HYPERLABS™
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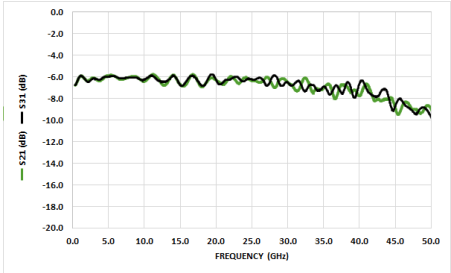
HL950x Series Integrated Baluns (500 kHz to 50 GHz)

Features and Technical Specifications[1] (HL9505-DDD shown)

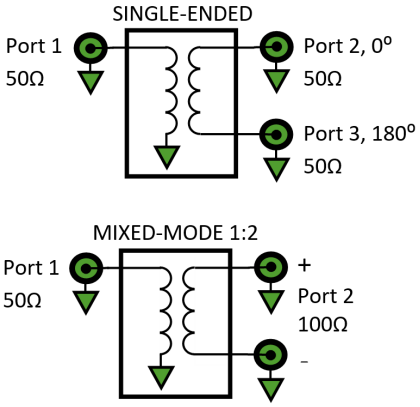
Bandwidth	500 kHz to 50 GHz
Amplitude Match	± 0.1 dB, f ≤ 40 GHz ± 0.25 dB, f > 40 GHz See *Fig. 1*
Phase Match	± 4°, f = 20 GHz ± 8°, f = 40 GHz See *Fig. 8*
Insertion Loss	6 dB, single-ended reference See *Figs. 1, 3-4*
Return Loss	> 15 dB, unbalanced port, f ≤ 30 GHz > 10 dB, unbalanced port, f > 30 GHz > 10 dB, balanced ports, f ≤ 30 GHz > 7.5 dB, balanced ports, f > 30 GHz See *Figs. 2, 5*
Capacitance	47 nF, all ports (opt. -DDD)
Group Delay	≈ 320 ps See *Fig. 7*
Breakdown Voltage	30 V
Max Input Power	1 W (+30 dBm)
Connectors	Available with SMA, 2.92 mm, or 2.4 mm connectors depending on model and bandwidth
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 HL9505-DDD. Full specifications for this and related models are available on Page 2 of this datasheet.

HL9505-DDD, standard configuration shown



Typical HL9505-DDD Single-ended Insertion Loss



HL950x Schematic and Port Assignments

PRODUCT SUMMARY

The HL950x series are ultra-broadband 180° signal splitters and combiners with integrated components such as DC blocks and bias tees.

These devices offer the same industry-best amplitude and phase match of other HYPERLABS baluns. Integrating commonly-used components reduces overall system size as well as cost.

They are suitable for use in 112 Gbps PAM4 communications systems, high-speed analog-to-digital conversion, frequencyresponse 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.

MODELS & OPTIONS

The following models and options are available:

HL9502, 26.5 GHz
HL9504, 40 GHz
HL9505, 50 GHz

-DDD, DC Block, all ports

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HL950x Full Specifications

Parameter	HL9502	HL9504	HL9505	Comments
Upper Frequency Limit	26.5 GHz	40 GHz	50 GHz	3 dB roll-off point, relative to nominal insertion loss
Lower Frequency Limit	500 kHz	500 kHz	500 kHz	3 dB roll-off point; based on balun performance
Amplitude Match *See Fig. 1*	± 0.1 dB	± 0.1 dB	± 0.1 dB, f ≤ 40 GHz ± 0.25 dB, f > 40 GHz	
Phase Match *See Fig. 8*	± 4°, f = 20 GHz	± 4°, f = 20 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, f ≤ 30 GHz, bal. ports > 7.5 dB, f > 30 GHz, bal. ports	> 15 dB, f ≤ 30 GHz, unbal. port > 12.5 dB, f > 30 GHz, unbal. port > 10 dB, f ≤ 30 GHz, bal. ports > 7.5 dB, f > 30 GHz, bal. ports	unbal. = unbalanced bal. = balanced
Rise Time	13 ps	9 ps	7 ps	
CMRR *See Fig. 6*	> 30 dB, f ≤ 20 GHz	> 30 dB, f ≤ 20 GHz > 20 dB, f > 20 GHz	> 30 dB, f ≤ 25 GHz > 20 dB, f > 25 GHz	Typical
Group Delay *See Fig. 7*	≈ 320 ps	≈ 320 ps	≈ 320 ps	
Max Input Power	1 W (+30 dBm)			
Impedance	50 Ω			Input and Outputs
Connectors	SMA, 3x jack/female SMA plug connectors upon request	2.92 mm, 3x jack/female 2.92 mm plug connectors upon request	2.4 mm, 3x jack/female 2.4 mm plug connectors upon request	
Dimensions (W x D x H)	2.57” x 1.64” x 0.55” 65.3 x 41.7 x 14 mm	2.57” x 1.64” x 0.55” 65.3 x 41.7 x 14 mm	2.73” x 1.64” x 0.55” 69.3 x 41.7 x 14 mm	Package including connectors
Weight	61 g (2.15 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			

