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Overview

Hewlett-Packard is a well recognized leader in test equipment and measurement techniques. From traditional RF and microwave areas to the latest wireless communication test requirements, HP strives to create solutions that meet tomorrow's test and measurement needs. HP's expertise is a result of decades of innovation in creating key building blocks for test system solutions. These core product technologies have evolved into a popular line of RF and microwave test accessories for use in test and measurement systems from dc to 110 GHz. This catalog contains coaxial and waveguide accessories that can be utilized in test setups for RF and microwave measurements such as:

- Impedance
- Attenuation
- Power
- Noise figure
- Spectrum analysis
- Calibration and metrology

These products are the result of a vertically-integrated approach to the manufacturing process. Exceptional precision is achieved through fabrication facilities equipped with advanced milling equipment and sophisticated metallurgical/plating processes.

Key Features and Benefits

- Exceptional repeatability provides higher measurement confidence
- Long life results in lower cost of ownership
- Broadband operation allows test simplification

Catalog Format

This catalog presents products by family and function. Products with complex functions have a short tutorial introductory section. Included in this tutorial section is an overview of applications and key specifications essential to an understanding of which products are best suited for your test and measurement solution. Chapter 16 is dedicated to waveguide accessories.

Applications

Benchtop

The most straightforward application for RF and microwave test accessories is in “benchtop” assemblies. These open architecture assemblies, common in both production and R&D lab environments, are characterized by loosely-arranged test setups which are readily accessible.

Signal Interface Unit Designs

RF and microwave test accessories are often utilized by customers as basic building blocks for the design of a test signal interface unit. In general, the interface unit performs the function of signal routing and conditioning within a "rack and stack" test architecture.

ISO 9000 Quality Management

The ISO 9000 series is a set of international standards for quality management and quality assurance. These standards were developed with the goal of documenting and implementing an effective quality system in a company. ISO standards are consistent with HP's quality system; in fact, the standards within HP's Quality Maturity System (QMS) exceed the intent of ISO 9000.

Almost all HP test and measurement divisions and calibration laboratories are ISO 9000 registered. Selected laboratories are accredited to ISO Guide 25. Key products are available with an optional ISO 9001/2 commercial calibration certificate.

Sales and Applications

It's easy to buy the right microwave test accessory from HP!

HP's complete line of catalogs, product data sheets and application notes give you the specification and application information needed to design RF and microwave test sets.

For answers to technical questions, literature, or ordering information, call HP DIRECT.

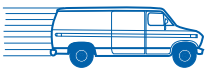
HP has technical sales and applications support available through a toll free phone number in the U.S. It's called HP DIRECT, and it puts you in touch with technical representatives who have been solving microwave measurement problems for years. Some companies hire telesales people who occasionally answer technical questions. HP hires technical representatives who can not only answer applications questions, but can also assist you in comparing specifications and finding product alternatives. They can even take your order on the same call.

HP DIRECT telephone representatives are available in many countries outside the U.S. as well. The HP DIRECT call centers are listed in Chapter 19 of this catalog. In the U.S., call **1-800-452-4844**.

For comprehensive technical support, call HP's local sales office.

When you need answers to complex technical test and measurement questions, or would like a face-to-face discussion of your requirements, call your local HP sales representative. HP sales representatives are trained for a broad variety of measurement applications, and are pleased to discuss your product needs. Their knowledge of HP test accessories, as well as other HP test and measurement products, assures you of a well-integrated solution. A current listing is available via HP's site on the Internet at **http://www.hp.com/go/mta**.

To save time, request QuickShip delivery.



Many of our most popular products are identified with an icon (shown above) in this catalog. Contact HP Direct or your local HP sales representative to confirm QuickShip availability.

New Products Highlights

The new products described on these pages complement HP's broad offering of RF and Microwave Test Accessories.

mm-wave to Coax Adapters 50-110 GHz HP V/W281C,D

These adapters offer a simple low loss, low SWR transition between coax and waveguide environments. The frequency range is from 50 to 110 GHz.

High Performance Transfer Switch HP 87222C dc to 26.5 GHz

This coaxial transfer switch features excellent reliability, repeatability and long life, increasing measurement confidence and lowering the cost of ownership. The HP 87222C can be used in a variety of applications such as drop-out switch, switching two outputs and inputs, and signal reversal.

1mm Coax Adapters HP 11920/1/2A,B,C,D HP 11923A Launch

These 1.0 mm series adapters offer an easy, repeatable way to measure coaxial devices at frequencies up to 110 GHz.

New Products Highlights (continued)

Matrix Switches for ATE

The HP 87406B and HP 87606B are six-port matrix switches that operate from 0-20 GHz. They can be configured to provide 15 different signal paths reducing the number of switches and components required in a complex signal solution.

Power Limiters HP 11930A,B

Allows increased power protection for sensitive input circuitry for a variety of RF and microwave test instrumentation. Protects network and spectrum analyzer inputs up to 6 watts peak.

New 7-16 Calibration Kit

HP offers calibration and adapter kits for 7-16 connectors. The HP 85038 family of calibration kits can be used for calibrating HP network analyzers. The HP 11906 family of adapter kits provides connections between 7-16 connectors and type-N, 3.5 mm, or 7 mm connectors.

Index Alphabetical

Index Alphabetical

Index HP Model Number

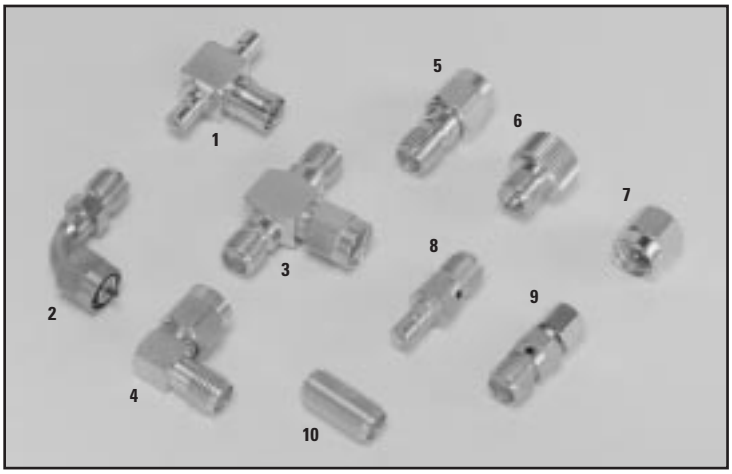
Index HP Model Number

Index HP Part Number

Note: Network Analyzer Accessories and Cal Kit part numbers can be found on pages 81-122.

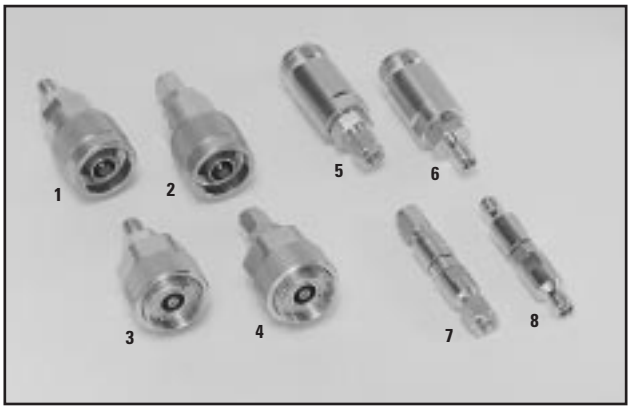
Adapters

1 HP 1250-1200 Adapter, BNC (f) to SMA (m)
2 HP 1250-1899 Adapter, BNC (f) to SMB (m)
3 HP 1250-0556 Adapter, BNC (f) to WECO Video (m)
4 HP 1250-0591 Adapter, BNC (f) to WECO Video (m)
5 HP 1250-1477 Standard, N (f) to BNC (m), Precision 50 Ohm
6 HP 1250-1473 Standard, N (f) to (m) to BNC (m), Precision 50 Ohm Adapter
7 HP 1250-0595 Adapter, BNC (f) to Triaxial (m)
8 HP 1250-1930
9 HP 1250-1830 Adapter, BNC (f) to Triaxial (f)
10 HP 1250-1857 Adapter, SMB (f) to BNC (m)
11 HP 1250-0562
12 HP 1250-1236 Adapter, SMB (f) to BNC (f)

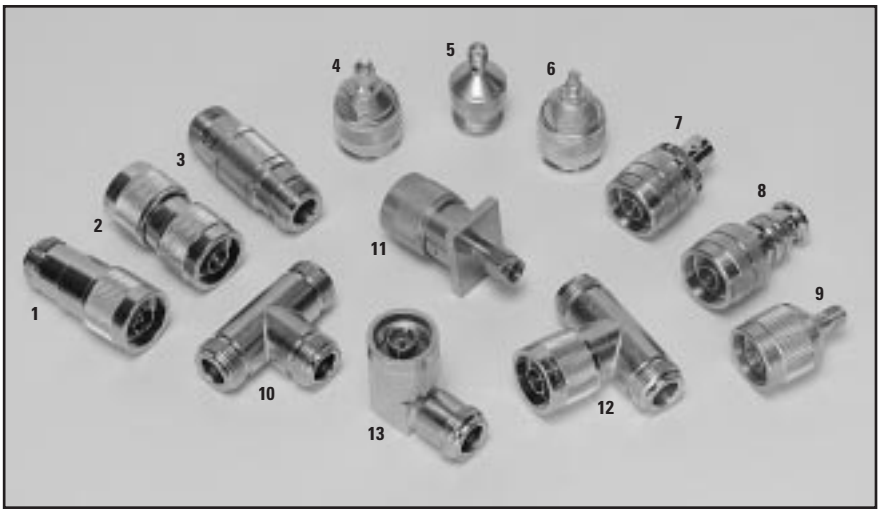


1 HP 1250-1391 Adapter, SMB Tee (f-m-m)
2 HP 1250-1741 SMA (f) to SMA (m) Right Angle Adapter
3 HP 1250-1698 Adapter, SMA Tee (m) (f) (f)
4 HP 1250-1249 Adapter, SMA Right Angle (m) (f)
5 HP 1250-1462 Adapter, SMA (m) to SMA (f)
6 HP 2020-5353 short 50 Ohm load
7 HP 2021-1314 short 50 Ohm load
8 HP 1250-0674 Adapter, SMB (m) to SMA (f)
9 HP 1250-1694 SMA (m) to SMA (f) Adapter
10 HP 1250-1158 SMA (f) to SMA (f) Adapter

Adapters



1 HP 1250-1744 Adapter, 3.5 mm (f) to Type-N (m), dc-18
2 HP 1250-1743 Adapter, 3.5 mm (m) to Type-N (m), DC to 18 GHz
3 HP 1250-1747 SMA (f) to APC-7 Adapter
4 HP 1250-1746 SMA (m) to APC-7 Adapter
5 HP 1250-1750 3.5 mm (m) to Type-N (f)
6 HP 1250-1745 3.5 mm (f) to Type-N (f)
7 HP 1250-1748 3.5 mm (f) to 3.5 mm (m) Instrument-Grade Adapter
8 HP 1250-1749 3.5 mm (f) to 3.5 mm (f)



1 HP 1250-0597 Adapter, Type-N (m) 50 Ohm to Type-N (f) 75 Ohm
2 HP 1250-1778 Standard N (m) to Standard N (m) Adapter, 50 Ohm
3 HP 1250-1529 Standard N (f) to Standard N (f) Adapter, 75 Ohm
4 HP 1250-1152 Adapter, SMC (f) to Type-N (m)
5 HP 1250-1404 Adapter, SMA (f) to Type-N (f)
6 HP 1250-1023 Adapter, SMC (m) to Type-N (m)
7 HP 2021-1535 Standard N (m) to BNC (f) Adapter, 75 Ohm
8 HP 1250-1533 Standard N (m) to BNC (m) Adapter, 75 Ohm
9 HP 1250-1250 Adapter, Type-N (m) to SMA (f), 50 Ohm
10 HP 1250-0846 Tee Adapter, Standard N (f) (f) (f)
11 HP 1250-1636 Adapter, Type-N (m) to SMA (m) 50 Ohm
12 HP 1250-0559 Tee Adapter, Standard N (m) (f) (f)
13 HP 1250-0176 Right Angle Standard N (m) to Standard N (f)

Adapters

Metrology/Instrument Grade Selection Guide [1]

Connector Type	1.85 mm	2.4 mm	2.92 mm	3.5 mm	7 mm	50 Ω Type-N	75 Ω Type-N
1.85 mm [2]	85058-60007 85058-60008 85058-60009						
2.4 mm		11900A,B,C	11904A,B,C,D	11901A,B,C,D	11902A,B	11903A,B,C,D	
3.5 mm				83059A,B,C 1250-1748 1250-1749	1250-1746 1250-1747	1250-1743 1250-1744 1250-1745 1250-1750	
7 mm						11524A, 11525A	
50 Ω Type-N							11852B

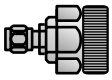
[1] See page 16 for general purpose grade adapters. See Network Analyzer/Waveguide Accessories chapters for additional adapter products.
[2] 1.85 mm is compatible with 2.4 mm. To adapt 1.85 mm to other connector types, use HP 1190X series adapters.

Typical Configuration

HP 11900A
HP 11901A
HP 11904A
HP 83059A
HP 1250-1159
HP 1250-1748
85058-60007

HP 11900B
HP 11901B
HP 11904B
HP 83059B
HP 1250-1158
HP 1250-1749
85058-60008

HP 11900C
HP 11901C
HP 11901D
HP 11904C
HP 11904D
HP 83059C
HP 1250-1462
85058-60009



HP 11533A
HP 11902A
HP 1250-1746

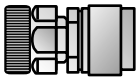
HP 11534A
HP 11902B
HP 1250-1747

HP 11903A
HP 1250-1636
HP 1250-1743

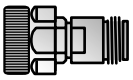
HP 11903D
HP 1250-1250
HP 1250-1744

HP 11903C
HP 1250-1562
HP 1250-1750

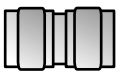
HP 11903B
HP 1250-1745
HP 1250-1772



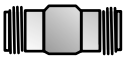
HP 11525A



HP 11524A



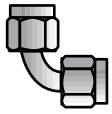
HP 1250-0778
HP 1250-1475
HP 1250-1528



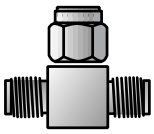
HP 1250-0777
HP 1250-1472
HP 1250-1529

HP 11852B
HP 11852B Opt. 004
HP 1250-0597

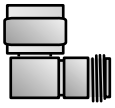
HP 1250-1249



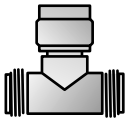
HP 1250-1397



HP 1250-1698



HP 1250-0176



HP 1250-0559

HP 1250-0846

Adapters

Metrology Grade [1]

HP Model	Type [2]	Frequency Range	Return Loss	Repeatability [3] (min)	Overall Length (nom) mm (in)	Ref. Plane to Ref. Plane Length (nom) mm (in)	Diameter (nom) mm (in)
11900A	2.4 mm (m), 2.4 mm (m)	dc to 50 GHz	>26 dB	–44 dB	16.2 (0.64)	12.4 (0.49)	9 (0.35)
11900B	2.4 mm (f), 2.4 mm (f)	dc to 50 GHz	>26 dB	–44 dB	18.5 (0.73)	12.4 (0.49)	8 (0.31)
11900C	2.4 mm (m), 2.4 mm (f)	dc to 50 GHz	>26 dB	–44 dB	17.4 (0.69)	12.4 (0.49)	9 (0.35)
11901A	2.4 mm (m), 3.5 mm (m)	dc to 26.5 GHz	>26 dB	–54 dB	20.9 (0.82)	16.1 (0.63)	9 (0.35)
11901B	2.4 mm (f), 3.5 mm (f)	dc to 26.5 GHz	>32 dB	–54 dB	21.1 (0.83)	16.1 (0.63)	8 (0.31)
11901C	2.4 mm (m), 3.5 mm (f)	dc to 26.5 GHz	>32 dB	–54 dB	20.2 (0.80)	16.1 (0.63)	9 (0.35)
11901D	2.4 mm (f), 3.5 mm (m)	dc to 26.5 GHz	>32 dB	–54 dB	21.8 (0.86)	16.1 (0.63)	9 (0.35)
11902A	2.4 mm (m), APC-7	dc to 18 GHz	>32 dB	–56 dB	43.8 (1.73)	38.5 (1.51)	22 (0.86)
11902B	2.4 mm (f), APC-7	dc to 18 GHz	>32 dB	–56 dB	44.8 (1.76)	38.5 (1.51)	22 (0.86)
11903A	2.4 mm (m), Type-N (m)	dc to 18 GHz	>28 dB	–48 dB	49.1 (1.93)	46.1 (1.82)	22 (0.86)
11903B	2.4 mm (f), Type-N (f)	dc to 18 GHz	>28 dB	–48 dB	58.3 (2.30)	46.1 (1.82)	15.7 (0.62)
11903C	2.4 mm (m), Type-N (f)	dc to 18 GHz	>28 dB	–48 dB	57.4 (2.26)	46.1 (1.82)	15.7 (0.62)
11903D	2.4 mm (f), Type-N (m)	dc to 18 GHz	>28 dB	–48 dB	50.0 (1.97)	46.1 (1.82)	22 (0.86)
11904A	2.4 mm (m), 2.92 mm (m) [4]	dc to 40 GHz	>24 dB	–40 dB	16.4 (0.64)	11.3 (0.45)	9 (0.35)
11904B	2.4 mm (f), 2.92 mm (f)	dc to 40 GHz	>24 dB	–40 dB	16.3 (0.64)	11.3 (0.45)	8 (0.31)
11904C	2.4 mm (m), 2.92 mm (f)	dc to 40 GHz	>24 dB	–40 dB	13.3 (0.52)	11.3 (0.45)	9 (0.35)
11904D	2.4 mm (f), 2.92 mm (m)	dc to 40 GHz	>24 dB	–40 dB	17.0 (0.67)	11.3 (0.45)	9 (0.35)
11904S	2.4 mm to 2.92 mm matched set						

Indicates QuickShip availability. Contact HP Direct or your local HP sales representative to confirm QuickShip.

[1] HP 1190X adapters are phase matched within each family.
[2] f = jack, m = plug.
[3] Repeatability = –20 Log $|\Delta\Gamma|$,where $|\Delta\Gamma| = |\Gamma m_1 - \Gamma m_2|$.
[4] 2.92 mm is compatible with 3.5 mm.

Adapters

Instrument Grade

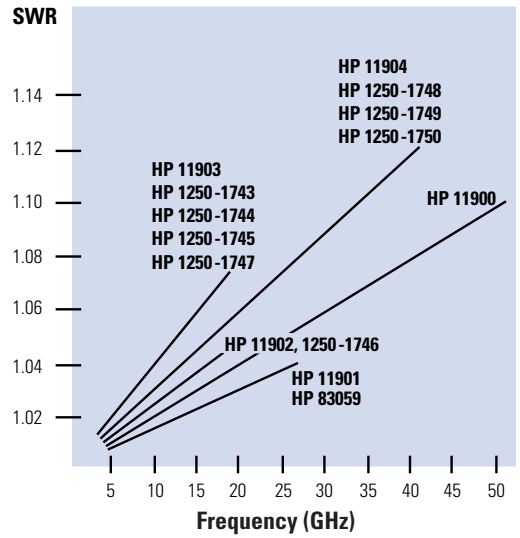
HP Model	Type[1]	Frequency Range	Return Loss (typ)	Overall Length (nom) mm (in)	Ref. Plane to Ref. Plane Length (nom) mm (in)	Diameter (nom) mm (in)
83059A	3.5 mm (m), 3.5 mm (m)	dc to 26.5 GHz	32 dB	28.4 (1.12)	23.1 (0.91)	10 (0.39)
83059B	3.5 mm (f), 3.5 mm (f)	dc to 26.5 GHz	32 dB	26.9 (1.06)	23.1 (0.91)	10 (0.39)
83059C	3.5 mm (m), 3.5 mm (f)	dc to 26.5 GHz	32 dB	25.7 (1.01)	23.1 (0.91)	10 (0.39)
83059K	Set of HP 83059A,B,C in wood case					
1250-1743	3.5 mm (m), Type-N (m)	dc to 18 GHz	28 dB	44.2 (1.74)	40.8 (1.61)	20.8 (0.82)
1250-1744	3.5 mm (f), Type-N (m)	dc to 18 GHz	28 dB	43.6 (1.72)	40.8 (1.61)	20.8 (0.82)
1250-1745	3.5 mm (f), Type-N (f)	dc to 18 GHz	28 dB	42.7 (1.68)	31.6 (1.24)	15.8 (0.62)
1250-1746	3.5 mm (m), APC-7	dc to 18 GHz	34 dB	37.9 (1.49)[2]	33.1 (1.30)	22.0 (0.87)
1250-1747	3.5 mm (f), APC-7	dc to 18 GHz	28 dB	37.0 (1.46)[2]	33.1 (1.30)	22.0 (0.87)
1250-1748	3.5 mm (m), 3.5 mm (m)	dc to 26.5 GHz	25 dB	45.1 (1.78)	39.6 (1.56)	9.2 (0.36)
1250-1749	3.5 mm (f), 3.5 mm (f)	dc to 34 GHz	23 dB	43.5 (1.71)	39.6 (1.56)	9.2 (0.36)
1250-1750	3.5 mm (m), Type-N (f)	dc to 18 GHz	24 dB	43.4 (1.71)	31.6 (1.24)	15.8 (0.62)
85058-60007	1.85 mm (m), 1.85 mm (m)[3]	dc to 65 GHz	22 dB	29.5 (1.16)	25.2 (0.99)	9.1 (0.36)
85058-60008	1.85 mm (f), 1.85 mm (f)[3]	dc to 65 GHz	22 dB	31.3 (1.23)	25.2 (0.99)	9.1 (0.36)
85058-60009	1.85 mm (m), 1.85 mm (f)[3]	dc to 65 GHz	22 dB	30.4 (1.20)	25.2 (0.99)	9.1 (0.36)
11852B[4]	50 ohm Type-N (f), 75 ohm Type-N (m)	dc to 3 GHz	30 dB	60.1 (2.37)	50.2 (1.98)	22 (0.87)
11852B Opt. 004[4]	50 ohm Type-N (m), 75 ohm Type-N (f)	dc to 3 GHz	30 dB	60.1 (2.37)	50.2 (1.98)	22 (0.87)

Indicates QuickShip availability. Standard model only. Contact HP Direct or your local HP sales representative to confirm QuickShip.

[1] f = jack, m = plug.
[2] Overall length with threaded coupling sleeve extended.
[3] 1.85 mm is compatible with 2.4 mm. To adapt 1.85 mm to other connector types, use HP1190X series adapters.
[4] Insertion loss is 5.7 dB typical.

Adapters

Typical Precision Adapter Performance



General Purpose Grade

Adapters APC-7 [1]	
11524A	APC-7 to Type-N (f)
11525A	APC-7 to Type-N (m)
11533A	APC-7 to SMA (m)
11534A	APC-7 to SMA (f)
Adapters Type-N, 50 Ω, SWR <1.03 to 1.3 GHz	
1250-1472	Type-N (f) to Type-N (f)
1250-1473	Type-N (m) to BNC (m)
1250-1474	Type-N (f) to BNC (f)
1250-1475	Type-N (m) to Type-N (m)
1250-1476	Type-N (m) to BNC (f)
1250-1477	Type-N (f) to BNC (m)
Adapters SMA	
1250-1158	SMA (f) to SMA (f)
1250-1159	SMA (m) to SMA (m)
1250-1249	SMA right angle (m) (f)
1250-1397	SMA right angle (m) (m)
1250-1462	SMA (m) to SMA (f)
1250-1698	SMA tee (m) (f) (f)
E9633A	SMA (m) to BNC (m)
E9634A	SMA (f) to BNC (m)

Indicates QuickShip availability. Contact HP Direct or your local HP sales representative to confirm QuickShip.

[1] APC-7 is a registered trademark of the Bunker Ramo Corporation.
[2] Type-N outer conductor; center pin sized for 75 Ω characteristic.
[3] BNC outer conductor; center pin sized for 75 Ω characteristic.
[4] SMB and SMC are often used inside HP instruments for inter-module RF connections. SMB is snap-on configuration. SMC is screw-on configuration.

General Purpose Grade (continued)

Adapters Type-N, Standard 50 Ω	
1250-0077	Type-N (f) to BNC (m)
1250-0082	Type-N (m) to BNC (m)
1250-0176	Type-N (m) to Type-N (f) right angle (use below 12 GHz)
1250-0559	Type-N tee, (m) (f) (f)
1250-0777	Type-N (f) to Type-N (f)
1250-0778	Type-N (m) to Type-N (m)
1250-0780	Type-N (m) to BNC (f)
1250-0846	Type-N tee (f) (f) (f)
1250-1250	Type-N (m) to SMA (f)
1250-1562	Type-N (f) to SMA (m)
1250-1636	Type-N (m) to SMA (m)
1250-1772	Type-N (f) to SMA (f)
Adapters Type-N, Standard 75 Ω [2]	
1250-0597	Type-N (m) (50 Ω) to Type-N (f) (75 Ω)
1250-1528	Type-N (m) to Type-N (m)
1250-1529	Type-N (f) to Type-N (f)
1250-1533	Type-N (m) to BNC (m)
1250-1534	Type-N (f) to BNC (m)
1250-1535	Type-N (m) to BNC (f)
1250-1536	Type-N (f) to BNC (f)
Adapters Type BNC, Standard 50 Ω	
1250-0076	Right angle BNC (UG-306/D)
1250-0080	BNC (f) to BNC (f) (UG-914/U)
1250-0216	BNC (m) to BNC (m)
1250-0591	BNC (f) to WECO Video (m)
1250-0595	BNC (f) to BNC Triaxial (m)
1250-0781	BNC tee (m) (f) (f)
1250-1830	BNC (f) to BNC Triaxial (f)
Adapters BNC, Standard 75 Ω [3]	
1250-1286	Right angle BNC (m) (f)
1250-1287	BNC (f) to BNC (f)
1250-1288	BNC (m) to BNC (m)
Adapters SMB, SMC [4]	
1250-0670	SMC tee (m) (m) (m)
1250-0671	SMB (m) to Type-N (m)
1250-0672	SMB (f) to SMB (f)
1250-0674	SMB (m) to SMA (f)
1250-0675	SMC (m) to SMA (f)
1250-0813	SMB (m) to SMB (m)
1250-0827	SMC (m) to SMC (m)
1250-0831	SMC (m) to BNC (m)
1250-0832	SMC (f) to BNC (f)
1250-0837	SMC tee (m) (m) (m)
1250-0838	SMC tee (f) (m) (m)
1250-1023	SMC (m) to Type-N (m)
1250-1113	SMC (f) to SMC (f)
1250-1152	SMC (f) to Type-N (m)
1250-1153	SMC (f) to Type-N (f)
1250-1236	SMB (f) to BNC (f)
1250-1237	SMB (m) to BNC (f)
1250-1391	SMB tee (f) (m) (m)
1250-1857	SMB (f) to BNC (m)

Adapters

- **Increased Measurement Versatility**
- **Ease-of-use for On Wafer and Coaxial measurements**

Increased Measurement Versatility

For Microwave and RF engineers making coax measurements at 50, 65 or 110 GHz, the HP 11920/1/2 series 1.0 mm adapters provide an easy way of measuring coaxial devices at high frequencies. The HP 11920 A/B/C 1.0 mm to 1.0 mm are designed for the measurement of components with 50 ohm 1.0 mm connectors. The HP 11921 A/B/C/D, 1.0 mm to 1.85 mm and the HP 11922 A/B/C/D, 1.0 mm to 2.4 mm are intended to be used as general purpose adapters that are versatile and interchangeable. These adapters increase the capability needed to use test systems, such as the HP 8510XF.

Ease of use for On Wafer and Coaxial measurements

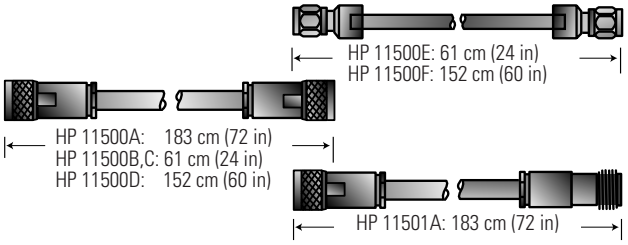
Each connector has an air dielectric interface and a center conductor that is supported by a low-loss plastic bead. Available with male and female connectors, these HP 1.0 mm adapters provide ease-of-use for microwave engineers who need to connect their test systems. The HP 1.0 mm adapters allow engineers to make fewer connections directly to their test port while maintaining the accuracy of their test system.

1.0 mm Adapters

HP Model	11920A 11920B 11920C	11921A 11921B 11921C 11921D	11922A 11922B 11922C 11922D	11923A
Features	← Excellent accuracy and Measurement versatility →			
Frequency Range	dc-20 GHz 20-50 GHz 50-75 GHz 75-110 GHz	dc - 65 GHz	dc - 50 GHz	dc - 110 GHz
Frequency Response				
Insertion Loss:	-0.5 dB	-0.5 dB	-0.7 dB	-1.0 dB
Return Loss:	-24 dB dc-20 GHz -20 dB 20-50 GHz -18 dB 50-75 GHz -14 dB 75-110 GHz	-20 dB	-20 dB	-16 dB
Input Power				
Max CW Power	← 10 W →			6W
Repeatability[1]	-35 dB	-35 dB 1.0 mm -40 dB 1.85 mm	-35 dB 1.0 mm -44 dB 2.4 mm	
RF Connectors				
A:	1mm(m) to 1mm(m)	1mm(m) to 1.85mm(m)	1mm(m) to 2.4mm(m)	1mm(f) to circuit card launch
B:	1mm(f) to 1mm(f)	1mm(f) to 1.85mm(f)	1mm(f) to 2.4mm(f)	
C:	1mm(m) to 1mm(f)	1mm(m) to 1.85mm(f)	1mm(m) to 2.4mm(f)	
D:		1mm(f) to 1.85mm(m)	1mm(f) to 2.4mm(m)	

1 Measured at 25° C

Cable Assemblies



HP Model	Frequency Range (GHz)	Length (nom) cm (in)	Connectors	SWR (max)	Ins. Loss (nom) (dB)
11500A	dc to 12.4	183 (72)	Type-N (m) (2)	—	—
11500B	dc to 12.4	61 (24)	Type-N (m) (2)	—	—
11501A	dc to 12.4	183 (72)	Type-N (m) to Type-N (f)	—	—
11500C	dc to 18	61 (24)	Precision N (m) (2)	1.4	1.5
11500D	dc to 18	152 (60)	Precision N (m) (2)	1.4	3.0
11500E	dc to 26.5	61 (24)	3.5 mm (m) (2)	1.4	2.0
11500F	dc to 26.5	152 (60)	3.5 mm (m) (2)	1.4	4.0

Indicates QuickShip availability. Contact HP Direct or your local HP sales representative to confirm QuickShip.

Precision 7-mm Connector Bead

HP 33391C Microwave Insulator (Bead) Assembly
The HP 33391C insulator bead assemblies are designed for use in 7-mm connectors such as type-N and APC-7. These are temperature stable devices, giving low signal loss due to their excellent reflection characteristics. They operate up to 18 GHz. The HP 33391C assemblies are packaged in convenient quantities of 50 per container.

HP 33391C Specifications
SWR (typ): 1.004, dc to 2 GHz; 1.004 + 0.0009/GHz, 2 to 18 GHz
Inner/Outer Ring Coplanarity: ±0.0005 inch typ., ± 0.0007 inch maximum.

Connectors

General

Many coaxial connector types are available in the RF and microwave industry, each designed for a specific purpose and application. For measurement applications, it is important to consider the number of connects/disconnects which impact the connector's useful life.

The frequency range of any connector is limited by the excitation of the first circular waveguide propagation mode in the coaxial structure. Decreasing the diameter of the outer conductor increases the highest usable frequency; filling the air space with dielectric lowers the highest usable frequency and increases system loss.

Performance of all connectors is affected by the quality of the interface for the mated pair. If the diameters of the inner and outer conductors vary from the nominal design, if plating quality is poor, or if contact separation at the junction is excessive, then the reflection coefficient and resistive loss at the interface will be degraded.

A few connectors (such as the APC-7) are designed to be sexless. Most are female connectors that have slotted fingers which introduce a small inductance at the interface. The fingers accommodate tolerance variations, but reduce repeatability and may ultimately break after 1000 connections. Hewlett-Packard offers slotless versions of connectors in certain measuring products which decrease inductance and increase repeatability.

The following is a brief review of common connectors used in test and measurement applications:

APC-7 (7 mm) Connector

The APC-7 (Amphenol Precision Connector-7 mm) offers the lowest reflection coefficient and most repeatable measurement of all 18 GHz connectors. Development of the connector was a joint effort between HP and Amphenol which began in the 1960s. This is a sexless design and is the preferred connector for the most demanding applications, notably metrology and calibration.

Type-N Connector

The type-N (Navy) 50-ohm connector was designed in the 1940s for military systems operating below 4 GHz. In the 1960s, improvements pushed performance to 12 GHz and later, mode-free, to 18 GHz. HP offers some products with slotless type-N center conductors for improved performance to 18 GHz. HP type-N connectors are completely compatible with MIL-C-39012. Certain 75-ohm products use a type-N design with smaller center conductor diameters, and thus are not compatible with 50-ohm connectors.

SMA Connector

The SMA (Subminiature A) connector was designed by Bendix Scintilla Corporation and is one of the most commonly used RF/microwave connectors. It is intended for use on semi-rigid cables and in components which are connected infrequently. Most SMA connectors have higher reflection coefficients than other connectors available for use to 24 GHz because of the difficulty to anchor the dielectric support.

3.5-mm Connector

The 3.5-mm connector was primarily developed at Hewlett-Packard, with early manufacturing at Amphenol. Its design strategy focused on highly-rugged physical interfaces that would mate with popular SMA dimensions, allowing thousands of repeatable connections. It is mode-free to 34 GHz.

1.0-mm Launch

The Launch adaptor has a 1.0-mm female connector on one end and a glass to metal seal interface on the other end. This is for transition of ultra-high frequency (up to 110 GHz) signals from coax into a microstrip package or onto a circuit board.

Connectors

2.92-mm Connector

The 2.92-mm connector mates with SMA and 3.5-mm connectors, and offers mode-free performance to 40 GHz.

2.4-mm Connector

The 2.4-mm connector was developed by HP, Amphenol, and M/A-COM for use to 50 GHz. This design eliminates the fragility of the SMA and 2.92-mm connectors by increasing the outer wall thickness and strengthening the female fingers. It can mate with SMA, 3.5-mm and 2.92-mm with the use of precision adapters. The 2.4-mm product is offered in three quality grades; general purpose, instrument and metrology. General purpose grade is intended for economy use on components, cables and microstrip, where limited connections and low repeatability is acceptable. Instrument grade is best suited for measurement applications where repeatability and long life are primary considerations. Metrology grade is best suited for calibration applications where the highest performance and repeatability are required.

1.85-mm Connector

The 1.85-mm connector was developed in the mid-1980s by HP for mode-free performance to 65 GHz. Hewlett-Packard offered their design as public domain in 1988 to encourage standardization of connector types; a few devices are available from various manufacturers for research work. The 1.85-mm connector mates with the 2.4-mm connector and has the same ruggedness. Many experts have considered this connector to be the smallest possible coaxial connector for common usage up to 65 GHz.

1.0-mm Connector

Designed to support transmission all the way to 110 GHz, this 1.0-mm connector is a significant achievement in precision manufacturing resulting in a reliable and flexible interconnect.

BNC Connector

The BNC (Bayonet Navy Connector) was designed for military use and has gained wide acceptance in video and RF applications to 2 GHz. Above 4 GHz, the slots may radiate signals. Both 50-ohm and 75-ohm versions are available. A threaded version (TNC) helps resolve leakage for common applications up to 12 GHz.

SMC Connector

The SMC (Subminiature C) is much smaller than an SMA connector, making it suitable for some applications with size constraints. It is often used up to 7 GHz where low leakage and few connections are required.

Connector Care and Signal Performance

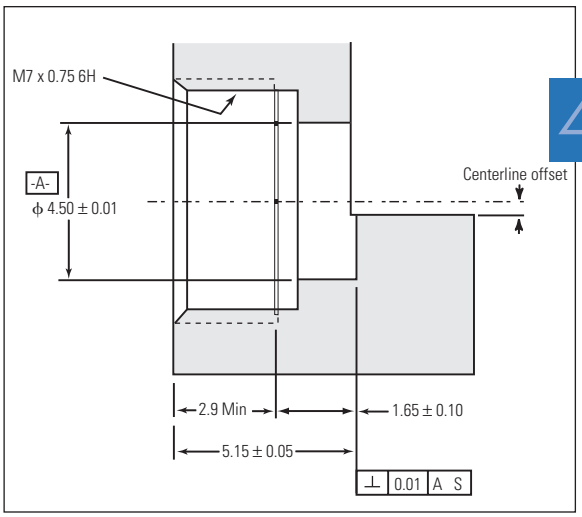
While many HP RF/microwave connectors have been designed for rugged mechanical interfaces, the user must be aware that cleanliness of the surfaces and care in applying torque to the connector nut are crucial to long life and full signal performance. Table 1 shows the recommended torque for various connector types. For additional information on RF/microwave connector care, request publication 08510-90360, "*Quick Reference – Connector Care.*"

* Note: For more infromation on connector care, visit the website **http://www.hp.com/go/mta/support/faq**

Table 1. Recommended Torque Values for Connectors

Connector Type	Torque lb-inch (N-cm)
Precision 7 mm	12 (136)
Precision 3.5 mm	8 (90)
SMA	5 (56) Use the SMA torque value to connect male SMA connectors to female precision 3.5-mm connectors. Use the 3.5-mm torque value to connect male 3.5-mm connectors to the female SMA (8 lb-inch).
Precision 2.4 mm	8 (90)
Precision 1.85 mm	8 (90)
Type-N	Type-N connectors may be connected finger tight. If a torque wrench is used, 12 lb-inch (136 N-cm) is recommended.

Connectors



Flexible micro-circuit packaging

The HP 11923A 1.0 mm female-connector launch threads into a package or fixture housing to transition a microwave circuit from microstrip to coaxial connector. The HP 11923A connector launch is intended for use with 8510XF and other test systems up to 110 GHz. The HP 11923A 1.0 mm female connector has an air dielectric interface and center conductor that is supported by a low-loss plastic bead on one end, and a glass-to-metal seal interface on the other end. This interface consists of a 0.162 mm diameter pin that extends inside the package or fixture for connection onto a microwave circuit.

The HP 11923A is pre-assembled and supplied with a machining detail for mounting the launch and assembly instructions (see figure 1). The user is responsible for making the connection onto the circuit card, machining the package, and installing the connector. If a quasi-hermetic seal is desired, epoxy may be applied to threads of the launch prior to installation. The procedure describing the necessary dimensions for the package and installation is provided with the launch assembly.

Specifications

Specifications describe the instrument's warranted performance over the temperature range 0 to 55° C (except where noted). Supplemental characteristics are intended to provide information for applying the instrument by giving typical but nonwarranted performance parameters. These are noted as "typical", "nominal" or "approximate".

1.0mm (f) Connector Launch

Model Number	Coax Connector Type	Frequency (GHz)	Insertion Loss
11923A	(f) to circuit card launch	dc- 110	better than: -1.0 dB

Supplemental characteristics

Model number	Return loss	Max CW Power
11923A	-16 dB	better than: 6W

Environmental Specifications

	Operating	Non-operating
Temperature	0° to 55°C	-40° to 75° C
Altitude	<15.000 meters (< 50.000 feet)	<15.000 meters (<50.000 feet)

Note: The operating temperature is a critical factor in the performance during measurements and between calibrations. Storage or operation within an environment other than that specified above may cause damage to the product and void the warranty.

Non-operating environmental specifications apply to storage and shipment. Products should be stored in a clean, dry environment. Operating environmental specifications apply when the product is in use. Products should not be operated in a condensing environment.

Key literature

HP 11923A Operating and Service Guide 11923-90001
1999/2000 MTA Catalog 5968-4314E

Slotless Connectors

Precision Slotless sockets (female connectors) were developed by HP to provide the most accurate traceable calibration possible. Connectors that use precision slotless sockets are metrology grade connectors. The outside diameter of the socket does not change when mated with pins of varying diameters, within the tolerance requirements of a metrology grade connector.

Conventional slotted sockets are flared by the inserted pin. Because physical dimensions determine connector impedance, electrical characteristics of the connector pair are dependent upon the mechanical dimensions of the pin. While connectors are used in pairs, their pin and socket halves are always specified separately as part of a standard, instrument, or device under test. Because the slotted socket's outer diameter changes with different pin diameters, it is very difficult to make precision measurements with the conventional slotted socket connector. The measurement of the device is a function of its connector.

Slotless sockets are used in the following calibration kits:

HP 85052B/C/D
HP 85054B/D
HP 85056A/D

Coaxial mechanical calibrations kits

Connector	Frequency Range	Type	VNA Calibration Accuracy	HP Model	Available Options	Page
Type-F(75 ohm)	DC to 3	Economy	5%-1%	**85039B**	1BP, 1BN, UK6, 00M, 00F	86
Type-F(75 ohm)	DC to 3	Economy	5%-1%	**85036E**	1BP, 1BP, UK6, 910	87
Type-F(75 ohm)	DC to 3	Standard	5%-1%	**85036B**	1BP, 1BP, UK6, 910	87
Type-F(50 ohm)	DC to 6	Economy	5%-1%	**85032E**	1BP, 1BP, UK6, 910	88
Type-F(50 ohm)	DC to 6	Standard	5%-1%	**85032B**	1BP, 1BP, UK6, 910, 001	88, 89
Type-F(50 ohm)	0.045 to 18	Economy	5%-1%	**85054D**	1BP, 1BP, 002	91
Type-F(50 ohm)	0.045 to 18	Standard	2%-0.3%	**85054B**	1BP, 1BP, 002	90
7-16	DC to 7.5	Standard	2%	**85038A**	none	92
7-16	DC to 7.5	Standard	2%	**85038F**	none	92
7-16	DC to 7.5	Standard	2%	**85038M**	none	92
7 mm	DC to 6	Economy	2%-0.3%	**85031B**	1BP, 1BP, UK6, 910	93
7 mm	0.045 to 18	Economy	5%-1%	**85050D**	1BP, 1BP, 910, 002	93
7 mm	0.045 to 18	Standard	2%-0.05%	**85050B**	1BP, 1BP, 910, 002	94
7 mm	0.045 to 18	Precision	0.3%-0.05%	**85050C**	1BP, 1BP, 910, 002	95
3.5 mm	DC to 6	Economy	5%-1%	**85033D**	1BP, 1BP, UK6, 910, 001, 002	96
3.5 mm	0.045 to 26.5	Economy	5%-1%	**85052D**	1BP, 1BP, 910, 002	97
3.5 mm	0.045 to 26.5	Standard	3%-0.5%	**85052B**	1BP, 1BP, 910, 002	98
3.5 mm	0.045 to 26.5	Precision	2%-0.5%	**85052C**	1BP, 1BP, 910, 002	99
2.92 mm	0.045 to 50	Economy	11%-4% (Option 001 65%-3%)	**85056K**	1BP, 1BP, 001*, 002	100, 101
2.4 mm	0.045 to 50	Economy	5%-1%	**85056D**	1BP, 1BP, 910, 002	102
2.4 mm	0.045 to 50	Standard	4%-0.5%	**85056A**	1BP, 1BP, 910, 002	103
1 mm	0.045 to 110	Precision	5%-1%	**85059A**	none	104, 105

Option description

002: Add calibration/verification data on magnetic tape in addition to 3.5" floppy
1BN: MIL standard 45662A calibration certification
1BP: MIL standard 45662A calibration certification with test data
UK6: Commercial calibration certificate with test data
00M: Includes male standards & male-male adapter
00F: Includes female standards and female-female adapter
001: Deletes 7 mm to 3.5 mm adapters
001*: Adds 2.4 mm sliding load an 2.4 mm gauges
001:** Adds data for HP 8702 ligthwave component analyzer
910: Adds extra manual

Note: For more information on connector care, visit the website *http://www.hp.com/go/mta/support/faq*

Slotless Connectors

Waveguide mechanical calibrations kits

Connector	Frequency Range	Type	VNA Calibration Accuracy	HP Model	Available Options	Page
WR-90	8.2 to 12.4	Precision	0.3%-0.05%	X11644A	002	106
WR-62	12.4 to 18	Precision	0.3%-0.05%	P11644A	002	107
WR-42	18 to 16.5	Precision	0.3%-0.05%	K11644A	002	108
WR-28	26.5 to 40	Precision	0.3%-0.05%	R11644A	002	109
WR-22	33 to 50	Precision	0.3%-0.05%	Q11644A	002	110
WR-19	40 to 60	Precision	0.3%-0.05%	U11644A	002	111
WR-15	50 to 75	Precision	0.3%-0.05%	V11644A	002	112
WR-10	75 to 110	Precision	0.3%-0.05%	W11644A	002	113

Coaxial electronic calibrations kits (Ecal)

Connector	Frequency Range	Type	VNA Calibration Accuracy	HP Model	Available Options	Page
7 mm	30kHz to 6GHz	Standard	1%-0.1%	85091A		115, 116
Type-N(50ohm)	30kHz to 6GHz	Standard	1%-0.1%	85092A		114, 115, 116, 117
3.5 mm	30kHz to 6GHz	Standard	2%-0.2%	85093A		114, 115, 116, 117
7 mm	1GHz to 18GHz	Standard	2%-0.05%	85060B		115, 116
3.5 mm	1GHz to 26.5GHz	Standard	3%-0.5%	85062B		114, 115, 116, 117
Type-N(50ohm)	1GHz to 18GHz	Standard	2%-0.1%	85064B		114, 115, 116, 117
PC Interface kit	n/a	n/a	n/a	85097A		115

Mechanical verification kits

Connector	Frequency Range	Type	VNA Calibration Accuracy	HP Model	Available Options	Page
Type-N	0.045 to 18GHz	Precision	n/a	85055A	1BP,002,910	118
7 mm	DC to 6GHz	Precision	n/a	85029B	1BP,001**,910	118
7 mm	0.045 to 18GHz	Precision	n/a	85051B	1BP,002,910	119
3.5 mm	0.045 to 26.5GHz	Precision	n/a	85053B	1BP,002	119
2.4 mm	0.045 to 50GHz	Precision	n/a	85057B	1BP,002	120
WR-28	26.5 to 40	Precision	n/a	R11645A	1BP,002	120
WR-22	33 to 50	Precision	n/a	Q11645A	1BP,002	121
WR-19	40 to 60	Precision	n/a	U11645A	1BP,002	121
WR-15	50 to 75	Precision	n/a	V11645A	1BP,002	122
WR-10	75 to 110	Precision	n/a	W11645A	1BP,002	122

Option description

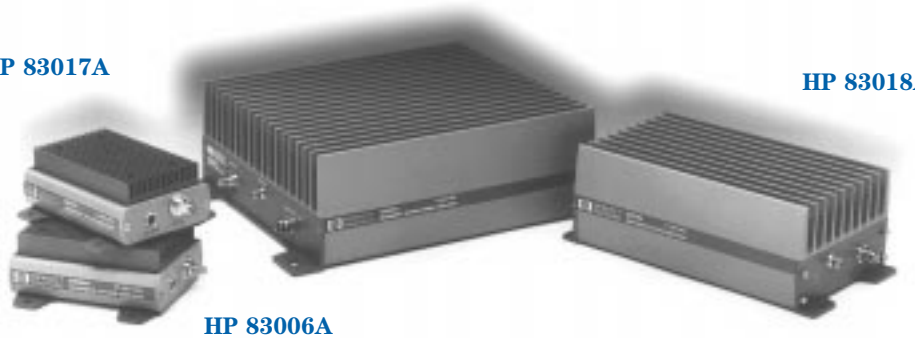
002: Add calibration/verification data on magnetic tape in addition to 3.5" floppy
1BN: MIL standard 45662A calibration certification
1BP: MIL standard 45662A calibration certification with test data
UK6: Commercial calibration certificate with test data
00M: Includes male standards & male-male adapter
00F: Includes female standards and female-female adapter
001: Deletes 7 mm to 3.5 mm adapters
001*: Adds 2.4 mm sliding load an 2.4 mm gauges
001:** Adds data for HP 8702 ligthwave component analyzer
910: Adds extra manual

Amplifiers

HP 83020A

HP 83017A

HP 83018A



HP 83006A

HP 83050/51A

HP 87415A

HP 87405A

The HP 83006/018/020/050/051A test system amplifiers offer ultra broadband performance up to 50 GHz. With excellent noise figure relative to their broad bandwidth and high gain, these products can be used to significantly reduce test system noise figure. By replacing several amplifiers with a single broadband product, test setups can be greatly simplified. And, you can place this amplification power where you need it, by using remotely-locatable HP power supplies. In addition, the HP 87415A provides octave band performance from 2 to 8 GHz. The HP 87405A preamplifier is designed for input signal preamplification of low level instruments such as the HP 859X series spectrum analyzers.

These amplifiers are supplied with a 2-meter bias cable that has a connector on one end and bare wires on the other (except for the HP 87405A). This bias cable can be used to interface with a power supply provided by the user. Or, for a complete solution, HP offers the HP 87421/422A remotely-locatable power supplies. The HP 87421A power supply is furnished with one 2-meter cable (HP 87422A, two 2-meter cables) for direct-connection to an HP amplifier as shown in the Amplifier Power Cable Cross Reference on page 34.

Amplifiers

Specifications (+20 to +30 °C)

HP Model	Frequency (GHz)	Output Power at P_{sat} (dBm/mW)	Output Power at P_{1dB} (dBm/mW) (min)	Gain (dB) (min)	Noise Figure (dB) (typ)	Detector [1] Output/dc Connector	Bias (nom)	RF Connectors (Input/Output)
83006A	0.01 to 26.5	+18/64 typ. to 10 GHz +16/40 typ. to 20 GHz +14/25 typ. to 26.5 GHz	+13/20 to 20 GHz +10/10 to 26.5 GHz	20	13 to 0.1 GHz 8 to 18 GHz 13 to 26.5 GHz	No	+12 V @ 450 mA -12 V @ 50 mA	3.5 mm (f)
83017A	0.5 to 26.5	+20/100 typ. to 20 GHz +15/32 typ. to 26.5 GHz	+18/64 to 20 GHz (18 - 0.75Δf) dBm [2] (64 - 7.8Δf) mw [2] (20 ≤ f ≤ 26.5 GHz)	25	8 to 20 GHz 13 to 26.5 GHz	Yes/BNC (f)	+12 V @ 700 mA -12 V @ 50 mA	3.5 mm (f)
83018A	2 to 26.5	+24/250 min to 20 GHz +21/125 min to 26.5 GHz	+22/160 to 20 GHz +17/50 to 26.5 GHz	27 to 20 GHz 23 to 26.5 GHz	10 to 20 GHz 13 to 26.5 GHz	Yes/BNC (f)	+12 V @ 2 A -12 V @ 50 mA	3.5 mm (f)
83020A	2 to 26.5	+30/1000 min to 20 GHz (30 - 0.7Δf) dBm min [2] (1000 - 65Δf) mw min [2] (20 ≤ f ≤ 26.5 GHz)	+27/500 to 20 GHz +23/200 to 26.5 GHz	30 to 20 GHz 27 to 26.5 GHz	10 to 20 GHz 13 to 26.5 GHz	Yes/BNC (f)	+15 V @ 3.2 A -15 V @ 50 mA	3.5 mm (f)
83050A	2 to 50	+20/100 min to 40 GHz (19 - 0.2Δf) dBm [3] (80 - 3.1Δf) mw [3] (40 < f ≤ 50 GHz)	+15/32 to 40 GHz +13/20 to 50 GHz	23	6 to 26.5 GHz 10 to 50 GHz	No	+12 V @ 830 mA -12 V @ 50 mA	2.4 mm (f)
83051A	0.045 to 50	+12/16 min to 45 GHz min +10/10 min to 50 GHz min	+8/6 to 45 GHz +6/4 to 50 GHz	23	12 to 2 GHz 6 to 26.5 GHz 10 to 50 GHz	No	+12 V @ 425 mA -12 V @ 50 mA	2.4 mm (f)
87405A	0.01 to 3	+26/400 typ.	+4/2.5	22 min 27 max	6.5 to 2 GHz 7.5 to 3 GHz	No	+15 V @ 80 mA	N (f) N (m)
87415A	2 to 8	+26/400 typ.	+23/200	25	13	No	+12 V @ 900 mA	SMA (f)

Weight: HP 83006A, 83017A, 83050A, 83051A, 87415A: 0.64 kg (1.4 lb), **HP 83018A:** 1.8 kg (4 lb), **HP 83020A:** 3.9 kg (8.5 lb), **HP 87405A:** 0.27 kg (0.6 lb)

Power Cable (shipped with amplifiers): 2-meter cable with a connector on one end and bare wires on the other. See Amplifier Power Cable Cross Reference on page 28.

Power Supply Specifications

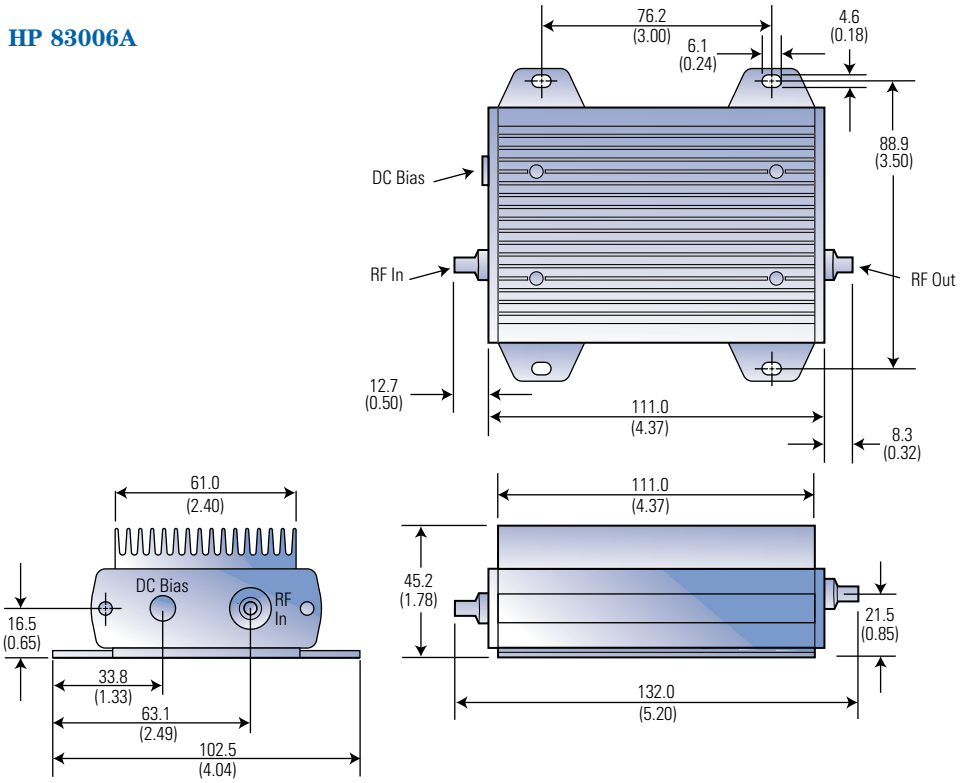
HP Model	ac Input Voltage	dc Output (nom)	Output Power	Size (H,W,D)
87421A	100 to 240 VAC 50/60 Hz	+12 V @ 2.0 A, -12 V @ 200 mA	25 W max	57, 114, 176 mm 2.3, 4.5, 6.9 in
87422A [4]	100 to 240 VAC 50/60 Hz	+15 V @ 3.3 A, -15 V @ 50 mA +12 V @ 2.0 A, -12 V @ 200 mA	70 W max	86, 202, 276 mm 3.4, 8.0, 10.9 in

Power Cable (shipped with power supplies): 2-meter cables to connect between amplifier and power supplies. See Amplifier Power Cable Cross Reference on page 28.

