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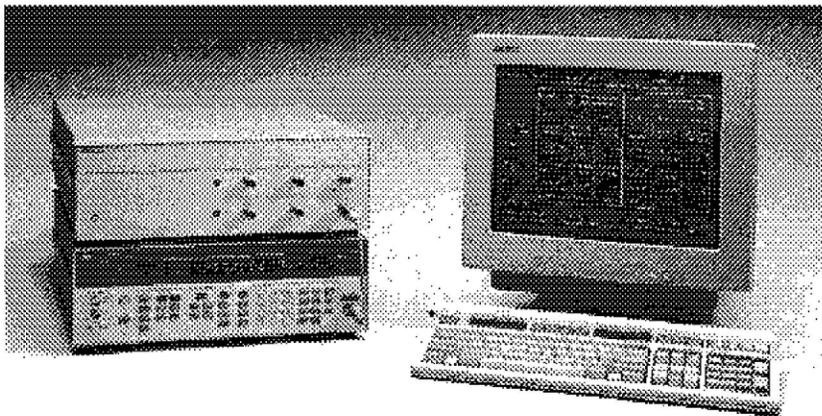
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Agilent Technologies

# HP 11759C RF Channel Simulator



- 40 MHz to 2700 MHz
- RF Bandwidth >6 MHz
- Doppler to  $\pm 425$  Hz (>500 km/ at 900 MHz)
- Rayleigh/Rice statistics
- Delay interval to 186  $\mu$ s with 1 ns resolution
- 12-Bit processing for low noise floor/distortion

### Versatile RF Multipath Simulations for Mobile Radio Signal Environments

The HP 11759C RF Channel Simulator has all the features and performance that make it the ideal solution for simulating the fast and slow fading, delay dispersion and Doppler effects found in the mobile radio or cordless telephone environments. The HP 11759C is specifically designed to test digital wireless radio systems with occupied bandwidths up to 6 MHz at RF frequencies to 2700 MHz under RF multipath conditions. This includes, for example, the GSM, NADC (TDMA, CDMA, or E-TDMA), JDC, DCS1800 and DECT cellular radio systems as well as other RF radio systems subject to delay dispersion and multipath degradations.

### RF Multipath Fading Simulation for Mobile Radio Systems of the 1990's

- GSM
- NADC
- JDC
- DCS1800
- MCA
- CT2
- PHP(JDCT)
- DECT

Testing susceptibility to multipath fading is particularly important in the development phase of digital cellular radios before equalizer algorithms have been implemented as custom integrated circuits, or before diversity systems have been committed to production. Equally important is sample testing the radios in production to verify and monitor the quality control process. And, for subscriber satisfaction, it is important that the Digital Mobile Cellular service provider qualify vendor radios for operation under the multipath conditions encountered in their service area.

Now, with the HP 11759C RF Channel Simulator's accurate, repeatable, and economical simulation of RF multipath fading conditions, it is possible to satisfy the multipath simulation needs of all three disciplines—Research and Development, Manufacturing Quality Control, and Type Acceptance.

## Two Multipath Channels Provide Test Flexibility

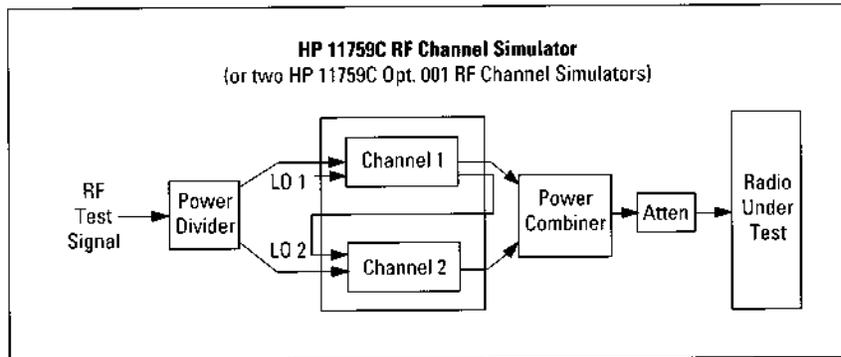
The HP 11759C RF Channel Simulator contains two independent 40 MHz to 2700 MHz RF channels of 3 paths each. Each path can be Doppler shifted or, Rayleigh or Log-normal faded, delayed, and attenuated relative to the others. In addition, under Rayleigh fading conditions, the correlation factor for path pairs in the two channels is adjustable from 0 to 1 in 0.1 steps.