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HL950x 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 HL9505-DDD 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.

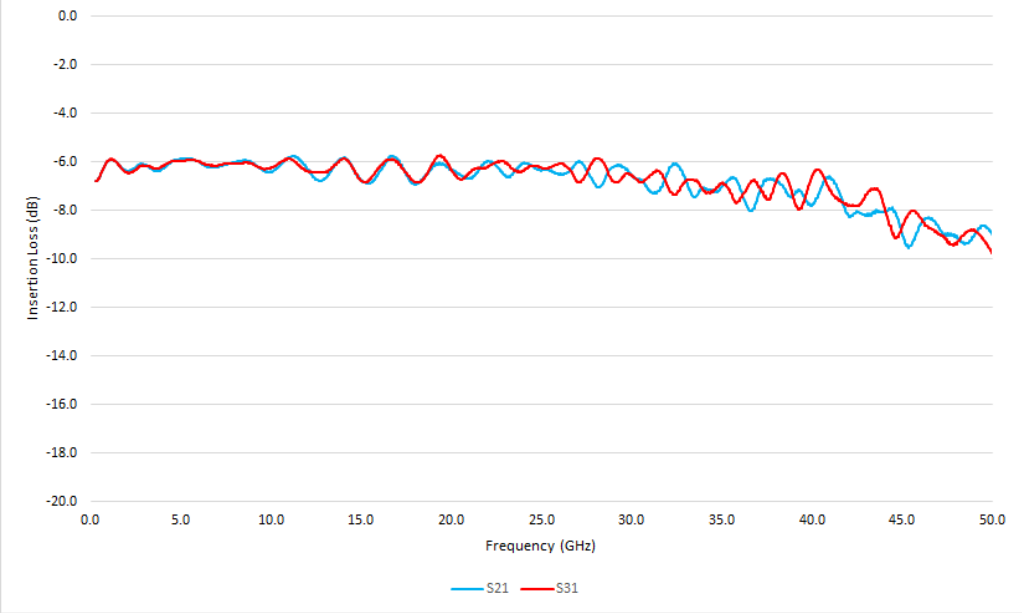

Figure 1: HL9505-DDD Single-ended Insertion Loss

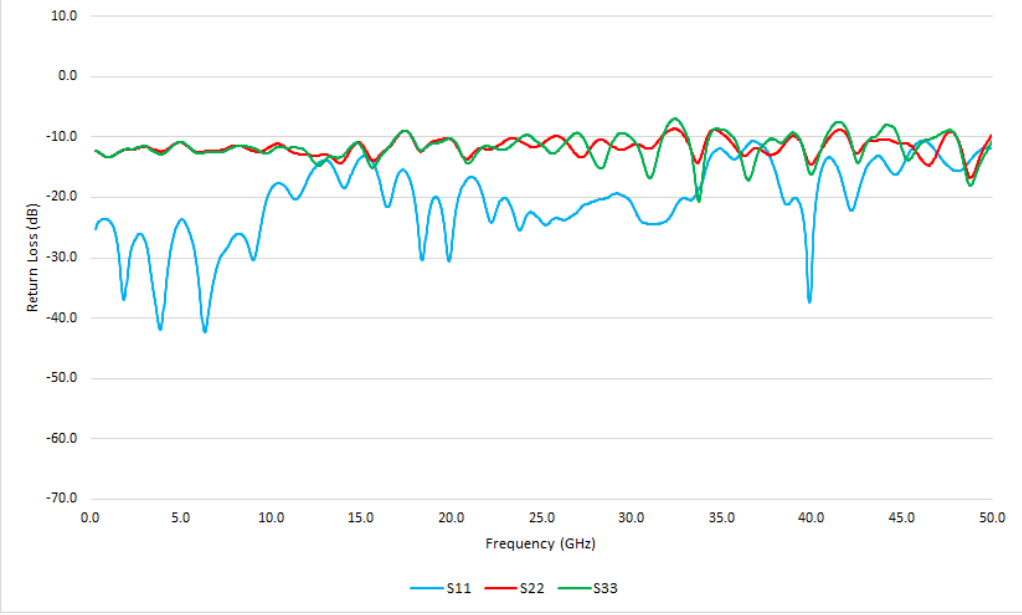

Figure 2: HL9505-DDD Single-ended Return Loss

HL950x 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 HL9505-DDD balun in mixed mode to 70 GHz. Other models show similar performance within their respective specified bandwidths.

