Keysight Technologies
ARINC 429 Eye-diagram and Pulse-shape Mask Testing

Application Note

KEYSIGHT TECHNOLOGIES

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 affects, reflections, system noise, over-shoot, ringing, signal edge timing, and jitter.

Eye-diagram and pulse-shape pass/fail mask testing can be performed on differential ARINC 429 signals using a Keysight Technologies, Inc. 3000T, 4000 or 6000 X-Series oscilloscope licensed with the DSOX-3AERO/DSOX4AERO/DSOX6AERO triggering and decode option (MIL-STD 1553 and ARINC 429), along with the DSOX3MASK/DSOX4MASK/DSOX6MASK mask test option. Various ARINC 429 mask files can be downloaded from Keysight's website at no charge. Save the appropriate ARINC 429 mask files (based on baud rate) to your personal USB memory stick and then insert the memory stick into the scope's front-panel USB port. The following ARINC 429 mask files are available:

- ARINC429 100 kbps Eye Test.msk
- ARINC429 100 kbps 1's Test.msk
- ARINC429 100 kbps 0's Test.msk
- ARINC429 100 kbps Null Test.msk
- ARINC429 12,5 kbps Eye Test.msk
- ARINC429 12,5 kbps 1's Test.msk
- ARINC429 12,5 kbps 0's Test.msk
- ARINC429 12,5 kbps Null Test.msk

Probing the Differential ARINC 429 Bus

ARINC 429 mask testing is based on capturing and overlaying all “1” and/or “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.

ARINC 429 Eye-diagram Mask Test

To perform an ARINC 429 eye-diagram mask test, do the following:

1. Press the [Default Setup] front panel key.
2. Press the [Save/Recall] front panel key; then press the Recall softkey.
3. Press the Recall: XXXX softkey; then select Mask as the type of file to recall.
4. Press the Location (or Press to go, or Load from) softkey; then navigate to the mask file named “ARINC429 100 kbps Eye Test.msk” or “ARINC429 12,5 kbps Eye Test.msk” based on the appropriate baud rate of your ARINC 429 system.
5. Press the Press to Recall softkey (or press the entry knob) to begin an eye-diagram mask test.

ARINC 429 Eye-diagram Mask Test *(Continued)*

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: 4.00 V/div
- Horizontal scaling: 1.000 µs/div for 100 kbps, or 20.00 µs/div for 12.5 kbps
- Delay: 2.5 µs for 100 kbps, or 10.0 µs for 12.5 kbps
- Upper threshold level: +3.00 V
- Lower threshold level: –3.00 V
- Triggering: All bits (rising edge crossings at +3 V and falling edge crossings at –3 V
- Noise reject: On
- BW limit (20 MHz): On

Figure 2 shows an ARINC 429 eye-diagram mask test on a differential bus based on a baud rate of 100 kbps. This particular test shows a "1's" pulse failing the mask test due to insufficient amplitude.

