Keysight Technologies

84904, 6, 7K/L Programmable Step Attenuators

Data Sheet



KEYSIGHT TECHNOLOGIES

Introduction

High Accuracy, Excellent Reliability, Long Life

Features and description

- DC to 26.5 GHz, DC to 40 GHz frequency coverage
- Optional calibration data
- 0 to 11 dB, 70 dB, 90 dB
- 1 dB steps, 10 dB steps
- High accuracy
- Excellent reliability, long life
- Exceptionally low insertion loss

These attenuators offer typical repeatability of ±0.03 dB max 5 million cycles per section.

This family of programmable step attenuators offers coaxial measurements to 26.5 GHz (K models) or to 40 GHz (L models), in a compact, rugged design. The first model in this family is the Keysight Technologies, Inc. 84906K/L, which offers outstanding performance with an attenuation range of 0 to 90 dB in 10 dB steps. Other models include the Keysight 84904K/L, with 0 to 11 dB of attenuation in 1 dB steps, and the Keysight 84907K/L, with 0 to 70 dB of attenuation in 10 dB steps.

This latest design evolution sets new standards for size and performance. High attenuation accuracy and low SWR are achieved through the use of miniature thin-film attenuation cards composed of high-stability tantalum nitride film on a sapphire substrate. Insertion loss performance is outstanding, with less than 2 dB of loss at 26.5 GHz and only 2.4 dB at 40 GHz (figure 1).

The compact size of the units, 35% smaller than the 8495/7 (26.5 GHz) family, allows for easy integration into instruments and ATE systems.

This family of step attenuators offers three connector types. For operation to 40 GHz, the 84904/6/7L models offer either the 2.4 mm connector, which is recommended for top performance and for rugged and repeatable connections, or the 2.92 mm connector, which is compatible with SMA and 3.5 mm connectors but is more delicate. For operation to 26.5 GHz, the 84904/6/7K models offer the 3.5 mm connector. This connector is compatible with SMA and 2.92 connectors, but is more rugged. Each model in the 84904/6/7K and L family comes with two female connectors (standard) or may be ordered with one female and one male connector for easy insertion into a microwave chain or to combine the 1 dB step 84904 with a 10 dB step 84906 or 84907 to cover an attenuation range of 121 dB or 81 dB in 1 dB steps.

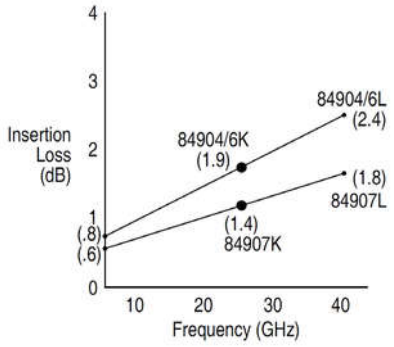


Figure 1. Insertion loss

Individual calibration data reports of attenuation and SWR are available. This data, measured with a Keysight automatic network analyzer, can be ordered as Option 8490XX-UK6.

Attenuation switching and control

These units feature the same small solenoids and switching circuits as the Keysight 8494/5/6/7 step attenuator family. Switching time is a maximum of 20 milliseconds, including contact settling time. Once switched, the units are latched with permanent magnets, capable of withstanding shocks over 10 Gs. The solenoids automatically disconnect after switching, which minimizes the attenuators' power requirements and simplifies the driver circuit design (figure 3). Solenoids are available in either 24 volt (standard, Option 8490xx-024), 15 volt (Option 8490xx-015), and 5 volt (Option 8490xx-011) ranges to fit your instrument or system requirements.

The units come equipped with 10-pin DIP headers for connecting dc control lines. Available accessories include a 203 mm (8 inch) or 406 mm (16 inch) ribbon cable with DIP-type connectors that is compatible with standard 14-pin DIP IC sockets (11764-60002 or 11764-60003, respectively). Alternatively, a 1524 mm (5 foot) cable with free wires for direct soldering (11764-60001), or a 1524 mm (5 foot) drive cable that connects to the 11713B/C attenuator/switch driver, allowing for easy integration into GPIB-controlled automatic test systems (11764-60004), may be ordered.

