VOLT -AMPERE -WATT METER

IEEE-488

MODEL 255/256*

TRUE RMS/WIDE BANDWIDTH

The Model 255 digital V-A-W meter provides TRUE RMS measurements of VOLTAGE, CURRENT, and POWER. These measurements are essentially independent of the waveshape and of the power factor from DC up to frequencies of hundreds of kilohertz. Voltage and current readings are typically within 1% to 400 kHz for sine waves. The power in a 100 kHz square wave may normally be measured within 2%.

WIDE MEASUREMENT RANGE AMPLE RESOLUTION

The Model 255 provides FOUR full scale current ranges from 5 mA to 5 A, THREE full scale voltage ranges from 20 V to 1000 V., TWELVE full scale power ranges from 100 mW to 5000 W and TWELVE, increased resolution POWER X10 ranges from 10.00 mV to 500.0 W.

A full four digit display provides $\pm$ 1 digits of resolution for full scale ranges corresponding to 1000, 2000, or 5000 digits.

ISOLATED OUTPUTS AND PROGRAMMING

The meters have optically isolated, digital options of:

A. Parallel, four digit BCD output
B. Remote control of FUNCTIONS
C. IEEE-488 Talker/Listener Board.

The meters have an optional isolated ANALOG output. One volt output for a Full Scale display reading.

CURRENT OR VOLTAGE RANGE EXTENSION

Full Scale CURRENT ranges down to 50.00 μA or VOLTAGE ranges down to 1.000 V or 2.000 V are possible. External broadband shunts or transformers allow CURRENT extension to 50.00 A or 500.0 A. External voltage dividers allow VOLTAGE extension to 3500 V. Full Scale POWER for each case is equal to the VOLTAGE X CURRENT product.

DEALS WITH MANY DIFFICULT MEASUREMENTS

The Model 255 is ideally suited to measuring almost any non-sinusoidal and/or low power factor waveshape. Typical uses are in connection with SWITCHING POWER SUPPLIES, TRANSFORMER LOSSES, FLUORESCENT LAMP BALLASTS, R-C FILTER RECTIFIER CIRCUITS, SCR CIRCUITS, MERCURY-ARC LAMP CIRCUITS, SERVO SYSTEMS, MOTOR TESTING, ULTRASONICS, MOV LOSS TESTING, AUTOMATIC TEST EQUIPMENT, SODIUM LAMP BALLASTS, FERRITE CORE LOSSES, TELEVISION SET LOSSES, AND ELECTRIC AUTOMOBILE EFFICIENCY MEASUREMENTS.

EASY TO USE/HARD TO DAMAGE

The Model 255 is an all solid state, digital readout instrument. The V-A-W meter is complete, self contained instrument that is easy to use, hard to damage, easy to service, and easy to maintain.

LOW CIRCUIT LOADING

An imput impedance of five Megohms for the VOLTAGE terminals coupled with a full scale voltage drop of 100 millivolts across the CURRENT terminals cause negligible circuit loading or errors in most practical cases.

PACKAGING/PROTECTION

The Model 255 is housed in a heavy duty aluminum case. The three lowest current range shunts are also diode and fuse protected.

*The Model 256 differs from the Model 255 by having a 100.0 V range instead of a 1000 V range and by having the CURRENT input fuse located on the front panel instead of internal to the instrument.