For test applications requiring more paths per channel (e.g. GSM(900) or DCS1800), the HP 11759C Opt. 001 configures the HP 11759C as one channel of 6 paths. By pairing two HP 11759C Opt. 001 units and controlling them from a single

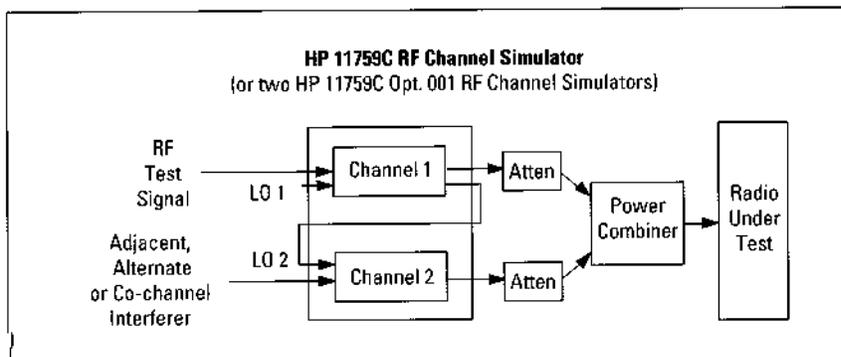
Personal Computer (PC), the full 12-tap testing requirements of the GSM and DCS1800 systems are easily accomplished. The Rayleigh correlation factor between the paths from one Opt 001 unit to the other is settable from 0-1 for performing tests on space diversity systems. And, to make the testing even easier, the 12- and 6-tap GSM/DCS1800 propagation models are pre-stored in PC memory for easy recall and set-up.

With an external power divider and/or a power combiner the HP 11759C (or two HP 11759C Opt 001 units) can easily be configured for single channel multipath (up to 12 paths) tests, cochannel interferer tests, adjacent and alternate channel

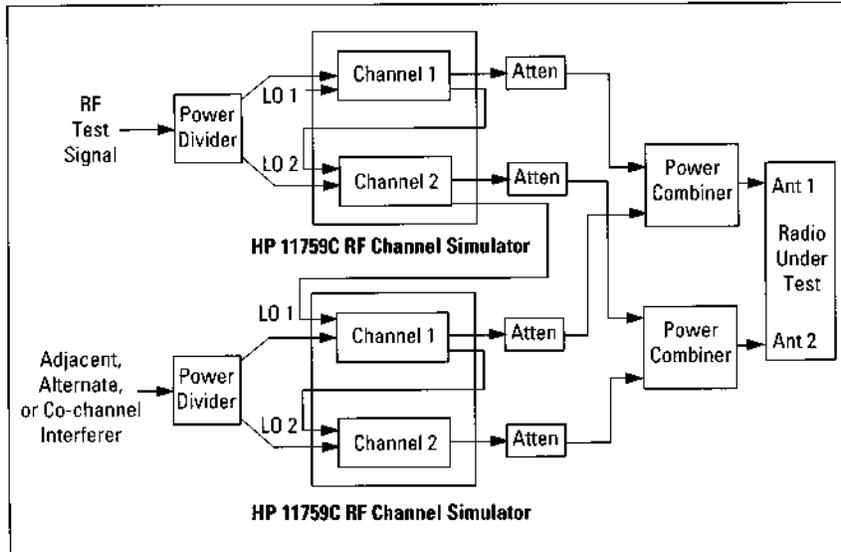
tests, and space and/or frequency diversity tests. Even duplex tests are possible, with one channel assigned for base station-to-mobile transmission and the second for mobile-to-base station transmission. Independent Local Oscillator (LO) inputs allow the freedom to select any combination of RF channels required to completely exercise the radio. Connect the convenient LO #1 output to the LO #2 input and perform 6- or 12-path single channel simulations and multipath cochannel interference testing. Without the restrictions of inflexible internal path and channel interconnections, test configurations are only limited by your imagination.