Selection switching

Figure 2 shows one attenuator section schematic. Each section utilizes one solenoid with dual coil windings, one coil to switch in the attenuator card (e.g. 10 dB) and one coil to switch in the thru line (0 dB).

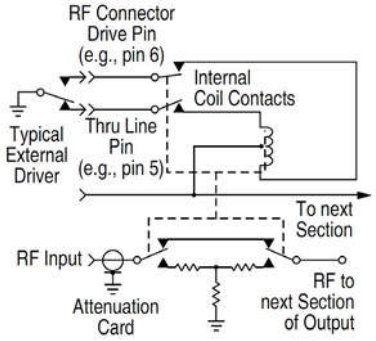


Figure 2. Section electrical diagram

With positive voltage applied to the common pin, the state (attenuator card or thru line) of a particular section is determined by connecting its attenuator card pin or thru pin to a negative voltage or ground. Figure 4 defines the pin assignments and wire color code for the 11764-60001/60002/60003 drive cables. Table 1 is a solenoid drive pin and attenuation guide. Table 2 (on page 5) defines recommended attenuator section activation.

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 attenuator card position (note the closed thru line coil contact). The switching is "break-before-make" type, thus a momentary interruption of the RF signal occurs at switching.

Although all sections can be switched simultaneously, the attenuator driver must not allow both pins of the same section (e.g. Section 1, pins 1 and 2) to be activated concurrently, or else that section would cycle rapidly. All terminals are "floating," so bipolar or unipolar power supplies can be used.

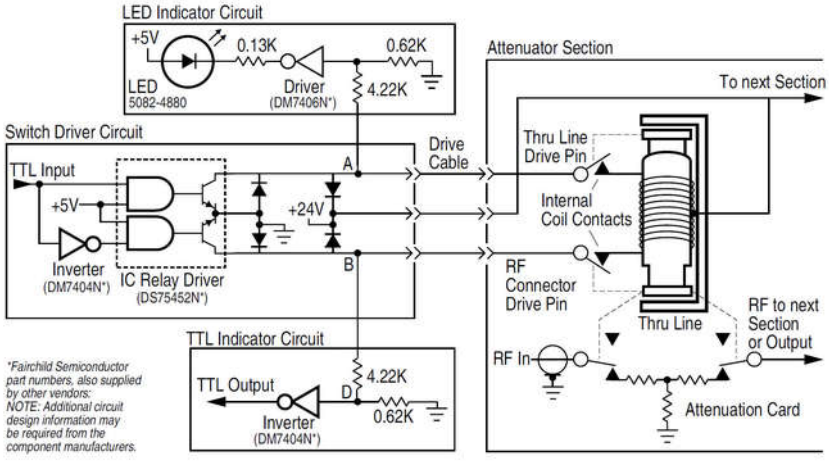


Figure 3. Driver and indicator circuits for one section of a Keysight 84904, 6, 7 K/L

Typical driver circuit

Figure 3 shows an economical TTL compatibility driver circuit for a single attenuation section which utilizes and IC relay driver and an inverter. A TTL "HI" input to the driver switches in the attenuation card, while a "LO" will activate the thru line for that section. This provides a complimentary driver for the section which assures that only one solenoid of the pair is activated at a time. Diode protection is required to protect the IC from the solenoid voltage flyback.

Switch position can be indicated remotely by utilizing the open and closed states of the internal coil contacts. Connected at A and B in figure 3 are two indicator circuits, one providing a TTL output and one that activates an LED. These circuits will output a TTL "HI" (LED lamp "ON") if the attenuation card is in the RF circuit, and will output a TTL "LO" (LED lamp "OFF") if the thru line is in the RF circuit. Since current is drawn through the coil for these circuits, inadvertent switching is prevented by limiting the current to 5 mA.