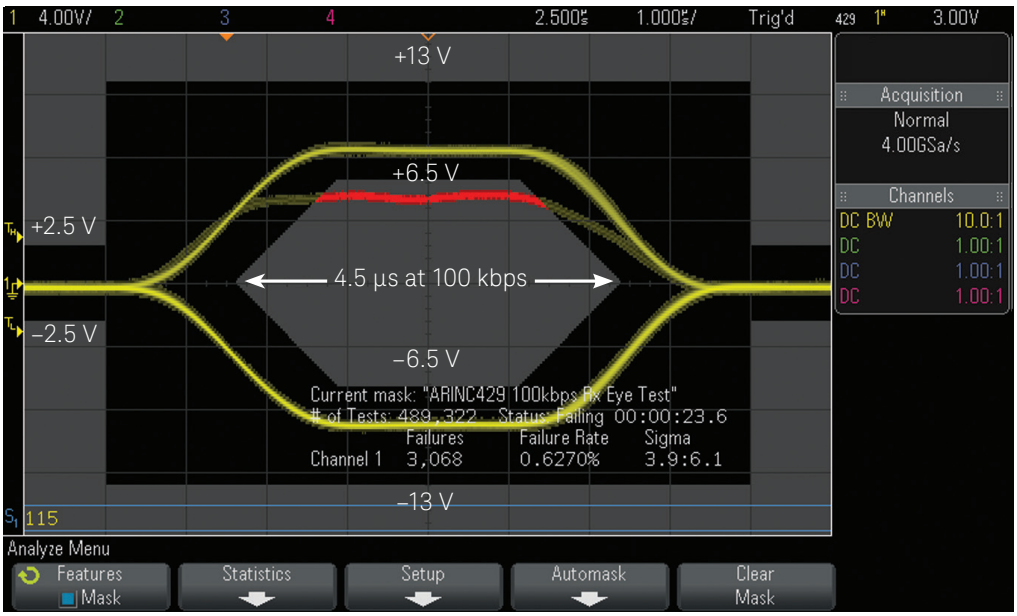


Figure 2. ARINC 429 eye-diagram mask test on 100 kbps data.

The top and bottom of the center eye mask region (6-point polygon) is based on the specified minimum input differential voltage levels (HI and LO) of ± 6.5 V. The upper and lower mask regions test against the specified maximum input voltage levels of ± 13.0 V, as well as the maximum null voltage levels of ± 2.5 V (ARINC 429 Specification, Part 1 – Page 75).

The width of the eye mask is based on the minimum specified half-bit width (Time X) of 4.75 µs for 100 kbps or 38.0 µs for 12.5 kbps. The beginning of the eye mask region is based on the ± 3.0 V threshold crossing time-point plus 125 ns for 100 kbps, or plus 1 µs for 12.5 kbps ([ideal half-bit width – specified half-bit width]/2). And the slopes of the leading and trailing edges of the center eye mask region are based on the maximum pulse rise and fall times of 2.0 µs for 100 kbps and 15 µs for 12.5 kpbs (ARINC 429 Specification, Part 1 – Page 118).

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

ARINC 429 “1’s” Pulse Test

To perform a pulse mask test based on just “1’s” (HI pulses), recall the “ARINC429 100 kbps 1’s Test.msk” or “ARINC429 12,5 kbps 1’s Test.msk” mask file based on the appropriate baud rate of your ARINC 429 system. Triggering for this test is based on rising edge crossings of “1’s” pulses only at the upper threshold level of +3.0 V. In addition to performing a mask test on just “1” pulses, this test will also turn on and display various parametric timing and amplitude measurements with continuously updated statistics as shown in Figure 3. The minimum and maximum values of these measurements can be compared against ARINC 429 published electrical specifications.

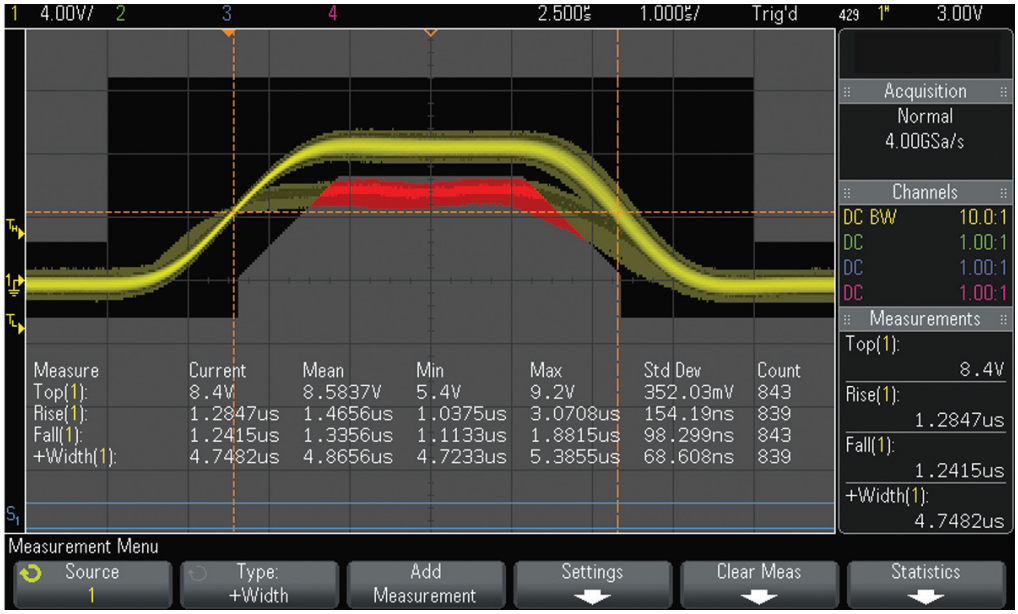


Figure 3. ARINC 429 “1’s” pulse mask test with parametric measurements.