**Figure 1. Six or twelve path Simulation Testing.** With a power divider on the RF test signal input and a power combiner on the HP 11759C RF outputs, multipath testing with up to 12 paths is easily accomplished. The Auxiliary LO output of Channel 1 connected to the LO input of Channel 2 eliminates the need for two Local Oscillators. For testing GSM or DCS 1800 radios, recall of the 6 or 12-tap propagation models stored in PC memory quickly configures the paths to the propagation conditions called for in their respective test standards.



**Figure 2. Interference testing made easy.** Independent RF inputs and a common Local Oscillator, provided by connecting the Auxiliary LO output of 1 channel to the LO input of the second channel, enables testing of the radio under the adverse conditions of a co-channel interfering transmission and adjacent or alternate channel interfering transmissions with up to 6 MHz separation.



**Figure 3. Space Diversity with Interference Test.** Even the most complex testing of a space diversity antenna configured radio becomes easy with the flexibility provided by the HP 11759C. Rayleigh fading with adjustable correlation factor between the paths in the 2 channels of each HP 11759C, delay dispersion and attenuation between paths are selectable with simulated Dopplers to 425 Hz (>500 km/h at 900 MHz).

### Easy to Use

Simple on-screen menus and pop-up help windows guide the user through the potentially complex task of creating RF multipath signals for testing a Digital Cellular Radio. The opening menu displays a choice of three different multipath simulations—Simulation Test, Travel Test and Dynamic Test.

The Simulation Test is used to create the static multipath conditions called for by the various Cellular Radio System Test Standards. The Travel Test provides Log-normal fading conditions for a unique user-created set of base station-to-moving mobile (or moving reflector) paths. The Dynamic Test allows the user to recall previously created propagation conditions which can include changing the delay, Doppler and attenuation for each path with time—conditions that are closer to the ‘real world’ and never before possible with a commercially available RF channel simulator.

After selecting the Simulation Test a table for entering path parameters appears on-screen. The operator can choose to enter parameters for the Spectrum type, Doppler, Delay, and Attenuation for each path or recall either previously user-stored parameter configurations (up to 10 configurations may be stored) or one of the nine factory stored 6/12-tap propagation models as defined in Annex 4 to GSM Rec.05.05. If the operator chooses to enter a particular set of parameters, then simple keystrokes, explained on-screen with pop-up windows, allow the operator to select parameters for any or all paths. Each path may be enabled to provide either a Doppler shifted spectrum or a Rayleigh faded spectrum.

If a Rayleigh spectrum is selected then Rayleigh fading conditions are applied to the signal with Doppler spreading up to 425 Hz selected by the operator. Well defined accuracy specifications on the Cumulative Probability Distribution and

Level Crossing Rate provide confidence that the Rayleigh faded signal statistics are correct. Also, if Rayleigh fading is chosen on selected paths in Ch1 and Ch2, the correlation factor of the Rayleigh statistics can be set in steps of 0.1 from 0 to 1. If a Doppler spectrum is chosen then a pure Doppler from 0 to  $\pm 425$  Hz may be entered. In addition, for both spectrum types, the delay interval of each path can be set from 0 to 186 us and the relative attenuation of each can be adjusted from 0 to 50 dB.

The Travel Test is a unique simulation that applies Log-normal statistics to the multipath signals rather than Rayleigh. The user first selects whether a moving receiver or moving reflector is desired. Then, a 30 x 30-km grid is displayed on-screen and, using simple keystrokes, a transmitter and omnidirectional reflectors (one for each path in the system configuration) with individually chosen loss factors are placed

anywhere on the grid. Next, receiver (or reflector) velocity, RF frequency, the Log-normal standard deviation and the loss exponent for the medium are selected. A keystroke then starts the vehicle (or reflector) moving from the origin to +15km along the X-axis. At each new position a new multipath profile is calculated and output. For each path the Doppler and level are corrected for the changed angle of arrival and path length and a log-normal amplitude distribution is applied. The resulting multipath signal is unique to the choice of reflector and transmitter positions and can be used to approximate actual multipath conditions encountered in a particular service area.

The Dynamic Test is truly unique in that it is user-defined and user-created. The source for the dynamic multipath scenario can be actual multipath conditions measured and recorded versus time in the field or a unique set of varying conditions that the user desires to simulate to stress the radio under unusual or anticipated conditions.

