



STEP ATTENUATORS FOR BENCH USE

models
8494A/B/G/H
8495A/B/G/H
8496A/B/G/H

TECHNICAL DATA 1 NOVEMBER 1985

MANUAL MODELS

A: DC to 4 GHz

B: DC to 18 GHz



8494A/B: 0-11 dB in 1-dB steps



8496A/B: 0-110 dB in 10-dB steps



8495A/B: 0-70 dB in 10-dB steps

FEATURES

- BROADBAND (DC TO 18 GHz)
- HIGH REPEATABILITY (TYPICALLY 0.01 dB)
- HIGH ACCURACY (TYPICALLY $\pm 2\%$ TO 18 GHz)
- LOW COST
- LIFE > 5 MILLION CYCLES/SECTION

PROGRAMMABLE MODELS

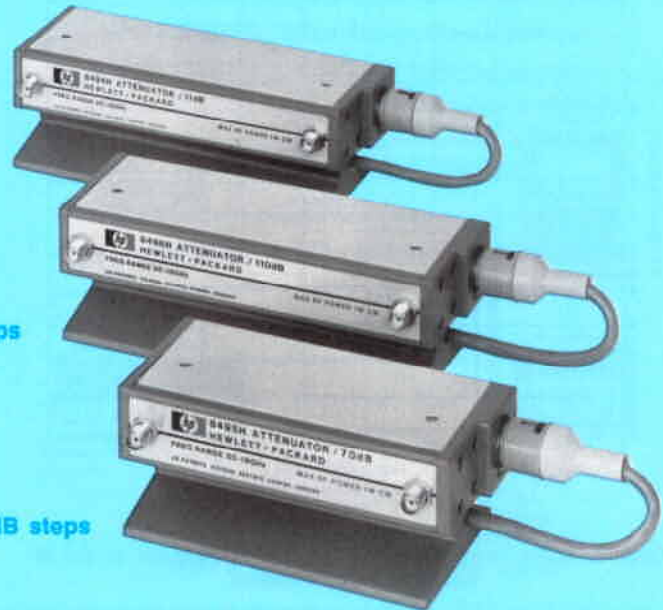
G: DC to 4 GHz

H: DC to 18 GHz

8494G/H: 0-11 dB in 1-dB steps

8496G/H: 0-110 dB in 10-dB steps

8495G/H: 0-70 dB in 10-dB steps



GENERAL DESCRIPTION

This family of HP step attenuators represents the state-of-the-art in attenuator design. These attenuators offer an unprecedented combination of broadband accuracy, high repeatability, and convenient size, all at a low cost to the user. Their precision and economy suit them to a wide variety of lab and production measurement applications. Equivalent versions of these attenuators for incorporation in equipment (i.e., "OEM"), are available under HP model numbers 33320, 33321, 33322.

Each attenuator is composed of three or four attenuation sections connected in cascade. Each section (see Figure 1) consists of a precision thin-film attenuation card with 10, 20, or 40 dB loss (1, 2, or 4 dB for the

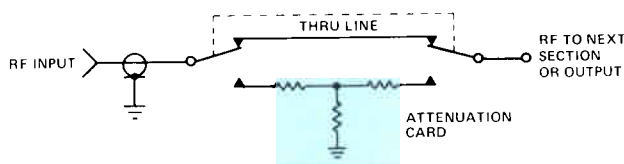


Figure 1. Schematic of Single Attenuator Section.

8494A/B/G/H), a lossless thru line, and a ganged pair of contacts (actually transmission lines) that switch the attenuation card in or out. This combination results in high accuracy and excellent repeatability.

PRODUCT INFORMATION

Manual and Programmable Models

BROADBAND ACCURACY AND LOW SWR

High accuracy (typically $\pm 2\%$ of the dB reading to 18 GHz) and low SWR (typically less than 1.30 to 18 GHz) are achieved through the use of miniature thin-film attenuation cards composed of high stability tantalum resistive film on a sapphire substrate. This thin-film technique permits the construction of circuits which are truly distributed and without stray reactances, even at very high microwave frequencies. These precision cards and the cascaded section design provide high step-to-step accuracy (typically better than ± 1 dB for a 10-dB step and ± 0.2 dB for a 1-dB step even in high attenuation and high frequency cases).

Figure 2 shows the typical frequency response from 1 to 18 GHz of the 8494B model, as tested on a computer controlled HP Automatic Network Analyzer. These 1-dB steps show typical step-to-step accuracy of better than ± 0.2 dB. This level of performance is particularly important when setting calibration lines and making precision measurements.

