HYPERLABS™
Innovation at Hyperspeed since 1992

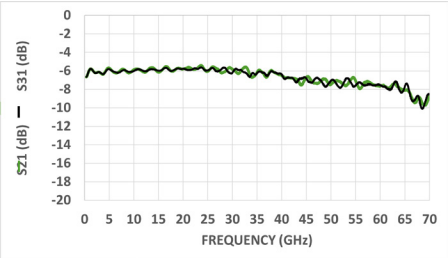
HL940x Series Baluns (500 kHz to 67 GHz)

Features and Technical Specifications[1] (HL9407 shown)

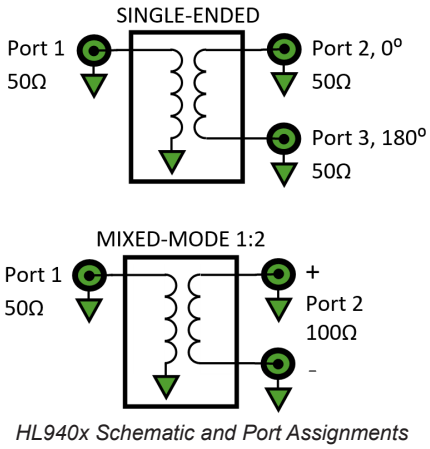
Bandwidth	500 kHz to 67 GHz
Amplitude Match	± 0.1 dB, f ≤ 50 GHz ± 0.25 dB, f > 50 GHz See *Fig. 1*
Phase Match	± 4°, f = 20 GHz ± 8°, f = 40 GHz See *Fig. 8*
Insertion Loss	6 dB, single-ended reference See *Figs. 1, 3-4*
Return Loss	> 15 dB, unbalanced port, f ≤ 40 GHz > 10 dB, unbalanced port, f > 40 GHz > 10 dB, balanced ports, f ≤ 50 GHz > 7.5 dB, balanced ports, f > 50 GHz See *Figs. 2, 5*
CMRR	> 25 dB See *Fig. 6*
Group Delay	≈ 270 ps See *Fig. 7*
Max Input Power	1 W (+30 dBm)
Connectors	Standard configuration is 1.85 mm, 3 x jack/female 1.85 mm plug connectors available at extra cost
Temperature Limits	-40° to +100° C, operating
RoHS Compliant	Yes, assembled with lead-free solder
REACH Compliant	Yes
Warranty	1 year, see website

NOTE 1 - Unless otherwise noted, the specifications in this table are typical for Model Number HL9407 using the standard connector configuration (3 x jack). Full specifications for this and related models are available on Page 2 of this datasheet.

HL9407-JJJ, standard configuration shown



Typical HL9407 Single-ended Insertion Loss



HL940x Schematic and Port Assignments

PRODUCT SUMMARY

The HL940x series are ultra-broadband 180° signal splitters and combiners that offer excellent amplitude and phase match over an industry-best bandwidth of 500 kHz to 67 GHz.

They are suitable for use in 112 Gbps PAM4 communications systems, high-speed analog-to-digital conversion, frequency response testing for differential devices, and many other applications.

DEPLOYMENT NOTES

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 balanced or unbalanced ports is non-zero, DC blocks are required. The balanced ports (2 and 3) are DC shorted.

MODELS & OPTIONS

The following models are available:

- ***HL9402***, 26.5 GHz
- ***HL9404***, 40 GHz
- ***HL9405***, 50 GHz
- ***HL9407***, 67 GHz

The following connector options are available:

- ***-JJJ***, jack/jack/jack

Extra cost options:

- ***-JPP***, jack/plug/plug
- ***-PJJ***, plug/jack/jack
- ***-PPP***, plug/plug/plug

