

## HL9407 Broadband Balun (67 GHz)

### Features and Technical Specifications

Bandwidth (-3 dB)	500 kHz to 67 GHz
Amplitude Match	$\pm 0.1$ dB to 30 GHz
	$\pm 0.3$ dB to 67 GHz <u>See Fig. 1 below</u>
Phase Match	$\pm 4$ - $6^\circ$ at 20 GHz
	$\pm 8$ - $12^\circ$ at 40 GHz <u>See Fig. 2 below</u>
Rise time	< 5.2 ps
Insertion Delay	$\approx 278$ ps
Insertion Loss	-6 dB
Return Loss	<u>See Figs. 3-4 below</u>
VSWR	<u>See Fig. 5 below</u>
CMRR	> 70 dB at 10 MHz
	> 30 dB at 50 GHz <u>See Fig. 6 below</u>
Eye Diagrams	<u>See Figs. 8-13 below</u>
Max Input Power	+30 dBm
Impedance	50 $\Omega$ In, 2 x 50 $\Omega$ Out
Connectors	1.85 mm; 3x Jack/Female
Dimensions	60.80 x 38.1 x 13.87 mm
	2.39" x 1.50" x 0.55"
Weight	45 g (1.6 oz)
Temperature Limits	-40° to +100° C, operating
RoHS Compliance	Made with lead-free solder
Warranty	1 year, see website

#### PRODUCT SUMMARY

The HL9407 is a signal splitter and combiner that offers industry-best amplitude and phase match over a bandwidth of 500 kHz to 67 GHz (-3 dB).

It is suitable for use in 40 Gbps communications systems, high-speed analog-to-digital conversion, frequency response testing for differential devices, and many other applications.



#### DEPLOYMENT NOTES

Although the HL9407 ports are labeled as RF In/Out, this device is bidirectional and can be used either as a signal splitter or combiner.

When the device is used as a signal combiner using differential signals with unmatched source impedance, attenuators (3-6 dB) may be required to improve isolation.

If the DC voltage of the input or output is not zero, DC block capacitors are required.

#### ADDITIONAL DATA

Higher-resolution versions of the charts on the following pages are available on our website, along with S-parameter files with normal and mixed-mode data to 67 GHz.

### HL9407 Bandwidth

Bandwidth for all HYPERLABS baluns is defined as the range of frequencies where insertion loss is within -3 dB of the reference level (-6 dB).

Figure 1 below shows better than -9 dB insertion loss up to 67 GHz when the device is used as a signal splitter.

### HL9407 Amplitude Match

Amplitude match is a comparison between the signals on the RF Out +/- ports of a balun used as a signal splitter. This specification is derived from the insertion loss (in dB) measured on the output ports of the device.

Figure 1 below shows typical HL9407 insertion loss from 5 MHz to 67 GHz when the device is used as a signal splitter.

The amplitude balance can be seen by comparing the non-inverting output (blue trace), with the inverting output (red trace).

