HYPERLABS™
Innovation at Hyperspeed since 1992

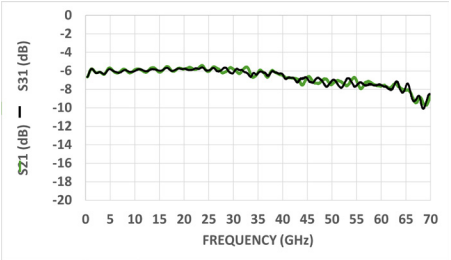
# HL940x Series Baluns (500 kHz to 67 GHz)

## Features and Technical Specifications[1] (HL9407 shown)

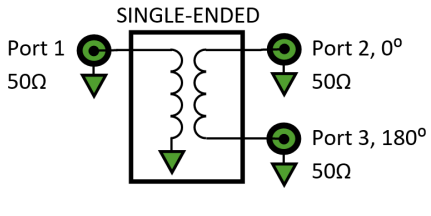
| | |
|---|---|
| Bandwidth | 500 kHz to 67 GHz |
| Amplitude Match | ± 0.1 dB, f ≤ 50 GHz<br>± 0.25 dB, f > 50 GHz<br>See *Fig. 1* |
| Phase Match | ± 4°, f = 20 GHz<br>± 8°, f = 40 GHz<br>See *Fig. 8* |
| Insertion Loss | 6 dB, single-ended reference<br>See *Figs. 1, 3-4* |
| Return Loss | > 15 dB,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

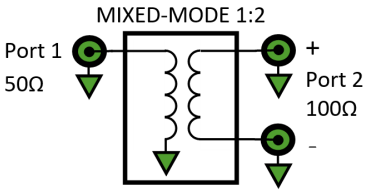
NOTE 1 - Unless otherwise noted, the specifications in this table are typical for Model Number HL9407. Full specifications for this and related models are available on Page 2 of this datasheet.


*HL9407, 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, options are available:

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

## 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<br>*See Fig. 1* | ± 0.1 dB | ± 0.1 dB | ± 0.1 dB | ± 0.1 dB, f ≤ 50 GHz<br>± 0.25 dB, f > 50 GHz | |
| Phase Match<br>*See Fig. 8* | ± 4°, f = 20 GHz | ± 4°, f = 20 GHz | ± 4°, f = 20 GHz<br>± 8°, f = 40 GHz | ± 4°, f = 20 GHz<br>± 8°, f = 40 GHz | |
| Insertion Loss<br>*See Figs. 1, 3-4* | 6 dB | | | | Single-ended reference |
| Return Loss<br>*See Figs. 2, 5* | > 15 dB, unbal. port<br>> 10 dB, bal. ports | > 15 dB, f ≤ 30 GHz, unbal. port<br>> 12.5 dB, f > 30 GHz, unbal. port,<br>> 10 dB, bal. ports | > 20 dB, f ≤ 30 GHz, unbal. port<br>> 15 dB, f > 30 GHz, unbal. port<br>> 10 dB, bal. ports | > 15 dB, f ≤ 40 GHz, unbal. port<br>> 10 dB, f > 40 GHz, unbal. port<br>> 10 dB, f ≤ 50 GHz, bal. ports<br>> 7.5 dB, f > 50 GHz, bal. ports | unbal. = unbalanced<br>bal. = balanced |
| Rise Time | 13 ps | 9 ps | 7 ps | 5 ps | |
| CMRR<br>*See Fig. 6* | > 30 dB, f ≤ 20 GHz | > 30 dB, f ≤ 20 GHz<br>> 25 dB, f > 20 GHz | > 30 dB, f ≤ 25 GHz<br>> 25 dB, f > 25 GHz | > 30 dB, f ≤ 25 GHz<br>> 25 dB, f > 25 GHz | Typical |
| Group Delay<br>*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 | SMA, 3x jack/female<br>SMA plug connectors upon request | 2.92 mm, 3x jack/female<br>2.92 mm plug connectors upon request | 2.4 mm, 3x jack/female<br>2.4 mm plug connectors upon request | 1.85 mm, 3x jack/female<br>1.85 mm plug connectors upon request | |
| Dimensions (W x D x H) | 2.25” x 1.50” x 0.55”<br>57.2 x 38.1 x 14 mm | 2.25” x 1.50” x 0.55”<br>57.2 x 38.1 x 14 mm | 2.35” x 1.50” x 0.55”<br>59.7 x 38.1 x 14 mm | 2.33” x 1.50” x 0.55”<br>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 | | | | |