HL940x Full Specifications

Parameter	HL9402	HL9404	HL9405	HL9407	Comments
Upper Frequency Limit	26.5 GHz	40 GHz	50 GHz	67 GHz	3 dB roll-off point, relative to nominal insertion loss
Lower Frequency Limit	500 kHz	500 kHz	500 kHz	500 kHz	3 dB roll-off point
Amplitude Match *See Fig. 1*	± 0.1 dB	± 0.1 dB	± 0.1 dB	± 0.1 dB, f ≤ 50 GHz ± 0.25 dB, f > 50 GHz	
Phase Match *See Fig. 8*	± 4°, f = 20 GHz	± 4°, f = 20 GHz	± 4°, f = 20 GHz ± 8°, f = 40 GHz	± 4°, f = 20 GHz ± 8°, f = 40 GHz	
Insertion Loss *See Figs. 1, 3-4*	6 dB				Single-ended reference
Return Loss *See Figs. 2, 5*	> 15 dB, unbal. port > 10 dB, bal. ports	> 15 dB, f ≤ 30 GHz, unbal. port > 12.5 dB, f > 30 GHz, unbal. port, > 10 dB, bal. ports	> 20 dB, f ≤ 30 GHz, unbal. port > 15 dB, f > 30 GHz, unbal. port > 10 dB, bal. ports	> 15 dB, f ≤ 40 GHz, unbal. port > 10 dB, f > 40 GHz, unbal. port > 10 dB, f ≤ 50 GHz, bal. ports > 7.5 dB, f > 50 GHz, bal. ports	unbal. = unbalanced bal. = balanced
Rise Time	13 ps	9 ps	7 ps	5 ps	
CMRR *See Fig. 6*	> 30 dB, f ≤ 20 GHz	> 30 dB, f ≤ 20 GHz > 25 dB, f > 20 GHz	> 30 dB, f ≤ 25 GHz > 25 dB, f > 25 GHz	> 30 dB, f ≤ 25 GHz > 25 dB, f > 25 GHz	Typical
Group Delay *See Fig. 7*	≈ 290 ps	≈ 280 ps	≈ 270 ps	≈ 270 ps	
Max Input Power	1 W (+30 dBm)				
Impedance	50 Ω				Input and Outputs
Connectors (Standard Config)	SMA, 3x jack/female	2.92 mm, 3x jack/female	2.4 mm, 3x jack/female	1.85 mm, 3x jack/female	Plug/male connectors available at extra cost
Dimensions (W x D x H)	2.25” x 1.50” x 0.55” 57.2 x 38.1 x 14 mm	2.25” x 1.50” x 0.55” 57.2 x 38.1 x 14 mm	2.35” x 1.50” x 0.55” 59.7 x 38.1 x 14 mm	2.33” x 1.50” x 0.55” 59.2 x 38.1 x 14 mm	Package including connectors
Weight	45.3 g (1.6 oz.)				
Operating Temp.	-40° to +100° C				Case temperature
RoHS Compliant	Yes, assembled with lead-free solder				
REACH Compliant	Yes				
Warranty	1 year, repair or replacement; see website for details				

Note: All specifications are based on test results using the standard connector configuration (3 x jack). Specifications may vary slightly for other configurations.

HL940x Single-ended Insertion Loss and Return Loss

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

Figure 1 shows the insertion loss and amplitude match of an HL9407 in single-ended mode.

Figure 2 shows the return loss of all ports in single-ended mode.

Other models show similar performance within their respective specified bandwidths.