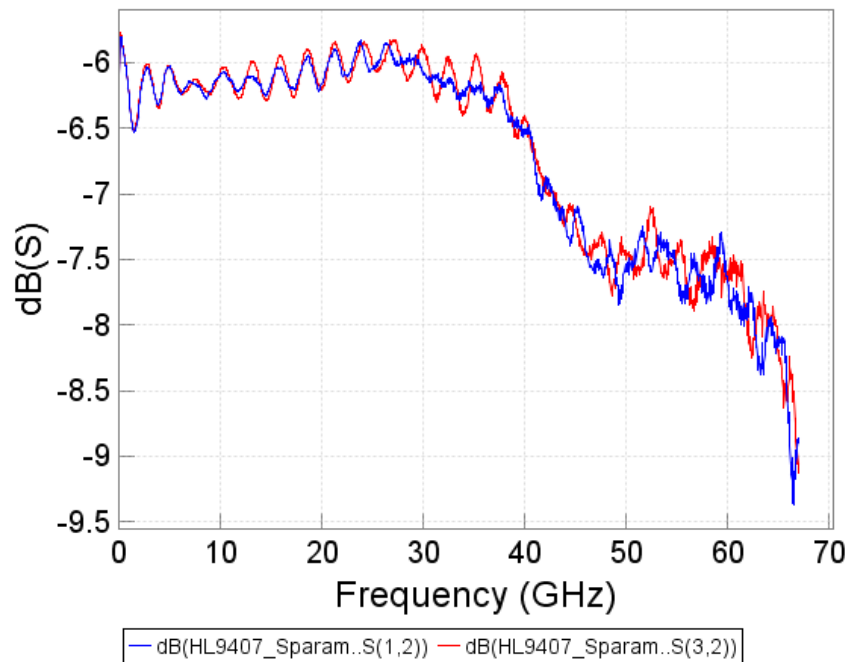


Figure 1: Typical insertion loss and amplitude match of the HL9407 RF Outputs when used as a signal splitter

When the HL9407 is used as a combiner, mixed mode parameters provide additional information on device performance.

For more on the HL9407 performance as a signal combiner, please see the section titled "[HL9407 Mixed Mode Data](#)".

### HL9407 Phase Match

The HL9407 is a 180° balun, so the phase match of the RF Out+ and RF Out- ports is specified to degrees from 180°.

Match is dependent on the delay of the output ports. For example, 2 degree mismatch at 10 GHz requires the delays be within  $\approx 0.5$  ps of each other. Phase mismatch increases with frequency.

Figure 2 below shows phase mismatch between the RF Outputs from 5 MHz to 67 GHz. The vertical range is 0-12°.

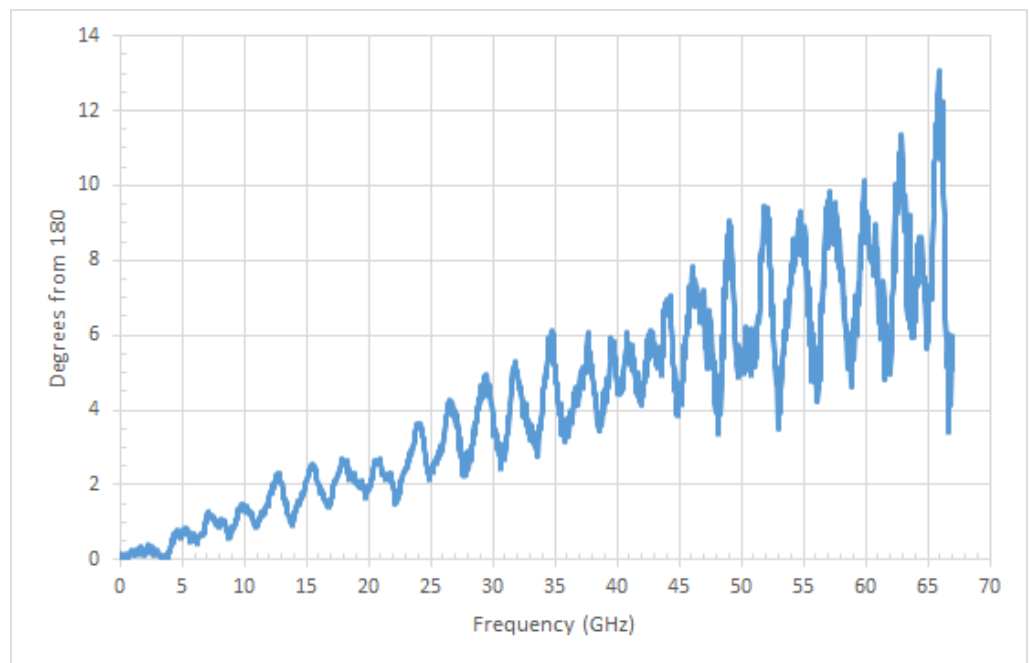


Figure 2: HL9407 phase match, represented as degrees from 180°

### HL9407 Return Loss

Figure 3 shows the return loss on the HL9404 RF Input of a device used as a signal splitter. Figure 4 shows the return loss on the RF Output+ port of a device used as a signal combiner. In both cases, bandwidth is from 5 MHz to 67 GHz.