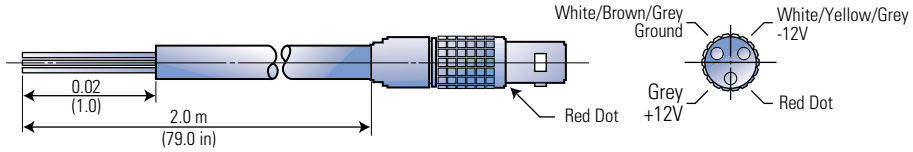
[1] Detector output can be utilized for leveling output power at the test port.
[2] Δf = f(GHz) – 20.
[3] Δf = f(GHz) – 40.
[4] The ±15 V output is designed to power the HP 83020A; the ±12 V output can be used to power an additional amplifier.

Outline Drawings

HP 83006A



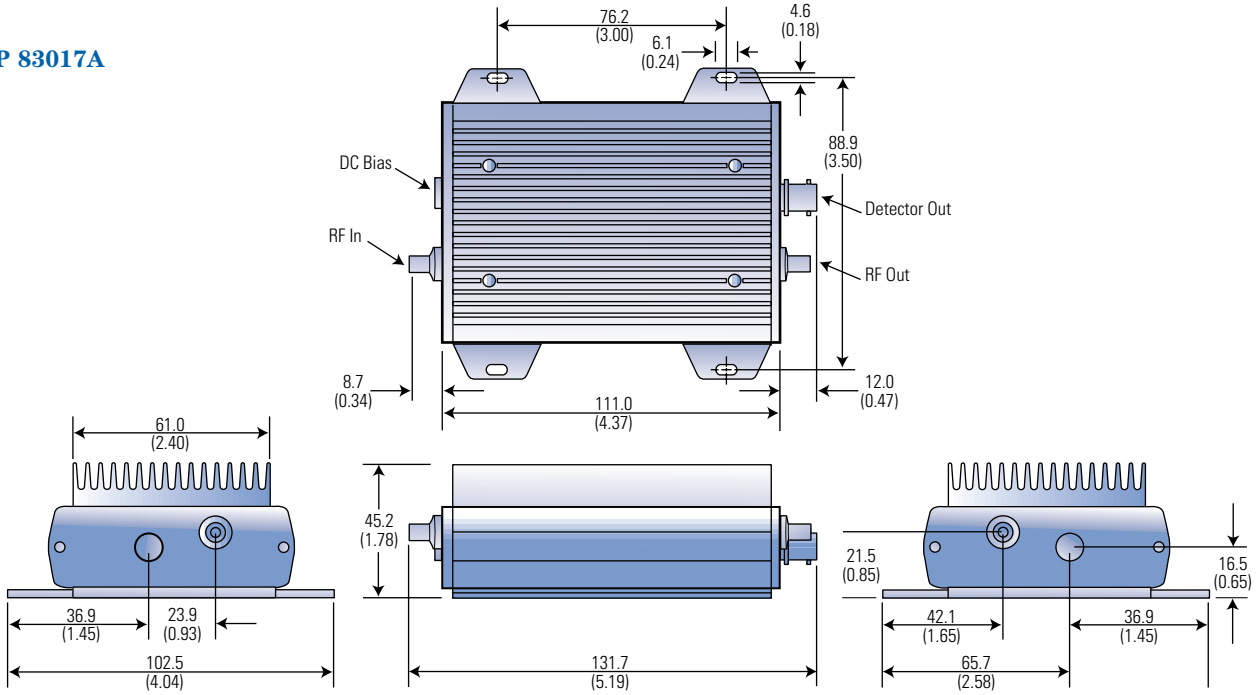
HP 83006-60004 Cable (Shipped with HP 83006A, 83017A, 83018A, 83050A, 83051A, 87415A)



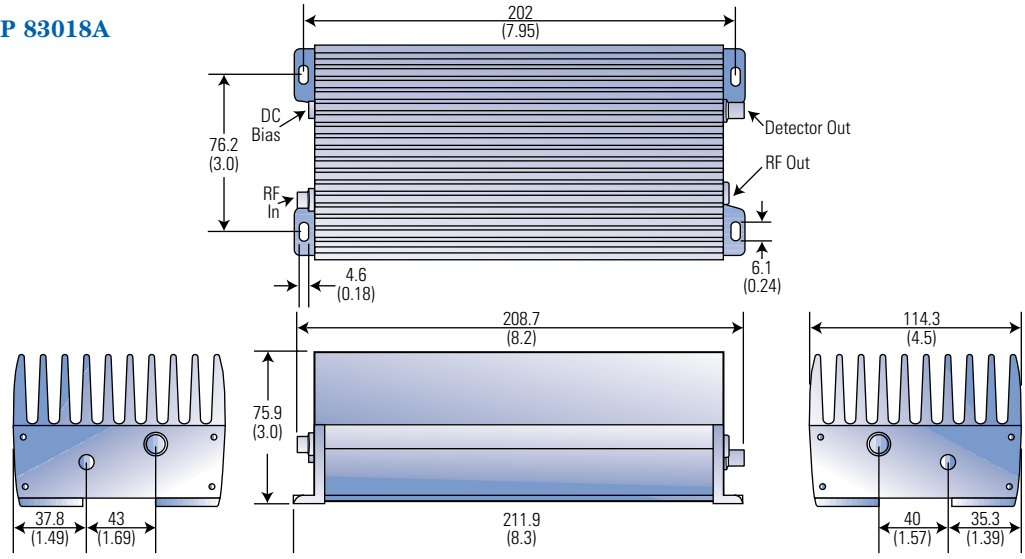
Dimensions are in mm (inches) nominal, unless otherwise specified.

Amplifiers

HP 83017A



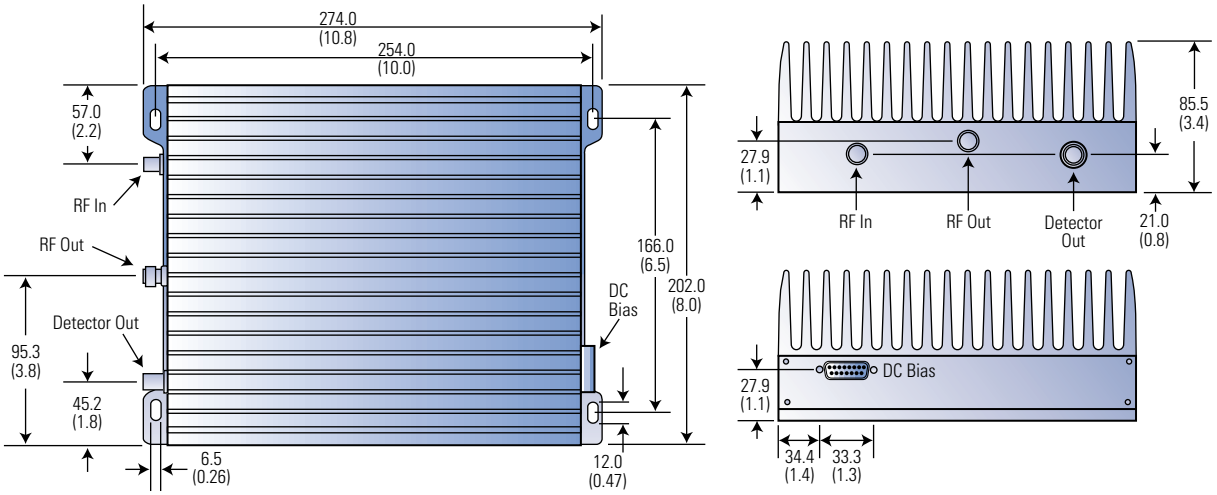
HP 83018A



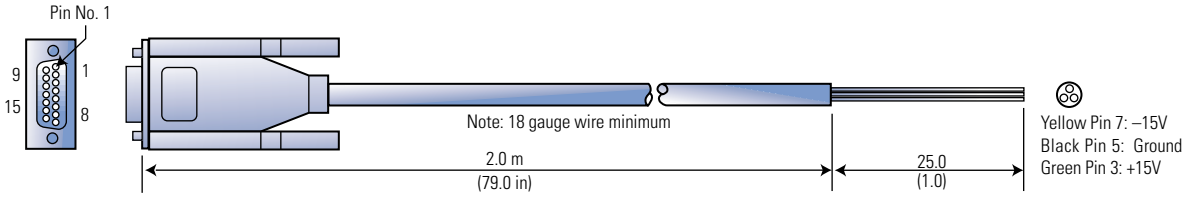
Dimensions are in mm (inches) nominal, unless otherwise specified.

Amplifiers

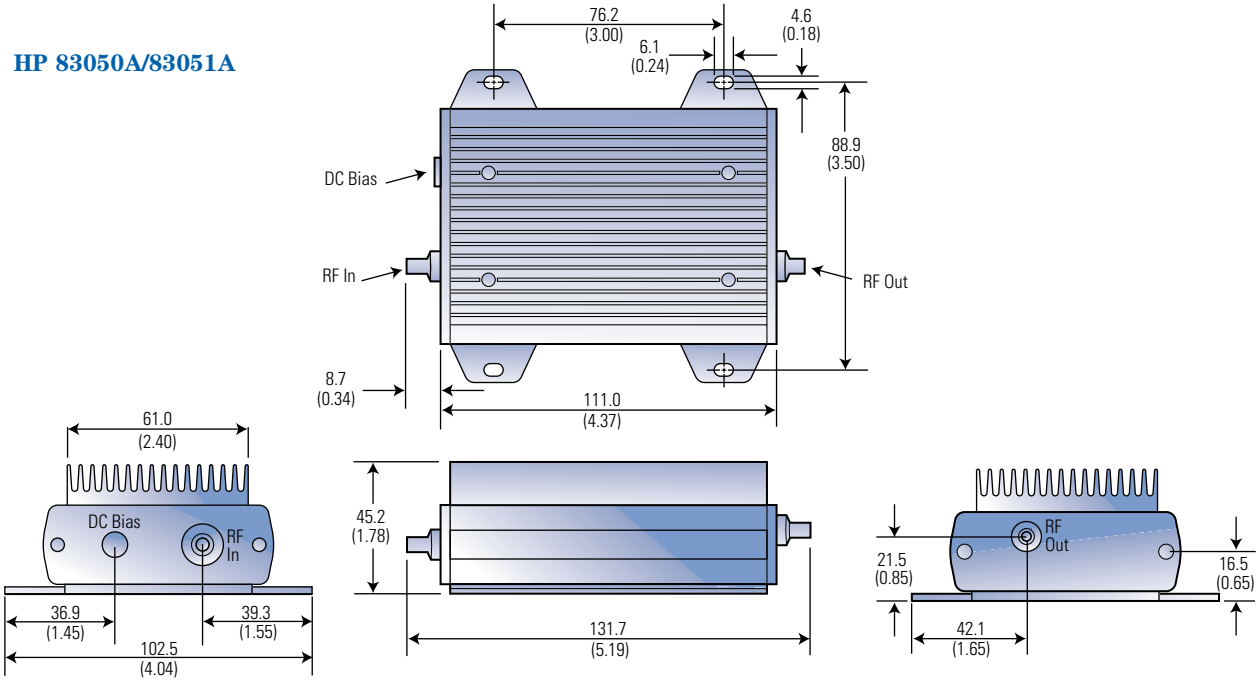
HP 83020A



HP 83020-60004 Cable (Shipped with HP 83020A)



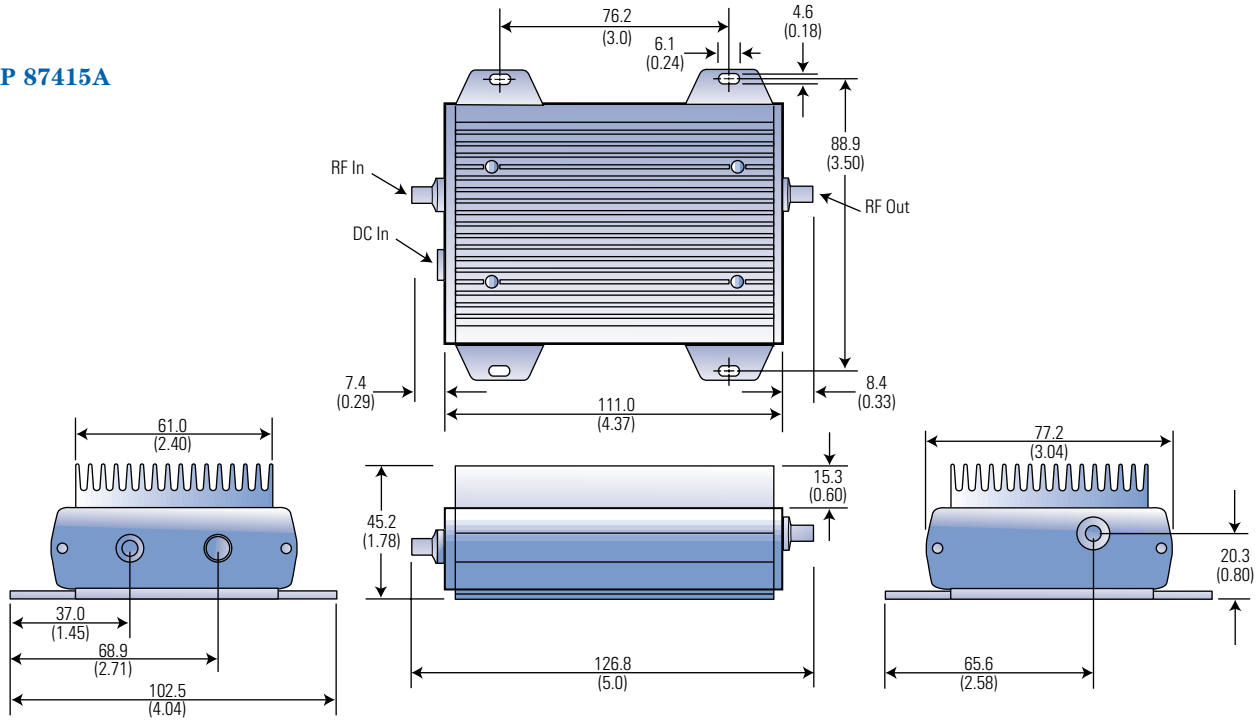
HP 83050A/83051A



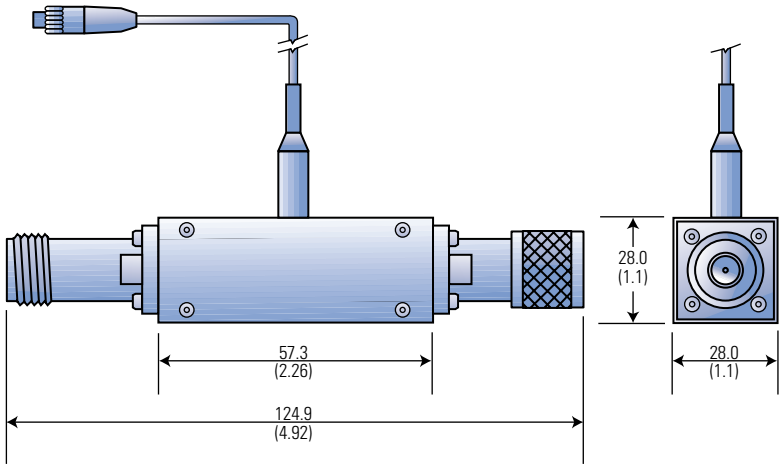
Dimensions are in mm (inches) nominal, unless otherwise specified.

Amplifiers

HP 87415A



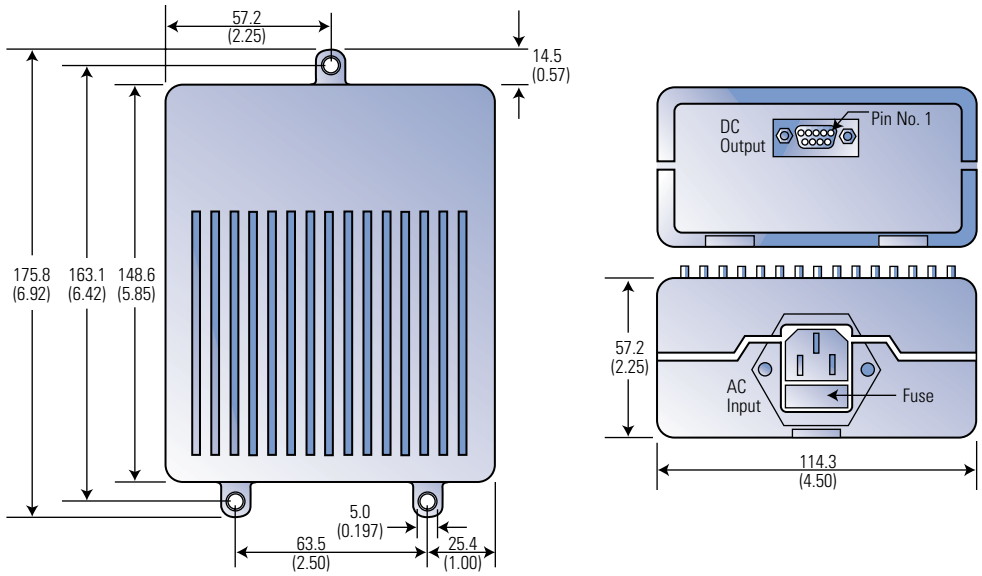
HP 87405A



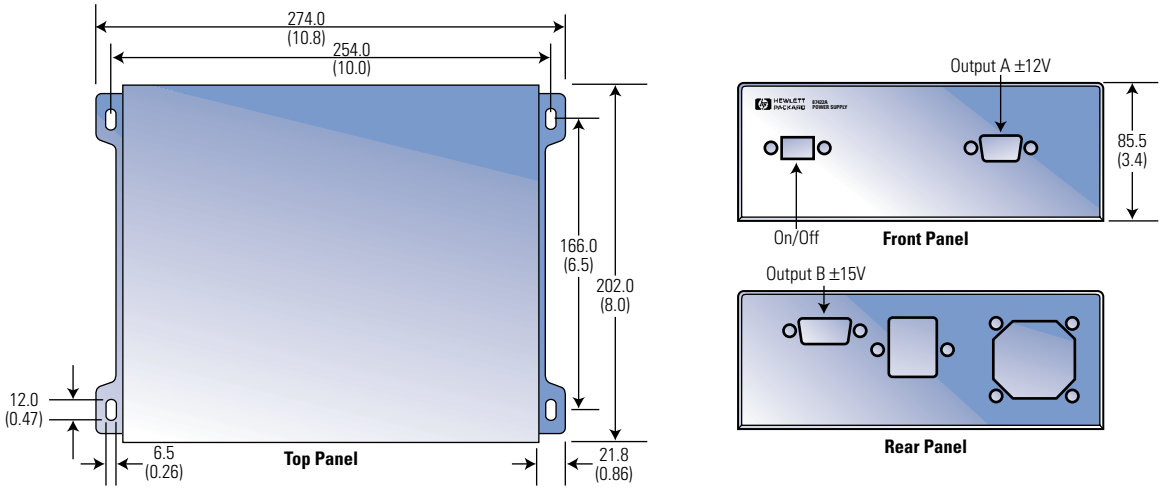
Dimensions are in mm (inches) nominal, unless otherwise specified.

Amplifiers

HP 87421A



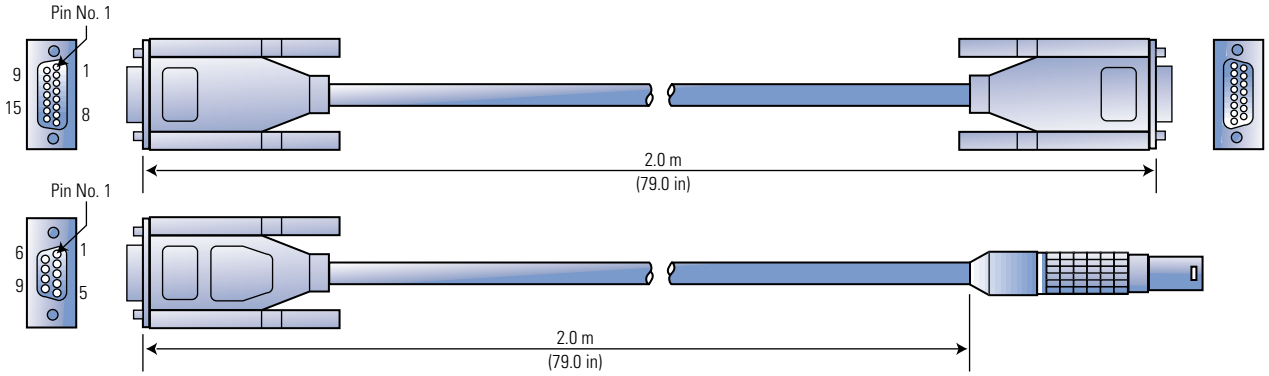
HP 87422A



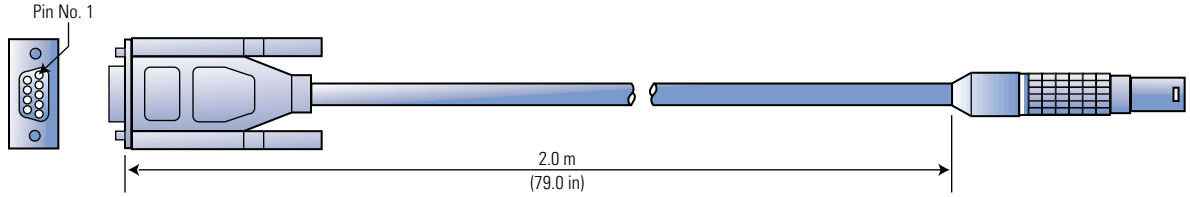
Dimensions are in mm (inches) nominal, unless otherwise specified.

Amplifiers

HP 87422-60001 and 83006-60005 Cable (Shipped with HP 87422A)



HP 83006-60005 Cable (Shipped with HP 87421A)



Dimensions are in mm (inches) nominal, unless otherwise specified.

Power Cable Cross Reference [1]

HP Model Number	HP Cable Part Number [2] (supplied with amplifier)	HP Power Supply Recommended	HP Cable Part Number [3] (supplied with power supply)
83006A	83006-60004	87421A	83006-60005
83017A	83006-60004	87421A	83006-60005
83018A	83006-60004	87421A	83006-60005
83050A	83006-60004	87421A	83006-60005
83051A	83006-60004	87421A	83006-60005
87415A	83006-60004	87421A	83006-60005
83020A	83020-60004	87422A [2]	87422-60001
			83006-60005
87405A	Integral cable	HP 11899A power supply or spectrum analyzer	

[1] See outline drawings for connector types.
[2] For use with available power supply.
[3] For use with power supply for direct connection.

Instrumentation Amplifiers

HP 8347A

HP 8348A

HP 8349B

The HP 8347/48/49 microwave amplifier family offers system-compatible, loss-compensation gain blocks in self-contained rack mountable or benchtop packages. Whether overcoming cable losses, driving high power amps, or driving HP millimeter-wave modules, this amplifier family features internal power supplies and bias networks to ensure simple system integration and trouble free operation.

The HP 8349B microwave amplifier's internal coupler and detector make it ideal for external leveling and system loss compensation applications with HP microwave sources. Benchtop and ATE applications will benefit from the simple drop-in system compatibility of these broadband amplifiers.

Millimeter-wave signal sources are easily configured using new or existing microwave sources with the HP 8349B as a driver for the HP 83550 series millimeter-wave source modules. The built-in source module interface on the HP 8349B ensures that proper dc bias and control signals are maintained.

The HP 8347A, 8348A and 8349B are general purpose broadband instrumentation amplifiers capable of producing power and gain to overcome systematic RF path losses, drive high-power devices, and improve measurement system performance.

Specifications

HP Model	Frequency Range	Output Power	Gain	Harmonics	Input SWR (typ)	Output SWR (typ)
8347A	Unleveled:					
	100 kHz to 2 GHz	—	≥ 25 dB	≤ 25 dBc	2.0	2.0
	2 GHz to 3 GHz		≥ 25 dB	≤ 25 dBc	2.0	3.0
	Leveled:					
	100 kHz to 3 GHz	≥ 20 dBm	≥ 25 dB	≤ 20 dBc	2.0	1.5
8348A	Unleveled:					
	2 to 20 GHz	≥ 25 dBm	≥ 25 dB	< -15 dBc (typ)	3.0	4.5
	20 to 26.5 GHz	≥ 23 dBm	≥ 23 dB	< -15 dBc (typ)	3.0	2.0
8349B	Unleveled:					
	2 to 18.6 GHz	≥ 20 dBm	≥ 15 dB	≤ 20 dBc	2.8	≤ 4.8
	18.6 to 20 GHz	≥ 18 dBm	≥ 13 dB	≤ 20 dBc	2.8	≤ 3.2
	Leveled:					
	2 to 18.6 GHz	≥ 19 dBm	≥ 15 dB	≤ 20 dBc	2.8	2.5
	18.6 to 20 GHz	≥ 17 dBm	≥ 13 dB	≤ 20 dBc	2.8	2.5

Instrumentation Amplifiers

HP 8447A

HP 8447D

HP 8447 Series Amplifiers

These low-noise, high-gain amplifiers improve the sensitivity of counters, spectrum analyzers, RF voltmeters, EMI meters, power meters, and other devices. They will also increase the maximum power available from a signal generator or sweeper.

Options

Standard connectors are BNC (f) on all amplifiers.
Option 010 – single-channel amplifier, N (f) connectors
Option 001 – dual-channel amplifier, BNC (f) connectors
Option 011 – dual-channel amplifier, N (f) connectors
Dual-channel, 50 Ω (nominal) amplifiers are ideal for dual-channel systems such as oscilloscopes or network analyzers. Channels may also be cascaded for increased small-signal gain.

General Specifications

Weight: net, 1.56 kg (3.4 lb); shipping, 2.30 kg (5.1 lb)
Size: 85.8 H x 130 W x 216 D mm (3.4 in x 5.1 in x 8.5 in)
Power requirements: 110 or 230 Vac ± 10%, 48-440 Hz, 15 watts.

Specifications

HP Model	HP 8447A	HP 8447D
Frequency Range	0.1 to 400 MHz	100 kHz to 1.3 GHz
Typical 3 dB Bandwidth	50 kHz to 700 MHz	75 kHz to 1.7 GHz
Gain (Mean, per channel)	20 dB ± 1.0 dB at 10 MHz (20 °C to 30 °C) 20 dB ± 1.7 dB at 10 MHz (0 °C to 55 °C)	>25 dB (20 °C to 30 °C)
Gain Flatness	± 1.8 dB (0 °C to 55 °C)	± 1.5 dB
Across Full Frequency Range	± 0.7 dB (20 °C to 30 °C) (Characteristic)	
Noise Figure	<7 dB	<8.5 dB
Output Power for 1 dB Gain Compression	>+6 dBm	>+7 dBm typical
Harmonic Distortion	–32 dB for 0 dBm output	–30 dB for 0 dBm output (typical)
Output for <–60 dB Harmonic Distortion	–25 dBm (Characteristic)	–30 dBm
SWR	<1.7	<2.0 input <2.2 output 1 to 1300 MHz
Reverse Isolation	>30 dB	>40 dB
Maximum DC Voltage Input	±10 V	±10 V
Options Available	001	001, 010, 011

Instrumentation Amplifiers

HP 8449B Preamplifier

- 1 to 26.5 GHz frequency range
- 30 dB gain
- 10 dB noise figure
- Measure extremely low-level signals
- <-150 dBm sensitivity
- Improve measurement speed

HP 8449B

This wideband 1 to 26.5 GHz preamplifier combines high gain with low noise making it suitable for a wide variety of applications. It is useful in the laboratory as a general purpose accessory to increase the sensitivity of spectrum analyzers, counters, power meters, and other instruments.

Specifications

Frequency range: 1.0 to 26.5 GHz
Maximum safe input power: +20 dBm
Maximum dc input: +20 Vdc

Gain compression: <1 dB for signals ≤ +7 dBm at the output (characteristic)
Gain: 20 to 30 °C: >26 dB (30 dB typ.)
0 to 55 °C: >23 dB

Noise Figure

Frequency Band	Guaranteed	Typical
1.0 to 12.7 GHz	<8.5 dB	7 dB
12.7 to 22.0 GHz	<12.5 dB	9 dB
22.0 to 26.5 GHz	<14.5 dB	12 dB

Third-order intercept:
+15 dBm at the output (characteristic)

Second harmonic distortion:
-30 dB for 0 dBm output (characteristic)

Gain Flatness

Band	Variation
1.0 to 26.5 GHz	+4.5 dB (0 to 55 °C)
2.0 to 22.0 GHz	+2.4 dB (20 to 30 °C, typical)

Amplitude temperature drift:
≤0.12 dB/°C (characteristic)

Displayed average noise level:
0 dB attenuation (characteristic)

With HP 8563E (1 Hz RBW)		With HP 8566B (10 Hz RBW)	
1.0 to 2.9 GHz	–165 dBm	1.0 to 2.5 GHz	–155 dBm
2.75 to 6.46 GHz	–168 dBm	2.0 to 5.8 GHz	–154 dBm
5.86 to 13.0 GHz	–163 dBm	5.8 to 12.5 GHz	–150 dBm
12.4 to 22.0 GHz	–160 dBm	12.5 to 18.6 GHz	–144 dBm
22.0 to 26.5 GHz	–158 dBm	18.6 to 22.0 GHz	–140 dBm

RF input/output 3.5 mm (m), 50 Ω (nominal)

Input SWR	1.0 to 2.0 GHz	2.0:1
	2.0 to 12.5 GHz	1.5:1
	12.5 to 26.5 GHz	2.0:1
Output SWR	1.0 to 26.5 GHz	2.0:1

Reverse isolation: >75 dB

Temperature:
Operation, 0 ° to +55 °C; storage, – 40 ° to +75 °C

EMI: FTZ 1046; CISPR Pub 11; MIL-STD 461C, part 7, CE03 and RE02

Power requirements: 100, 120, 220, or 240 volts (+10%), 47-63 Hz

Calibration cycle: 3 years (recommended)

Weight: 4 kg (8.8 lb)

Size:
102 H x 213 W x 297 mm D (4 in x 8.4 in x 11.74 in)

Ordering Information

HP 8449B (1 to 26.5 GHz preamplifier)
Option 907 front handle kit
Option 908 rack mount kit (half rack width)

Attenuators

Applications

HP fixed and step attenuators[1] find use in a wide variety of applications for signal conditioning and level control.

- Reducing signal levels
- Matching impedances of sources and loads
- Measuring gain or loss of a two-port device

Key Specifications

- SWR
- Accuracy
- Repeatability
- Life

SWR

Most attenuators use some form of distributed thin-film attenuating element, designed to operate over multi-octave ranges and for low SWR match at input and output. The SWR characteristic is controlled with careful design of the element as well as the transition from RF connector to the element's planar geometry.

When an attenuator is inserted into a test network, the interaction of its SWR and the network SWR results in frequency-varying mismatch which degrades the accuracy of the measurement. The amount of variation often exceeds the flatness specification of the attenuator. As an example, if, at a given frequency, a 3 dB attenuator with SWR of 1.22 at each port is inserted into a microwave network that has a source and load SWR of 1.35, the variation from the expected 3 dB change could be as great as ±0.5 dB. This change is due to SWR alone and points out the importance of the SWR specification in a precision attenuator.

[1] See Waveguide chapter for additional products.

Accuracy

The accuracy of an attenuator directly affects the uncertainty of the measurement where the attenuator is used. In many measurement and metrology applications, attenuators are the basic standard against which other components and instruments are calibrated.

HP attenuator accuracy specifications always include the effect of frequency response. And, HP attenuators use "edgeline" coaxial structure technology to achieve low insertion loss and SWR resulting in better accuracy.

HP attenuators achieve flat frequency response and high accuracy through the use of thin-film attenuator cards. These cards are composed of high-stability tantalum nitride resistive film, deposited on sapphire or alumina substrates. Advanced design and state-of-the-art processes in the deposition stages allow precise control of the geometry and thus the attenuation value. The result is very flat frequency response and greater accuracy.

Ultimate specified accuracy of RF/microwave attenuators is limited by the accuracy to which National Institute of Standards and Technology (NIST) can measure, plus the uncertainty of the measurement transfer process which calibrates the production test equipment. See Figure 1, on the next page, for an accuracy traceability example. At HP, performance to specifications is verified by fully testing each attenuator with an ATE system including an automatic network analyzer (ANA). In turn, the ANA is periodically calibrated using standards traceable to NIST.

Each published specification has been established using a "specification budget" process. This process provides for "guardbands" to account for transfer uncertainties between NIST, HP Metrology Labs, and the HP production test systems. Figure 2, on the next page, shows how the specification budget is allocated.

Repeatability

Fixed attenuators are often used as standards of reference in microwave measurements. Therefore, the accuracy of the measurement depends not only on the reference accuracy, but on the repeatability of the insertion processes. Typical production test situations might require hundreds of connects/disconnects per day. So, measurement repeatability depends strongly on the connectors used. HP attenuators use precision type-N and APC-7 connectors, with repeatability that exceeds the International Electrotechnical Commission (IEC) standard for 7-mm connectors. For higher frequencies, HP uses 3.5-mm connectors that are fully SMA compatible, but are more rugged and repeatable than SMA. For applications to 50 GHz, HP uses 2.4-mm connectors that also have larger mating surfaces for rugged and repeatable connections. Design verification testing of 3.5-mm connectors showed virtually no test deterioration even after 1000 connections. For step attenuators, the repeatability of the internal RF connections is also of concern. HP uses an "edgeline" transmission line structure in which the outer conductor is a continuous ground plane and only the center conductor is switched to insert or remove an attenuation step. Keys to achieving long term repeatability include precision control of all dimensions that affect contact pressure, careful selection and control of plating processes, and careful monitoring and control of the assembly process. The result is a step attenuator with repeatability specified at 0.03 dB maximum over 5 million cycles per section.

Life

The life of step attenuators is usually specified in cycles, i.e. the number of times a given attenuator section switches from one position to another and back. HP determines life by cycling attenuators to the point of degradation. Typically, HP attenuators in life cycle tests perform to specification for at least twice as many cycles as warranted. HP step attenuator families have a specified life of 5 million cycles per section (except the HP 355E,F). This long life results in lower cost of ownership by reducing periodic maintenance, downtime and repairs.

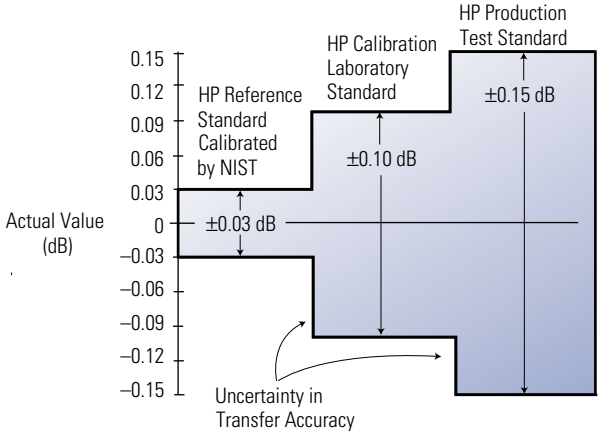


Figure 1. **Accuracy traceability example.**

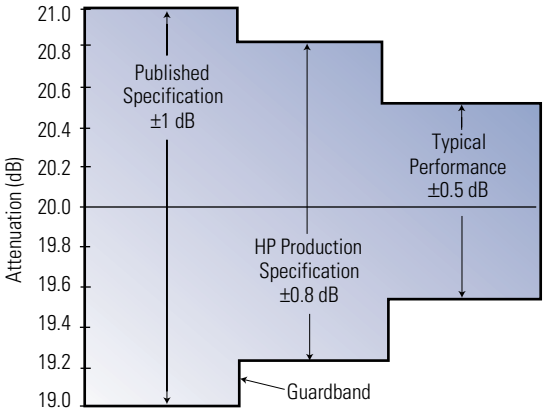


Figure 2. **Guardband example.**

Attenuators

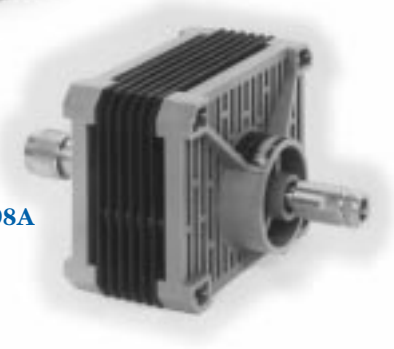
HP 8490D

HP 8491A/B/C

HP 8492A

HP 8493A

HP 8498A



HP 8491A,B,C, 8492A, 8493A,B,C

Hewlett-Packard coaxial fixed attenuators provide precise attenuation, flat frequency response, and low SWR over broad frequency ranges. Attenuators are available in nominal attenuations of 3 dB and 6 dB, as well as 10 dB increments from 10 dB to 60 dB. These attenuators are swept-frequency tested to ensure specification compliance at all frequencies. Calibration points are provided on a nameplate chart attached to each unit (except for the HP 8491C).

HP 8498A High Power Attenuator

The HP 8498A Option 030 is designed to meet the needs of high power attenuation applications in the RF and microwave frequency range. It is a 25 watt average, 30 dB fixed attenuator with a frequency range of dc to 18 GHz. The maximum peak power specification is 500 watts (dc to 5.8 GHz) and 125 watts (5.8 to 18 GHz). Available only in a 30 dB version, the unit offers a 1.3 SWR and ±1 dB accuracy at 18 GHz. Large heat-dissipating fins keep the unit cool even under continuous maximum input power conditions.

HP 8490D 50-GHz Fixed Attenuator

Hewlett-Packard coaxial fixed attenuators have been the standard for accurate flat response and low SWR. The HP 8490D offers exceptional performance to 50 GHz using the 2.4-mm connector. Attenuation values available are 3, 6, 10, 20, 30, and 40 dB. Ideally suited for extending the range of sensitive power meters, or for use as calibration standards, these broadband attenuators are manufactured with the same meticulous care as their lower frequency counterparts.

HP 11581A, 11582A, 11583A,C Attenuator Sets

A set of four attenuators (3, 6, 10 and 20 dB) is furnished in a walnut accessory case. The HP 11581A set consists of HP 8491A attenuators; the HP 11582A set, HP 8491B attenuators; the HP 11583A set, HP 8492A attenuators; and the HP 11583C set, HP 8493C attenuators. These sets are ideal for calibration labs or where precise knowledge of attenuation and SWR is desired.

HP 86213A Attenuator Set

Provides a set of four, 3, 6, 10 and 20 dB, 75 ohm type-N attenuators in a walnut accessory case (HP 0955-0765, 0955-0766, 0955-0767, and 0955-0768), respectively. Used for reducing power and improving match. SWR is 1.12 to 1.3 GHz and 1.3 to 3 GHz. Attenuation accuracy is ±0.5 dB.

Fixed

Specifications

HP Model	Frequency Range (GHz)	Maximum Input Power			Option: Atten.	003 3 dB	006 6 dB	010 10 dB	020 20 dB	030 30 dB	040 40 dB	Connectors
8490D	dc to 50	1 W avg.	**Attenuation:**	**Min:** 0 to 50 GHz		2.5	5.4	9.4	19.2	29.2	38.2	2.4 mm (m, f)
				Max: 0 to 26.5 GHz		3.9	6.9	10.9	21.3	31.3	42.5	
				Max: 26.5 to 50 GHz		4.8	7.8	11.3	21.7	31.7	42.5	
			SWR:	**Max:** 0 to 26.5 GHz		1.15	1.15	1.15	1.15	1.15	1.08	
				Max: 26.5 to 40 GHz		1.25	1.25	1.25	1.25	1.25	1.15	
				Max: 40 to 50 GHz		1.45	1.45	1.45	1.45	1.45	1.25	

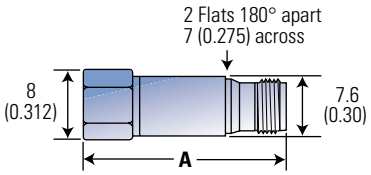
Specifications

HP Model	Frequency Range (GHz)	Maximum SWR	Maximum Input Power	Attenuation Accuracy (± dB) 3 dB	6 dB	10 dB	20 dB	30 dB	40 dB	50 dB	60 dB	Connectors
8491A 3 to 30 dB 40 to 60 dB	dc to 12.4	1.2 to 8 GHz 1.3 to 12.4 GHz	2 W avg. 100 W peak	0.3	0.3	0.5	0.5	1.0	1.5	1.5	2	N (m, f)
8491B 3 to 30 dB 40 to 60 dB	dc to 18	1.2 to 8 GHz 1.3 to 12.4 GHz 1.5 to 18 GHz		0.3	0.3 to 12.4 GHz 0.4 to 18 GHz	0.6	0.6 to 12.4 GHz 1.0 to 18 GHz	1.0	1.5	1.5	2	N (m, f)
8491C 3 to 30 dB	dc to 18	1.2 to 8 GHz 1.3 to 12.4 GHz 1.5 to 18 GHz		0.3 to 12.4 GHz 0.4 to 18 GHz	0.4 to 12.4 GHz 0.5 to 18 GHz	0.6	0.6 to 12.4 GHz 1.0 to 18 GHz	1.0	—	—	—	N (m, f)
8492A 3 to 30 dB 40 to 60 dB	dc to 18	1.15 to 8 GHz 1.25 to 12.4 GHz 1.35 to 18 GHz		0.3	0.3 to 12.4 GHz 0.4 to 18 GHz	0.6	0.6 to 12.4 GHz 1.0 to 18 GHz	1.0	1.5	1.5	2	APC-7
8493A 3 to 20 dB 30 dB	dc to 12.4	1.2 to 8 GHz 1.3 to 12.4 GHz		0.3	0.3	0.5	0.5	1.0	—	—	—	SMA (m, f)
8493B 3 to 20 dB 30 dB	dc to 18	1.2 to 8 GHz 1.3 to 12.4 GHz 1.5 to 18 GHz		±0.3 dB	0.3 to 12.4 GHz 0.4 to 18 GHz	0.6	0.6 to 12.4 GHz 1.0 to 18 GHz	1.0	—	—	—	SMA (m, f)
8493C 3 to 30 dB	dc to 26.5	1.1 to 8 GHz 1.15 to 12.4 GHz 1.25 to 26.5 GHz[1]		0.5 to 18 GHz 1.0 to 26.5 GHz	0.6	0.3	0.5	0.7	1.0	—	—	3.5 mm (m, f)
40 dB					0.6	0.5	0.6	1.0	1.3			
8498A 30 dB	dc to 18	1.15 to 8 GHz 1.25 to 12.4 GHz 1.30 to 18 GHz	25 W avg. 500 W peak (dc to 5.8 GHz) 125 W peak 500 W/ms max. per pulse (5.8 to 18 GHz)	—	—	—	—	1.0	—	—	—	N (m, f)

Indicates QuickShip availability. Contact HP Direct or your local HP sales representative to confirm QuickShip.

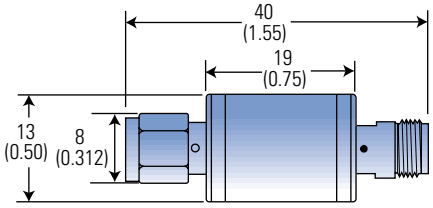
[1] 1.27 for Option 006.

Fixed

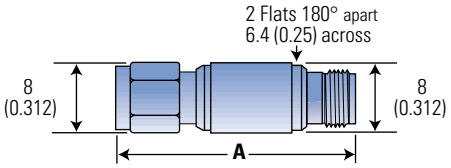


Dimension A
3, 6, 10, 20 dB: 27 (1.06)
30, 40 dB: 29 (1.14)

HP 8490D



HP 8493A,B



Dimension A
3, 6, 10, 20 dB: 33.8 (1.330)
30, 40 dB: 36.8 (1.450)

HP 8493C

Dimensions are in mm (inches) nominal, unless otherwise specified.

Fixed Attenuator Ordering Information

HP 8490/91/92/93/98 Series Ordering Example [1]

HP 849 **3C** Option **010** Option **UK6**

Frequency Range
0D: dc to 50 GHz
1A: dc to 12.4 GHz
1B: dc to 18 GHz
1C: dc to 18 GHz
2A: dc to 18 GHz
3A: dc to 12.4 GHz
3B: dc to 18 GHz
3C: dc to 26.5 GHz
8A: dc to 18 GHz

Attenuation
003: 3 dB
006: 6 dB
010: 10 dB
020: 20 dB
030: 30 dB
040: 40 dB [2]
050: 50 dB [2]
060: 60 dB [2]

Calibration Documentation
UK6: Commercial calibration test data with certificate
UKS: Commercial calibration certificate

[1] Each order must specify an attenuation option.
[2] Not available on all models. See specification table.

Programmable and Manual Step

Step Attenuator Selection Guide

	Step Size	Attenuation Range	Frequency Range				
			dc to 1000 MHz	dc to 4 GHz	dc to 18 GHz	dc to 26.5 GHz	dc to 40 GHz
Manual	1 dB	0 to 11 dB		8494A	8494B		
		0 to 12 dB	355C				
	10 dB	0 to 70 dB		8495A	8495B	8495D	
		0 to 110 dB		8496A	8496B		
		0 to 120 dB	355D				
Programmable	1 dB	0 to 11 dB		8494G	8494H	84904K	84904L
		0 to 12 dB	355E				
	10 dB	0 to 70 dB		8495G	8495H	8495K	
						84907K	84907L
		0 to 90 dB				8497K	
						84906K	84906L
		0 to 110 dB		8496G	8496H		
		0 to 120 dB	355F				

HP 355 Series Specifications

Manual	**HP 355C**	(0 to 12 dB, 1 dB steps)
	HP 355D	(0 to 120 dB, 10 dB steps)
Programmable	**HP 355E**	(0 to 12 dB, 1 dB steps)
	HP 355F	(0 to 120 dB, 10 dB steps)

HP 355C,D

The manual and programmable HP 355 series attenuators offer exceptional attenuation accuracy to 1 GHz; 0.1 dB to 1 kHz, 0.25 dB to 500 MHz, 0.35 dB to 1 GHz. They feature BNC (f) RF connectors, with optional type-N (Option 001) and TNC (Option 005) also available. To achieve 1 dB steps up to a range of 132 dB, serially connect two attenuators using a standard UG-491A/U BNC (m)-to-BNC (m) adapter. Programmable HP 355EF models feature a 7-pin connector. To protect your transistor driver against transients during the switching cycle, order Option 007 to install a protective diode between each solenoid and driver.

Programmable and Manual Step

HP 84904L

HP 8494/95/96A,B,D

HP 8494/95/96G,H,K

HP 84904/906/907 Series

This family of programmable step attenuators offers unmatched attenuation performance to 40 GHz. The K models brings superior accuracy and reliability to 26.5 GHz, and the L models offers unparalleled performance to 40 GHz.

HP step attenuators consist of 3 or 4 cascaded sections of specific attenuation values, e.g., 1, 2, 4, or 10, 20, 30 or 40 dB. Both families offer the selection, performance, accuracy and reliability expected from HP: attenuation ranges of 11, 70, or 90 dB, 1 dB, and 10 dB step sizes, 5 million cycles per section and better than 0.03 dB repeatability. RF connector choices include precision 3.5 mm on the 26.5 GHz K models, and precision 2.4 mm or 2.92 mm on the L models. While the 2.92-mm connector format is compatible with both 3.5-mm and SMA connectors, Hewlett-Packard recommends the more rugged 2.4-mm connectors.

HP programmable step attenuators feature electro-mechanical designs that achieve 20 milliseconds switching time, including settling time. The permanent magnet latching allows automatic interruption of the dc drive voltage to cut power consumption and simplify circuit design. They are equipped with 10-pin DIP sockets (m) and have optional interconnect cables available.

HP 8494/95/96/97 Series

This family of manual step attenuators offers fast, precise signal level control in three frequency ranges, dc to 4 GHz, dc to 18 GHz and dc to 26.5 GHz. They feature exceptional repeatability and reliability in a wide range of frequency, attenuation and connector options.

Attenuation repeatability is specified to be less than 0.03 dB (0.05 dB, 18 to 26.5 GHz) for 5 million cycles per section. This assures low measurement uncertainty when designed into automatic test systems. Electromechanical step attenuators offer low SWR, low insertion loss and high accuracy required by high-performance test and measurement equipment.

Precision plated leaf-spring contacts insert/remove attenuator sections (miniature tantalum nitride thin-film T-pads on sapphire and alumina substrates) from the signal path. Unique process controls and material selection ensure unmatched life and contact repeatability.

Programmable Models

Miniature drive solenoids in the programmable models keep switching time, including settling, down to less than 20 milliseconds. Once switched, strong permanent magnets hold the solenoids (and attenuation value) in place. Current interrupts automatically disconnect solenoid current, simplifying driver circuit design and minimizing heat dissipation. Programming is done through a 12-pin Viking socket or optional ribbon cables with DIP plugs. Automatic drive control is easy using the HP-IB compatible HP 11713A or 87130A attenuator/switch driver and an external controller.

Programmable Driver Instruments

Programmable drive options for step attenuators include the HP 11713A attenuator/switch driver, which permits users to easily integrate the attenuator into HP-IB compatible automatic test systems. Also, see page 110 for product descriptions of the HP 87130A and 70611A (MMS) attenuator/switch drivers.

Interconnect cable selections include various connector and ribbon cable configurations to match user applications. Standard interconnect cables are described in the Attenuator Cables table on page 47.

Manual Models

These models provide excellent performance with the simplicity and convenience of positive manual switching. A low torque camshaft activates the insertion and removal of the attenuation sections. Positive detents and an attenuation level indicator ensures quick and accurate control.

Attenuator Interconnecting Kits

To achieve 1 dB step resolution up to 81 dB, 101 dB or 121 dB, combine the HP 8494 with 8495/96/97 using the HP 11716A,B,C interconnect kits to cascade attenuators in series. The HP 11717A attenuator/switch rack mount support kit allows easy rack mounting (See page 47).

Programmable and Manual Step

Specifications

HP Model (Switching Mode)	Frequency Range (GHz)	Attenuation Range	Insertion Loss @ 0 dB	Maximum SWR	Repeatability [1] Life	Maximum RF Input Power	Shipping Weight
355C (Manual)	dc to 1	0 to 12 dB 1 dB steps	0.2 dB + 2.3 dB/GHz	1.2 to 250 MHz 1.3 to 500 MHz 1.5 to 1 GHz	0.03 dB max 0.5 million cycles per section	0.5 W avg. 350 W peak [2] (10 µs max.)	1.4 kg (3 lb)
355E (Programmable)	dc to 1	0 to 12 dB 1 dB steps					
355D (Manual)	dc to 1	0 to 120 dB 10 dB steps					
355F (Programmable)	dc to 1	0 to 120 dB 10 dB steps					
8494A (Manual)	dc to 4	0 to 11 dB 1 dB steps	0.6 dB + 0.09 dB/GHz	1.5	0.03 dB max 5 million cycles per section	1 W avg. 100 W peak [2] (10 µs max.)	0.9 kg (2 lb)
8494G (Programmable)	dc to 4	0 to 11 dB 1 dB steps					
8494B (Manual)	dc to 18	0 to 11 dB 1 dB steps		1.5 to 8 GHz 1.6 to 12.4 GHz 1.9 to 18 GHz			
8494H (Programmable)	dc to 18	0 to 11 dB 1 dB steps					
8495A (Manual)	dc to 4	0 to 70 dB 10 dB steps	0.4 dB + 0.07 dB/GHz	1.35			
8495G (Programmable)	dc to 4	0 to 70 dB 10 dB steps					
8495B (Manual)	dc to 18	0 to 70 dB 10 dB steps		1.35 to 8 GHz 1.5 to 12.4 GHz 1.7 to 18 GHz			
8495H (Programmable)	dc to 18	0 to 70 dB 10 dB steps					
8495D (Manual)	dc to 26.5	0 to 70 dB 10 dB steps	0.5 dB + 0.13 dB/GHz	1.6 to 6 GHz 1.6 to 12.4 GHz 1.9 to 18 GHz 2.2 to 26.5 GHz	0.03 dB max to 18 GHz 0.05 dB max to 26.5 GHz 5 million cycles per section		
8495K (Programmable)	dc to 26.5	0 to 70 dB 10 dB steps					
8496A (Manual)	dc to 4	0 to 110 dB 10 dB steps	0.6 dB + 0.09 dB/GHz	1.5	0.03 dB max 5 million cycles per section		
8496G (Programmable)	dc to 4	0 to 110 dB 10 dB steps					
8496B (Manual)	dc to 18	0 to 110 dB 10 dB steps		1.5 to 8 GHz 1.6 to 12.4 GHz 1.9 to 18 GHz			
8496H (Programmable)	dc to 18	0 to 110 dB 10 dB steps					
8497K (Programmable)	dc to 26.5	0 to 90 dB 10 dB steps	0.4 dB + 0.09 dB/GHz	1.25 to 6 GHz 1.45 to 12.4 GHz 1.6 to 18 GHz 1.8 to 26.5 GHz	0.03 dB max to 18 GHz 0.05 dB max to 26.5 GHz 5 million cycles per section		

Indicates QuickShip availability. Available on HP 355 C,E standard models only. Available on HP 849X A,B,G,H models with Option 001 only. Available on HP 849X D,K models with Option 004 only. Contact HP Direct or your local HP sales representative to confirm QuickShip.

[1] Measured at 25 °C. [2] Not to exceed average power.

HP 355 Series Options

	Std.	Opt. 001	Opt. 005
RF Connectors	BNC (f)	N (f)	TNC (f)
Drive Circuit Protection	**Opt. 007:** Protection diodes for HP 355E,F		

HP 8494/95/96/97 Series Options

	Std.	Opt. 011	Opt. 015
Supply Voltage			
Supply Voltage Range	20 to 30 Vdc	4.5 to 7 Vdc	13 to 22 Vdc
Supply Voltage (nom)	24 Vdc	5 Vdc	15 Vdc
Current Drawn	125 ma	300 ma	187 ma
RF Connectors			
A,B,G,H models	**Opt. 001:** N (f)	**Opt. 002:** SMA (f)	**Opt. 003:** APC-7
K models	**Opt. 004:** 3.5 mm (f)		
DC Connectors			
G,H,K models	**Std:** 12-pin Viking connector **Opt. 008:** 8-inch ribbon cable with 14-pin DIP plug **Opt. 016:** 16-inch ribbon cable with 14-pin DIP plug		
Calibration Documentation	See ordering information		

Programmable and Manual Step

Specifications

HP Model (Switching Mode)	Frequency Range (GHz)	Attenuation Range	Insertion Loss (dB)	Maximum SWR Std. (Opt. 006)	Repeatability [1] Life	Maximum RF Input Power	Shipping Weight
84904K (Programmable)	dc to 26.5	0 to 11 dB 1 dB steps	0.8 dB + 0.04 dB/GHz	1.3 (1.5) to 12.4 GHz 1.7 (1.9) to 34 GHz 1.8 (2.0) to 40 GHz	0.03 dB max. 5 million cycles per section	1 W avg. 100 W peak [2] (10 µs max)	0.29 kg (10.32 oz)
84904L (Programmable)	dc to 40						
84906K (Programmable)	dc to 26.5	0 to 90 dB 10 dB steps	0.8 dB + 0.04 dB/GHz	1.3 (1.5) to 12.4 GHz 1.7 (1.9) to 34 GHz 1.8 (2.0) to 40 GHz			0.29 kg (10.32 oz)
84906L (Programmable)	dc to 40						
84907K (Programmable)	dc to 26.5	0 to 70 dB 10 dB steps	0.6 dB + 0.03 dB/GHz	1.25 (1.4) to 12.4 GHz 1.5 (1.7) to 34 GHz 1.7 (1.9) to 40 GHz			0.23 kg (8.1 oz)
84907L (Programmable)	dc to 40						

[1] Measured at 25 °C.

[2] Not to exceed average power.

HP 84904/906/907 Series Options

	Std.	Opt. 011	Opt. 015
Supply Voltage			
Supply Voltage Range	20 to 30 Vdc	4.5 to 7 Vdc	13 to 22 Vdc
Supply Voltage (nom)	24 Vdc	5 Vdc	15 Vdc
RF Connectors			
K models	**Std.:** 3.5 mm (f)	**Opt. 104:** 3.5 mm (f) [3] 3.5 mm (m) [4]	
L models	**Std.:** 2.4 mm (f)	**Opt. 006:** 2.92 mm (f) **Opt. 100:** 2.4 mm (f) [3] 2.4 mm (m) [4]	**Opt. 106:** 2.92 mm (f) [3] 2.92 mm (m) [4]
Calibration Documentation	See ordering information		

[3] Drive cable end.

[4] End opposite to drive cable.