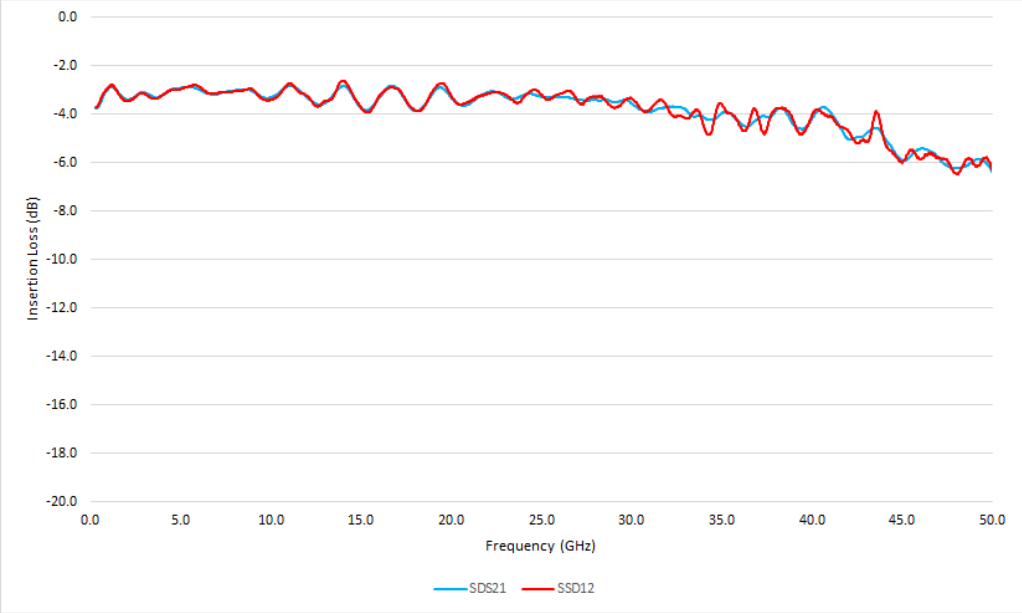

Figure 3: HL9505-DDD Differential Mode Insertion Loss

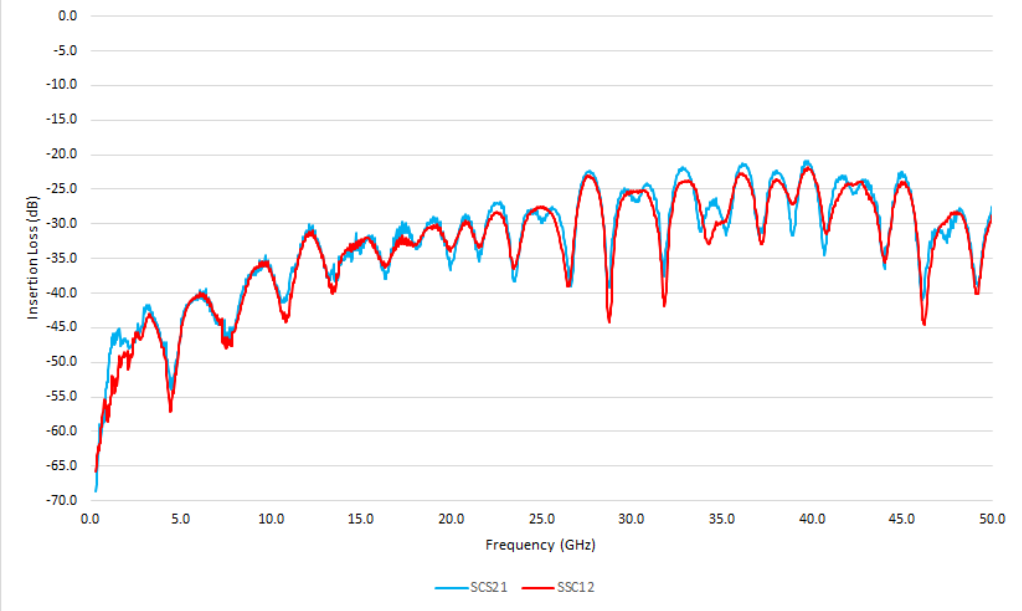

Figure 4: HL9505-DDD Common Mode Insertion Loss

HL950x Mixed-mode Return Loss

Figure 5 shows the typical mixed-mode return loss of the unbalanced and balanced ports of an