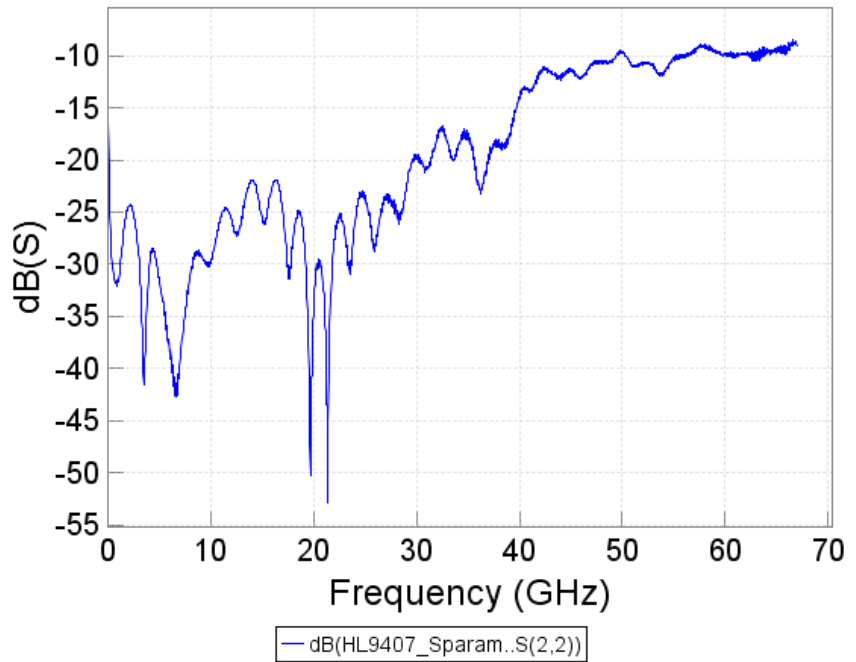


Figure 3: Typical return loss on RF In port of the HL9407

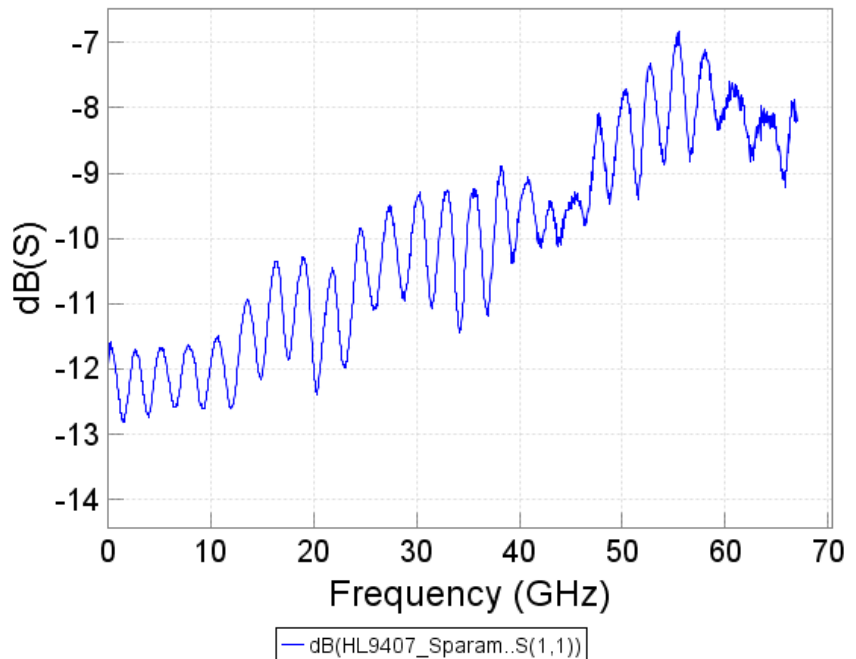
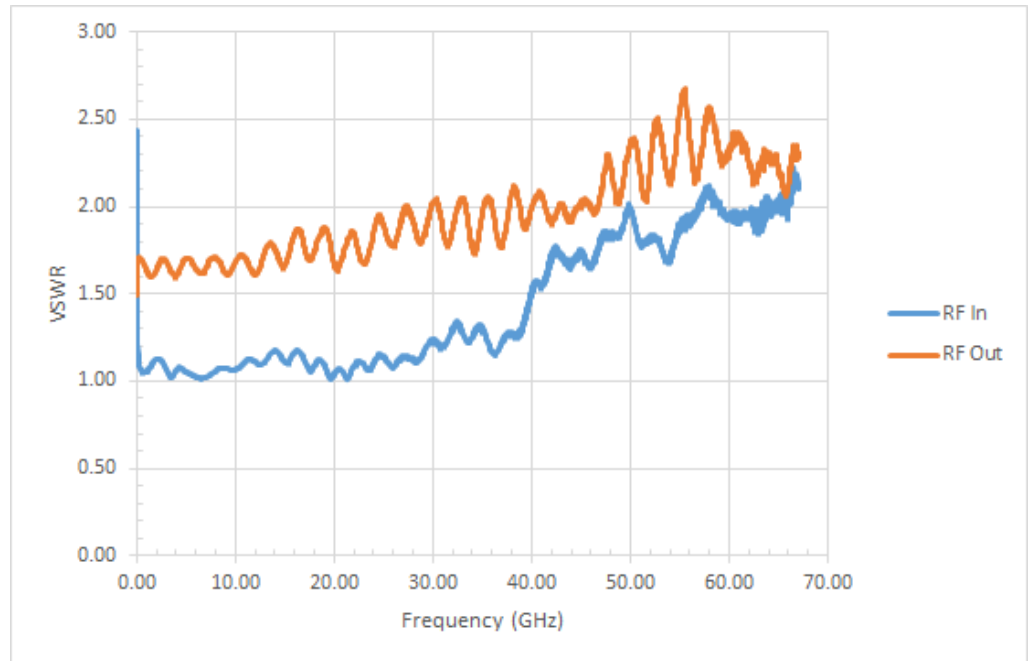


Figure 4: Typical return loss on the HL9407 RF Output+ ports

### HL9407 VSWR

The typical Voltage Standing Wave Ratio (VSWR) of the HL9407 is shown in *Figure 5* below. The blue and orange traces show typical VSWR on the RF In and RF Out+ ports, respectively.