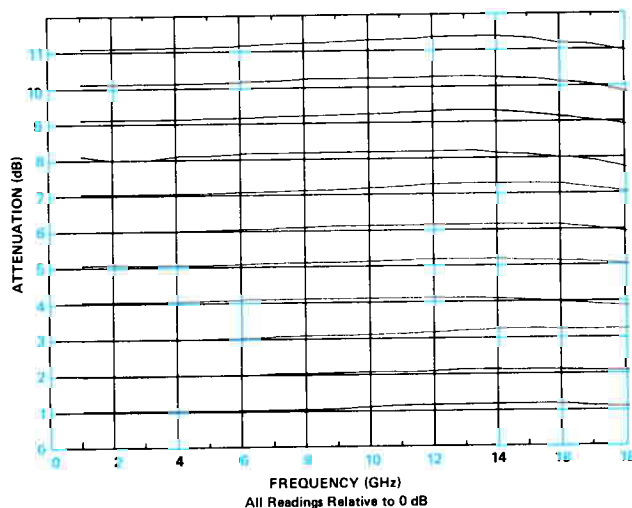


Figure 2. 8494B Typical Frequency Response as Measured on the HP Automatic Network Analyzer.

HIGH REPEATABILITY

Excellent repeatability (typically 0.01 dB for up to five million cycles) has been achieved by employing "edge line" design for the transmission line.¹ The unique design feature of switching only the center conductor eliminates high friction sliding contacts, characteristic of turret type attenuators. The resulting benefits are long life and highly repeatable measurements.

RAPID SWITCHING SOLENOIDS

In the programmable models, use of miniature solenoids has resulted in more than a two-to-one improvement in switching speed over previous models. The 20-millisecond maximum switching time includes contact settling and is a significant advantage for automatic testing, and other applications where speed is of prime importance. Once switched, the solenoids are held in place by strong permanent magnets able to withstand shocks over 10 G's.

A unique design feature of these attenuators is that the solenoid coils automatically disconnect after switching. This feature greatly simplifies the driver circuit design (see Figure 4) and minimizes the amount of heat dissipated by the solenoids.

RELIABLE PERFORMANCE

Each unit is tested over its operating frequency range by the computer controlled HP Automatic Network Analyzer to ensure consistent, accurate measurements, traceable to the National Bureau of Standards. This measurement system brings standards lab accuracy to production testing and assures that each attenuator meets specifications over the entire frequency range.

LOW COST

Utilizing state-of-the-art manufacturing processes, including numerically controlled machining, thin-film deposition and computer controlled testing, this family of attenuators offers a significant technical contribution at a low cost to the user.

¹ HP Journal Article, May 1974, p. 21.

ATTENUATOR SECTION SWITCHING

Figure 3 shows a section schematic. Each attenuation section utilizes one solenoid with dual coil windings, one coil to switch in the attenuation card (e.g. 10 dB) and one to switch in the thru line (0 dB).

With a positive voltage applied to pin 1, the desired state (attenuation card or 0 dB) of a particular section is attained by connecting the corresponding attenuation card pin or thru line pin to a negative voltage or ground.

As a section is switched, the internal contacts of the activated coil open, thus shutting off current flow. At the same time, the internal contacts for the other coil close so that it can be activated when desired. Figure 3 shows a section that has been switched to the thru line position (note the open thru line coil contacts and the closed attenuation card coil contacts).

Although all sections can be switched simultaneously, the attenuator driver must not allow both pins of the same section (e.g., Section 1, pins 5 and 6) to be activated concurrently, or else that section would cycle rapidly. All terminals are "floating," so bipolar or unipolar power supplies can be used. Solenoid drive voltage is 20 to 30 volts, switching current is 110 mA at 24 volts. Coil impedance is approximately 220 ohms and 0.07 henries.

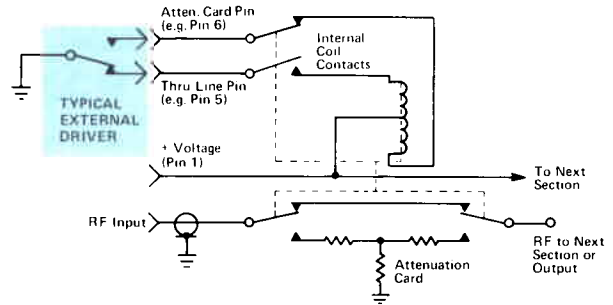


Figure 3. Section Electrical Diagram.