HL9505-DDD to 70 GHz. Other models show similar performance within their respective specified bandwidths.

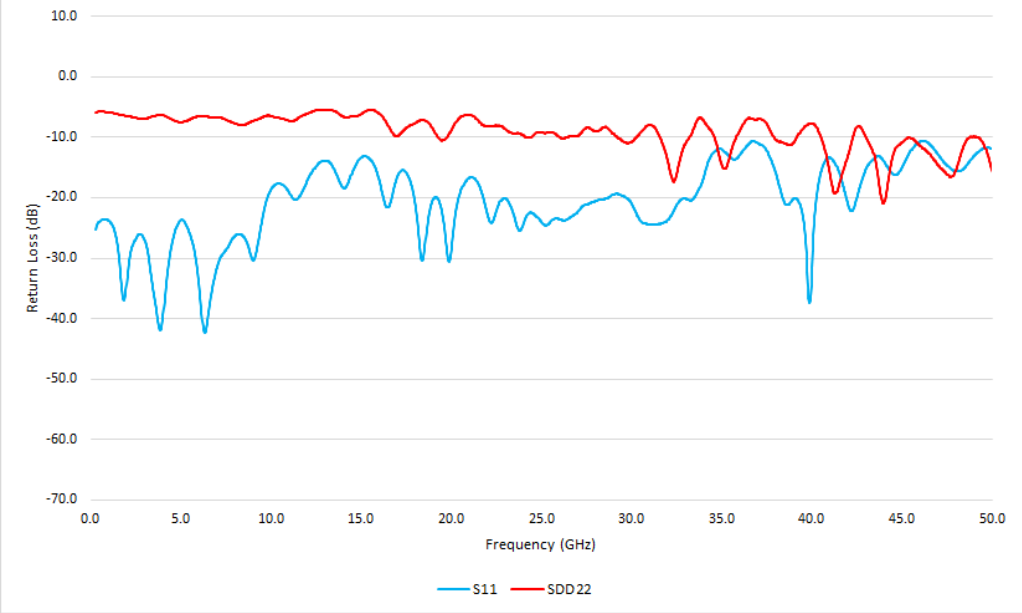

Figure 5: HL9505-DDD Mixed-mode Return Loss

HL950x Common-mode Rejection Ratio

Figure 8 shows the typical common-mode rejection ratio (CMRR) of an HL9505-DDD.