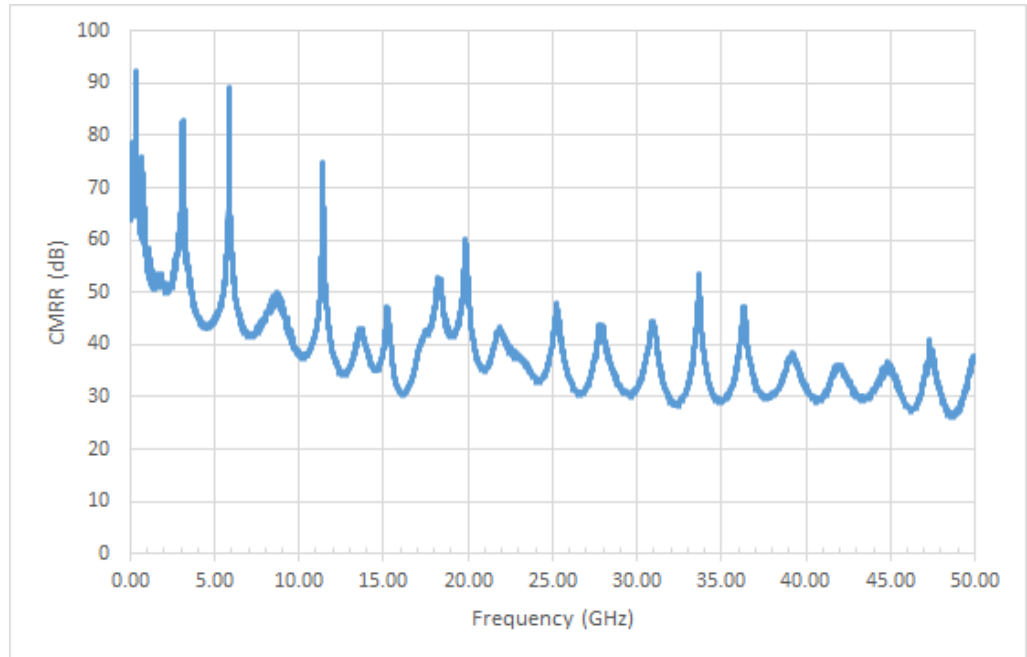


*Figure 5: Typical VSWR of HL9407 RF Input and RF Out+*

### HL9407 CMRR

The exceptional Common Mode Rejection Ratio (CMRR) of the HL9407 allows it to be used as a signal combiner as well as a splitter.

*Figure 6* shows the CMRR of the HL9407 when used to combine a differential signal from a 50 GHz VNA source.



*Figure 6: HL9407 CMRR (to 50 GHz)*

## HL9407 Mixed Mode Data

The design of HYPERLABS baluns allows the HL9407 to be used as a signal combiner as well as a signal splitter.

In combiner mode, the balun converts a differential source signal into a single-ended output, minimizing common mode noise and harmonic distortion.

In certain combiner applications using differential signals with unmatched source impedance, attenuators (3-6 dB) may be required to improve isolation between the differential ports. In applications with a well-matched differential input, or where the balun is used as a splitter, attenuators are not required.

HL9407 combiner performance is best characterized from mixed-mode S-parameters using a 4-port VNA as a differential source.

Figure 7 below shows the mixed-mode measurements of a typical HL9407 unit. Full mixed-mode data for the HL9407 can be found in the S-parameters file available on the HYPERLABS website.

