



9301A

True RMS Millivoltmeter

Operator Handbook

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**MANUAL NO.
015**

**True RMS Millivoltmeter
9301A**

Operators Handbook

226234

RACAL

The Electronics Group

9301A

TRUE RMS MILLIVOLTMETER

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True R.M.S. Millivoltmeter
9301A

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TECHNICAL SPECIFICATION

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VOLTAGE RANGES:	1 mV to 3 V r.m.s. f.s.d. in 8 switchable ranges. Lowest reading 100 μ V.
MAXIMUM VOLTAGES:	(1) 50 Ω socket: 4 V (DC plus AC) (2) Probe: 9 V peak AC plus up to 100V DC.
FREQUENCY RANGE:	10 kHz to 1.5 GHz (useable as an indicator to 2 GHz.
INPUT IMPEDANCE:	Probe: 100 k Ω in parallel with less than 3 pF. Probe with Isolator Tip: 100 k Ω in parallel with less than 10 pF. Internal Terminated Input: 50 Ω , VSWR <1.1 to 1 GHz.
BASIC ACCURACY:	Probe used with internal 50 Ω load: $\pm 1\%$ of f.s.d. $\pm 1.5\%$ of reading (+20 $^{\circ}$ C to 25 $^{\circ}$ C). $\pm 3\%$ of f.s.d. $\pm 2\%$ of reading (0 $^{\circ}$ C to +40 $^{\circ}$ C).
FREQUENCY ERRORS:	10 kHz to 500 MHz: Nil 500 MHz to 1 GHz: $\pm 5\%$ of reading 1 GHz to 1.5 GHz: $\pm 10\%$ of reading relative to the supplied calibration curve.
CREST FACTOR:	12 dB at f.s.d. on all ranges to 1 V, increasing inversely for readings below f.s.d. (for example, 18 dB at half scale).
READING HOLD:	Press-to-hold switch on probe holds reading to within 0.5% for 3 minutes.
DC OUTPUT:	-1 V for f.s.d. from 1 k Ω source impedance.
POWER SUPPLY:	AC: 94 V to 130 V and 188 V to 260 V 45 Hz to 440 Hz. DC: plus and minus 17 V to 25 V.

CONSUMPTION

Approximately 8 VA.

TEMPERATURE RANGE

Operating: 0°C to +40°C
Storage: -40°C to +70°C.
Humidity: 95% r.h. at +40°C.

DIMENSIONS

	<u>Height</u>	<u>Width</u>
Case only:	83 mm	240 mm
Overall:	110 mm	284 mm

Depth: 268 mm Weight: 2.5 kg

ACCESSORIES SUPPLIED

Isolator Tip 11-1151. Accuracy: Add $\pm 3\%$ of reading from 10 kHz to 200 MHz.
Flexible Earth Lead 11-1160.
H.F. Earth Clip-Prod 13-1520
Remote Control Connector 11-1161.
2 Spare Probe Tips 14-1459.
AC Supply Fuse (94-130V operation).
Power Lead.

OPTIONAL ACCESSORIES

20 dB Attenuator. Accuracy: Add $\pm 6\%$ of reading from 10 kHz to 500 MHz.
11-1155
Input impedance
100 k Ω in parallel
with less than 3 pF.

40 dB Attenuator: Accuracy: Add $\pm 6\%$ reading from 1 MHz to 500 MHz.
11-1156
Input impedance less than 3 pF.

50-75 Ω Adaptor: Attenuation 10 dB.
23-3230
Probe/BNC Adaptor 11-1131.
Accessory Box 11-1162.
Carrying Case 15-0434.
Probe 'T' Assembly 11-1353.

REMOTE PROGRAM

Remote programming is selected by the REMOTE position on the front panel RANGE switch. The remote program BCD control is fed in via the rear panel remote control socket. Levels are TTL compatible and may be taken to a maximum of +70 V for a '1' state and -70 V for a '0' state without damage to the instrument. The encoding details are in Table 1 below.