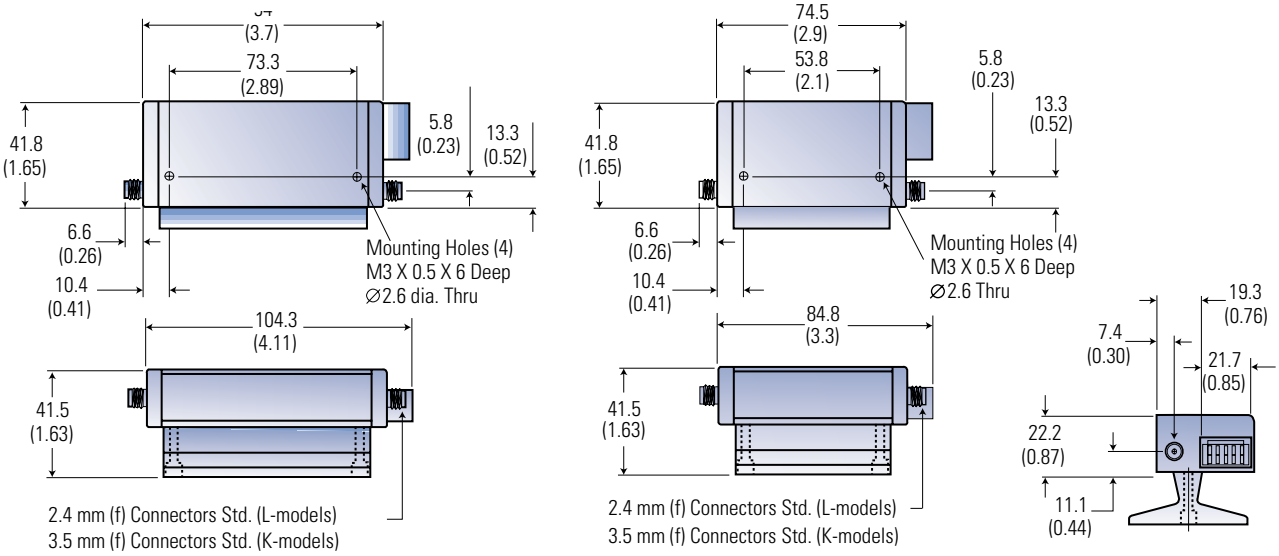
Some HP attenuators are available as OEM equivalents to standard models. This table shows the corresponding model numbers.

HP Model Number	OEM Model Number	HP Model Number	OEM Model Number
8494A	33320A	**8496H**	33322H
8494B	33320B	**8497K**	33323K
8494G	33320G	**84904K**	33324K
8494H	33320H	**84904L**	33324L
8495G	33321G	**84906K**	33326K
8495H	33321H	**84906L**	33326L
8495K	33321K	**84907K**	33327K
8496G	33322G	**84907L**	33327L

OEM models of step attenuators are furnished without a base.

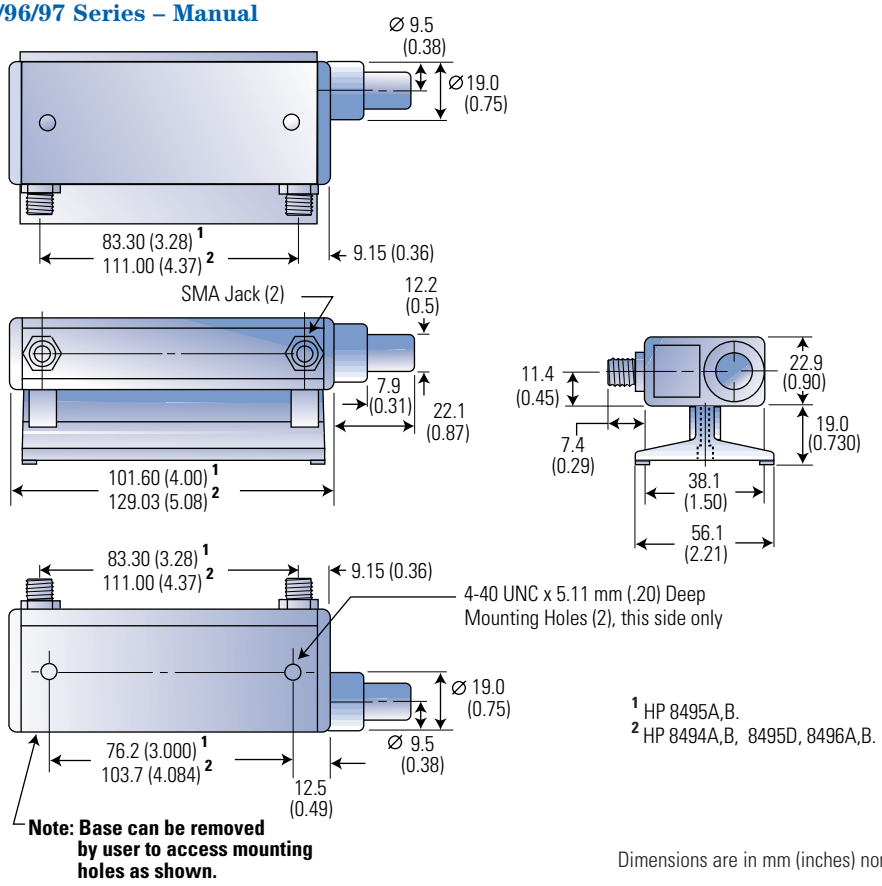
Outline Drawings

HP 84904/906/907 Series – Programmable



See ordering example for connector options

HP 8494/95/96/97 Series – Manual

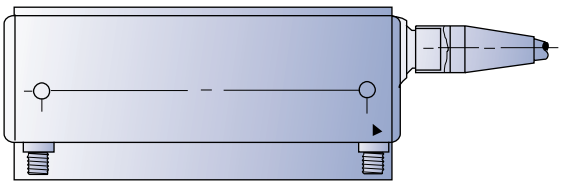


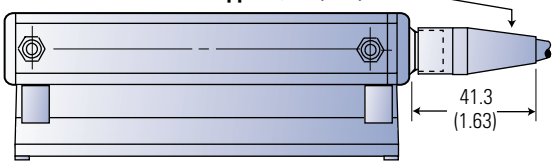
[1] HP 8495A,B.
[2] HP 8494A,B, 8495D, 8496A,B.

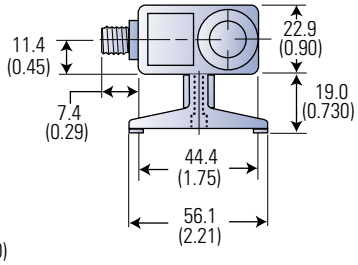
Dimensions are in mm (inches) nominal, unless otherwise specified.

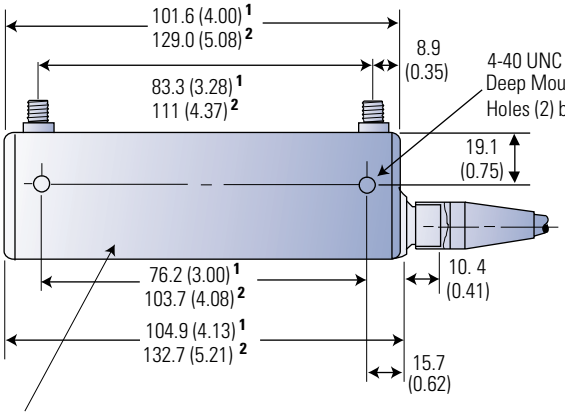
Programmable and Manual Step

HP 8494/95/96/97 Series – Programmable

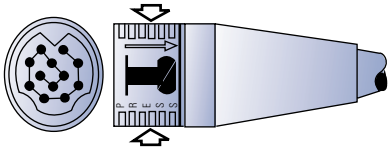








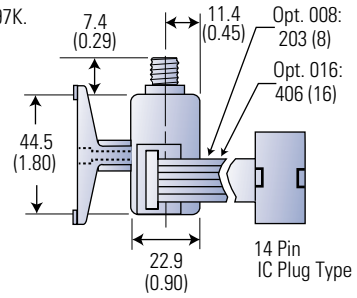
Solenoid Drive Plug Detail

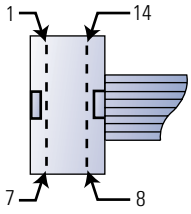


To Remove: Press at arrows with thumb and finger; pull to detach. Caution: Do not twist.

Note: Base can be removed by user to access mounting holes as shown above.

[1] HP 8495G,H.
[2] HP 8494G,H, 8495K, 8496G,H, 8497K.





Plug Bottom View

Dimensions are in mm (inches) nominal, unless otherwise specified.

Programmable and Manual Step

Step Attenuator Ordering Information

HP 355 Series Ordering Example

HP 355 D Option 001 Option 007

Type/Attenuation Range
C: Manual, 0 to 12 dB, 1 dB steps
D: Manual, 0 to 120 dB, 10 dB steps
E: Programmable, 0 to 12 dB, 1 dB steps
F: Programmable, 0 to 120 dB, 10 dB steps

RF Connector
Std: BNC (f)
001: N (f)
005: TNC (f)

Drive Circuit Protection
007: Protection diodes for HP 355E,F (see page 38)

HP 8494/95/96/97 Series Ordering Example

HP 849 4 A Option 001 Option 011 Option 008 Option UK6

Attenuation Range
4: 11 dB max, 1 dB steps
5: 70 dB max, 10 dB steps
6: 110 dB max, 10 dB steps
7: 90 dB max, 10 dB steps

Type/Frequency Range
A: Manual, dc to 4 GHz
B: Manual, dc to 18 GHz
D: Manual, dc to 26.5 GHz [2]
G: Programmable, dc to 4 GHz
H: Programmable, dc to 18 GHz [3]
K: Programmable, dc to 26.5 GHz

RF Connector [1]
A,B,G,H models:
001: N (f)
002: SMA (f)
003: APC-7
D,K models:
004: 3.5 mm (f) [3]

Supply Voltage
Std.: 24 Vdc
011: 5 Vdc

DC Connector
G, H, K models
Std.: 12-pin Viking connector
008: 8-inch ribbon cable with 14-pin DIP plug
016: 16-inch ribbon cable with 14-pin DIP plug

Calibration Documentation [5]
UK6: Commercial calibration test data with certificate
UKS: Commercial calibration certificate

[1] Each order must include RF connector option.
[2] Available with HP 8495 only.
[3] Available with HP 8495/97 only.

HP 84904/906/907 Series Ordering Example [4]

HP 8490 4 K Option 011 Option 006 Option UK6

Attenuation Range
4: 11 dB max, 1 dB steps
6: 90 dB max, 10 dB steps
7: 70 dB max, 10 dB steps

Frequency Range
K: dc to 26.5 GHz
L: dc to 40 GHz

Supply Voltage
Std.: 24 Vdc
011: 5 Vdc
015: 15 Vdc

RF Connector
K models
104: 3.5 mm (f) drive cable end
3.5 mm (m) opposite end

L models
006: 2.92 mm (f) both ends
100: 2.4 mm (f) drive cable end, 2.4 mm (m) opposite end
106: 2.92 mm (f) drive cable end, 2.92 mm (m) opposite end

Calibration Documentation [5]
UK6: Commercial calibration test data with certificate
UKS: Commercial calibration certificate

[4] Drive cable not included. See Attenuator Cables table on next page.
[5] Option UK6/UKS not available with Option 106.

Programmable and Manual Step

Attenuator Cables

HP Model Number	HP Part Number	Where Used	Description
11764A		11713A to 84904/906/907	10-pin DIP to Viking conn., 60 inches
11764B		84904/906/907 to ribbon	10-pin DIP to 60 inch ribbon cable, bare leads
11764C		84904/906/907 to DIP	10-pin DIP to 14-pin DIP, 8-inch ribbon cable
11764D		84904/906/907 to DIP	10-pin DIP to 14-pin DIP, 16-inch ribbon cable
	11764-60005	84941A dist bd to 8494/95/96/97	Viking to (4) 4-pin Berg conn., 30 inches
	11764-60006	84941A dist bd to 84904/906/907	10-pin DIP to (4) 4-pin Berg conn., 30 inches
	70612-60017	84941A dist bd to 8494/95/96/97	Viking to (4) 4-pin Berg conn., 20 inches
	70612-60018	84941A dist bd to 84904/906/907	10-pin DIP to (4) 4-pin Berg conn., 20 inches

For complete cable configuration information, request publication number 5963-2038E, *HP 70611A, HP 87130A and HP 11713A Switch Attenuator Driver Configuration Guide.*

Attenuator/Switch Driver Attenuator Accessories

HP 11713A

HP 11716A

HP 11713A Attenuator/Switch Driver

This driver provides HP-IB or "local" front panel drive control for programmable attenuators and electro-mechanical switches. Concurrently drive up to two HP 8494/95/96 and HP 87904/906/907 programmable attenuators and two electromechanical switches (HP 8761, 8762 or 8765 series). The HP 11713A can also be used to supply +24V common and ten pairs of current sinking contacts (total current draw <1.25A peak for 1 sec., 0.65A steady state) to independently control up to 10 relays. An integral power supply (with short circuit protection) eliminates the need for an external power source. Each HP 11713A is supplied with two plug-in drive cables to simplify connection to programmable attenuators. Switching time is less than 10 milliseconds.

Attenuator Accessories

HP 11716 Series Attenuator Interconnect Kits

These kits can be utilized to connect any two of the HP 8494/95/96 attenuators in series. The rigid interconnect cable is available in type-N, APC-7, and SMA connectors as described below.

HP 11716A Attenuator Interconnect Kit (type-N)
HP 11716B Attenuator Interconnect Kit (APC-7)
HP 11716C Attenuator Interconnect Kit (SMA)

HP 11717A Attenuator/Switch Rack Mount Support Kit

This kit provides the necessary hardware to mount programmable attenuators and switches inside a test system rack mount cabinet.

Detectors

Applications

Hewlett-Packard broadband detectors[1] span frequencies from 100 kHz to 50 GHz. These detectors are widely used on the design and production test bench, as well as for internal components of test system signal interface units. They find use in a variety of test and measurement applications.

- Power monitoring
- Source leveling
- Video detection
- Swept transmission and reflection measurements

Technology

HP detectors are available in two families – Silicon Low Barrier Schottky Diode (LBSD) and Gallium Arsenide Planar Doped Barrier Diode (GaAs PDBD) detectors. The Gallium Arsenide detector technology produces diodes with extremely flat frequency response to 50 GHz. Also, the GaAs PDB detector has a wider operating temperature range (-65 °C to +100 °C), and is less sensitive to temperature changes.

Key Specifications:

- Frequency range
- Frequency response
- Open circuit voltage sensitivity
- Tangential sensitivity
- Output voltage versus temperature
- Rise time
- SWR
- Square-law response
- Input power

Frequency Range

Frequency range can be one of the most important factors to consider when specifying detectors. In the past, broadband frequency coverage was equated with high performance. It is important to note that though broadband coverage may be desirable in multi-octave applications, a good octave range detector may be your best solution for non-swept applications. Broadband coverage saves you from the inconvenience of having to switch between detectors when making measurements, but you may be sacrificing SWR and frequency response flatness. All of HP's 8474 family of coaxial detectors are available in both octave band and broadband versions. The guaranteed performance of the octave band models are characterized for frequency response flatness and SWR.

Frequency Response

Frequency response is the variation in output voltage versus frequency, with a constant input power. Frequency response is referenced to the lowest frequency of the band specified. HP typically uses -30 dBm to measure frequency response. HP uses precision thin-film input circuitry to provide good, broadband input matching. Exceptionally flat frequency response is provided by the very low internal capacitance of the PDB diode. Also, excellent control of the video resistance of the PDB diode is obtained by the precision growth of molecular beam epitaxy (MBE) layers during diode fabrication.

Figure 1 displays frequency response characteristics comparing HP LBSD and PDBD detectors. The figure indicates typical performance of each device and the published specifications. Frequency response specifications include the mismatch effects of the detector input SWR specifications. Note that the HP 8474E, representative of PDB detectors, is exceptionally flat beyond 26.5 GHz.

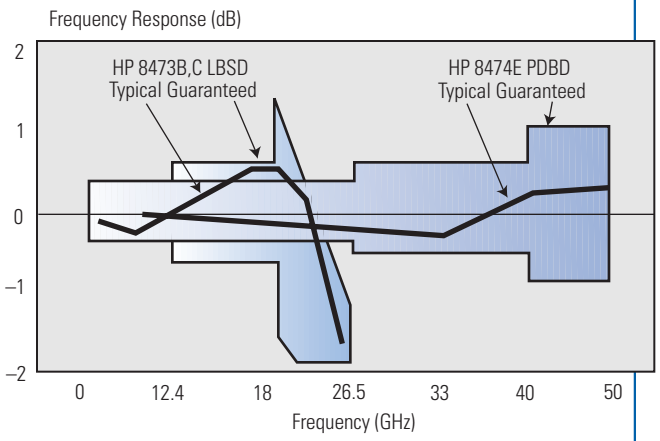


Figure 1. Detector frequency response characteristics.

[1] See Waveguide chapter for additional products.

Open Circuit Voltage Sensitivity

The open circuit voltage sensitivity (K) describes the slope of the transfer function of the detectors. This represents the conversion of RF/microwave power to a voltage at the output connector, typically specified in mV/µW. The value is an indication of the efficiency of the diode in converting the input power to a useful voltage.

Sensitivity is measured with the detector terminated in a high impedance. When used in video pulse applications, the sensitivity will appear to be much lower when terminated in 50 or 75 ohms for connection to an oscilloscope. Another factor, called the Figure of Merit, gives an indication of low-level sensitivity without consideration of a load circuit. It is useful for comparing detectors with different values of K and R_V. Figure of Merit equals $K/\sqrt{R_V}$, where R_V = internal video resistance.

Tangential Sensitivity

Tangential sensitivity is the lowest input signal power level for which the detector will have an 8 dB signal-to-noise ratio at the output of a test video amplifier. Test amplifier gain is not relevant because it applies to both signal and noise. HP detectors are designed for optimal flatness and SWR. Figure 2 shows typical tangential sensitivity.

$$P_{tss\ (watts)} = \frac{3.23 \times 10^{-10} \sqrt{BFR_V}}{K} \quad @\ 300\ °K$$

Where: B = Video Amplifier Bandwidth (Hz)
F = Video Amplifier Noise Factor = 10 (Noise Figure/10)
R_v = Video Resistance (Ω)
K = Open Circuit Voltage Sensitivity (µv/µW)

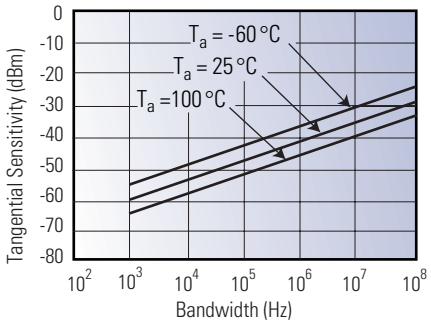


Figure 2. Typical tangential sensitivity performance.

Output Voltage Versus Temperature

For applications such as power monitoring and leveling, that require stable output voltage versus input power, the designer can choose a resistive termination that will optimize the transfer function over a wide temperature range. Figure 3 shows how sensitivity changes over temperature with different load resistances. In this case, a value between 1 kΩ and 10 kΩ will be optimum for 0 to 50 °C.

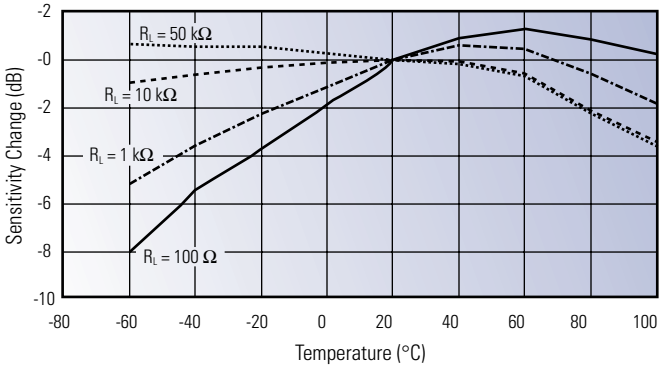


Figure 3. Typical output response with temperature (Pin < -20 dBm).

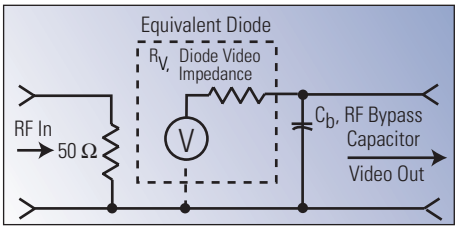
Rise Time

In applications where the frequency response of another microwave device is being measured, or where a fast rise time response is required for accurate measurements, the rise time of the detector becomes very important. It is critical to note that the rise time is dependent upon the characteristics of the detector AND the test equipment.

Figure 4 shows the typical equivalent circuit of a test detector, and can help in devising the external terminations and cables to connect to an oscilloscope or other instrument. The following equation gives the approximate rise time for different conditions of load resistance and capacitance. Note that rise time can be improved (lowered) with a termination less than 50 Ω. This rise time improvement comes at the expense of lower pulse output voltage. The lower voltage can be overcome with the gain of a high performance oscilloscope.

$$T_r\ (10\%\ \text{to}\ 90\%) = \frac{2.2 * R_L * R_v * (C_L + C_b)}{R_L + R_v} = \frac{0.35}{BW}$$

Where	Determined by
R_L = Load Impedance	Measuring Equipment
R_v = Video Impedance	Detector
C_L = Load Capacitance	Measuring Equipment
C_b = Bypass Capacitance	Detector



Typical values:

R_v (diode video impedance) = 1.5 kΩ[1]

C_b (RF bypass capacitor) = 27 pF nom.

[1] @ 25 °C and P_{in}<-20 dBm. Extremely sensitive to power and temperature.

Figure 4. Detector model.

Broadband Match (SWR)

In many applications, the match (SWR) of the detector is of prime importance in minimizing the uncertainty of power measurement. If the input of the detector is not well matched to the source, simple and multiple mismatch errors will result, which reduces the accuracy of the measurement.

Figure 5 represents the mismatch error introduced by multiple reflections caused by mismatch between the detector and the source. For a detector SWR of 2.0 and source SWR of 2.0, this uncertainty is ±1.0 dB. For the LBSD and PDBD models, the integration of the diode with the 50 Ω matching resistor results in excellent broadband match. Both LBSD and PDBDs utilize thin-film technology which yields a precision matching circuit that minimizes stray reactance and yields very good performance. Figure 6 displays typical SWR for the HP 8473B,C LBSD detector and the HP 8473D PDBD detector.

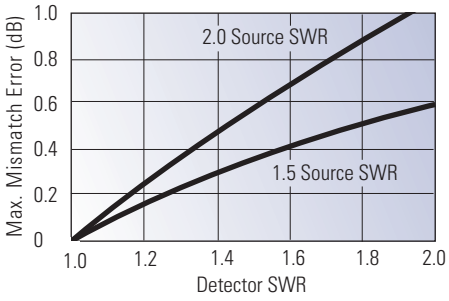


Figure 5. Mismatch error from detector and source mismatch.

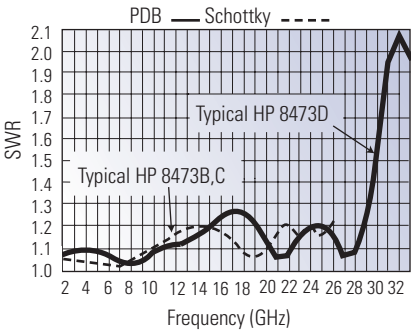


Figure 6. Typical SWR of detectors.

Square Law Performance

When detectors are used in reflectometer and insertion loss setups, the measurement uncertainty depends on the output voltage being proportional to input power. The term square law comes from the output voltage being proportional to the input power (input voltage squared). Most microwave detectors are inherently square law from the P_{tss} level up to about -15 dBm. Figure 7 shows this characteristic.

Figure 8 shows detector output in dB relative to P_{in} = -20 dBm. As P_{in} exceeds -20 dBm, the detector response deviates from square law. The user can select a load resistor that will extend the upper limit of the square law range beyond ±15 dBm. By choosing Option 002, 102 (optional square law load), the deviation from ideal square law response will be ±0.5 dB (although the sensitivity specification is decreased by a factor of 4).

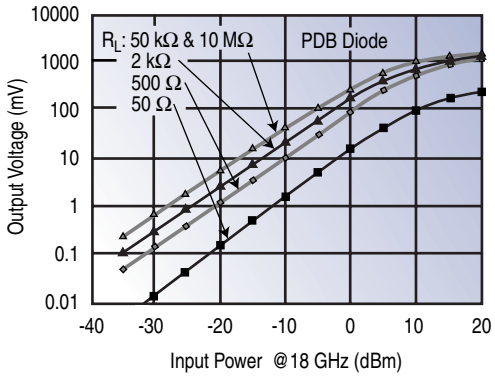


Figure 7. Typical detector square law response (mV).

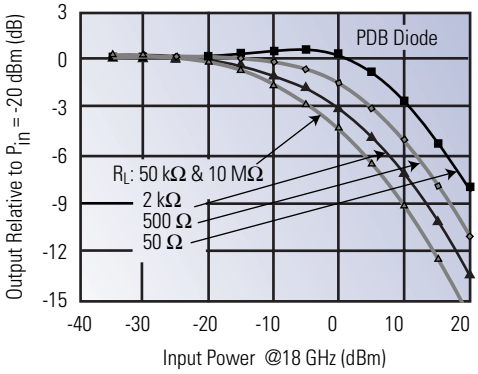


Figure 8. Typical detector square law response (dB).

Detectors

HP 423B

Low-Barrier Schottky Diode Detectors

HP 423B, 8470B, 8472B, 8473B,C 33330B,C LBSD detectors have been widely used for many years in a variety of applications includ- ing leveling and power sensing. They offer good performance and rugged- ness. Matched pairs (Option 001) offer very good detector tracking. A video load option (Option 002) extends the square law region to at least 0.1 mW (-10 dBm).

HP 8471D,E

Planar-Doped Barrier Detectors

HP 8471D,E detectors are planar-doped barrier detectors offering excellent performance to 2 and 12 GHz. The HP 8471D covers 100 kHz to 2 GHz with a BNC (m) input connector and the HP 8471E covers 10 MHz to 12 GHz with a SMA (m) input connector. Both detectors come standard with negative polarity output, a positive polarity output is available as Option 103.

High Performance Planar-Doped Barrier Detectors

HP 8474B,C,E and 33330D detectors are the newest additions to the HP family of high perfor- mance detectors. Utilizing a gallium arsenide, planar-doped barrier detecting diode, these detectors offer superior performance when compared to Schottky diodes. They feature extremely flat frequency response (typically better than ±1 dB to 50 GHz) and very stable frequency response versus temperature.

These detectors are available with type-N, 3.5-mm, or 2.4-mm connectors. They are also offered with an option for positive output polarity (Option 103). Additionally, some detectors have an optimal square law load available (Option 102).

For applications requiring an octave band or less, HP 8474B,C,E detectors are available with frequency band options that feature lower SWR and flatter frequency response. See PDBD Frequency Band Options table on page 56.

HP 8472B

HP 8473D

HP 8474 Family

Planar-Doped Barrier Diode

Specifications

HP Model	8471D	8471E	8473D	8474B	8474C	8474E	33330D
Frequency Range (GHz)	0.0001 to 2	0.01 to 12	0.01 to 33	0.01 to 18	0.01 to 33	0.01 to 50	0.01 to 33
Frequency Response (dB)	±0.2 to 1 GHz ±0.4 to 2 GHz	±0.23 to 4 GHz ±0.6 to 8 GHz ±0.85 to 12 GHz	±0.25 to 14 GHz ±0.4 to 26.5 GHz ±1.25 to 33 GHz	±0.35 to 18 GHz	±0.4 to 26.5 GHz ±0.7 to 33 GHz	±0.3 to 26.5 GHz ±0.6 to 40 GHz ±1.0 to 50 GHz	±0.25 to 14 GHz ±0.4 to 26.5 GHz ±1.25 to 33 GHz
Maximum SWR	1.23 to 1 GHz 1.46 to 2 GHz	1.2 to 4 GHz 1.7 to 8 GHz 2.4 to 12 GHz	1.2 to 14 GHz 1.4 to 26.5 GHz 3.0 to 33 GHz	1.3 to 18 GHz	1.4 to 26.5 GHz 2.2 to 33 GHz	1.2 to 26.5 GHz 1.6 to 40 GHz 2.8 to 50 GHz	1.2 to 14 GHz 1.4 to 26.5 GHz 3.0 to 33 GHz
Low-Level Sensitivity (mV/µW)	>0.5	>0.5	>0.5	>0.4	>0.4	>0.4 to 40 GHz >0.34 to 50 GHz	>0.4
Maximum Operating Input Power	100 mW	← 200 mW →					
Typical Short Term Maximum Input Power (<1 minute)	0.7 W	0.7 W	← 1 W →				
Video Impedance (nom)	← 1.5 kΩ →						
RF Bypass Capacitance (nom)	6800 pF	← 30 pF →					
Output Polarity	← Negative →						
Input Connector	BNC (m)	SMA (m)	3.5 mm (m)	Type-N (m)	3.5 mm (m)	2.4 mm (m)	3.5 mm (m)
Output Connector	BNC (f)	SMC (m)	BNC (f)	BNC (f)	SMC (m)	SMC (m)	SMC (m)

Options

HP Model	8471D	8471E	8473D	8474B	8474C	8474E	33330D
Optimal Square Law Load[1]	Opt. 102	N/A	N/A	Opt. 102	N/A	N/A	N/A
Positive Polarity Output	Opt. 103	Opt. 103	N/A	Opt. 103	Opt. 103	Opt. 103	Opt. 003
Frequency Band	N/A	N/A	N/A	See PDBD Frequency Band Options table on page 56			N/A

Indicates QuickShip availability. Standard models only.
Contact HP Direct or your local HP sales representative to confirm QuickShip.

[1] Defined as ±0.5 dB from ideal square law response.

Low-Barrier Schottky Diode Detector

Specifications

HP Model	423B	8470B	8472B	8473B	8473C	33330B	33330C
Freq. Range (GHz)	0.01 to 12.4	0.01 to 18	0.01 to 18	0.01 to 18	0.01 to 26.5	0.01 to 18	0.01 to 26.5
Freq. Response (dB) (±0.2 dB over any octave from 0.01 to 8 GHz on all models)	±0.3 to 12.4 GHz	±0.3 to 12.4 GHz ±0.5 to 15 GHz ±0.6 to 18 GHz	±0.3 to 12.4 GHz ±0.5 to 15 GHz ±0.6 to 18 GHz	±0.3 to 12.4 GHz ±0.6 to 18 GHz	±0.3 to 12.4 GHz ±0.6 to 20 GHz ±1.5 to 26.5 GHz[1]	±0.3 to 12.4 GHz ±0.6 to 18 GHz	±0.3 to 12.4 GHz ±0.6 to 20 GHz ±1.5 to 26.5 GHz[1]
Maximum SWR (Measured at -20 dBm)	1.15 to 4 GHz 1.3 to 12.4 GHz	1.15 to 4 GHz 1.3 to 15 GHz 1.4 to 18 GHz	1.15 to 4 GHz 1.35 to 7 GHz 1.5 to 12.4 GHz 1.7 to 18 GHz	1.2 to 4 GHz 1.5 to 18 GHz	1.2 to 4 GHz 1.5 to 18 GHz 2.2 to 26.5 GHz	1.2 to 4 GHz 1.5 to 18 GHz	1.2 to 4 GHz 1.5 to 18 GHz 2.2 to 26.5 GHz
Low-Level Sensitivity (mV/μW)	>0.5	>0.5	>0.5	>0.5	>0.5 to 18 GHz >0.18 to 26.5 GHz	>0.5	>0.5 to 18 GHz >0.18 to 26.5 GHz
Maximum Operating Input Power	200 mW						
Typical Short Term Maximum Input Power (< 1 minute)	1 W						
Noise	<50 μV						
Video Impedance (nom)	1.3 kΩ						
RF Bypass Capacitance (nom)	30 pf						
Output Polarity	Negative						
Input Connector	Type-N (m)	APC-7 (m)	SMA (m)	3.5 mm (m)	3.5 mm (m)	3.5 mm (m)	3.5 mm (m)
Output Connector	BNC (f)	BNC (f)	BNC (f)	BNC (f)	BNC (f)	SMC (m)	SMC (m)

Options

HP Model	423B	8470B	8472B	8473B	8473C	33330B	33330C
Matched Response[2] (Option 001)	±0.2 dB to 12.4 GHz	±0.2 dB to 12.4 GHz ±0.3 dB to 18 GHz	±0.2 dB to 12.4 GHz ±0.3 dB to 18 GHz	±0.2 dB to 12.4 GHz ±0.3 dB to 18 GHz	±0.2 dB to 12.4 GHz ±0.3 dB to 18 GHz ±0.5 dB to 26.5 GHz	±0.2 dB to 12.4 GHz ±0.3 dB to 18 GHz	±0.2 dB to 12.4 GHz ±0.3 dB to 18 GHz ±0.5 dB to 26.5 GHz
Optimal Square Law Load[3]	**Option 002**	**Option 002**	**Option 002**	**Option 002**	**Option 002**	N/A	N/A
Positive Polarity Output	**Option 003**	**Option 003**	**Option 003**	**Option 003**	**Option 003**	**Option 003**	**Option 003**
Connector		**Option 012** Type-N (m) input connector	**Option 100** OSSM (f) output connector				
Field Replaceable Detector Elements Standard:	00423-60003	08470-60012	08470-60012	08473-80001	08473-80004	33330-80003	33330-80006
Option 001	00423-60007	08470-60016	08470-60016	08473-80002	08473-80005	33330-80004	33330-80007
Option 002	00423-60005	08470-60014	08470-60014	08473-80003	08473-80006	33330-80005	33330-80008
Option 003	00423-60004						

Indicates QuickShip availability. Standard models only. Contact HP Direct or your local HP sales representative to confirm QuickShip.

[1] From a -3.3 dB linear slope beginning @ 20 GHz.

[2] Must order a quantity of 2 standard units and 2 Option 001s for a pair of detectors with matched frequency response.

[3] Defined as ±0.5 dB from ideal square law response.

Detectors

HP 8474B Options	002	004	008	012	018	
Frequency Range (GHz)	0.01 to 2	2 to 4	4 to 8	8 to 12.4	12.4 to 18	
Frequency Response (dB)	±0.25	±0.25	±0.25	±0.25	±0.30	
Maximum SWR	1.09	1.1	1.2	1.3	1.3	
HP 8474C Options	**004**	**008**	**012**	**018**	**026**	**033**
Frequency Range (GHz)	2 to 4	4 to 8	8 to 12.4	12.4 to 18	18 to 26.5	26.5 to 33
Frequency Response (dB)	±0.2	±0.2	±0.25	±0.3	±0.3	±0.3
Maximum SWR	1.1	1.16	1.2	1.3	1.4	2.2
HP 8474E Options	**026**	**040**	**050**			
Frequency Range (GHz)	18 to 26.5	26.5 to 40	33 to 50			
Frequency Response (dB)	±0.3	±0.5	±0.8			
Maximum SWR	1.2	1.6	2.8			

Outline Drawings

Diagram 1

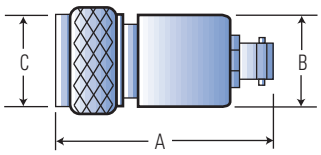


Diagram 2

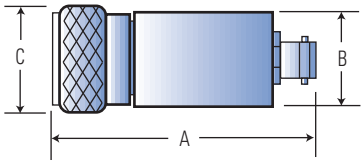


Diagram 3

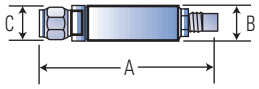


Diagram 4

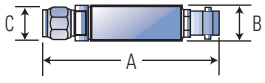
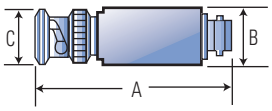


Diagram 5



HP Model	Length (Dim A)	Barrel Diameter (Dim B)	Input Connector Diameter (Dim C)	Net Weight	Shipping Weight
Diagram 1					
423B	63 mm (2.47 in)	20 mm (0.78 in)	21 mm (0.82 in)	114 g (4 oz)	454 g (16 oz)
8474B	60 mm (2.36 in)	19 mm (0.74 in)	21 mm (0.82 in)	85 g (3 oz)	454 g (16 oz)
Diagram 2					
8470B	62 mm (2.50 in)	19 mm (0.75 in)	22 mm (0.87 in)	114 g (4 oz)	454 g (16 oz)
Diagram 3					
8471E	39 mm (1.54 in)	9.3 mm (0.36 in)	7.9 mm (0.31 in)	39 g (2 oz)	227 g (8 oz)
8474C	41 mm (1.62 in)	9.7 mm (0.38 in)	7.9 mm (0.31 in)	14 g (0.5 oz)	227 g (8 oz)
8474E	37 mm (1.47 in)	7.6 mm (0.30 in)	7.9 mm (0.31 in)	9 g (0.3 oz)	227 g (8 oz)
33330B	43 mm (1.7 in)	9.7 mm (0.38 in)	7.9 mm (0.31 in)	14 g (0.5 oz)	227 g (8 oz)
33330C	43 mm (1.7 in)	9.7 mm (0.38 in)	7.9 mm (0.31 in)	14 g (0.5 oz)	227 g (8 oz)
33330D	41 mm (1.62 in)	9.7 mm (0.38 in)	7.9 mm (0.31 in)	14 g (0.5 oz)	227 g (8 oz)
Diagram 4					
8472B	64 mm (2.50 in)	14 mm (0.56 in)	7.9 mm (0.31 in)	57 g (2 oz)	227 g (8 oz)
8473B	48 mm (1.89 in)	10 mm (0.39 in)	7.9 mm (0.31 in)	57 g (2 oz)	227 g (8 oz)
8473C	48 mm (1.89 in)	10 mm (0.39 in)	7.9 mm (0.31 in)	57 g (2 oz)	227 g (8 oz)
8473D	48 mm (1.89 in)	10 mm (0.39 in)	7.9 mm (0.31 in)	57 g (2 oz)	227 g (8 oz)
Diagram 5					
8471D	63 mm (2.50 in)	16 mm (0.62 in)	14 mm (0.54 in)	43 g (1.5 oz)	454 g (16 oz)

Environmental Specifications

HP 423B, 8470B, 8472B, 8473B,C, 33330B,C (LBSD)

Operating Temperature:	-20 °C to +85 °C (Except 423B: 0 °C to +55 °C)
Vibration:	20 g; 80 to 2000 Hz
Shock:	100 g, 11 ms

HP 8471D,E, 8473D, 8474B,C,E, 33330D (PDBD)

Operating Temperature:	-65 °C to +100 °C (Except HP 8474B: 0 °C to +75 °C)
Temperature Cycling: (non-operating)	-65 °C to +100 °C; MIL-STD 883, Method 1010
Vibration:	0.6 inches D.A. 10 to 80 Hz; 20 g, 80 to 200 Hz; MIL-STD 883, Method 2007
Shock:	500 g, 0.5 ms; MIL-STD 883, Method 2002
Acceleration:	500 g; MIL-STD 883, Method 2001
Altitude:	50,000 ft (15,240 m); MIL-STD 883, Method 1001
Salt Atmosphere:	48 hr, 5% solution; MIL-STD 883, Method 1009
Moisture Resistance:	25 °C to 40 °C, 95% RH; MIL-STD 883, Method 1004
RFI:	MIL-STD 461B
ESD:	10 discharges at 25 kV to the body, not to the center conductor

Directional Detector

HP 83036C Broadband Directional Detector

This broadband microwave power sampler operates in much the same way as a directional coupler and detector combination. It is comprised of a resistive bridge and PDB diode that yields a very broadband device with excellent frequency response, temperature response and square law response characteristics.

With a 10 MHz to 26.5 GHz frequency range, a single HP 83036C can be used in many applica- tions where two directional couplers and detectors were once required.

The maximum SWR is 1.7 above 50 MHz on both the input and output ports. Directivity of 14 dB matches that of most miniature couplers currently available. The maximum insertion loss is 2.2 dB.

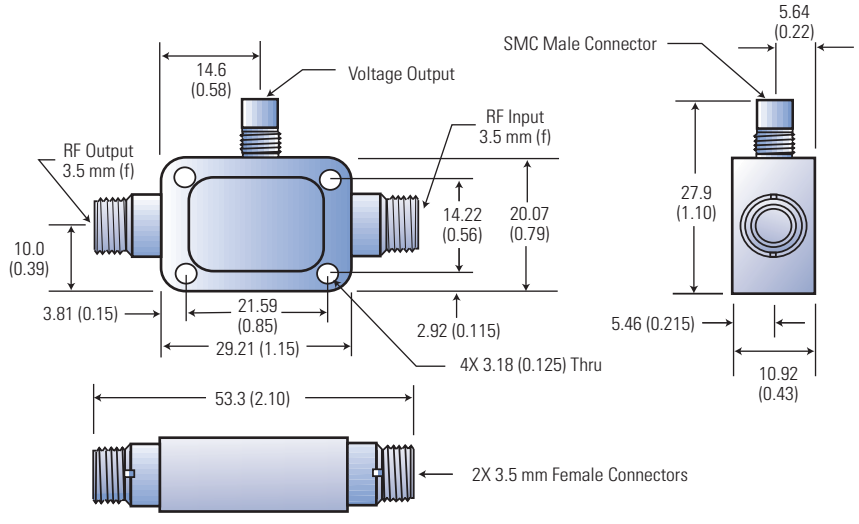
The HP 83036C has been used with great success as the sampling element for external leveling of broadband swept frequency sources. The extended frequency range increases the usable band to 100 MHz to 26 GHz, giving the user full use of a broadband source with external leveling. Other uses include the internal leveling element for sources, and forward/reverse power monitoring.

HP 83036C

Specifications[1]

HP Model	Frequency Range (GHz)	Frequency Response (dB)	Max. SWR Input/Output (50 Ω nom)	Maximum Thru Line Loss (dB)	Low Level Sensitivity	Maximum Input Power[2] (Into 50 Ω Load)	Maximum Input Power[2] (Into Open)	Input/Output Connector
83036C	0.01 to 26.5	±1.0	1.7	2.2	18 µV/µW	32 dBm	21 dBm	3.5 mm (f)

[1] The OEM equivalent model number is HP 33336C.
[2] With 2:1 source match.



Environmental

Non-Operating Temperature: -65 to +150 °C

Random Vibration: In accordance with MIL-STD-883, Method 2026, Condition IIA: 5.9 g, 50 to 2000 Hz.

Shock: In accordance with MIL-STD-883, Method 2002, Condition B: 1500 g for 0.5 ms.

Moisture Resistance: In accordance with MIL-STD-883, Method 1004: 10 cycles, -10 to +65 °C at 90 to 100% RH.

Altitude: In accordance with MIL-STD-883, Method 1001, Condition C: 50,000 ft. operating altitude.

Directional Couplers and Bridges

Applications

Directional couplers[1] are general purpose tools used in RF and microwave signal routing for isolating, separating or combining signals. They find use in a variety of measurement applications:

- Power monitoring
- Source leveling
- Isolation of signal sources
- Swept transmission and reflection measurements

Key Specifications

The key specifications for a directional coupler depend on its application. Each of them should be carefully evaluated to ensure that the coupler meets its intended use.

- Directivity
- SWR
- Coupling coefficient
- Transmission loss
- Input power

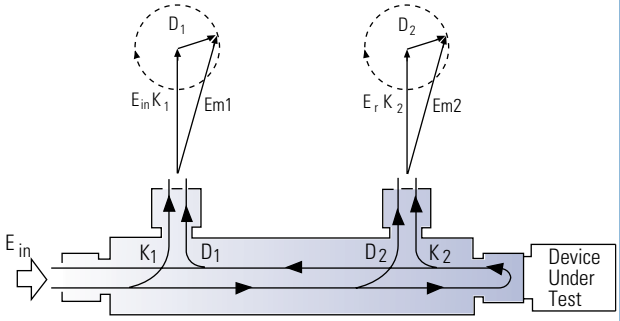
Directivity

Directivity is a measure of how well the coupler isolates two opposite-travelling (forward and reverse) signals. In the case of measuring reflection coefficient (return loss) of a device under test, directivity is a crucial parameter in the uncertainty of the result. Figure 1 shows how the reflection signal, E_r, is degraded by the undesired portion of the incident signal D_2. And since the undesired signal, D_2, combines with the reflected signal as a phasor, the error in the measured signal E_{m2} can only be compensated or corrected on a broadband basis using vector analyzers.

[1] See Waveguide chapter for additional products.

Because the reverse-coupled signal is very small, it adds a negligible amount of uncertainty when measuring large reflections. But as the reflected signal becomes smaller, the reverse-coupled signal becomes more significant.

For example, when the return loss in dB equals the value of directivity, the measurement error can be between -6 to +8 dB. The higher the directivity specified in dB, the higher the measurement accuracy. The effect of the directivity error on the forward-coupler output, E_{m1}, is less important because the desired signal is usually a large value. When HP couplers are used for power monitoring and leveling, directivity is less important than coupling coefficient flatness.



K1 and K2: Coupling Coefficients (dB)
D1 and D2: Directivities (dB)
Ein = Input Signal
Er = Reflected Signal from DUT
Em = Measured Signal (includes directivity error)

Figure 1.
Effect of directivity on reflection measurement.

SWR

For many applications, coupler SWR is important to minimize low mismatch errors and to improve measurement accuracy. For example, when making swept reflection measurements, it is customary to set a full reflection (0 dB return loss) reference by connecting a short at the test port of the coupler. Some of the reflected signal re-reflects due to the output port (test port) SWR. This re-reflected signal goes through a wide phase variation because of the width of the frequency sweep, adding to and subtracting from the reflected signal. This phase variation creates a ripple in the full reflection (0 dB return loss) reference. The magnitude of the re-reflected signal, and thus the measurement uncertainty, can be minimized by selecting couplers with the lowest SWR.

Coupling Coefficient

In power monitoring and leveling, the most desired specification is a highly accurate and flat coupling value, because the coupling factor directly affects the measurement data. For wideband leveling, the coupling factor directly influences the flatness of the output power. Coupling values of 10 and 20 dB are most common but for high power and pulsed systems, there can be a need for 40 dB coupling.

In reflection measurements, coupling factor is less important than directivity and SWR, since both the forward and reverse coupling elements are usually identical, and so the variation of coupling factors match versus frequency.

Transmission Loss

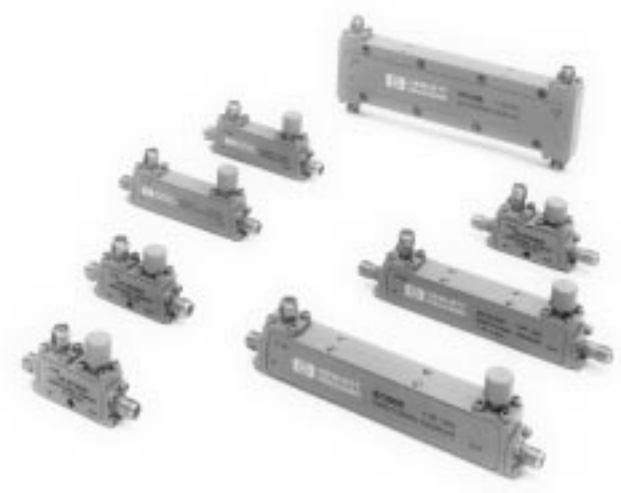
Transmission loss is the total loss in the main line of a directional coupler, and includes both insertion loss and coupling loss. For example, for a 10 dB coupler, 10% of the forward signal is coupled off, which represents approximately 0.4 dB of signal loss added to the inherent losses in the main transmission line.

Transmission loss is usually not important at low frequencies where most swept sources have sufficient available power. However, in the millimeter ranges, power sources are limited and lower loss devices become significant. In general, broadband couplers have transmission losses on the order of 1 dB. On the other hand, directional bridges, which are sometimes used in place of couplers for reflection/transmission measurements, have insertion losses of at least 6 dB. This loss directly subtracts from the dynamic range of the measurement.

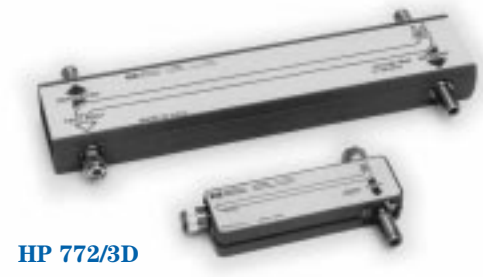
Input Power

High power handling characteristics of directional couplers are critical when used for monitoring pulsed power systems. Most couplers designed for test and measurement applications are not ideal for system powers in the kilowatt range. One reason is that the coupler's secondary transmission line often has an internal termination that limits the coupler's mainline power handling capability. A second reason is the maximum power rating of the connectors. Such models have a power rating from 20 to 50 W average.

Single- and Dual-Directional Couplers, 90° Hybrid Coupler



HP 87300/301 Series, 87310B



HP 772/3D

HP 87300/301 Series Directional Couplers

This line of compact, broadband directional couplers is ideal for signal monitoring, or, when combined with a coaxial detector, for signal leveling. The HP 8474 series coaxial detectors are recommended if output detection is desired. A broad offering of products is available with frequencies up to 50 GHz.

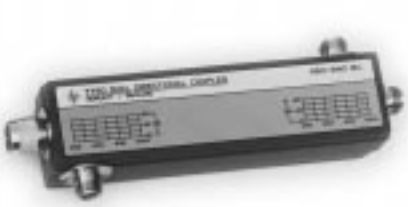
HP 87310B Hybrid Coupler

The HP 87310B is a 3 dB hybrid coupler, intended for applications requiring a 90 degree phase difference between output ports. In that sense, it is different from typical power dividers and power splitters, which have matched signal phase at their output ports.

HP 773D Directional Coupler
HP 772D Dual-Directional Coupler

These high-performance couplers are designed for broadband swept measurements in the 2 to 18 GHz range. The HP 773D is ideal for leveling broadband sources when used with an HP 8474B detector. (Also, see the HP 83036C directional detector). For reflectometer applications, the HP 772D dual coupler is the best coupler to use with HP power sensors and power meters (such as the HP 438A dual power meter). Forward and reverse power measurements on transmitters, components, or other broadband systems are made simpler by using the HP 772D. The broadband design allows the use of a single test setup and calibration for tests spanning the entire 2 to 18 GHz frequency range.

Single- and Dual-Directional Couplers, 90° Hybrid Coupler



HP 775D

HP 776D

HP 777D

HP 778D

HP 779D

HP 775D-778D Dual-Directional Couplers

These couplers cover a frequency spread of more than 2:1, each centered on one of the important VHF/UHF bands. HP 778D covers a multi-octave band from 100 to 2000 MHz. With their high direc- tivity and mean coupling accuracy of ±0.5 dB, these are ideal couplers for reflectometer applications. Power ratings are 50 W average, 500 W peak.

HP 779D Directional Coupler

This high directivity coupler has a multi-octave range of 1.7 to 12.4 GHz. With directivity over 30 dB to 4 GHz and 26 dB to 12.4 GHz, it is useful for broadband reflectometer measurements. With ±0.75 dB coupling variation, the coupler is also useful for power leveling applications. Optional connectors provide flexibility in mating with various devices under test.

HP 11691D and 11692D Directional Couplers

HP 11691D is a single coupler for 2 to 18 GHz with a 20 dB coupling factor. With 30 dB directivity to 8 GHz and 26 dB to 18 GHz, it is useful for broadband reflectometry. It features many connector options to match test device requirements. HP 11692D is a dual-directional coupler with the same performance specifications as the HP 11691D. The dual couplers make it possible to measure both reflection and transmission parameters of a device under test at one time.

HP 11691D

HP 11692D

Single- and Dual-Directional Couplers, 90° Hybrid Coupler

Specifications [1]

HP Model	Frequency Range (GHz)	Nominal Coupling & Variation (dB)	Directivity (dB)	Maximum SWR	Insertion Loss (dB)	Power Rating Average, Peak
87300B	1 to 20	10±0.5	>16	1.35	<1.5	20 W, 3 kW
87300C	1 to 26.5	10±1.0	>14 to 12.4 GHz >12 to 26.5 GHz	1.35 to 12.4 GHz 1.5 to 26.5 GHz	<1.2 to 12.4 GHz <1.7 to 26.5 GHz	20 W, 3 kW
87300C Option 020	1 to 26.5	20±1.0	>14	1.4	<1.2	20 W, 3 kW
87300D	6 to 26.5	10±0.5	>13	1.40	<1.3	20 W, 3 kW
87301B	10 to 46	10±0.7	>10	1.80	<1.9	20 W, 3 kW
87301C	10 to 50	10±0.7	>10	1.80	<1.9	20 W, 3 kW
87301D	1 to 40	13±1.0	>14 to 20 GHz >10 to 40 GHz	1.5 to 20 GHz 1.7 to 40 GHz	<1.2 to 20 GHz <1.9 to 40 GHz	20 W, 3 kW
87301E	2 to 50	10±1.0	>13 to 26.5 GHz >10 to 50 GHz	1.5 to 26.5 GHz 1.8 to 50 GHz	<2.0	20 W, 3 kW
772D [2]	2 to 18	20±0.9	>30 to 12.4 GHz >27 to18 GHz	1.28 to12.4 GHz 1.4 to 18 GHz	<1.5	50 W, 250 W
773D [2]	2 to 18	20±0.9	>30 to 12.4 GHz >27 to 18 GHz	1.2	<0.9	50 W, 250 W
775D [3]	0.45 to 0.94	20±1	>40	1.15	<0.40	50 W, 500 W
776D [3]	0.94 to 1.9	20±1	>40	1.15	<0.35	50 W, 500 W
777D [3]	1.9 to 4	20±0.4	>30	1.2	<0.75	50 W, 500 W
778D	0.1 to 2	20±1.5	>36 to 1 GHz [4] >32 to 2 GHz [4]	1.1	<0.60	50 W, 500 W
779D	1.7 to 12.4	20±0.75	>30 to 4 GHz >26 to 12.4 GHz	1.2 [5]	<0.60	50 W, 500 W
11691D	2 to 18	20±1.0	>30 to 8 GHz >26 to 18 GHz [6]	1.2 [5]	<2.0	50 W, 250 W
11692D	2 to 18	20±1 incident to test port	>30 to 8 GHz >26 to 18 GHz [6]	1.3 to 12.4 GHz 1.4 to 18 GHz	<1.5	50 W, 250 W

[1] See page 66 for connector types.
[2] See data sheet for typical out of band data from 0.1 to 2 GHz and 18 to 20 GHz.
[3] Maximum auxiliary arm tracking: 0.3 dB for HP 776D; 0.5 dB for HP 777D.
[4] 30 dB to 2.0 GHz, input port.
[5] Apparent SWR at the output port of a coupler when used in a closed-loop leveling system.
[6] 24 dB with Type-N connector on the test port.