For an ARINC 429 “1’s” test, compare the following on-screen oscilloscope measurements to the following published electrical specifications:

- Compare Top(Ch#)Min against the minimum input high level specification of +6.5 V.
- Compare Top(Ch#)Max against the maximum input high level specification of +13.0 V.
- Compare Rise(Ch#)Max against the maximum rise time specifications of 2.0 µs for 100 kbps or 15 µs for 12.5 kbps.
- Compare Fall(Ch#)Max against the maximum fall time specifications of 2.0 µs for 100 kbps or 15 µs for 12.5 kbps.
- Compare +Width(Ch#)Min against the minimum half-bit width specification of 4.75 µs for 100 kbps or 38.0 µs for 12.5 kbps.
- Compare +Width(Ch#)Max against the maximum half-bit width specification of 5.25 µs for 100 kbps or 42.0 µs for 12.5 kbps.

In the example shown in Figure 3, Top(1)Min measured 5.4 V. This fails to meet the minimum required input high level specification of +6.5 V. This is also indicated in red in the mask test where some high level pulses cross through the mask region. In addition, +Width(1)Min, which measured 4.7233 µs, fails to meet the minimum half-bit width specification 4.75 µs for a 100 kbps ARINC 429 system. All other measurements pass.

ARINC 429 “0’s” Pulse Test

To perform a pulse mask test based on just “0’s” (LO pulses), recall the “ARINC429 100 kbps 0’s Test.msk” or “ARINC429 12,5 kbps 0’s Test.msk” mask file based on the appropriate baud rate of your ARINC 429 system. Triggering for this test is based on falling edge crossings of “0’s” pulses only at the lower threshold level of –3.0 V. In addition to performing a mask test on just “0” pulses, this test will also turn on and display various parametric timing and amplitude measurements with continuously updated statistics as shown in Figure 4. The minimum and maximum values of these measurements can be compared against ARINC 429 published electrical specifications.

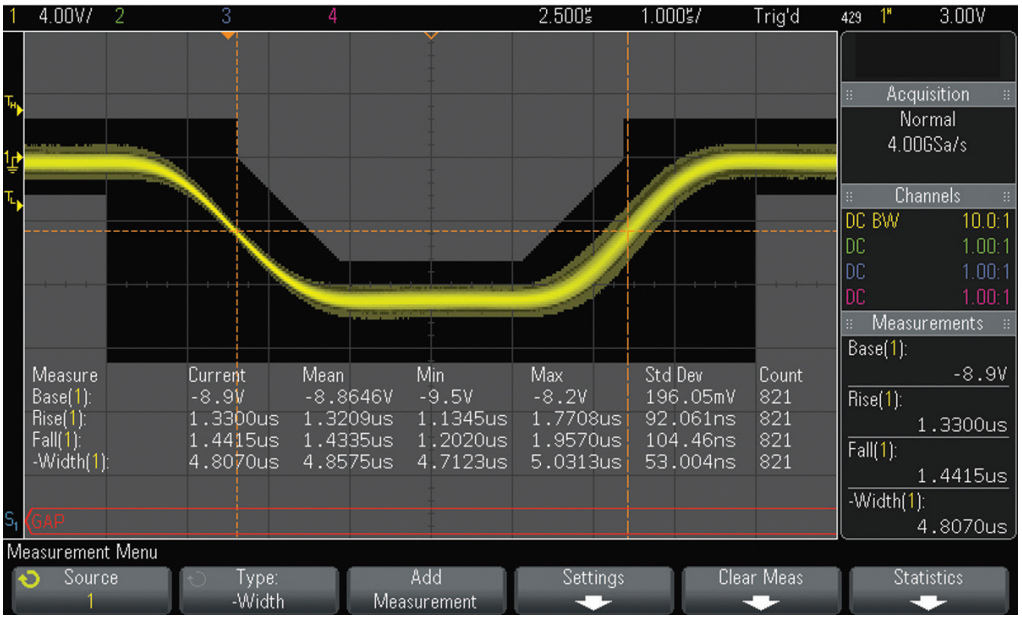


Figure 4. ARINC 429 “0’s” pulse mask test with parametric measurements.