## 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.

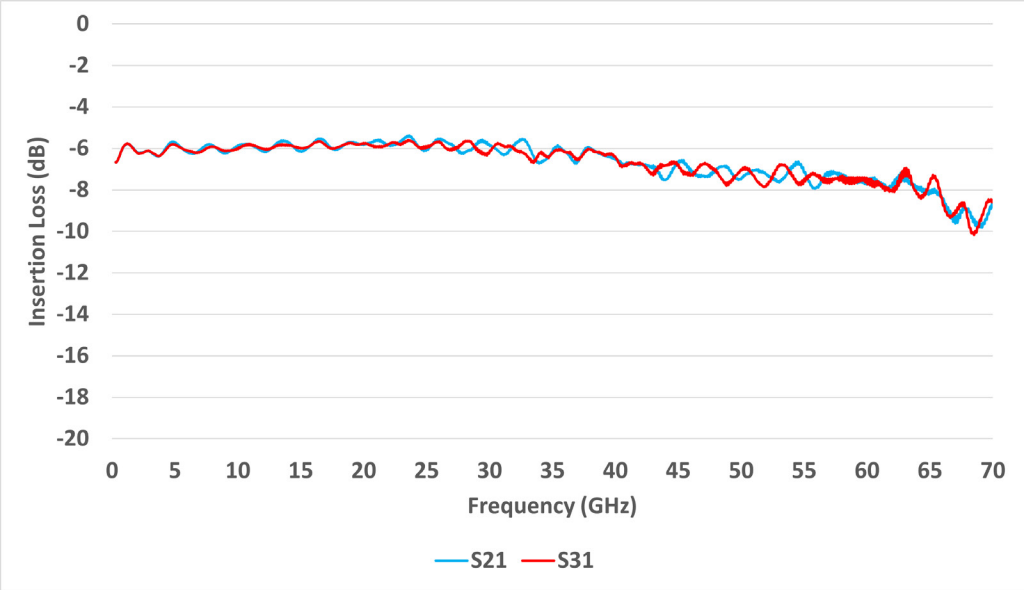



*Figure 1: HL9407 Single-ended Insertion Loss*

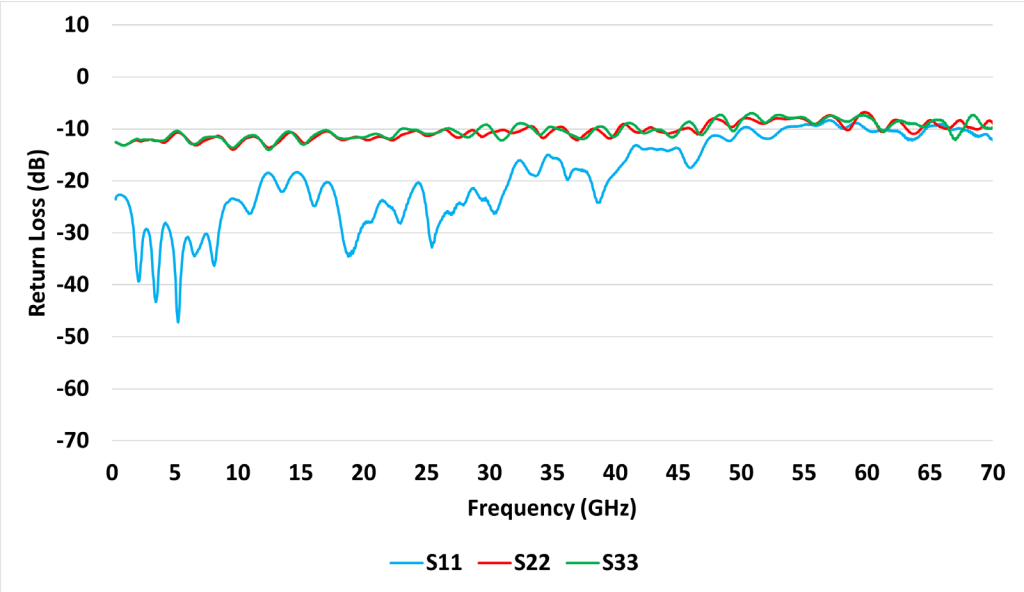



*Figure 2: HL9407 Single-ended Return Loss*

## 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.

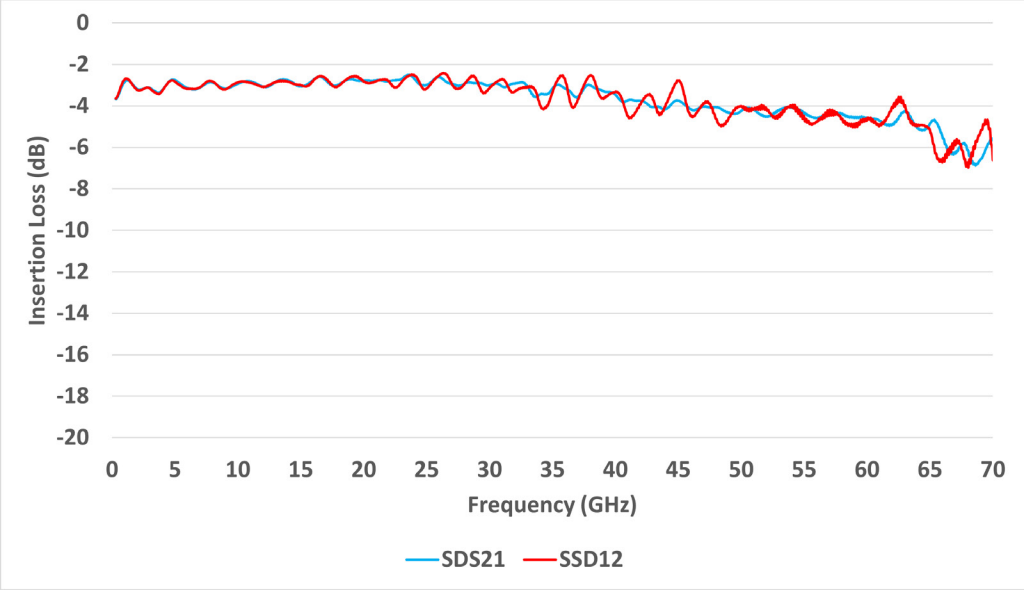