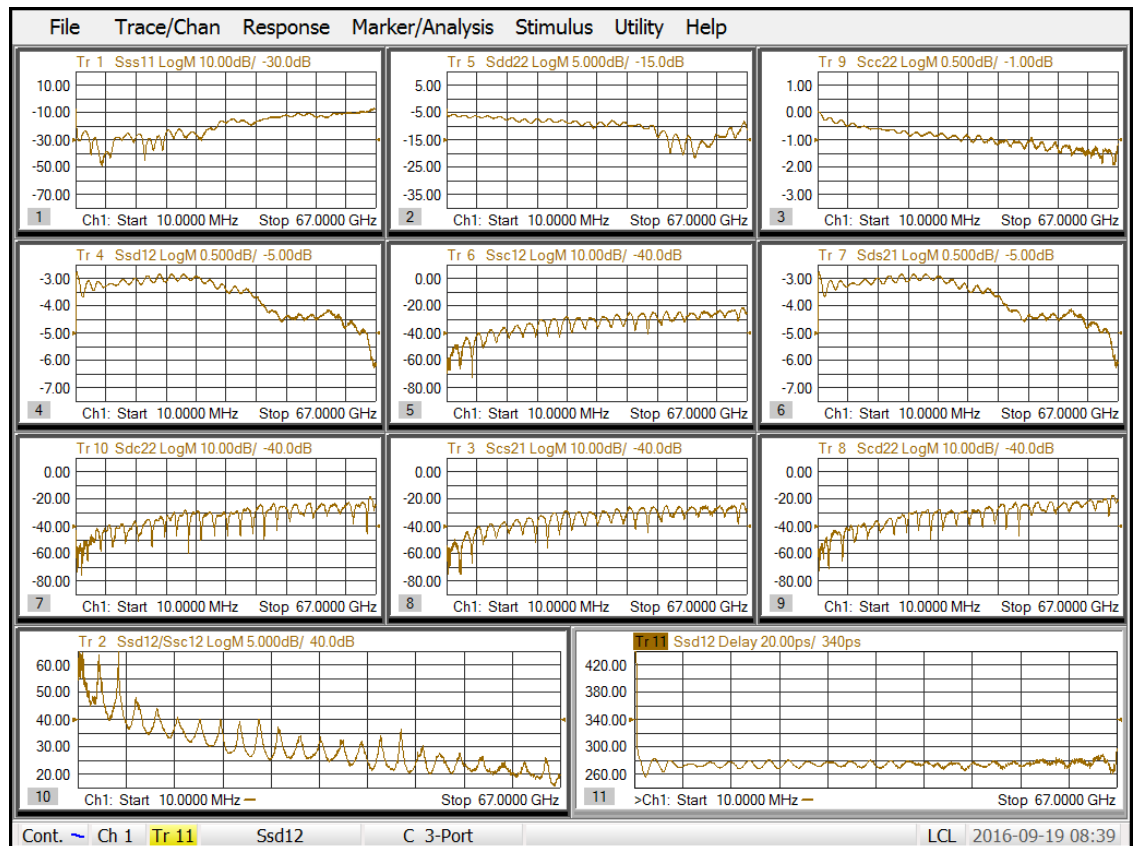


Figure 7: Mixed mode data for the HL9407 measured on a VNA with differential source to 67 GHz

## HL9407 Eye Diagrams

The following pages contain pseudo-random binary sequence (PRBS) eye diagrams for the HL9407. Measurements were taken at 10 Gbps, using long (31-bit) and short (7-bit) patterns.