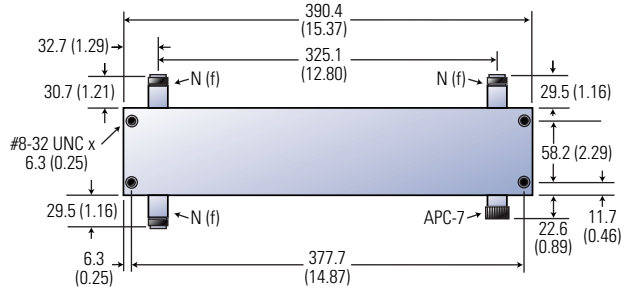
HP 87310B Specifications

Frequency Range	1 to 18 GHz
Coupling	3 dB
Amplitude Imbalance	±0.5 dB at each port, centered at -3 dB
Phase Imbalance	±10 Degrees
Isolation	>17 dB
Maximum SWR	1.35
Insertion Loss	<2.0 dB
Power Rating	
Average	20 W
Peak	3 kW
Connectors	SMA (f)
Weight in Grams (oz)	148 (5.2)

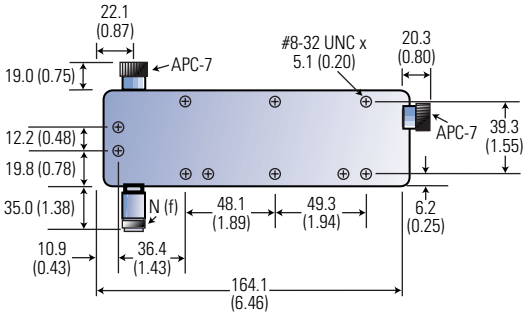
Single- and Dual-Directional Couplers, 90° Hybrid Coupler

Outline Drawings

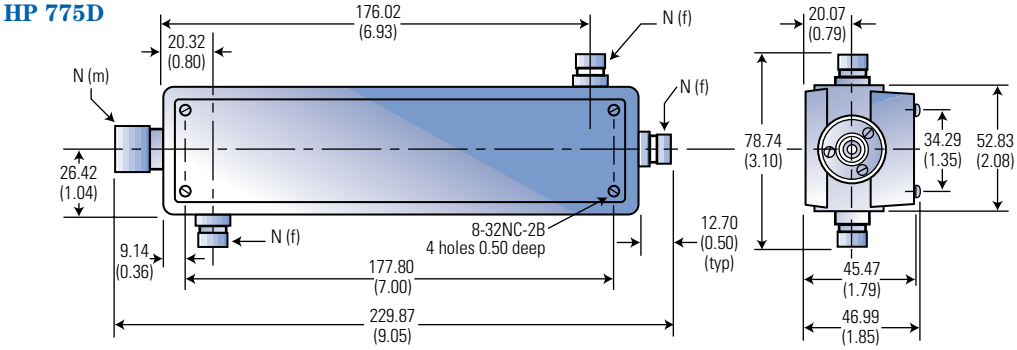
HP 772D



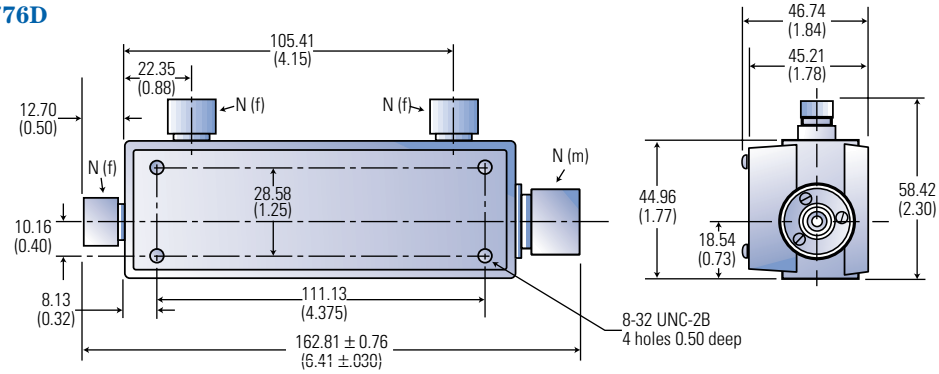
HP 773D



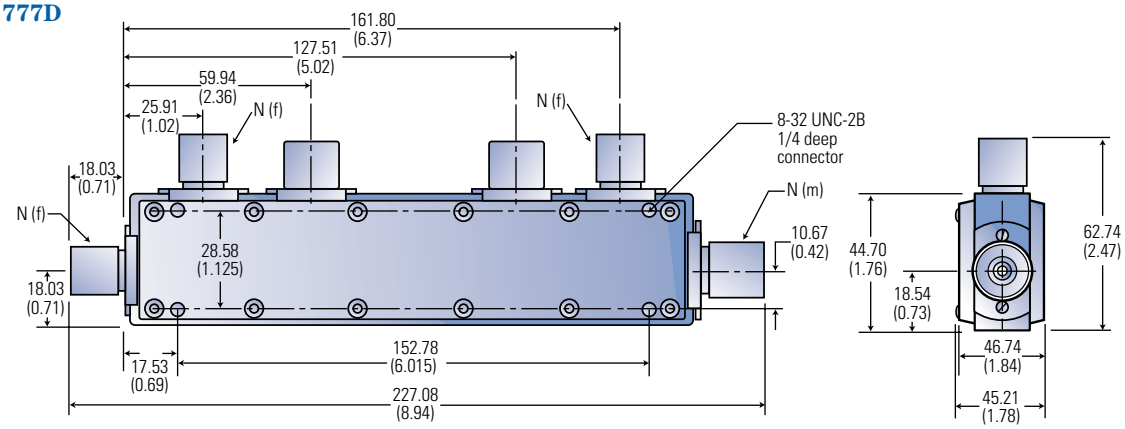
HP 775D



HP 776D



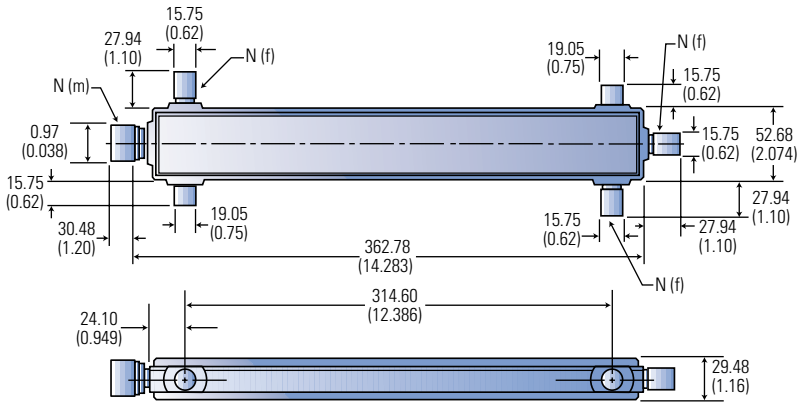
HP 777D



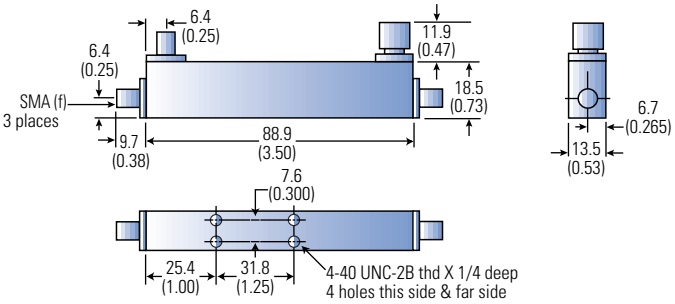
Dimensions are in mm (inches) nominal, unless otherwise specified.

Single-and Dual-Directional Couplers, 90° Hybrid Coupler

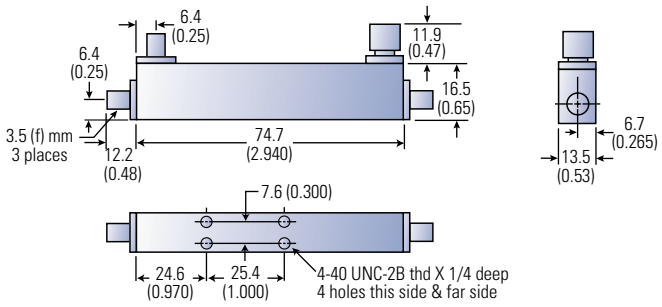
HP 778D



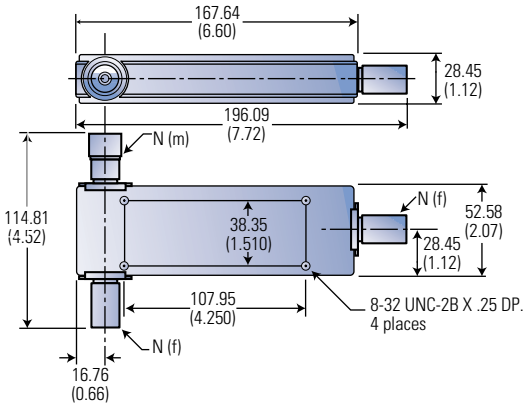
HP 87300B



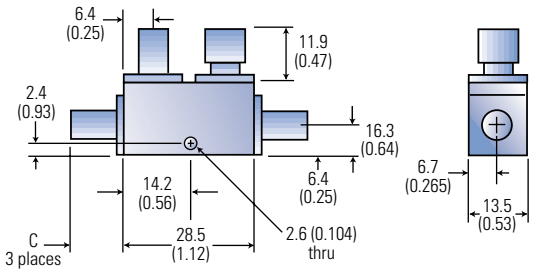
HP 87300C



HP 779D



HP 87300D, 87301B, 87301C

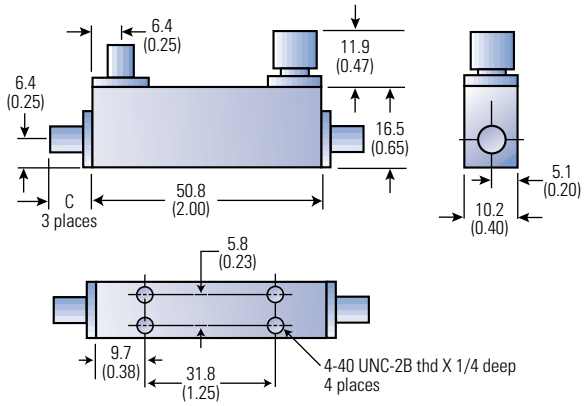


HP Model	Connector Type	C Dimension
87300D	3.5 mm (f)	12.2 (0.48)
87301B	2.9 mm (f)	9.7 (0.38)
87301C	2.4 mm (f)	28.4 (1.0)

Dimensions are in mm (inches) nominal, unless otherwise specified.

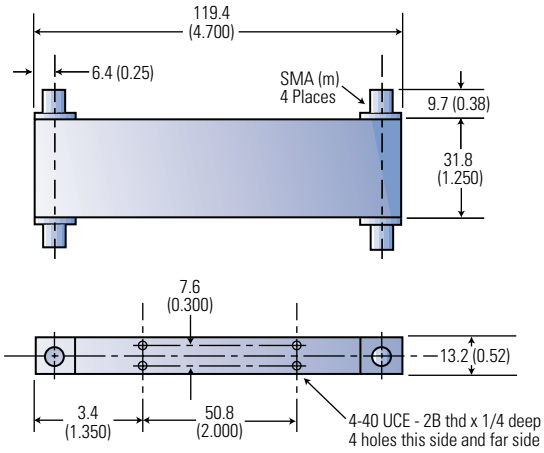
Single- and Dual-Directional Couplers, 90° Hybrid Coupler

HP 87301D,E



Connector Type	C Dimension
2.4 mm (f)	9.7 (0.38)
2.92 mm (f)	9.7 (0.38)

HP 87310B



HP Model	Standard Connectors and Options
772D	Primary line: APC-7, APC-7
	Auxiliary arms: N (f)
Option 001	All N (f)
773D	Primary line: APC-7, APC-7
	Auxiliary arms: N (f)
Option 001	All N (f)
775D -777D	Primary line: N (m), N (f)
	Auxiliary arms: N (f), N (f)
778D	Primary line: N (f), N (m)
	Auxiliary arms: N (f), N (f)
Option 011	Primary line: APC-7, N (f)
Option 012	Primary line: N (m), N (f)
779D	Primary line: N (m) input, N (f) output
	Auxiliary arm: N (f)
Option 010	Primary line: N (f) input, N (m) output
	Auxiliary: N (f)
11691D	Primary: APC-7, APC-7, Auxiliary: N (f)
Option 001	All N (f)
Option 002	Primary: N (f), N (m), Auxiliary: N (f)
Option 003	Primary: N (f), APC-7, Auxiliary: N (f)
Option 004	Primary: N (f), APC-7, Auxiliary: APC-7
Option 005	All APC-7
11692D	Primary: N (f), APC-7, Auxiliary: N (f), N (f)
Option 001	Primary: N (f), N (f) Auxiliary: N (f), N (f)
Option 002	Primary: N (f), N (m) Auxiliary: N (f), N (f)
Option 003	Primary: N (f), APC-7, Auxiliary: APC-7, APC-7
Option 004	All APC-7
87300B	SMA (f), SMA (f), SMA (f)
87300C	3.5 mm (f), 3.5 mm (f), 3.5 mm (f)
Option 020	3.5 mm (f), 3.5 mm (f), 3.5 mm (f)
87300D	3.5 mm (f), 3.5 mm (f), 3.5 mm (f)
87301B	2.92 mm (f), 2.92 mm (f), 2.92 mm (f)
87301C	2.4 mm (f), 2.4 mm (f), 2.4 mm (f)
87301D	2.4 mm (f), 2.4 mm (f), 2.4 mm (f),
Option 292	2.92 mm (f), 2.92 mm (f), 2.92 mm (f)
87301E	2.4 mm (f), 2.4 mm (f), 2.4 mm (f)
87302C	3.5 mm (f), 3.5 mm (f), 3.5 mm (f)
87303C	3.5 mm (f), 3.5 mm (f), 3.5 mm (f)
87304C	3.5 mm (f), 3.5 mm (f), 3.5 mm (f)
87310B	SMA (m), SMA (m), SMA (m)

Dimensions are in mm (inches) nominal, unless otherwise specified.

Directional Couplers and Bridges

RF Bridges

These high directivity RF bridges are ideal for accurate reflection measurements and signal-leveling applications. They combine the directivity and broadband frequency range of directional bridges and the low insertion loss and flat coupling factor of directional couplers. These bridges can be used with the HP 8711A RF scalar network analyzer, the HP 8753 family of RF vector analyzers as well as HP spectrum analyzers.

HP 86205/207A

HP 86205A

This 50 ohm bridge offers high directivity and excellent port match from 300 kHz to 6 GHz. Directivity is 30 dB to 3 GHz. Coupling factor is 16 dB with a slope of +0.15 dB per GHz to 3 GHz. Insertion loss is 1.5 dB with a slope of +0.1 dB per GHz. Connectors are type-N (f).

HP 86207A

This 75 ohm type-N bridge has high directivity and excellent port match from 300 kHz to 3 GHz. It is used for external reflection measurements or coupling signal from main path. Directivity is 30 dB to 5 MHz, 40 dB to 1.3 GHz, 35 dB to 2 GHz, and 30 dB to 3 GHz. Coupling factor is 16 dB with a slope of +0.15 dB per GHz to 3 GHz. Insertion loss is 1.5 dB with a slope of +0.1 dB per GHz. Connectors are type-N (f).

HP Model	HP 86205A	HP 86207A
Frequency Range	300 kHz to 6 GHz	300 kHz to 3 GHz
Impedance	50 Ω	75 Ω
Directivity (min)	30 dB, 0.3 MHz to 5 MHz 40 dB, 5 MHz to 2 GHz 30 dB, 2 GHz to 3 GHz 20 dB, 3 GHz to 5 GHz (typical) 6 dB, 5 GHz to 6 GHz (typical)	30 dB, 0.3 MHz to 5 MHz 40 dB, 5 MHz to 1.3 GHz 35 dB, 1.3 GHz to 2 GHz 30 dB, 2 GHz to 3 GHz (typical)
Return Loss (min)	23 dB, 0.3 MHz to 2 GHz 20 dB, 2 GHz to 3 GHz 18 dB, 3 GHz to 5 GHz (typical) 16 dB, 5 GHz to 6 GHz (typical)	20 dB, 0.3 MHz to 1.3 GHz 18 dB, 1.3 GHz to 2 GHz 18 dB, 2 GHz to 3 GHz (typical)
Insertion Loss (max)	1.5 dB, +0.1 dB/GHz	1.5 dB, +0.1 dB/GHz
Coupling Factor (nom)	(<3 GHz) 16.0 dB, +0.15 dB/GHz (>3 GHz) 16.5 dB, -0.20 dB/GHz	(<3 GHz) 16.0 dB, +0.15 dB/GHz (>3 GHz) 16.5 dB, -0.20 dB/GHz

Power Limiters

Increased power protection

The HP 11930A/B limiters provide input protection for a variety of RF and microwave instrumentation. For example, the input circuits of network analyzers may be protected for inputs up to 6 watts peak or 3 watts average power using the HP 11930A. The HP 11930B provides the same protection to spectrum analyzers and sources. At even greater power levels, failure mode for the limiter is either an open circuit or a short circuit to ground, thereby protecting the instrument from damage.

Excellent accuracy

The HP 11930A is furnished with an APC-7 connector and the HP 11930B has a type-N connector. The limiters offer low insertion loss and linear operation at low input levels while providing protection against transients or short duration overloads. A typical application is shown in Figure 1. Here port 2 of an HP 8753E network analyzer is protected from inadvertent overload due to high level signals from the amplifier under test. In Figure 2 typical data for putput power versus input power is shown for HP 11930A/B. Figures 3 and 4 illustrate typical insertion loss and return loss.

HP 11930A,B
Power Limiters

Figure 1. HP 11930A/B typical output power versus input power.

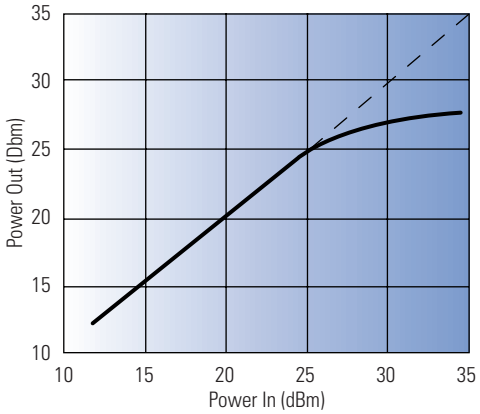


Figure 2. HP 11930A typical insertion and return loss versus frequency.

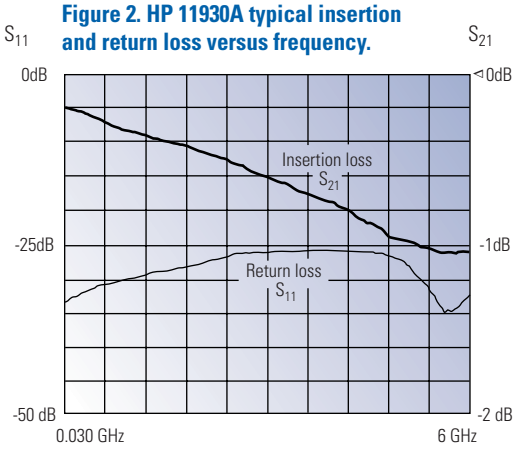
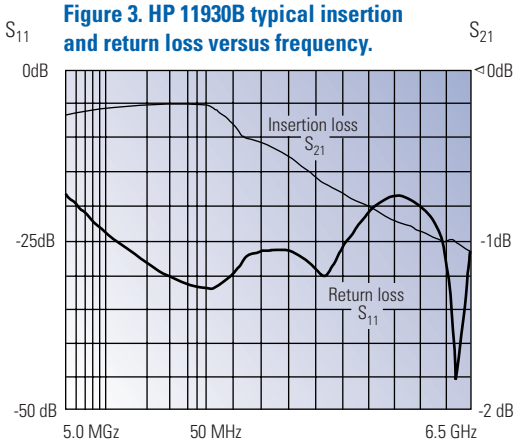


Figure 3. HP 11930B typical insertion and return loss versus frequency.



Power Limiters (continued)

Specifications

HP Model	HP 11930A	HP 11930D
Features	High power protection Exceptional return loss Excellent accuracy	
Impedance	50 ohm, nomimal	
Frequency Range	dc to 6 GHz	5 MHz to 6.5 GHz[1]
Frequency Response		
Insertion Loss:	1.0 dB dc to 3 GHz 1.5 dB 3 to 6 GHz	1.0 dB 16 MHz to 3 GHz[2] 1.5 dB 3 to 6.5 GHz
Return Loss:	22 dB 30 kHz to 3 GHz 20 dB 3 to 6 GHz	21 dB 16 MHz to 3 GHz[2] 17 dB 3 to 6.5 GHz
Maximum DC Current	350 mA	N/A
Maximum Input Power Levels		
Continuous:	3 Watts	
Pulse:	6 Watts	
Pulse Width:	30 ms	
Duty Cycle:	10%	
Limiting Threshold	30 dBm, typical	
Maximum DC Volt	30 V	
Input/Output Connectors	APC-7 (7 mm)	Type-N

[1] 6 to 6.5 GHz, typical
[2] 5 to 16 MHz insertion and return loss limited by internal 1500 pfarads blocking cap

Filters

HP 11668A

This high pass filter is recommended for making measurements on active devices that have high gain below 50 MHz. Use of this filter, with the HP 11665B modulator, reduces the modulation drive feedthrough from 8 mV to 1 mV and helps prevent amplifier saturation.

HP 11668A

HP 0955-0759 50 Ω Band Pass Filter

This 50 Ω band pass filter has a center frequency of 175 MHz, a 3 dB bandwidth of 150 to 200 MHz, and 50 dB stop band rejection. Insertion loss is 2.5 dB, SWR is 2:1 and connectors are type-N (f) to N (m).

HP 0955-0760 75 Ω Band Pass Filter

This 75 Ω band pass filter has a center frequency of 175 MHz, a 3 dB bandwidth of 150 to 200 MHz, and 50 dB stop band rejection. Insertion loss is 2.5 dB, SWR is 2:1 and connectors are type-N (f) to N (m).

Specifications

Frequency Range	Return Loss	Insertion Loss
50 to 100 MHz	≥12 dB	≤ 2.5 dB
100 MHz to 8 GHz	≥16 dB	≤1.0 dB
8 to 12 GHz	≥14 dB	≤1.0 dB
12 to 18 GHz	≥14 dB	≤1.5 dB

Maximum Input: +27 dBm
Connectors: N (f), N (m)
Shipping Weight: 0.28 kg (10 oz)

Frequency Meter

General

Passive frequency meters are intended for moderate (±0.05%) accuracy applications in microwave measuring setups. Reaction cavity types are usually best for this purpose since they permit full power flow down the transmission line except at the precise tuned frequency. At the tuned frequency, a slight amount of power (1.5 dB dip) is absorbed by the cavity which is visible on a scope or SWR meter display.

Key Specifications

- SWR
- Insertion loss
- Accuracy
- Tuning dip
- Spurious response

Low SWR and insertion loss are important to provide flat power transmission off-frequency. HP's frequency meter features broadband coupling loops that are very flat versus frequency. Accurate calibration is maintained by attention to thermal considerations and metal selection in design. Long effective scales are provided with a highly-readable spiral dial.

Constant tuning dip is necessary to yield readable indications at all frequencies in the band. The HP frequency meter is carefully designed and tested for uniformity of tuning dip. Likewise, spurious responses are undesirable since two responses near the same input frequency cause confusion. Although this meter covers more than 1 octave, the design uses a loaded coaxial cavity that prevents resonance at 3/4 λ tuned frequencies providing low-error operation.

HP 537A

This direct-reading frequency meter measures frequencies from 3.7 to 12.4 GHz quickly and accurately. Its long scale length and numerous calibration marks provide high resolution. This is partic-ularly useful when measuring frequency differences or small frequency changes. Frequency is read directly in GHz so interpolation or charts are not required.

The instrument comprises a special transmission section with a high-Q resonant cavity tuned by a choke plunger. A 1-dB or greater dip in output indicates resonance; virtually full power is transmitted off resonance. Tuning is by a precision lead screw, spring-loaded to eliminate backlash.

Resolution is enhanced by a long, spiral scale calibrated in small frequency increments. Resettability is extremely good, and all frequency calibrations are visible so that the measurement point is directly indicated. Overall accuracy of the frequency meter includes allowance for 0 to 100 percent relative humidity and temperature variation from 13 to 33 °C. There are no spurious modes or resonances.

Specifications

HP Model	Frequency Range	Dial Accuracy	Overall Accuracy	Minimum Dip at Resonance	Calibration Increment	Connector	Dimensions mm (in)	Shipping Weight kg (lb)
537A	3.7 to 12.4 GHz	0.100%	0.170%	1 dB	10 MHz	N (f)	118 x 146 x 89 (4.6 x 5.8 x 3.5)	2.3 (5)

Mixers

HP 11970, 11974 Series

HP 11974 Series Preselected Millimeter Mixers

Eliminate the need for signal identification at millimeter frequencies. The HP 11974 series mixers are preselected from 26.5 to 75 GHz for faster, easier testing of millimeter devices and systems. Preselection reduces mixer overload from broadband signals and reduces radiation of local oscillator harmonics back to the device under test. Equipment operators can quickly locate true signals. Also, software development for automated measurements is greatly simplified.

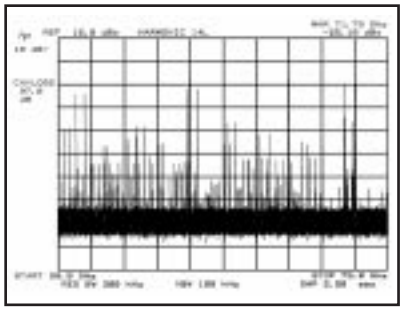
These mixers feature advanced barium-ferrite technology and come with a standalone power supply. They are particularly useful for broadband millimeter signal analysis, millimeter electromagnetic-interference (EMI) measurements, and unattended monitoring of millimeter signals.

Compatibility

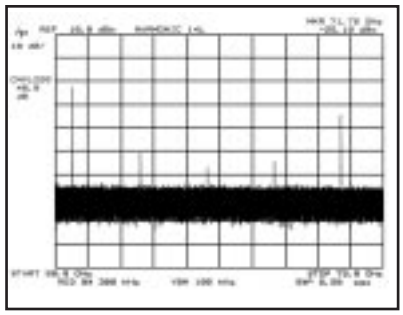
All HP 8560E series analyzers and HP 70907B external mixer interface modules are fully compatible with the HP 11974 series.

HP 11970 Series Harmonic Mixers

These waveguide mixers are general purpose harmonic mixers. They employ a dual-diode design to achieve flat frequency response and low conversion loss. This is achieved without external dc bias or tuning stubs. Manual operation and computer controlled hardware operation are simplified because mixer bias and tuning adjustment are not required.



50 to 75 GHz Sweep Without Preselection



50 to 75 GHz Sweep Using HP 11974 Series Mixer

Specifications

HP Model [1]	Frequency Range (GHz)	Sensitivity (Displayed Avg. Noise Level/10 Hz) (dBm)	Calibration Accuracy (dB)	Image Rejection (dBc)	1 dB Gain [2] Compression (dBm)
11974A	26.5 to 40	–111	<±2.3	–54	+6
11974Q	33 to 50	–106	<±2.3	–50	0
11974U	40 to 60	–109	<±2.6	–50	0
11974V	50 to 75	–100	<±4.5	–50 (to 67 GHz) –40 (67 to 75 GHz)	+3

[1] Specifications apply when connected to the HP 8566B or 70000 series spectrum analyzers.

[2] Typical characteristic.

Mixers

Specifications

HP Model	Frequency Range (GHz)	LO Harmonic Number	Maximum Conversion Loss (dB)	Noise Level (dB) 1 kHz RBW	Freq.[1] Response (dB)	1 dB Gain[2] Compression (dBm)
11970K	18 to 26.5	6+	24	–105	±1.9	–3
11970A	26.5 to 40	8+	26	–102	±1.9	–5
11970Q	33 to 50	10+	28	–101	±1.9	–7
11970U	40 to 60	10+	28	–101	±1.9	–7
11970V	50 to 75	14+	40	–92	±2.1	–3
11970W	75 to 110	18+	47	–85	±3.0	–1

[1] Frequency of the mixers is reduced by 1 dB with LO input power of 14.5 to 16.0 dBm.

[2] Typical characteristic.

- Preselected mixers to eliminate signal identification
- State-of-the-art technology
- Easier automated measurements
- Low conversion loss
- Individually amplitude calibrated
- No bias or tuning adjustments
- High 100 mW safe input level

Compatibility

The HP 11970 series mixers extend the frequency range of the HP 8560E, 8561E, 8562E, and 8563A,E portable spectrum analyzers; except the HP 8560A,E with built-in tracking generator (Option 002). The HP 11970 series mixers are also compatible with the HP 8566B spectrum analyzer (used with the HP 11975A amplifier); and the HP 70000 modular measurement system (used with the HP 70907A,B external mixer interface module, or the HP 70909A and 70910A RF sections).

HP 11970 and 11974 Series Specifications

IF Range: dc to 1.3 GHz
LO Amplitude Range: +14 to +16 dB; +16 optimum
Calibration Accuracy: ±2.0 dB for HP 11970 series with optimum LO amplitude
Typical RF Input SWR: <2.2:1, <3.0:1 for HP 11974 series
Bias Requirements: none
Typical Odd-Order Harmonic Suppression: >20 dB (does not apply to HP 11974 series)
Maximum CW RF Input Level: +20 dBm (100 mW), +25 dBm for HP 11974 series
Maximum Peak Pulse Power: 24 dBm (250 mW) with <1 µs pulse (avg. power = +20 dBm)
Bandwidth: 100 MHz minimum (HP 11974 series only)
Environmental: Meets MIL-T-28800C, Type III, Class 3, Style C
IF/LO Connectors: SMA female
Tune IN Connector: BNC
LO Range: 3.0 to 6.1 GHz

Ordering Information

HP 11974A: 26.5 to 40 GHz preselected mixer
HP 11974Q: 33 to 50 GHz preselected mixer
HP 11974U: 40 to 60 GHz preselected mixer
HP 11974V: 50 to 75 GHz preselected mixer
Option 003: Delete power supply (HP 11974 series only)
HP 11970K: 18 to 26.5 GHz mixer
HP 11970A: 26.5 to 40 GHz mixer
HP 11970Q: 33 to 50 GHz mixer
HP 11970U: 40 to 60 GHz mixers
HP 11970V: 50 to 75 GHz mixers
HP 11970W: 75 to 110 GHz mixers
HP 11970
Option 009: Mixer connection set adds three-1 meter low-loss SMA cables, wrench, allen driver for any HP 11970 series mixer. Carrying case with storage space for cables and tools included.
HP 11975A: 2 to 8 GHz amplifier
HP 281A,B: Coaxial to waveguide adapters
R281A: 26.5 to 40 GHz, 2.4 mm (f)
R281B: 26.5 to 40 GHz, 2.4 mm (m)
Q281A: 33 to 50 GHz, 2.4 mm (f)
Q281B: 33 to 50 GHz, 2.4 mm (m)
U281A: 40 to 60 GHz, 1.85 mm (f)
U281B: 40 to 60 GHz, 1.85 mm (m)
V281A: 50 to 64 GHz, 1.85 mm (f)
V281B: 50 to 64 GHz, 1.85 mm (m)

Network Analyzer Accessories and Cal Kits

Overview

Accessories for the HP 8712E, 8753E, 8720D, and the 8510C series network analyzers include a variety of calibration kits, verification kits, cables, and adapters from dc to 110 GHz.

Calibration Kits

Error-correction procedures require that the systematic errors in the measurement system be characterized by measuring known devices (standards) on the system over the frequency range of interest. HP offers two types of calibration kits: mechanical and electronic.

Electronic Calibration (ECal) Modules

ECal modules consist of connector specific modules, adapters for test ports and a torque wrench for proper connection. ECal modules (85091A, 85092A, 85093A, 85060B, 85062B, 85064B) are controlled via the 85097A PC interface kit and ECal software the runs on a PC. The PC interface module is the interface between the parallel port on your computer, the ECal module(s) and the external power supply.

Mechanical Calibration Kits

All network analyzer coaxial mechanical calibration kits contain precision standard devices to characterize the systematic errors of the HP 8712, 8753 series, 8720 series or 8510C network analyzer system. Each mechanical calibration kit also contains adapters for test ports and a torque wrench for proper connection.

Verification Kits

Measuring known devices, other than the calibration standards, is a straightforward way of verifying that the network analyzer system is operating properly. HP offers verification kits that include precision airlines, mismatch airlines, and precision fixed attenuators. Traceable measurement data is shipped with each kit on disk. Verification kits may be recertified by Hewlett-Packard. This recertification includes a new measurement of all standards and new data with uncertainties.

Test Port Cables and Adapters

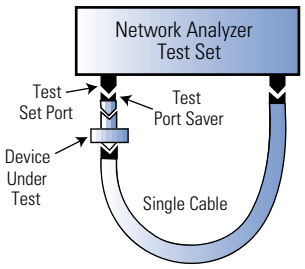
Test port cable and adapter sets are available for various connector types. The cable/adapter configura- tions are described below. All cables are designed with one end that connects directly to the special rugged ports of the network analyzer test set, and one end that connects to the device under test.

Special test port adapter sets are also available to convert the rugged ports of the network analyzer test set to the desired connector interface. Each kit contains two adapters, one male and one female.

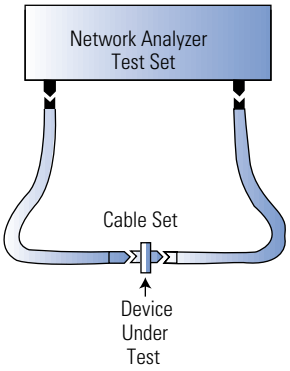
Cables and special adapters have a 3.5 mm or 2.4 mm ruggedized female connector on one end which is designed to connect to HP network analyzer two-port test sets. This connector cannot be mated to standard 3.5 mm or 2.4 mm connectors. However, the other end of the cable or adapter has a connector that can be mated to standard 3.5 mm or 2.4 mm connectors.

Test port cables are available for two test configurations as shown below. Configuration A utilizes a single (96.5 cm, [38 inches] long) test port cable for use when the device under test (DUT) is connected directly to the port on the test set. Configuration B utilizes two test port cables, each cable is 62.2 cm [24.5 inches] long. It provides more flexibility since the DUT is connected between the test port cables. See next page for recommended cables/adapters associated with each configuration.

Configuration A



Configuration B



Network Analyzer Accessories and Cal Kits

Configuration A

3.5 mm test set ports

DUT Connector	Cables/adapters
3.5 mm	HP 85131C Semi-rigid Cable with a 3.5 mm (f) connector
	HP 85131E Flexible Cable with a 3.5 mm (f) connector
	HP 85130D Adapter Set with 3.5 mm (m,f) connectors
7 mm	HP 85132C Semi-rigid Cable with 7 mm connector
	HP 85132E Flexible Cable with a 7 mm connector
	HP 85130B Adapter Set with 7 mm connectors
Type-N	Use 7 mm cables and the 7 mm to Type-N adapters included in the HP 85054B,D calibration kit.

Configuration A

2.4 mm test set ports

DUT Connector	Cables/adapters
2.4 mm	HP 85133C Semi-rigid Cable with a 2.4 mm (f) connector
	HP 85133E Flexible Cable with a 2.4 mm (f) connector
	HP 85130G Adapter Set with 2.4 mm (m,f) connectors
3.5 mm	HP 85134C Semi-rigid Cable with a 3.5 mm (f) connector
	HP 85134E Flexible Cable with a 3.5 mm (f) connector
	HP 85130F Adapter Set with 3.5 mm (m,f) connectors
7 mm	HP 85135C Semi-rigid Cable with a 7 mm connector
	HP 85135E Flexible Cable with a 7 mm connector
	HP 85130E Adapter Set with 7 mm connectors

Accessories

HP 86211A 75 ohm type-N to type-F adapter kit

Adapter kit which provides type-N to type-F adapters necessary when measuring type-F devices on a network analyzer with 75 ohm type-N test ports.

HP 11742A Blocking Capacitor

The HP 11742A blocking capacitor blocks dc signals below 45 MHz and passes signals up to 26.5 GHz. Ideal for use with high frequency oscilloscopes or in biased microwave circuits, the HP 11742A will suppress low frequency signals that can damage expensive measuring equipment or will affect the accuracy of your RF and microwave measurements.

Cables (for Network analyzer)

11857B 75-ohm Type-N test port cables (two)
11851B 50-ohm Type-N cables (four)
11857F 75-ohm Type-F cables (two)

Configuration B

3.5 mm test set ports

DUT Connector	Cable set
3.5 mm	HP 85131D Semi-rigid Cable Set with 3.5 mm (m,f) connectors
	HP 85131F Flexible Cable Set with 3.5 mm (m,f) connectors
7 mm	HP 85132D Semi-rigid Cable Set with 7 mm connector
	HP 85132F Flexible Cable Set with 7 mm connector
Type-N	Use 7 mm cables and the 7 mm to Type-N adapters included in the HP 85054B,D calibration kit.

Configuration B

2.4 mm test set ports

DUT Connector	Cable set
2.4 mm	HP 85133D Semi-rigid Cable Set with 2.4 mm (m,f) connectors
	HP 85133F Flexible Cable Set with 2.4 mm (m,f) connectors
3.5 mm	HP 85134D Semi-rigid Cable Set with 3.5 mm (m,f) connectors
	HP 85134F Flexible Cable Set with 3.5 mm (m,f) connectors
7 mm	HP 85135D Semi-rigid Cable Set with 7 mm connectors
	HP 85135F Flexible Cable Set with 7 mm connectors

Adapter Kits

11906A	**7-16 to 3.5 mm adapter kit**
	3.5 (m) to 7-16 (m)
	3.5 (f) to 7-16 (f)
	3.5 (f) to 7-16 (m)
	3.5 (m) to 7-16 (f)
11906B	**7-16 to Type-N 50 ohm adapter kit**
	N (m) to 7-16 (m)
	N (f) to 7-16 (f)
	N (f) to 7-16 (m)
	N (m) to 7-16 (f)
11906C	**7-16 to 7mm adapter kit**
	7mm to 7/16 (m)
	7mm to 7/16 (f)
11853A	**50 ohm Type-N accessory kit**
	(m) to (m)
	(f) to (f)
	(m) short
	(m) short
11854A	**50 ohm BNC accessory kit**
	(m) short
	BNC (m) to N (m)
	BNC (f) to N (f)
	BNC (m) to N (f)
	BNC (f) to N (m)

Selection Guide

Coaxial mechanical calibration kits

Connector	Frequency Range(GHz)	Type	VNA Calibration Accuracy	HP Model	Available Options	Page
Type-F (75 ohm)	DC to 3	Economy	5% - 1%	85039B	1BP,1BN,UK6, 00M, 00F	86
Type-N (75 ohm)	DC to 3	Economy	5% - 1%	85036E	1BN,1BP,UK6,910	87
Type-N (75 ohm)	DC to 3	Standard	5% - 1%	85036B	1BN,1BP,UK6,910	87
Type-N (50 ohm)	DC to 6	Economy	5% - 1%	85032E	1BN,1BP,UK6,910	88
Type-N (50 ohm)	DC to 6	Standard	5% - 1%	85032B	1BN,1BP,UK6,910,001	88, 89
Type-N (50 ohm)	0.045 to 18	Standard	2% - 0.3%	85054B	1BN,1BP,002	90
Type-N (50 ohm)	0.045 to 18	Economy	5% - 1%	85054D	1BN,1BP,002	91
7-16	DC to 7.5 GHz	Standard	2%	85038A	none	92
7-16	DC to 7.5 GHz	Standard	2%	85038F	none	92
7-16	DC to 7.5 GHz	Standard	2%	85038M	none	92
7 mm	DC to 6	Economy	2% - 0.3%	85031B	1BN, 1BP, UK6, 910	93
7 mm	0.045 to 18	Economy	5% - 1%	85050D	1BN, 1BP, 910, 002	93
7 mm	0.045 to 18	Standard	2% - 0.05%	85050B	1BN, 1BP, 910, 002	94
7 mm	0.045 to 18	Precision	0.3% - 0.05%	85050C	1BN, 1BP, 910, 002	95
3.5 mm	DC to 6	Economy	5% - 1%	85033D	1BN,1BP,UK6,910,001,002	96
3.5 mm	0.045 to 26.5	Economy	5% - 1%	85052D	1BN,1BP, 910,002	97
3.5 mm	0.045 to 26.5	Standard	3% - 0.5%	85052B	1BN,1BP, 910,002	98
3.5 mm	0.045 to 26.5	Precision	2% - 0.5%	85052C	1BN,1BP, 910,002	99
2.92 mm	0.045 to 50	Economy	11% - 4% (OPT oo1 65 -3%)	85056K	1BN,1BP,001*,002	100, 101
2.4 mm	0.045 to 50	Economy	5% - 1%	85056D	1BN,1BP,910,002	102
2.4 mm	0.045 to 50	Standard	4% - 0.5%	85056A	1BN,1BP,910,002	103
1 mm	0.045 to 110 GHz	Precision	5% - 1%	85059A	none	104, 105

Waveguide mechanical calibration kits

Connector	Frequency Range(GHz)	Type	VNA Calibration Accuracy	HP Model	Available Options	Page
WR-90	8.2 to 12.4	Precision	0.3% - 0.05%	X11644A	002	106
WR-62	12.4 to 18	Precision	0.3% - 0.05%	P11644A	002	107
WR-42	18 to 26.5	Precision	0.3% - 0.05%	K11644A	002	108
WR-28	26.5 to 40	Precision	0.3% - 0.05%	R11644A	002	109
WR-22	33 to 50	Precision	0.3% - 0.05%	Q11644A	002	110
WR-19	40 to 60	Precision	0.3% - 0.05%	U11644A	002	111
WR-15	50 to 75	Precision	0.3% - 0.05%	V11644A	002	112
WR-10	75 to 110	Precision	0.3% - 0.05%	W11644A	002	113

Option description

002: Add calibration/verification data on magnetic tape in additon to 3.5" floppy
1BN: MIL standard 45662A calibration certification
1BP: MIL standard 45662A calibration certification with test data
UK6: Commerical calibration certificate with test data
00M: Includes male standards & male-male adapter
00F: Includes female standards and female-female adapter
001: Deletes 7 mm to 3.5 mm adapters
001*:Adds 2.4 mm sliding load and 2.4 mm gauges
001**: Adds data for HP 8702 lightwave component analyzer
910: Adds extra manual

Selection Guide

Coaxial electronic calibration kits (ECal)

Connector	Frequency Range(GHz)	Type	VNA Calibration Accuracy	HP Model	Available Options	Page
7 mm	30 kHz to 6 GHz	Standard	1% - 0.1%	85091A	See detailed descriptions	115, 116
Type-N (50 ohm)	30 kHz to 6 GHz	Standard	1% - 0.1%	85092A		114, 115, 116, 117
3.5 mm	30 kHz to 6 GHz	Standard	2% - 0.2%	85093A		114, 115, 116, 117
7-mm	1 GHz to 18 GHz	Standard	2% - 0.05%	85060B		115, 116
3.5 mm	1 GHz to 26.5 GHz	Standard	3% - 0.5%	85062B		114, 115, 116, 117
Type-N (50 ohm)	1 GHz to 18 GHz	Standard	2% - 0.1%	85064B		114, 115, 116, 117
PC Interface kit	N/A	N/A	N/A	85097A		115

Mechanical verification kits

Connector	Frequency Range(GHz)	Type	VNA Calibration Accuracy	HP Model	Available Options	Page
Type-N	0.045 to 18 GHz	Precision	N/A	85055A	1BP,002,910	118
7 mm	DC to 6 GHz	Precision	N/A	85029B	1BP,001**,910	118
7 mm	0.045 to 18 GHz	Precision	N/A	85051B	1BP,002,910	119
3.5 mm	0.045 to 26.5 GHz	Precision	N/A	85053B	1BP,002,910	119
2.4 mm	0.045 to 50 GHz	Precision	N/A	85057B	1BP,002,910	120
WR-28	26.5 to 40	Precision	N/A	R11645A	1BP,002	120
WR-22	33 to 50	Precision	N/A	Q11645A	1BP,002	121
WR-19	40 to 60	Precision	N/A	U11645A	1BP,002	121
WR-15	50 to 75	Precision	N/A	V11645A	1BP,002	122
WR-10	75 to 110	Precision	N/A	W11645A	1BP,002	122

Option description

002: Add calibration/verification data on magnetic tape in additon to 3.5" floppy
1BN: MIL standard 45662A calibration certification
1BP: MIL standard 45662A calibration certification with test data
UK6: Commerical calibration certificate with test data
00M: Includes male standards & male-male adapter
00F: Includes female standards and female-female adapter
001: Deletes 7 mm to 3.5 mm adapters
001*:Adds 2.4 mm sliding load and 2.4 mm gauges
001**: Adds data for HP 8702 lightwave component analyzer
910: Adds extra manual

Coaxial Mechanical Calibration Kits

HP 85039B Calibration Kit, Type-F

The HP 85039B 75 Ω type-F calibration kit is used to calibrate HP 8752C, HP 8753 and HP 8712E network analyzer systems for measurements of components with 75 Ω type-F connectors up to 3 GHz.

Electrical Specifications

75Ω Type-F Device	Specifications	Frequency
Male Load, Female Load:	Return Loss ≥45 dB (ρ≤0.006)	dc to ≤1GHz
	Return Loss ≥38 dB (ρ≤0.013)	>1 to ≤3 GHz
Male Short[1], Female Short:	±0.60° from nominal	dc to ≤1 GHz
	±1.00° from nominal	>1 to ≤3 GHz
Male Open[1], Female Open:	±0.55° from nominal	dc to ≤1 GHz
	±1.30° from nominal	> 1 to ≤3 GHz

Adapters

Type-F to Type-F	Return Loss ≥40 dB (ρ≤0.013)	dc to ≤1 GHz
	Return Loss ≥32 dB (ρ≤0.025)	>1 to ≤3 GHz
Type-N to Type-F	Return Loss ≥38 dB (ρ≤0.013)	dc to ≤1 GHz
	Return Loss ≥32 dB (ρ≤0.025)	>1 to ≤3 GHz

[1] The specifications for the open and short are given as allowed deviation from the nominal model as defined in the standard definitions. See Table A-3

Part Number	Description	85039B	Opt 00M	Opt 00F
85939-60007	75 ohm Type-F male load	X	X	
85939-60008	75 ohm Type-F male short	X	X	
85939-60009	75 ohm Type-F male open	X	X	
85939-60004	75 ohm Type-F female load	X		X
85939-60003	75 ohm Type-F female load	X		X
85939-60005	75 ohm Type-F female load	X		X
85939-60006	75 ohm Type-F male to male adapter	X		
85939-60002	75 ohm Type-F female to female adapter	X		
85939-60013	75 ohm Type-F female to male adapter	X		
85939-60011	75 ohm Type-F male to Type-N female adapter	X		
Additional adapters available from HP but not included in the cal kit.				
85939-60010	75 ohm Type-F male to Type-N male			
85939-60012	75 ohm Type-F male to Type-F female			
85939-60014	75 ohm Type-F female to Type-N female			

Coaxial Mechanical Calibration Kits

HP 85036E Economy Calibration Kit, Type-N, 75 Ohm

The HP 85036E economy calibration kit contains precision type-N (m) fixed termination and a one piece type-N (m) open /short circuit. The kit is specified from DC to 3 GHz.

HP 85036B Calibration Kit, Type-N, 75 Ohm

The HP 85036B calibration kit contains precision type-N standards used to calibrate HP network analyzers for measurement of devices with 75 ohm type-N connectors. Standards include fixed terminations, open circuits, and short circuits in both sexes. Precision phase-matched adapters are included for accurate measurements of non-insertable devices. This kit is specified from DC to 3 GHz.

Electrical Specifications

75 ohm Device	Specification	Frequency (GHz)
Type-N Loads	Return Loss ≥46 dB (ρ≤0.00501)	DC to ≤2
	Return Loss ≥40 dB (ρ≤0.01000)	>2 to ≤3

Replaceable Parts for the HP 85036E

Item No.	Description	Qty Per Kit	HP Replacement Part Number
	Calibration Devices		
1	75Ω Type-N Male Broadband Load	1	00909-60019
2	75Ω Type-N Male Combined Open/Short	1	85036-60016

Item No.	Description	Qty Per Kit	HP Replacement Part Number
	Calibration Devices		
1	75Ω Type-N Male Broadband Load	1	00909-60019
2	75Ω Type-N Female Broadband Load	1	00909-60020
3	75Ω Type-N Male Short	1	85036-60012
4	75Ω Type-N Female Short	1	85036-60011
5	75Ω Type-N Male Open	1	85032-60007
6	75Ω Type-N Female Open Body	1	85032-20001
7	75Ω Type-N Female Open Center Conductor Extender	1	85036-60019

Item No.	Description	Qty Per Kit	HP Replacement Part Number
	Adapters		
8	Type-N Male to Male	1	85036-60013
9	Type-N Female to Female	1	85036-60014
10	Type-N Male to Female	1	85036-60015

Coaxial Mechanical Calibration Kits

HP 85032E Economy Calibration Kit, Type-N, 50 Ohm

The HP 85032E economy calibration kit contains a type-N (m) fixed termination and a one piece type-N (m) open /short circuit. The kit is specified from DC to 6 GHz.

HP 85032B Calibration Kit, Type-N, 50 Ohm

The HP 85032B calibration kit contains precision 50 ohm type-N standards used to calibrate HP 8752C, the HP 8753 and 50 ohm test sets for measurement of devices with 50 ohm type-N connectors. Precision phase-matched 7 mm to 50 ohm type-N adapters are included for accurate measurements of non-insertable devices. Standards include fixed terminations, open circuits, and short circuits in both sexes. This kit is specified from DC to 6 GHz. Option 001 removes the precision phase-matched 7 mm to Type-N adapters.

Coaxial Mechanical Calibration Kits

Electrical Specifications

The electrical specifications in Table 2-2 apply to the devices in both the HP 85032B and HP 85032E 50 ohm type-N calibration kits.

Table 2-2 Electrical Specifications for 50 Ω Type-N Devices

Device	Frequency (GHz)	Parameter	Specifications
Loads	DC to ≤2	Return Loss	≥49dB (≤0.00355ρ)
	> 2 to ≤3	Return Loss	≥46 dB (≤0.00501ρ)
	> 3 to ≤6	Return Loss	≥40 dB (≤0.01000ρ)
Female Open[1]	DC to ≤6	Deviation from Nominal: Phase	±0.50° ±0.484° / GHz
Female Short[1]	DC to ≤6	Deviation from Nominal: Phase	±0.490° ±0.385° / GHz
Male Open[1]	DC to ≤6	Deviation from Nominal: Phase	±0.501° ±0.234° / GHz
Male Short[1]	DC to ≤6	Deviation from Nominal: Phase	±0.441° ±0.444° / GHz
Adapters (7 mm to type-N)	DC to ≤6	Return Loss	≥30 dB (≤0.03162ρ)

Description	Qty Per Kit	HP Replacement Part Number
Calibration Devices		
50Ω Type-N Male Broadband Load	1	00909-60009
50Ω Type-N Combination Male Open/Short	1	85032-60011

Description	Qty Per Kit	HP Replacement Part Number
Calibration Devices		
50Ω Type-N Male Broadband Load	1	00909-60009
50Ω Type-N Female Broadband Load	1	00909-60010
50Ω Type-N Male Short	1	85032-60008
50Ω Type-N Female Short	1	85032-60009
50Ω Type-N Male Open	1	85032-60007
50Ω Type-N Female Open [2]	1	85032-60012
Adapters (not included with Option 001)		
50Ω Type-N Male to 7 mm	2	85054-60009
50Ω Type-N Female to 7 mm	2	85054-60001

[1] The specifications for the opens and shorts are given as allowed deviation from the nominal model as defined in the standard definitions.
[2] Includes center conductor extender

Coaxial Mechanical Calibration Kits

HP 85054B Mechanical Calibration Kit, Type-N

The HP 85054B mechanical calibration kit contains precision standard devices to characterize the systematic errors of the HP 8720 series or 8510C network analyzer system in the Type-N interface. This kit also contains adapters to change the sex of the test port, connector gages for verifying and maintain in the connector interface, and a torque wrench for proper connection. Included are standards definitions on disk for the 8510C.

Electrical Specifications

Device	Frequency (GHz)	Parameter	Specifications
Lowband Loads	DC to ≤ 2	Return Loss	≥ 48dB (≤0.00398 ρ)
Sliding Loads	> 2 to ≤ 18	Return Loss	≥ 42dB (≤0.00794 ρ)
Adapters	DC to ≤ 8	Return Loss	≥ 34dB (≤0.00200 ρ)
(both types)	> 8 to ≤ 18	Return Loss	≥ 28 dB (≤0.00398 ρ)
Offset Opens	at 18	Deviation from Nominal: Phase	±1.5°
Offset Shorts	at 18	Deviation from Nominal: Phase	±1.0°

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
Type-N (m) Sliding Load	1	85054-60035
Type-N (f) Sliding Load	1	85054-60036
Type-N (m) Lowband Load	1	00909-60011
Type-N (f) Lowband Load	1	00909-60012
Type-N (m) Offset Short	1	85054-60025
Type-N (f) Offset Short	1	85054-60026
Type-N (m) Offset Open	1	85054-60027
Type-N (f) Offset Open	1	85054-60028
Type-N (m) to Type-N (m)	1	85054-60038
Type-N (f) to Type-N (f)	1	85054-60037
Type-N (f) to 7 mm	2	85054-60031
Type-N (m) to 7 mm	2	85054-60032
¾ in., 135 N-cm (12 in-lb) Torque	1	8710-1766
Spanner	1	08513-20014
Screw-On N Gage	1	85054-80011
Type-N Gage Set (includes items listed below)		85054-60049
Type-N Gage (f)	1	85054-60050
Type-N Gage Master (f)	1	85054-60052
Type-N Gage (m)	1	85054-60051
Type-N Gage Master (m)	1	85054-60053
Centering Beads	2	85054-80028

Coaxial Mechanical Calibration Kits

HP 85054D Economy Mechanical Calibration Kit, Type-N

The HP 85054D type-N economy calibration kit is used to calibrate network analyzer systems (such as the HP 8510 or HP 8720 series) for measurements of components with type-N connectors up to 18 GHz.

Electrical Specifications

Device	Frequency (GHz)	Parameter	Specifications
Broadband Loads	DC to ≤2	Return Loss	≥40dB (≤0.01000 ρ)
	>2 to ≤8	Return Loss	≥36dB (≤0.01585 ρ)
	>8 to ≤18	Return Loss	≥42dB (≤0.01995 ρ)
Adapters (both types)	DC to ≤8	Return Loss	≥34dB (≤0.00200 ρ)
	>8 to ≤18	Return Loss	≥28 dB (≤0.00398 ρ)
Offset Opens	at 18	Deviation from Nominal: Phase	±1.5°
Offset Shorts	at 18	Deviation from Nominal: Phase	±1.0°

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
Type-N Broadband Load (m)	1	85054-60046
Type-N Broadband Load (f)	1	85054-60047
Type-N Offset Short (m)	1	85054-60025
Type-N Offset Short (f)	1	85054-60026
Type-N Offset Open (m)	1	85054-60027
Type-N Offset Open (f)	1	85054-60028
Type-N (m) to Type-N (m)	1	85054-60038
Type-N (f) to Type-N (f)	1	85054-60037
Type-N (f) to 7 mm	2	85054-60031
Type-N (m) to 7 mm	2	85054-60032
¾ in., 135 N-cm (12 in-lb) Torque	1	8710-1766
Spanner	1	08513-20014

Coaxial Mechanical Calibration Kits

HP 85038A 7-16 Calibration Kit

The HP 85038A 7-16 calibration kit contains fixed loads, open and short circuits in both sexes. It can be used to calibrate the HP 8753 and HP 8712E network analyzers for measurement of components with 50 ohm 7-16 connectors up to 7.5 GHz.

The HP 85038M and HP 85038F are single sex calibration kits and contain male only and female only standards respectively.

Electrical Specifications

Frequency range	dc to 7.5 GHz
Reference Impedance	50 ohms
Short circuits:	
Reflection coefficient	0.99 minimum
Open circuits:	
Reflection coefficient	0.99 minimum
Reflection phase	+/- 1 degree
Fixed termination:	
VSWR	1.02 maximum

HP also offers the following adapter kits.

HP 11906A	7-16 to 7-16
HP 11906B	7-16 to Type-N 50 ohm
HP 11906C	7-16 to 7 mm
HP 11906D	7-16 to 3.5 mm

Parts List

HP 85038A 7-16 calibration kit

Part Number	Description	85038A	85038M	85038F
85038-80002	open female	X		X
85038-80003	open male	X	X	X
85038-80004	short female	X		X
85038-80005	short male	X	X	X
85038-80006	load female	X		X
85038-80007	load male	X	X	
85038-80015	male to male adapter		X	
85038-80016	female to female adapter			X

HP 11906B 7-16 to Type-N 50 ohm

Part Number	Qty	Description
11906-80007	1	Type-N male to 7-16 male
11906-80008	1	Type-N female to 7-16 female
11906-80009	1	Type-N female to 7-16 male
11906-80010	1	Type-N male to 7-16 female

HP 11906A 7-16 to 7-16

Part Number	Qty	Description
11906-80015	1	7-16 male to 7-16 male
11906-80016	1	7-16 female to 7-16 female
11906-80017	1	7-16 female to 7-16 male

HP 11906C 7-16 to 7 mm

Part Number	Qty	Description
11906-80012	1	7 mm to 7-16 male
11906-80013	1	7 mm to 7-16 female

HP 11906D 7-16 to 3.5 mm

Part Number	Qty	Description
11906-80002	1	3.5 mm male to 7-16 male
11906-80003	1	3.5 mm female to 7-16 female
11906-80004	1	3.5 mm female to 7-16 male
11906-80005	1	3.5 mm male to 7-16 female

Coaxial Mechanical Calibration Kits

HP 85031B Calibration Kit, 7 mm

The HP 85031B calibration kit contains a set of precision 7 mm fixed terminations, and a one-piece open/short circuit used to calbrate the HP 8753 and its 50 ohm test sets for measurement of devices with precision 7 mm connectors. This kit is specified 300 kHz to 6 GHz.