*Figure 3: HL9407 Differential Mode Insertion Loss*

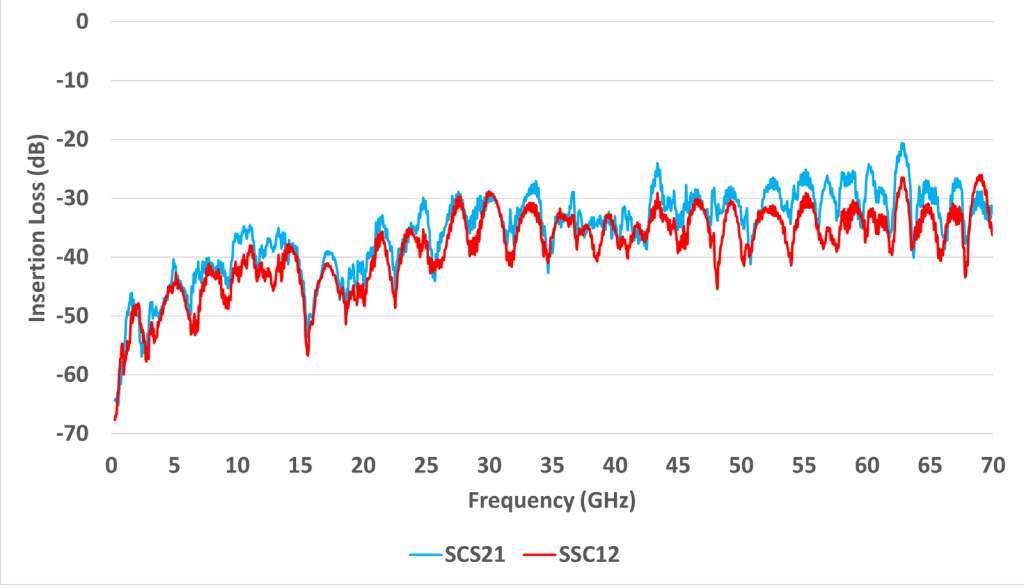



*Figure 4: HL9407 Common Mode Insertion Loss*

## 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.

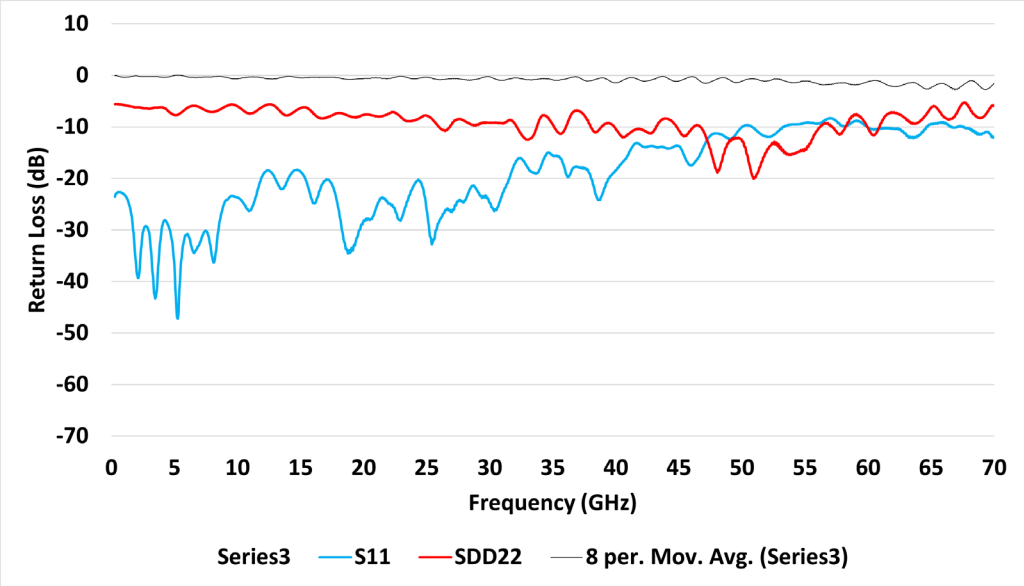



*Figure 5: HL9407 Mixed-mode Return Loss*