TABLE 1

Remote Program Coding

Ranges	Connector Pin Numbers and Logic Levels		
	Pin 1	Pin 2	Pin 3
1 mV/-50 dB	0	0	0
3 mV/-40 dB	1	0	0
10 mV/-30 dB	0	1	0
30 mV/-20 dB	1	1	0
100 mV/-10 dB	0	0	1
300 mV/0 dB	1	0	1
1V/+10 dB	0	1	1
3V/+20 dB	1	1	1

NOTE: To revert to local control, set all inputs to '0' level or disconnect the remote program connector.

CHAPTER 1

=====

GENERAL DESCRIPTION

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INTRODUCTION

1. The 9301A is a wide-band millivoltmeter of exceptional accuracy and advanced design, providing true r.m.s. measurements of r.f. sinusoidal, pulse and noise waveforms.
2. The specified frequency range is 10 kHz to 1.5 GHz, and useful indications are obtainable up to 2 GHz. The meter has two voltage scales, and a 'dB' scale referenced to 0 dBm into 50 Ω . Voltages from 100 μ V to 3.0 V can be measured in eight ranges selected by switch or remote program. Attenuator options are available to extend the measurement range to 30 V and 300 V at frequencies below 500 MHz. Fast and slow meter responses can be selected by a front panel switch.
3. The instrument operates from AC mains supply. Provision is made for the connection of a customer's DC power supply via rear panel terminals. Reverse polarity protection by series diodes is built into the instrument.
4. Measurements are made via the attached probe. A 50 Ω termination is provided within the instrument, or an external 50 Ω load can be used by means of an optional BNC adaptor. The use of the various accessories is described in Chapter 4.

PRINCIPLE OF OPERATION

5. The 9301A employs a random sampling system in which the amplitude of the sampler output is proportional to the input signal level at the instant of sampling.
6. The sampling process is followed by r.m.s. conversion, which gives true r.m.s. readings at all frequencies and over the complete voltage measuring range.

THE PROBE UNIT

7. The Probe Unit, which is permanently connected to the instrument, is used for all measurements and has an input impedance of 100 k Ω in parallel with less than 3 pF. It incorporates a sampling circuit that is linear to below 100 μ V. It has a frequency response which is virtually flat to 1.5 GHz, and an operating temperature range which is the same as the main instrument. A 'press to hold' button on the probe allows a reading to be stored at an accuracy of $\pm 0.5\%$ for up to 3 minutes. Stowage for the probe and cable is provided on the underside of the instrument.

8. The probe is calibrated for accurate measurements in terminated 50 Ω systems. Such measurements may be made either by using a Probe/BNC adaptor (optional accessory) with the customer's own external 'T' piece and 50 Ω load, or by using the internal 50 Ω termination.
9. At frequencies below 200 MHz accurate measurements may be made in other than 50 Ω systems by employing the Isolator Tip supplied. Refer to the technical specification for performance data. Optional attenuator tips are available to extend the voltage range of the instrument to 30 V and 300 V.

IN-BUILT 50 Ω TERMINATION

10. Accurate measurements in 50 Ω circuits may be made by means of the internal 50 Ω termination. To use this facility, the probe is inserted into the front panel PROBE socket and the signal is applied to the adjacent 'N' type socket (50 Ω INPUT). This provides a 50 Ω termination in a convenient and readily available form. The accuracy under these conditions is given in the technical specification. Above 500 MHz the calibration curve must be used.
11. Measurements may also be made in 75 Ω circuits via the internal 50 Ω termination, by using the optional 50 Ω /75 Ω adaptor. The adaptor introduces a precise 10 dB of attenuation, and thus moves all meter readings down by the equivalent of one step of the range switch.

DC OUTPUT

12. A DC output corresponding to the r.m.s. value of the input signal is available from a rear panel BNC socket for connection to a digital voltmeter, DC recorder or other processor. The DC output is -1V at the meter f.s.d. on any range.