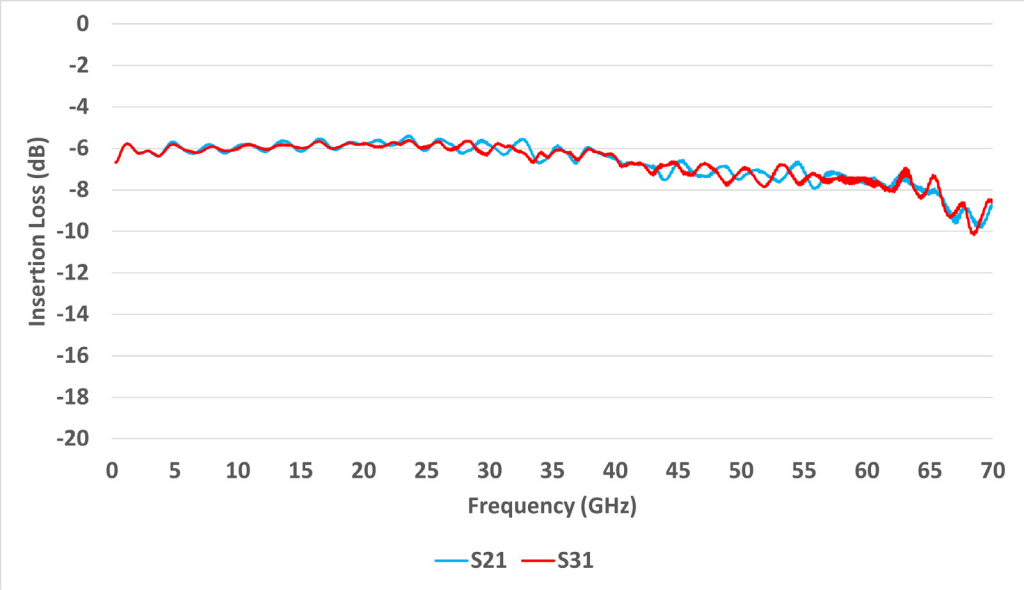


Figure 1: HL9407 Single-ended Insertion Loss

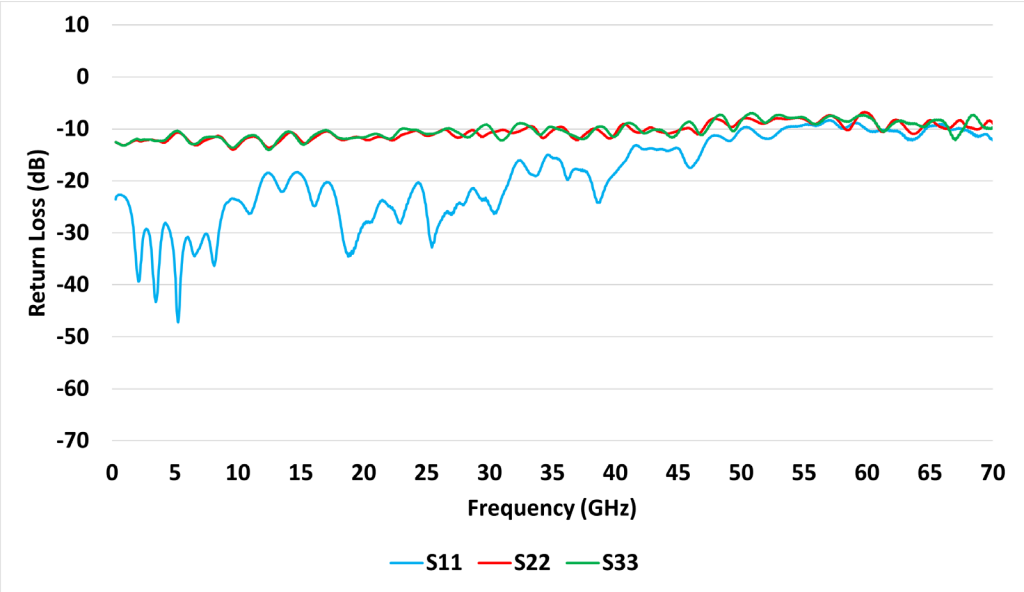


Figure 2: HL9407 Single-ended Return Loss

HL940x Mixed-mode Insertion Loss

Mixed-mode S-parameters are useful for characterizing the performance of differential circuits such as broadband baluns.

Figures 3-4 show the insertion loss of an HL9407 balun in mixed mode to 70 GHz. Other models show similar performance within their respective specified bandwidths.