Device	Specification	
50 ohm Loads	dc to 5 GHz	Return loss ≥52 dB
	5 to 6 GHz	Return loss ≥46 dB
	6 to 18 GHz	Return loss (typical) ≥26.4 dB

Part or Model Number	Quantity	Description
85031-60001	1	7 mm 50 ohm Combination Open/Short
00909-60008	2	7 mm 50 ohm Terminations

HP 85050D 7 mm Economy Mechanical Calibration Kit

The HP 85050D economy mechanical calibration kit contains precision standard devices to characterize the systematic errors of the HP 8720 series or 8510C network analyzer system in the 7 mm interface. This kit also contains adapters to change the sex of the test port and a torque wrench for proper connection. Included are standards definitions on disk for the 8510C. Connector gages may be ordered separately.

Electrical Specifications

Device	Specifications	Frequency (GHz)
Broadband Loads	≥38 dB Return Loss	dc to 18 GHz
Short (collet style)	±0.2° from nominal	dc to 2 GHz
	±0.3° from nominal	2 to 8 GHz
	±0.5° from nominal	8 to 18 GHz
Open with collet pusher	±0.3° from nominal	dc to 2 GHz
	±0.4° from nominal	2 to 18 GHz
	±0.6° from nominal	8 to 18 GHz

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
7 mm Broadband Load	1	85050-60006
7 mm Short	1	85050-80007
7 mm Open	1	85052-80010

Coaxial Mechanical Calibration Kits

HP 85050B Mechanical Calibration Kit, 7mm

The HP 85050B mechanical calibration kit contains precision standard devices to characterize the systematic errors of the HP 8720 series or 8510C network analyzer system in the 7 mm interface. This kit also contains adapters to change the sex of the test port, connector gages for verifying and maintaining the connector interface, and a torque wrench for proper connection. Included are standards definitions on disk for the 8510C.

Electrical Specifications

Device	Specifications	Frequency (GHz)
Lowband Loads	≥52 dB Return Loss	dc to 2 GHz
Broadband Loads	≥38 dB Return Loss	dc to 18 GHz
Short collet style	±0.2° from nominal	dc to 2 GHz
	±0.3° from nominal	2 to 8 GHz
	±0.5° from nominal	8 to 18 GHz
Open with collet pusher	±0.3° from nominal	dc to 2 GHz
	±0.4° from nominal	2 to 18 GHz
	±0.6° from nominal	8 to 18 GHz

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
7 mm Lowband Load	1	00909-60008
7 mm Sliding Load	1	85050-60014
7 mm Broadband Load	1	85050-60006
7 mm Short	1	85050-80007
7 mm Open	1	85052-80010
7 mm Center Conducter Collets	4	85050-20001
7 mm Connector Collet Extractor Tool	1	5060-0370
3/4 in., 135 N-cm (12 in-lb) Torque	1	8710-1766

Coaxial Mechanical Calibration Kits

HP 85050C 7 mm Precision Mechanical Calibration Kit

The HP 85050C precision mechanical calibration kit contains precision standard devices to characterize the systematic errors of the HP 8720 series or 8510C network analyzer system in the 7 mm interface. This kit also contains adapters to change the sex of the test port, connector gages for verifying and maintaining the connector interface, and a torque wrench for proper connection. Included are standards definitions on disk for the 8510C.

Electrical Specifications

Device	Specifications	Frequency (GHz)
Lowband Loads	≥52 dB Return Loss	dc to 2 GH
Broadband Loads	≥38 dB Return Loss	dc to 18 GHz
Short (collet style)	±0.2° from nominal	dc to 2 GHz
	±0.3° from nominal	2 to 8 GHz
	±0.5° from nominal	8 to 18 GHz
Open with collet pusher	±0.3° from nominal	dc to 2 GHz
	±0.4° from nominal	2 to 18 GHz
	±0.6° from nominal	8 to 18 GHz
Precision Airline	>60 dB Return Loss	2 to 18 GHz

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
7 mm Broadband Load	1	85050-60006
7 mm Lowband Load	1	00909-60008
7 mm Short (collet style)	1	85050-80009
7 mm Short (threaded center conductor style)	1	85050-80008
TRL Adapter	1	85050-60005
7 mm Open	1	85052-80010
7 mm Precision Airline	1	85050-80010
3/4 in., 135 N-cm (12 in-lb) Torque	1	8710-1766
7 mm Connector Collet Extractor	1	5060-0370

Coaxial Mechanical Calibration Kits

HP 85033D Calibration Kit, 3.5 mm

The HP 85033D calibration kit contains fixed loads and open and short circuits in both sexes to calibrate the 50 ohm test sets for measurement of devices with precision 3.5 mm and SMA connectors. Phase-matched 7 mm to 3.5 mm adapters for male and female connectors are included for use with 7 mm test port cables. This kit is specified from dc to 6 GHz. Option 001 removes the precision phase-matched 7 mm to 3.5 mm adapter.

Electrical Specifications

Device	Specifications	Frequency (GHz)
Broadband Loads (male and female)	Return Loss ≥46 dB (ρ≤0.005)	dc to ≤1.3
	Return Loss ≥44 dB (ρ≤0.006)	> 1.3 to ≤3
	Return Loss ≥38 dB (ρ≤0.013)	> 3 to ≤6
Offset Opens[1] (male and female)	±0.65° from nominal	dc to ≤1.3
	±0.65° from nominal	> 1.3 to ≤3
	±0.85° from nominal	> 3 to ≤6
Offset Shorts1 (male and female)	±0.48° from nominal	dc to ≤1.3
	±0.50° from nominal	> 1.3 to ≤3
	±0.55° from nominal	> 3 to ≤6

[1] The specifications for the open and short are given as allowed deviation from the nominal model as define in the standard definitions.

Replaceable Parts

Item No.	Description	Qty Per Kit	HP Replacement Part Number
	Calibration Devices		
1	3.5 mm Male Broadband Load	1	85033-60009
2	3.5 mm Female Broadband Load	1	85033-60010
3	3.5 mm Male Offset Open	1	85033-60011
4	3.5 mm Female Offset Open	1	85033-60012
5	3.5 mm Male Offset Short	1	85033-60013
6	3.5 mm Female Offset Short	1	85033-60014
	Adapters (not included with option 001)		
7	7 mm to 3.5 mm Male	2	85052-60004
8	7 mm to 3.5 mm Female	2	85052-60003
	Adapters (Option 002)		
9	Type-N Male to 3.5 mm Male	1	1250-1743
10	Type-N Male to 3.5 mm Female	1	1250-1744
11	Type-N Female to 3.5 mm Female	1	1250-1745
12	Type-N Female to 3.5 mm Male	1	1250-1750

Coaxial Mechanical Calibration Kits

HP 85052D Economy Mechanical Calibration Kit, 3.5 mm

The HP 85052D economy mechanical calibration kit contains precision standard devices to characterize the systematic errors of the HP 8720 series or 8510C network analyzer system in the 3.5 mm interface. This kit also contains adapters to change the sex of the test port and a torque wrench for proper connection. Included are standards definitions on disk for the 8510C. Connector gages may be ordered separately.

Electrical Specifications

Device	Specifications	Frequency (GHz)
Broadband Loads	≥46 dB Return Loss (≤0.00501ρ)	dc to ≤2
	≥44 dB Return Loss (≤0.00631ρ)	> 2 to ≤3
	≥38 dB Return Loss (≤0.01259ρ)	> 3 to ≤8
	≥36 dB Return Loss (≤0.01585ρ)	> 8 to ≤20
	≥34 dB Return Loss (≤0.01995ρ)	> 20 to ≤26.5
Adapters	30 ≥dB Return Loss (≤0.03162ρ)	dc to ≤8
	28 ≥dB Return Loss (≤0.03981ρ)	>8 to ≤18
	26 ≥dB Return Loss (≤0.05012ρ)	>18 to ≤26.5
Offset Opens	±0.65° from nominal	dc to ≤3
	±1.20° from nominal	> 3 to ≤8
	±2.00° from nominal	> 8 to ≤20
	±2.00° from nominal	> 20 to ≤26.5
Offset Shorts	±0.50° from nominal	dc to ≤3
	±1.00° from nominal	> 3 to ≤8
	±1.75° from nominal	> 8 to ≤20
	±1.75° from nominal	> 20 to ≤26.5

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
3.5 mm Broadband Load (m)	1	00902-60003
3.5 mm Broadband Load (f)	1	00902-60004
3.5 mm Offset Short (m)	1	85052-60006
3.5 mm Offset Short (f)	1	85052-60007
3.5 mm Offset Open (m)	1	85052-60008
3.5 mm Offset Open (f)	1	85052-60009
3.5 mm (m) to 3.5 mm (m)	1	85052-60014
3.5 mm (m) to 3.5 mm (f)	1	85052-60013
3.5 mm (f) to 3.5 mm (f)	1	85052-60012
5/16 in., 90 N-cm (8 in-lb) Torque	1	8710-1765
7 mm Open-end	1	8710-1761

Coaxial Mechanical Calibration Kits

HP 85052B Mechanical Calibration Kit, 3.5 mm

The HP 85052B mechanical calibration kit contains precision standard devices to characterize the systematic errors of the HP 8720 series or 8510C network analyzer system in the 3.5 mm interface. This kit also contains adapters to change the sex of the test port, connector gages for verifying and maintaining the connector interface, and a torque wrench for proper connection. Included are standards definitions on disk for the 8510C.

Electrical Specifications

Device	Specifications	Frequency (GHz)
Broadband Loads	≥46 dB Return Loss (≤0.00501ρ)	dc to ≤2
	≥44 dB Return Loss (≤0.00631ρ)	> 2 to ≤3
	≥38 dB Return Loss (≤0.01259ρ)	> 3 to ≤8
	≥36 dB Return Loss (≤0.01585ρ)	> 8 to ≤20
	≥34 dB Return Loss (≤0.01995ρ)	> 20 to ≤26.5
Sliding Loads	≥44 dB Return Loss (≤0.00631ρ)	3 to ≤26.5
Adapters	30 ≥dB Return Loss (≤0.03162ρ)	dc to ≤8
	28 ≥dB Return Loss (≤0.03981ρ)	>8 to ≤18
	26 ≥dB Return Loss (≤0.05012ρ)	>18 to ≤26.5
Offset Opens	±0.65° from nominal	dc to ≤3
	±1.20° from nominal	3 to ≤8
	±2.00° from nominal	> 8 to ≤20
	±2.00° from nominal	20 to ≤26.5
Offset Shorts	±0.50° from nominal	dc to ≤3
	±1.00° from nominal	> 3 to ≤8
	±1.75° from nominal	> 8 to ≤20
	±1.75° from nominal	> 20 to ≤26.5

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
3.5 mm Sliding Load (m)	1	00911-60019
3.5 mm Sliding Load (f)	1	00911-60020
3.5 mm Broadband Load (m)	1	00902-60003
3.5 mm Broadband Load (f)	1	00902-60004
3.5 mm Offset Short (m)	1	85052-60006
3.5 mm Offset Short (f)	1	85052-60007
3.5 mm Offset Open (m)	1	85052-60008
3.5 mm Offset Open (f)	1	85052-60009
3.5 mm (m) to 3.5 mm (m)	1	85052-60014
3.5 mm (m) to 3.5 mm (f)	1	85052-60013
3.5 mm (f) to 3.5 mm (f)	1	85052-60012
5/16 in., 90 N-cm (8 in-lb) Torque	1	8710-1765
7 mm Open-end	1	8710-1761

Coaxial Mechanical Calibration Kits

HP 85052C

The HP 85052C is a laboratory-grade 3.5 mm calibration kit. Its purpose is to provide high quality calibrations up to 26.5 GHz for microwave network analyzers such as the HP 8510 and HP 8720 using the TRL (thru-reflect-line) calibration method. The calibration devices in this kit have very precise mechanical dimensions, and must be handled with care.

Electrical Specifications

Device	Specifications	Frequency (GHz)
Broadband Loads	≥46 dB Return Loss (≤0.00501ρ)	dc to ≤2
	≥44 dB Return Loss (≤0.00631ρ)	> 2 to ≤3
	≥38 dB Return Loss (≤0.01259ρ)	> 3 to ≤8
	≥36 dB Return Loss (≤0.01585ρ)	> 8 to ≤20
	≥34 dB Return Loss (≤0.01995ρ)	> 20 to ≤26.5
Long Precision Airline	≥56 dB Return Loss (≤0.00158ρ)	> 2 to ≤7
Short Precision Airline	≥50 dB Return Loss (≤0.00316ρ)	> 7 to ≤26.5
Precision Adapters	≥30 dB Return Loss (≤0.03162ρ)	dc to ≤20
	≥27 dB Return Loss (≤0.00447ρ)	>20 to ≤26.5
Offset Opens	±0.65° from nominal	dc to ≤3
	±1.20° from nominal	> 3 to ≤8
	±2.00° from nominal	> 8 to v20
	±2.00° from nominal	> 20 to ≤26.5
Offset Shorts	±0.50° from nominal	dc to ≤3
	±1.00° from nominal	> 3 to ≤8
	±1.75° from nominal	> 8 to ≤20
	±1.75° from nominal	> 20 to ≤26.5

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
3.5 mm Broadband Load (m)	1	00902-60003
3.5 mm Broadband Load (f)	1	00902-60004
3.5 mm Offset Short (m)	1	85052-60006
3.5 mm Offset Short (f)	1	85052-60007
3.5 mm Offset Open (m)	1	85052-60008
3.5 mm Offset Open (f)	1	85052-60009
3.5 mm (m) to 3.5 mm (m)	1	85052-60033
3.5 mm (m) to 3.5 mm (f)	1	85052-60032
3.5 mm (f) to 3.5 mm (f)	1	85052-60034
Long Precision Air Line, 2-7 GHz (includes insertion tool)	1	85052-60036
Short Precision Air Line, 7-32 GHz (includes insertion tool)	1	85052-60035
Spanner	1	08513-20014
5/16 in., 90 N-cm (8 in-lb) Torque	1	8710-1765
Hex Balldriver, 4mm	1	8710-1933
Adapter Anti-Rotation Clamp	2	85052-20060

Coaxial Mechanical Calibration Kits

HP 85056K Mechanical Calibration Kit, 2.4 mm & 2.92 mm

The HP 85056K calibration kit was designed to give network analyzer systems with 2.4 mm test ports (such as the HP 8510 or HP 8722) the ability to perform measurements on devices with 2.92 mm connectors. The kit can be used to achieve calibrated measurements of 2.92 mm devices up to 40 GHz, and 2.4 mm devices up to 50 GHz.

Electrical Specifications

Device	Frequency (GHz)	Parameter	Specifications
Broadband Loads	DC to ≤4	Return Loss	≥42dB (≤0.00794ρ)
	> 4 to ≤20	Return Loss	≥34 dB (≤0.01995ρ)
	> 20 to ≤26.5	Return Loss	≥30 dB (≤0.03163ρ)
	> 26.5 to ≤50	Return Loss	≥30 dB (≤0.05019ρ)
Sliding Loads	4 to ≤20	Return Loss	≥42dB (≤0.00794ρ)
	> 20 to ≤36	Return Loss	≥40 dB (≤0.01000ρ)
	> 36 to ≤40	Return Loss	≥38 dB (≤0.01259ρ)
	> 40 to ≤50	Return Loss	≥36 dB (≤0.01585ρ)
Adapters (2.4 mm to 2.4 mm)	DC to ≤4	Return Loss	≥32dB (≤0.02512ρ)
	> 4 to ≤26.5	Return Loss	≥30 dB (≤0.03162ρ)
	> 26.5 to ≤40	Return Loss	≥25 dB (≤0.05623ρ)
	> 40 to ≤50	Return Loss	≥20 dB (≤0.01000ρ)
Adapters (2.4 mm to 2.92 mm)	DC to ≤40	Return Loss	≥24dB (≤0.06310ρ)
Offset Opens	DC to ≤2	Deviation from Nominal:	±0.5°
	> 2 to ≤20	Deviation from Nominal:	±1.25°
	> 20 to ≤40	Deviation from Nominal:	±1.75°
	> 40 to ≤50	Deviation from Nominal:	±2.25°
Offset Shorts	DC to ≤2	Deviation from Nominal:	±0.5°
	> 2 to ≤20	Deviation from Nominal:	±1.25°
	> 20 to ≤40	Deviation from Nominal:	±1.5°
	> 40 to ≤50	Deviation from Nominal:	±2.0°

2.4 mm to 2.92 mm Adapter Characteristics

Frequency (GHz)	Parameter	Typical Value
DC to ≤2	Return Loss	≥38 dB (≤0.01259ρ)
> 2 to ≤20	Return Loss	≥35 dB (≤0.01778ρ)
> 20 to ≤40	Return Loss	≥30 dB (≤0.03162ρ)
DC to ≤40	Electrical Length	39.631 ps ±0.14 ps
DC to ≤40	Insertion Loss	< 0.075 dB

Coaxial Mechanical Calibration Kits

HP 85056K Mechanical Calibration Kit, 2.4 mm & 2.92 mm (continued)

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
2.4 mm Broadband Load (m)	1	00901-60003
2.4 mm Broadband Load (f)	1	00901-60004
2.4 mm Offset Short (m)	1	85056-60020
2.4 mm Offset Short (f)	1	85056-60021
2.4 mm Offset Open (m)	1	85056-60022
2.4 mm Offset Open (f)	1	85056-60023
2.4 mm (m) to 2.4 mm (m)	1	85056-60005
2.4 mm (m) to 2.4 mm (f)	1	85056-60006
2.4 mm (f) to 2.4 mm (f)	1	85056-60007
2.4 mm (m) to 2.92 mm (m)	1	11904-60001
2.4 mm (m) to 2.92 mm (f)	1	11904-60003
2.4 mm (f) to 2.92 mm (m)	1	11904-60004
2.4 mm (f) to 2.92 mm (f)	1	11904-60002
5/16 in., 90 N-cm (8 in-lb) Torque	1	8710-1765
5/16 in., 56 N-cm (5 in-lb) Torque	1	8710-1582
7 mm Open-end	1	8710-1761
2.4 mm Sliding Load (m)	1	00915-60003
2.4 mm Sliding Load (f)	1	00915-60004
2.4 mm (m/f) Gage Set	1	11752E
Centering Bead (for gaging 2.4 mm sliding load)	2	85056-20001
Tube Package	1	15040-0803

Coaxial Mechanical Calibration Kits

HP 85056D Economy Mechanical Calibration Kit, 2.4 mm

The HP 85056D economy mechanical calibration kit contains precision standard devices to characterize the systematic errors of the HP 8720 series or 8510C network analyzer system in the 2.4mm interface. This kit also contains adapters to change the sex of the test port and a torque wrench for proper connection. Included are standards definitions on disk for the 8510C. Connector gages may be ordered separately.

Electrical Specifications

Device	Frequency (GHz)	Parameter	Specifications
Broadband Loads	DC to ≤4	Return Loss	≥42dB (≤0.00794ρ)
	> 4 to ≤20	Return Loss	≥34 dB (≤0.01995ρ)
	> 20 to ≤26.5	Return Loss	≥30 dB (≤0.03163ρ)
	> 26.5 to ≤50	Return Loss	≥30 dB (≤0.05019ρ)
Adapters (2.4 mm to 2.4 mm)	DC to ≤4	Return Loss	≥32dB (≤0.02512ρ)
	> 4 to ≤26.5	Return Loss	≥30 dB (≤0.03162ρ)
	> 26.5 to ≤40	Return Loss	≥25 dB (≤0.05623ρ)
	> 40 to ≤50	Return Loss	≥20 dB (≤0.01000ρ)
Offset Opens	DC to ≤2	Deviation from Nominal:	±0.5°
	> 2 to ≤20	Deviation from Nominal:	±1.25°
	> 20 to ≤40	Deviation from Nominal:	±1.75°
	> 40 to ≤50	Deviation from Nominal:	±2.25°
Offset Shorts	DC to ≤2	Deviation from Nominal:	±0.5°
	> 2 to ≤20	Deviation from Nominal:	±1.25°
	> 20 to ≤40	Deviation from Nominal:	±1.5°
	> 40 to ≤50	Deviation from Nominal:	±2.0°

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
2.4 mm Broadband Load (m)	1	00901-60003
2.4 mm Broadband Load (f)	1	00901-60004
2.4 mm Offset Short (m)	1	85056-60020
2.4 mm Offset Short (f)	1	85056-60021
2.4 mm Offset Open (m)	1	85056-60022
2.4 mm Offset Open (f)	1	85056-60023
2.4 mm (m) to 2.4 mm (m)	1	85056-60005
2.4 mm (m) to 2.4 mm (f)	1	85056-60006
2.4 mm (f) to 2.4 mm (f)	1	85056-60007
5/16 in., 90 N-cm (8 in-lb) Torque	1	8710-1765
7 mm Open-end	1	8710-1761

Coaxial Mechanical Calibration Kits

HP 85056A Calibration Kit

The HP 85056A 2.4 mm calibration kit is used to calibrate network analyzer systems (such as the HP 8510 or HP 8722) for measurements of components with 2.4 mm connectors up to 50 GHz.

Electrical Specifications

Device	Frequency (GHz)	Parameter	Specifications
Broadband Loads	DC to ≤4	Return Loss	≥42dB (≤0.00794ρ)
	> 4 to ≤20	Return Loss	≥34 dB (≤0.01995ρ)
	> 20 to≤26.5	Return Loss	≥30 dB (≤0.03163ρ)
	> 26.5 to ≤50	Return Loss	≥30 dB (≤0.05019ρ)
Sliding Loads	4 to ≤20	Return Loss	≥42dB (≤0.00794ρ)
	> 20 to ≤36	Return Loss	≥40 dB (≤0.01000ρ)
	> 36 to ≤40	Return Loss	≥38 dB (≤0.01259ρ)
	> 40 to ≤50	Return Loss	≥36 dB (≤0.01585ρ)
Adapters (2.4 mm to 2.4 mm)	DC to ≤4	Return Loss	≥32dB (≤0.02512ρ)
	> 4 to ≤26.5	Return Loss	≥30 dB (≤0.03162ρ)
	> 26.5 to ≤40	Return Loss	≥25 dB (≤0.05623ρ)
	> 40 to ≤50	Return Loss	≥20 dB (≤0.01000ρ)
Offset Opens	DC to ≤2	Deviation from Nominal:	±0.5°
	> 2 to ≤20	Deviation from Nominal:	±1.25°
	> 20 to ≤40	Deviation from Nominal:	±1.75°
	> 40 to ≤50	Deviation from Nominal:	±2.25°
Offset Shorts	DC to ≤2	Deviation from Nominal:	±0.5°
	> 2 to ≤20	Deviation from Nominal:	±1.25°
	> 20 to ≤40	Deviation from Nominal:	±1.5°
	> 40 to ≤50	Deviation from Nominal:	±2.0°

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
2.4 mm Sliding Load (m)	1	00915-60003
2.4 mm Sliding Load (f)	1	00915-60004
2.4 mm Broadband Load (m)	1	00901-60003
2.4 mm Broadband Load (f)	1	00901-60004
2.4 mm Offset Short (m)	1	85056-60020
2.4 mm Offset Short (f)	1	85056-60021
2.4 mm Offset Open (m)	1	85056-60022
2.4 mm Offset Open (f)	1	85056-60023
2.4 mm (m) to 2.4 mm (m)	1	85056-60005
2.4 mm (m) to 2.4 mm (f)	1	85056-60006
2.4 mm (f) to 2.4 mm (f)	1	85056-60007
5/16 in., 90 N-cm (8 in-lb) Torque	1	8710-1765
7 mm Open-end	1	8710-1761

Coaxial Mechanical Calibration Kits

HP 85059A Precision Calibration/Verification Kit, 1.0 mm

The HP 85059A is a 1.0 mm calibration/verification kit designed for vector network analyzer systems operating over the frequency range of 45 MHz to 110 GHz. The opens, shorts and loads in this kit were optimized to provide accurate calibrations over the specified frequency range. For best results, the calibration techniques recommended are the open-short-load-thru (OSLT) calibration from 45 MHz to 50 GHz, and the offset-shorts calibration from 50 GHz to 110 GHz, all in one calibration sequence.

Electrical Specifications for 1.0 mm 50 ohm Devices

Device	Frequency (GHz)	Parameter	Specifications Male	Female
Loads	DC to 2 GHz	Return Loss	30 dB	30 dB
	2 GHz to 18 GHz		30 dB	30 dB
	18 GHz to 40 GHz		26 dB	26 dB
	40 GHz to 50 GHz		24 dB	24 dB
Opens	DC to 2 GHz	Deviation from	±1.0°	±1.0°
	2 GHz to 18 GHz	Nominal Phase	±1.5°	±3.0°
	18 GHz to 50 GHz		±2.5°	±4.0°
Short 3	DC to 2 GHz	Deviation from	±0.8°	±1.0°
	2 GHz to 18 GHz	Nominal Phase	±1.2°	±2.0°
	18 GHz to 50 GHz		±1.5°	±2.5°
	50 GHz to 110 GHz		±3.0°	±5.0°
Short 1	50 GHz to 110 GHz	Deviation from Nominal Phase	±2.5°	±4.0°
Short 2	75 GHz to 110 GHz	Deviation from Nominal Phase	±2.5°	±4.0°
Short 4	50 GHz to 75 GHz	Deviation from Nominal Phase	±2°	±4.5°

Device	Frequency (GHz)	Parameter	Specifications
Lossy Delay Line	DC to 110 GHz	Return Loss	18 dB
Adapters	DC to 20 GHz	Return Loss	24 dB
	20 GHz to 50 GHz		20 dB
	50 GHz to 75 GHz		18 dB
	75 GHz to 110 GHz		14 dB
Verification Match Thru (adapter)	DC to 20 GHz	Return Loss	24 dB
	20 GHz to 50 GHz		20 dB
	50 GHz to 75 GHz		18 dB
	75 GHz to 110 GHz		14 dB
Verification Mismatch Thru (adapter)	DC to 110 GHz	Return Loss	6 dB @ ~22.6 GHz intervals

Coaxial Mechanical Calibration Kits

HP 85059A Precision Calibration/Verification Kit, 1.0 mm (continued)

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
Shorts:		
M Short 3	1	85059-60003
F Short 3	1	85059-60007
M Short 4	1	85059-60004
F Short 4	1	85059-60008
M Short 2	1	85059-60002
F Short 2	1	85059-60006
M Short 1	1	85059-60001
F Short 1	1	85059-60005
Opens:		
Male Open	1	85059-60009
Female Open	1	85059-60010
Loads:		
Male Load	1	85059-60019
Female Load	1	85059-60020
Lossy Delay Line	2	85059-60021
Adapters:		
Male to Male Adapter	1	11920-60001
Female to Female Adapter	1	11920-60002
Male to Female Adapter	1	11920-60003
Cables:		
Female to Female Cable (8.8 cm)	1	11500-60001
Verification Devices		
Mismatched Thru Adapter	1	85059-60016
Matched Thru Adapter	1	85059-60017
Wrenches		
6 mm 4 in-lb Torque	1	8710-2079
6 mm Open-end	1	8710-2156

Waveguide Mechanical Calibration Kits

HP X11644A WR-90 Mechanical Calibration Kit, 8.2 GHz to 12.4 GHz

The HP X11644A calibration kit contains the precision mechanical standards required to calibrate the systematic errors of the HP 8510C or 8720 series network analyzer systems. This calibration kit has a precision 50 ohm airline for performing the Thru-Reflect-Line (TRL) calibration, the most accurate error-correction technique for coaxial measurements. This kit also contains flush-short-circuit, a precision shim, and a fixed termination.

Electrical Specifications

Device	Specifications
Frequency Range	8.2 to 12.4 GHz
Termination	≥42 dB Return Loss

Adapter Characteristics

SWR	<1.05
Insertion Loss	0.08 dB
Center Conductor	0.0076 to 0.038 mm
Pin Recession Tolerance	(0.0003 to 0.015 in)
Equivalent Flange Type	UG-135/U

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
Termination	2	00910-60003
Short	1	11644-20018
¼ Wavelength Shim	1	11644-20021
7 mm Coax-to-Waveguide Adapter (f)	2	K281C
Standard Section	1	00896-60008
Alignment Pin	6	11644-20024
Slip Pin	6	11644-20025
8-32 Pozi Dr Screw 0.625 inches long	6	2510-0109
8-32 Pozi Dr Screw 1.0 inches long	6	2510-0115
#8 Lock Washer	12	2190-0009
8-32 Hex Nut	12	2580-0002
¼ Wrench	1	8720-0014

Waveguide Mechanical Calibration Kits

HP P11644A WR-62 Mechanical Calibration Kit, 12.4 GHz to 18.0 GHz

The HP P11644A calibration kit contains the precision mechanical standards required to calibrate the systematic errors of the HP 8510C or 8720 series network analyzer systems. This calibration kit has a precision 50 ohm airline for performing the Thru-Reflect-Line (TRL) calibration, the most accurate error-correction technique for coaxial measurements. This kit also contains flush short circuit, a precision shim, and a fixed termination.

Electrical Specifications

Device	Specifications
Frequency Range	8.2 to 12.4 GHz
Termination	≥42 dB Return Loss

Adapter Characteristics

SWR	<1.06
Insertion Loss	0.10 dB
Center Conductor	0.0076 to 0.038 mm
Pin Recession Tolerance	(0.0003 to 0.015 in)
Equivalent Flange Type	UG-419/U

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
Termination	2	00910-60002
Short	1	11644-20017
¼ Wavelength Shim	1	11644-20020
7 mm Coax-to-Waveguide Adapter (f)	2	P281C
Standard Section	1	00896-60007
Alignment Pin	6	11644-20023
Slip Pin	6	11644-20025
6-32 Pozi Dr Screw 0.562 inches long	6	2360-0229
6-32 Pozi Dr Screw 0.875 inches long	6	2360-0207
#8 Lock Washer	12	2190-0007
6-32 Hex Nut	12	2420-0003
¼ Wrench	1	8720-0014

Waveguide Mechanical Calibration Kits

HP K11644A WR-42 Mechanical Calibration Kit, 18 GHz to 26.5 GHz

The HP K11644A calibration kit contains the precision mechanical standards required to calibrate the systematic errors of the HP 8510C or 8720 series network analyzer systems. This calibration kit has a precision 50 ohm airline for performing the Thru-Reflect-Line (TRL) calibration, the most accurate error-correction technique for coaxial measurements. This kit also contains flush shortcircuit, a precision shim, and a fixed termination.

Electrical Specifications

Device	Specifications
Frequency Range	18 to 26.5 GHz
Termination	≥42 dB Return Loss

Adapter Characteristics

SWR	<1.07
Insertion Loss	0.12 dB
Center Conductor	0.0076 to 0.038 mm
Pin Recession Tolerance	(0.0003 to 0.015 in)
Equivalent Flange Type	UG-597/U

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
Termination	2	00910-60001
Short	1	11644-20016
1/4 Wavelength Shim	1	11644-20019
3.5 mm Coax-to-Waveguide Adapter (m)	1	K281C opt 12
3.5 mm Coax-to-Waveguide Adapter (f)	1	K281C
Standard Section	1	00896-60006
Alignment Pin	6	11644-20022
Slip Pin	6	11644-20027
4-40 Pozi Dr Screw 0.750 inches long	12	2200-0151
Lock Washer M2.5	12	2190-0643
4-40 Hex Nut	12	2260-0002
3/16 Wrench	1	8720-0013

Waveguide Mechanical Calibration Kits

HP R11644A WR-28 Mechanical Calibration Kit, 26.5 GHz to 40 GHz

The HP R11644A calibration kit contains the precision mechanical standards required to calibrate the systematic errors of the HP 8510C or HP 8720 series network analyzer systems. This calibration kit has a precision 50 ohm airline for performing the Thru-Reflect-Line (TRL) calibration, the most accurate error-correction technique for coaxial measurements. This kit also contains flush short circuit, a precision shim, and a fixed termination.

Electrical Specifications

Device	Specifications
Frequency Range	26.5 to 40 GHz
Termination	≥46 dB Effective Return Loss

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
Standard Section (5 cm)	2	11644-60016
Standard Section (10 cm)	2	11644-60001
Waveguide Load	1	00914-60028
Short	1	11644-20005
R-band Shim	1	11644-20003
Alignment Pin	6	11644-20009
Slip Pin	6	11644-20006
4-40 Hex Nut .094 inches thick	12	2260-0002
4-40 SKT HD Screw .750 inches long	12	3030-0721
Lock Washer .115 inches	12	2190-0030
Open End Wrench	1	8720-0013
Hex Ball	1	8710-1539

Waveguide Mechanical Calibration Kits

HP Q11644A WR-22 Mechanical Calibration Kit, 33 GHz to 50 GHz

The HP Q11644A calibration kit contains the precision mechanical standards required to calibrate the systematic errors of the HP 8510C network analyzer system. This calibration kit has a precision 50 ohm airline for performing the Thru-Reflect-Line (TRL) calibration, the most accurate error-correction technique for coaxial measurements. This kit also contains flush short circuit, a precision shim, and a fixed termination.

Electrical Specifications

Device	Specifications
Frequency Range	30 to 50 GHz
Termination	≥46 dB Effective Return Loss

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
Q-band Standard Section (5 cm)	2	11644-60017
Q-band Standard Section (10 cm)	2	11644-60002
Q-band Waveguide Load	1	11644-60005
Q-band Shim	1	11644-20001
Short (Q-band)	1	11644-20004
Alignment Pin	6	11644-20008
Slip Pin	6	11644-20006
4-40 SKT HD Screw .500 inches long	12	3030-0209
4-40 Captive Screw .43 inches long	12	1390-0764
4-40 Captive Screw .31 inches long	24	1390-0671
Hex Ball	1	8710-1539

Waveguide Mechanical Calibration Kits

HP U11644A WR-19 Mechanical Calibration Kit, 40 GHz to 60 GHz

The HP U11644A calibration kit contains the precision mechanical standards required to calibrate the systematic errors of the HP 8510C network analyzer system. This calibration kit has a precision 50 ohm airline for performing the Thru-Reflect-Line (TRL) calibration, the most accurate error-correction technique for coaxial measurements. This kit also contains flush short circuit, a precision shim, and a fixed termination.

Electrical Specifications

Device	Specifications
Frequency Range	40 to 60 GHz
Termination	≥46 dB Effective Return Loss

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
U-band Standard Section (5 cm)	2	11644-60018
U-band Standard Section (10 cm)	2	11644-60003
U-band Waveguide Load	1	11644-60006
U-band Shim	1	11644-20002
Short (U-band)	1	11644-20004
Alignment Pin	6	11644-20008
Slip Pin	6	11644-20006
4-40 SKT HD Screw .500 inches long	12	3030-0209
4-40 Captive Screw .43 inches long	12	1390-0764
4-40 Captive Screw .31 inches long	24	1390-0671
Hex Ball	1	8710-1539

Waveguide Mechanical Calibration Kits

HP V11644A WR-15 Mechanical Calibration Kit, 50 GHz to 75 GHz

The HP V11644A calibration kit contains the precision mechanical standards required to calibrate the systematic errors of the HP 8510C network analyzer system. This calibration kit has a precision 50 ohm airline for performing the Thru-Reflect-Line (TRL) calibration, the most accurate error-correction technique for coaxial measurements. This kit also contains flush short circuit, a precision shim, and a fixed termination.

Electrical Specifications

Device	Specifications
Frequency Range	50 to 75 GHz
Termination	≥38.2 dB Return Loss
Element SWR	±1.025

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
V-band Fixed Load	1	11643-60025
V-band Standard Section	3	11644-60012
V-band Shim	1	11644-20013
Short (V-band)	1	11644-20015
Slip Pin	6	11644-20007
4-40 Captive Screw .41 inches long	12	1390-0765
4-40 Captive Screw .31 inches long	24	1390-0671
Hex Ball	1	8710-1539

Waveguide Mechanical Calibration Kits

HP W11644A WR-10 Mechanical Calibration Kit, 75 GHz to 110 GHz

The HP W11644A calibration kit contains the precision mechanical standards required to calibrate the systematic errors of the HP 8510C network analyzer system. This calibration kit has a precision 50 ohm airline for performing the Thru-Reflect-Line (TRL) calibration, the most accurate error-correction technique for coaxial measurements. This kit also contains flush short circuit, a precision shim, and a fixed termination.

Electrical Specifications

Device	Specifications
Frequency Range	75 to 110 GHz
Termination	≥36.6 dB Return Loss
Element SWR	±1.03

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
W-band Fixed Load	1	11643-60026
W-band Standard Section	3	11644-60013
W-band Shim	1	11644-20014
Short (W-band)	1	11644-20015
Slip Pin	6	11644-20007
4-40 Captive Screw .41 inches long	12	1390-0765
4-40 Captive Screw .31 inches long	24	1390-0671
Hex Ball	1	8710-1539

Coaxial Electronic Cal Kits

Parts for Type-N 50 ohm ECal Modules

Description	Qty	HP Part Number
HP 85064B 1GHz to 18 GHz Microwave ECal Modules		
Insertable (Standard)	1	85064-60002
Non-Insertable Male (Option 00M)	1	85064-60004
Non-Insertable Female (Option 00F)	1	85064-60006
HP 85092A 30 kHz to 6 GHz RF ECal Modules		
Insertable (85064B Option 001 or 85092A)	1	85092-60001
Non-Insertable Male (85064B Option 001 and Option 00M or 85092A Option 00M)	1	85092-60002
Non-Insertable Female (85064B Option 001 and Option 00F or 85092A Option 00F)	1	85092-60003
Adapters (added with option 00A)		
Type-N Female-to-Female	1	85054-60037
Type-N Male-to-Male	1	85054-60038

Parts for 3.5mm ECal Modules

Description	Qty	HP Part Number
HP 85062B 1GHz to 26.5 GHz Microwave ECal Modules		
Module with Male/Female Connectors (standard)	1	85062-60002
Module with Male/Male Connectors (option 00M)	1	85062-60004
Module with Female/Female Connectors (option 00F)	1	85062-60006
HP 85093A 30 kHz to 6 GHz RF ECal Modules		
Module with Male/Female Connectors (85062B option 001 or 85093A)	1	85093-60001
Module with Male/Male Connectors (85062B option 001 and 00M, or 85093A option 00M)	1	85093-60002
Module with Female/Female Connectors (85062B option 001 and 00F, or 85093A option 00F)	1	85093-60003
Adapters (added with option 00A)		
3.5 mm Female/Female	1	85052-60012
3.5 mm Male/Male	1	85052-60014

Electronic calibration (ECal) is a precision, single-connection, one or two-port calibration technique for your HP vector network analyzer. HP ECal modules use fully-traceable and verifiable electronic impedance standards. The modules are state-of-the-art, solid-state devices with programmable and highly repeatable impedance states. ECal modules are transfer standards that provide consistent calibrations and eliminate operator errors while bringing convenience and simplicity to your calibration routine. Consistent calibrations provide consistent measurements.

ECal replaces the traditional calibration technique which uses mechanical standards. With mechanical standards you are required to make numerous connections to the test ports for a single calibration. These traditional calibrations require intensive operator interaction, which are prone to error. With ECal, a full two-port calibration can be accomplished with a single connection to the ECal module and minimal operator interaction. This results in faster and more repeatable calibrations, and less wear on the connectors—and on you. Calibrations for non-insertable devices are equally convenient and straightforward.

Coaxial Electronic Cal Kits

ECal modules and available options[A, B]

Connector type[1]	Frequency Range	ECal module Model Number	Available Options
7 mm	30 kHz to 6 GHz[2]	**HP 85091A**	1BN, 1BP, 910, UK6
7 mm	1 GHz to 18 GHz	**HP 85060B**	001, 1BN, 1BP, 910, UK6
Type-N	30 kHz to 6 GHz[2]	**HP 85092A**	00F, 00M, 00A, 1BN, 1BP, 910, UK6
Type-N	1 GHz to 18 GHz	**HP 85064B**	001, 00F, 00M, 00A, 1BN, 1BP, 910, UK6
3.5 mm	30 kHz to 6 GHz[2]	**HP 85093A**	00F, 00M, 00A, 1BN, 1BP, 910, UK6
3.5 mm	1 GHz to 26.5 GHz	**HP 85062B**	001,00F, 00M, 00A, 1BN, 1BP, 910, UK6

Options

Option	Description
001	Adds a 30 kHz to 6 GHz RF module[2]
00F	Replace f/m connectors on ECal module(s) with f/f connectors
00M	Replace f/m connectors on ECal module(s) with m/m connectors
00A	Adds male-to-male and female-to-female adapters (also adds a 5/16" 90 N-cm [8 in-lb] torque wrench to 3.5 mm modules)
1BN	Mil-STD 45662 calibration certificate
1BP	Mil-STD 45662 calibration certificate with measured data
910	Add an extra operating and service manual
UK6	Commercial calibration certificate with measured data

HP 85097A PC interface kit

Ordering information

Select an ECal module based on the connector type required and the frequency range of your HP vector network analyzer (refer to table at right).

Order an HP 85097A PC interface module with control software to drive all HP ECal modules. If you will be using the HP 85097A to control an older HP 85060 series module with serial number below 800, the module will require a slight modification by an HP service center.

PC requirements

The HP 85097A requires a customer-supplied PC meeting the followingminimum requirements:

- Windows ® 95, Windows NT ® 4.0 or later operating system
- 486 or later CPU
- 32 MB of RAM
- 10 MB available hard-disk space
- One of the following HP-IB interface cards: HP 82340A/B, 82341C/D, National AT-GPIB/TNT, National AT-GPIB/TNT (plug-and-play) or National PCI-GPIB

[1] For ECal modules with sexed (m-f) connectors, the standard modules have one female and one male connector.

[2] RF ECal modules are specified to operate from 300 kHz to 6 GHz, with typical performance down to 30 kHz.

[A] HP 85060 series modules cover a frequency range of 1 GHz to either 18 or 26.5 GHz. The upper frequency is limited by the connector cutoff frequency. Each module is supplied with a torque wrench and foam-padded wood storage box.

[B] HP 85090 series modules cover a frequency range of 30 kHz to 6 GHz. Each module is supplied with a torque wrench and foam-padded wood storage box.

Coaxial Electronic Cal Kits

ECal module specifications and characteristics

Specifications describe product performance covered by the product warranty over a temperature range of 0° C to +55° C.
Characteristics describe performance that is useful in the application of the product, but not warranted. Typical values describe non-warranted performance that most units will exhibit. **Characteristics and typical values are shown in italics.**

	HP 85091A[1]	HP 85092A[1]	HP 85093A[1]	HP 85060B	HP 85062B	HP 85064B
Frequency range						
Standard	30 kHz - 6 GHz	30 kHz - 6 GHz	30 kHz - 6 GHz.	1 - 18 GHz.	1 - 26.5 GHz.	1 - 18 GHz.
Option 001[1,2]	N/A.	N/A.	N/A.	30 kHz - 18 GHz	30 kHz - 26.5 Hz	30 kHz - 18 GHz
Maximum power	+20 dBm	+20 dBm	+20 dBm	+20 dBm	+20 dBm	+20 dBm
Minimum power	–45 dBm	–45 dBm	–45 dBm	–45 dBm	–45 dBm	–45 dBm
Connectors						
Standard	7 mm	Type-N (m-f)	3.5 mm (m-f)[3]	7 mm	3.5 mm (m-f)[3]	Type-N (m-f)
Option 00F	N/A	Type-N (f-f)	3.5 mm (f-f)	N/A	3.5 mm (f-f)	Type-N (f-f)
Option 00M	N/A	Type-N (m-m)	3.5 mm (m-m)	N/A	3.5 mm (m-m)	Type-N (m-m)

Measurement port specifications[4] (Residual e-terms)

7 mm ECal modules

RF ECal module

HP 85091A	Frequency range			
	30 kHz to 300 kHz (typical)	300 kHz to 300 MHz	300 MHz to 3 GHz	3 GHz to 6 GHz
Directivity (dB)	–52	–52	–56	–55
Source match (dB)	–45	–45	–45	–42
Reflection tracking (±dB)	.05	.038	.038	.068
Transmission tracking (±dB)	0.14	.060	0.055	0.085
Load match (dB)	–41	–48	–47	–46

Microwave ECal module

HP 85060B	Frequency range (GHz)		
	1 to 2	2 to 8	8 to 18
Directivity (dB)	–50	–49	–46
Source match (dB)	–46	–45	–40
Reflection tracking (±dB)	.032	.046	.065
Transmission tracking (±dB)	.043	.050	0.14
Load match (dB)	–46	–44	–40

Option 001	Add RF ECal Module (30 kHz to 6 GHz)	See HP 85091A specifications

[1] Performance is specified from 300 kHz to 6 GHz and typical from 30 kHz to 300 kHz.

[2] Option 001 adds an RF ECal module (30 kHz - 6 GHz)

[3] 3.5 mm modules have precision slotless connectors that guarantee the best calibration accuracy is transferred to your system.

[4] Specifications include the effects of the following environmental conditions: sine vibration, random vibration, storage survival, operating temperature stability, shock and humidity.

Coaxial Electronic Cal Kits

Type-N ECal modules

RF ECal module

HP 85092A	Frequency range			
	30 kHz to 300 kHz (typical)	300 kHz to 300 MHz	300 MHz to 3 GHz	3 GHz to 6 GHz
Directivity (dB)	–52	–52	–54	–52
Source match (dB)	–45	–45	–45	–42
Reflection tracking (±dB)	0.05	0.037	0.037	0.068
Transmission tracking (±dB)	0.14	0.060	0.055	0.090
Load match (dB)	–41	–48	–47	–44

Microwave ECal module

HP 85064B	Frequency range (GHz)		
	1 to 2	2 to 8	8 to 18
Directivity (dB)	–50	–49	–46
Source match (dB)	–46	–45	–40
Reflection tracking (±dB)	0.034	0.046	0.065
Transmission tracking (±d	0.043	0.050	0.14
Load match (dB)	–46	–44	–40

Option 001	Add RF ECal Module (30 kHz to 6 GHz)	See HP 85092A specifications

3.5 mm ECal modules[3]

RF ECal module

HP 85093A	Frequency range			
	30 kHz to 300 kHz (typical)	300 kHz to 300 MHz	300 MHz to 3 GHz	3 GHz to 6 GHz
Directivity (dB)	–52	–50	–52	–50.5
Source match (dB)	–45	–45	–43	–40
Reflection tracking (±dB)	0.05	0.043	0.043	0.055
Transmission tracking (±dB)	0.14	0.050	0.045	0.085
Load match (dB)	–41	–48	–47	–44

Microwave ECal module

HP 85062B	Frequency range (GHz)			
	1 to 2	2 to 8	8 to 20	20 to 26.5
Directivity (dB)	–48	–49	–46	–44
Source match (dB)	–45	–43	–40	–37
Reflection tracking (±dB)	0.041	0.041	0.064	0.088
Transmission tracking (±dB)	0.048	0.068	0.13	0.17
Load match (dB)	–45	–43	–40	–38

Option 001	Add RF ECal Module (30 kHz to 6 GHz)	See HP 85093A specifications

[3] 3.5 mm modules have precision slotless connectors that guarantee the best calibration accuracy is transferred to your system.

Mechanical Verification Kits

HP 85055A Verification Kit, Type-N

The HP 85055A Type-N verification kit is used with an HP 85054B Type-N calibration kit, and Network Analyzers such as the HP 8510, HP 8719, or HP 8720 Series. Use the HP 85055A verification kit to verify that your network analyzer system is working within its specifications, and that you have performed a valid measurement calibration. This verification kit is traceable to the U.S. National Institute of Standards and Technology (NIST).

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
20 dB Attenuator with data	1	85055-60003
50 dB Attenuator with data	1	85055-60004
50 ohm Airline with data	1	85055-60006
20 ohm Mismatch Airline with data	1	85055-60007
Open-End 5.5 wrench	1	8710-1770

HP 85029B Verification Kit, 7 mm

Measuring known devices, other than the calibration standards, is a convenient way of verifying that the HP 8753 measurement system is operating properly. The HP 85029B verification kit contains a set of precision 7 mm devices, with data traceable to NIST, used to verify the calibrated performance of an HP 8753 measurement system. The devices have precision 7 mm connectors and include a 20 dB pad, a 50 dB pad, and a mismatch attenuator. The verification process requires only an HP 85031B calibration kit, and an HP 85029B verification kit. Option 001 is intended solely for use with the HP 8702B lightwave component analyzer. Option 001 adds verification data that is compatible with the HP 8702B.

Replaceable Parts

The three attenuators are separately available and should be ordered by the numbers given below. Each of these devices has a serial number and the kit has a serial number. All four serial numbers appear on the verification disc label.

Description	HP Part Number
7mm mismatch attenuator	85029-60004
7mm 20dB attenuator	85029-60005
7mm 50dB attenuator	85029-60006

Mechanical Verification Kits

HP 85051B 7 mm Verification Kit

The HP 85051B 7 mm verification kit is used with an HP 85050 7 mm calibration kit, and Network Analyzers such as the HP 8510, HP 8719, or HP 8720 Series. Use the HP 85051B verification kit to verify that your network analyzer system is working within its specifications, and that you have performed a valid measurement calibration. This verification kit is traceable to the U.S National Institute of Standards and Technology (NIST).

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
20 dB Attenuator with data	1	85051-60001
50 dB Attenuator with data	1	85051-60002
50 ohm Airline with data	1	85051-60010
20 ohm Mismatch Airline with data	1	85051-60011
Open-End 5.5 wrench	1	8710-1770

HP 85053B Verification Kit, 3.5 mm

The HP 85053B 3.5 mm verification kit is used with an HP 85052 2.4 mm calibration kit, and Network Analyzers such as the HP 8510, HP 8719, or HP 8720 Series. Use the HP 85053B verification kit to verify that your network analyzer system is working within its specifications, and that you have performed a valid measurement calibration. This verification kit is traceable to the U.S National Institute of Standards and Technology (NIST).

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
20 dB Attenuator with data	1	85053-60001
40 dB Attenuator with data	1	85053-60002
50 ohm Airline with data	1	85053-60010
20 ohm Mismatch Airline with data	1	85053-60011

Mechanical Verification Kits

HP 85057B Verification Kit, 2.4 mm

The HP 85057B 2.4 mm verification kit is used with an HP 85056A 2.4 mm calibration kit, and Network Analyzers such as the HP 8510 or HP 8722. Use the HP 85057B verification kit to verify that your network analyzer system is working within its specifications, and that you have performed a valid measurement calibration. This verification kit is traceable to the U.S National Institute of Standards and Technology (NIST).

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
20 dB Attenuator with data	1	85057-60010
40 dB Attenuator with data	1	85057-60011
50 ohm Airline with data	1	85057-60008
20 ohm Mismatch Airline with data	1	85057-60009

HP R11645A W-28 Verification Kit

The HP R band millimeter-waveguide verification kit is used with the R11644A calibration kit, and network analyzer systems such as the HP 8510 and HP 85106. Use the R11645A series verification kit to verify that your network analyzer system is working within its specifications, and that you have performed a valid measurement calibration.This verification kit is traceable to the U.S National Institute of Standards and Technology (NIST).

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
20 dB Attenuator with data	1	11645-60021
50 dB Attenuator with data	1	11645-60022
50 ohm Airline with data	1	11645-60016
25 ohm Mismatch Airline with data	1	11645-60011
Lock Washer	6	2190-0030
Hex Nut	6	2260-0002
Waveguide Alignment Pin (short)	6	11644-20009
Waveguide Alignment Pin (long)	6	11644-20006
4-40 Hex Ball Screw 0.75 inches long	6	3030-0721
3/32-inch Hex Ball Driver	1	8710-1539

Mechanical Verification Kits

HP Q11645A W-22 Verification Kit

The HP Q band millimeter-waveguide verification kit is used with the Q11644A calibration kit, and network analyzer systems such as the HP 8510 and HP 85106. Use the Q11645A series verification kit to verify that your network analyzer system is working within its specifications, and that you have performed a valid measurement calibration. This verification kit is traceable to the U.S National Institute of Standards and Technology (NIST).

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
20 dB Attenuator with data	1	11645-60023
50 dB Attenuator with data	1	11645-60024
50 ohm Airline with data	1	11645-60017
25 ohm Mismatch Airline with data	1	11645-60012
4-40 Captive Screw 0.31 inch	6	1390-0671
4-40 Captive Screw 0.43 inch	6	1390-0764
Waveguide Alignment Pin (short)	6	11644-20008
Waveguide Alignment Pin (long)	6	11644-20006
3/32-inch Hex Ball Driver	1	8710-1539

HP U11645A W-19 Verification Kit

The HP U band millimeter-waveguide verification kit is used with the U11644A calibration kit, and network analyzer systems such as the HP 8510 and HP 85106. Use the U11645A series verification kit to verify that your network analyzer system is working within its specifications, and that you have performed a valid measurement calibration. This verification kit is traceable to the U.S National Institute of Standards and Technology (NIST).

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
20 dB Attenuator with data	1	11645-60025
50 dB Attenuator with data	1	11645-60006
50 ohm Airline with data	1	11645-60018
25 ohm Mismatch Airline with data	1	11645-60013
4-40 Captive Screw 0.31 inch	6	1390-0671
4-40 Captive Screw 0.43 inch	6	1390-0764
Waveguide Alignment Pin (short)	6	11644-20008
Waveguide Alignment Pin (long)	6	11644-20006
3/32-inch Hex Ball Driver	1	8710-1539

Mechanical Verification Kits

HP V11645A W-15 Verification Kit

The HP V band millimeter-waveguide verification kit is used with the V11644A calibration kit, and network analyzer systems such as the HP 8510 and HP 85106. Use the V11645A series verification kit to verify that your network analyzer system is working within its specifications, and that you have performed a valid measurement calibration. This verification kit is traceable to the U.S National Institute of Standards and Technology (NIST).

Replaceable Parts

Description	Qty Per Kit	HP Replacement Part Number
20 dB Attenuator with data	1	11645-60007
50 dB Attenuator with data	1	11645-60008
50 ohm Airline with data	1	11645-60019
25 ohm Mismatch Airline with data	1	11645-60014
4-40 Captive Screw 0.31 inch	6	1390-0671
4-40 Captive Screw 0.41 inch	6	1390-0765
Waveguide Alignment Pin V/W	6	11644-20007
3/32-inch Hex Ball Driver	1	8710-1539

HP W11645A W-10 Verification Kit

The HP W band millimeter-waveguide verification kit is used with the W11644A calibration kit, and network analyzer systems such as the HP 8510 and HP 85106. Use the W11645A series verification kit to verify that your network analyzer system is working within its specifications, and that you have performed a valid measurement calibration. This verification kit is traceable to the U.S National Institute of Standards and Technology (NIST).

Replaceable Parts

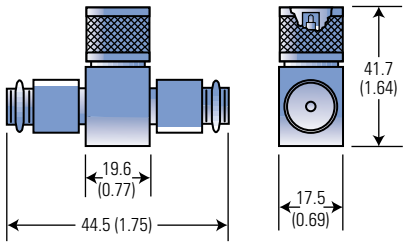
Description	Qty Per Kit	HP Replacement Part Number
20 dB Attenuator with data	1	11645-60009
50 dB Attenuator with data	1	11645-60010
50 ohm Airline with data	1	11645-60020
25 ohm Mismatch Airline with data	1	11645-60015
4-40 Captive Screw 0.31 inch	6	1390-0671
4-40 Captive Screw 0.41 inch	6	1390-0765
Waveguide Alignment Pin V/W	6	11644-20007
3/32-inch Hex Ball Driver	1	8710-1539

Power Dividers and Splitters

HP 11636A,B Power Dividers

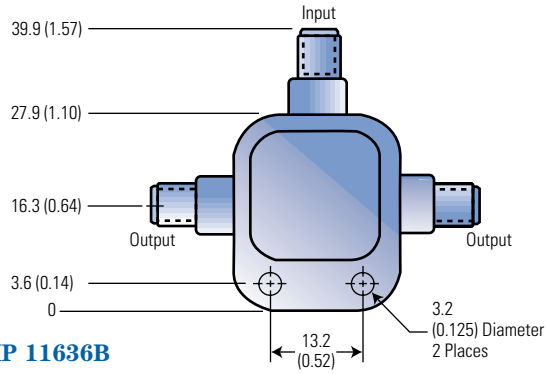
These power dividers provide good match and excellent tracking characteristics from dc to 26.5 GHz. Power dividers are recommended for applications such as transmission line fault testing, as well as power combining. They are not recommended for ratio and leveling applications.