For an ARINC 429 “0’s” test, compare the following on-screen oscilloscope measurements to the following published electrical specifications:

- Compare Base(Ch#)Max against the minimum input low level specification of –6.5 V.
- Compare Top(Ch#)Min against the maximum input low level specification of –13.0 V.
- Compare Rise(Ch#)Max against the maximum rise time specifications of 2.0 µs for 100 kbps or 15 µs for 12.5 kbps.
- Compare Fall(Ch#)Max against the maximum fall time specifications of 2.0 µs for 100 kbps or 15 µs for 12.5 kbps.
- Compare -Width(Ch#)Min against the minimum half-bit width specification of 4.75 µs for 100 kbps or 38.0 µs for 12.5 kbps.
- Compare -Width(Ch#)Max against the maximum half-bit width specification of 5.25 µs for 100 kbps or 42.0 µs for 12.5 kbps.

Although the mask test does not indicate any failures for the example shown in Figure 4, note that the -Width(1)Min measurement, which measured 4.7123 µs, fails to meet the minimum half-bit width specification of 4.75 µs for a 100 kbps ARINC 429 system.

ARINC 429 “Null” Test

To perform a noise mask test based on just “null” signal levels between all “1” and “0” pulses, recall the “ARINC429 100 kbps Null Test.msk” or “ARINC429 12,5 kbps Null Test.msk” mask file based on the appropriate baud rate of your ARINC 429 system. Triggering for this test is based on the “All bits” trigger setting (same as eye test). In addition to performing a mask test on just the null level signal between pulses, this test will also turn on and display various parametric amplitude measurements with continuously updated statistics in order to characterize noise as shown in Figure 5. The maximum values of these displayed measurements can be compared against ARINC 429 published electrical specifications.

For an ARINC 429 “Null” test, compare the following on-screen oscilloscope measurements to the following published electrical specifications:

- Compare Max(Ch#)Max against the maximum null level specification of +2.5 V.
- Compare Min(Ch#)Min against the minimum null level specification of –2.5 V.
- Avg–FS(Ch#)Mean provides the average null level for information purposes only.
- AC RMS-FS(Ch#)Mean provides the RMS noise level (standard deviation) for information purposes only.

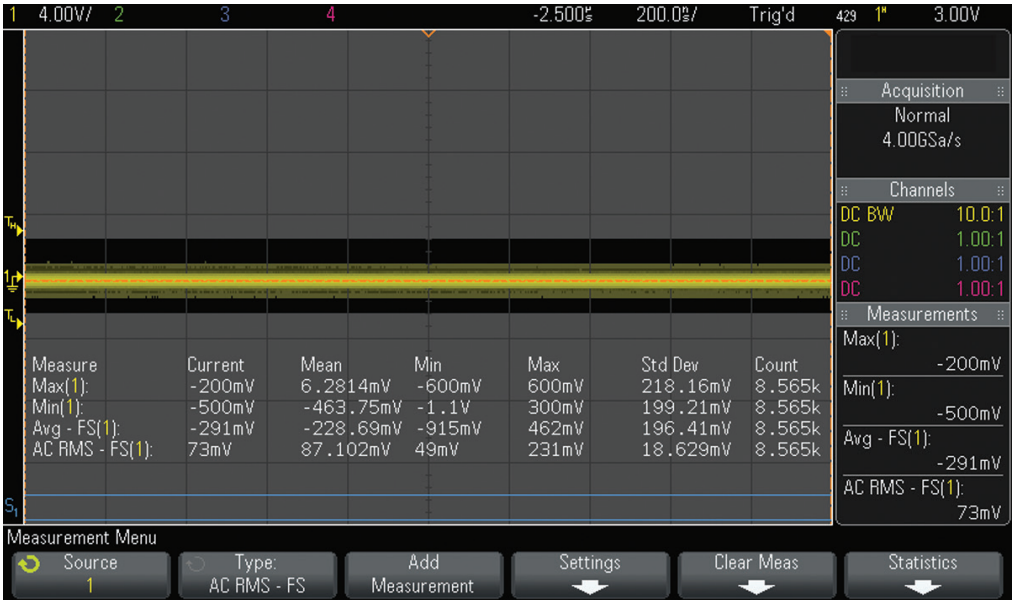


Figure 5. ARINC 429 “null” mask test with parametric measurements.