## HL940x Common-mode Rejection Ratio

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

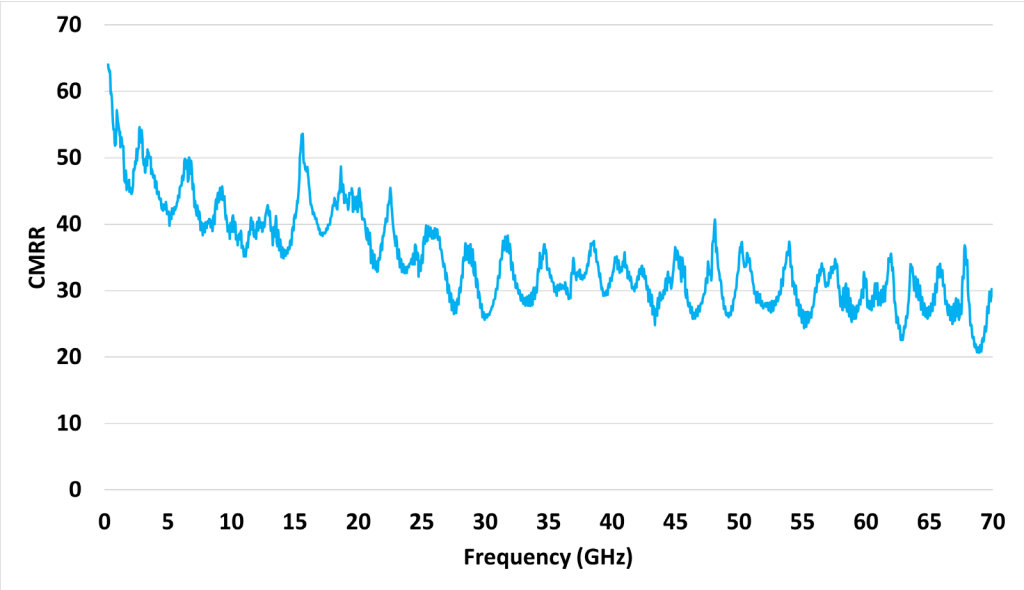



*Figure 6: HL9407 Common Mode Rejection Ratio (CMRR)*

## 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.

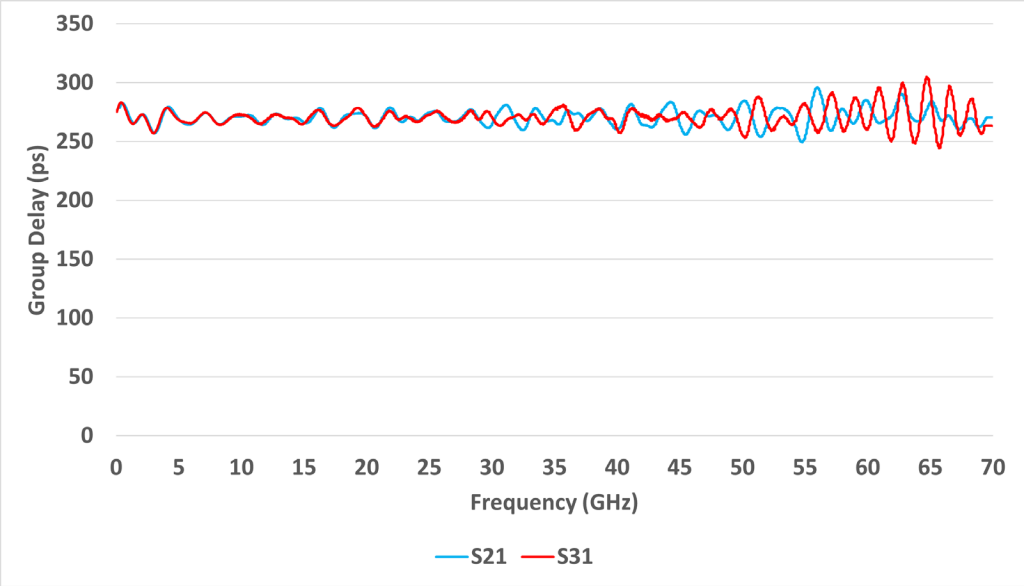



*Figure 7: HL9407 Single-ended Group Delay*