REMOTE PROGRAM CONTROL

13. All voltage ranges are remotely programmable, using a standard BCD code at TTL compatible levels, applied via three lines to a multiway connector on the rear panel. The BCD coding is given on page Tech Spec 3. This facility and the DC output enable the 9301A to be incorporated directly into automatic test equipment systems. The fast and slow meter response facility is not selectable by remote control.

CARRYING HANDLE AND BENCH STAND

14. The combined carrying handle and bench stand can be set in several positions. To change the position, press in both handle bosses simultaneously (they are marked PUSH) and move the stand to the required position for bench operating or carrying.

MAINTENANCE

15. It is recommended that customers should take advantage of the servicing and calibration service offered by Racal Dana Instruments Ltd. and their agents. For customers wishing to carry out their own servicing a comprehensive maintenance manual is available from Racal Dana Instruments Ltd. at the address on the title page of this manual. When ordering the serial number of the instrument should be quoted.

CHAPTER 2

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DESCRIPTION OF CONTROLS, INDICATORS

=====

AND CONNECTIONS

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1. FRONT PANEL ITEMS

POWER ON/OFF Switch

A two-pole toggle switch which switches the transformer secondary supplies to the power rectifiers. The external DC supply path is not switched in the instrument.

RANGE Switch

A BCD coded switch which switches in a 70 dB attenuator in 10 dB steps. The voltage range markings are in black and the dB markings in red. The switch also selects REMOTE program control.

SET ZERO Adjuster

This screwdriver adjustment permits zero setting of the meter pointer by cancelling internal circuit noise. The symbol \triangle advises the user that adjustment must be carried out according to the instructions in Chapter 3, paragraph 5.

Meter

The meter is scaled:-

- (i) 0 to 1.0V
- (ii) 0 to 3.2V
- (iii) -12 to +3 dB.

The units of voltage measurement should be interpreted according to the range selected by the switch.

The dB scale is referenced to the RANGE switch dB setting. For example, if the 20 dB range is selected, an input level of +20 dBm would give a meter reading of zero. A +23 dBm input level would give a +3 dB reading.

RESPONSE SWITCH

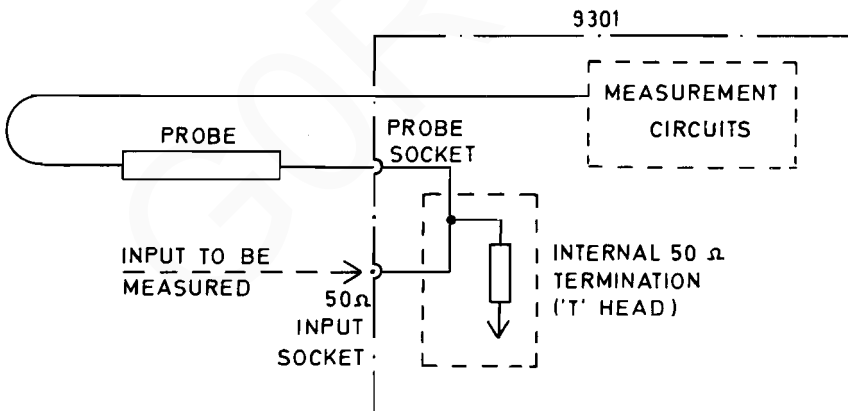
In the FAST position the meter indicates within the specified accuracy in less than 0.8 seconds. In the SLOW position the meter indicates within the specified accuracy in less than 3 seconds.

The Probe Unit

The Probe Unit, which is stowed on the underside of the instrument, is used for all measurements. It has an input impedance of $100\text{ k}\Omega$ in parallel with less than 3 pF . It incorporates a sampling circuit and a 'press-to-hold' button which permits a reading to be stored to within $\pm 0.5\%$ for up to 3 minutes. Accessories supplied for use with the probe are a flexible earthing lead and clip-prod, an isolator tip, and two spare probe tips. Optional accessories available are listed in the Technical Specification.