Keysight assumes no responsibility for the use of any circuits described herein and makes no representation or warranties, express or implied, that such circuits are free from patent infringement.

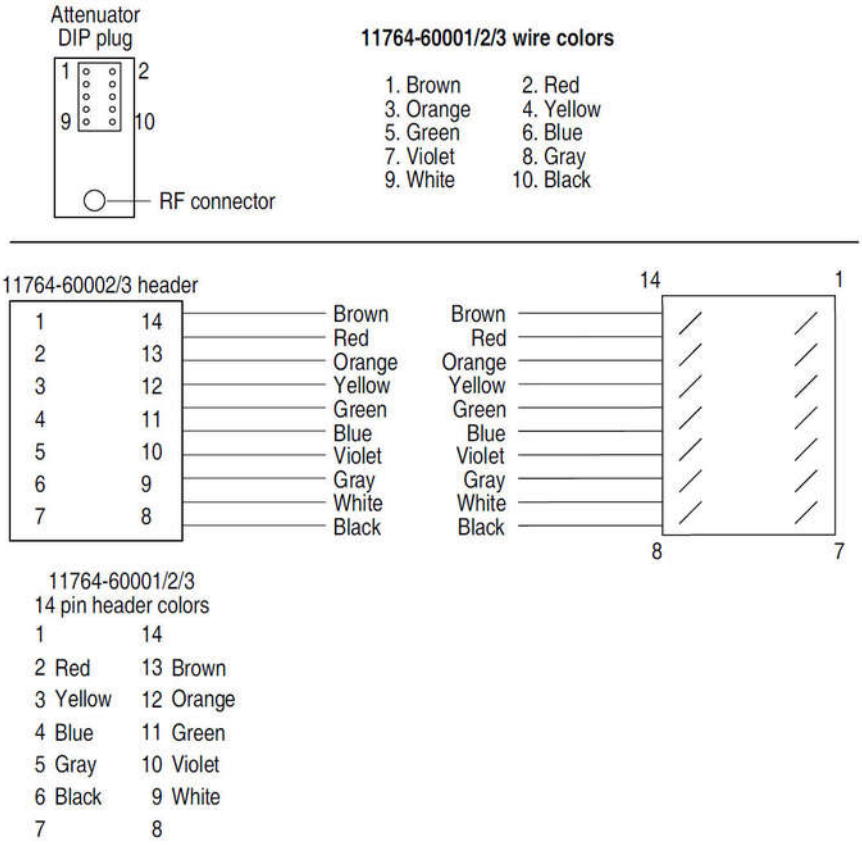


Figure 4. Attenuator switching pinout

Drive Cables

11764-60001	10 pin DIP to 60" long ribbon cable
11764-60002	10 pin DIP to 14 pin DIP, 8" long
11764-60003	10 pin DIP to 14 pin DIP, 16" long
11764-60004	10 pin DIP to 12 pin Viking connector, 60" long. Used with 11713A driver

Table 1. Solenoid pin and attenuation guide

Section:	Section 1		Section 2		Section 3		Section 4	
Model Number	**Thru Line**	**Attn Card**	**Thru Line**	**Attn Card**	**Thru Line**	**Attn Card**	**Thru Line**	**Attn Card**
84906K/L								
Attenuation (dB)	0	10	0	20	0	30	0	30
Actuating pin	1	2	5	8	4	9	6	7
11764-60004 plug Pin number	5	6	7	8	9	10	11	12
11764-60002/60003 flat Header pin number	13	2	11	5	3	9	4	10
84907K/L								
Attenuation (dB)	0	10	0	20	0	40		
Actuating pin	1	2	5	8	4	9		
11764-60004 plug Pin number	5	6	7	8	9	10		
11764-60002/60003 flat Header pin number	13	2	11	5	3	9		
84904K/L								
Attenuation (dB)	0	1	0	2	0	4	0	4
Actuating pin	1	2	5	8	4	9	6	7
11764-60004 plug Pin number	5	6	7	8	9	10	11	12
11764-60002/60003 flat Header pin number	13	2	11	5	3	9	4	10

Pin 10 is +V Supply

Table 2. Attenuator section activation guide

Recommended switching sequence: The following switching sequence (ie. which 30 dB section to use for the 84906K/L or which 4 dB section for the 84904K/L should be followed to insure performance to specs.