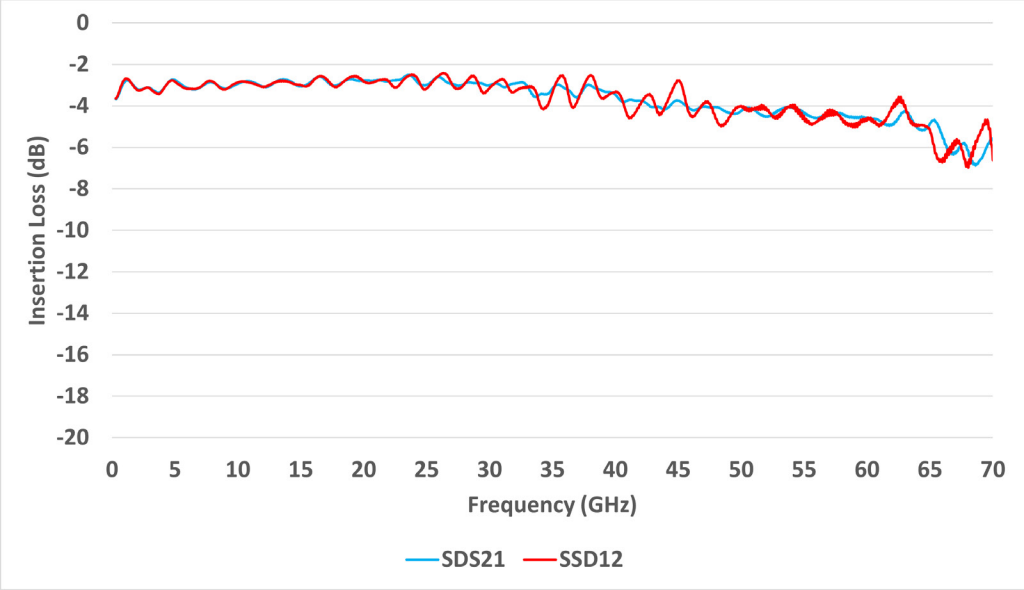


Figure 3: HL9407 Differential Mode Insertion Loss

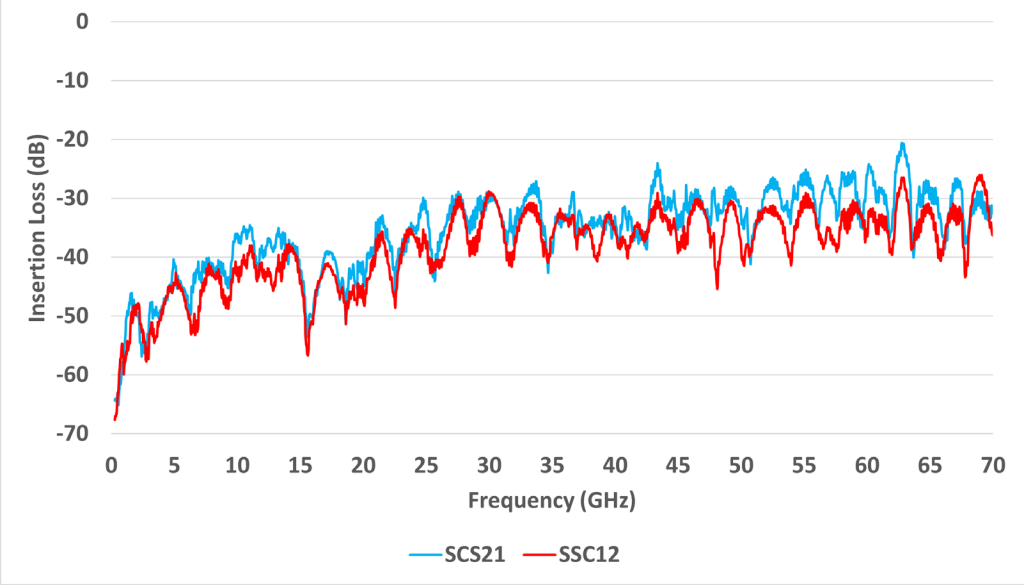


Figure 4: HL9407 Common Mode Insertion Loss

HL940x Mixed-mode Return Loss

Figure 5 shows the typical mixed-mode return loss of the unbalanced and balanced ports of an HL9407 to 70 GHz. Other models show similar performance within their respective specified bandwidths.