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ACCURACY AND BANDWIDTH

VOLTAGE and CURRENT

Readings between 1/12 and 1.7 times Full Scale

Frequency Range [3]		Accuracy
dc to 30 Hz [1]	± 0.6% Full Scale	± 0.4% Reading
30 Hz to 100 kHz	± 0.4% Full Scale	± 0.2% Reading
100 kHz to 300 kHz	± 0.6% Full Scale	± 0.6% Reading

POWER

$$\text{Power Factor} = \frac{\text{Power}}{\text{Input V.A.}} \geq 0.5$$

Input V.A. / $I_{range} V_{range}$	dc to 30 Hz [1]	30 Hz - 50 kHz	50 kHz - 100 kHz
less than 1.5	± 0.6% F.S. ± 0.4% V.A.	0.4% F.S. 0.2% V.A.	0.6% F.S. 0.6% V.A.
between 1.5 and 2.5	± 1% V.A.	0.6% V.A.	1% V.A.

$$\text{Power Factor}^{(2)} = \frac{\text{Power}}{\text{Input V.A.}} < 0.5$$

Input V.A. / $I_{range} V_{range}$	30 Hz - 25 kHz	25 kHz - 50 kHz	50 kHz - 100 kHz
less than 1.5	± 0.4% F.S. ± 0.2% V.A.	0.5% F.S. 0.5% V.A.	0.7% F.S. 0.8% V.A.
between 1.5 and 2.5	± 0.6% V.A.	1% V.A.	1.5% V.A.

Terms: V.A. means the actual product of the input Volts and Amperes as measured on the model 255.

$I_{range}V_{range}$ means the Full Scale (F.S.) value of the POWER "range". This is the product of the Current range value and the Voltage range value.

Power Factor is defined as the ratio of the measured POWER to the measured VOLT-AMPERES. In the case where both current and voltage are sinusoidal, then the Power Factor is the cosine of the phase angle between the voltage and the current.

POWER x 10

In cases where BOTH the input *Voltage* and the input *current* are less than 40% of their full scale values, the POWER x 10 scale allows an additional decade of resolution. The decimal point is automatically adjusted to give a direct reading of power. The measurement accuracy in Watts or milliwatts remains as stated for POWER.

POWER FACTOR (Sine Wave Inputs ONLY)

"Sinusoidal like" inputs between 30 Hz and 25 kHz. Current and Voltage inputs individually each less than 1.7 full scale. Input Voltage-Ampere product between 1/3 and three times the corresponding Power full scale value.

±3.0% of Full Scale

CREST FACTOR

Except for the top voltage and current ranges (which are amplitude restricted) the Model 255 will measure pulse or "spike" inputs with peak values of 3.5 times the full scale may be seven times the full scale d-c level.) (Peak to Peak values around a zero average value, may be seven times the full scale d-c level).

NOTES:

(1) Additional internal filtering will be necessary to prevent the display from "tracking" the input for input frequencies below 10 Hz. Provision has been made for the easy addition of such filtering.

(2) In the Model 255/256 the two COMMON terminals are connected together internally. (THIS WAS NOT TRUE IN EARLIER VERSIONS). In normal usage the meter is connected so that the load current flows through the internal shunt and the meter voltage measures the sum of the load and the shunt voltage drops. Thus the POWER reading is the load power plus I^2r, where r is the shunt resistance. In high power factor situations the I^2r correction term is usually negligible. In low power factor situations the I^2r term may make up 90% of the reading.

(3) 5A scale specified to 200 kHz only

RESOLUTION-USEFUL RANGE RMS

Nominal FULL SCALE	LOWER LIMIT	UPPER LIMIT	RESOLUTION
20 V	1.6 V	34 V	10 mV
200 V	16 V	340 V	100 mV
1000 V	83 V	1000 V	1 V
5 mA	400 uA	8.5 mA	1 uA
50 mA	4 mA	85 mA	10 uA
500 mA	40 mA	850 mA	100 uA
5000 mA	400 mA	7.5 A	1 mA

INPUT IMPEDANCES / PROTECTION

RANGE	INPUT IMPEDANCE	PROTECTION and/or LIMITS
20 V, 200 V	5 Megohm / 6 pF	2 kV-peak input
1000 V	5 Megohm / 6 pF	2 kV-peak input
5 mA, 50 mA and 500 mA	20 ohm/2.0 ohm/ 0.33	1½ Amp "FAST" FUSE
5 Ampere	28 milliohm (includes internal connections)	

At frequencies up to 600 Hz the COMMON terminals may be operated up to 250 V rms (400 V peak) above the grounded metal case.