HP 11636A

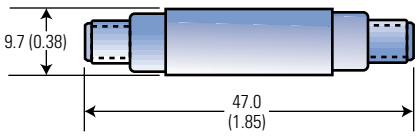


Dimensions are in mm (inches) nominal, unless otherwise specified.

HP 87302C



HP 11636B



Dimensions are in mm (inches) nominal, unless otherwise specified.

HP 87302/303/304C Hybrid Power Dividers

These power dividers are designed for power splitting applications that require minimal insertion loss and high isolation between ports. They are available in three models that cover multi-octave bands to 26.5 GHz. Models with narrower frequency coverage have less insertion loss. Hybrid dividers have insertion loss between the main line and output port which is 1 to 2 dB less than equivalent resistive power splitters. Designed for critical signal processing applications, phase and amplitude tracking between the two output ports is controlled and specified.

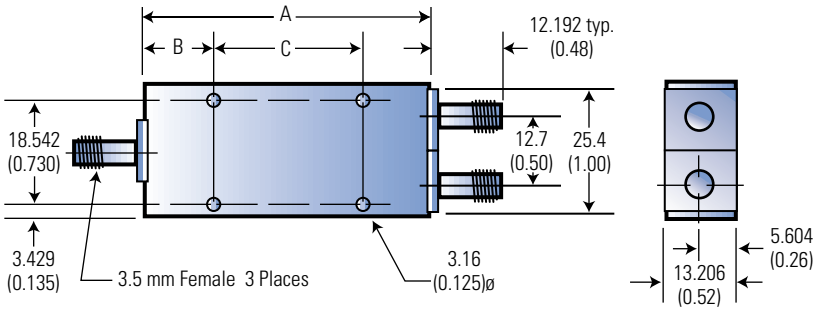
HP Model	Frequency Range (GHz)	Max. SWR	Maximum Insertion Loss (dB)	Minimum Isolation (dB)	Maximum Amplitude Tracking (dB) [1]	Maximum Phase Tracking Deg) [1]
11636A	dc to 18	1.35	6.0 typ. [2]		0.5 [3]	±2° typ.
11636B	dc to 18	1.29	7.5		0.25 [3]	±2° typ.
	18 to 26.5				0.5	
87302C	0.5 to 18	1.45	1.5	19	0.3	6
	18 to 26.5	1.60	1.9	19	0.5	10
87303C	1.0 to 18	1.45	1.2	19	0.3	6
	18 to 26.5	1.60	1.6	21	0.5	10
87304C	2.0 to 18	1.45	1.1	19	0.3	6
	18 to 26.5	1.60	1.4	18	0.5	10
11636A,B	1.0 W max					

Power Rating: 1 watt, CW (2:1 maximum load SWR)
Connectors: 3.5 mm (f), (SMA compatible)
Weight: 170 g (6 oz) net, 340 g (12 oz) shipping

[1] at 18 GHz.
[2] 5.8 to 7.2 dB up to 10 GHz; 5.8 to 7.5 dB up to18 GHz.
[3] Amplitude and phase tracking are the ratio of one output to the other in dB or degrees, respectively.

Power Dividers and Splitters

HP 87302/303/304C



HP Model	A	B	C
87302C	196.85 (7.75)	28.702 (1.13)	139.7 (5.50)
87303C	105.41 (4.15)	26.162 (1.03)	2.10 (53.34)
87304C	57.15 (2.25)	28.702 (1.13)	0.00 (0.00)

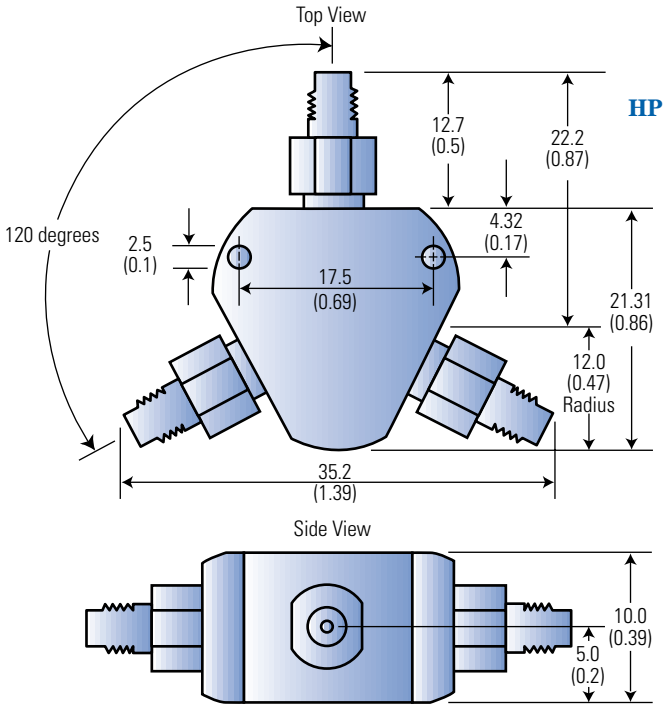
Dimensions are in mm (inches)
nominal, unless otherwise specified.

HP 11667A

HP 11667B

HP 11667A,B Power Splitters

These power splitters feature excellent match and tracking between outputs, operating from dc to 26.5 GHz. Power splitters are recommended for external source leveling and ratio measurements.



HP 11667C

HP 11667C Power Splitter

This two-resistor power splitter is recommended for applications that require external source leveling, or for ratio measurements. It covers the entire dc to 50 GHz frequency band by use of 2.4 mm connectors and advanced micro-circuitry for the resistive components. These two-resistor type splitters provide excellent output SWR at the auxiliary arm when used for source leveling or ratio measurement applications. The tracking between output arms over a frequency range from dc to 50 GHz allows wideband measurements to be made with a minimum of uncertainty.

Dimensions are in mm (inches) nominal, unless otherwise specified.

Power Dividers and Splitters

HP 11850C,D

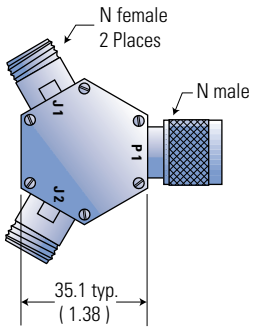
HP 11850C,D Power Splitter

These three-way power splitters are designed for source leveling or ratio measurements. One output port provides the reference for a leveling or ratio detector, while the other two ports can be used for two independent transmission measurements or a comparison measurement.

Specifications

HP Model	Frequency Range	Equivalent Output SWR (Nominal 50 Ω)	Maximum Input Power	Nominal Insertion Loss (Input to Either Output)	Tracking Between Any Two Ports	Connectors	Shipping Weight lb (kg)
11667A	dc to 18.0 GHz	1.10: dc to 4 GHz	0.5 W	7 dB	0.20 dB to 8 GHz	N (f) all ports	0.2 (0.5)
Option 001		1.20: dc to 8 GHz			0.25 dB to 18 GHz	**Opt. 001:** N (m) in, N (f) out	
Option 002		1.33: dc to 18 GHz				**Opt. 002:** N (f) in, APC-7 out	
11667B	dc to 26.5 GHz	1.22	0.5 W	7 dB	<0.25 dB	3.5 mm (f) all ports	0.14 (0.3)
11667C	dc to 50 GHz	1.65	0.5 W	8.5 dB	<0.40 dB	2.4 mm (f) all ports	0.14 (0.3)
11850C	dc to 3.0 GHz	1.22	0.1 W	9.5 dB + 1 dB/GHz	+0.25 dB, ±3 °	N (f) 50 Ω all ports	0.2 (0.5)
11850D	dc to 2 GHz	1.09		7.8 dB	±0.2 dB, ±2.5 °	N (f) 50 Ω in N (f) 75 Ω out	0.2 (0.5)

HP 0955-0751



Dimensions are in mm (inches) nominal, unless otherwise specified.

HP 0955-0751

HP 0955-0751 Power Splitter

This power splitter is recommended for most 50 Ω economy network analyzer applications. A two resistor splitter provides excellent output SWR at the auxiliary arm over frequency allowing wideband measurements to be made with minimum uncertainty. The frequency range is dc to 3 GHz. Tracking flatness is within ± 0.25 dB and ± 3 degrees of phase. Equivalent source match is 25 dB to 2 GHz and 20 dB to 3 GHz. Insertion loss is 6 dB. Input port match is 20 dB to 3 GHz. Connectors are type-N (f) output and type-N (m) input.

HP 0955-0752 Power Splitter

This 75 Ω power splitter has a frequency range from dc to 3 GHz. Tracking flatness is within ± 0.25 dB and ± 3 degrees of phase. Equivalent source match is 25 dB to 2 GHz and 20 dB to 3 GHz. Insertion loss is 6 dB. Input port match is 25 dB to 3 GHz. Connectors are type-N (m) input, type-N (f) output.

Power Sensors

HP 8480 Series Specifications

25 Watt Sensors 1mW to 25W (0 to +44dBm)

HP Model	Frequency Range	Maximum SWR	Power linearity [1]	Maximumx Power	Connector Type
8481B	10MHz to 18GHz	10MHz to 2GHz:1.10 2 to 12.4 GHz:1.18 12.4 to 18GHz:1.28	+35 to +44 dBm; +/-4%	0°to 35°C:30W avg [2] 35°to55°C:25W avg 0.01 to 5.8GHz:500W pk	Type-N(m)
8482B	100kHz to 4.2GHz	100kHz to 2 GHz: 1.10 2 to 4.2GHz:1.18		5.8 to 18GHz:125W pk 500 W-ms per pulse	Type-N(m)

3 Watt Sensors 100mW to 3W (-10 to +35 dBm)

8481H	10MHz to 18GHz	10MHz to 8GHz:1.20 8 to 12.4GHz:1.25 12.4 to 18GHz:1.30	+25 to +35dBm; +/-5%	3.5W avg,100W pk 100W-ms per pulse	Type-N(m)
8482H	100kHz to 4.2GHz	100kHz to 4.2GHz:1.20			Type-N(m)

100mW Sensors 1 mW to 100mW (-30 to +20 dBm)

8485A	50MHz to 26.5GHz	50 to 100MHz:1.15 100MHz to 2GHz:1.10	+10 to +20dBm; +2,-4% 2 to 2.4GHz:1.15 12.4 to 18GHz:1.20 18 to 26.5GHz:1.25	300mW avg,15W pk	APC-3.5mm(m) 30W-ms per pulse
Option 033	50MHz to 33GHz	26.5 to 33GHz:1.40			
8481A	10MHz to 18GHz	10 to 30MHz:1.40 30 to 50MHz:1.18 50MHz to 2GHz:1.10 2 to 12.4GHz:1.18 12.4 to 18GHz:1.28			Type-N(m)
8482A	100kHz to 4.2GHz	100 to 300kHz:1.60 0.3 to 1MHz:1.20 1MHz to 2GHz:1.10 2 to 4.2GHz:1.30			Type-N(m)
8483A (75Ω)	100kHz to 2GHz	100 to 600kHz:1.80 600kHz to 2GHz:1.18		300mW avg, 10W pk	Type-N(m) (75Ω)
R8486A	26.5 to 40GHz	1.4	+10 to +20dBm; +2, -4%	300mW avg, 15W pk 30W-ms per pulse	Waveguide Flange UG-599/U
Q8486A	33 to 50GHz	1.5			Waveguide Flange UG-383/U
V8486A	50 to 75GHz	1.06	+1,-3%	200mW avg 50W peak	Waveguide Flange UG-385/U
W8486A	75 to 110GHz	1.08	+1, -3%	200mW avg 40W peak	Waveguide Flange UG-387/U
8487A	50MHz to 50GHz	50 to 100MHz:1.15 100MHz to 2GHz:1.10 2 to 12.4GHz:1.15 12.4 to 18GHz:1.20 18 to 26.5GHz:1.25 26.5 to 40GHz:1.30 40 to 50GHz:1.50	+10 to +20dBm; +2,-4%	300mW avg, 15W pk 30W-ms per pulse	2.4mm(m)

[1] Negligible deviation except for those power ranges noted.

[2] For pulses greater than 30W the maximum average power (P_a) is limited by the energy per pulse (E) in W -ms according to P_a=30-0.02E.

Power Sensors

High Sensitivity Sensors 100pW to 10mW (-70 to –20 dBm)

HP Model	Frequency Range	Maximum SWR	Power linearity[1]	Maximum power	Connector type
8481D[2,3]	10MHz to 18GHz	10 to 30MHz:1.40	-30 to –20dBm; 30MHz to 4GHz:1.15 4 to 10GHz:1.20 10 to 15GHz:1.30 15 to 18GHz:1.35	100mW avg +/-1%	Type-N(m) 100mW pk
8485D	50MHz to 26.5GHz	0.05 to 0.1GHz:1.19 0.1 to 4GHz:1.15	-30 to –20dBm; 4 to 12GHz:1.19 12 to 18GHz:1.25 18 to 26.5GHz:1.29	100mW avg +/-2%	APC-3.5mm(m) 100mW pk
Option 033	50MHz to 33GHz	26.5 to 33GHz:1.35			
8487D[2]	50MHz to 50GHz	0.05 to 0.1GHz:1.19 0.1 to 2GHz:1.15 2 to 12.4GHz:1.20 12.4 to 18GHz:1.29 18 to 34GHz:1.37 34 to 40GHz:1.61 40 to 50GHz:1.89	-30 to –20dBm; +/-2%	100mW pk 100mW avg	2.4mm(m)
R8486D[2]	26.5 to 40GHz	1.4	-30 to –25dBm; +/-3%	100mW avg or pk 40Vdc max	Waveguide Flange UG-599/U
Q8486D[2]	33 to 50GHz	1.4	-25 to –20dBm; +/-5%		Waveguide Flange UG-383/U

Wide Dynamic Range CW Sensors

E4412A	10MHz to 18GHz	10MHz to 30MHz:1.34 30MHz to 10GHz:1.22 10GHz to 18GHz:1.27	-70 to +10dBm +/-4%(25+/-5°C) -70 to +10dBm +/-8%(0 to 55°C) +10 to +20dBm +/-5.5%(25+/-5°C) +10 to +20dBm +/-11%(0+/-55°C)	200mW avg	Type-N(m)
E4413A	50MHz to 26.5GHz	50MHz to 2GHz:1.25 2GHz to18GHz:1.21 18GHz to 26.5GHz:1.26		200mW avg	Type-N(m)

[1] Negligible deviation except for those power ranges noted.
[2] Includes HP 11708A 30dB attenuator for calibrating against a 0dBm, 50MHz power reference. HP 11708A is factory set to 30dB +/-0.05 dB at 50MHz, traceable no NIST.SWR,1.05 at 50MHz.
[3] This sensor directly replaces the popular HP 8484A power sensor.

Spectrum Analyzer Accessories

HP 8447D

HP 11975A

HP 8449B

HP 8447 Series Amplifier (9 kHz to 1300 MHz)

These amplifiers feature low noise and wide bandwidths. They are ideal for improving spectrum analyzer sensitivity and noise figure while providing input isolation. Broad frequency coverage, flat frequency response, and low distortion ensure accurate measurements. See page 30 for specification summary.

HP 11975A Amplifier (2 to 8 GHz)

Used in stimulus-response systems, this amplifier allows a wide variety of sources to be leveled to ±1 dB and amplitude calibrated from +6 dBm to +16 dBm. As a preamplifier, its small signal gain varies between 9 and 15 dB depending upon frequency.

HP 8449B Preamplifier (1 to 26.5 GHz)

This high-gain, low-noise preamplifier increases the sensitivity of any RF/microwave spectrum analyzer for detection and analysis of very low level signals. The improved sensitivity can dramatically reduce measurement time. See page 31 for specification summary.

Spectrum Analyzer Accessories

HP 11694A 75 Ω Matching Transformer (3 to 500 MHz)

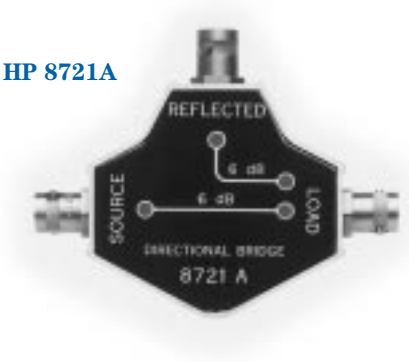
Allows measurements in 75 Ω systems while retaining amplitude calibration with a 50 Ω spectrum analyzer input. VSWR is less than 1.2; insertion loss is less than 0.75 dB. See Option 001 and 002 for 75 Ω versions of the HP 8590 series spectrum analyzer. Connectors are type BNC (m) 50Ω to BNC (f) 75Ω.

HP 11694A

HP 8721A Directional Bridge (100 kHz to 100 MHz)

Used in return-loss measurements made with a swept source such as a tracking generator and spectrum analyzer. This 50 Ω bridge (75 Ω option) has a 6 dB insertion loss and 6 dB coupled to the auxiliary arm. The frequency response is ±0.5 dB (0.1 to 110 MHz); directivity is >40 dB (1 to 110 MHz) and load-port return loss is >30 dB; maximum input power is + 20 dBm. See HP 86205/207A RF bridges for reflection measurements above 110 MHz.

HP 8721A



HP 85024A High Frequency Probe

Makes in-circuit measurements easy. Input capacitance of only 0.7 pF shunted by 1 MΩ resistance permits high frequency probing without adverse loading of the circuit under test. Excellent frequency response and unity gain guarantee highly accurate swept measurements. High sensitivity and low distortion levels allow measurements that take full advantage of the analyzer's dynamic range. Directly compatible with many HP RF spectrum and network analyzers.

HP 41800A Active Probe

This probe offers high input impedance from 5 Hz to 500 MHz. It works with many HP spectrum analyzers to evaluate the quality of circuits by measuring spurious level, harmonics, and noise. Low input capacitance offers probing with negligible circuit loading for precise, in-circuit measurements of audio, video, HF, and VHF bands.

HP 11742A Blocking Capacitor

The HP 11742A blocking capacitor blocks dc signals below 45 MHz and passes signals up to 26.5 GHz. Ideal for use with high frequency oscilloscopes or in biased microwave circuits, the HP 11742A will suppress low frequency signals that can damage expensive measuring equipment or affect the accuracy of your RF and microwave measurements.

Ordering Information

HP 8447A: 0.1 to 400 MHz amplifier

HP 8447D: 0.1 to 1300 MHz amplifier

HP 8447F: 9 kHz to 1300 MHz amplifier

HP 11975A: 2 to 8 GHz amplifier

HP 8449B: 1 to 26.5 GHz preamplifier

Hp 87405A: Preamplifier

HP 11867A: dc to 1.8 GHz RF limiter

HP 11693A: 0.1 to 12.4 GHz microwave limiter

HP 11694A: 75 Ω matching transformer

HP 11852B: 75Ω minimum-loss pad
Option 004: 50Ω Type-N (m), 75Ω Type-N (f)

HP 8721A: Directional bridge
Option 008: 75 Ω impedance

HP 85024A: High-frequency probe

HP 41800A: 5 Hz to 500 MHz active probe

Limiters

HP 87405A Preamplifier

The HP 87405A preamplifier has a frequency range of 0.01 to 3GHz. Compact size, 22 to 27 dB gain, 6.5 dB noise figure, and convenient probe-power bias connection make it ideal for use with a number of instruments.

HP 11867A and 11693A

These limiters can be used to protect the input circuits of spectrum analyzers, counters, amplifiers, and other instruments from high power levels with minimal effect on measurement performance. The HP 11867A RF limiter (dc to 1800 MHz) reflects signals up to 10 watts average power and 100 watts peak power. Insertion loss is less than 0.75 dB. The HP 11693A microwave limiter (0.1 to 12.4 GHz, useable to 18 GHz) guards against input signals over 1 milliwatt up to 1 watt average power and 10 watts peak power.

HP 11867A

HP 11693A

Switches

Applications

RF/microwave switches find use in a wide variety of signal routing applications for test and measurement systems. Typical applications include:

- Selection of multiple signal sources to one output
- Selection of multiple input signals to one measurement instrument
- Transfer switching to insert or remove a device in a signal path
- Matrix switching of multiple inputs and outputs

Technology

HP electromechanical coaxial switches feature low insertion loss, high isolation, broadband performance, long life and exceptional repeatability. HP coaxial switches are all designed with an "edge-line" coaxial structure. This transmission line structure provides for movement of the edge-line center conductor between two fixed, continuous ground planes. The main advantage of this innovation is that the moving contacts can be easily activated, yet maintain high isolation and low insertion loss.

The RF contact configuration is designed for controlled wiping action. Since the outer conductor is not part of the switching function, repeatability and life are enhanced. The switching action occurs typically within 15 to 30 milliseconds, after which permanent magnets latch the contacts to retain the new switch position.

The HP 87104/106 and 87204/206 family of switches use optoelectronic sensing to provide the coil current interrupt function. Since no mechanical contacts are involved in this function, the switch reliability is improved.

Key Specifications

- Frequency range
- Input power
- Insertion loss
- Isolation
- SWR
- Repeatability
- Life

Frequency Range

One of the main advantages of electromechanical switches is that they transmit signals all the way down to dc. The top frequency limits are set by the size of the coaxial structure and connectors. Various HP models are available up to 40 GHz. Parameters such as insertion loss, isolation and SWR behave in a predictable manner. Typically, these parameters will linearly degrade at higher frequencies.

Input Power

The ability of a switch to handle power depends very much on the materials used for the signal carrying components of the switch and on the switch design. Two switching conditions should be considered: "hot" switching and "cold" switching. Hot switching occurs when RF/microwave power is present at the ports of the switch at the time of the switching function. Cold switching occurs when the signal power is removed before activating the switching function.

Hot switching causes the most stress on internal contacts, and can lead to premature failure. Cold switching results in lower contact stress and longer life, and is recommended in situations where the signal power can be removed before switching.

Insertion Loss

Insertion loss for electromechanical switches is very low, ranging from 0.1 dB at low frequencies to 1.5 dB at high frequencies. This performance distinguishes them from solid-state switches which range from 0.5 dB to 6 dB. Factors that influence loss are: path length, types of material used on signal carrying surfaces, contact wear, corrosion or other contamination. Insertion loss can play an important role whether high or low power are present. In high-power systems, this additional loss may require that the source power be increased to compensate. In receiver applications, the effective sensitivity of the system is reduced by the amount of insertion loss. In other systems, additional power may not be available, due to the prohibitive cost of supplying more power.

Isolation

High isolation in switches is important to almost every measurement application, because it prevents unwanted signals from interfering with the desired signal. Isolation is the amount that the unwanted signal is attenuated before it is detected at the port of interest. HP switches have high isolation, with typical values >90 dB to 18 GHz and >50 dB to 26.5 GHz. High isolation can be particularly important in measurement systems where signals from sources are being routed. If too much power from an unselected source is allowed to flow through a device under test, measurement results will not be accurate.

SWR

The standing wave ratio (SWR) of a switch specifies how well the connectors and switching signal path are matched to an ideal 50-ohm transmission line. Low SWR is crucial in test set design when signal routing configurations involve multiple components in series, thereby adding to measurement uncertainty. SWRs of 1.1 to 1.5 are typical in HP switches.

Repeatability

Repeatability plays an important role in any test system. In test applications where accuracies of less than a few tenths of a dB are required, the system designer must consider the effects of switch repeatability in addition to test equipment capabilities. In automated test systems where switches are used for signal routing, every switch will add to the repeatability error. Such errors cannot be calibrated out of the system due to their random nature. HP switches are designed for high repeatability, 0.03 dB maximum over 5 million cycles.

Repeatability is a measure of the change in a specification from cycle to cycle over time. When used as a part of a measurement system, switch repeatability is critical to overall system measurement accuracy. Repeatability can be defined for any of the specifications of a switch, which includes: insertion loss, reflection, isolation and phase. Insertion loss repeatability is specified for all HP switches, as this tends to be the specification most sensitive to changes in switch performance.

Factors that affect insertion loss repeatability include:

- Debris
- Contact pressure
- Plating quality
- Contact shape and wiping action

Debris is generated in a switch when two surfaces come in contact during movement. The debris may find its way between contacts, causing an open circuit. HP has developed processes that control contamination and debris generation to minimize these effects.

Switch contacts are typically gold plated to maximize conductivity and minimize surface corrosion. Special plating materials, surface finish, contact shape and wiping pressure all combine to minimize surface effects on insertion loss repeatability.

Contact resistance is inversely proportional to contact pressure. Insufficient pressure increases life but also increases contact loss. Too much pressure damages the contact surfaces, with little insertion loss improvement. Contact surface wiping provides a means for breaking through surface corrosion and moving debris away from the contacts. This allows the switch to clean the contact surfaces with each switch cycle.

Life

The life of a switch is usually specified in cycles, i.e. the number of times it switches from one position to another and back. HP determines life by cycling switches to the point of degradation. Typically, HP switches, in life cycle tests, perform to specifications for at least twice as many cycles as warranted.

Three HP switch families have a specified life of 5 million cycles. This long life results in lower cost of ownership by reducing periodic maintenance, downtime and repairs.

Switches

HP 8761A

HP 8762/63/64 Family

HP 8765 Family

HP offers a broad line of coaxial switches, covering up to 40 GHz, for use in test and measurement applications. All switches use magnetically-latched solenoids and are primarily designed with break-before-make RF contacts for test simplicity. The Selection Guide on page 89 describes the product families and their features.

SPDT - Configurable Connectors

HP 8761A,B SPDT switches operate up to 18 GHz. Each port features six connector options plus 50-ohm termination for design flexibility.

SPDT - High Performance

HP 8762A,B,C switches operate up to 26.5 GHz. They provide exceptional isolation of 90 dB to 18 GHz and switched terminations, so that all ports maintain a 50-ohm match. Internal loads are rated at 1 watt average (100 W peak, 10 µsec pulse width). Control voltage Options T15 and T24 are compatible with TTL/5V CMOS drive circuitry. Another model, HP 8762F, is designed for 75-ohm transmission lines, making it valuable for communication applications up to 4 GHz.

SPDT - High Reliability

HP 8765A,B,C,D,F are SPDT switches that offer outstanding performance and a life of 5 million cycles. This switch family is available in four models up to 40 GHz, as well as a 75-ohm model to 4 GHz.Unlike the HP 8762 switches, they do not have internal, switched RF loads or dc current interrupts. Coil voltage options cover the complete range from 5 Vdc to 24 Vdc. Since the switches are magnetically latched, the coil voltage may be switched off after 15 ms.

The standard HP 8765 switch comes with ribbon cables and standard printed circuit board with a 0.025-inch connector for convenient assembly. Optional solder terminals are available.

Coaxial - High Performance

HP 8763A,B,C switches operate up to 26.5 GHz. They are preferred for drop-in, drop-out applications because of their compact design. These switches are used to automatically insert or remove a test component from a signal path. Because of their excellent isolation, they can also be used as the intersection (crosspoint) switch in full-access matrix switching applications. One port is internally terminated. Options T15 and T24 are available for TTL/5V CMOS compatibility.

HP 8764A,B,C switches operate up to 26.5 GHz, similar to the HP 8763, but with the internal termination replaced by a fifth port. The fifth port can be utilized for signal path reversal or as a calibration port. Options T15 and T24 offer TTL/5V CMOS compatibility.

Multiport - Low Profile

HP 8766/67/68/69K series switches are modified versions of the HP 8494/95/96/97 series step attenuators (dc to 26.5 GHz) for applications requiring a single-pole, 3-throw, 4-throw, 5-throw or 6-throw coaxial switch. The switch ports are unterminated. These switches offer warranted repeatability of 0.03 dB maximum over 5 million switching cycles.

The switches are available with several optional cables and connectors to make them compatible with standard 14-pin DIP sockets. Isolation and insertion loss vary with frequency, and depend upon the port selected.

Switches

HP 8766/67/68/69 Family

HP 87104/106 Family

HP 87204/206 Family

Multiport - High Performance

HP 87104A,B,C and 87106A,B,C multiport switches operate up to 26.5 GHz. These switches offer warranted repeatability of 0.03 dB maximum over 5 million switching cycles.

For rigorous requirements such as matrix switching, you can rely on port-to-port isolation of better than 100 dB at 4 GHz, 70 dB at 20 GHz, and 65 dB at 26.5 GHz. When used in switching trees or in full access matrixes, isolation and insertion loss repeatability is crucial to measurement confidence.

HP 87104 is a single-pole-4-throw (SP4T) and the HP 87106 is a SP6T function. Both switches have internal solid-state logic that automatically programs the non-used ports to a matched load when any one port is programmed to "on". This relieves the user from having to provide external logic drive pulses. For user-designed circuit drivers, Option T24 is available. It provides internal circuits that are compatible with external TTL/5V CMOS digital ICs.

Internal current interrupts and position indicators are optoelectronically coupled to the electromechanical switch action. These solenoids are all magnetically latched, eliminating the need for maintaining coil current. This provides highly-reliable solenoid control along with accurate position indication to monitor circuits. Unselected RF ports are terminated in a well-matched 50-ohm load for eliminating unwanted reflections in unused signal lines.

The HP 87104/106 models have the capability to perform switching with a make-before-break action, by energizing the coils in the proper logic sequence.When this function is engaged, the impedance momentarily goes to 25 ohms, and then returns to the nominal 50-ohm match.

HP 87204A,B,C and 87206A,B,C switches are fully equivalent to models HP 87104/106 in their RF switching performance. However, their drive circuits are primarily designed to work with the HP 87130A and 70611A switch drivers. In particular, the switches are best suited for interfacing with the switch driver's monitor circuits. In automated systems, the importance of switch position monitoring and reporting is often critical to system operation. See pages 110 and 111 for more information on switch driver instruments. The standard HP 87204/206 provides a 16-pin drive connector while Option 100 provides solder terminals. The HP 87204/206 can perform make-before-break or break-before-make switching.

HP-IB Compatibility

All of the HP switch families can be remotely and automatically controlled from switch driver instruments such as the HP 11713A, 3235A, 3488A, or E1700A. These drivers are all HP-IB (IEEE 488) compatible as is the HP 87130A switch driver, a standalone system for automated control of up to 248 switches. For systems configured in the HP Modular Measurement System, use the HP 70611A to operate up to 248 switches. Drivers are also available for HP VXI and HP VEE systems. For more information on switch drivers available, see page 110.

Switch Driver Cables

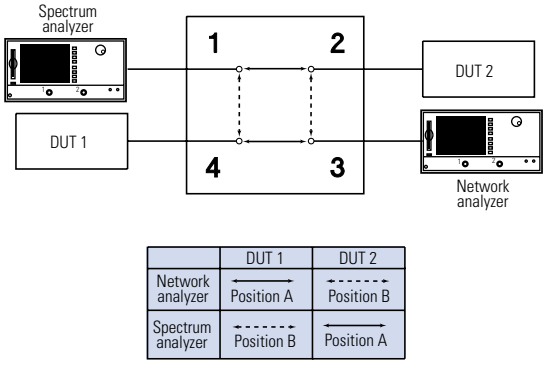
See page 109 for a brief listing of driver cables.
For complete cable configuration information, request publication number 5963-2038E, *HP 70611A, HP 87130A and HP 11713A Switch and Attenuator Driver Configuration Guide*.

High Performance Transfer Switch

Applications

The HP 87222C transfer switch can be used in many different applications to increase system flexibility and simplify system design. The following are five examples: switch between two inputs and two outputs, use as a drop-out switch, use for signal reversal, configure as a SPDT switch, and bypass an active device.

The HP 87222C transfer switch has the ability to exchange two signals between two inputs and two outputs. The transfer switch can connect two different instruments with two devices under test (DUT). Once switched, the signals are exchanged between the two instruments and the two DUTs. The exchanged signals allow complete network and spectrum analysis on two devices with a single switch and one test setup. See Figure 1 for an example of this application.



	DUT 1	DUT 2
Network analyzer	Position A	Position B
Spectrum analyzer	Position B	Position A

Figure 1. Switching two instruments and two DUTs

The HP 87222C can be used as a simple drop-out switch where a signal is either run through the device under test or straight through the switch, bypassing the device. See Figure 3.

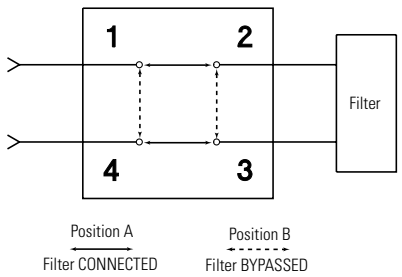


Figure 3. Drop-out switch

In the signal reverse configuration, a device can be connected across two diagonal ports of the HP 87222C transfer switch. This will allow the signal direction through the device to be reversed. See Figure 2.

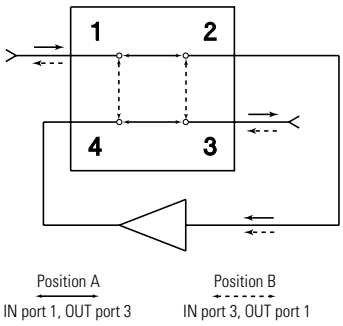


Figure 2. Signal reversal

By attaching an external termination, the designer can use the HP 87222C in a SPDT terminated switch configuration. See Figure 4.

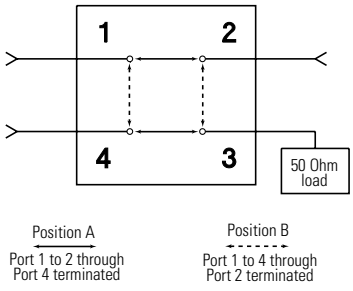
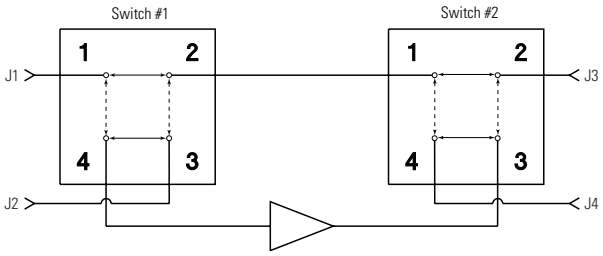


Figure 4. SPDT terminated

In Figure 5, an active device, such as an amplifier, is inserted into a signal path presenting a unique problem. A single transfer switch has the undesirable characteristic of shunting the output of the amplifier to its input when the signal is bypassing the amplifier. The advantage of using two transfer switches is that an additional signal path is available, however two SPDT switches can also be used. This additional path can utilize the same amplifier when the original path is bypassed.



Switch states		Signal paths	
Switch #1	Switch #2		
Position A	Position A	J1 — J3	J2 ▷ J4
Position B	Position A	J2 — J3	J1 ▷ J4
Position A	Position B	J2 ▷ J3	J1 — J4
Position B	Position B	J1 ▷ J3	J2 — J4

Figure 5. Bypassing an active device

Driving the switch

There are two positions for the HP 87222C transfer switch. See Table A. Position A has RF Port 1 connected to RF Port 2 and RF Port 3 connected to RF Port 4. Position B has RF Port 2 connected to RF Port 3 and RF Port 1 connected to RF Port 4. The switch can be driven with a standard grounding drive control with or without a separate ground. Single line or Dual line TTL control are also available. The switch operates in a break-before-make mode.

(I) Standard drive:

See Figure 8 for drive connection diagrams.

- Connect Pin 1 to supply (+20 VDC to +32 VDC)
- Connect Pin 9 to ground (see note 1)
- Select position "A" by applying ground to Pin 3 (see note 3)
- Select position "B" by applying ground to pin 5 (see note 3)

(II) Single line TTL drive:

See Figure 8 for drive connection diagrams. See Figure 9 for TTL Voltage States.

- Connect Pin 1 to supply (+20 VDC to +32 VDC)
- Connect Pin 9 to ground (see notes 2,4)
- Connect Pin 8 to TTL "High"
- Select position "A" by applying TTL "High" to pin 7 (see note 3)
- Select position "B" by applying TTL "Low" to pin 7 (see note 3)

(III) Dual line TTL drive:

See Figure 8 for drive connection diagrams. See Figure 9 for TTL Voltage States.

- Connect Pin 1 to supply (+20 VDC to +32 VDC)
- Connect Pin 9 to ground (see notes 2,4)
- Select position "A" by applying TTL "High" to pin 7 and TTL "Low" to pin 8 (see note 3)
- Select Position "B" by applying TTL "Low" to pin 7 and TTL "High" to pin 8 (see note 3)

Notes:

1. Pin 9 does not need to be grounded for the switch to operate in standard drive mode. If pin 9 is not grounded, the position indicators will only function while the appropriate drive has ground applied. Therefore, if a pulse drive is used and continuous indicator operation is required, pin 9 must be grounded.

2. For TTL drive, pin 9 must be grounded.

3. After the RF path is switched and latched, the drive current is interrupted by the electronic position-sensing circuitry. Pulsed control is not necessary, but if implemented, the pulse width must be 15 ms minimum to ensure that the switch is fully latched.

4. In addition to the quiescent current supplying the electronic position-sensing circuitry, the drive current flows out of pin 9 (during switching) when using TTL drive.

High Performance Transfer Switch

Drive control alternatives

RF path	(I) Standard drive voltage		(II) Single line TTL/5V CMOS Drive voltage		(III) Dual line TTL/5V CMOS Drive voltage	
	Drive A Pin 3	Drive B Pin 5	TTL Drive A Pin 7	TTL Drive B Pin 8	TTL Drive A Pin 7	TTL Drive B Pin 8
Position A **1 to 2, 3 to 4**	Ground	Open	High	High	High	Low
Position B **2 to 3, 1 to 4**	Open	Ground	Low	High	Low	High

Table A

Specifications

Specifications describe the instrument's warranted performance. Supplemental and typical characteristics are intended to provide information useful in applying the instrument by giving typical, but not warranted performance parameters.

Standard switch drive specifications

Parameter	Conditions	Min	Nom	Max	Units
Supply voltage		20	24	32	V
Supply current, Icc	Switching: Pulse width > 15 ms: Vcc = 24 VDC		200		mA
Supply current (Quiescent)		25		50	mA

Table B

TTL Specific drive specifications

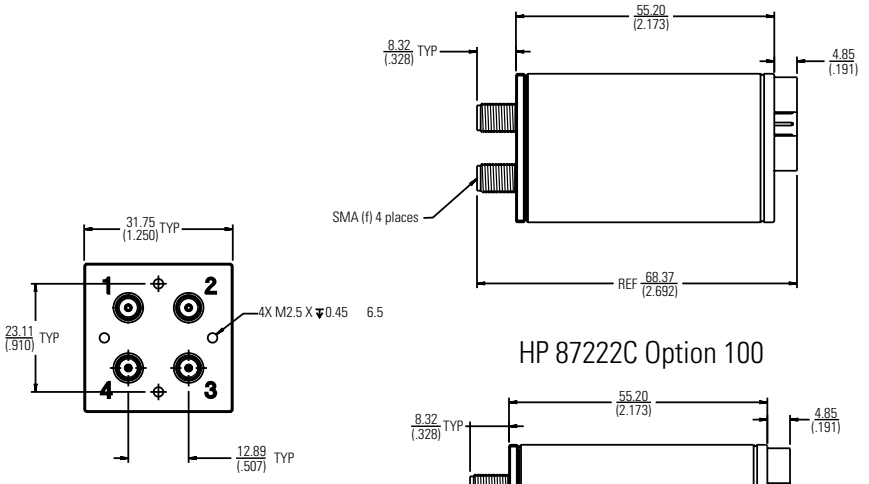
Parameter	Conditions	Min	Nom	Max	Units
High level input		3		7	V
Low level input				0.8	V
Max high input current	Vcc = Max V input = 3.85 VDC		1	1.4	mA

Table C

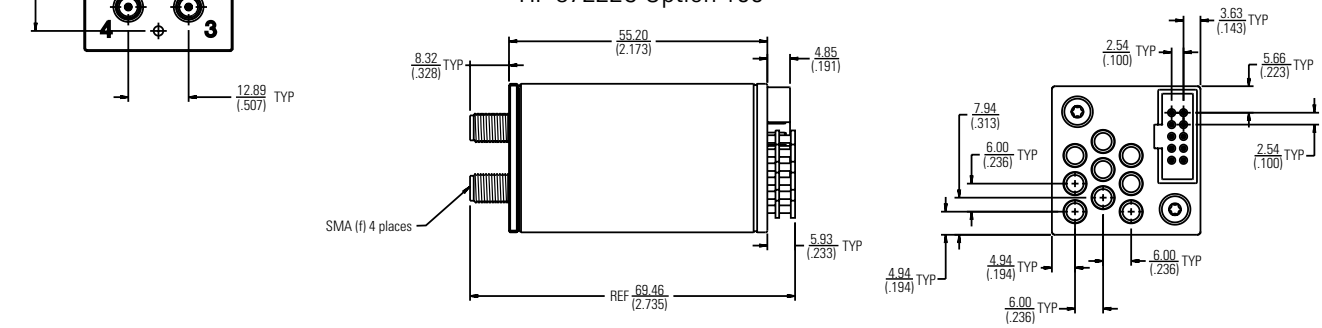
High Performance Transfer Switch

Product outlines

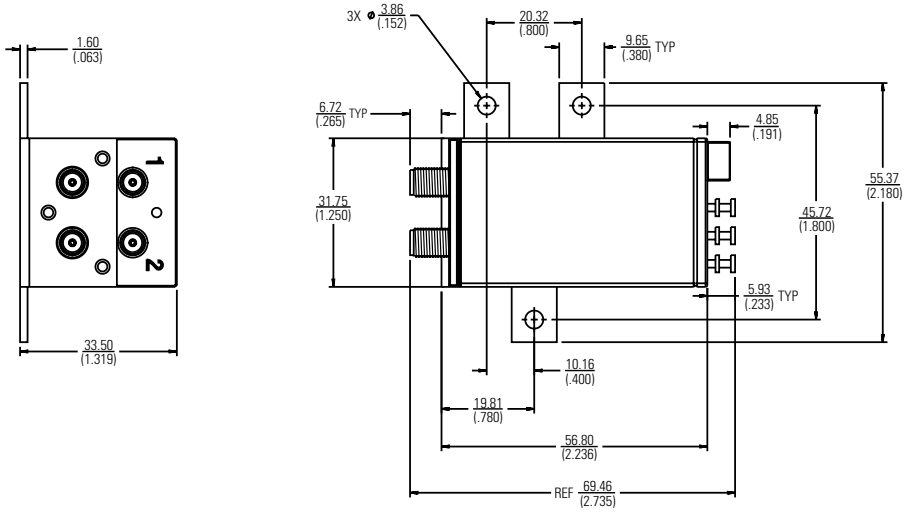
HP 87222C Standard



HP 87222C Option 100



HP 87222C Option 100 and 201



Note: Dimensions are in millimeters and (inches) nominal unless otherwise specified.

High Performance Matrix Switch

Applications

Matrix Signal Routing

Figures 1 and 2 show the HP 87406B and 87606B configured for blocking 2 x 4 and 3 x 3 applications. With outstanding repeatability and life greater than 5 million cycles, these switches enhance measurement confidence and reduce cost of ownership. In addition, the matrix switch has the versatility to provide single pole multiple throw signal routing up to 1 x 5 (SP5T).

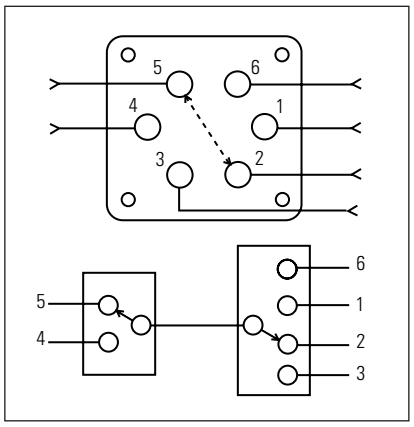


Figure 1.
Matrix switch configured for a 2 x 4 blocking application (RF Path 5 to 2 shown)

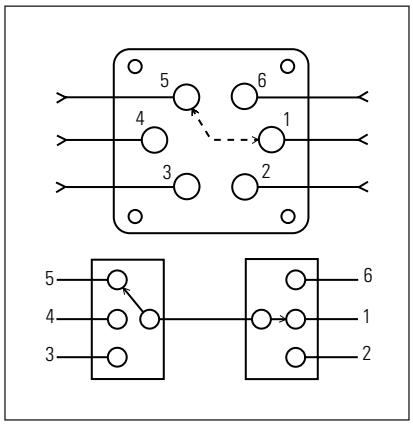


Figure 2.
Matrix switch configured for a 3 x 3 blocking application (RF Path 5 to 1 shown)

Driving the Switch

DC power connection

- Connect pin 1 to supply (+20 V DC to +32 V DC)
- Connect pin 15 to chassis ground to enable the electronic position-indicating circuitry and drive logic circuitry.
  WARNING: DAMAGE TO SWITCH WILL OCCUR IF PIN 15 IS NOT GROUNDED

RF Path Selection

To connect any two RF ports, apply control signals to the corresponding drive pins as shown below:

HP 87406B RF Port Drive Pin Control Data

RF Port	6	5	4	3	2
1	3, 13	3, 11	3, 9	3, 7	3, 5
2	5, 13	5, 11	5, 9	5, 7	
3	7, 13	7, 11	7, 9		
4	9, 13	9, 11			
5	11, 13				

Table 1.
HP 87406B RF Port Control Data

Using this table, **select** (close) the desired RF path by connecting ground (standard and Option 100) or applying TTL “High” (Option T24 or Option T00) to the corresponding "drive" pins.

Unselect (open) RF paths by disconnecting ground (standard and Option 100) or applying TTL “Low” (Option T24 or Option T00) to the corresponding “drive” pins.

Example: Configure the RF path from port 2 to port 5
Using the data in Table 1, select pins 5 and 11 while ensuring no other pins are selected:

RF Port	1	2	3	4	5	6	Open All*
Drive Pin	3	5	7	9	11	13	16
Standard, Option 100	U	G	U	U	G	U	X**
Options T24, T00	L	H	L	L	H	L	X**

U = Ungrounded, G = Grounded, L = TTL “Low”, H = TTL “High”, X = Don’t care

***** “Open All Ports” is not available with Option 100 and Option T00.
****** “Open all RF Ports” feature is overridden by port selection.

Selected ports will be closed and unselected ports will be automatically opened by the internal logic circuits when new port selections are made. After the RF port is switched and magnetically latched, the selenoid current is interrupted by the solid-state position sensing circuitry. The drive voltage must be maintained to aviod RF path disconnection by the internal logic. For this reason, pulsed drive is NOT recommended. Use the HP 87606B if pulse drive, such as used on HP 70611A or 87130A, is desired.

High Performance Matrix Switch

Open all RF ports
Unselecting all RF ports and selecting Pin 16 on standard and Option T24 opens all RF ports:

U = Ungrounded, G = Ground, L = TTL "Low", H = TTL "High"

Drive Pin	3	5	7	9	11	13	16
Standard	U	U	U	U	U	U	G
Option T24	L	L	L	L	L	L	H

Selecting an RF port will override the "open all RF ports" for each selected port. If desired, pin 16 can be wired directly to ground (standard) or TTL "High" (Option T24) to open all RF ports at power-up.

Break-Before-Make
Remove the control inputs from the undesired port, then select the desired port. The internal logic will unselect the old port automatically upon application of the new port selection.

Make-Before-Break
Select the new RF port while maintaining the control input on the original ports. Allows 15 ms for the switching action to be completed, then unselect the original port; the original port will be automatically disconnected by the internal logic.

RF Path Selection

Close an RF Port

To connect any two RF ports, apply control signals to the corresponding drive pins as shown below:

RF Port	6	5	4	3	2
1	3, 13	3, 11	3, 9	3, 7	3, 5
2	5, 13	5, 11	5, 9	5, 7	
3	7, 13	7, 11	7, 9		
4	9, 13	9, 11			
5	11, 13				

Table 2.
HP 87606B "Close" RF Port Control Data

Using Table 2, **select** (close) the desired RF path by connecting ground to the corresponding "drive" pins.

Open an RF Port

To open RF ports, apply control signal to the corresponding drive pins as shown below:

RF Port	1	2	3	4	5	6
Drive Pin	3	5	7	9	11	13

Table 3.
HP 87606B "Open" RF Port Control Data

Using Table 3, **unselect** (open) the desired RF path by connecting ground to the corresponding "drive" pins.

Example: Configure the RF path from port 2 to port 5:
Using the data in Tables 2 and 3, close ports 2 and 5 while opening all other ports (1, 3, 4, 6); ground pins 4, 5, 8, 10, 11, 14; all other drive pins must be removed from ground. Another method is to first apply ground to pin 16; with all other drive pins (3-14) ungrounded, for 15 milliseconds to open all paths, then apply ground to pins 5 and 11, to close parts 2 and 5.

Example: Configure the RF path from port 2 to port 5:
Using the data in Tables 1 and 2, close ports 2 and 5 while opening all other ports (1, 3, 4, 6); ground pins 5, 11, 4, 8, 10, 14; all other drive pins must be removed from ground. Another method is to first apply ground to pin 16, with all other drive pins (3-14) ungrounded, for 15 milliseconds. This will open all paths. Next, apply ground to pins 5 and 11, to close ports 2 and 5.

RF Port	1		2		3		4		5		6	
Drive Pin	3	4	5	6	7	8	9	10	11	12	13	4
Standard, Option 100	U	G	G	U	U	G	U	G	G	U	U	G

U = Ungrounded, G = Grounded

Removing all drive pins (3-14) from ground, and grounding pin 16 will open all RF paths.
Simultaneously grounding any "RF port close" pin and pin 16 will cause rapid cycling and premature failure of the switch.

Break-Before-Make
Open the undesired RF path. After 15 ms (minimum), close the new RF port(s).

Make-Before-Break
Close the new RF port(s). After 15 ms (minimum), open the undesired RF port(s).

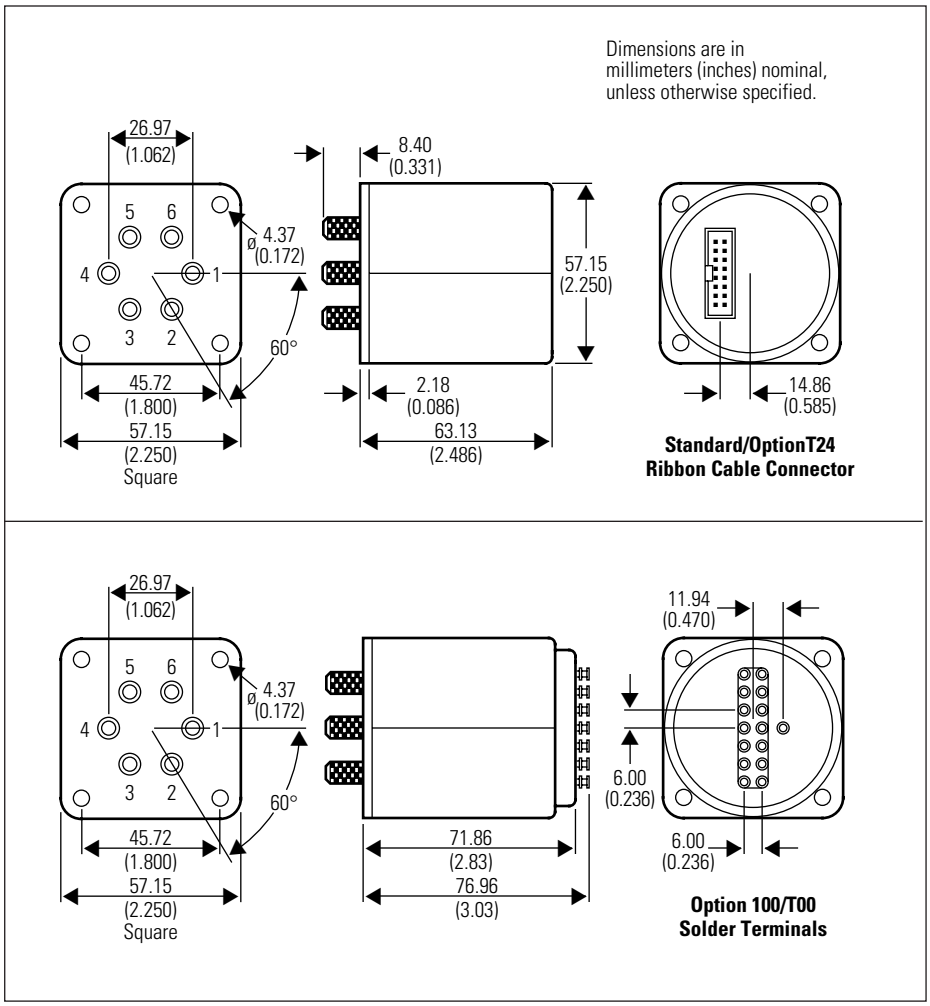
Switch Drive Specifications

Parameter	Conditions	Min	Nom	Max	Units
Supply voltage, Vcc		20	24	32	V
Switching current	Vcc=24 VDC		200[1]		mA
Standby current (quiescent)		25		50	mA
Options T24 / T00					
High level input		3		7	V
Low level input				0.8	V
Max high input current	Vcc=Max ; Vinput=3.85 VDC		1	1.4	mA

[1] 200 mA is required for each RF port closed or open. Using "open all ports" (pin 16) will require up to 1200 mA (6 ports times 200 mA each). See General Operation Section.

Switches

Product outline



Transfer

Specifications

HP Model	87222C
Configuration	4-Port
Features	Opto-electronic indicators and interrupts[1] TTL/5V CMOS compatible Unterminated
Impedance	50 ohms
Frequency Range	dc to 26.5 GHz
Insertion Loss (dB)	0.2 dB + 0.025x frequency (GHz)
SWR	1.10 maximum dc to 2 GHz 1.15 maximum 2 to 4 GHz 1.25 maximum 4 to 12.4 GHz 1.40 maximum 12.4 to 20 GHz 1.65 maximum 20 to 26.5 GHz
Isolation (dB)	120 dB -2.0x frequency (GHz)
Input Power	
Average	1W
Peak[2]	50W
Switching speed (max)	15 ms
Repeatability (max)[3]	0.03 dB
Life (min)	5 million cycles
RF Connectors	SMA (f)

Options	
100	Solder terminals in addition to ribbon cable
201	Mounting bracket; assembly required

[1] Provides position sensing when used with HP 87130A/70611A switch driver and the HP 11764-60010 accessory cable.
[2] Not to exceed 1W average
[3] Measured at 25° C

Matrix

HP Model	87406B	87606B
Configuration	SP6T	
Features	3x3, 2x4 and 1x5 blocking matrix configurations Make-before-break or break-before-make operation Terminated Ports	
	Opto electronic indicators and interrupts[1]	Self interrupting drive circuit
Impedance	50 ohms	
Frequency Range	dc to 20 GHz	
Insertion Loss (dB)	0.34 dB + 0.033 x frequency (GHz) maximum	
SWR	1.21 maximum from dc to 4 GHz 1.35 maximum from 4 to 10 GHz 1.5 maximum from 10 to 15 GHz 1.7 maximum from 15 to 18 GHz 1.9 maximum from 18 to 20 GHz	
Isolation (dB)	100 dB minimum to 12 GHz 80 dB minimum from 12 to 15 GHz 70 dB minimum from 15 to 20 GHz	
Input Power		
Average	1 W	
Peak[2]	50 W (10 µs max)	
Switching time (max)	15 ms	
Repeatability (max)[3]	0.03 dB	
Life (min)	5,000,000 cycles	
RF Connectors	SMA (f)	

HP Model Number	Options:
HP 87406B	**100:** Solder terminals to replace ribbon cable **T24:** TTL/5V CMOS compatibility (requires 24VDC power supply) **T00:** Solder terminals to replace ribbon cable and TTL/5V CMOS compatibility
HP 87606B	**100:** Solder terminals to replace ribbon cable

[1] Provides position sensing when used with HP 87130A/70611A switch driver or customer supplied external circuitry.
[2] Not to exceed 1 W average
[3] Measured at 25° C

Selection Guide

HP Model	Frequency Range	Features	Product Category: SPDT Configurable Connectors	SPDT High Performance	SPDT High Reliability	Transfer High Performance 4-port	Transfer High Performance 5-port	Multiport Low-profile SP3T	Multiport Low-profile SP4T	Multiport Low-profile SP5T	Multiport Low-profile SP6T	Multiport High Performance SP4T	Multiport High Performance SP6T
8761A	dc to 18 GHz	• 1 million cycles	X										
8761B	dc to 18 GHz	• Selectable connector configuration	X										
8762A	dc to 4 GHz	• 1 million cycles		X									
8762B	dc to 18 GHz	• High repeatability			X								
8762C	dc to 26.5 GHz	• All-ports terminated		X									
8762F (75 Ω)	dc to 4 GHz	• Current interrupts and position indication capability • TTL/5V CMOS option		X									
8763A	dc to 4 GHz	• 1 million cycles				X							
8763B	dc to 18 GHz	• High repeatability				X							
8763C	dc to 26.5 GHz	• 1-port terminated • Current interrupts and position indication capability • TTL/5V CMOS option				X							
8764A	dc to 4 GHz	• 1 million cycles					X						
8764B	dc to 18 GHz	• High repeatability					X						
8764C	dc to 26.5 Ghz	• Unterminated • Current interrupts and position indication capability • TTL/5V CMOS option					X						
8765A	dc to 4 GHz	• Highest frequency range			X								
8765B	dc to 20 GHz	• 5 million cycles			X								
8765C	dc to 26.5 GHz	• High repeatability			X								
8765D	dc to 40 GHz	• Unterminated			X								
8765F (75 Ω)	dc to 4 GHz				X								
8766K	dc to 26.5 GHz	• 5 million cycles						X					
8767K	dc to 26.5 GHz	• High repeatability							X				
8768K	dc to 26.5 GHz	• Unterminated								X			
8769K	dc to 26.5 GHz	• Current interrupts and position indication capability									X		
87104A	dc to 4 GHz	• 5 million cycles										X	
87104B	dc to 20 GHz	• High repeatability										X	
87104C	dc to 26.5 GHz	• All-ports terminated										X	
87106A	dc to 4 GHz	• Optoelectronic interrupts and position indicators											X
87106B	dc to 20 GHz												X
87106C	dc to 26.5 GHz	• TTL/5V CMOS option											X
87204A	dc to 4 GHz	• 5 million cycles										X	
87204B	dc to 20 GHz	• High repeatability										X	
87204C	dc to 26.5 GHz	• All-ports terminated										X	
87206A	dc to 4 GHz	• Optoelectronic interrupts and position indication capability											X
87206B	dc to 20 GHz												X
87206C	dc to 26.5 GHz												X

Selection Guide (cont.)