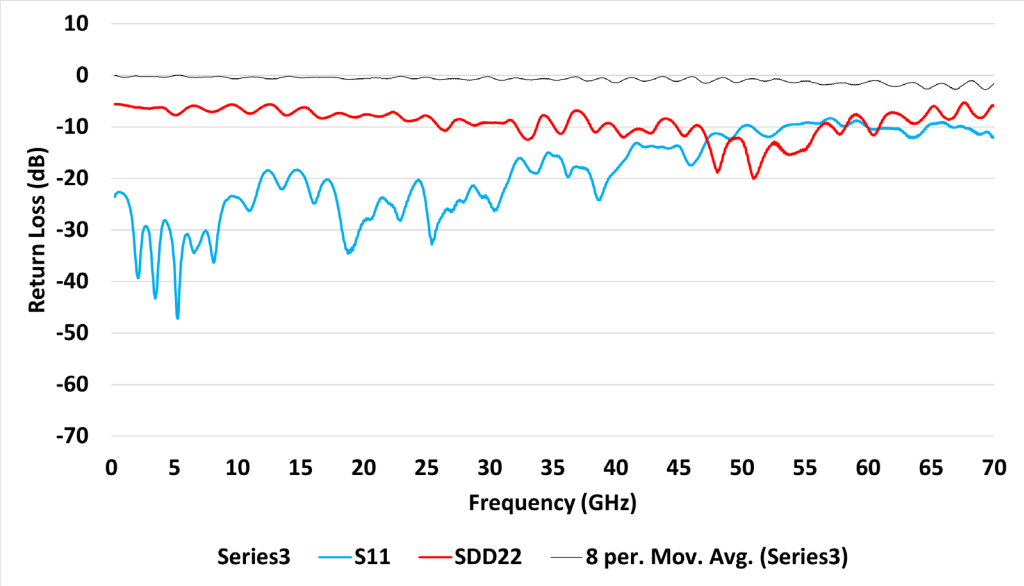


Figure 5: HL9407 Mixed-mode Return Loss

HL940x Common-mode Rejection Ratio

Figure 6 shows the typical common-mode rejection ratio (CMRR) of an HL9407.

