

# Keysight Technologies

## MIL-STD 1553 Eye-diagram Mask Testing

Application Note





## Introduction

Eye-diagram mask testing is used in a broad range of today's serial bus applications. An eye-diagram is basically an overlay of all bits captured by the scope to show when bits are valid and not valid. This provides a composite picture of the overall quality of a system's physical layer characteristics, which includes amplitude variations possibly due to transmission line effects, reflections, system noise, over-shoot, ringing, signal edge timing, and jitter.

Eye-diagram mask testing can be performed on differential MIL-STD 1553 signals using the Keysight Technologies, Inc. 3000, 4000 or 6000 X-Series oscilloscope licensed with the DSOX3AERO/DSOX4AERO/DSOX6AERO triggering and decode option (MIL-STD 1553 & ARINC 429), along with the DSOX3MASK/DSOX4MASK/DSOX6MASK mask test option. Various MIL-STD 1553 mask files can be downloaded from Keysight's website at no charge. Save the appropriate MIL-STD 1553 mask files to your personal USB memory stick and then insert the memory stick into the scope's front-panel USB port. The following MIL-STD 1553 mask files are available:

- System xfmr-coupled Input Mask – .msk
- BC xfmr-coupled Input Mask – .msk
- RT xfmr-coupled Input Mask – .msk
- System direct-coupled Input Mask – .msk
- BC direct-coupled Input Mask – .msk
- RT direct-coupled Input Mask – .msk

## Probing the Differential MIL-STD 1553 Bus

MIL-STD 1553 eye-diagram mask testing is based on capturing and overlaying all "1" and "0" bits of the differential bus. The differential bus must be probed using a differential active probe. Keysight recommends using the N2818A 200-MHz differential active probe shown in Figure 1. Also available is the N2791A 25-MHz differential active probe.



Figure 1: Keysight's N2818A 200-MHz differential active probe.

## Executing an eye-diagram mask test

To perform a MIL-STD 1553 eye-diagram mask test, do the following:

1. Press the **[Default Setup]** front panel key.
2. Turn on the channel that the differential probe is connected to; turn off all other channels.
3. Press the **[Save/Recall]** front panel key; then press the **Recall** softkey.
4. Press the **Recall: XXXX** softkey; then select **Mask** as the type of file to recall.
5. Press the **Location** (or **Press to go**, or **Load from**) softkey; then navigate to the appropriate MIL-STD 1553 mask file.
6. Press the **Press to Recall** softkey (or press the entry knob) to begin an eye-diagram mask test sequence.

When the mask file is recalled, in addition to recalling the pass/fail limit mask, the scope will automatically be configured in the follow state:

- Probe attenuation: 10:1
- Vertical scaling: 1.00 V/div
- Horizontal scaling: 125 ns/div
- Upper threshold level: +333 mV
- Lower threshold level: -333 mV
- Triggering: All Data Words, or All Command Words with transmit bit set, or All Status Words (depends on specific mask file recalled)
- Noise reject: Off
- BW limit (20 MHz): Off

To exit an ARINC 429 mask test, either turn off mask testing or press **Clear Mask** in the scope's **[Analyze]** menu.

## System input mask test

When you recall a "System Input Mask Test", the scope will establish triggering on all Data Words, including both transmitted and received. However, the scope's vertical scaling will be set to primarily test just received/input Data Words (lower amplitude words). Command and Status Words are excluded from the test. Although the default vertical scaling is initially set to 1.0 V/div, if the signals received at the input test points exhibit marginal peak-to-peak voltage swings, you can rescale the V/div setting for increased vertical resolution.

Figure 2 shows an example of eye-diagram mask test after recalling the "**System xmfr-coupled Input Mask – X.msk**" file. The scope repetitively captures and overlays all 17 Manchester-encoded bits of every Data Word received and transmitted at the input test points of a specific Remote Terminal (RT) or Bus Controller (BC).

The diamond-shaped polygon mask limits are based on the zero-crossing-distortion input specification of  $\pm 150$  ns (300 ns between mask regions), and the minimum voltage swing input specification of 860 mVpp for transformer-coupled systems or 1.2 Vpp for direct-coupled systems (MIL-STD 1553b Specification, paragraph 4.5.2.1.2.1 and paragraph 4.5.2.2.2.1).