Attenuation selected												
84906K/L	**0 dB**	**10 dB**	**20 dB**	**30 dB**	**40 dB**	**50 dB**	**60 dB**	**70 dB**	**80 dB**	**90 dB**		
Section 1 (10 dB)		X			X			X		X		
Section 2 (20 dB)			X			X			X	X		
Section 3 (30 dB)				X	X	X	X	X	X	X		
Section 4 (30 dB)							X	X	X	X		
84907K/L	**0 dB**	**10 dB**	**20 dB**	**30 dB**	**40 dB**	**50 dB**	**60 dB**	**70 dB**				
Section 1 (10 dB)		X		X		X		X				
Section 2 (20 dB)			X	X			X	X				
Section 3 (40 dB)					X	X	X	X				
84904K/L	**0 dB**	**1 dB**	**2 dB**	**3 dB**	**4 dB**	**5 dB**	**6 dB**	**7 dB**	**8 dB**	**9 dB**	**10 dB**	**11 dB**
Section 1 (1 dB)		X		X		X		X				X
Section 2 (2 dB)			X	X			X	X			X	X
Section 3 (4 dB)					X	X	X	X	X	X	X	X
Section 4 (4 dB)									X	X	X	X

Switching notes: Pins relate to 10-pin attenuator header as shown (Table 1), NOT terminating connector on any attached drive cable. Solenoids are magnetic latching type; drive voltage may be removed after switching. Current is self-interrupting in less than 20 ms.

GPIB attenuator/ switch driver

Employing programmable step attenuators and switches in an automatic test system becomes an easy task when the Keysight 11713B/C attenuator/switch driver is specified into the system.

The 11713B/C has all of the necessary features to provide GPIB, USB, or LAN control of up to four programmable attenuators of the 84904/6/7 series, and concurrently up to four electromechanical switches (e.g., the 8671B or 8762 Series).

The 11713B/C includes an integral power supply (with short circuit protection) that can simultaneously provide 125 milliamps at 24 volts to all contacts for control of the attenuators and switches, so no external power supply is needed. Connecting between the 11713B/C and the 84904/6/7 step attenuators is easy with the 11764-60004 drive cable.

The 11713B/C also features convenient front panel keys so the user can manually activate the individual attenuation sections and switches when in the "local" mode. Switching time for the drivers is less than 10 milliseconds.

Optional calibration data for the Keysight 84904/6/7

Use of calibration data (i.e., accuracy, recorded, data of a device's characteristics) has always been an effective means of reducing measurement uncertainty at RF and microwave frequencies. Step attenuators have long been used as reference standards in the measurement of gain, attenuation, and receiver sensitivity. Since the accuracy specifications include margins for frequency response and unit-to-unit variations, calibration data can improve overall measurement uncertainty.

Calibration data is available as Option 8490xx-UK6 and is generated from measurements made by a Keysight network analyzer.

Option 8490xx-UK6 provides a tabular list of attenuation and reflection coefficients in 250 MHz steps from 1500 MHz to 40 GHz. Measurements are traceable to NIST (National Institute of Standards and Technology, formerly NBS) standards and feature very low measurement uncertainties (See tables 3 and 4).

For devices with option 8490xx-006 and option 8490xx-106, option 8490xx-UK6 and NIST traceability are not available.