HP Model	Frequency Range	Features	Product Category	
			High Performance Transfer 4-port	High Performance Matrix SP6T
87222C	dc to 26.5 GHz	5 million cycles High repeatability Opto-electronic indicators and interrupts TTL/5V CMOS compatible Unterminated	X	
87406B	dc to 20 GHz	5 million cycles High repeatability Opto-electronic indicators and interrupts TTL/5V CMOS option Terminated ports		X
87606B	dc to 20 GHz	5 million cycles High repeatability Opto-electronic indicators and interrupts Sensing capability Terminated ports		X

SPDT

Specifications

HP Model	8761A, 8761B	8762A, 8762B	8762C	8762F	8765A, 8765B, 8765C	8765D	8765F
Features	Unterminated Break-before-make Selectable connector configuration	Terminated Break-before-make Current interrupts Position indication capability[1]			Unterminated Break-before-make		
Impedance	50 Ω	50 Ω	50 Ω	75 Ω	50 Ω	50 Ω	75 Ω
Frequency Range	dc to 18 GHz	**A:** dc to 4 GHz **B:** dc to 18 GHz	dc to 26.5 GHz	dc to 4 GHz	**A:** dc to 4 GHz **B:** dc to 20 GHz **C:** dc to 26.5 GHz	dc to 40 GHz	dc to 4 GHz
Insertion Loss (dB)	<0.5 to 12.4 GHz <0.8 to 18 GHz	**A:** <0.20 to 2 GHz <0.25 to 4 GHz **B:** <0.25 to 2 GHz <0.50 to 18 GHz	<0.25 to 2 GHz <0.50 to 18 GHz <1.25 to 26.5 GHz	<0.4	**A & B:** **$0.2 + 0.025f^2$** max **C:** **$0.25 + 0.027f^2$** max 0.2 @ 4 GHz typ. 0.5 @ 20 GHz typ. 0.7 @ 26.5 GHz typ.	**$0.2 + 0.023f^2$** max 0.2 typ. @ 4 GHz 0.5 typ. @ 20 GHz 0.7 typ. @ 26.5 GHz **$0.75 + 0.023\Delta f^3$** max $(26.5 \le f \le 40)$ 1.0 typ. @ 40 GHz	<0.18 to 1 GHz <0.24 to 2 GHz <0.4 to 4 GHz
SWR (Through Line)	See Connector Code Option data on page 93	**A:** <1.2 to 4 GHz **B:** <1.1 to 2 GHz <1.2 to 12.4 GHz <1.3 to 18 GHz	<1.15 to 2 GHz <1.25 to 12.4 GHz <1.40 to 18 GHz <1.8 to 26.5 GHz	<1.30	**A & B:** <1.2 to 4 GHz <1.35 to 12.4 GHz <1.45 to 18 GHz <1.7 to 20 GHz **C:** <1.25 to 4 GHz <1.45 to 18 GHz <1.7 to 26.5 GHz	<1.25 to 4 GHz <1.45 to 18 GHz <1.7 to 40 GHz	<1.15 to 1 GHz <1.20 to 4 GHz
SWR (Into Termination) Option 7:	Add 0.05 to SWR (Through Line) of connector selected	**A:** <1.1 to 2 GHz <1.2 to 4 GHz **B:** <1.15 to 2 GHz <1.20 to 12.4 GHz <1.30 to 18 GHz	<1.15 to 2 GHz <1.25 to 12.4 GHz <1.40 to 18 GHz <1.8 to 26.5 GHz	<1.30	N/A		
Isolation (dB)	>50 to 12.4 GHz >45 to 18 GHz	>100 to 4 GHz >90 to 18 GHz	>90 to 18 GHz >50 to 26.5 GHz	>100	**$110 - 2.25f^2$** min 120 typ. @ 4 GHz 90 typ. @ 20 GHz 60 typ. @ 26.5 GHz	**$110 - 2.25f^2$** min 120 typ. @ 4 GHz 90 typ. @ 20 GHz 60 typ. @ 26.5 GHz 55 typ. @ 40 GHz >50 (26.5 to 40 GHz)	>100 to 1 GHz >90 to 4 GHz

Indicates QuickShip availability. HP 8762A,B,C standard models only. HP 8765A,B,C with Option 024 only. Contact HP Direct or your local HP sales representative to confirm QuickShip.

[1] Provides position sensing when used with HP 87130A/70611A or customer supplied external circuitry.
[2] f is frequency in GHz.
[3] $\Delta f = f\ (GHz) - 26.5$.

SPDT

Specifications (continued)

HP Model	8761A,B	8762A,B	8762C	8762F	8765A,B,C	8765D	8765F
Input Power							
Average	10 W	1 W			2 W		
Peak [1]	5 kW [2]	100 W (10 µs max)			100 W (10 µs max)		
Switching Time (max)	50 ms	30 ms			15 ms		
Repeatability (max) [3]	0.03 dB	0.03 dB	0.03 dB to 18 GHz 0.5 dB to 26.5 GHz	0.03 dB	0.03 dB		
Life (min)	1,000,000 cycles	1,000,000 cycles			5,000,000 cycles		
RF Connectors	See connector options in ordering example	SMA (f)	3.5 mm (f)	Mini SMB (m) [4] (75 Ω)	A & B: SMA (f) C: 3.5 mm (f)	2.4 mm (f) See options	Mini SMB (m) [4] (75 Ω)
DC Connectors	Solder terminals	Solder terminals			Ribbon cable		

[1] Not to exceed average power (non-switching).
[2] Option 7: 2 W average, 100 W peak (10 µs max).
[3] Measured at 25 °C.
[4] 75 Ω Mini SMB does not mate with 75 Ω SMB. See data sheet for more information.

Options

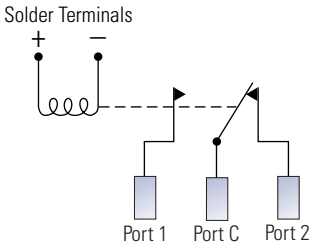
HP Model	8761A	8761B	8762A,B,C,F			8765A,B,C,D,F			
Supply Voltage, Current and Impedance [5]			**Std. / Opt. T24**	**Opt. 011**	**Opt. 015/Opt. T15**	**Opt. 005**	**Opt. 010**	**Opt. 015**	**Opt. 024**
Supply Voltage Range	12 to 15 Vdc	24 to 30 Vdc	20 to 32 Vdc	4.5 to 7 Vdc	12 to 20 Vdc	4.5 to 7 Vdc	7 to 12 Vdc	12 to 20 Vdc	20 to 32 Vdc
Supply Voltage (nom)	12 Vdc	24 Vdc	24 Vdc	5 Vdc	15 Vdc	5 Vdc	10 Vdc	15 Vdc	24 Vdc
Current (nom)	80 mA	65 mA	120 mA	400 mA	182 mA	385 mA	300 mA	200 mA	120 mA
Impedance (nom)	150 Ω, 90 mH	400 Ω, 300 mH	200 Ω, 127 mH	13 Ω, 8 mH	82 Ω, 57 mH	13 Ω, 8 mH	33 Ω, 25 mH	75 Ω, 55 mH	200 Ω, 135 mH
Control Logic	N/A		**Opt. T15:** TTL/5V CMOS compatible logic with 15 Vdc supply [6] **Opt. T24:** TTL/5V CMOS compatible logic with 24 Vdc supply [6]			N/A			
RF Connector	See ordering information		N/A			**D (Opt. 292):** 2.92 mm (f)			
DC Connectors	N/A					**Opt. 100:** Solder terminals **Opt. 108:** 8-inch ribbon cable extension **Opt. 116:** 16-inch ribbon cable extension			
Calibration Documentation	See ordering information								

[5] Must specify option for HP 8765 series products.
[6] Not available with HP 8762F.

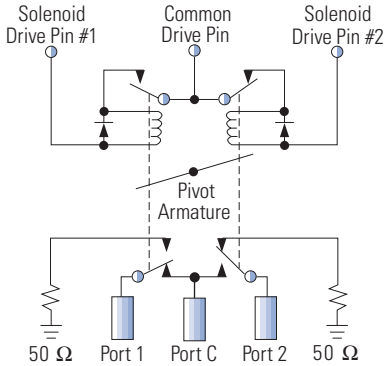
SPDT

Schematics

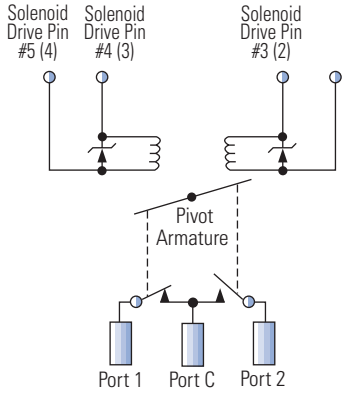
HP 8761 Series



HP 8762 Series



HP 8765 Series[1]



[1] Opt. 100 Solder Terminal numbers in parenthesis

Signal Path Control Data

The tables shown here can be used to better understand how to select a signal path for each switch. For example, the HP 8762 switch has two drive control alternatives i.e. a standard drive scheme and a TTL/5V CMOS drive scheme. For TTL/5V CMOS drive, it is required that the supply voltage be applied to pin C and that pin 1 is grounded. To close the path from port 1 to port C, apply a TTL "low" to pin 2. Additional information related to signal path control can be found in the product data sheet.

HP 8761 Series

RF Path	DC Drive Control Voltage	
	Pin "+"	Pin "–"
1 to C	Negative	Positive
2 to C	Positive	Negative

HP 8762 Series

RF Path	Drive Control Alternatives			
	Standard Drive Voltage[2]		TTL/5V CMOS Drive Voltage[2,3]	
	Pin 1	Pin 2	Pin 1	Pin 2
1 to C	Ground	Open	Ground	"High"
2 to C	Open	Ground	Ground	"Low"

[2] Drive pin C is supply voltage.
[3] Not available on HP 8762F.

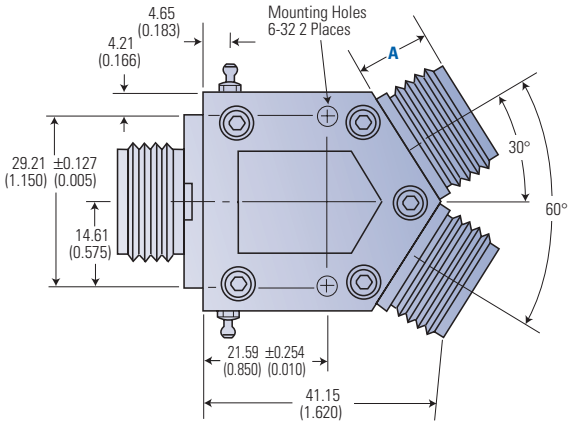
HP 8765 Series

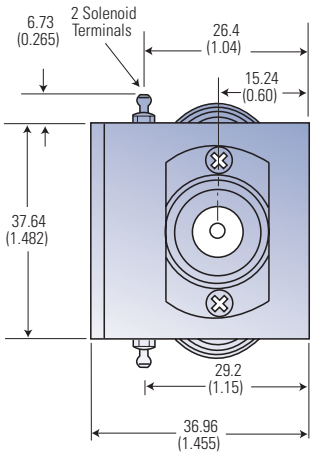
RF Path	Drive Control Alternatives[4]								
		Common Positive Drive Voltage			Common Negative Drive Voltage			Polarity Reversal Drive Voltage		
	Std. (Opt. 100)	Pin 1 (1)	Pin 3/4 (2/3)	Pin 5 (4)	Pin 3 (2)	Pin 1/5 (1/4)	Pin 4 (3)	Pin 1 (1)	Pin 3/4 (2/3)	Pin 5 (4)
1 to C		Open	Supply voltage	Ground	Open	Ground	Supply voltage	Ground	Connected	Supply voltage
2 to C		Ground	Supply voltage	Open	Supply voltage	Ground	Open	Supply voltage	Connected	Ground

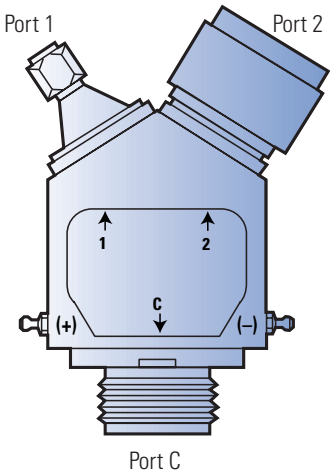
[4] See data sheet for additional information on these drive control alternatives.

SPDT

HP 8761 Series







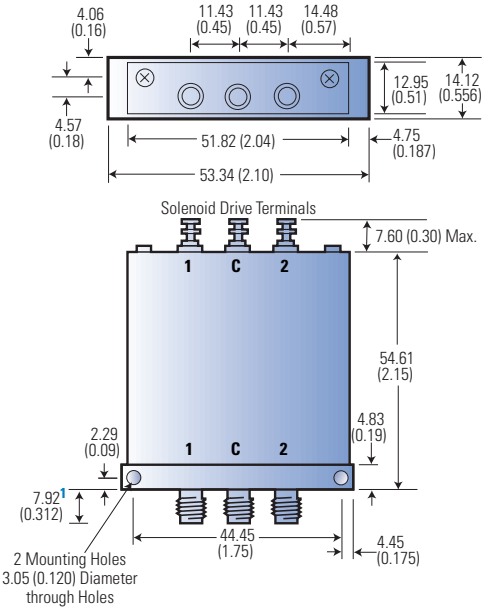
See ordering example for HP 8761 options on P.95

HP 8761 Series Connector Dimensions

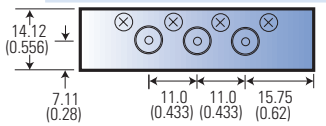
Connector Code Option	Connector Type	Dimension "A" mm	(inch)	SWR (Through Line)
0	Type-N (f)	13.72	(0.540)	<1.25 to 18 GHz
1	Type-N (m)	19.79	(0.775)	<1.25 to 18 GHz
2	APC-7 threaded sleeve	9.27	(0.365)	<1.2 to 18 GHz
3	APC-7 coupling nut	11.94	(0.470)	<1.2 to 18 GHz
4	UT-250 coax	9.27	(0.365)	<1.25 to 18 GHz
5	SMA (f)	16.13	(0.635)	<1.35 to 18 GHz
6	SMA (m)	17.15	(0.675)	<1.35 to 18 GHz
7	50 Ω termination	30.5	(1.20)	

Dimensions are in millimeters (inches) nominal, unless otherwise specified.

HP 8762 Series



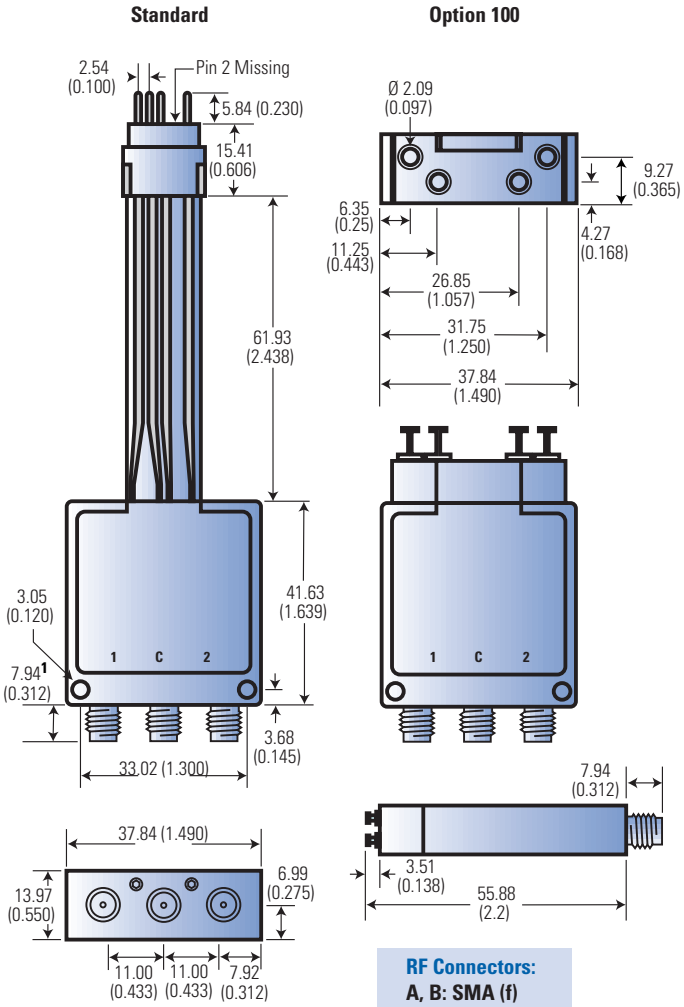
RF Connectors:
A,B: SMA (f) C: 3.5 mm (f) F: 75 Ω Mini-SMB



[1] 10.0 (0.393) for F version

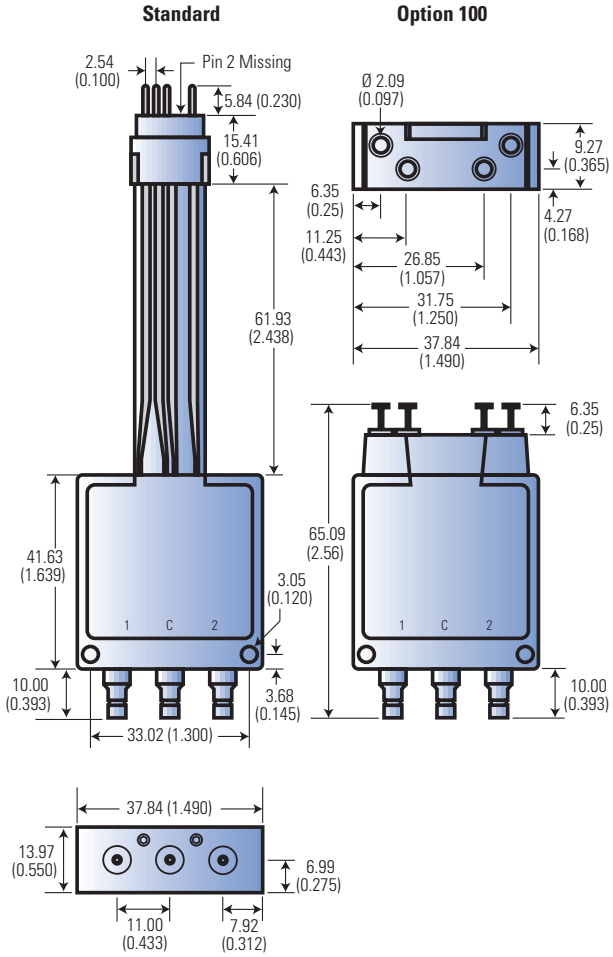
SPDT

HP 8765A,B,C,D



RF Connectors:
A, B: SMA (f)
C: 3.5 mm (f)
D: 2.4 mm (f)

HP 8765F



RF Connectors:
75 Ω Mini-SMB (m)[2]

[1] 8.46 (0.333) for D versions.

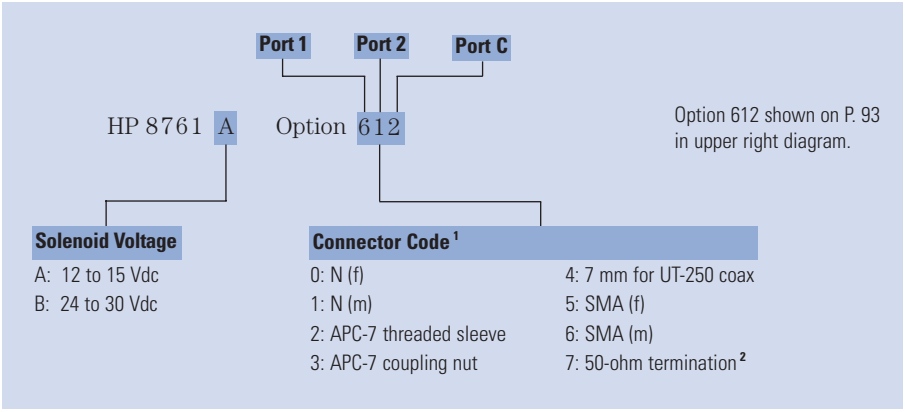
[2] 75 Ω Mini-SMB (m) does not mate with 75 Ω SMB connectors. See data sheet for details.

Dimensions are in millimeters (inches) nominal, unless otherwise specified.

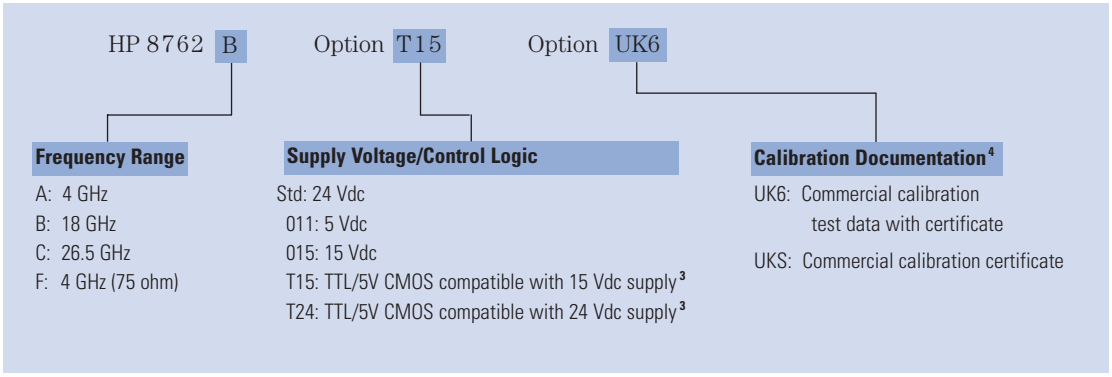
SPDT

Ordering Information

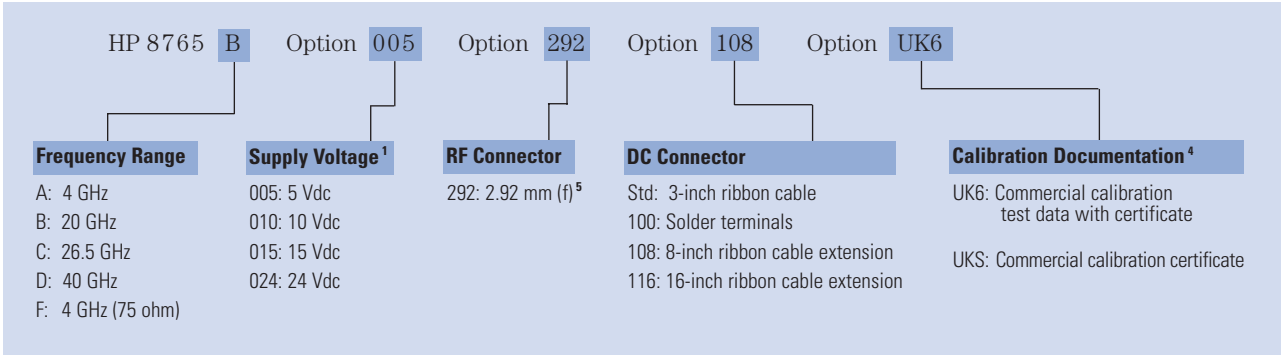
HP 8761 Series Ordering Example



HP 8762 Series Ordering Example



HP 8765 Series Ordering Example



[1] This option must be specified when ordering this product.
[2] Port 1 or port 2 only.
[3] Not available with HP 8762F.
[4] Not available for HP 8762F, 8765D Opt. 292, or 8765F.
[5] Available with HP 8765 only.

Coaxial

Specifications

	8763A	8763B	8763C	8764A	8764B	8764C
Configuration	← 4-Port →			← 5-Port →		
Features	Terminated			Unterminated		
	Break-before-make ← Current interrupts → Position indication capability[1]					
Impedance	← 50 Ω →					
Frequency Range	dc to 4 GHz	dc to 18 GHz	dc to 26.5 GHz	dc to 4 GHz	dc to 18 GHz	dc to 26.5 GHz
Insertion Loss (dB)	<0.20 to 2 GHz <0.25 to 4 GHz	<0.20 to 2 GHz <0.50 to 18 GHz	<0.25 to 2 GHz <0.50 to 18 GHz <1.25 to 26.5 GHz	<0.20 to 2 GHz <0.25 to 4 GHz	<0.20 to 2 GHz <0.50 to 18 GHz	<0.25 to 2 GHz <0.50 to 18 GHz <1.25 to 26.5 GHz
SWR (Through Line)	<1.1 to 2 GHz <1.2 to 4 GHz	<1.1 to 2 GHz <1.2 to 12.4 GHz <1.3 to 18 GHz	<1.15 to 2 GHz <1.25 to 12.4 GHz <1.40 to 18 GHz <1.8 to 26.5 GHz	<1.1 to 2 GHz <1.2 to 4 GHz	<1.1 to 2 GHz <1.2 to 12.4 GHz <1.3 to 18 GHz	<1.15 to 2 GHz <1.25 to 12.4 GHz <1.40 to 18 GHz <1.8 to 26.5 GHz
SWR (Into Termination)	<1.1 to 2 GHz <1.2 to 4 GHz	<1.15 to 4 GHz <1.2 to 4 GHz <1.3 to 18 GHz	<1.15 to 2 GHz <1.25 to 12.4 GHz <1.40 to 18 GHz <1.8 to 26.5 GHz	N/A	N/A	N/A
Isolation (dB)	>100 to 4 GHz	>90 to 18 GHz	>90 to 18 GHz >50 to 26.5 GHz	>100 to 4 GHz	>90 to 18 GHz	>90 to 18 GHz >50 to 26.5 GHz
Input Power						
Average	← 1 W →					
Peak[2]	← 100 W (10 µs max) →					
Switching Time (max)	← 30 ms →					
Repeatability (max)[3]	0.03 dB	0.03 dB	0.03 dB to 18 GHz 0.5 dB to 26.5 GHz	0.03 dB	0.03 dB	0.03 dB to 18 GHz 0.5 dB to 26.5 GHz
Life (min)	← 1,000,000 cycles →					
RF Connectors	SMA (f)	SMA (f)	3.5 mm (f)	SMA (f)	SMA (f)	3.5 mm (f)
DC Connectors	← Solder Terminals →					

Indicates QuickShip availability. Standard models only.
Contact HP Direct or your local HP sales representative to confirm QuickShip.

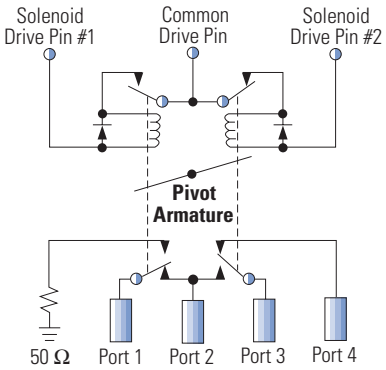
Options

Control Logic	**Opt. T15:** TTL/5V CMOS compatible logic with 15 Vdc supply **Opt. T24:** TTL/5V CMOS compatible logic with 24 Vdc supply		
Supply Voltage, Current and Impedance	**Std/Opt. T24**	**Opt. 011**	**Opt. 015/Opt. T15**
Supply Voltage Range	20 to 32 Vdc	4.5 to 7 Vdc	12 to 20 Vdc
Supply Voltage (nom)	24 Vdc	5 Vdc	15 Vdc
Current (nom)	120 mA	400 mA	182 mA
Impedance (nom)	200 Ω, 127 mH	13 Ω, 8 mH	82 Ω, 57 mH
Calibration Documentation	See ordering information		

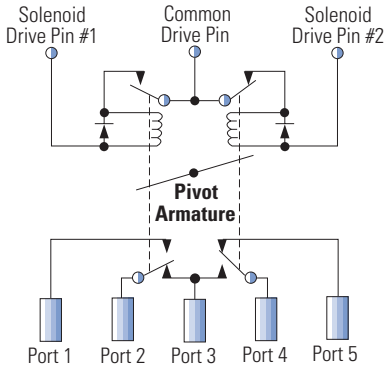
[1] Provides position sensing when used with HP 87130A/70611A switch driver or customer supplied external circuitry.
[2] Not to exceed 1 W average (non-switching).
[3] Measured at 25 °C.

Schematics

HP 8763 Series



HP 8764 Series



Signal Path Control Data

The table at right can be used to better understand how to select a signal path for each switch. For example, the HP 8763 switch has two drive control alternatives i.e. a standard drive scheme and a TTL/5V CMOS drive scheme. For standard drive, it is required that the supply voltage be applied to pin C. The path from port 1 to port 2 and port 3 to port 4 can be closed by grounding pin 1 and opening pin 2. Additional information related to signal path control can be found in the product data sheet for each of the products shown here.

HP 8763/64 Series

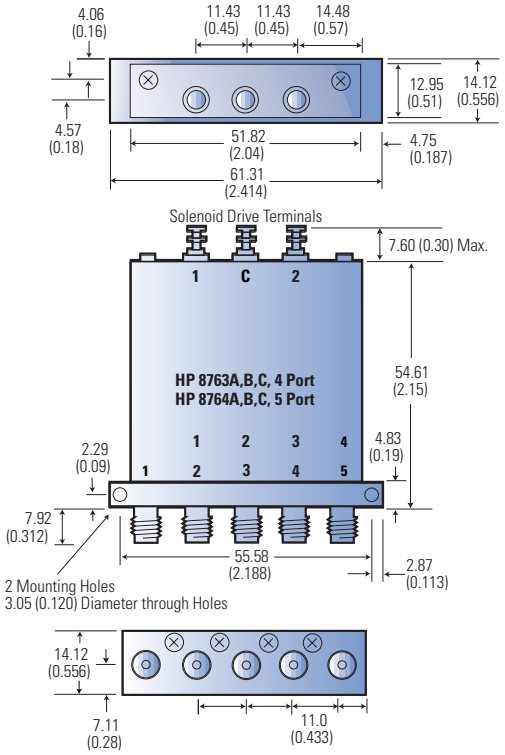
HP Model	RF Path	Drive Control Alternatives			
		Standard Drive Voltage [1]		TTL/5V CMOS Drive Voltage [1]	
		Pin 1	Pin 2	Pin 1	Pin 2
8763A,B,C	1 to 2 3 to 4	Ground	Open	Ground	"Low"
	2 to 3 1 terminated 4 open	Open	Ground	Ground	"High"
8764A,B,C	2 to 3 4 to 5 1 open	Ground	Open	Ground	"Low"
	1 to 2 3 to 4 5 open	Open	Ground	Ground	"High"

[1] Drive Pin C is supply voltage.

Coaxial

Outline Drawing

HP 8763/64 Series



RF Connectors: **A, B: SMA (f) C: 3.5 mm (f)**

Dimensions are in millimeters (inches) nominal, unless otherwise specified.

Ordering Information

HP 8763/64 Series Ordering Example

HP 876 3 B Option 015 Option UKS

Type
3: 4 port
4: 5 port

Frequency Range
A: 4 GHz
B: 18 GHz
C: 26.5 GHz 015: 15 Vdc

Supply Voltage/Control Logic
Std: 24 Vdc
011: 5 Vdc
T15: TTL/5V CMOS compatible logic with 15 Vdc supply
T24: TTL/5V CMOS compatible logic with 24 Vdc supply

Calibration Documentation
UK6: Commercial calibration test data with certificate
UKS: Commercial calibration certificate

Low Profile Multiport

Specifications

HP Model	8766K	8767K	8768K	8769K
Configuration	SP3T	SP4T	SP5T	SP6T
Features	Unterminated Break-before-make Current interrupts Position indication capability[1]			
Impedance	50 Ω			
Frequency Range	dc to 26.5 GHz			
Insertion Loss (dB)	**Signal Path** Common to Port 1: 0.2 dB + 0.05 dB x f (GHz) Common to Port 2: 0.2 dB + 0.06 dB x f (GHz) Common to Port 3: 0.2 dB + 0.08 dB x f (GHz) Common to Port 4: 0.25 dB + 0.095 dB x f (GHz) Common to Port 5: 0.25 dB + 0.108 dB x f (GHz) Common to Port 6: 0.25 dB + 0.12 dB x f (GHz)			
SWR (Through Line)	<1.3 to 8 GHz <1.5 to 12.4 GHz <1.6 to 18 GHz <1.8 to 26.5 GHz			<1.3 to 8 GHz <1.55 to 12.4 GHz <1.8 to 18 GHz <2.05 to 26.5 GHz
Isolation (dB)	See chart on page 102			
Input Power Average Peak[2]	1 W 100 W (10 µs max)			
Switching Time (max)	30 ms			
Repeatability (max)[3]	0.01 dB to 18 GHz 0.05 dB to 26.5 GHz			
Life (min)	5,000,000 cycles			
RF Connectors	3.5 mm (f)			
DC Connectors	Viking cable connector			

Options

Supply Voltage, Current, and Impedance	Std.	Opt. 011	Opt. 015
Supply Voltage Range	20 to 30 Vdc	4.5 to 7 Vdc	13 to 22 Vdc
Supply Voltage (nom)	24 Vdc	5 Vdc	15 Vdc
Current (nom)	130 mA	332 mA	187 mA
Impedance (nom)	185 Ω, 65 mH	17 Ω, 5.5 mH	80 Ω, 30 mH
RF Connectors	**Opt. 002:** SMA (f)[4]		
DC Connectors	**Opt. 008:** 8-inch ribbon cable		
	Opt. 016: 16-inch ribbon cable		
Calibration Documentation	See ordering information		

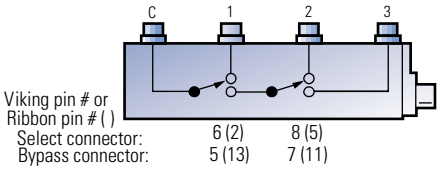
Indicates QuickShip availability. Standard models only.
Contact HP Direct or your local HP sales representative to confirm QuickShip.

[1] Provides position sensing when used with HP 87130A/70611A switch driver or customer supplied external circuitry.
[2] Not to exceed 1 W average (non-switching).
[3] Measured at 25 °C.
[4] Use to 18 GHz only.

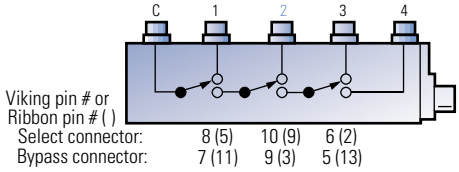
Low Profile Multiport

Simplified Schematics

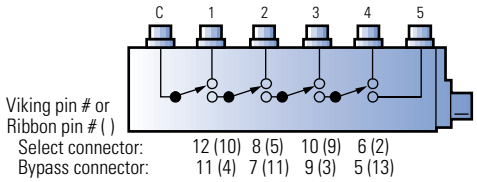
HP 8766K



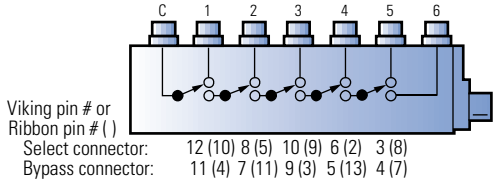
HP 8767K



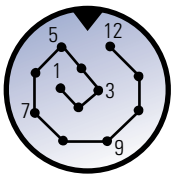
HP 8768K



HP 8769K

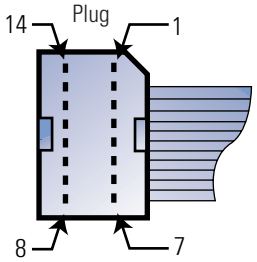


Viking Plug Detail [1, 2]



STD

DIP Plug [3]



Option 008, 016

[1] DC drive interface cable has color coded tinned leads at opposite end.
[2] Supply voltage is Pin 1 (red wire).
[3] Supply voltage is Pin 6.

Dimensions are in millimeters (inches) nominal, unless otherwise specified.

Signal Path Control Data

The tables below can be used to better understand how to select a signal path for each switch. The standard drive connector for each switch is a Viking connector with a 5 ft. cable. Alternately, a flat ribbon cable with a 14-pin DIP plug is available as an option. As an example, to connect the path from port C to port 2 of the standard HP 8767K, it is required that the supply voltage be applied to pin 1 (red lead) and that pin 10 (blue lead) and pin 7 (black lead) are grounded. This will "bypass" port 1 and "select" port 2. Note that section 3 can be selected or bypassed; however, isolation performance will be affected (see next page for further information). Additional information related to signal path control can be found in the product data sheet.

HP 8766K SP3T Switch

Switching Section	1		2	
Section State	Select	Bypass	Select	Bypass
Std. Viking Pin	6	5	8	7
Std. Viking Wire Color	Yellow	Violet	Green	Black
Opt. 008/016 Dual Inline Pin Connector	2	13	5	11
Common to Port 1	X			
Common to Port 2		X	X	
Common to Port 3		X		X

HP 8767K SP4T Switch

Switching Section	1		2		3	
Section State	Select	Bypass	Select	Bypass	Select	Bypass
Std. Viking Pin	8	7	10	9	6	5
Std. Viking Wire Color	Green	Black	Blue	Orange	Yellow	Violet
Opt. 008/016 Dual Inline Pin Connector	5	11	9	3	2	13
Common to Port 1	X					
Common to Port 2		X	X			
Common to Port 3		X		X	X	
Common to Port 4		X		X		X

HP 8768K SP5T Switch

Switching Section	1		2		3		4	
Section State	Select	Bypass	Select	Bypass	Select	Bypass	Select	Bypass
Std. Viking Pin	12	11	8	7	10	9	6	5
Std. Viking Wire Color	White	Brown	Green	Black	Blue	Orange	Yellow	Violet
Opt. 008/016 Dual Inline Pin Connector	10	4	5	11	9	3	2	13
Common to Port 1	X							
Common to Port 2		X	X					
Common to Port 3		X		X	X			
Common to Port 4		X		X		X	X	
Common to Port 5		X		X		X		X

HP 8769K SP6T Switch

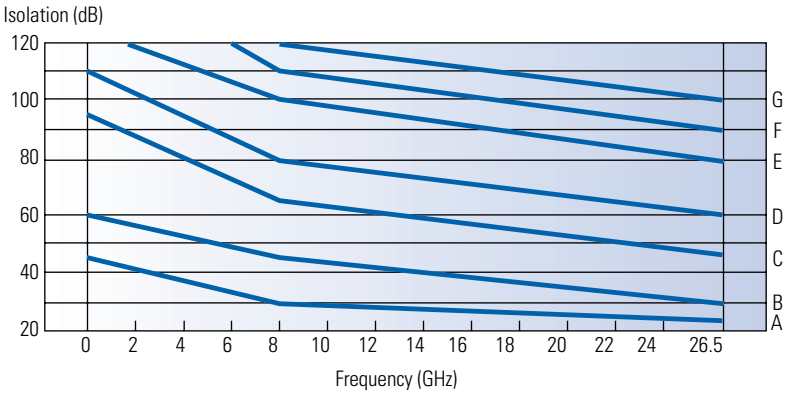
Switching Section	1		2		3		4		5	
Section State	Select	Bypass	Select	Bypass	Select	Bypass	Select	Bypass	Select	Bypass
Std. Viking Pin	12	11	8	7	10	9	6	5	3	4
Std. Viking Wire Color	White	Brown	Green	Black	Blue	Orange	Yellow	Violet	Gray	White/Red
Opt. 008/016 Dual Inline Pin Connector	10	4	5	11	9	3	2	13	8	7
Common to Port 1	X									
Common to Port 2		X	X							
Common to Port 3		X		X	X					
Common to Port 4		X		X		X	X			
Common to Port 5		X		X		X		X	X	
Common to Port 6		X		X		X		X		X

Sections identified by this cross-hatch symbol can be selected or bypassed; however, isolation performance will be affected (see next page for further information).

Low Profile Multiport

Isolation Calculation Characteristics

Isolation and insertion loss vary with frequency and depend on the port selected as shown in the chart and tables below. The input connector "C" is always defined as the connector at the end of the switch opposite the dc drive cable. The output ports are numbered sequentially from the input connector. For example, if an HP 8768K is being used, use the HP 8768K table to determine the isolation to each port. If port three (the third connector from the input) is selected, the isolation to ports 1 and 2 will follow curve A. Isolation to port 4 will follow curve B and isolation to port 5 will follow curve C. At 8 GHz, the worst case isolation to ports 1 and 2 will be 30 dB; to port 4, 45 dB, and to port 5, 65 dB. Note: in selecting ports 1 or 2, isolation to disconnected ports can be varied by choosing the position of each section to "bypass" or "select". Depending on the user's application, port assignments can be critical for optimizing performance at higher frequencies.



HP 8766K SP3T Switch

Section	Section Status 1	Section Status 2	Isolation Curve for Port ( ) 1	Isolation Curve for Port ( ) 2	Isolation Curve for Port ( ) 3
Common to Port 1	Select	Select	-	B	D
Common to Port 1	Select	Bypass	-	C	B
Common to Port 2	Bypass	Select	A	-	B
Common to Port 3	Bypass	Bypass	A	A	-

HP 8767K SP4T Switch

Section	Section Status 1	Section Status 2	Section Status 3	Isolation Curve for Port ( ) 1	Isolation Curve for Port ( ) 2	Isolation Curve for Port ( ) 3	Isolation Curve for Port ( ) 4
Common to Port 1	Select	Select	Select	-	B	D	E
Common to Port 1	Select	Select	Bypass	-	B	E	D
Common to Port 1	Select	Bypass	Select	-	C	B	D
Common to Port 1	Select	Bypass	Bypass	-	C	C	B
Common to Port 2	Bypass	Select	Select	A	-	B	C
Common to Port 2	Bypass	Select	Bypass	A	-	C	B
Common to Port 3	Bypass	Bypass	Select	A	A	-	A
Common to Port 4	Bypass	Bypass	Bypass	A	A	A	-

Isolation Calculation Characteristics

HP 8768K SP5T Switch

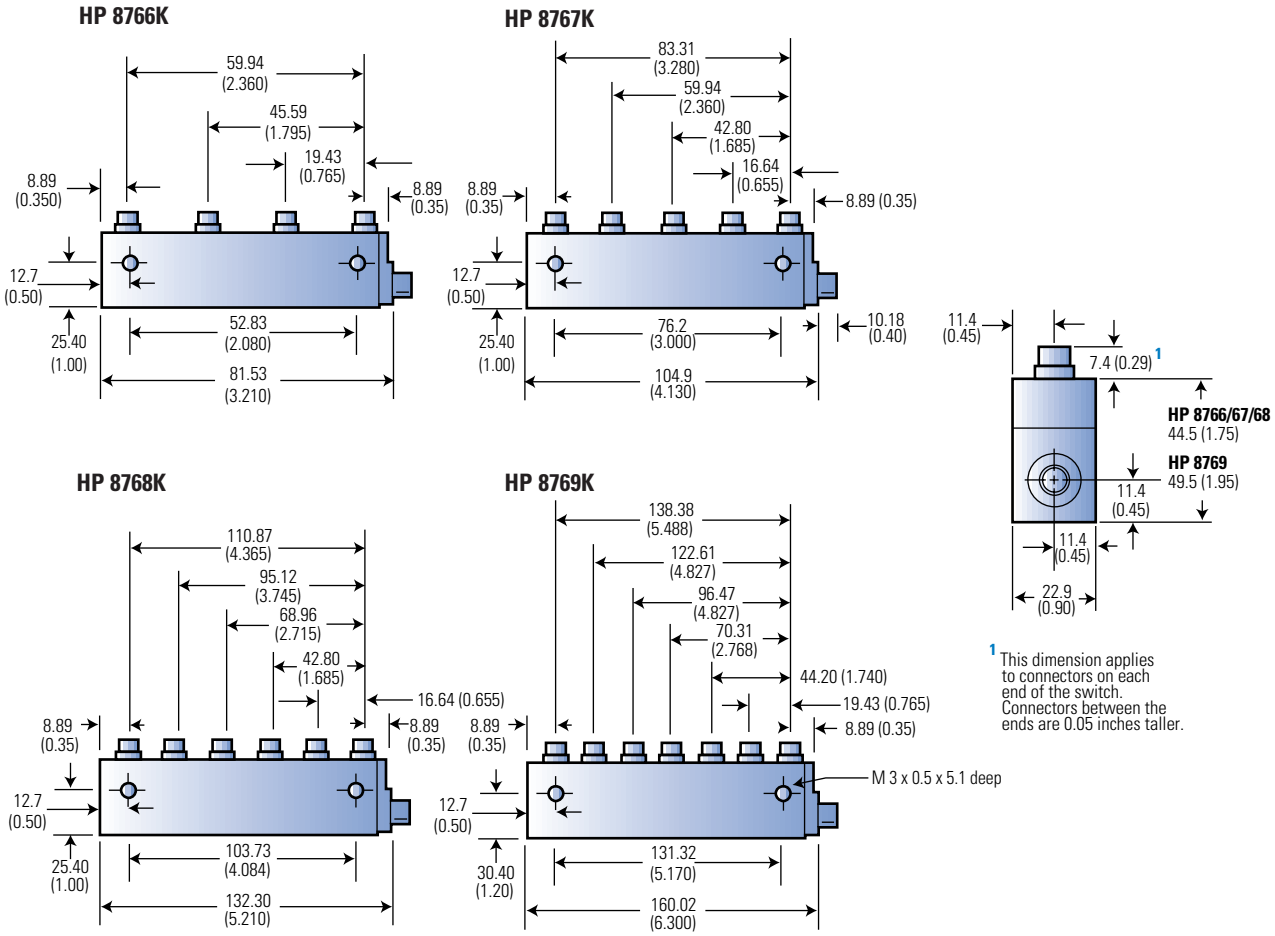
Section	Section Status 1	2	3	4	Isolation Curve for Port ( ) 1	2	3	4	5
Common to Port 1	Select	Select	Select	Select	–	B	D	E	F
Common to Port 1	Select	Select	Bypass	Select	–	B	E	D	E
Common to Port 1	Select	Bypass	Select	Select	–	C	B	D	E
Common to Port 1	Select	Bypass	Bypass	Select	–	C	C	B	C
Common to Port 2	Bypass	Select	Select	Select	A	–	B	D	E
Common to Port 2	Bypass	Select	Bypass	Select	A	–	C	B	C
Common to Port 3	Bypass	Bypass	Select	Select	A	A	–	B	C
Common to Port 4	Bypass	Bypass	Bypass	Select	A	A	A	–	A
Common to Port 5	Bypass	Bypass	Bypass	Bypass	A	A	A	A	–

HP 8769K SP6T Switch

Section	Section Status 1	2	3	4	5	Isolation Curve for Port ( ) 1	2	3	4	5	6
Common to Port 1	Select	Select	Select	Select	Select	–	B	D	E	F	G
Common to Port 1	Select	Select	Select	Bypass	Select	–	B	D	F	E	F
Common to Port 1	Select	Select	Bypass	Select	Select	–	B	E	D	E	F
Common to Port 1	Select	Bypass	Select	Select	Select	–	C	B	D	E	F
Common to Port 1	Select	Bypass	Bypass	Select	Select	–	C	C	B	C	F
Common to Port 1	Select	Bypass	Bypass	Bypass	Select	–	C	C	C	B	D
Common to Port 1	Select	Bypass	Bypass	Bypass	Bypass	–	C	C	C	C	B
Common to Port 2	Bypass	Select	Select	Select	Select	A	–	B	D	E	E
Common to Port 2	Bypass	Select	Bypass	Select	Select	A	–	C	B	C	F
Common to Port 2	Bypass	Select	Bypass	Bypass	Bypass	A	–	C	C	C	B
Common to Port 3	Bypass	Bypass	Select	Select	Select	A	A	–	B	C	E
Common to Port 3	Bypass	Bypass	Select	Bypass	Select	A	A	–	A	B	D
Common to Port 3	Bypass	Bypass	Select	Bypass	Bypass	A	A	–	C	C	A
Common to Port 4	Bypass	Bypass	Bypass	Select	Bypass	A	A	A	–	A	C
Common to Port 5	Bypass	Bypass	Bypass	Bypass	Select	A	A	A	A	–	B
Common to Port 6	Bypass	Bypass	Bypass	Bypass	Bypass	A	A	A	A	A	–

Low Profile Multiport

Outline Drawings



All connectors are 3.5 mm (f). Dimensions are in millimeters (inches) nominal, unless otherwise specified.

Ordering Information

HP 8766/67/68/69 Series Ordering Example

HP 8767K Option 011 Option 002 Option 008 Option UK6

Type
6: SP3T
7: SP4T
8: SP5T
9: SP6T

Supply Voltage
Std: 24 Vdc
011: 5 Vdc
015: 15 Vdc

RF Connector
Std: 3.5 mm (f)
002: SMA (f)

DC Connector
Std: Viking cable connector
008: 8-inch ribbon cable
016: 16-inch ribbon cable

Calibration Documentation
UK6: Commercial calibration test data with certificate
UKS: Commercial calibration certificate

High Performance Multiport

Specifications

HP Model	87104A 87104B 87104C	87106A 87106B 87106C	87204A 87204B 87204C	87206A 87206B 87206C
Configuration	SP4T	SP6T	SP4T	SP6T
Features	Terminated Break-before-make or make-before-break Optoelectronic current interrupts Optoelectronic position indicator[1] Internal control logic		Terminated Break-before-make or make-before-break Optoelectronic current interrupts Optoelectronic position indication capability[2] Direct path control	
Impedance	50 Ω			
Frequency Range	**A**: dc to 4 GHz **B:** dc to 20 GHz **C:** dc to 26.5 GHz			
Insertion Loss (dB)	0.3 + 0.015 x freq (GHz)			
SWR	<1.2: dc to 4 GHz <1.35: 4 to 12.4 GHz <1.45: 12.4 to 18 GHz <1.7: 18 to 26.5 GHz			
Isolation (dB)	>100 dB: dc to 4 GHz >80 dB: 12 to 15 GHz >70 dB: 15 to 20 GHz >65 dB: 20 to 26.5 GHz			
Input Power				
Average	1 W			
Peak[3]	50 W (10 µs max)			
Switching Time (ms)	<15			
Repeatability (max)[4]	0.03 dB			
Life (min)	5,000,000 cycles			
Supply Voltage and Current				
Supply Voltage Range	20 to 32 Vdc			
Supply Voltage (nom)	24 Vdc			
Current (nom)[5]	200 mA			
RF Connectors	SMA (f)			
DC Connectors	Ribbon cable receptacle			

Indicates QuickShip availability. Standard models and Option 100 only.
Contact HP Direct or your local HP sales representative to confirm QuickShip.

Options

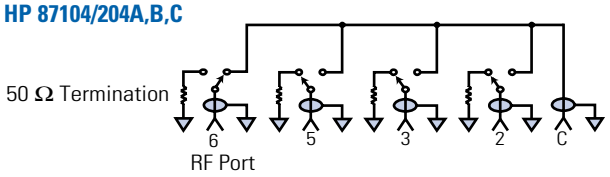
	87104A,B,C	87106A,B,C	87204A,B,C	87206A,B,C
Control Logic	**Opt. T24:** TTL/5V CMOS compatible logic with 24 Vdc supply		N/A	
DC Connectors	**Opt. 100:** Solder terminals			
Calibration Documentation	See ordering information			

[1] Position sensing when used with customer supplied external circuitry only.
[2] Position sensing when used with HP 87130A/70611A switch driver or customer supplied external circuitry.
[3] Not to exceed average power (non-switching).
[4] Measured at 25 °C.
[5] Closing one RF path requires 200 mA. Add 200 mA for each additional RF path closed or opened.

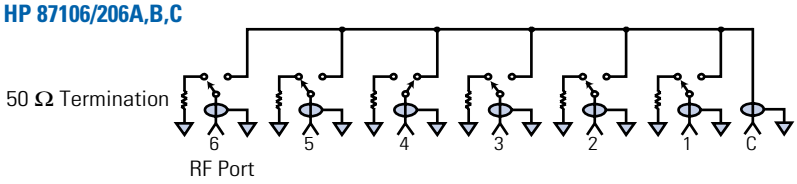
High Performance Multiport

Simplified Schematics

HP 87104/204A,B,C



HP 87106/206A,B,C



Signal Path Control Data

The table shown here can be used to better understand how to select a signal path for HP 87104/106 multiport switches. For example, there are two drive control alternatives, i.e. a standard drive scheme and a TTL/5V CMOS drive scheme. For standard drive, it is required that the supply voltage be applied to pin 1 and that pin 15 is grounded. The path from port C to port 2 can be closed by grounding pin 5. Note that all other RF paths are simultaneously opened by internal logic. Further, the HP 87104/106 permits closing 1 or more RF paths simultaneously, allowing make-before-break RF switching transitions. See product data sheet for more information.

HP 87104/106 Series Signal Path Control Data[1]

RF Path	Pin No.[2]	Drive Control Voltages[2]	
		Standard	TTL/5V CMOS
1 to C[3]	3	Ground	"High"
2 to C	5	Ground	"High"
3 to C	7	Ground	"High"
4 to C[3]	9	Ground	"High"
5 to C	11	Ground	"High"
6 to C	13	Ground	"High"
Open all paths	16[4]	Ground	"High"

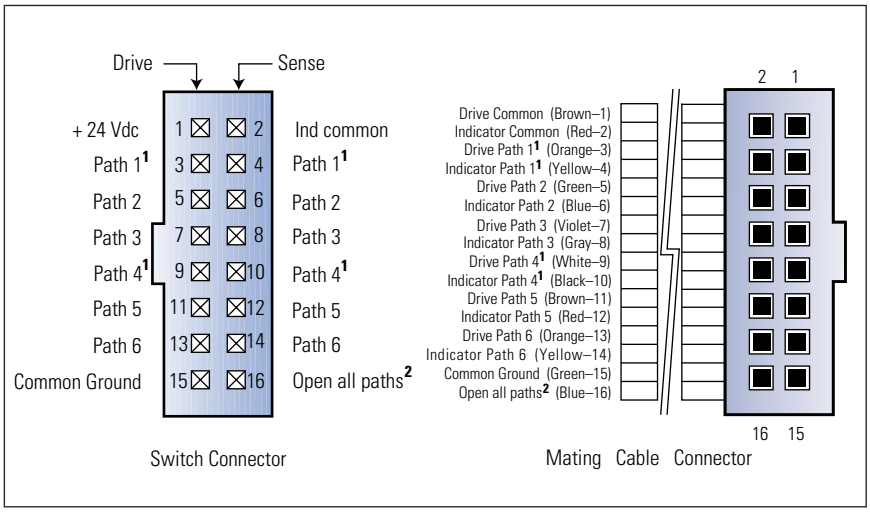
[1] HP recommends the HP 87130A/70611A switch driver for HP 87204/206 series products. See data sheet for additional information related to driving these switches.
[2] Pin 1 is supply voltage. Pin 15 is common ground.
[3] Paths 1 and 4 are not available for HP 87104A,B,C.
[4] Not available on Option 100.