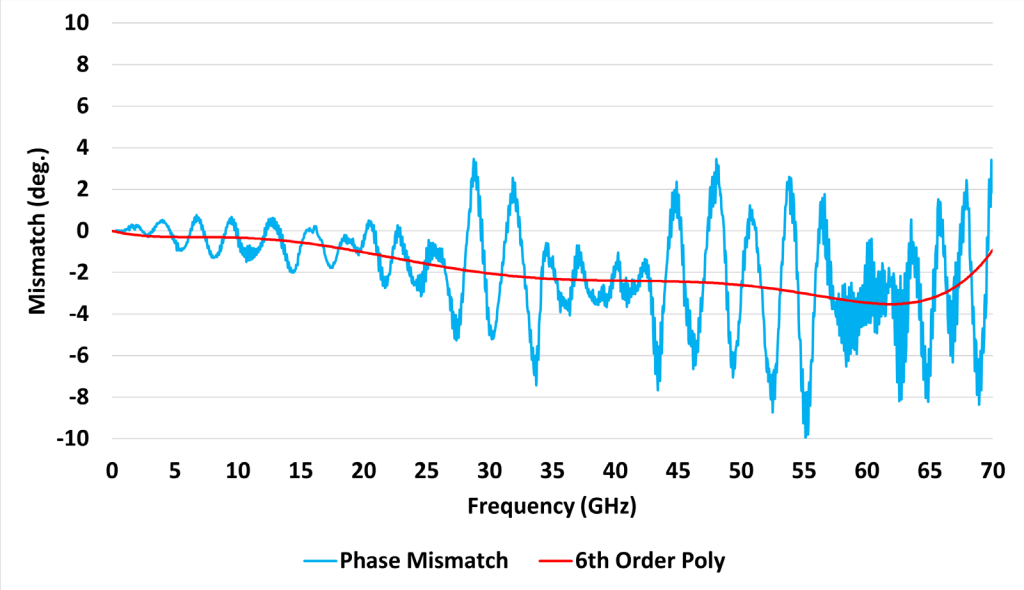



*Figure 8: HL9407 Phase Mismatch*

## 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.

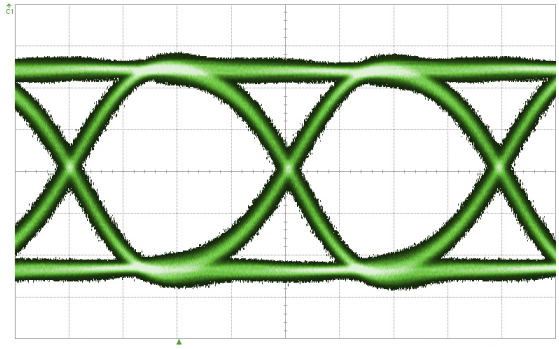


*Figure 9: HL9407 56 Gpbs PRBS 11, RF Input*

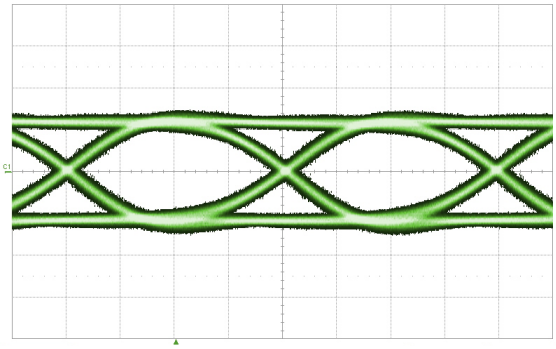


*Figure 10: HL9407 56 Gpbs PRBS 11, RF Output*