Figure 8: 10 Gbps PRBS pattern as applied to the HL9407 RF In port

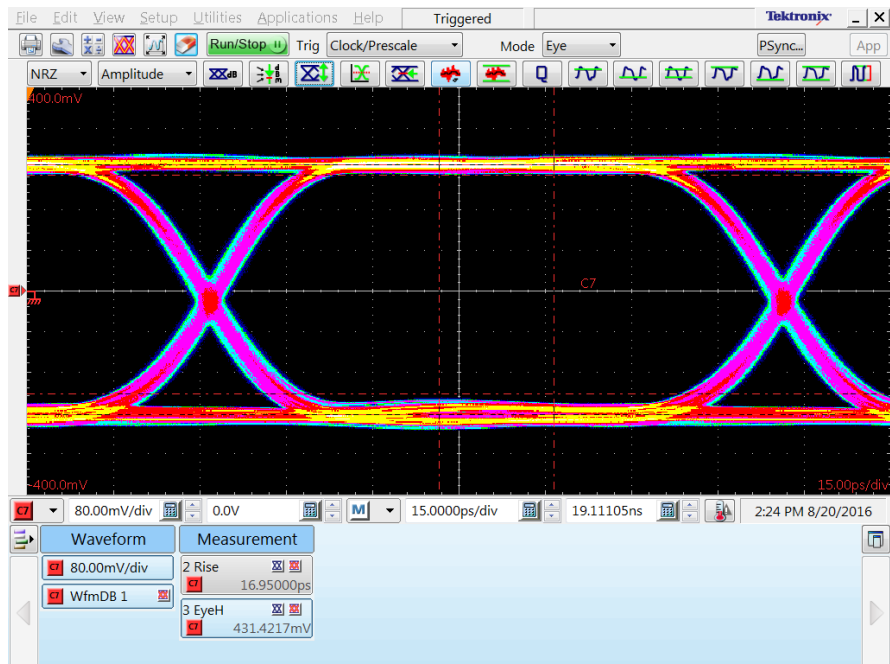


Figure 9: Eye diagram (10 Gbps, 7-bit pattern) of the HL9407 RF In port



### HL9407 Eye Diagrams (cont.)

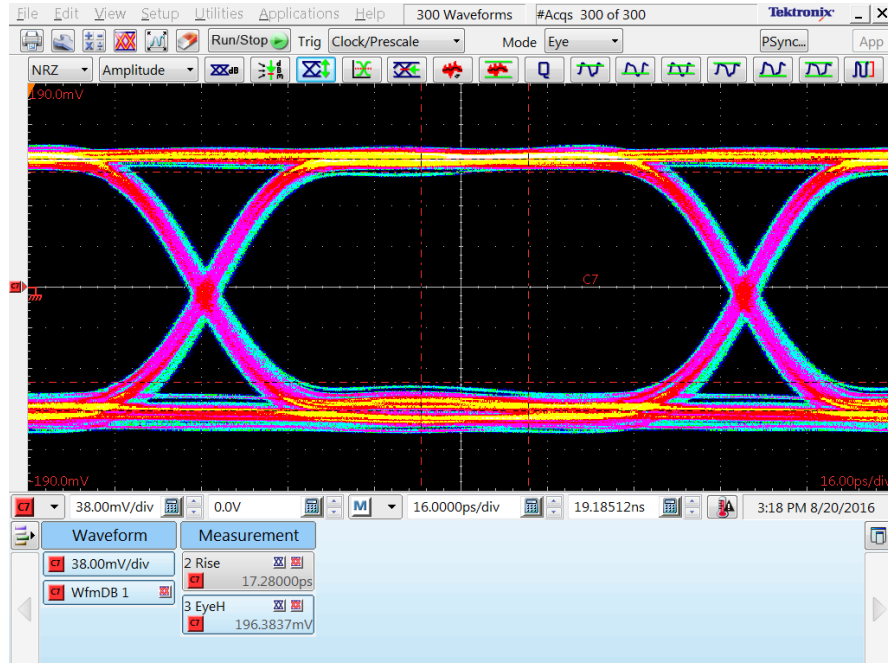


Figure 10: Eye diagram (10 Gbps, 7-bit pattern) of the HL9407 RF Out+ (non-inverting) port

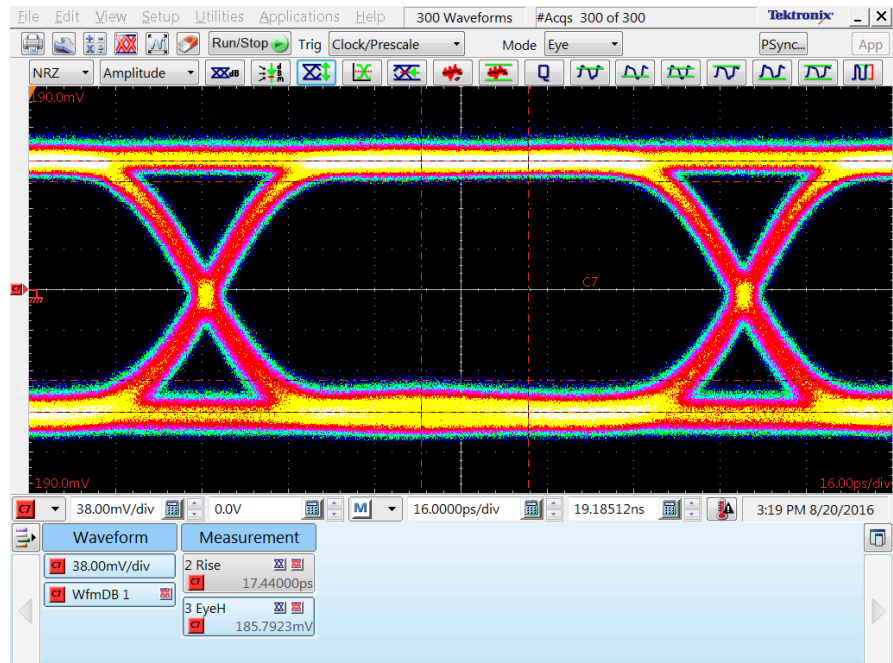


Figure 11: Eye diagram (10 Gbps, 31-bit pattern) of the HL9407 RF Out+ (non-inverting) port

