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TM 9954

Logarithmic Amplifier

INSTRUCTION MANUAL

MARCONI INSTRUMENTS

Instruction Manual

No. EBM 9954

for

Logarithmic Amplifier

TM 9954

MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND

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Chapter 1

General information

1.1 INTRODUCTION

Logarithmic Amplifier TM 9954 is intended for use in swept frequency applications to expand the dynamic display range of detected signals and to present this range on a logarithmic scale. Hence each equal factor of change in r.f. input level produces an equal increment of change in output voltage, enabling the oscilloscope display to be calibrated linearly in dB, e.g. 10 dB/cm.

As well as the logarithmic mode described above there is also a DIRECT mode in which the input from the detector is connected directly to the output. The DIRECT mode is used for calibration and also eliminates the need to disconnect the instrument when the logarithmic function is not required.

The instrument is self-powered by mercury cells and battery life will typically be in excess of two years.

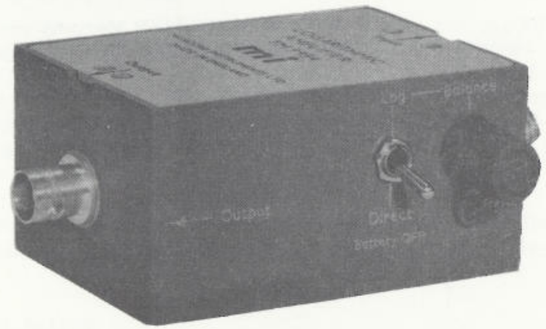

Fig. 1.1 Logarithmic Amplifier TM 9954

1.2 DATA SUMMARY

For use with (1) VHF/UHF Detector TM 9701,
(2) VHF/UHF Probe Detector TM 9650.

These detectors will provide a negative d.c. input signal to the amplifier for input frequencies from 1 MHz to 1000 MHz with a flatness of ±0.25 dB.

Note : Can also be used with Video Detector TM 9703 and Video Probe Detector TM 9651 if the diode polarity is reversed.

INPUT VOLTAGE :	3 mV to 3 V r.m.s. input to r.f. detector.
DYNAMIC RANGE :	60 dB, useful indication to 70 dB (1 mV).
RESPONSE :	Logarithmic ±1.0 dB.
OUTPUT SCALE FACTOR :	15 mV/dB above 3 mV r.m.s.
NOISE :	Corresponds to uncertainty of approximately ±1 dB at 3 mV r.m.s.
OUTPUT :	Approximately 1 V, negative polarity.
OUTPUT IMPEDANCE :	Less than 2 kΩ.
CONNECTORS :	Input - BNC male. Output - BNC female.
POWER SUPPLY :	4 x Mallory TR 132 R Mercury cell batteries with about 5000 hours life for continuous operation.
DIMENSIONS :	125 mm (4 3/4 in) x 63 mm (2 1/2 in) x 41 mm (1 5/8 in) including connectors.
WEIGHT :	0.283 kg (10 oz).

Chapter 2

Operation

2.1 APPLICATIONS AND TECHNIQUES

ASSOCIATED EQUIPMENT

Logarithmic Amplifier TM 9954 was designed for use in swept frequency techniques and specifically for use with Marconi Instruments VHF and UHF Detectors TM 9650 and TM 9701. But it will also operate with any negative polarity output germanium diode detector, including our TM 9651 and TM 9703, if the detector's diodes are reversed in their sockets. Silicon diode detectors are, however, unsuitable.

The frequency range over which the logarithmic amplifier is usable is determined by the detector it is used with. Also the dynamic range, which is potentially 70 dB, will be limited if the voltage available for detection does not cover this range. For example, with the VHF/UHF Detector TM 9701 the frequency range is 1 MHz to 1 GHz and with Marconi Instruments Sweep Generator TF 2361 the dynamic range is limited to 54 dB unless the equipment under test has gain, because the generator has a maximum output voltage of 0.5 V r.m.s.

RANGE OF APPLICATION

The logarithmic amplifier is ideal for filter or attenuator response measurements (see Fig. 2.1 for equipment set-up) and amplitude against frequency measurements involving low levels or wide dynamic ranges of r.f. signal. At the points where such responses are a large number of dB below the reference level (e.g. 60 dB), details can be seen that are lost on a normal display - see Fig. 2.2.

The wide generality of the instrument's function will allow users to devise many other applications suiting their particular requirements.

GENERAL NOTES

1. Time constants

The detectors with which the instrument will be used have a distinct time constant. This may affect the displayed characteristic if too fast a sweep rate is used.

The effect will be exaggerated by the logarithmic amplifier which has itself a time constant that increases with decrease in level. To ensure that the sweep rate you are using is not too high, reduce it progressively and see if the display changes (i.e. slopes get steeper). If it does then the sweep rate at which this change occurs is the greatest that should be used.

With Marconi Instruments Sweep Generator TF 2361 a convenient check is possible as follows:

Set the RATIO switch to 1:1 and switch off the BLANKING. If the sweep rate is not too high the forward and backward sweep traces will exactly coincide.

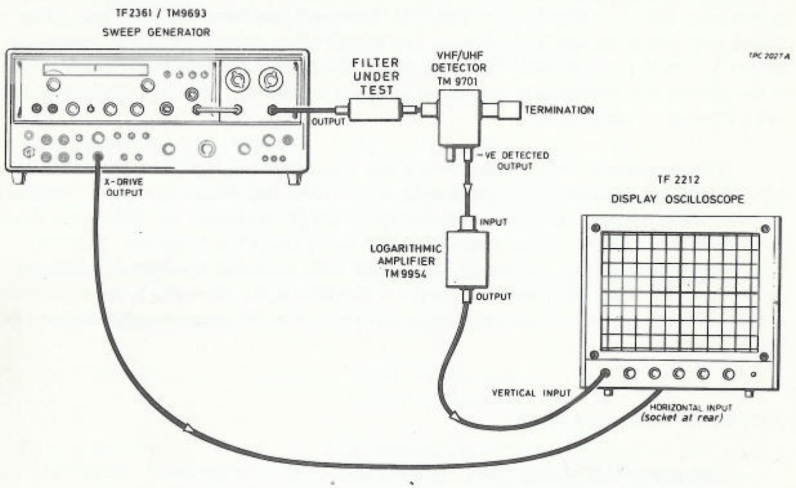

Fig. 2.1 Set-up for frequency response measurement.

2. Earthing

To avoid the possibility of the formation of hum loops the OUTPUT socket is isolated from the case. Therefore it is necessary to ensure that associated equipment is earthed. If there is no common earth connection between the associated equipment, it is necessary to connect a link between the outers of the input and output sockets on the logarithmic amplifier.

3. Noise etc.

The dynamic range may be restricted by the presence of noise, hum or d.c. in the output of the sweep generator used. It is, of course, important to check the magnitude of these factors in order not to attribute them to the equipment under test.

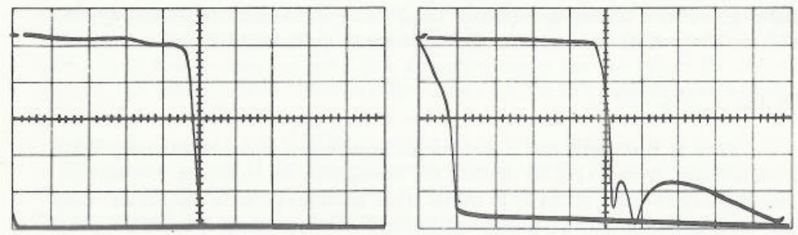

Fig. 2.2 Typical Low-pass filter response.

4. Microphony

The logarithmic amplifier is designed to be connected directly to a detector and the equipments under test, rather than by means of cables, to avoid possible microphony effects. For the same reason it should be ensured that the equipment is isolated from any source of mechanical vibration.

2.2 CONTROLS

LOG/DIRECT switch

In the LOG mode the logarithmic amplifier has the battery supply connected to it and is fully operational whereas in the DIRECT mode the battery supply is disconnected and the output from the detector being used is routed directly from the INPUT socket to the OUTPUT socket. Although the batteries have a very long life (5000 hours on load, approx.) it is advisable to switch to DIRECT when the instrument is not is use. The DIRECT mode is also used in calibrating the instrument (see Section 2.4).

PRESET BALANCE

This is a potentiometer of approximately 20 turns which adjusts the d.c. offset between input and output of the operational amplifier and is used in setting up the baseline calibration of the instrument (see Section 2.3). Access to it is via a small hole in the case adjacent to the only knob (FINE BALANCE).

FINE BALANCE

This is a normal potentiometer which adjusts the d.c. offset between input and output of the operational amplifier and is used in setting up the bottom limit calibration of the dynamic range (see Section 2.3).

OUTPUT SOCKET

This is BNC type and provides an impedance of approximately 2 kΩ. It is isolated from earth to obviate the possibility of hum loop formation. The signal available from it is taken from the logarithmic amplifier when the LOG/DIRECT switch is set to LOG and directly from the INPUT plug when the LOG/DIRECT switch is set to DIRECT.

INPUT PLUG

This is BNC type. The signal to it is routed to the logarithmic amplifier when the LOG/DIRECT switch is set to LOG or directly to the OUTPUT socket when the LOG/DIRECT switch is set to DIRECT.

2.3 SETTING UP

Before making a measurement the logarithmic law of the instrument should be correctly set up. The procedure is in two parts, baseline calibration and bottom limit calibration. Baseline calibration is the coarser part and should thus be performed first. Bottom limit calibration is the finer and need not be performed at all if only the top 40 dB part of the dynamic range is to be looked at. The operations are described with reference to the simple equipment set-up shown in Fig. 2.1.

BASELINE CALIBRATION

(1) With the equipment connected as shown in Fig. 2.1 (ensuring that the detector is loaded if d.c. return is not provided by the sweep generator) set the LOG/DIRECT switch to DIRECT and align the baseline level on the DISPLAY OSCILLOSCOPE (i.e. the flyback trace) with a convenient graticule line.

(2) Set the LOG/DIRECT switch to LOG, the FINE BALANCE control to mid-position and adjust the PRESET BALANCE control to bring the baseline level trace to the same position as in (1). Generator noise during retrace may alter baseline level; therefore, insert attenuation on the sweep generator, until further attenuation has no effect on baseline position (usually less than 30 dB will suffice). The PRESET BALANCE control is a multi-turn control and to adjust it you will need a small screwdriver (or trimming tool) that easily fits into the hole in the case that gives access to it.

BOTTOM LIMIT CALIBRATION

When the baseline calibration has been carried out it is necessary to carry out finer calibration at the bottom limit of the dynamic range you intend to observe if the full specified accuracy of the instrument is required. The logarithmic law is then set over this dynamic range but not below the bottom limit. The rate of drift with time increases as the level decreases and is, therefore, worst at the bottom limit of the full dynamic range (70 dB). Thus it is unwise to carry out this finer calibration at the bottom limit of the full 70 dB dynamic range if the lowest level you are observing is the bottom limit of, say, a 50 dB dynamic range, as it will require resetting more often. For any dynamic range the calibration will require resetting periodically up to a rate of every few minutes for the bottom limit of the full 70 dB dynamic range.

The procedure is as follows:

(1) Set the LOG/DIRECT switch to LOG, output attenuator of the SWEEP GENERATOR to 0 dB and the V GAIN of the DISPLAY OSCILLOSCOPE to give a convenient display height, with the top of the sweep trace aligned with a convenient graticule line.

(2) Switch the attenuator through the dynamic range you intend to observe and adjust the V GAIN of the DISPLAY OSCILLOSCOPE such that at the top end of the dynamic range equal attenuation steps give convenient vertical shift steps (e.g. 1 cm/10 dB). (See general note 1 in Section 2.1.)

(3) The linear relationship set up in (2) may not hold when the attenuation switched in is greater than about 40 dB, the deviation from it increasing as attenuation increases. Adjust the FINE BALANCE control to give this relationship on the final step and check that it now applies throughout the range.

Chapter 3

Technical description

3.1 GENERAL

Logarithmic Amplifier TM 9954 is designed to operate from the d.c. output of an M.I. r.f. detector (see Section 2.1). This output is then routed either to the logarithmic amplifier when switch LOG/DIRECT is set to LOG, or directly to the OUTPUT socket when switch LOG/DIRECT is set to DIRECT. The LOG/DIRECT switch is also the on-off switch as it turns off the battery supply to the logarithmic amplifier when set to DIRECT. The rest of this summary assumes that the LOG/DIRECT switch is set to LOG.

The d.c. output of the logarithmic amplifier is proportional to the logarithm of the r.f. input to the detector. To achieve this, compensation is incorporated in the logarithmic amplifier for the non-linearity of detector responses. Also, a high impedance is presented to the detector.

The main principle used to achieve the logarithmic response is that of an infinite gain amplifier with logarithmic element in the feedback loop.

To achieve the wide dynamic range complete screening of the amplifier is necessary and so a cast aluminium box with a close-fitting lid is used.

3.2 CIRCUIT DETAILS

The logarithmic amplifier is built around a UC 4250 C operational amplifier which is an integrated circuit (IC1). Another integrated circuit (IC2) provides the logarithmic feedback element, three transistors being connected as three series diodes (IC2a, IC2b and IC2c). Transistors connected as diodes give better results than straightforward diodes because of their high β and matched characteristics. A further transistor connected as a diode (IC2d) forms a long-tailed pair with IC2c to provide temperature compensation.

The logarithmic element is connected in the feedback path between the output (pin 6) and the negative input (pin 2) of the operational amplifier, 10 kΩ to earth (R1) providing the requisite gain. When the output from the operational amplifier is high the diodes in the feedback loop are forward biased and their effective resistance therefore low; thus the overall gain is low. When the operational amplifier output is low the diodes have very little current flowing through them, their resistance therefore being high; thus the overall gain is high. At very high input levels the feedback diodes lose their logarithmic response because they have finite minimum resistance. Diodes MR1, MR2 and MR3 take over to compensate by reducing the overall gain. These

three shunt diodes, incorporated in the emitter follower circuit of transistor VT1, also compensate for non-linearity in the output of the r.f. detector used. They are selected in calibration so that each 10 dB step of r.f. input to the r.f. detector produces a proportional change in d.c. output level from the logarithmic amplifier. Added stabilization of the r.f. detector response is provided in the form of temperature compensation for the germanium diode in the detector by diode MR4 and resistor R7. The current drained from pin 1 (differential balance) of the operational amplifier increases as temperature increases owing to the drop in MR4 resistance.

The amplifier will be truly logarithmic only if the equivalent zero input level is correctly set; that is, the logarithmic element must have exactly the right voltage across it for zero input at the INPUT plug. This is achieved with the balance controls - the PRESET BALANCE potentiometer RV1 and the FINE BALANCE potentiometer RV2 (see Section 2.3). The range of the balance controls is set during calibration by selection of resistor R4 (nominally 6.8 MΩ) to give ideal conditions for a typical detector with the controls in mid-position. Setting up the range of the balance controls is necessary because the voltage at the input to the operational amplifier (pin 3 of IC1) is dependent on the output impedance of the r.f. detector used and the bias current out of pin 3 of IC1.

The power supply is provided by non-rechargeable mercury cells. These are eight 1.35 V cells packed as four standard batteries (Mallory type TR 132 R or equivalent) which should give an average life of about 5000 hours on load. The batteries are arranged to provide two voltage rails of +2.7 V and -8.1 V respectively.