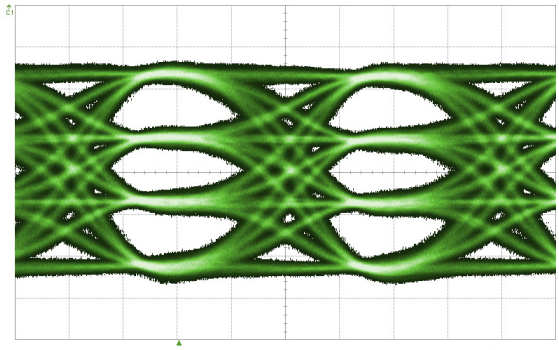


*Figure 11: HL9407 112 Gbps PAM4, RF Input*

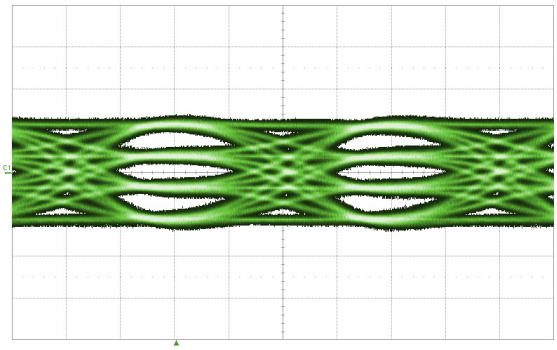


*Figure 12: HL9407 112 Gbps PAM4, RF Output*

## 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.

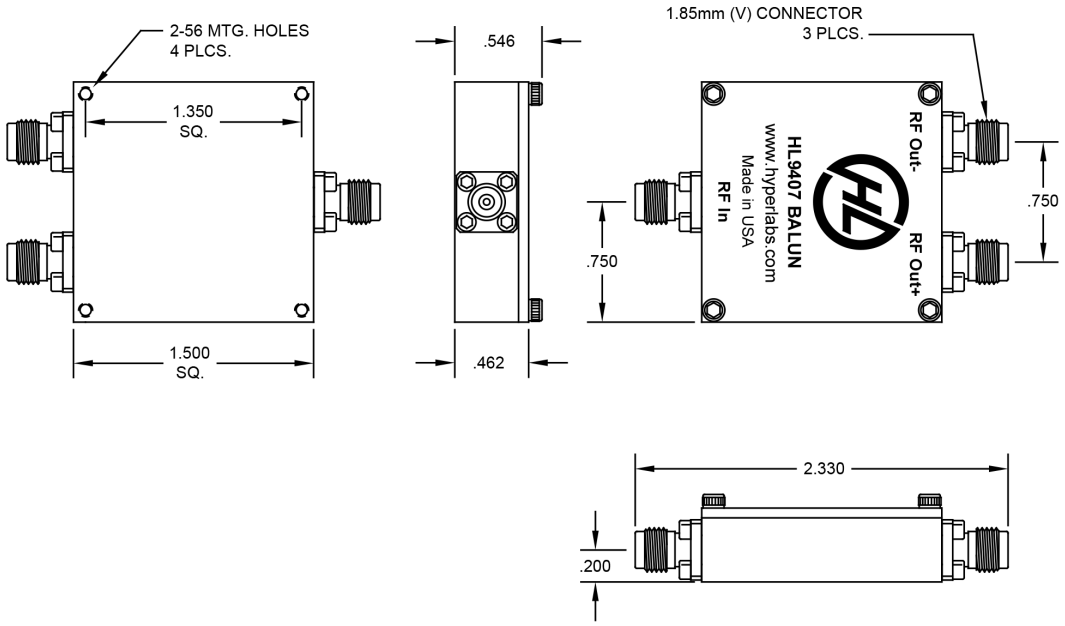



*Fig. 13: HL9407 Mechanical Drawing*