DISPLAYS, OUTPUTS, AND CONTROLS

The Model 255 has a four digit display with full scale values of 5000, 2000, and 1000 depending upon the function being displayed.

The numeric display is made up of four identical 10.9 mm (0.43 inch) high, seven segment, high efficiency, LED units mounted in sockets. A non-glare, optically matched, filter covers the display. Decimal point placement is automatic. Four separate LEDs indicate NEGATIVE power or power factor readings, INPUT OVERLOAD, OUTPUT OVERLOAD, and MILLIWATTS.

The BCD equivalent of each display module is held in a separate latch. An isolated BCD or an isolated IEEE-488 output is available. An isolated switch closure or an isolated IEEE-488 control of FUNCTIONS is available.

The seven position FUNCTION switch provides ON/OFF control, the selection of the five different FUNCTIONS (I,V,P, P x 10, and Power Factor) and a REMOTE position. In REMOTE any FUNCTION may be selected by an appropriate contact closure that is capable of "sinking" 1.0 mA to ground.

MEASUREMENT RATE

The measurement rate and the display rate are locked to the power line frequency and are normally set at 10 readings/second (60 Hertz operation) or at 8.33 readings/second (50 Hertz operation). Other "line locked" rates are possible as well as the use of an external clock to control the timing.

TEMPERATURE

Operating Temperature Range: 0° to 50°C
Specified Accuracy : 15° to 35°C

DIMENSIONS

Width 290 mm. (11.4 inches) Height 132 mm. (5.2 inches)
Depth 330 mm. (13 inches)

WEIGHT 4.1 kg. (9 lbs.) **RACK MOUNT AVAILABLE**

POWER REQUIREMENTS

95-105 V or 105-125 V or 210-240 V, 50-60 Hz.
Specify line voltage and line frequency when ordering.

THREE PHASE MEASURMENTS

Three phase power transmission systems exist in both three wire and four wire versions. To measure the power in a "N" wire system we must measure the currents in at least (N - 1) of the wires and we must measure at least (N-1) appropriate voltages.

We can define a single phase wattmeter as a device that senses one line current and multiplies it by an appropriate voltage to produce a power reading. Two properly connected single phase wattmetters will always be sufficent to measure the power in a three wire, three phase system and three properly connected connected single phase wattmeters will always be sufficent to measure the power in any three phase system of either three or four wires.

If one is dealing with "normal" line frequencies of from 50-500 Hertz and with line currents of up to 7.5 Amperes RMS then one can use any of the Clarke-Hess Models 255,256, or 259 as the single phase wattmeter defined above. The connections for both the two wattemeter/three wire case and for the three wattmeter case are shown below.

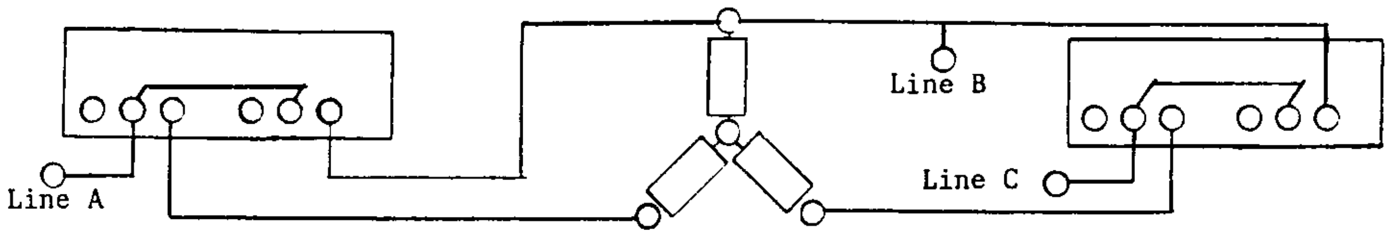
In either case note that only three connections are necessary to each wattmeter. For normal line frequencies one should not encounter any difficulties in "floating" the internal circuitry of any Clarke-Hess wattmeter at voltages up to 480 V above the normal earth ground.