Table 3.
Keysight 84904/6/7K/L reflection coefficient data uncertainty

Frequency Range (GHz)	
dc to 12.4	± .017
14.4 to 26.5	± .023
26.5 to 34	± .025
34 to 40	± .028

Table 4.
Keysight 84904/6/7K/L attenuation data uncertainties

Attenuation (dB)	dc to 20 GHz	20 to 26.5 GHz	26.5 to 40 GHz
0	± 0.12	± 0.12	± 0.15
10	± 0.16	± 0.24	± 0.30
20	± 0.16	± 0.25	± 0.30
30	± 0.17	± 0.30	± 0.30
40	± 0.32	± 0.47	± 0.30
50	± 0.36	± 0.54	± 0.30
60	± 0.36	± 0.54	± 0.30
70	± 0.52	± 0.72	± 0.35
80	± 0.50	± 0.52	± 0.60
90	± 0.66	± 0.91	± 1.05

Attenuator Setting

Attenuation accuracy (±dB; referenced from 0 dB setting):

	84907K/L 84906K/L										
Attenuator setting	10	20	30	40	50	60	70	80	90		
Frequency range dc to 40 GHz[2]	0.5	0.6	0.7	1.0	1.2	1.6	1.8	2.7	2.9		
	84904K/L										
Attenuator setting (dB)	1	2	3	4	5	6	7	8	9	10	11
Frequency range											
dc to 18 GHz	0.35	0.45	0.55	0.55	0.55	0.55	0.60	0.60	0.65	0.70	0.80
18 to 26.5 GHz	0.40	0.50	0.70	0.70	0.70	0.70	0.80	0.80	0.85	0.90.	1.10
26.5 to 40 GHz[2]	0.60	0.60	0.80	0.80	0.80	0.90	1.10	1.10	1.20	1.30	1.50

1. *Step-to-step accuracy is the maximum variation from the nominal step size when changing attenuation values. It is a second specification on accuracy, and is used in combination with the absolute accuracy specifications to limit maximum allowable variation from nominal. Typical step-to-step accuracy for the 84906L and 84907L is ±0.6 dB to 26.5 GHz, ±0.9 dB to 40 GHz; for the 84904L is ±0.3 to 26.5 GHz, ±0.4 to 40 GHz.*
2. *Attenuation accuracy to 26.5 GHz for K models.*

Specifications

Insertion loss

(in dB 0 dB position, f = freq. in GHz)

84904K/L (0.8 + 0.04xf)
84906K/L (0.8 + 0.04xf)
84907K/L (0.6 + 0.03xf)

SWR	Connector Option	dc to 12.4 GHz	12.4 GHz to 34 GHz	34 GHz to 40 GHz	SWR	Connector Option	dc to 12.4 GHz	12.4 GHz to 34 GHz
L models					**K models**			
84904L	with 101	1.3	1.7	1.8	84904K	004	1.3	1.7
84904L	with 006	1.5	1.9	2.0	84904K	104	1.3	1.7
84904L	with 100	1.3	1.7	1.8	84906K	004	1.3	1.7
84904L	with 106	1.5	1.9	2.0	84906K	104	1.3	1.7
84906L	with 101	1.3	1.7	1.8	84907K	004	1.25	1.5
84906L	with 006	1.5	1.9	2.0	84907K	004	1.25	1.5
84906L	with 100	1.3	1.7	1.8				
84906L	with 106	1.5	1.9	2.0				
84907L	with 101	1.25	1.5	1.7				
84907L	with 006	1.4	1.7	1.9				
84907L	with 100	1.25	1.5	1.7				
84907L	with 106	1.4	1.7	1.9				

Attenuation temperature coefficient
Less that 0.0001 dB/dB/C°

Power sensitivity
0.001 dB/Watt

RF Input power (max.)
1 Watt average, 50 Watts peak (10 µs max. pulse width)

Life (min.)
5 million cycles per section

Repeatibility
±0.03 dB max 5 million cycles per section, typical

Environmental capabilities
(Up to 5 million cycles)

Temperature, operating
–20°C to +75°C

Temperature, non-operating
–55°C to +85°C

Altitude, operating
4,570 meters (15,000 ft.)