PROBE Socket

By plugging the probe into the PROBE socket a connection is made to the internal $50\text{ }\Omega$ termination (see Fig. 2.1 below). When the $50\text{ }\Omega$ termination is in use the calibration curve must be used at frequencies above 500 MHz.



Probe And Input Connections
For Internal 50Ω Termination

Fig.2.1

50 Ω INPUT Socket

This input is connected to the internal 50 Ω Termination Assembly. Fig. 1 on page 2-2 shows the relationship between the Probe, the Probe socket and the 50 Ω Input socket.

2. REAR PANEL ITEMS

Power Input Plug (AC)

A 3-pin fixed plug of the IEC type. A power lead with mating connector is supplied with the instrument.

AC Supply Fuse

The fuse is a glass cartridge anti-surge type, 20 x 5 mm. The required rating is marked on the panel.

Voltage Selection Switches

Two slide switches with locking plate provide four AC voltage ranges. Setting instructions are in Chapter 3, paragraph 1.

DC Supply Terminals

Three screwed terminals marked +20V, 0V, -20V provide for the connection of an external DC supply with centre tapped earth.

DC OUTPUT Socket (BNC)

Provides a -1V output at f.s.d. on the 0 to 1 scale of the meter (or at a reading of 3.162 on the 0.3 - 3.2 scale).

REMOTE INPUT Plug

A 9-way plug, to carry attenuator control instructions to the instrument in BCD code at TTL levels. The range selection code is given in the technical specification. To revert to local control all the input lines must be set to the '0' state, or the input plug must be disconnected.

CHAPTER 3

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PREPARATION FOR USE

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POWER SUPPLY

Voltage Selection

1. Mains voltage selection is made by means of two rear panel slide switches, which are fitted with a locking plate. Proceed as follows:-
 - (1) On the rear panel extract the two screws securing the cut-away locking plate and remove the plate.
 - (2) Refer to Table 2 below and set the slide switches to the positions for the required voltage range.
 - (3) Ease the plate over the slide switches such as to align the screw holes. Secure the plate with the two screws previously removed.
 - (4) Verify that the cut-out in the plate allows the required voltage annotation to be seen.

TABLE 2

Mains Voltage Selection

Switch Settings		Instrument Voltage Range For Local AC Supply
* Left Hand Switch	Right Hand Switch	
Down	Up	94 V to 110 V
Up	Up	110 V to 130 V
Down	Down	188 V to 220 V
Up	Down	220 V to 260 V

* Left hand and right hand are as seen when viewing the rear of the instrument.

Line Fuse

2. Check that the line fuse rating is correct for the local AC supply voltage. The fuse is a 5mm x 20mm glass cartridge, anti-surge type. The Racal Data part numbers for replacement fuses are:-

94 V to 130 V supply	200mA	23-0027
188 V to 260 V supply	100mA	23-0033

Power Lead

3. The power lead must be fitted with a suitable connector in accordance with the standard colour code.

	<u>European</u>	<u>American</u>
Live	Brown	Black
Neutral	Blue	White
Earth (Ground)	Green/Yellow	Green

DC Supply

4. The customer's DC supply can be connected to the +20 V, 0 V, -20 V screwed 2 mm terminals on the rear panel. The DC supply should be an earthed centre tapped system, capable of supplying not less than 8 VA continuously and fitted with 500 mA fuse protection. The permitted voltage tolerance is 17 V to 25 V.

CALIBRATE (SET ZERO) ADJUSTMENT

5. (1) Switch on.
(2) Select 1 mV range.
(3) Set the RESPONSE switch to SLOW.
(4) Insert the Probe into the front panel PROBE socket.
(5) There must be no input to the 50 Ω INPUT socket.
(6) The meter pointer should indicate the zero position. If necessary carefully adjust the CALIBRATE potentiometer (use a screwdriver) so that the zero position is just obtained.

CAUTION: Do not over-adjust, as the pointer cannot move below the zero position and excessive adjustment will cause errors.