High Performance Multiport

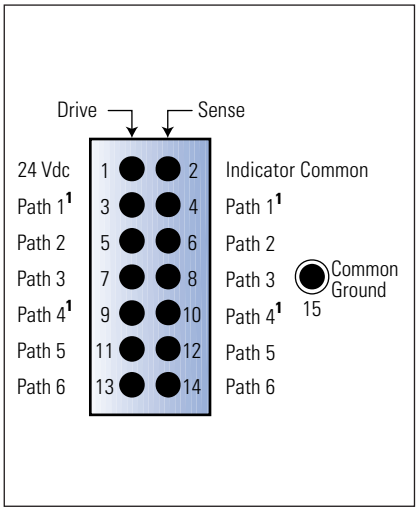
Drive Connection Diagrams

HP 87104/106 Series

Standard/Option T24

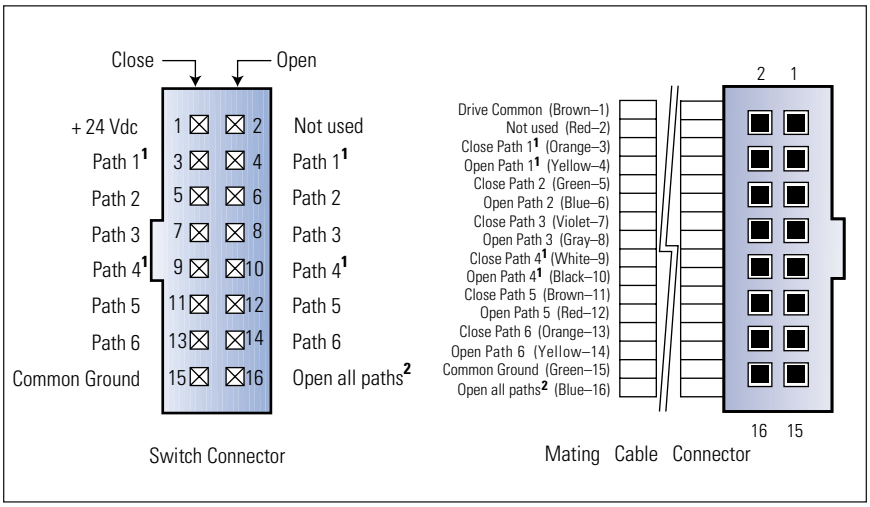


Option 100 (Solder Terminals)

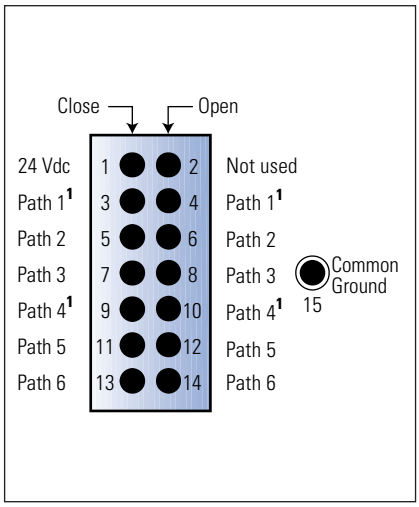


HP 87204/206 Series

Standard



Option 100 (Solder Terminals)



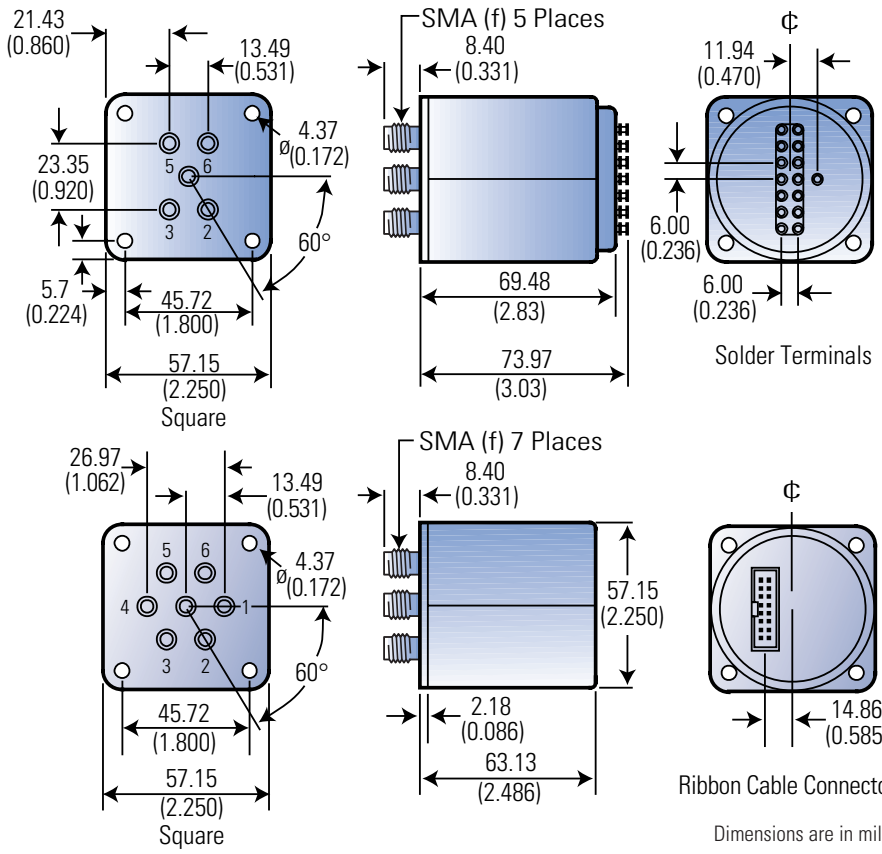
[1] Paths 1 and 4 are not connected for HP 87104/204 series.

[2] This function is not available on Option 100.

High Performance Multiport

Outline Drawings

HP 87104/106, 87204/206 Series



Dimensions are in millimeters (inches) nominal, unless otherwise specified.

Ordering Information

HP 87104/106/204/206 Series Ordering Example

Sensing Type

1: Provides position sensing when used with customer supplied external circuitry only.

2: Provides position sensing when used with HP 87130A/70611A driver or customer supplied external circuitry.

HP 87204B Option 100 Option T24 Option UK6

Switch Type
4: SP4T
6: SP6T

Frequency Range
A: 4 GHz
B: 20 GHz
C: 26.5 GHz

DC Connector
Std: Ribbon receptacle
100: Solder terminals

Control Logic[1]
T24: TTL/5V CMOS compatible logic with 24 Vdc supply

Calibration Documentation
UK6: Commercial calibration test data with certificate
UKS: Commercial calibration certificate

[1] Option T24 not available with HP 87204/206 series products.

Switches

Switch Cables[1]

HP Model Number	HP Part Number	Where Used	Description
11761A		11713A to 8765	Viking to (4) ribbon cable connectors
	11764-60007	84941A dist bd to 87104/106[2]	16-pin DIP to (6) 4-pin Berg connector, 30-inches
	11764-60008	84941A dist bd to 87204/206	16-pin DIP to (6) 4-pin Berg connector, 30-inches
	70611-60008	84941A dist bd to 8762/63/64, 8765 Opt. 100	(31) 52-inch cables, 4-pin Berg connector to bare wires
		84941A dist bd to 87104/106 Opt. 100[2]	
		84941A dist bd to 87204/206 Opt. 100	
84941A-K03		84941A dist bd to 8769K	12-pin Viking to (5) 4-pin Berg connector, 60-inches
	5061-0969	11713A to 87104/106 Opt. 100 11713A to 87204/206 Opt. 100	Viking to bare wires, 60-inches (2 required for HP 87106/206)

[1] For complete cable configuration information, used for connection to HP attenuator/switch drivers, request publication number 5963-2038E, *HP 70611A, HP 87130A and HP 11713A Switch Attenuator Driver Configuration Guide.*

[2] Does not provide sensing when used with HP attenuator/switch drivers.

Some HP switches are also available as OEM equivalents. This table shows the corresponding model numbers.

HP Model Number	OEM Model Number
8762A	33311A
8762B	33311B
8762C	33311C
8763B	33312B
8764A	33313A
8764B	33313B
8764C	33313C
8765A	33314A
8765B	33314B
8765D	33314D

Drivers and Interface Modules

Figure 1. HP 11713A (upper left), HP 70611A (upper right), HP 87130A (lower).

Figure 2. HP 87130A with various attenuators and switches.

HP 11713A Attenuator/Switch Driver

The HP 11713A attenuator/switch driver provides simple HP-IB control of up to ten 24 Vdc solenoid activated switch or attenuator sections. The HP 11713A supplies 24 Vdc common and ten pairs of current sinking contacts to control up to 10 relays. The internal 24 Vdc power supply of the HP 11713A can deliver control signals totaling 0.625 amps continuously or 1.25 amps for one second. Each HP 11713A comes equipped with two plug-in drive cables for driving attenuators. Other cables are also available. The convenient front panel controls allow manual control of individual attenuator sections and/or switches.

HP 70611A Attenuator/Switch Driver for MMS

The HP 70611A is a 1 / 8 MMS module capable of driving up to 248 electromechanical switches or attenuator switch sections. The HP 70611A is MSIB, SCPI and HP-IB compatible. In addition to being programmable, the HP 70611A features an extremely user-friendly manual interface via any MMS display unit. The highlight of the manual interface is the operator's ability to customize groups of switch control lines and their settings, then identify these switch settings with user- defined alphanumeric labels. In this manner, end users of the HP 70611A can define custom menus with their own identification labels for simplified manual control.

The HP 70611A can store up to 256 user-defined, labeled paths. Path definitions can be stored in non-volatile EPROM. Groups of paths can be stored in "directories" for easier access to similar path commands. The HP 70611A controls switches or attenuator sections in banks of 31 (eight banks total) through individual HP 84940A I/O driver cards which are, in turn, directly wired to the switches and/or attenuators.

HP 70612/613 Series MMS Interface Modules

In addition to custom interface modules, HP offers off-the-shelf interface solutions in MMS. The HP 70612 (1 x 6 switch tree) series and the HP 70613 (2 x 5 switch tree) series are microwave matrixes available in 2 / 8 MMS modules with integrated controllers. They are equipped with front panel indicators to facilitate manual use and the integrated controller has all the capabilities of the HP 70611A attenuator/switch driver. A variety of options are available for the HP 70612/13 series including performance to 26.5 GHz, terminated or unterminated switches, integrated attenuators and a choice of port locations. For a more detailed description of these products, refer to publication number 5091-4897E, Modular Measurement System Technical Data Sheet.

HP 87130A Attenuator/Switch Driver

The HP 87130A is a 3.5-inch high (2 rack units), full rack width attenuator/switch driver capable of driving up to 248 electromechanical switches or attenuator sections. The HP 87130A is controlled over HP-IB via standard commands for programmable instruments (SCPI). The HP 87130A has been designed for use in both ATE switching systems and computer controlled bench-top applications. Control and programming are accomplished via application programs in IBASIC, RMB, C or Pascal. An ITG driver is also available for use separately or in conjunction with HP's Visual Engineering Environment (VEE).

The HP 87130A is electronically identical to the HP 70611A and shares its performance characteristics with the exception of the method of manual control. The HP 87130A has no front panel controls. Manual control of the HP 87130A is realized through its ITG driver and a computer controller. The HP 87130A can drive 31 switches or attenuator sections directly

Drivers and Interface Modules

and up to an additional 217 switches via seven additional HP 84940A driver cards. A distribution board, HP 84941A (see opposite), is available to facilitate the interconnection of the HP 87130A to switches or attenuators.

HP E1368A, E1369A and E1370A VXI Attenuator and Switch Drivers

HP's VXI family of instrumentation includes modules for microwave switching and attenuation control up to 18.0 GHz. HP E1368A contains three factory-installed SPDT switches such as the HP 8762B which feature all-port termination, dc to 18.0 GHz. HP E1369A is identical to the HP E1368A except that the switches are not included. This allows user-substitution of HP 8763/64 series transfer switches. HP E1370A allows the user to customize the internal configuration for HP 8766 series multiport switches or HP 8494/95/96/97 series step attenuators.

For more information, request a copy of the HP VXI Catalog, Pub. no. 5964-3970E, 5964-6898E (CD format).

HP 84940A Switch Driver and HP 84941A Distribution Card

The HP 84940A is an expansion driver card for the HP 70611/12/13 family of MMS attenuator/switch drivers and the HP 87130A attenuator/switch driver. The HP 84940A has been designed for incorporation into large interfaces located remotely from their controller. A single HP 84940A can control up to 31 switches and can be located up to 150 feet (45 m) from an HP 70611/12/13 or HP 87130A. The physical interconnection to the switches or attenuators is realized via 31 four-pin output connectors which permit quick connection and disconnection of the switches or attenuators. The HP 84941A is a signal distribution card designed to simplify the interconnection of the drive cable from an HP 70611A, Option 001, or HP 87130A to the 31 components directly driven by these controllers. The HP 84941A also provides 31 four-pin connectors for convenient interconnection to switches or attenuators. Included with the HP 84941A is a pack of 31 cables, to connect as many as 31 switches or attenuator sections to the HP 84941A.

Custom Switch Matrices

A switch matrix provides automatic routing of signals between test equipment and the device under test (DUT) in a microwave ATE system. Multiple measurements can be performed automatically with a single connection to the DUT, minimizing measurement time and connector wear. A switch matrix can also supply signal conditioning with internal attenuators, filters, amplifiers, and couplers.

HP switch matrices are available in three platforms:

1. Rack-and-stack (HP System II): HP 8760 series matrices are rackmount boxes with size, weight, connector type and location designed to your specifications. Frequency coverage from DC to 50 GHz is available.
2. VXI HP E6490 series matrices are built on the modular VXI platform, operating up to 26.5 GHz.
3. MMS the HP 70612 series matrices are based on the Modular Measurement System platform. They provide frequency coverage up to 26.5 GHz.

Custom Switch Matrices (continued)

HP designs and manufactures high-performance switch matrices for a wide variety of applications. There are hundreds of custom matrices built each year using a mature manufacturing process that ensures the same quality found in our RF and microwave instruments. Each matrix is optimized for a particular measurement system by a design process in which the customer directly participates.

The exceptional performance of HP switch matrices is the result of unmatched design expertise and the use of HP's coaxial switches, components, and semi-rigid cables. These switches have typical isolation of more than 90 dB, SWR less than 1.2:1 and insertion loss repeatability of 0.03 dB for high measurement confidence. This performance is guaranteed over a life of 5 million cycles. The semi-rigid cables are manufactured to strict standards to ensure that the high performance switch is transferred to your DUT.

Refer to HP Custom Switch Matrices product note on HP's WEB site. The URL is:
(http://literature.hp.com:8220/litwebbin/purl.cgi?pub_id=5966-2916E)

All HP matrices are fully documented and use off-the-shelf HP components with guaranteed quick delivery.

Features

- DC to 50 GHz
- Automatic routing of stimulus and response signals plus signal conditioning
- Available in rack-and-stack and modular (VXI and MMS) platforms
- High-quality HP coaxial switches and semi-rigid cables ensure top performance

Specifications

HP switch matrices are built to your specifications. We can use your specification documents, or you can provide us with a completed Switch Matrix Specification Form. From HP's WEB site at URL:
(http://www.tmo.hp.com/tmo/literature/English/mta_SpecificationFormSwitchMatrices .html)

Ordering information for custom switch matrices

The Switch Matrix Specification Form documents your specific electrical and mechanical requirements. We will review the specification form and provide you with a detailed proposal that includes an RF block diagram, specifications, price and delivery. The proposal may also include suggestions for cost reduction or performance improvement. Once the proposal is approved we design the optimum switch matrix for your application. When the design is complete, you will have an opportunity to approve it before manufacturing begins. Also, HP can build-to-print a matrix from your RF design.

For detailed information on electrical and mechanical specifications, basic designs, switch drivers and the ordering process, see the HP Custom Switch Matrices product note.
(http://literature.hp.com:8220/litwebbin/purl.cgi?pub_id=5966-2916E)

Key Literature

- **Custom Switch Matrices video** (12 minutes)
  Literature # 5967-5660EN (PAL system)
  Literature # 5967-5660ECU (NTSC system)
- **Why Buy a Switch Matrix from Hewlett-Packard?** Liturature # 5966-0990E
- **HP Custom Switch Matrices** product note .
  Literature # 5966-2916E

(http://literature.hp.com:8220/litwebbin/purl.cgi?pub_id=5966-2916E)

Fixed

HP 909 Series

The HP 909 series are fixed low-reflection loads for terminating a 50 Ω (75 Ω for HP 909E) coaxial system in its characteristic impedance. Whereas the HP 909A is designed for general purpose applications, the HP 909C,D,E,F series are intended for use as calibration standards. All loads find wide use as accessories for both broadband and narrowband measurement instruments, with models covering dc to 26.5 GHz.

HP 909A

HP 909C

HP 909D

HP 909E

HP 909F

Fixed

Specifications

HP Model	Impedance	Frequency Range (GHz)	Maximum SWR	Maximum Power	Connector Type	Length mm (in)	Diameter mm (in)	Shipping Weight kg (lb)
909A	50 Ω	dc to 18	0 to 4 GHz: 1.05 4 to 12.4 GHz: 1.1 12.4 to 18 GHz: 1.25	2 W avg. 300 W peak	APC-7	51 (2)	23 (0.9)	0.2 (0.5)
909A Opt. 012	50 Ω	dc to 18	0 to 4 GHz: 1.06 4 to 12.4 GHz: 1.11 12.4 to 18 GHz: 1.30		**Opt. 012:** N (m)	51 (2)	21 (0.8)	
909A Opt. 013	50 Ω	dc to 18			**Opt. 013:** N (f)	51 (2)	16 (0.63)	
909C	50 Ω	dc to 2	1.005	1/2 W avg. 100 W peak	APC-7	51 (0.5)	22 (0.9)	
909C Opt. 012	50 Ω	dc to 2	1.01		**Opt. 012:** N (m)	51 (2)	21 (0.8)	
909C Opt. 013	50 Ω	dc to 2	1.01		**Opt. 013:** N (f)		17 (0.7)	
909C Opt. 200	50 Ω	dc to 0.2	1.005		Must also order **Opt. 012:** N (m) or **Opt. 013:** N (f)		21 (0.8) 17 (0.7)	
909C Opt. 201	50 Ω	dc to 0.2	1.01		Must also order **Opt. 012:** N (m)		21 (0.8)	
909D	50 Ω	dc to 26.5	dc to 3 GHz: 1.02 3 to 6 GHz: 1.036 6 to 26.5 GHz: 1.12	2 W avg. 100 W peak	3.5 mm (m)	23 (0.9)	9 (0.4)	
909D Opt. 011	50 Ω	dc to 26.5			3.5 mm (f)	23 (0.9)	8 (0.3)	
909D Opt. 040	50 Ω	dc to 26.5	dc to 4 GHz: 1.02 4 to 6 GHz: 1.036 6 to 26.5 GHz: 1.12		3.5 mm (m)	23 (0.9)	8 (0.3)	
909E	75 Ω	dc to 3	1.02	1/2 W avg. 100 W peak	N (m)	51 (2)	21 (0.8)	
909E Opt. 011	75 Ω	dc to 3	1.02		N (f)		16 (0.6)	
909E Opt. 201	75 Ω	dc to 0.2	1.01		N (m)		21 (0.8)	
909F	50 Ω	dc to 18	dc to 5 GHz: 1.005 5 to 6 GHz: 1.01 6 to 18 GHz :1.15		APC-7		22 (0.9)	
909F Opt. 012	50 Ω	dc to 18	dc to 2 GHz: 1.007 2 to 3 GHz: 1.01		**Opt. 012:** N (m)		21 (0.8)	
909F Opt. 013	50 Ω	dc to 18	3 to 6 GHz: 1.02 6 to 18 GHz: 1.15		**Opt. 013:** N (f)		17 (0.7)	
85138A	50 Ω	dc to 50			2.4 (m)			
85138B	50 Ω	dc to 50			2.4 (f)			

Sliding

HP 911 Series

The HP 911D,E family of sliding loads represents an advance in calibration and verification of network analyzers. They utilize integral connectors to form a near perfect airline without the discontinuities associated with changeable connectors, which cause reflections. The load element is highly stable, with a reflection coefficient variation of less than 0.00032 as the element location is varied, greatly increasing the integrity of a calibration. A locking mechanism is used to locate and lock the center conductor reference plane to within 0.00005 inch of the outer reference plane.

HP 911D,E

Specifications

HP Model	Frequency Range (GHz)	Load Stability Connector & Airline	Maximum Input Power	Connector Type	Length mm (in)	Shipping Weight kg (lb)
911D	3 to 26.5	1.008	1 W avg. 1 kW peak	3.5 mm (m) 256 (10.1)	0.95 (2)	
911E	3 to 26.5	1.008	1 W avg. 1 kW peak	3.5 mm (f)	256 (10.1)	0.95 (2)

Selection Guide

Type	Uses	HP Model Number Series [1]	Frequency Coverage by Band – GHz							
			X	P	K	R	Q	U	V	W
			8.20-12.4	12.4-18.0	18.0-26.5	26.5-40.0	33.0-50.0	40.0-60.0	50.0-75.0	75.0-110.0
Adapters	Interconnect coaxial-waveguide system	**281A** [2]	X			X	X	X	X	
		281B		X		X	X	X	X	
		281C	X	X	X				X	X
		281D							X	X
Variable Attenuators	Measure reflection coefficient, insertion loss, transfer characteristics by RF substitution source mismatch	**382A**	X	X	X	X				
Detectors	Detect RF power, CW or pulsed; measure reflection coefficient, insertion loss	**422C**			X	X				
Directional Couplers	Sample high power, level power, measure reflection coefficient, reduce mismatch	**752C**	X	X	X	X	X	X	X	X
		752D	X	X	X	X	X	X	X	
		752CS, DS				X				
Isolators	Reduce mismatch at mm-wave frequencies	**365A**				X	X	X	X	X
Mixers [3]	Extend spectrum analyzer frequency range to millimeter band	**11970K**			X					
		11970R				X				
		11970Q					X			
		11970U							X	
		11970V								X
		11970W								
Network Analyzer [4]	Waveguide calibration kits	**11644A**	X	X	X	X	X	X	X	X
	Waveguide verification kits	**11645A**				X	X	X	X	X
Terminations	Fixed loads for terminating waveguide systems, sliding loads for separating load reflections from other system reflections	**910A**		X		X	X	X		
		910B	X							
		910C								X
		914B	X							

[1] For complete model number, add the appropriate waveguide band designator as a prefix to the model number (except mixers) e.g. the model number for a coax to waveguide adapter in "X" band would be X281A.
[2] Also available in the following bands (in GHz): S (2.6 to 3.95), G (3.95 to 5.85), J (5.3 to 8.2), and H (7.05 to 10).
[3] See Mixer section of this catalog for product details.
[4] See Network Analyzer section of this catalog for product details.

Coaxial to Waveguide Adapters

HP 281 Series

HP 281A,B,C series adapters transform waveguide transmission line into 50 Ω coaxial line. Power can be transmitted in either direction, and each adapter covers the full frequency range of its waveguide band with SWR less than 1.3.

Specifications

HP Model	Frequency Range (GHz)	Maximum SWR	Waveguide [1] Designator EIA MIL-W-85/( )	Flange [1] Designator UG-( )/U MIL-F-3922/( )	Coaxial Connector	Length mm (in)	Shipping Weight kg (lb)
S281A	2.6 to 3.95	1.25	WR-284 1-041	584 56B-002	N (f)	140 (5.5)	0.54 (1.19)
G281A	3.95 to 5.85	1.25	WR-187 1-053	407 57B-001	N (f)	95 (3.75)	0.27 (0.5)
J281A	5.3 to 8.2	1.3	WR-137 1-065	441 55B-002	N (f)	51 (2)	0.45 (1)
H281A	7.05 to 10	1.25	WR-112 1-071	138 54C-006	N (f)	41 (1.63)	0.45 (1)
X281A	8.2 to 12.4	1.25	WR-90 1-077	135 54C-008	N (f)	35 (1.38)	0.45 (1)
X281C	8.2 to 12.4	1.05	WR-90 1-077	135 54C-008	APC-7 **Opt. 012:** N (m) **Opt. 013:** N (f)	73 (2.88)	0.5 (1)
P281B	12.4 to 18	1.25	WR-62 1-090	419 70A-008	APC-7 **Opt. 013:** N (f)	64 (2.5)	0.5 (1)
P281C	12.4 to 18	1.06	WR-62 1-090	419 70A-008	APC-7 **Opt. 012:** N (m) **Opt. 013:** N (f)	52 (2)	0.5 (1)
K281C	18 to 26.5	1.07	WR-42 1-103	597 54C-002	3.5 mm (f) **Opt. 012:** 3.5 mm (m)	35 (1.38)	0.5 (1)
R281A	26.5 to 40	1.13	WR-28 3-009	599 —	2.4 mm (f)	39 (1.5)	0.2 (0.5)
R281B	26.5 to 40	1.13	WR-28 3-009	599 —	2.4 mm (m)	39 (1.5)	0.2 (0.5)
Q281A	33 to 50	1.17	WR-22 3-013	383 67B-013	2.4 mm (f)	39 (1.5)	0.2 (0.5)
Q281B	33 to 50	1.17	WR-22 3-013	383 67B-013	2.4 mm (m)	39 (1.5)	0.2 (0.5)
U281A	40 to 60	1.17	WR-19 —	383 (mod) —	1.85 mm (f)	39 (1.5)	0.2 (0.5)
U281B	40 to 60	1.17	WR-19 —	383 (mod) —	1.85 mm (m)	39 (1.5)	0.2 (0.5)
V281A	50 to 64	1.17	WR-15 —	385 —	1.85 mm (f)	32 (1.25)	0.2 (0.5)
V281B	50 to 64	1.17	WR-15 —	385 —	1.85 mm (m)	32 (1.25)	0.2 (0.5)
V281C	50 to 75	1.16	WR-15 3-018	385 67B-002	1.0 mm (f)	32 (1.25)	0.1 (0.2)
V281D	50 to 75	1.16	WR-15 3-018	385 67B-002	1.0 mm (m)	32 (1.25)	0.1 (0.2)
W281C	75 to 110	1.16	WR-10 3-024	387 67B-010	1.0 mm (f)	32 (1.25)	0.1 (0.2)
W281D	75 to 110	1.16	WR-10 3-024	387 67B-010	1.0 mm (m)	32 (1.25)	0.1 (0.2)

[1] The Waveguide/Flange Designator is provided to determine interface dimensions and generic material of HP products.

Variable Attenuators

HP R382A

HP P382A

HP 382A Series

The attenuation value of these direct-reading, precision attenuators depends on the rotation angle of the resistive card, rather than on the resistivity value of the attenuating material. Therefore, they are insensitive to changes in temperature and humidity which can affect the resistive card of ordinary adjustable flap attenuators. The attenuation value is highly accurate and is stable from 0 to 50 dB. The instruments feature large, easy-to-read dials, and can handle considerable microwave power.

Specifications

HP Model	Frequency Range (GHz)	Maximum SWR	Attenuation Accuracy	Attenuation Range (dB)	Maximum Residual Attenuation (0 dB Setting) (dB)	Maximum Power (CW) (watts)	Waveguide[1] Designator EIA MIL-W-85/( )	Flange[1] Designator UG-( )/U MIL-F-3922/( )	Dimensions mm (in)	Shipping Weight kg (lb)
X382A	8.2 to 12.4	1.15	±2% of reading or 0.1 dB, whichever is greater	0 to 50	1	10	WR-90 1-077	135 54C-008	397 x 194 x 119 (15.63 x 7.63 x 4.69)	3.6 (8)
P382A	12.4 to 18				1	5	WR-62 1-090	419 70A-008	318 x 197 x 121 (12.5 x 7.75 x 4.75)	3.6 (8)
K382A	18 to 26.5				1	2	WR-42 1-103	595 54C-002	194 x 156 x 121 (7.63 x 6.13 x 4.75)	2.7 (6)
R382A	26.5 to 40				1	1	WR-28 3-008	599 54C-003	162 x 156 x 121 (6.38 x 6.13 x 4.75)	2.7 (6)

[1] The Waveguide/Flange Designator is provided to determine interface dimensions and generic material of HP products.

Detectors

HP K422C

HP K/R422C

The HP K422C (18 to 26.5 GHz) and R422C (26.5 to 40 GHz) are GaAs Planar-Doped Barrier diode detectors. They both have negative output polarity as standard, and the HP K422C is available with an optional square law load resistor to extend the dynamic range to approximately 0 dBm.

Specifications

HP Model	K422C	R422C
Frequency Range	18 to 26.5 GHz	26.5 to 40 GHz
Frequency Response (dB)	±0.6	±0.6
Maximum SWR	1.36	1.78
Low Level Sensitivity (mV/µW)	>0.42	>0.42
Maximum Input Power (avg)	100 mW	100 mW
Typical Short Term Power (max. < 1 minute)	1 W	1 W
Video Impedance	1.5 kΩ	1.5 kΩ
RF Bypass Capacitance (nominal)	10 pF	10 pF
Standard Output Polarity	Negative	Negative
Optional Square Law Load	**Opt. 002**	—
Waveguide Designator [1]		
EIA	WR-42	WR-28
MIL-W-85/( )	1-103	3-008
Flange Designator [1]		
UG-( )/U	595	599
MIL-F-3922/( )	54C-002	54-003
Output Connector	BNC (f)	BNC (f)
Shipping Weight – kg (lb)	0.5 (1)	0.5 (1)

[1] The Waveguide/Flange Designator is provided to determine interface dimensions and generic material of HP products.

Directional Couplers

HP X752C,D

HP R752DS

HP 752 Series

The HP 752 series couplers are an essential part of many microwave measurement applications. Attenuation measurements, reflectometer setups, power measurements, source leveling and network analysis are just a few areas in which directional couplers find use.

HP's X, P, K, and R band couplers have a conventional multi-hole design featuring greater than 40 dB directivities. The HP R752CS,DS and Q, U, V, W 752C,D couplers are designed with "split-block" technology, and provide greater than 33 dB directivity. Split-block designs are used to assure greater precision in machining the ultra-small internal dimensions required by the 26.5 to 110.0 GHz waveguide. The split block units are equipped to interface with the precision circular cover flanges with matching alignment pins common to those applications.

Each coupler is swept-frequency tested to ensure that the main guide SWR and directivity specifications are accurate. Performance characteristics are unaffected by humidity, temperature and time. This makes these units especially useful in microwave "standards" measurements.

Specifications

HP Model	Frequency Range (GHz)	Nominal [1] Coupling (dB)	Mean Coupling Accuracy (dB)	Maximum Coupling Variation (dB)	Minimum Directivity (dB)	Maximum Primary Line SWR	Maximum Auxiliary Arm SWR	Maximum Primary Line Power (CW) (Watts)	Waveguide Designator EIA MIL-W-85/( )	[2]Flange [2] Designator UG-( )/U MIL-F- 3922/( )	Length mm (in)	Shipping Weight kg (lb)
X752C	8.2 to 12.4	10	±0.4	±0.5	40	1.05	1.15	10	WR-90	39	399 (15.69)	1.4 (3)
X752D		20				1.05	1.15	100	1-079	54C-007	399 (15.69)	
P752C	12.4 to 18	10	±0.4	±0.5	40	1.05	1.2	10	WR-62	419	311 (12.25)	0.9 (2)
P752D		20				1.05	1.2	100	1-089	70A-007	311 (12.25)	
K752C	18 to 26.5	10	±0.7	±0.5	40	1.05	1.2	5	WR-42	595	252 (9.94)	0.45 (1)
K752D		20				1.05	1.2	50	1-102	54C-001	252 (9.94)	
R752C	26.5 to 40	10	±0.7	±0.5	40	1.05	1.2	5	WR-28	599	219 (8.63)	0.45 (1)
R752D		20		±0.6		1.05	1.2	50	3-006	54C-003	222 (8.72)	
R752CS	26.5 to 40	10	±0.7	±0.6	40	1.04	1.05	5	WR-28	381	165 (6.5)	0.24 (.5)
R752DS		20				1.04	1.05	50	3-009	67B-005		
Q752C	33 to 50	10	±0.7	±0.7	40	1.05	1.1	5	WR-22	383	140 (5.5)	0.45 (1)
Q752D		20				1.05	1.1	50	3-013	67B-013		
U752C	40 to 60	10	±0.7	±0.7	39	1.06	1.1	5	WR-19	383 (mod)	140 (5.5)	0.45 (1)
U752D		20				1.06	1.1	50	3-014	67B-007		
V752C	50 to 75	10	±1.0	±0.7	36	1.08	1.14	3	WR-15	385	97 (3.81)	0.45 (1)
V752D		20				1.08	1.14	30	3-017	67B-008		
W752C	75 to 110	10	±1.0	±0.7	33	1.08	1.14	2	WR-10	387 (mod)	97 (3.81)	0.45 (1)
W752D		20				1.08	1.14	20	3-023	67B-010		

[1] Nominal Coupling, Coupling Factor, and Coupling Attenuation are terms that describe the same parameter.
[2] The Waveguide/Flange Designator is provided to determine interface dimensions and generic material of HP products.

Isolators, Stand/Holders

HP 365A Series

These products are ideal isolators for test and measurement applications. Their high, broadband isolation (better than 25 dB) minimizes the reflection effects of a source. Their low SWR and low insertion loss help to improve accuracy without the attenuation of matching pads.

The HP 365A isolators use a Faraday-rotation design. It consists of a waveguide section that contains low-loss ferrite material and impedance matching elements. A permanent magnet supplies the external magnetic bias field to the ferrite core.

HP V365A

Specifications

HP Model	Frequency Range (GHz)	Max. SWR	Maximum Insertion Loss (dB)	Minimum Isolation (dB)	Minimum Input Power (avg)	Waveguide [1] Designator EIA MIL-W-85/( )	Flange [1] Designator UG-( )/U MIL-F-3922/( )
R365A	26.5 to 40	1.4	1.5	25	1.5 W	WR-28 3-006	599 54C-003
Q365A	33 to 50	1.4	1.6	25	1.5 W	WR-22 3-010	383 67B-006
U365A	40 to 60	1.4	1.8	25	1.5 W	WR-19 3-014	383 (mod) 67B-007
V365A	50 to 75	1.5	2.0	25	1 W	WR-15 3-017	385 67B-008
W365A	75 to 110	1.5	2.5	25	1 W	WR-10 3-023	387 (mod) 67B-010

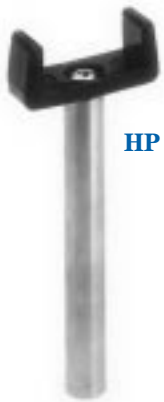
[1] The Waveguide/Flange Designator is provided to determine interface dimensions and generic material of HP products.

HP 11540A Waveguide Stand
HP 11545/546/547/548A Waveguide Holders

The HP 11540A waveguide stand locks HP waveguide holders at any height from 70 to 133 mm (2.75 in to 5.25 in). The stand is 64 mm (2.5 in) high, and the base measures 121 mm (4.75 in) in diameter.

HP 11545/546/547/548A waveguide holders are offered in four sizes to hold waveguide covering frequencies from 8.2 to 40 GHz. They consist of a molded plastic cradle with a center rod, as follows: HP 11545A X-Band, 11546A P-Band, 11547A K-Band, 11548A R-Band.

HP 11540A Waveguide Stand Shipping Weight: 454 g (1 lb). HP 11545A to 11548A Waveguide Holder Shipping Weight: 220 g (8 oz).



HP 11545A

HP 11540A

Terminations, Fixed and Sliding

HP P910A

HP X914B

HP 910 Series Fixed Terminations

HP 910 waveguide loads are designed for terminating test systems operating at low average powers. The loads are carefully designed to absorb virtually all of the applied power and ensure a lower SWR. They may be used wherever a matched load is required, as in the measurements of reflection, discontinuities, or obstacles in waveguide systems.

HP X914B Sliding Load

This sliding load consists of a movable, tapered, low-reflection load element mounted in a section of precision waveguide. A plunger controls the position of the load, and provides a controllable range of at least one-half wavelength at the lowest waveguide frequency. This movement permits the phase of the residual load reflection to be reversed so that this reflection can be separated from other small reflections in the waveguide system. Sliding loads are often used in calibration procedures.

Specifications

HP Model	Frequency Range (GHz)	Maximum SWR	Maximum Power (avg)	Waveguide [1] Designator EIA MIL-W-85/( )	Flange [1] Designator UG-( )/U MIL-F-3922/( )	Length mm (in)	Shipping Weight kg (lb)
X910B	8.2 to 12.4	1.015	1 W	WR-90 1-077	39 54C-008	168 (6.6)	0.9 (2)
P910A	12.4 to 18	1.02	1 W	WR-62 1-089	419 70A-007	111 (4.4)	0.45 (1)
R910A	26.5 to 40	1.025	1 W	WR-28 3-006	599 54-003	60 (2.4)	0.2 (0.5)
Q910A	33 to 50	1.03	1 W	WR-22 3-013	383 67B-013	71 (2.8)	0.2 (0.5)
U910A	40 to 60	1.04	1 W	WR-19 3-015	383 (mod) 67B-007	71 (2.8)	0.2 (0.5)
W910C	75 to 110	1.03	0.2 W	WR-10 3-024	387 (mod) 67B-010	56 (2.2)	0.013 (0.03)
X914B	8.2 to 12.4	1.01 (Load Element)	1 W	WR-90 1-077	39 54C-008	257 (10.1)	0.9 (2)

[1] The Waveguide/Flange Designator is provided to determine interface dimensions and generic material of HP products.

Waveguide Accessories

HP Waveguide Products Data

HP Band Designation	Frequency Range TE_{10} mode (GHz)	Waveguide Band Designator [1]						Materials [1]	Flange Designator [1]					
		EIA WR-( )	IEC R-( )	British WG-( )	JAN RG-( )/U	MIL-W-85/( )	Other Common Usage		MIL-F-3922/( )	Cover JAN UG-( )/U	EIA CMR-( )	MIL-F 3922/( )	Choke JAN UG-( )/U	EIA CPR-( )
S	2.6 to 3.95	284	32	10	75	1-041		Alum Alloy	56B-002	584	284	61-001	585A	284
G	3.95 to 5.85	187	48	12	95	1-053	C, H	Alum Alloy	57B-001	407	187	62-001	406B	187
J	5.85 to 8.2	137	70	14	106	1-065	Xn, C, G	Alum Alloy	55B-002	441	137	60-002	440B	137
H	7.05 to 10	112	84	15	51	1-073	Xb, W	Copper Alloy	54C-005	51	112	59D-015	522B	
					68	1-072		Alum Alloy	54C-006	138	—	59D-016	137B	112
X	8.2 to 12.4	90	100	16	52	1-079		Copper Alloy	54C-007	39	90	59D-013	40B	—
					67	1-078		Alum Alloy	54C-008	135	—	59D-014	136B	90
M	10 to 15	75	120	17	346	1-085		Copper Alloy	70A-004	—	75	59D-010	—	—
					347	1-084		Alum Alloy	70A-005	—	—	—	—	—
P	12.4 to 18	62	140	18	91	1-089	Ku, Y, U	Copper Alloy	70A-007	419	—	59D-001	541A	—
					349	1-091		Alum Alloy	70A-008	—	—	59D-002	—	—
N	15 to 22	51	180	19	353	1-096		Copper Alloy	70A-010	—	—	69D-004	—	—
					351	1-098		Alum Alloy	70A-011	—	—	69D-005	—	—
K	18 to 26.5	42	220	20	53	1-102		Copper Alloy	54C-001	595	—	59D-003	596A	—
					121	1-104		Alum Alloy	54C-002	597	—	59D-004	598A	—
R	26.5 to 40	28	320	22	96	3-007	V, Ka, U,	Copper Alloy	54C-003	599	—	59D-005	600A	—
					—	3-009	A	Alum Alloy	—	—	—	—	—	—
Q	33 to 50	22	400	23	272	3-011		Copper Alloy	67B-006	383	—	—	—	—
					—	3-013		Alum Alloy	67B-013	—	—	—	—	—
U	40 to 60	19	500	24	358	3-015		Copper Alloy	67B-007	383 (mod)	—	—	—	—
					—	—		Alum Alloy	—	—	—	—	—	—
V	50 to 75	15	620	25	273	3-018	M	Copper Alloy	67B-002	385	—	—	—	—
					—	—		Alum Alloy	—	—	—	—	—	—
W	75 to 110	10	900	27	359	3-024		Copper Alloy	67B-010	387 (mod)	—	—	—	—
					—	—		Alum Alloy	—	—	—	—	—	—

[1] The Waveguide/Flange Designator is provided to determine interface dimensions and generic material of HP products.

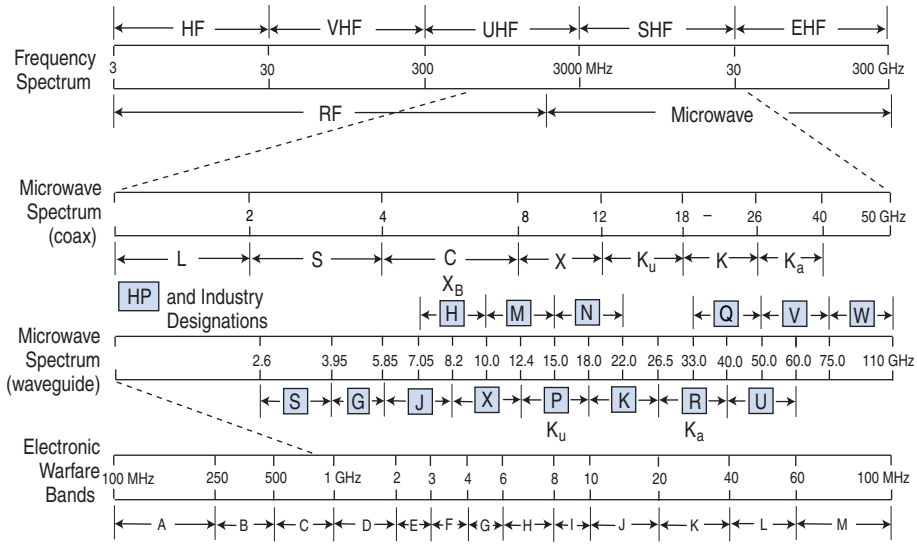
Abbreviations
EIA – Electronic Industries Association
IEC – International Electrotechnical Commission
JAN – Joint Army Navy

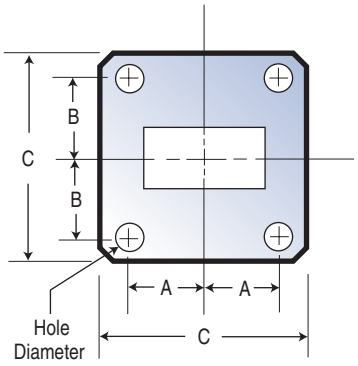
Waveguide Accessories

HP Band Designation	Waveguide Dimensions										
	Inside Dimensions			Outside Dimensions			Nom. Wall Thickness mm (in)	Cutoff Frequency (GHz)	Theoretical Attenuation Low to High Frequency (dB/100 ft)	Theoretical Peak Power Rating- Low to High Frequency megawatts (kw)	Theoretical CW Power Rating- Low to High Frequency kilowatts (watts)
	Width mm (in)	Height mm (in)	Tol ± mm (in)	Width mm (in)	Height mm (in)	Tol ± mm (in)					
S	72.14 (2.84)	34.04 (1.34)	0.15 (0.006)	76.20 (3.0)	38.10 (1.5)	0.15 (0.006	2.03 (0.08)	2.08	0.950 - 0.651	7.645 - 10.85	13.42 - 19.59
G	47.55 (1.872)	22.15 (0.872)	0.13 (0.005)	50.80 (2.0)	25.40 (1.0)	0.13 (0.005)	1.63 (0.064)	3.155	1.785 - 1.238	3.296 - 4.69	5.165 - 7.446
J	34.85 (1.372)	15.80 (0.622)	0.10 (0.004)	38.10 (1.5)	19.05 (0.75)	0.10 (0.004)	1.63 (0.064)	4.285	3.532-1.999	1.975 - 2.53	2.076 - 3.667
H	28.50 (1.122)	12.62 (0.497)	0.10 (0.004)	31.75 (1.250)	15.88 (0.625)	0.10 (0.004)	1.63 (0.064)	5.260 5.260	4.114 - 3.197 4.166 - 3.238	1.284 - 1.702 1.284 - 1.702	1.607 - 2.067 1.523 - 1.958
X	22.86 (0.900)	10.16 (0.40)	0.10 (0.004)	25.40 (1.0)	12.70 (0.5)	0.10 (0.004)	1.27 (0.05)	6.560 6.560	6.424 - 4.445 6.506 - 4.502	0.758 - 1.124 0.758 - 1.124	0.8621 - 1.246 0.8169 - 1.180
M	19.05 (0.75)	9.53 (0.375)	0.08 (0.003)	21.59 (0.850)	12.07 (0.475)	0.08 (0.003)	1.27 (0.05)	7.847 7.847	7.601 - 5.309 7.698 - 5.377	0.622 - 0.903 0.622 - 0.903	0.6621 - 0.9479 0.6273 - 0.8982
P	15.80 (0.622)	7.90 (0.311)	0.06 (0.0025)	17.83 (0.702)	9.93 (0.391)	0.08 (0.003)	1.02 (1.02)	9.490 9.490	9.578 - 7.041 9.700 - 7.131	0.457 - 0.633 0.457 - 0.633	0.4513 - 0.6139 0.4276 - 0.5816
N	12.95 (0.51)	6.48 (0.255)	0.06 (0.0025)	14.99 (0.59)	8.51 (0.335)	0.08 (0.003)	1.02 (0.04)	11.54 11.54	13.08 - 9.477 13.25 - 9.598	0.312 - 0.433 0.312 - 0.433	0.2899 - 0.4000 0.2746 - 0.3791
K	10.67 (0.42)	4.32 (0.17)	0.05 (0.002)	12.70 (0.5)	6.35 (0.25)	0.08 (0.003)	1.02 (0.04)	14.08 14.08	20.48 - 15.04 20.74 - 15.23	0.171 - 0.246 0.171 - 0.246	0.1565 - 0.2132 0.1483 - 0.2020
R	7.11 (0.280)	3.56 (0.14)	0.04 (0.0015)	9.14 (0.36)	5.59 (0.22)	0.05 (0.002)	1.02 (0.04)	21.10 21.10	23.02 - 15.77 34.46 - 23.59	(96.0 - 146) (96.0 - 146)	(109.7 - 160.1) (73.27 - 107.0)
Q	5.69 (0.224)	2.84 (0.112)	0.03 (0.001)	7.72 (0.304)	4.88 (0.192)	0.05 (0.002)	1.02 (0.04)	26.35 26.35	32.44 - 22.05 48.53 - 32.99	(64.4 - 97.0) (64.4 - 97.0)	(68.89 - 101.4) (46.05 - 67.74)
U	4.78 (0.188)	2.39 (0.094)	0.03 (0.001)	6.81 (0.268)	4.42 (0.174)	0.05 (0.002)	1.02 (0.04)	30.69 30.69	39.81 - 28.60 —	(48.0 - 70.0) (48.0 - 70.0)	(51.32 - 71.43) —
V	3.76 (0.148)	1.88 (0.074)	0.03 (0.001)	5.79 (0.228)	3.91 (0.154)	0.05 (0.002)	1.02 (0.04)	39.90 39.90	60.25 - 41.17 —	(30.0 - 40.0) (30.0 - 40.0)	(30.27 - 44.30) —
W	2.54 (0.100)	1.27 (0.05)	0.03 (0.001)	4.57 (0.18)	3.30 (0.13)	0.05 (0.002)	1.02 (0.04)	58.85 58.85	105.6 - 74.26 —	(14.0 - 20.0) (14.0 - 20.0)	(14.73 - 20.86) —

Waveguide Accessories

Frequency Band Data





Rectangular Flanges

Figure 1. Rectangular Flanges H, X, M, P, N, K, R Bands

HP Flange Data (7.05 to 40.0 GHz) [1]

HP Band	Waveguide Designator: Frequency Range (GHz)	Waveguide Designator: EIA	Waveguide Designator: MIL-W-85/( )	Flange Designator: Material B: Copper Alloy A: Alum. Alloy	Flange Designator: JAN UG-( )/U	Flange Designator: MIL-F-3922/( )	Dimensions mm (in): A	Dimensions mm (in): B	Dimensions mm (in): C	Dimensions mm (in): Hole Diameter
H	7.05 to 10	WR-112	1-073	B	51	54C-005	17.2	18.7	47.6	4.3
			1-072	A	138	54C-006	(0.676)	(0.737)	(1.875)	(0.169)
X	8.2 to 12.4	WR-90	1-079	B	39	54C-007	15.5	16.3	41.3	4.3
			1-078	A	135	54C-008	(0.61)	(0.64)	(1.625)	(0.169)
M	10 to 15	WR-75	1-085	B	—	70A-004	13.2	14.2	38.1	3.6
			1-084	A	—	70A-005	(0.52)	(0.561)	(1.50)	(0.14)
P	12.4 to 18	WR-62	1-089	B	419	70A-007	12.6	12.1	33.5	3.7
			1-091	A	—	70A-008	(0.497)	(0.478)	(1.32)	(0.144)
N	15 to 22	WR-51	1-096	B	—	70A-010	10.3	11.3	30.1	3.6
			1-098	A	—	70A-011	(0.405)	(0.443)	(1.187)	(0.14)
K	18 to 26.5	WR-42	1-102	B	595	54C-001	8.1	8.5	22.2	2.9
			1-104	A	597	54C-002	(0.32)	(0.335)	(0.875)	(0.116)
R	26.5 to 40	WR-28	3-007	B	599	54-003	6.4	6.7	19.1	2.9
			3-009	A	—	—	(0.25)	(0.265)	(0.75)	(0.116)

[1] See Figure 1.

Waveguide Accessories

Figure 2a.

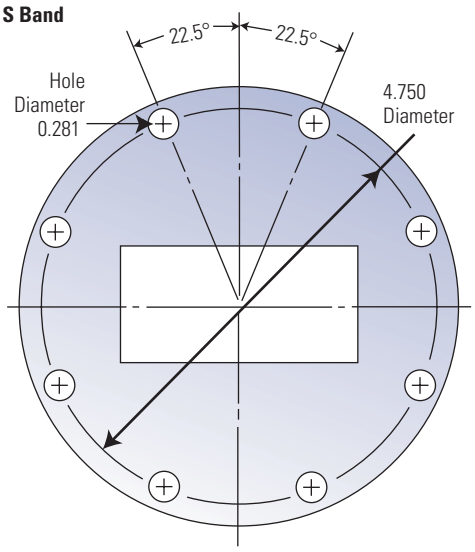


Figure 2b.

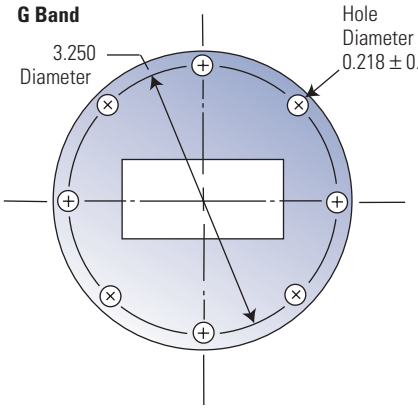
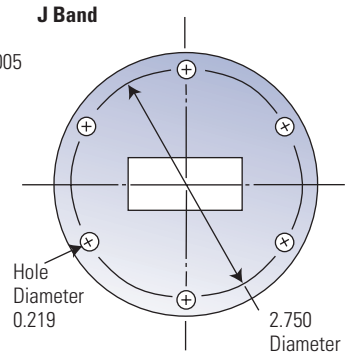


Figure 2c.



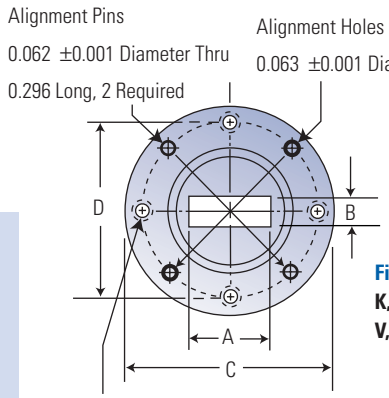


Figure 3.
K, R, Q, U, V, W Bands

HP Circular Flange Data (2.6 to 8.2 GHz)[1]

HP Band	Frequency Range (GHz)	Waveguide Designator EIA	MIL-W-85/( )	Material	Flange Designator MIL-F-3922/( )	JAN UG-( )/U
S	2.60 to 3.95	WR-284	1-041	Alum. Alloy	56B-002	584
G	3.95 to 5.85	WR-187	1-053	Alum. Alloy	57B-001	407
J	5.85 to 8.20	WR-137	1-065	Alum. Alloy	55B-002	441

[1] See Figures 2a, 2b, and 2c.

HP Precision Circular Flange Data (18.0 to 110.0 GHz)[2]

HP Band	Frequency Range (GHz)	Waveguide Designator EIA	MIL-W-85/( )	Material B: Copper Alloy A: Alum. Alloy	Flange Designator MIL-F 3922/( )	JAN UG-( )/U	Dimensions mm (in) A	B	C Diameter	D Diameter
K	18 to 26.5	WR-42	1-102	B	67B-004	425	10.7	4.3	28.6	23.8
			1-104	A	67B-011	—	(0.42)	(0.17)	(1.125)	(0.9375)
R	26.5 to 40	WR-28	3-007	B	67B-005	381	7.1	3.6	28.6	23.8
			3-009	A	67B-012	—	(0.28)	(0.14)	(1.125)	(0.9375)
Q	33 to 50	WR-22	3-011	B	67B-006	383	5.7	2.8	28.6	23.8
			3-013	A	67B-013	—	(0.224)	(0.112)	(1.125)	(0.9375)
U	40 to 60	WR-19	3-015	B	67B-007	383 (mod)	4.8	2.4	28.6	23.8
			—	A	—	—	(0.188)	(0.094)	(1.125)	(0.9375)
V	50 to 75	WR-15	3-018	B	67B-002	385	3.8	1.9	19.1	14.3
			—	A	—	—	(0.148)	(0.074)	(0.75)	(0.5625)
W	75 to 110	WR-10	3-024	B	67B-010	387 (mod)	2.5	1.3	19.1	14.3
			—	A	—	—	(0.10)	(0.050)	(0.75)	(0.5625)

[2] See Figure 3.

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HiPerformance Systems (Pty.) Ltd.
HP DIRECT
Private Bag
Wendywood 2144
Tel: 011 806 1193
Fax: 011 806 1213

United States

Hewlett-Packard
HP DIRECT
Tel: (800) 452-4844
Fax: (303) 754-4800

HP Test & Measurement Call Centers

For countries without HP Call Centers, please contact your local Hewlett-Packard sales office. A current listing is available via HP's site on the Internet at **http://www.hp.com/go/mta**.

If you do not have access to the Internet, please contact one of the HP Centers listed below and they will direct you to your nearest HP representative.

Europe:

Hewlett-Packard
European Marketing Centre
P.O. Box 999
1180 AZ Amstelveen
The Netherlands

Latin America:

Hewlett-Packard
Latin American Region Headquarters
5200 Blue Lagoon Drive
9th Floor
Miami, Florida 33126
U.S.A.
Tel: (305) 267 4245/4220

Asia Pacific:

Hewlett-Packard Asia Pacific Ltd
17-21/F Shell Tower, Times Square,
1 Matheson Street, Causeway Bay,
Hong Kong
Fax: (852) 2506 9285

For the latest updates and additions to this listing visit HP's website:

http://www.hp.com/go/mta