System Requirements

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

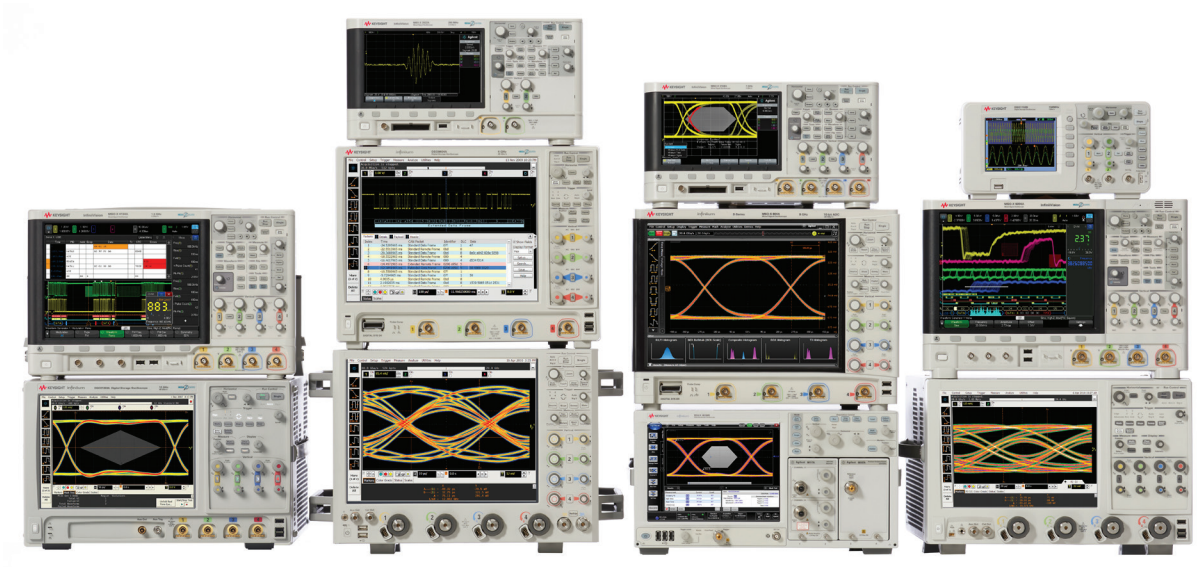
Related Literature

Publication title	Publication number
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
Serial Bus Options for InfiniiVision X-Series Oscilloscopes - Data Sheet	5990-6677EN
Mask/Waveform Limit Testing For InfiniiVision Series Oscilloscopes - Data Sheet	5990-3269EN
N2792A/N2818A 200 MHz and N2793A/N2819A 800 MHz Differential Probes - Data Sheet	5990-4753EN
N2790A 100 MHz, N2791A 25 MHz and N2891A 70 MHz High-voltage Differential Probes - Data Sheet	5990-3780EN
Oscilloscopes in Aerospace/Defense Debugging MIL-STD 1553 Serial Buses - Brochure	5990-9167EN
Evaluating Oscilloscope Mask Testing for Six Sigma Quality Standards - Application Note	5990-3200EN

To download these documents, insert the publication number in the URL:
http://literature.cdn.keysight.com/litweb/pdf/5992-0140EN.pdf

Product Web site

For the most up-to-date and complete application and product information, please visit our product Web site at: **www.keysight.com/find/morescope**



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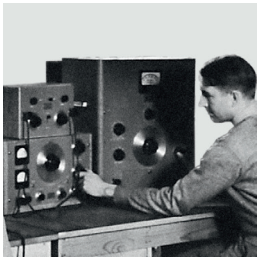

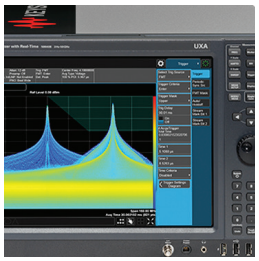

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