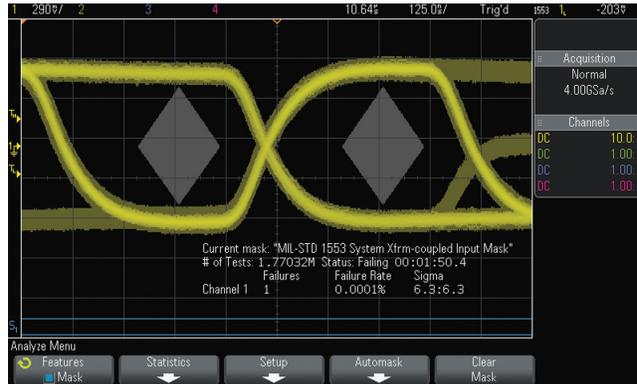


Figure 2. MIL-STD 1553 eye-diagram mask test on all Data Words.

Since the MIL-STD 1553 serial bus is based on Manchester bi-phase encoded data transmission, there are actually two “eyes” and two separate masks for each bit as shown in Figure 2. With this type of data encoding, signal edge transitions should occur near the mid-point of each bit field for bit times 4 through 20. We should never see a signal remain high or remain low extending across this pair of half-bit masks. Since the 3-bit synchronization field does not adhere to Manchester encoding, these particular bits of each word are not tested.

## RT input mask test

An “RT Input Mask Test” will perform an eye-diagram mask test on all Command Words received at a Remote Terminal (differential probing point) with the transmit bit (bit #9) set high. An example of this test is shown in Figure 3.



Figure 3. MIL-STD 1553 eye-diagram mask test on Command Words received at a specific remote terminal.

To test only Command Words with a specific RTA, you can press the **[Trigger]** front panel key and then change the RTA from all “don’t cares” to the desired RTA. If you want to test both transmit and receive Command Words, then you can change bit #9 to “don’t care” (X), but then you will also need to enter all or part of a specific sub-address in bit times #10 through #14. Otherwise the scope will also trigger on and capture Status Words.

After customizing the triggering condition, you should **Reset Statistics** in the mask test **[Analyze]** menu, and also **Clear Persistence** in the **[Display]** menu. To exit the MIL-STD 1553 eye-diagram mask sequence test, either turn off mask testing, or press **Clear Mask** in the **[Analyze]** menu.

In the eye-diagram mask test shown in Figure 3, note the shifted bit with a slow rising edge that crosses through the first diamond-shaped mask region. Uncovering this type of timing problem would be very difficult to detect without this eye-diagram mask test.

## BC input mask test

A “BC Input Mask Test” will perform an eye-diagram mask test on all Status Words received at a Bus Controller (differential probing point) with all status bits set to “0”. An example of this test is shown in Figure 4.

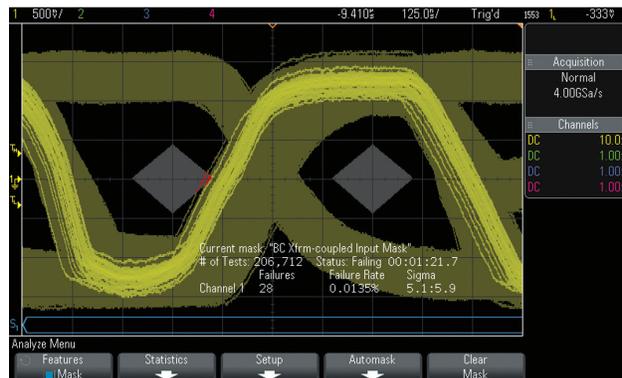


Figure 4: MIL-STD 1553 eye-diagram mask test on Status Words received at the Bus Controller.

To test only Status Words received from a specific Remote Terminal, you can press the **[Trigger]** front panel key and then enter a specific RTA. Again, if you customize the triggering condition, remember to **Clear Persistence** in the **[Display]** menu, and **Reset Statistics** in the mask test **[Analyze]** menu.