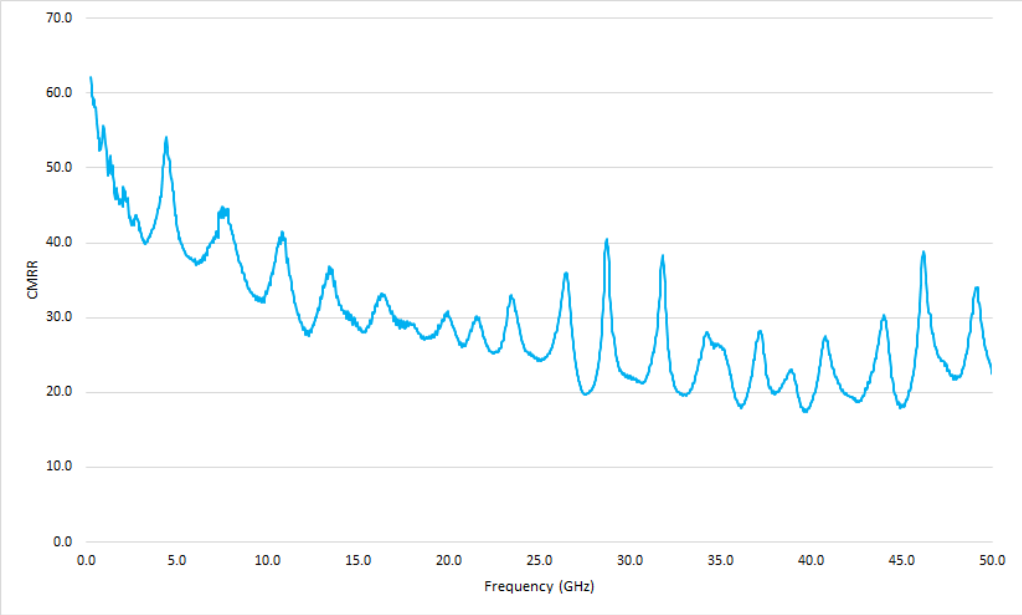

Figure 6: HL9505-DDD Common Mode Rejection Ratio (CMRR)

HL950x Group Delay and Phase Match

Figure 6 shows the typical group delay of an HL9505-DDD used as a signal splitter. The average slope of the phase mismatch, shown in *Figure 7*, is equal to the group delay mismatch. Other models show similar performance within their respective specified bandwidths.