REMOVAL OF COVERS

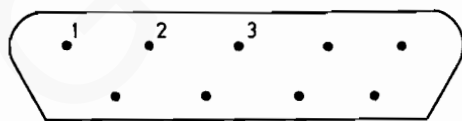
WARNING DANGEROUS AC VOLTAGES ARE EXPOSED IF COVERS ARE REMOVED WITH MAINS SUPPLY CONNECTED. COVERS SHOULD BE REMOVED BY AUTHORISED PERSONNEL ONLY.

NOTE: No adjustments should be made within the instrument except as instructed in the Maintenance Manual.

6.
 - (1) Switch the instrument POWER switch to OFF and switch off the AC supply at the bench outlet. Unplug the power lead from the rear panel of the instrument. Disconnect the DC supply (if fitted).
 - (2) Remove the rubber plugs (located near to the rear end) from both side panels of the instrument and slacken, by about two turns, the screws revealed.
 - (3) Grip the rear panel assembly and ease it back from the main case to the maximum extent available (about 5 mm).
 - (4) The rear edge of either cover can now be lifted and the cover withdrawn outwards and rearwards.

CONNECTION OF REMOTE PROGRAM CONTROL

7. Connections are made to the rear panel 9-way socket, using the free plug supplied. Only pins 1, 2 and 3 are used (see Fig. 3.1, below). Table 1 in the technical specification gives the coding. Remote program levels are TTL compatible, and may be taken to a maximum +70V ('1' state) and -70V ('0' state) without damage to the instrument.

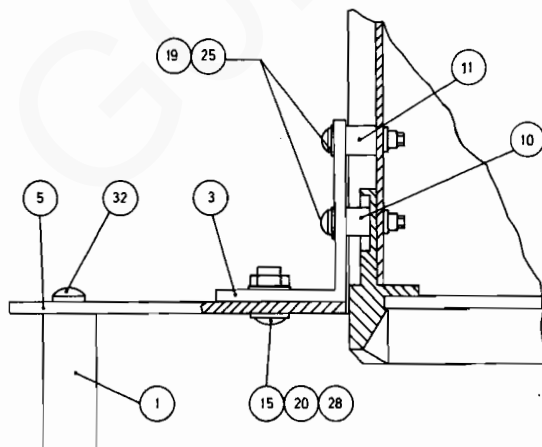


Remote Program Socket Pin Identification
(Viewed On Rear Panel)

Fig.3.1

FITTING RACK MOUNTING KIT (OPTION) TYPE 11-1126

- 8.
- (1) Remove the bench type handle assembly by carefully prising off the plastic caps from the handle pivots, and then extracting the screws which secure the assembly to the unit. Store safely for possible future use.
 - (2) Remove the rubber bungs fitted in the side trim strips towards the rear of the instrument and completely remove the two screws revealed. This allows the rear panel to be drawn away from the side panels (as far as wiring permits).
 - (3) With the rear panel drawn backwards, slide out the trim strips from the side panels. Store them safely for possible future use. Then refit the rear panel and secure firmly with the two screws removed in (2).
 - (4) At the front of the instrument, remove the screw securing the front panel on one side and discard. Refer to diagram below and fit bracket (item 3) using spacers (items 10 and 11) screws (item 25) and washers (item 19).
 - (5) Repeat (4) on the other side of the front panel.
 - (6) Fit the rack type handles (item 1) to the plates (item 5) using two Taprite screws (item 32) to each handle.
 - (7) Fit the plate assemblies to brackets on the unit, using two of items 15, 20 and 28 to each plate assembly.



Plan View: Rack Mounting 11-1126 Fig.3.2

CHAPTER 4

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OPERATING PROCEDURE

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INTRODUCTION

1. The instrument should be prepared for use in accordance with the instructions in Chapter 3. If the instrument is being used for the first time, or at a new location, pay particular attention to the setting of the supply voltage selector switches.

LOCAL CONTROL

2. (1) Switch POWER to ON and check that the indicator lights.
(2) Select the required range and meter response.
(3) Connect the signal to be measured to the 9301A in accordance with the instructions given in paragraph 4.