Table 1. Solenoid Pin and Color Code Assignment Guide.

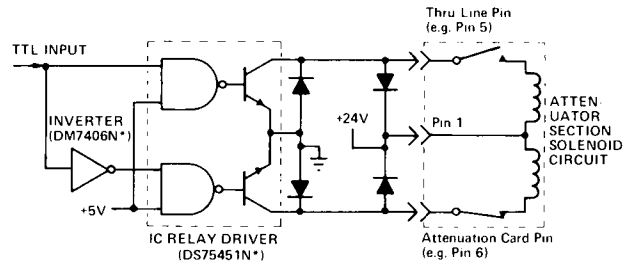
Section	Section 1		Section 2		Section 3		Section 4	
	Thru Line	Atten. Card	Thru Line	Atten. Card	Thru Line	Atten. Card	Thru Line	Atten. Card
Cable Wire Color Code*	PUR	YEL	BLK	GRN	ORG	BLU	BRN	WHT
Connector Plug Pin Number**	5	6	7	8	9	10	11	12
8494G,H (11 dB)	0 dB	1 dB	0 dB	2 dB	0 dB	4 dB	0 dB	4 dB
8495G,H (70 dB)	0 dB	10 dB	0 dB	20 dB	0 dB	40 dB	***	***
8496G,H (110 dB)	0 dB	10 dB	0 dB	20 dB	0 dB	40 dB	0 dB	40 dB

* Five-foot cable and mating plug assembly provided.
 ** Pin 1 (red wire) is common for all coils. Pins 2, 3 and 4 are not used on all models.
 *** Not used.

TYPICAL DRIVER CIRCUIT

Figure 4 shows an economical TTL compatible driver circuit for a single attenuation section utilizing an IC relay driver and an inverter. A TTL 'HI' input to the driver activates the attenuation element, while a 'LO' will activate the thru line for that section. This provides a complementary driver for the section which assures that only one solenoid of the pair can be activated at a time. Diode protection is required to protect the IC from the solenoid voltage flyback.

Additional circuit design information may be required from the component manufacturers since modifications may be necessary depending on the specific application.



*National Semiconductor Part Numbers, also supplied by other vendors.

Figure 4. Typical Section Driver Circuit.

AUTOMATIC TESTING APPLICATIONS

For automatic measurements, these programmable step attenuators can be used to give precise control of signal levels with highly repeatable results. By using the HP 59306A relay actuator and a 24-volt power supply as the driving mechanism, the attenuators are easily integrated into an HP-IB automated system. Figure 5 illustrates a 2 to 18-GHz, high resolution, moderate dynamic range setup for measuring transmission (gain or loss) as a function of input signal level and frequency.

Similar measurements can be made in the 1 to 2600 MHz frequency range by using an 8660C Synthesized Signal Generator as the programmable source.

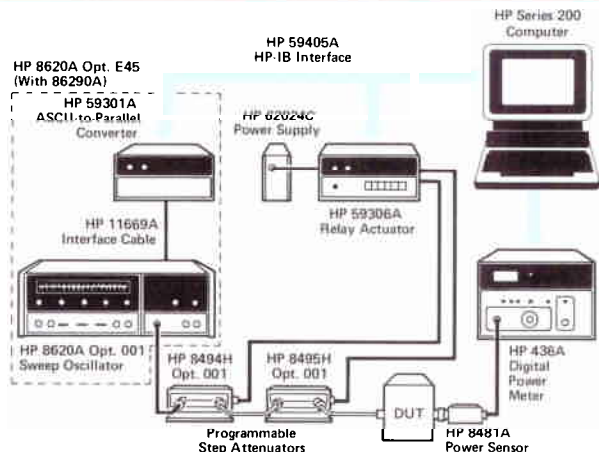


Figure 5. Typical HP-IB Measurement System.

SPECIFICATIONS

ELECTRICAL

ATTENUATION ACCURACY (\pm dB Referenced from 0-dB Setting):

Model Number	8495A/B/G/H (70-dB max)*										
	8496A/B/G/H (110-dB max)*										
Frequency Range	Attenuator Setting (dB)										
	10	20	30	40	50	60	70	80	90	100	110
dc-4 GHz (A, G only)	0.2	0.4	0.5	0.7	0.8	1.0	1.2	1.3	1.5	1.6	1.8
dc-12.4 GHz (B, H only)	0.5	0.7	0.9	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3
12.4-18 GHz (B, H only)	0.6	0.8	1.2	1.6	2.0	2.4	2.8	3.2	3.6	4.0	4.4

* Typical step-to-step accuracy is ± 1 dB to 18 GHz.