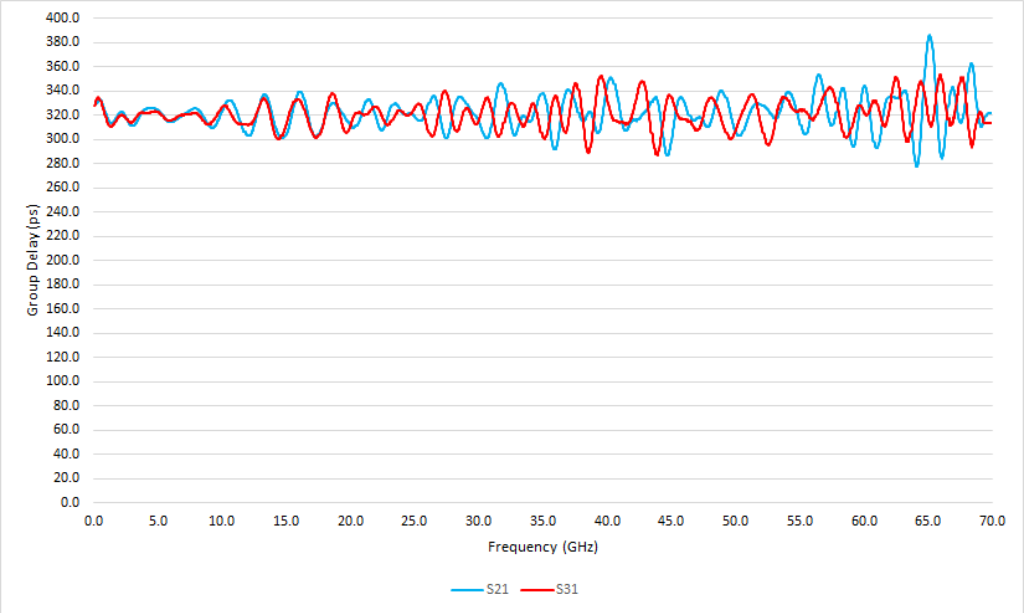

Figure 7: HL9505-DDD Single-ended Group Delay

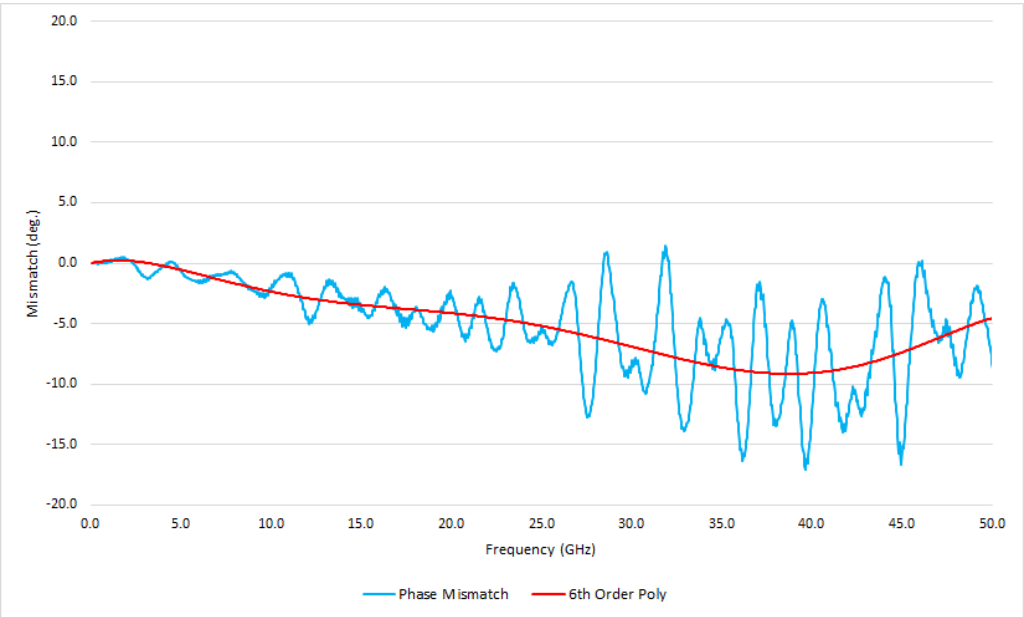

Figure 8: HL9505-DDD Phase Mismatch

HL950x Eye Diagrams

The eye diagrams in *Figures 9-10* show a 56 Gbps PRBS11 pattern passed through an HL9505-DDD.

Figures 11-12 show a 112 Gbps PAM4 signal passed through the HL9505-DDD.