Altitude, non-operating
13,700 meters (50,000 ft.)

Humidity
Cycling 5 days, 40°C at 95% RH with condensation

Shock operating
10 Gs, six ms, on six sides, three blows

Shock, non-operating
500 Gs, 1.8 ms, in six directions

Vibration, operating
5 Gs, 34-2000 Hz

EMC
Radiated interference is within the requirements of MIL-STD-461 method RE02, VDE 0871 and CISPR Publication II

Mechanical Information

Net weight	84904K/L	84906K/L	84907K/L
	291 grams	291 grams	229 grams
	(10.3 oz)	(10.3 oz)	(8.1 oz)

Mounting position (any)

RF connectors

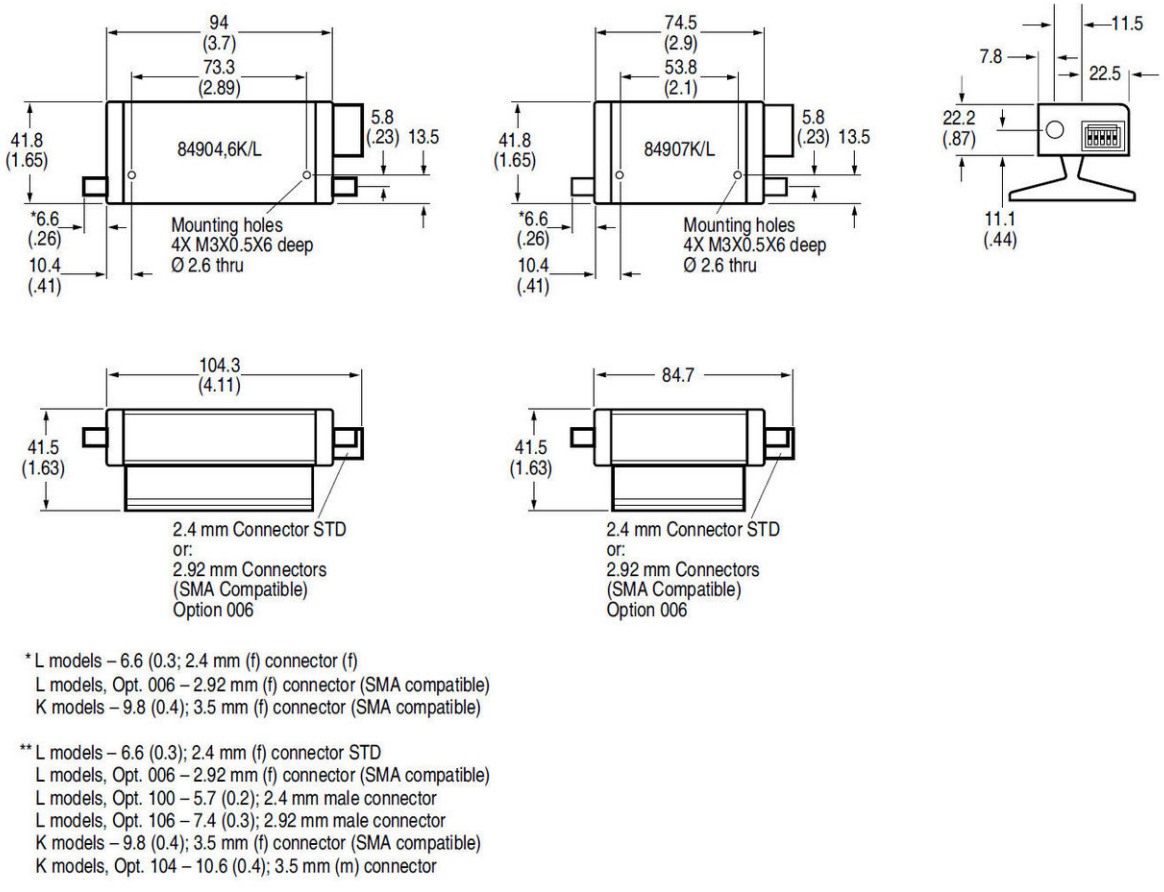
2.4 mm connectors standard, L models only
2.92 mm (SMA compatible), L models only
3.5 mm (SMA compatible), K models only