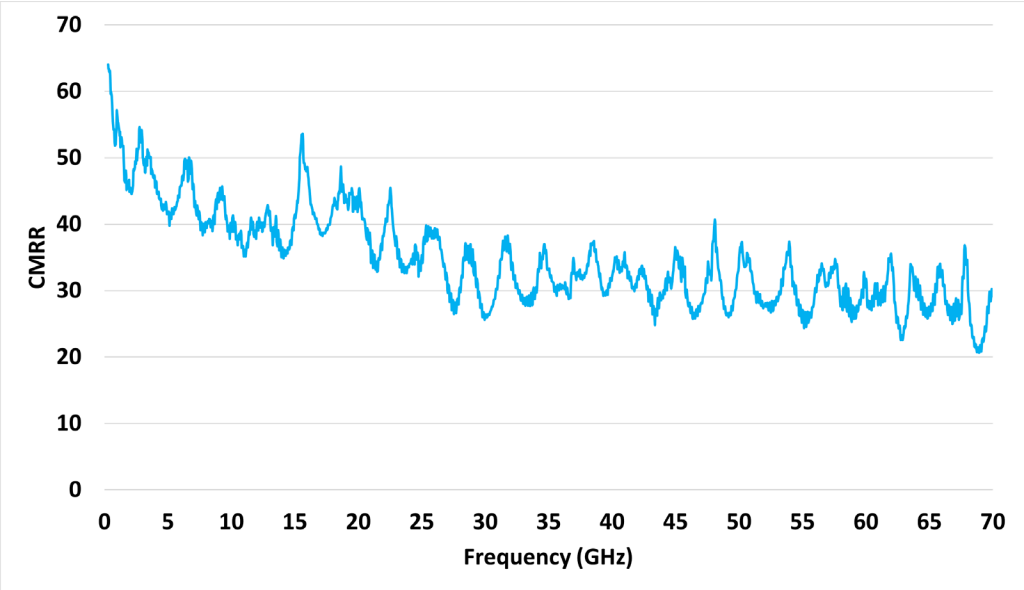


Figure 6: HL9407 Common Mode Rejection Ratio (CMRR)

HL940x Group Delay and Phase Match

Figure 7 shows the typical group delay of an HL9407 used as a signal splitter. The average slope of the phase mismatch, shown in *Figure 8*, is equal to the group delay mismatch. Other models show similar performance within their respective specified bandwidths.