In either case the total power is the ALGEBRAIC SUM of all the wattmeter readings. In the three wattmeter case a balanced load and balanced input voltages should lead to three equal power readings. In fact if one could guarantee that the load would always be balanced and that the input lines were equal then only one wattmeter would be necessary. In that case the total power would just be three times the reading of the single wattmeter. In the two wattmeter case the two wattmeter readings are only equal in both magnitude and sign for the very special case of a balanced and unity power factor load. For low power factor loads the readings will be opposite in sign so that the net result may be smaller in magnitude than either reading. For very low power factor load cases one might be better off with three wattmeters so as to avoid the errors that might result from obtaining an answer as the difference of two almost equal numbers.

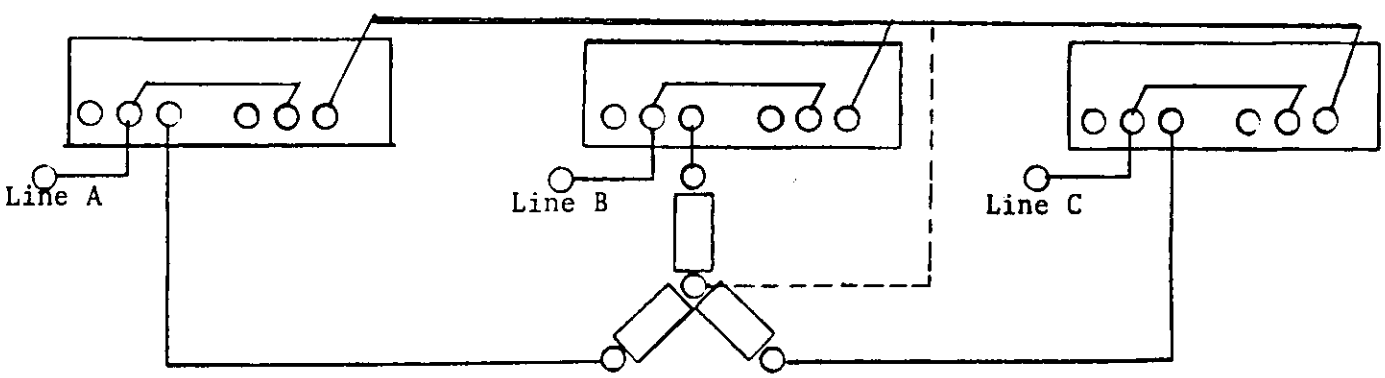
The necessary meter summation may be done by the operator or by a computer if the various wattmeters are each equiped with either an isolated IEEE-488 bus or with an isolated BCD readout. For the two wattemeter case Clarke-Hess has an option that provides for the isolated interconnection of the digital portion of the two instruments so that when the "master" unit has a front panel toggle switch placed in the "three phase" position then that instrument displays the algebraic sum of what would be the power readings of the two individual instruments.

For currents above 7.5 amperes one must use either external shunts, current transformers, or Hall effect transducers to extend the current range of the instruments. The easiest extensions are to convert the 50 mA range into a 50 Ampere range or the 500 mA range into a 500 Ampere range. In either case the power readings are correct as long as they are called kilowatts instead of watts.

For higher frequency three phase measurements the use of three wattmeters and broad band current transformers provides current isolation that allows one to tie the three voltage common terminals both together and to the chassis ground. Broadband current transformers can be provided for currents from 500 mA or more. In this special case the HIGH voltage terminals are connected to the high voltage lines while the COMmon voltage terminals are tied together and the current transformers are connected so that positive power readings are obtained into a resistive load. The advantage of being able to tie the COMmon terminals to the chassis ground is that it prevents high frequency pickup between a "floating" COMmon and the grounded metal case.



