**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.

**Features and Technical Specifications**

- **Bandwidth (-3 dB)**: 500 kHz to 67 GHz
- **Amplitude Match**:
  - ± 0.1 dB to 30 GHz
  - ± 0.3 dB to 67 GHz
  - See Fig. 1 below
- **Phase Match**:
  - ± 4-6° at 20 GHz
  - ± 8-12° at 40 GHz
  - See Fig. 2 below
- **Rise time**: < 5.2 ps
- **Insertion Delay**: = 278 ps
- **Insertion Loss**: -6 dB
- **Return Loss**: See Figs. 3-4 below
- **VSWR**: See Fig. 5 below
- **CMRR**:
  - > 70 dB at 10 MHz
  - > 30 dB at 50 GHz
  - See Fig. 6 below
- **Eye Diagrams**: See Figs. 8-10 below
- **Max Input Power**: +30 dBm
- **Impedance**: 50 Ω In, 2 x 50 Ω 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

**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](image)

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+](image-url)
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.

![CMRR Graph](image)

*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. These data were simulated using ADS software and S-parameter files from a measured HL9407 device.

Figure 8: 64 Gbps PRBS pattern as applied to the HL9407 RF In port
HL9407 Eye Diagrams (cont.)

Figure 9: Eye diagram (64 Gbps) of the HL9407 RF Out+ (non-inverting) port

Figure 10: Eye diagram (64 Gbps) of the HL9407 RF Out- (inverting) port