Off-line, using a programming language of choice, the user writes a program to create an ASCII data file that defines the delay, Doppler and attenuation parameters at multiple points in time for each path to be controlled. Each set of parameters represents the multipath conditions at one point in time and

will be sequenced through at a rate set within the file created. A translator utility converts the ASCII data file to a binary file used to control the HP 11759C. Thus, when the file is recalled using the Dynamic Test mode, the HP 11759C path parameters set by the file are stepped through sequentially, changing the multipath conditions dynami-

cally with time. Sample programs written in QUICK BASIC are included with the HP 11759C software enabling the user to access subroutines for calculating Doppler, delay and level changes versus time as a receiver moves at an angle relative to a transmitter and/or a reflector.

```

HP 11759C RF Channel Simulator Rev 3.20                CHANNEL SIMULATION TEST
Copyright (c) Hewlett-Packard Co. 1993

-----MAIN MENU-----

S: Simulation Test
D: Dynamic Test
T: Travel Test
C: Configuration
H: Help (first-time installation tips)
Q: Quit

Enter selection...

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HP 11759C RF Channel Simulator Rev 3.20                CHANNEL SIMULATION TEST
GSN/FCM RAX Rural Area, 6-tap setting, option 2

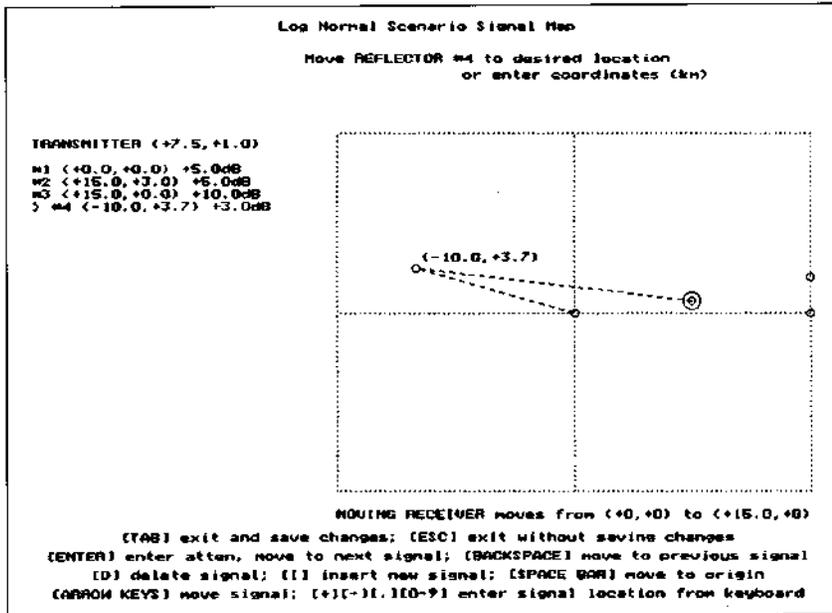
CHAN 1          RF Frequency = 900.000000 MHz
                LO Frequency = 894.000000 MHz

Spectrum:
(file name)
Delay:
Doppler or
Phase:
Atten:
Correlations:
(Rayleigh)

Path 1 Path 2 Path 3 Path 4 Path 5 Path 6
DOPPLER RAYLEIGH RAYLEIGH RAYLEIGH RAYLEIGH O F F
RAY4250 RAY4250 RAY4250 RAY4250 RAY4250
0.00 km 0.00 km 0.06 km 0.12 km 0.18 km 0.00 km
0.00 us 0.00 us 0.20 us 0.40 us 0.60 us 0.00 us
175.0 kmh 250.0 kmh 250.0 kmh 250.0 kmh 250.0 kmh 0.0 kmh
145.9 Hz 208.5 Hz 208.5 Hz 208.5 Hz 208.5 Hz 0.0 Hz
0.6 dB 8.9 dB 2.0 dB 10.0 dB 20.0 dB 0.0 dB
To Path 4 To Path 5 To Path 6 (0.0) 0.0 (0.0)

[ARROW KEYS] Move [ESC] Exits Set SPECTRUM to turn path ON or OFF
[ENTER] Sets Value [CTRL][BACKSPACE] Resets [ALT-F] Save/Recall Profiles