TWO WATTMETER/THREE WIRE CASE. LOAD MAY BE EITHER Y OR DELTA.

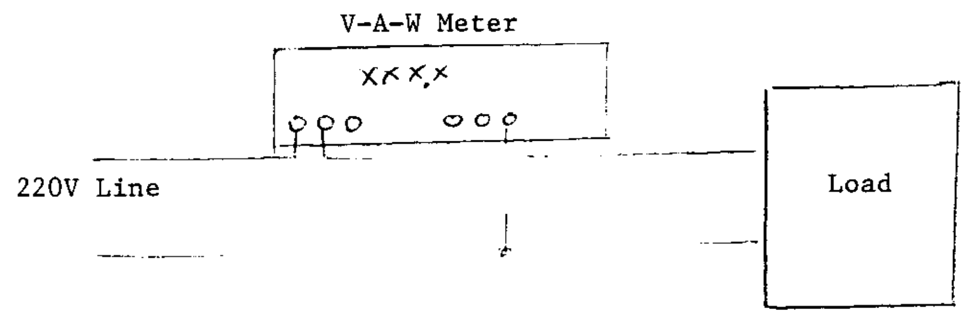


THREE WATTMETER/THREE OR FOUR WIRE CASE.

Both figures are shown for the case where the line current is less than 800 ma RMS. For line currents from 500 to 7000 mA the meter-to-load connections should be made via the 5 Ampere (far left hand) current terminal of each meter.

For the normal Model 255 or the Model 256 the external COMmon/COM/mon connection shown MUST BE MADE for each meter. The Model 259 (or Model 255's or Model 256's that have been modified for use with a broadband shunt) has this connection made internally so that NO EXTERNAL CONNECTION should be made in that case.

All meters should read positive with a resistive load. The "meter loading" error in the power readings will be a positive amount equal to the square of the line current times the shunt resistance of the meter. If the load resistance is 1000 times or more greater than the internal shunt resistance then this error will be less than 0.1%. Loads greater than 300 ohms with a 500 mA connection or greater than 30 ohms with a 5 Ampere connection will satisfy the condition for an error of less than 0.1% from this source.



The VOLTAGE COMmon is connected internally to the CURRENT COMmon. No external connection is necessary or desirable.

If the external shunt is used instead of the internal one then the line goes through the shunt. The coaxial cable from the shunt provides the VOLTAGE COMmon and the single VOLTAGE lead goes from the right hand VOLTAGE terminal to the other line.