Switching speed

Maximum 20 msec including settling time

Solenoids	Coil voltage	Switching current	Nominal coil impedance
Option 024	24 V 20 to 30 V)	125 mA (at 24 V)	190 Ω
Option 015	15 V (13 to 22 V)	188 mA (at 15 V)	80 Ω
Option 011	5 V (4.5 to 7 V)	325 mA (at 5 V)	17 Ω

1. *1 Current per section; approximately 10 msec duration before internal contacts open the coil circuit*



* L models – 6.6 (0.3; 2.4 mm (f) connector (f)
L models, Opt. 006 – 2.92 mm (f) connector (SMA compatible)
K models – 9.8 (0.4); 3.5 mm (f) connector (SMA compatible)

** L models – 6.6 (0.3); 2.4 mm (f) connector STD
L models, Opt. 006 – 2.92 mm (f) connector (SMA compatible)
L models, Opt. 100 – 5.7 (0.2); 2.4 mm male connector
L models, Opt. 106 – 7.4 (0.3); 2.92 mm male connector
K models – 9.8 (0.4); 3.5 mm (f) connector (SMA compatible)
K models, Opt. 104 – 10.6 (0.4); 3.5 mm (m) connector

Figure 5. Dimensions are in millimeters and inches.

Ordering information

Programmable step attenuators

84904K 0 to 11 dB, 1 dB steps; dc to 26.5 GHz
84904L 0 to 11 dB, 1 dB steps; dc to 40.0 GHz
84906K 0 to 90 dB, 10 dB steps; dc to 26.5 GHz
84906L 0 to 90 dB, 10 dB steps; dc to 40.0 GHz
84907K 0 to 70 dB, 10 dB steps; dc to 26.5 GHz
84907L 0 to 70 dB, 10 dB steps; dc to 40.0 GHz

Options

To add options to a product, use the following ordering scheme:
Model: 84904/6/7x (x = K, L)
Model options: 84904/6/7x-opt#1 or 84904/6/7x-opt#2

Supply voltage (must choose one)

84904/6/7x-011 5 V dc supply voltage
84904/6/7x-015 15 V dc supply voltage
84904/6/7x-024 24 V dc supply voltage (standard option)

RF connectors (must choose one)

84904/6/7K-004	3.5 mm female connector, 3.5 mm female connector (standard option)
84904/6/7K-104	3.5 mm male connector, 3.5 mm female connector
84904/6/7L-006	2.92 mm female connector, 2.92 mm female connector (UK6 not available with this option)
84904/6/7L-100	2.4 mm male connector, 2.4 mm female connector
84904/6/7L-101	2.4 mm female connector, 2.4 female connector (standard option)
84904/6/7L-106	2.92 mm male connector, 2.92 mm female connector (UK6 not available with this option)

Calibration documentation (optional)

84904/6/7x-UK6 Calibration data

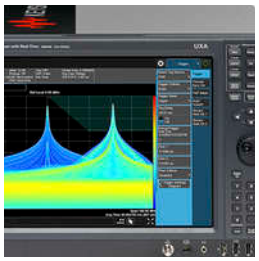
Accessories (optional)

11764-60001	10-pin dip plug (for attenutor connection) to 1524 mm (5 foot) ribbon cable
11764-60002	203 mm (8 inch) ribbon cable with 14-pin headers, female 10-pin receptacle
11764-60003	406 mm (16 inch) ribbon cable with 14-pin headers, female 10-pin receptacle
11764-60004	Interconnect cable 10-pin dip plug to “Viking” connector (for use with 11713B/C)

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