```



### Economical and Simple to Configure

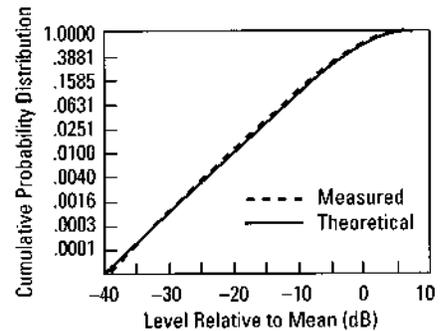
The HP 11759C RF Channel Simulator consists of the applications software and the RF processing hardware. To complete the RF multipath simulation system two other user-supplied components are necessary—a PC acting as a front panel/controller for the HP 11759C and a local oscillator used to determine the RF operating frequency and to supply a 10 MHz timebase.

This separation of functions permits an acquisition cost significantly less than one normally expects for a product of this complexity and capability. Significant savings are achieved by not burdening the HP 11759C with the cost of built-in local oscillator and control functions. Many users will already have an appropriate PC and local oscillator in their equipment inventory.

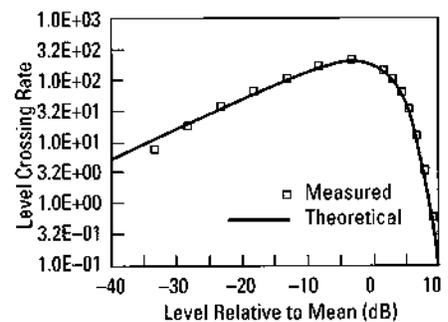
The PC must be at least 486DX-based, running at 33 MHz or faster, 4 MB of add-on memory, and MS-DOS 5.0 or higher installed. A hard disk drive, floppy disk drive, parallel interface and VGA monitor are also required (an additional HP-IB interface is required if remote control is to be implemented). The local oscillator (synthesized) must cover the RF frequency range of interest, offset low by 6.0 MHz, with at least +10 dBm output level and have a 10 MHz timebase output of 0 dBm. Both are equipment normally available in the inventory of a company engaged in the Mobile radio business.

Remote control of the HP 11759C RF Channel Simulator software is also easily accomplished with readily available equipment. The PC which is used to control the HP 11759C is itself controlled through an HP-IB interface card installed in the PC. Most menus can be accessed and controlled from a remote terminal or remote computer.

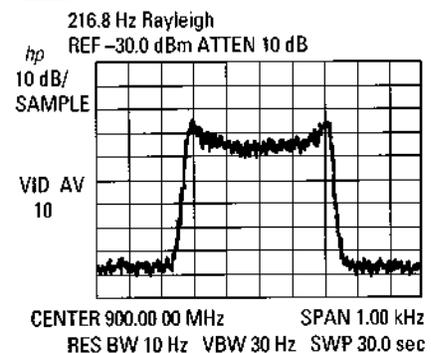
### Typical Rayleigh Faded Signal Characteristics Generated by the HP 11759C at a Simulated 216.8 Hz Doppler



Typical measured cumulative probability density function vs. theoretical.



Typical measured level crossing rate vs. theoretical.



Typical measured power spectral density.

Specifications describe the instrument's warranted performance over the 15° to 35°C temperature range. Supplemental characteristics (*in italics*) are intended to provide information useful in applying the instrument by giving typical but not warranted performance parameters. These are denoted as "typical" or "nominal."

NOTE: All Specifications measured under the following conditions:

RF Input Frequency = 50/900/1800/2700 MHz  
RF Input Level = -10 dBm nominal (0.1 dB <power over range)  
LO Input Frequency = RF Input Frequency less 6 MHz  
LO Input Level = +10 dBm  
Controller: HP Vectra 486/33T, 4 MB Extended Memory, and MSDOS Version 5.00.

## RF Channel Specifications

### Number of independent RF Channels:

2 (1, Opt 001)

*Impedance (RFin, RFout, LOin):* 50 Ω nominal

*RF Input level (+20 dBm maximum - damage level):* -10 dBm nominal (Automatic sensor indicates peak power in excess of optimum)

**RF Frequency Range:** 40 MHz to 2700 MHz

*RF Bandwidth (1 dB):* >6 MHz typical

*Group Delay variation over 6 MHz bandwidth:* <±15 nsec typical

*Path Insertion Loss (0 dB attenuation, band center):* Typically 24 dB ±3 dB, 40-2700 MHz

*Insertion Loss variation (path to path within a Channel):* <±0.1 dB typical at band center.

*Path Insertion Delay (RFin to RFout, 0 ns delay):* <600 ns typical.

*Path to Path Insertion Delay variation:* <±10 ns typical at band center.

**LO Input Frequency Range:** RF Input Freq. less 6 MHz

**LO Input level:** +10 dBm to +13 dBm

*LO Feedthrough on RFout:* typically <-20 dBm

**Image Feedthrough on RFout (RFin less 12 MHz):** = RFout level

*Path ON/OFF Ratio (RFin = 900 MHz):* >65 dB typical

*Path RFout S/N Ratio (RFin =900 MHz, 10 kHz BW):* -82 dBc typical

### **RFout Spurious levels In-band (±<3 MHz):**

*-55 dBc typical in simulation test and low delay resolution; -50 dBc typical in travel test and simulation test with high delay resolution.*

## Channel Simulation Specifications

### Number of independent paths per channel:

3 (6, Opt 001) Independent Rayleigh fading, Delay, Doppler (or Phase) and level available on each path.

### Path Attenuation:

**Range:** 0 to 50 dB

**Resolution:** 0.1 dB

**Accuracy:** ±0.3 dB typical 0-30 dB; ±1.0 dB typical >30 - 40 dB; ±2.0 dB typical >40 - 50 dB

### Relative Delay Interval between paths:

**Range:** 0 to 186 us in Channel Simulation Test mode 0 to 39.9 us in Travel Test mode

**Resolution:** 1.0 ns high resolution mode; 50 ns, low resolution mode.

**Accuracy:** typically ±25 ns + Insertion Delay variation, low resolution mode; typically ±0.5 ns + insertion delay variation, high resolution mode.

### Simulated Vehicle Speeds:

**Range:** 0 to ±509 km/h at 900 MHz RFin

**Resolution:** 0.10 km/h

### Simulated Doppler (Static (pure) or Classical):

**Range:** 0 to ±425 Hz

**Resolution:** 0.1 Hz

**Rayleigh Amplitude Distribution:** available on all paths for Doppler to 425 Hz (vehicle speed to >500 km/h at 900 MHz)

**Repetition interval:** >27 seconds

**Deviation from theoretical CPDF:**

<±1.0 dB typical from +10 to -20 dB of the mean power level

<±3.0 dB typical from -20 to -30 dB of the mean power level

**Level Crossing Rate Accuracy (+10 dB to -30 dB of the mean power level):** typically

deviates from the theoretical LCR curve

<±5% of the simulated vehicle Doppler

**Correlation Coefficient between CH1 and CH2 (paths 1/4, 2/5/, 3/6):** Adjustable from 0-1 in 0.1 steps

Note: With two HP 11759C Opt 001 connected to one PC the correlation coefficient is adjustable 0-1 in 0.1 steps between paths 1/7, 2/8, 3/9, 4/10, 5/11, 6/12.

### Relative Phase between Paths (PHASE SPECTRUM MODE only)

**Range:** 0 to ±360 degrees

**Resolution:** 0.1 degrees

### Channel Simulation Features (Menus)

1. Simulation Test—Allows 1 to 12 path Rayleigh faded or Doppler shifted simulation. Spectrum (Rayleigh or Doppler), relative delay, Doppler and attenuation may be selected independently for each path. Delay may be entered as path distance (km) or time (us) and Doppler may be entered as velocity (km/h) or frequency (Hz). If velocity is entered, Doppler is calculated using the RF channel frequency assigned (default is 900 MHz).

Doppler, in Hz, must be common for all Rayleigh faded paths. The correlation factor between Rayleigh faded paths (CH1 to CH2) is selectable. In addition to the nine factory stored 6/12 tap propagation models as defined in Annex 4 to GSM Rec.05.05, up to 10 user defined path configurations may be saved and recalled.

2. Travel Test—Allows 1 to 12 path log-normal fading simulation with either a moving receiver or a moving reflector. The user positions a Base Station and 1 to 12 omni-directional reflectors on a 30 km x 30 km grid. The receiver (or reflector) moves from the origin to +15km on the X-axis at a velocity selected by the user. RF frequency, path loss in dB/decade, reflector loss and the standard deviation for the log-normal fading are selectable.