To exit the MIL-STD 1553 eye-diagram mask sequence test, either turn off mask testing, or press **Clear Mask** in the **[Analyze]** menu.

## System requirements

In addition to requiring the Keysight N2818A differential active probe (or equivalent) to probe the differential bus, performing MIL-STD 1553 eye-diagram mask tests requires that your Keysight 3000, 4000 or 6000 X-Series oscilloscope be licensed with the DSOX3AERO/DSOX4AERO/DSOX6AERO serial trigger and decode option (MIL-STD 1553 & ARINC 429), as well as the DSOX3MASK/DSOX4MASK/DSOX6MASK mask test option. In addition, your Keysight 3000 X-Series scope must be running on firmware version 2.0 or later.

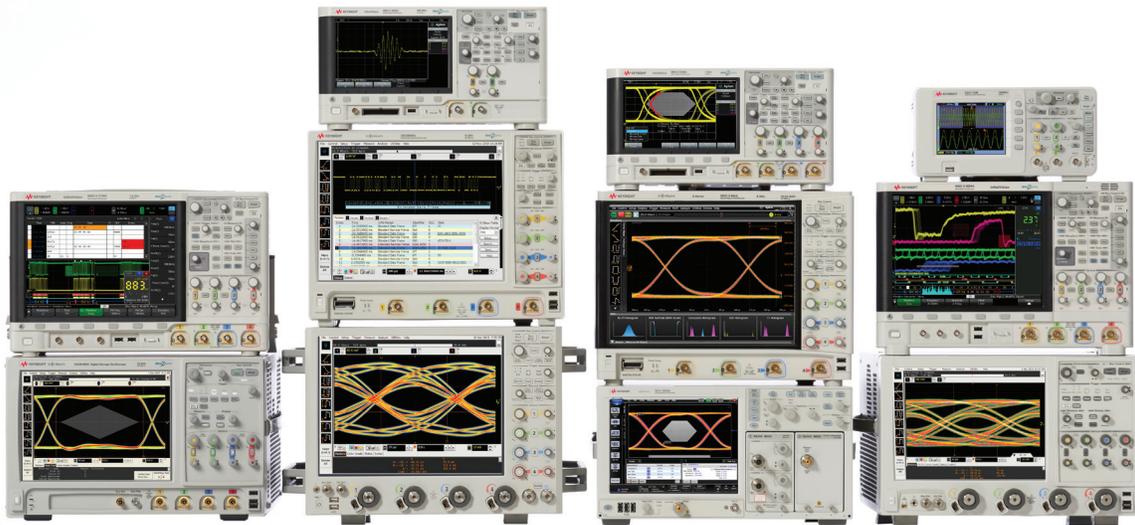
## Related literature

Publication title	Publication type	Publication number
<i>InfiniiVision 3000 X-Series Oscilloscopes</i>	Data sheet	5990-6619EN
<i>InfiniiVision 4000 X-Series Oscilloscopes</i>	Data sheet	5991-1103EN
<i>InfiniiVision 6000 X-Series Oscilloscopes</i>	Data sheet	5991-4087EN
<i>Serial Bus Applications for InfiniiVision 3000 and 4000 X-Series Oscilloscopes</i>	Data sheet	5990-6677EN
<i>Mask/Waveform Limit Testing for Keysight InfiniiVision Series Oscilloscopes</i>	Data sheet	5990-3269EN
<i>N2818A 200-MHz Differential Active Probe</i>	Data sheet	5990-4753EN
<i>N2791A 25-MHz Differential Active Probe</i>	Data sheet	5990-3780EN
<i>Oscilloscopes in Aerospace/Defense – Debugging MIL-STD 1553 serial buses</i>	Application note	5990-9167EN
<i>Oscilloscope Mask Testing for Six Sigma Quality Standards</i>	Application note	5990-3200EN

To download these documents, insert the publication number in the URL:  
<http://cp.literature.keysight.com/litweb/pdf/xxxx-xxxxEN.pdf>

## Product web site

For the most up-to-date and complete application and product information, please visit our product Web site at:  
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