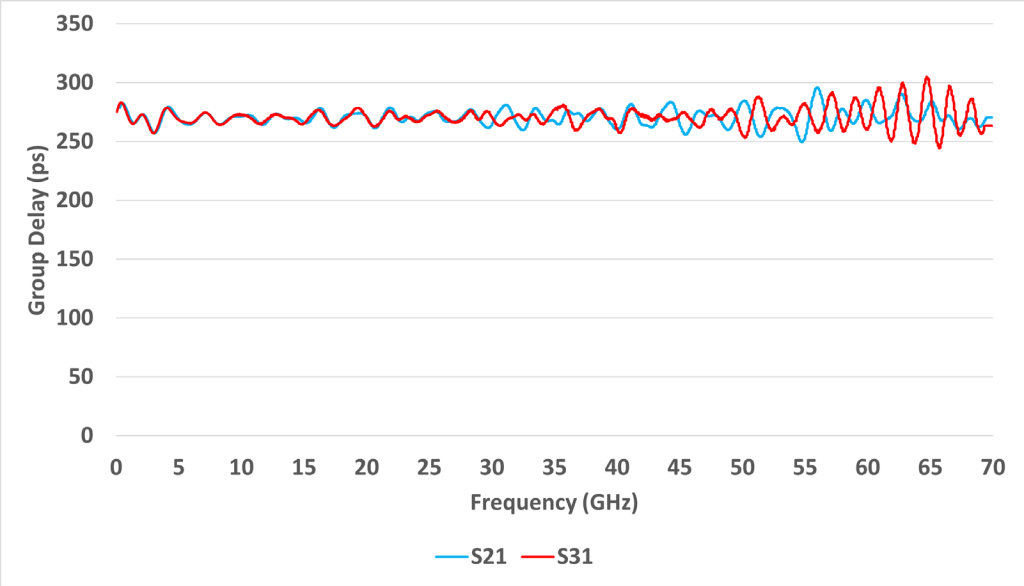


Figure 7: HL9407 Single-ended Group Delay

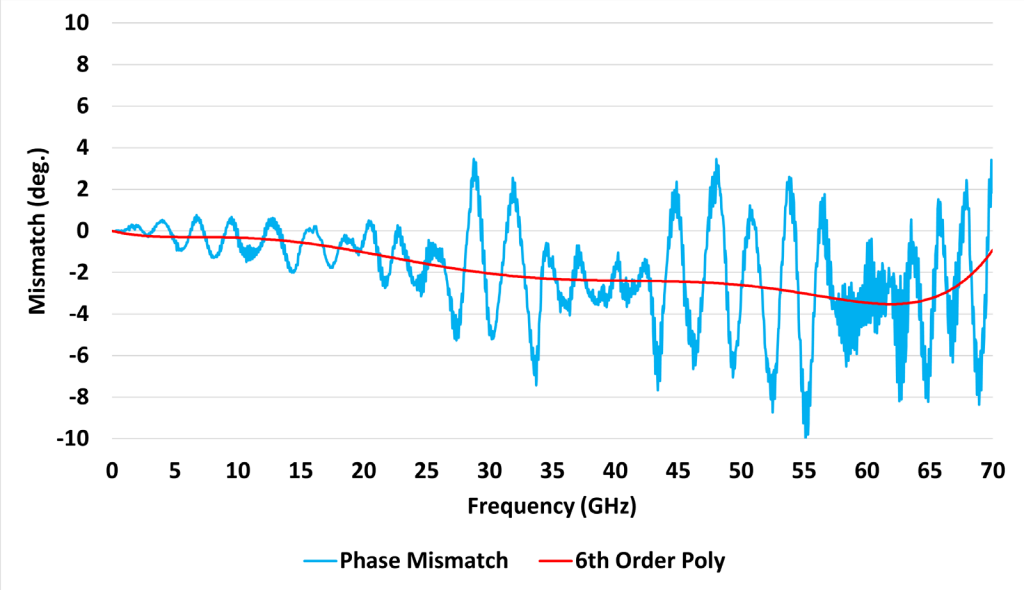


Figure 8: HL9407 Phase Mismatch

HL940x Eye Diagrams

The eye diagrams in *Figures 9-10* show a 56 Gbps PRBS11 pattern passed through an HL9407.

Figures 11-12 show a 112 Gbps PAM4 signal passed through the HL9407.

All plots have an input signal amplitude of 395 mV and are shown at 89 mV/div.