Model Number	8494A/B/G/H (11-dB max)*										
	Attenuator Setting (dB)										
Frequency Range	1	2	3	4	5	6	7	8	9	10	11
	dc - 4 GHz (A, G only)	0.2	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4
dc - 12.4 GHz (B, H only)	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.7
12.4 - 18.0 GHz (B, H only)	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.9	0.9

* Typical step-to-step accuracy is ± 0.2 dB to 18 GHz.

SWR

Characteristic Impedance: 50 ohms.

Frequency Range	Model Number	
	8495A/B/G/H	8494A/B/G/H 8496A/B/G/H
dc - 4 GHz (A, G only)	1.35	1.5
dc - 8 GHz (B, H only)	1.35	1.5
8 GHz - 12.4 GHz (B, H only)	1.5	1.6
12.4 - 18.0 GHz (B, H only)	1.7	1.9

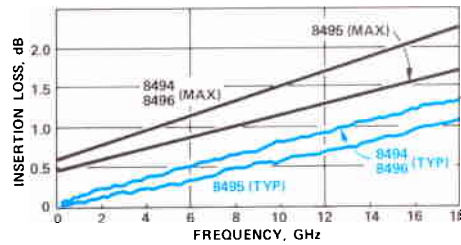
INSERTION LOSS

8494A/B/G/H: $(0.6 + 0.09 f)$ dB

8495A/B/G/H: $(0.4 + 0.07 f)$ dB

8496A/B/G/H: $(0.6 + 0.09 f)$ dB

Where f is frequency in GHz.



Life, Minimum: 5 million cycles per section.¹

Repeatability: ± 0.01 dB, typical.

RF Input Power (max.): 1 watt average, 100 watts peak (10 μ s pulse width).

Switching Speed (G, H only): Max. 20 milliseconds including settling time.

Power Sensitivity: 0.001 dB/dB/watt.

Attenuation Temperature Coefficient: Less than 0.0001 dB/dB/ $^{\circ}$ C.

MECHANICAL

Net Weight:

8495 A/B: 312 grams (11 oz); G/H: 340 grams (12 oz).

8494 } A/B: 425 grams (15 oz); G/H: 454 grams (16 oz).
8496 }

Dimensions: In millimeters (inches).

Models	Manual (A and B)			Programmable (G and H)		
	Length	Width	Height	Length	Width	Height
8495	130,2 (5.13)	73,0 (2.89)	42,9 (1.69)	140,5 (5.53)	79,4 (3.13)	42,9 (1.69)
8494 8496	158,8 (6.25)	73,0 (2.89)	42,9 (1.69)	167,9 (6.61)	79,4 (3.13)	42,9 (1.69)

Accessory Provided:

Solenoid drive plug on five-foot-cable included with G and H models.

¹A cycle is defined as switching from the thru-line position to the attenuation card and back to the thru-line position or vice versa

ORDERING INFORMATION

To order, basic model number, suffix letter, and connector option must be specified. The basic model number defines the step size and maximum attenuation value: 8494 (1-dB step, 11-dB max.), 8495 (10-dB step, 70-dB max.), 8496 (10-dB step, 110-dB max.). The suffix letter denotes frequency range and switching mode (manual or programmable): A and B denote dc to 4 GHz and dc to 18 GHz respectively for the manual model, G and H denote dc to 4 GHz and dc to 18 GHz respectively for the programmable models. This information is summarized in the following chart and in the adjacent ordering example.

Model Number*	8494		8495		8496	
	A	B	A	B	A	B
Suffix Letter*						
Manual	G	H	G	H	G	H
Programmable						
Frequency Range	dc-4 GHz	dc-18 GHz	dc-4 GHz	dc-18 GHz	dc-4 GHz	dc-18 GHz
Step Size	1 dB		10 dB		10 dB	
Attenuation Range	0-11 dB		0-70 dB		0-110 dB	
Connector* Options (All models)	001—N Female 002—SMA Female 003—APC-7					

* Must be specified, see adjacent ordering example.

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Ordering Example:

