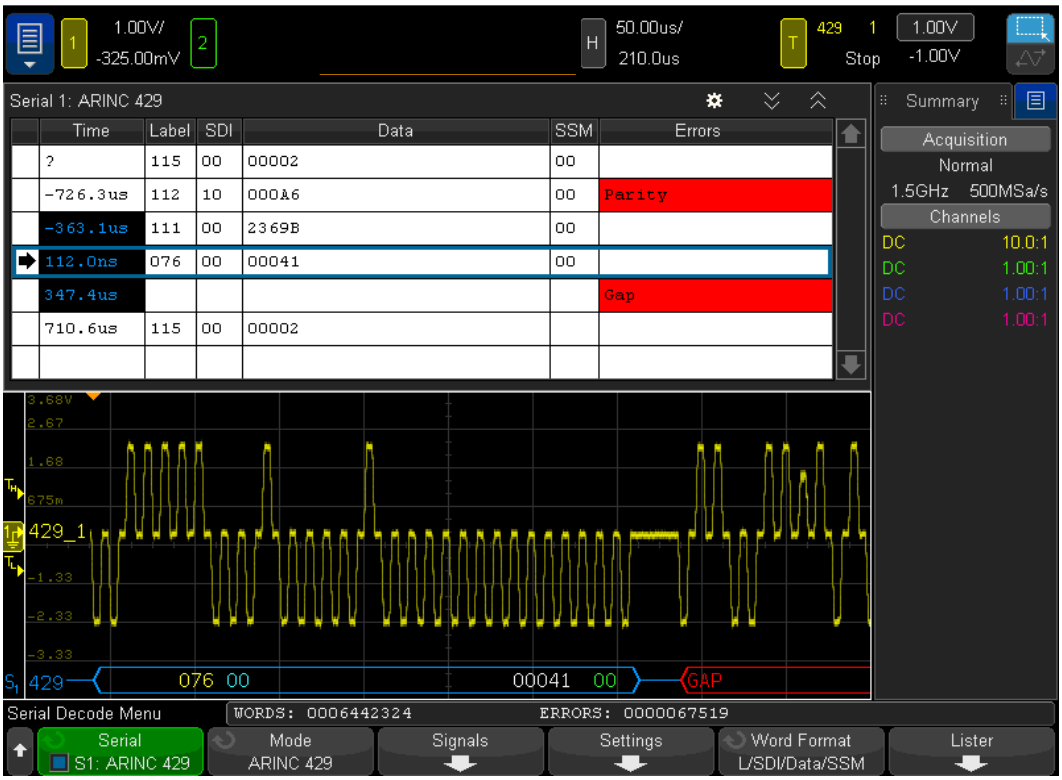

Figure 3. ARINC 429 decode on an InfiniiVision X-Series oscilloscope.

Mask Testing (Pass/fail waveform limits)

If you need to validate the quality and stability of your electronic components and systems, the InfiniiVision oscilloscope's mask/waveform limit testing capability, which is enabled with the Aero Software Package, can save you time and provide pass/fail statistics almost instantly. Mask testing offers a fast and easy way to test your signals to specified standards, as well as the ability to uncover unexpected signal anomalies, such as glitches. Mask testing on other oscilloscopes is usually based on software-intensive processing technology, which tends to be slow.

The InfiniiVision scope's mask testing is based on hardware technology, meaning that they can perform up to 270,000 real-time waveform pass/fail tests per second. This makes your testing throughput orders of magnitude faster than you can achieve on other oscilloscope mask test solutions.

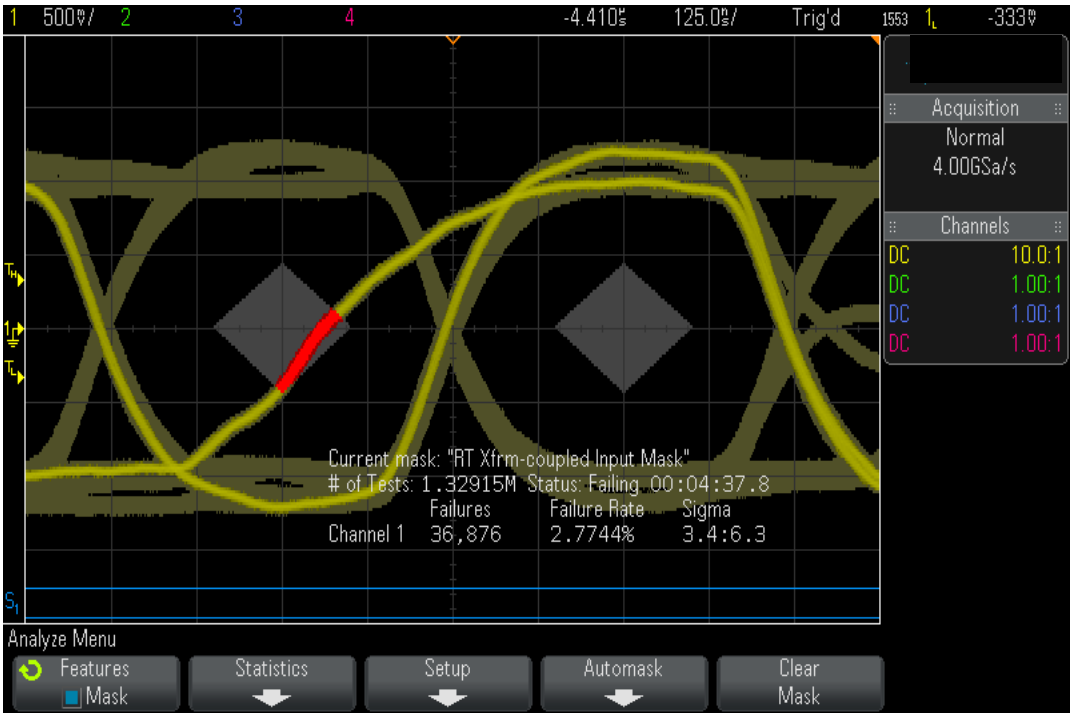

Figure 4. MIL-STD 1553 eye-diagram mask test.

Features

- Test up to 270,000 waveforms per second with the industry's fastest hardware-accelerated mask testing technology
- Automatic mask creation using input standard
- Easily download multi-region masks and setups based on industry standards (MIL-STD 1553 and ARINC eye-diagram and pulse-shape mask files available for download at no charge)
- Detailed pass/fail statistics
- Test to high-quality standards based on sigma
- Multiple user-selectable test criteria

Table 4. Mask Test Performance Characteristics

Mask test source	Analog channels 1, 2, 3, or 4
Maximum test rate	2000 X-Series: Up to 50,000 waveforms tested per second
	3000 and 4000 X-Series: Up to 270,000 waveforms tested per second
	6000 X-Series: Up to 130,000 waveforms tested per second
Acquisition modes	Real-time sampling–non-averaged, Real-time sampling–averaged
Mask creation	
• Automask-divisions	± X divisions, ± Y divisions
• Automask-absolute	± X seconds, ± Y volts
• Mask file import	Up to 8 failure regions (created in text editor)
Mask scaling	Source lock on (mask automatically re-scales with scope settings)
	Source lock off (mask scaling fixed relative to display when loaded or created)
Test criteria	Run until forever, Minimum number of tests, Minimum time, Minimum sigma
Action on error	Stop acquisitions, save image, print, perform measurements
Trigger output	On failure
Statistics display	Number of tests, Number of failures (for each channel tested), Failure rate (for each channel tested), Test time (hours – minutes – seconds), Sigma (actual versus maximum without failures)
Display formats	Mask – translucent gray, failing waveform segments – red, Passing waveform segments – channel color
Save/recall	4 non-volatile internal registers (.msk format), USB memory stick (.msk format)

Frequency Response Analysis (Bode gain and phase plots)

Frequency Response Analysis (FRA) is often a critical measurement used to characterize the frequency response (gain and phase versus frequency) of a variety of today's electronic designs, including passive filters, amplifier circuits, and negative feedback networks of switch mode power supplies (loop response). FRA capability is included in the Aero Software Package. This frequency-domain measurement capability is achieved with a swept gain and phase measurement versus frequency (Bode plot). The InfiniiVision oscilloscope uses the scope's built-in waveform generator (WaveGen) to stimulate the circuit under test at various frequency settings and then captures the input and output signals using two channels of the oscilloscope. At each test frequency, the scope measures, computes, plots gain ($20\text{Log}V_{OUT}/V_{IN}$) logarithmically and phase linearly.

- Dynamic range: > 80 dB (typical)
- Frequency range: 10 Hz to 20 MHz
- Sweep or single frequency test modes
- Fixed test amplitude or custom Amplitude Profile
- 60 to 1000 points across Start/Stop sweep range
- Two pair of tracking gain and phase markers
- Plots gain and phase and tabular view of test results
- Easily export and/or save measurement results in .csv format for offline analysis

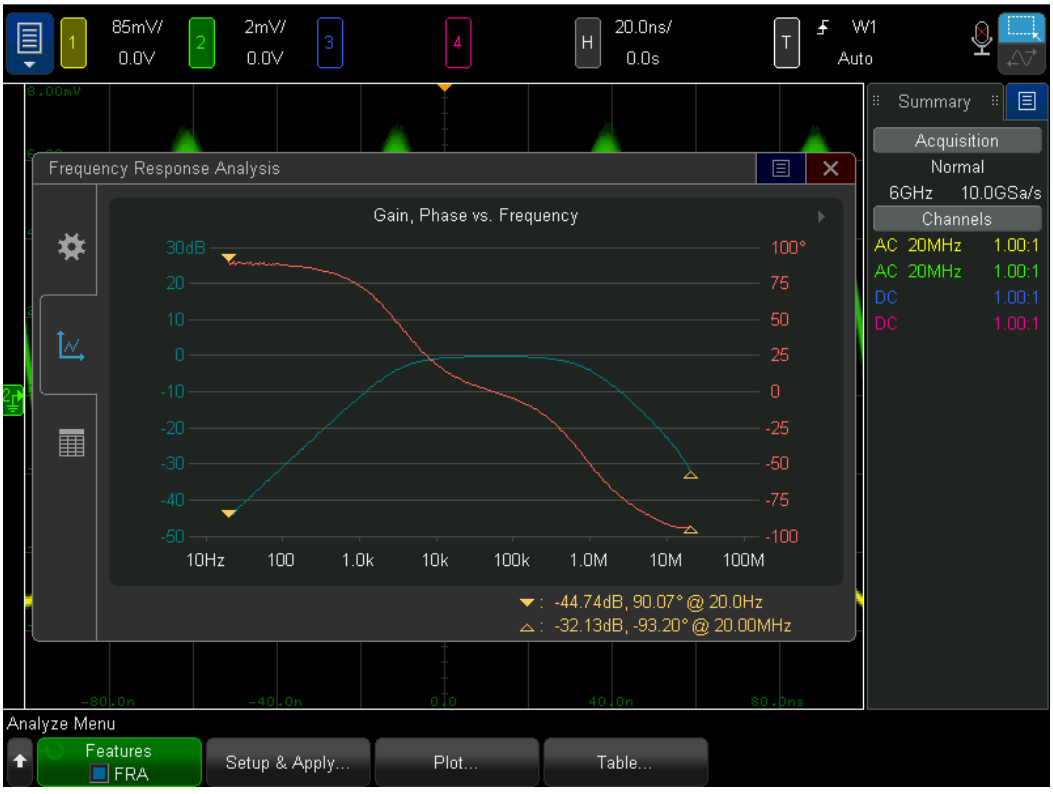

Figure 5. Frequency response analysis (gain and phase) on a bandpass filter.

Table 5. Frequency Response Analysis Performance Characteristics

	Frequency Response Analysis	
Frequency mode	Sweep or single	
Frequency range	10 Hz to 20 MHz	
Test amplitude modes	Fixed or amplitude profile	
Test amplitude range	3000T	10 mVpp to 2.5 Vpp into 50-Ω load
		20 mVpp to 5.0 Vpp into high impedance load
	4000A/6000A	10 mVpp to 5.0 Vpp in 50-Ω load
		20 mVpp to 10.0 Vpp into high impedance load
Input and output sources	Channel 1, 2, 3, and 4	
Number of test points	60 to 1000 points across Start/Stop sweep range	
Test results	Overlaid gain and phase plot and tabular view	
Dynamic range	> 80 dB (typical) based on 0 dBm (630 mVpp) input into 50-Ω load	
Measurements	Dual pair of tracking gain and phase markers	
Plot scaling	Auto-scaled during test and manual setting after test	

Enhanced HDTV Video Triggering and Analysis

Whether you are debugging consumer electronics with HDTV or characterizing a design, the enhanced HDTV video triggering and analysis capabilities that's included in the Aero Software Package provides support for a variety of HDTV standards for triggering and analysis. This enhanced video measurement capability supports a video IRE display grid with cursor measurements performed in video IRE units for NTSC and PAL standards. In addition, enhanced video analysis provides an array of additional HDTV triggering standards that will help speed debug and characterization for engineers working on HDTV video applications.

Enhanced video analysis provides triggering on an array of HDTV standards, including:

- 480p/60, 567p/50, 720p/50, 720p/60
- 1080i/50, 1080i/60
- 1080p/24, 1080p/25, 1080p/30, 1080p/50, 1080p/60
- Generic (custom bi-level and tri-level sync video standards)

Note that InfiniiVision X-Series oscilloscopes already come standard with NTSC, PAL, PAL-M, and SECAM support.

Figure 6. Triggering on 1080p HDTV.

Advanced Waveform Math (3000A X-Series only)

Advanced waveform math functions come standard on all models of the InfiniiVision X-Series oscilloscopes except for the 3000A Series. Refer to the appropriate InfiniiVision X-Series oscilloscope data sheet to see a complete list of standard waveform math functions on each model. When licensed with Aero Software Package, advanced waveform math functions are also enabled on the InfiniiVision 3000A Series oscilloscope.

The Keysight 3000A X-Series oscilloscopes come standard with the following waveform math functions:

- Add
- Subtract
- Multiply
- Divide
- Integrate
- Differentiate
- Square Root
- FFT

The Aero Software Package adds the following waveform math functions on the Keysight 3000A X-Series:

- Ax + B
- Square
- Absolute
- Common Logarithm
- Natural Logarithm
- Exponential
- Base 10 Exponential
- Low-pass Filter
- High-pass Filter
- Measurement Trend
- Magnify
- Chart Logic Bus Timing
- Chart Logic Bus State

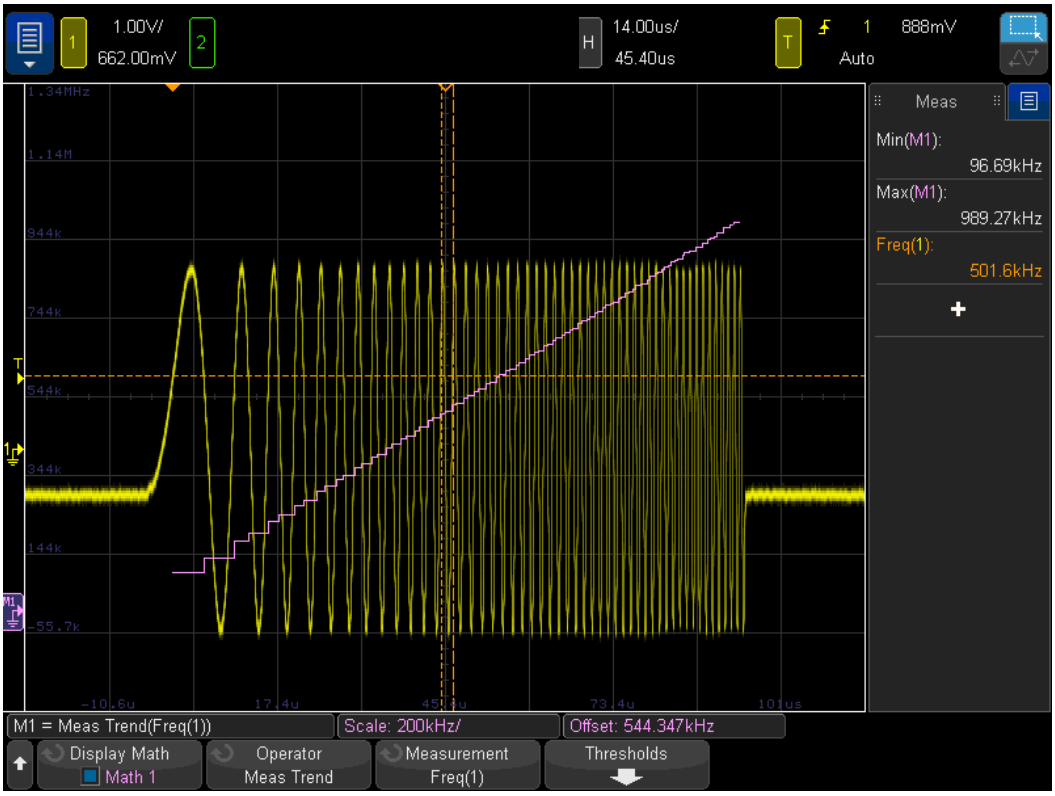

Figure 7. Measurement trend math function used to plot frequency versus time of a FM burst.

Probing Differential Serial Buses

Many of today's serial buses are based on differential signaling including MIL-STD 1553 and ARINC 429. Keysight offers a wide range of differential active probes compatible with the InfiniiVision X-Series oscilloscopes for various bandwidth and dynamic range applications. Table 6 shows the differential probes that Keysight recommends for each of the listed differential serial buses.

Figure 8. Keysight's N2818A 200-MHz differential active probe.

Table 6. Recommended probes for MIL-STD 1553 and ARINC 429 differential buses

Differential bus (max bit rate)	N2791A (25-MHz bandwidth)	N2818A (200-MHz bandwidth)
MIL-STD 1553 (1 Mbps)	X	X
ARINC 429 (100 kbps)	X	X

Extreme Temperature Probing

When probing differential signals inside environmental chambers at extreme temperatures, Keysight offers the N7013A extreme temperature extension kit shown in Figure 9. The N7013A is compatible with the N2791A and N2818A differential probes and can operate in temperatures ranging from –40 to +85 °C. To learn more about Keysight's extreme temperature probing solutions, refer to the Extreme Temperature Probing Solutions selection guide (publication number 5991-3504EN) listed at the end of this document.

Figure 9. Extreme temperature probing kit.

Related Literature

Table 7. Related literature

Publication title	Publication number
Debugging MIL-STD 1553 Serial Buses	5990-9167EN
MIL-STD 1553 Eye-diagram Mask Testing – Application Note	5990-9324EN
Oscilloscopes in Aerospace/Defense Debugging ARINC 429 Serial Buses - Flyer	5990-9139EN
ARINC 429 Eye-diagram and Pulse-shape Mask Testing - Application Note	5990-9325EN
Segmented Memory for Serial Bus Applications - Application Note	5990-5817EN
InfiniiVision 3000T X-Series Oscilloscopes - Data Sheet	5992-0140EN
InfiniiVision 4000 X-Series Oscilloscopes - Data Sheet	5991-1103EN
InfiniiVision 6000 X-Series Oscilloscopes - Data Sheet	5991-4087EN
M924XA InfiniiVision PXIe Modular Oscilloscopes - Data Sheet	5992-2003EN
P924XA InfiniiVision USB Oscilloscopes - Data Sheet	5992-2897EN
InfiniiVision Oscilloscope Probes and Accessories - Selection Guide	5968-8153EN
Extreme Temperature Probing Solutions - Data Sheet	5990-3504EN
N2792A/N2818A 200 MHz and N2793A/N2819A 800 MHz Differential Probes – Data Sheet	5990-4753EN

Ordering Information

Table 8. Aero Software Package model numbers

InfiniiVision Series	Aero Software Package
3000 X-Series	D3000AERB
4000 X-Series	D4000AERB
6000 X-Series	D6000AERB
P9240 Series	P9240AERC
M9240 Series	M9240AERB

Table 9. Recommended probing solutions

Recommended probes and accessories	Model number
25 MHz differential active probe	N2791A
200 MHz differential active probe	N2818A
Extreme temperature probing kit	N7013A