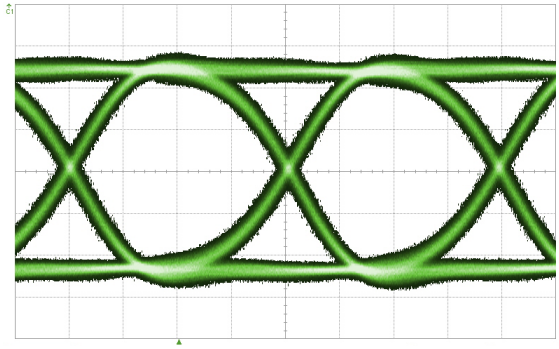


Figure 9: HL9407 56 Gpbs PRBS 11, RF Input

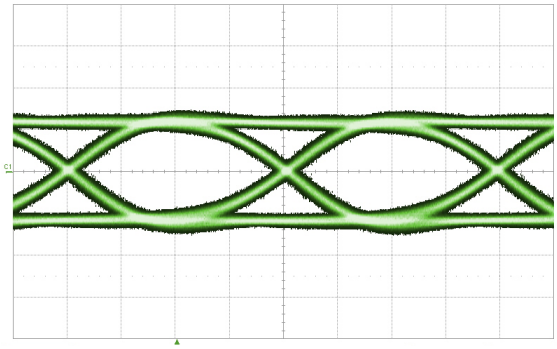


Figure 10: HL9407 56 Gpbs PRBS 11, RF Output

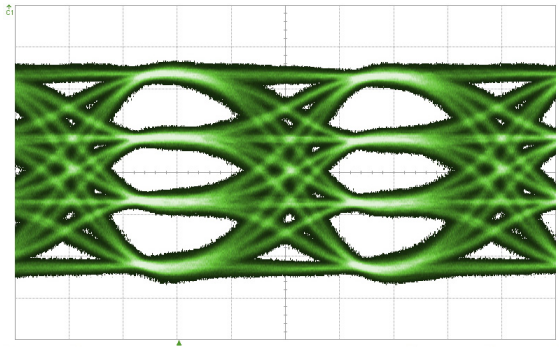


Figure 11: HL9407 112 Gbps PAM4, RF Input

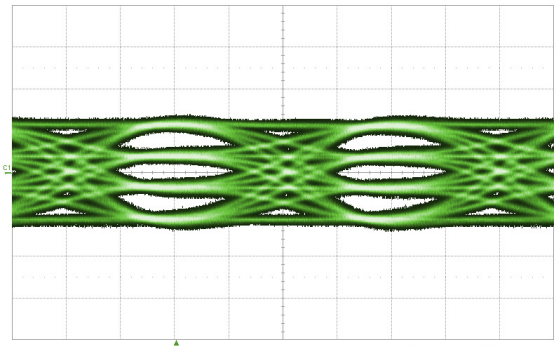


Figure 12: HL9407 112 Gbps PAM4, RF Output

HL940x Dimensional Drawing

Figure 13 shows a mechanical drawing of an HL9407. Unless otherwise noted, all units are in inches. Other models vary in width based on connectors. See page 2 for full dimensions.

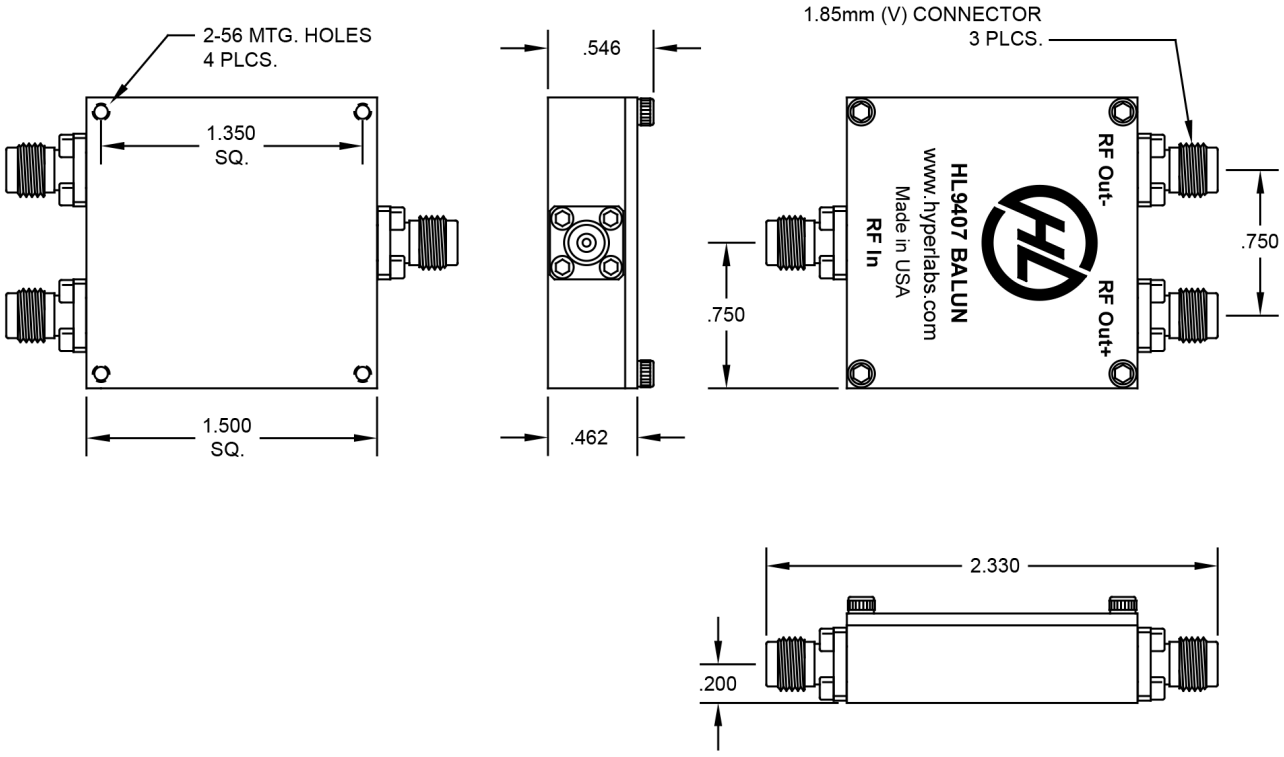


Fig. 13: HL9407 Mechanical Drawing