### HL9407 Eye Diagrams (cont.)

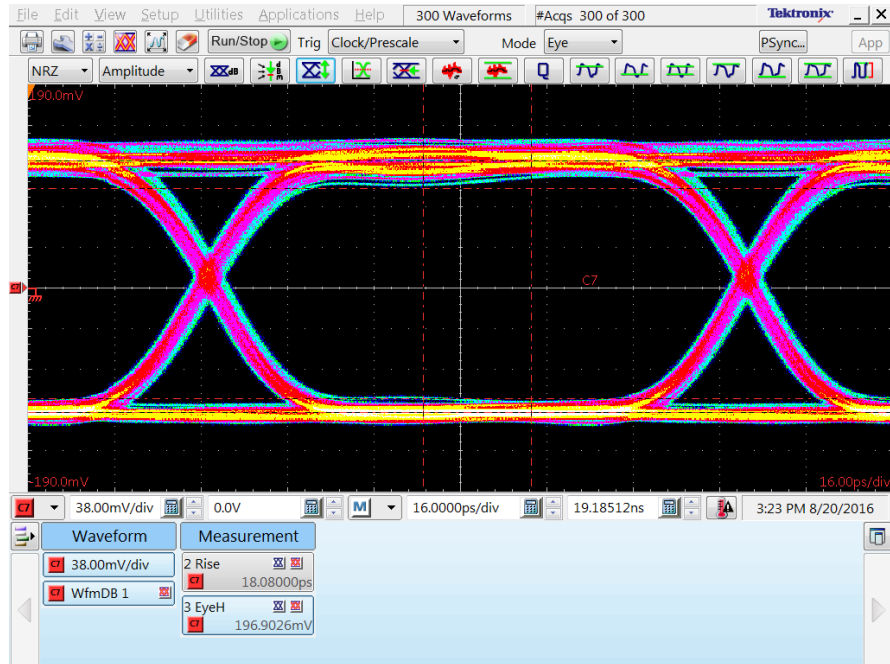


Figure 12: Eye diagram (10 Gbps, 7-bit pattern) of the HL9407 RF Out- (inverting) port

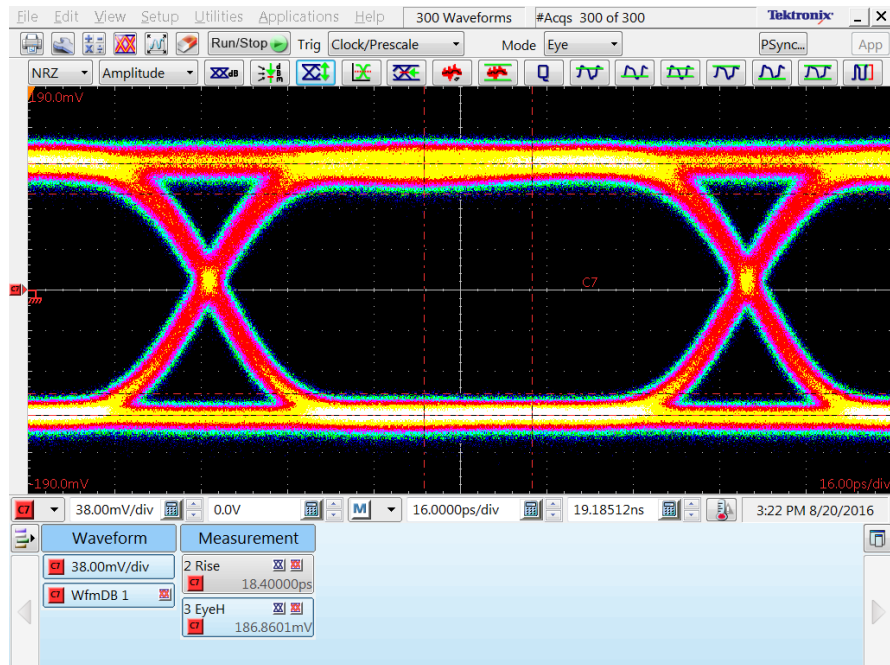


Figure 13: Eye diagram (10 Gbps, 31-bit pattern) of the HL9407 RF Out- (inverting) port