REMOTE PROGRAM CONTROL

3. (1) Prepare the remote control connections in accordance with Chapter 3 paragraph 7.
(2) Switch POWER to ON and check that the indicator lights.
(3) Select the required meter response.
(4) Set the RANGE switch to remote and select the required range at the remote program control point.
(5) Connect the signal to be measured to the 9301A in accordance with the instructions given in paragraph 4.

CONNECTION OF THE SIGNAL TO BE MEASURED

4. The signal to be measured is sampled by means of the probe. The following paragraphs give instructions for connecting the signal to be measured to the probe, using the probe accessories. Some of the accessories available are shown in Fig. 4.1. The accessories should only be used in the manner described.

Measurements Using the Internal Termination

5. The recommended method of making measurements, which gives the greatest accuracy, is with the signal to be measured terminated using the internal 50 Ω load of the 9301A.

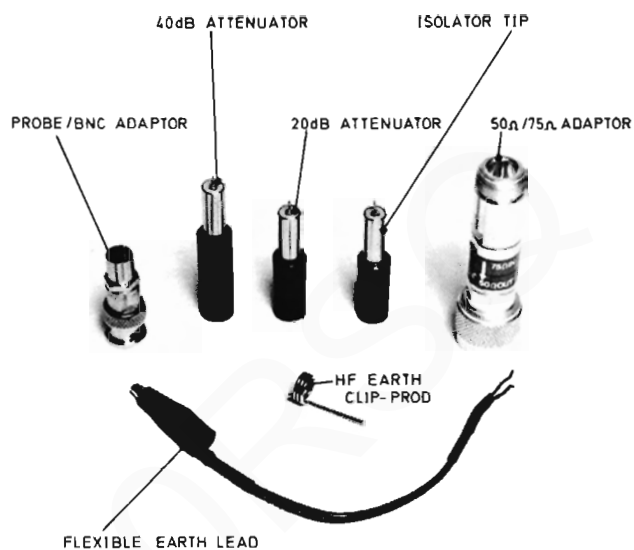
- (1) Connect the signal to the front panel 50 Ω INPUT socket, using 50 Ω coaxial cable.

CAUTION: THE MAXIMUM PERMITTED SIGNAL IS 4V r.m.s. (DC + AC).

- (2) Insert the probe, without accessories attached, into the PROBE socket. The instrument will now measure the signal across the 50 Ω load.
 - (3) At frequencies above 500 MHz, scale the reading obtained according to the instrument's individual calibration curve. The calibration curve will be found in the pouch secured to the bottom panel.
6. A 75 Ω to 50 Ω adaptor, Racal-Dana part number 23-3230, is available as an optional accessory. This may be inserted in the 50 Ω INPUT socket of the 9301A to provide a termination for 75 Ω systems. When the adaptor is used 10 dB must be added to the measurements made. This should be done after scaling the meter reading as instructed in paragraph 5(3).

Measurements Using the High Impedance Probe

7. Often the circuit on which measurements are to be made cannot be loaded with 50 Ω , or connection of the circuit to the 50 Ω INPUT socket is impracticable. In these cases measurements at frequencies in the range from 10 kHz to 200 MHz can be made by connecting the probe across the circuit in the following manner:-
- (1) Fit the isolator tip (Racal-Dana part number 11-1151) to the probe. This prevents the accuracy of the probe being affected by the source impedance of the signal being measured.
 - (2) Ground Connection - Frequencies below 10 MHz.
Fit the HF earth clip or the flexible earth lead and clip to the body of the isolator.
 - (3) Ground Connection - Frequencies from 10 MHz to 200 MHz.
Fit the HF earth clip to the body of the isolator.
 - (4) Connect the relevant earth clip to the common line and the isolator tip to the signal line of the circuit under test.
 - (5) If required, the probe, with the isolator tip attached, may be connected to BNC systems using the optional Probe-to-BNC adaptor, Racal-Dana Part number 11-1131.