* Application	120 VAC 60 Hz	120 VAC 50 Hz	120 VAC 400 Hz	120 VAC 415 Hz	240 VAC 60 Hz	240 VAC 50 Hz	208 VAC 60 Hz	220 VAC 50 Hz	Tolerance
Model number	GS-2	GS-2A	GS-2B	GS-2C	GS-2D	GS-2E	GS-2F	GS-2G	
Power failure									
Threshold	80 Vrms	80 Vrms	80 Vrms	80 Vrms	160 Vrms	160 Vrms	160 Vrms	160 Vrms	10%
Minimum duration	500 mS	500 mS	500 mS	500 mS	500 mS	500 mS	500 mS	500 mS	20%
High line voltage									
Threshold	125 Vrms	125 Vrms	125 Vrms	125 Vrms	250 Vrms	267 Vrms	217 Vrms	231 Vrms	3%
Minimum duration	100 mS	100 mS	100 mS	100 mS	100 mS	100 mS	100 mS	100 mS	10%
Low line voltage									
Threshold	105 Vrms	105 Vrms	105 Vrms	105 Vrms	210 Vrms	211 Vrms	182 Vrms	198 Vrms	3%
Minimum duration	100 mS	100 mS	100 mS	100 mS	100 mS	100 mS	100 mS	100 mS	10%
Voltage spike									
Threshold	200 Vpeak	200 Vpeak	200 Vpeak	200 Vpeak	200 Vpeak	200 Vpeak	200 Vpeak	200 Vpeak	10%
Minimum duration	10 µS	10 µS	10 µS	10 µS	10 µS	10 µS	10 µS	10 µS	10%
Voltage drop									
Threshold	80 Vrms	80 Vrms	80 Vrms	80 Vrms	160 Vrms	160 Vrms	160 Vrms	160 Vrms	10%
Minimum Duration	20 mS	20 mS	20 mS	20 mS	20 mS	20 mS	20 mS	20 mS	10%
High frequency noise									
Threshold	2 Vpk-to-pk	2 Vpk-to-pk	2 Vpk-to-pk	2 Vpk-to-pk	2 Vpk-to-pk	2 Vpk-to-pk	2 Vpk-to-pk	2 Vpk-to-pk	10%
Minimum duration	50 mS	50 mS	50 mS	50 mS	50 mS	50 mS	50 mS	50 mS	10%
Specified frequency	100 KHz	100 KHz	100 KHz	100 KHz	100 KHz	100 KHz	100 KHz	100 KHz	
Usable response	25 KHz-2MHz	25 KHz-2MHz	25 KHz-2MHz	25 KHz-2MHz	25 KHz-2MHz	25 KHz-2MHz	25 KHz-2MHz	25 KHz-2MHz	
High line frequency									
Threshold	61 Hz	51 Hz	408 Hz	423 Hz	61 Hz	51 Hz	61 Hz	51 Hz	1%
Minimum duration	500 mS	500 mS	500 mS	500 mS	500 mS	500 mS	500 mS	500 mS	
Low line frequency									
Threshold	59 Hz	49 Hz	392 Hz	407 Hz	59 Hz	49 Hz	59 Hz	49 Hz	1%
Minimum duration	500 mS	500 mS	500 mS	500 mS	500 mS	500 mS	500 mS	500 mS	