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

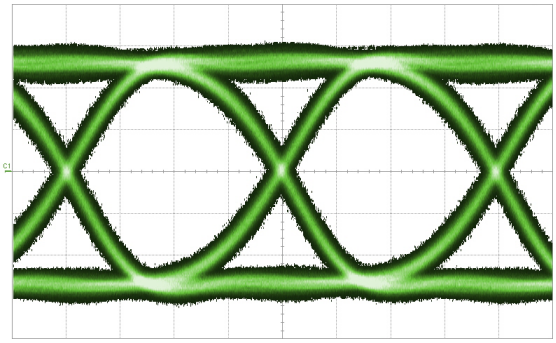

Figure 9: HL9505-DDD 56 Gpbs PRBS 11, RF Input

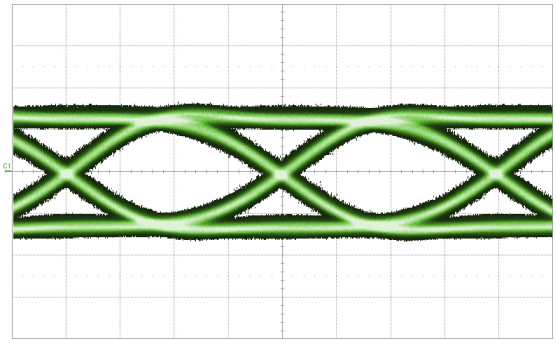

Figure 10: HL9505-DDD 56 Gpbs PRBS 11, RF Output

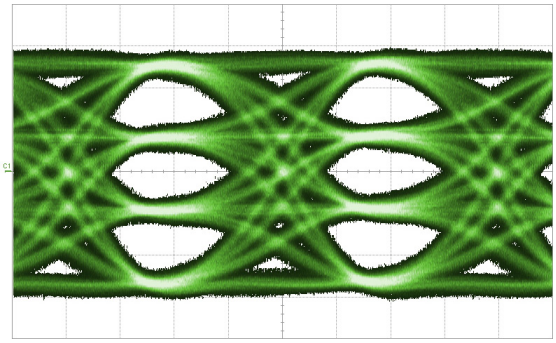

Figure 11: HL9505-DDD 112 Gbps PAM4, RF Input

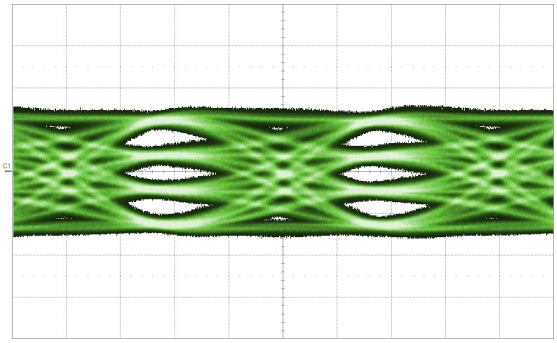

Figure 12: HL9505-DDD 112 Gbps PAM4, RF Output

HL950x Dimensional Drawing

Figure 13 shows a mechanical drawing of an HL9505-DDD. Unless otherwise noted, all units are in inches. Other models vary in width based on connectors. See page 2 for full dimensions.

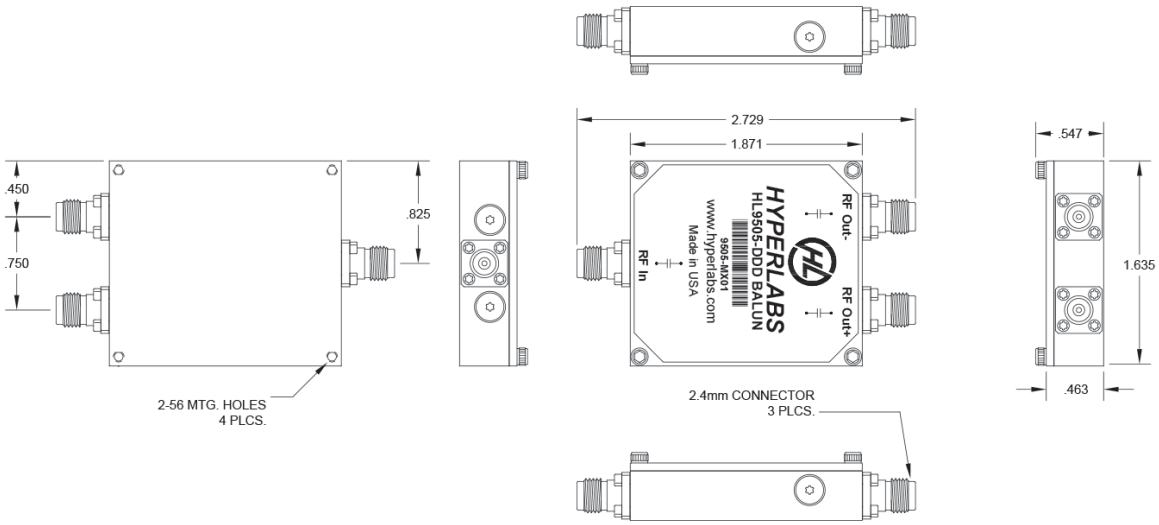

Fig. 13: HL9505-DDD Mechanical Drawing