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9301 Accessories

Fig.4.1

Using the Attenuators

8. Two attenuators of 20 dB and 40 dB, Racal-Dana part numbers 11-1155 and 11-1156, are available as optional accessories. Both attenuators plug onto the end of the probe, (the isolator tip should NOT be used) and may be used to make measurements from any source impedance.

WARNING: DANGEROUS VOLTAGES MAY BE INDUCED IN THE PROBE BODY WHEN MAKING HIGH VOLTAGE MEASUREMENTS AT HIGH FREQUENCY. OBSERVE THE FOLLOWING PRECAUTIONS:

- (1) ENSURE THAT THE ATTENUATOR BODY IS PROPERLY EARTHED AT THE POINT OF MEASUREMENT.
- (2) DO NOT HOLD THE PROBE WHEN MAKING HIGH VOLTAGE MEASUREMENTS.
- (3) USE THE PROBE-TO-BNC ADAPTOR IN ADDITION TO THE ATTENUATOR WHENEVER POSSIBLE.

The frequency ranges and maximum permitted inputs are shown in Table 3.

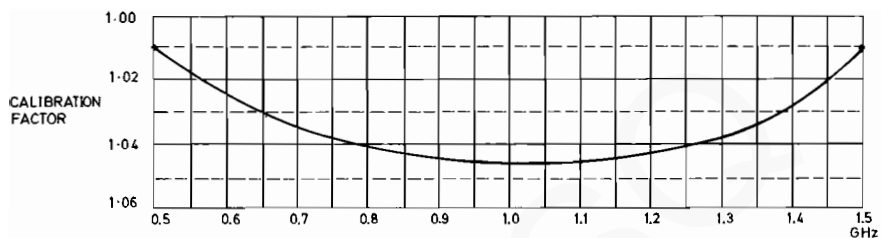
TABLE 3
Attenuator Characteristics

	Frequency Response	Max. Input	Input Impedance
20 dB	10 kHz to 500 MHz	30V	100 k Ω in parallel with less than 3 pF
40 dB	1 MHz to 500 MHz	300V	Less than 3 pF

9. When an attenuator is used without the Probe-to-BNC adaptor connect the probe and attenuator to the circuit under test as follows:
- (1) Ground Connection - Frequencies below 10 MHz.
Fit the HF earth clip or the flexible earth lead and clip to the body of the attenuator.
 - (2) Ground Connection - Frequencies from 10 MHz to 500 MHz.
Fit the HF earth clip to the body of the attenuator.
 - (3) Connect the earth clip to the common line and the attenuator tip to the signal line of the circuit under test.

In-Line Measurements

10. In-line measurements in 50 Ω systems are made using the Probe T Assembly, Racal-Dana part number 11-1353.
11.
 - (1) Connect the Probe T Assembly into the system on which measurement is to be made, using the type N connectors.
 - (2) Insert the probe, without accessories attached, into the receptacle at the side of the assembly.
 - (3) At frequencies above 500 MHz scale the readings obtained, first according to the instrument's individual calibration curve and then using Fig. 4.2.
12. In-line measurement may also be made using the Probe-to-BNC adaptor and a BNC T piece. The calibration of the instrument cannot be guaranteed when this method is used, because the loading effect of the probe and accessories is not compensated for in the BNC T piece.
13.
 - (1) Insert the BNC T piece into the system on which measurements are to be made.
 - (2) Fit the probe with either an attenuator, if this is required, or with the isolator tip.
 - (3) Connect the probe to the T piece using the Probe-to-BNC adaptor.



NOTES : 1. THIS CALIBRATION CURVE RELATES TO THE
T-PIECE ACCESSORY 11-1353

2. THE CALIBRATION FACTOR IS A MULTIPLIER WHICH SHOULD
BE APPLIED AFTER SCALING THE READING ACCORDING TO
CALIBRATION CURVE ATTACHED TO THE INSTRUMENT.

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Calibration Curve for T-Piece Assembly

Fig.4.2