* Customized specifications if applicable, appear on inside back cover

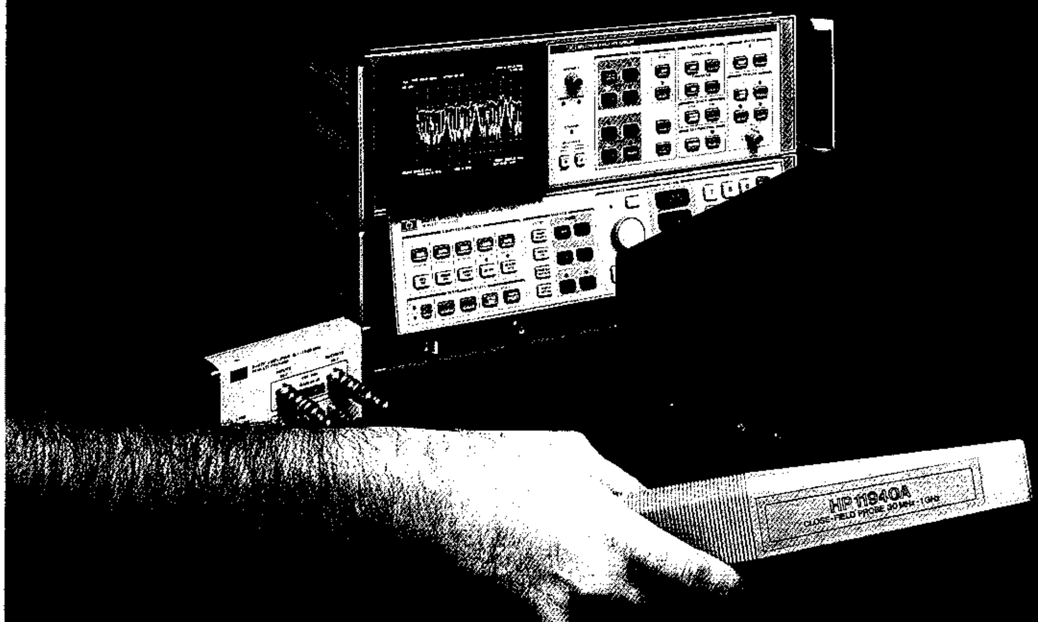
HEWLETT PACKARD

CLOSE-FIELD PROBE
30 MHz to 1 GHz

model
HP 11940A

TECHNICAL DATA 1 DEC 85

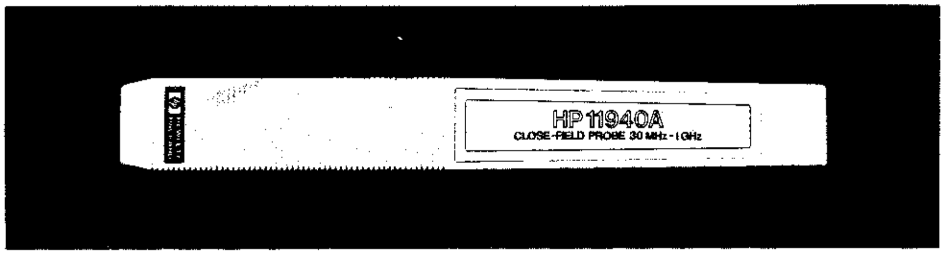
Design for EMC



with the HP 11940A Electromagnetic Field Sensor

The HP 11940A Close-Field Probe is a small, hand-held, electromagnetic-field sensor developed for use with a spectrum analyzer in electromagnetic interference (EMI) diagnostic and troubleshooting applications. Unlike a simple magnetic-loop sensor, the Close-Field Probe gives you repeatable, absolute magnetic-field measurements over a wide 30 MHz to 1 GHz frequency range. Especially designed to measure radiation from surface currents, slots, and cables, the HP 11940A is an ideal tool for diagnostic testing of printed circuit boards, cabling, and shielded enclosures. Its unique ability to provide calibrated absolute-amplitude information lets you accurately measure the magnetic-field strength of emissions. When attached to a source, the probe will generate a localized magnetic field for susceptibility testing.

How Does the Close-Field Probe Work?



The Close-Field Probe's dual-loop configuration and balun structure rejects signals due to direct and stray electric-field coupling. This stray electric-field coupling is often a major source of measurement error. The electric-field rejection provided by the HP 11940A, however, significantly reduces this error, allowing you to make repeatable measurements independent of cable layout, measurement-equipment orientation, and ambient environment.

Use the probe in conjunction with a variety of spectrum analyzers and preamplifiers to measure the frequency and absolute amplitude of problem emissions. This gives you an efficient way to track down the emission sources. Because the Close-Field Probe is a small, lightweight, passive device, it maneuvers easily around enclosures or cabling with minimal disturbance of the field. The tip is held very close to potential radiating points, which enables you to accurately locate emission "hot spots." Use the HP 8447D Preamplifier with the HP 11940A Close-Field Probe to isolate sources with amplitudes below MIL-STD 461A/B emission levels.

Who Uses the Close-Field Probe?

Circuit and mechanical designers will find that, as a diagnostic tool, the HP 11940A Close-Field Probe expands the utility of the spectrum analyzer.

Circuit Designer

The Close-Field Probe lets you optimize new product designs to reduce radiation early in the design cycle. Use the probe to help assure circuit compatibility within your design and between system components. Proper modeling of your radiation sources allows you to use data from this sensor to estimate far-field emission levels.

As a source of magnetic fields, the Close-Field Probe can be used in localized susceptibility testing. For this application, a known signal fed into the HP 11940A creates a magnetic field at the tip of the device. For broadband susceptibility testing, use the probe with a swept or tracking source such as the HP 8444A Option 059 Tracking Generator.