3. Dynamic Test—User defined dynamic parameter modification. Utilities provided enable dynamic control of delay, Doppler and attenuation for up to 12 independent paths at rates up to 100 complete 12 path modifications per second.

### Remote Control

Channel Simulator software is remotely controllable through a HP-IB Interface card installed in the Personal Computer controlling the HP11759C. Most menus can be accessed and controlled from a remote terminal or remote computer.

### General

**Operating Temperature Range:** 0° to +55°C

Note: Specifications warranted +15° to +35°C

**Storage Temperature:** -55° to +75°C

**Humidity (Operating):** up to 95% relative humidity to +40°C

**EMC:** Conducted and radiated interference is within the requirements of EN55011, Group 1, Class A/CISPR Pub. 11 (1990). Meets the requirements of EN50082-1 (1992)/IEC 801-2, -3, -4

### Acoustic Noise Emissions/Geraeuschemission:

	LpA: Per EN 27779
<i>Operator Position: am Arbeitsplatz:</i>	44 dB (typical)
<i>Bystander Position: Nachbararbeitsplatz</i>	36 dB (typical)

**Power:** 90-132/190-264 V; 48-66 Hz; 325 VA maximum

**Weight:** Net: 13.6 kg (30 lb); Shipping: 19 kg (42 lb)

**Dimensions:** 620mm D x 425mm W x 146mm H (24.4" x 16.8" x 5.7")

### Rear Panel Connectors:

**LO #1 and LO #2 Output (Type N(f)):**

+10 dBm nominal

**Timebase Input (BNC(f)):** 10 MHz; 0 dBm nominal

**System Interface:** 36-pin Female Centronics

**Supplied with each HP 11759C:** Power cord, Operating and Service Manual, System Software supplied on 3 1/2" 1.44 MB capacity floppy disk media and 5 1/4" 1.2 MB capacity floppy disk media and a parallel interface cable (2.0m) P/N HP 11759-60069.

### System Controller Minimum Requirements<sup>1</sup>:

≥33 MHz PC compatible, 486DX CPU

4 MB Add-on extended memory

32 MB free Hard Disk space, and a 3 1/2" 1.44 MB or 5 1/4" 1.2 MB Floppy Disk drive

Parallel Printer Interface

Graphics Adapter and VGA monitor

MS-DOS Version 5.0 or higher

### Minimum System Configuration

1 ea HP 11759C RF Channel Simulator

1 ea System controller (Personal Computer as described above)

1 ea Local Oscillator with a 10 MHz timebase output

1 ea 25-pin Male Centronics® to 36-pin Male Centronics® cable P/N HP 11759-60069, 2.0 m (6.6 ft.)

<sup>1</sup>The "System Controller Minimum Requirements" listed are only meant to provide a generic guideline for a PC that may be suitable as a HP 11759C controller. HP cannot guarantee which particular brands and models of non HP PC's meeting these guidelines will operate properly.

## Recommended Accessories

### PC Controller

**HP Vectra 486/33XM** P/N HP D2913B

#### Model 240

plus: VGA Color Display P/N HP D1194A

Optional HP-IB Interface P/N HP 82335B

Optional Serial/Parallel P/N HP 24540B

Interface for Second

HP 11759C

### Local Oscillator

HP 8656B Signal Generator 0.1-990 MHz or

HP 8657A Signal Generator 0.1-1040 MHz or

HP 8657B Signal Generator 0.1-2060 MHz or

HP 8644A Signal Generator 0.25-1030 MHz or

HP 8647A Signal Generator 0.25-1000 MHz

Please consult your HP sales representative for information on additional PC controllers and Local Oscillators available from Hewlett-Packard Co.

### Power Divider/Combiner

HP 11636A Power Divider/Combiner ▶

## Ordering Information

### HP 11759C RF Channel Simulator

#### Options:

001 One channel of 6 paths

002 Rear panel only RF connectors

003 One channel of 6 paths with rear panel only RF connectors

907 Front panel handle kit

908 Rack mount flange kit

909 Rack mount flange kit with handles

910 Extra operating and service manual

W30 Two additional years of Return-to-HP service

Data Subject to Change

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