Mechanical Designer

You can evaluate and compare the relative shielding effectiveness of various enclosures and shielded structures using the Close-Field Probe. This application teams the HP 11940A with a spectrum analyzer and a tracking generator. The tracking generator output signal radiates from any antenna placed inside the enclosure-under-test, while the probe and spectrum analyzer provide frequency and relative amplitude information.

The HP 11940A Close-Field Probe provides the electromagnetic compliance (EMC) test engineer with a valuable tool for diagnosing radiation and susceptibility problems. This makes the goal of electromagnetic compatibility easier to achieve.

HP 11940A Characteristics

Antenna Factor:	Calibrated to within ±2 dB in a 377 ohm field impedance. See Figure 1 for typical antenna factor data.
VSWR:	<3:1, typically
Connector:	SMA, replaceable barrel
Maximum Input Power:	0.5 Watts
Temperature Range:	Typical variation over 0°C - +40°C, <±1 dB
Dielectric Breakdown:	1 kV, typically

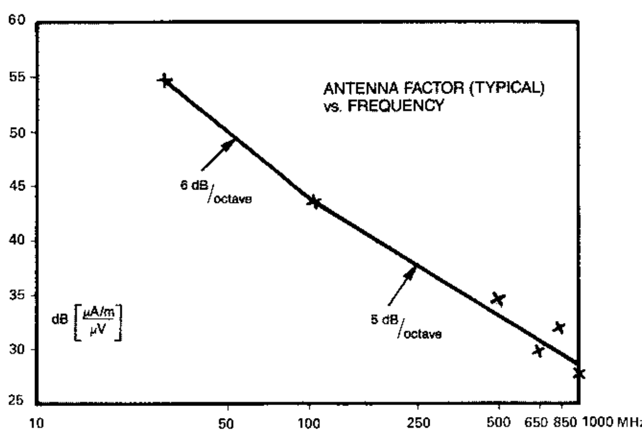


Figure 1. *The antenna-factor units used in this chart (dB (µA/m/µV)) should be added to the measured voltage in dBµV on the spectrum analyzer to give magnetic-field strength in dB (µA/m).*

The Close-Field Probe is supplied with a calibration chart giving output voltage versus magnetic field strength at five selected frequencies.

Ordering Information

HP 11940A Close-Field Probe	$ 500.
Option 001 **Rotary Joint** (available June 1986)	375.
Option 002 **RG223 Cable** (shielded cable) 2m, with SMA connectors	83.
Spectrum Analyzers:	
HP 8567A **RF Spectrum Analyzer** (10 kHz - 1.5 GHz)	27,000.
HP 8568B **RF Spectrum Analyzer** (100 Hz - 1.5 GHz)	34,600.
HP 8566B **Microwave Spectrum Analyzer** (100 Hz - 22 GHz)	55,000.
Accessories:	
HP 8447D Preamplifier (100 kHz - 1.3 GHz)	$ 1,100.
HP 8444A Option 059 Tracking Generator (100 MHz - 1.5 GHz)	4,760.
HP 8656B Signal Generator (0.1 - 990 MHz)	6,500.

For more information, call your local HP sales office listed in the telephone directory white pages. Ask for the Electronic Instruments Department. Or write to Hewlett-Packard: **U.S.A.** — P.O. Box 10301, Palo Alto, CA 94303-0890. **Europe** — P.O. Box 999, 1180 AZ Amstelveen, the Netherlands. **Canada** — 6877 Goreway Drive, Mississauga, L4V 1M8, Ontario. **Japan** — Yokogawa-Hewlett-Packard Ltd., 3-29-21, Takaido-Higashi, Suginami-ku, Tokyo 168. Elsewhere in the world, write to Hewlett-Packard Intercontinental, 3495 Deer Creek Road, Palo Alto, CA 94304.

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5954-2722 (D)

PRINTED IN U.S.A.