Chapter 4

Maintenance

4.1 REMOVAL AND REPLACEMENT OF LID

The lid is the engraved face of the instrument. It is secured by a spring clip at each end and is thus easily removed in the following way:

(1) At each end of the instrument above the input and output connectors there is a small slot in the case beneath the lid. Find a small screwdriver that just fits these slots.

(2) Push the screwdriver into the slot at one end and lever upwards carefully until the spring clip is felt to disengage. Do the same at the other end. The lid should now be free to lift off.

Note that the lid fits one way round only, the spring clip mounting at the battery end being arranged to clear the battery casing. It is positioned correctly when the OUTPUT engraving on it corresponds, with respect to the case end, with the OUTPUT engraving on the side of the case.

To replace the lid simply position it correctly, as above, and squeeze it into the case at each end until you feel the spring clips 'snap' into their recesses. If the lid is positioned the wrong way round the spring clip at the battery end will not locate and damage to the battery casing may ensue.

4.2 CHANGING BATTERIES

The batteries are non-rechargeable mercury cells and will typically last about 5000 hours on load. There are four 2.7 V batteries of two cells each housed in two identical plastic holders. The retaining lids of these holders are just below the instrument lid. The battery connectors should be periodically inspected and cleaned to maintain optimum performance. The procedure for changing the batteries is as follows :

(1) Switch the LOG/DIRECT switch to DIRECT (supply off) and remove the instrument lid as described in Section 4.1.

(2) Remove the two screws securing each battery holder lid and lift them off.

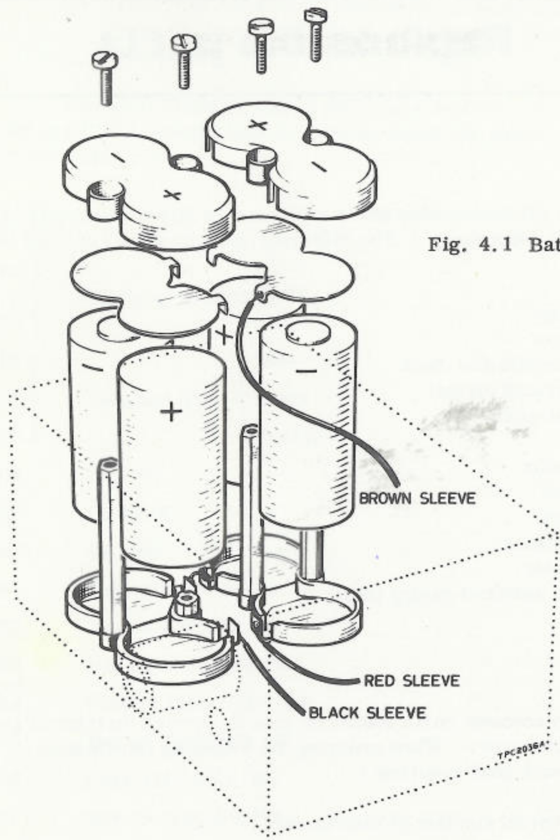

Fig. 4.1 Battery Arrangement.

(3) Carefully lift away the flat connectors that electrically connect each two units together. The batteries can now be lifted out.

(4) Replace the batteries with Mallory type TR 132 R or equivalent ensuring that the configuration with respect to polarity is as shown in Fig. 4.1.

(5) Replace the connectors, again referring to Fig. 4.1.to ensure that each connector is paired with the correct pair of batteries.

(6) Replace the container lids ensuring that the slots in them mate with the spigots on the connectors.

(7) Replace the instrument lid.

Chapter 6

Replaceable parts

Introduction

In this chapter all replaceable parts are listed in alpha-numerical order of their circuit references. The following abbreviations are used in this chapter.

B	:	battery
Carb	:	carbon
D	:	semiconductor diode
IC	:	integrated circuit
Met ox	:	metal oxide
PL	:	plug
R	:	resistor
S	:	switch
SKT	:	socket
TR	:	transistor
Var	:	variable
†	:	value selected during test

Ordering

Orders for replacement parts should be sent to service division at the address given on back cover. When ordering the following information should be given for each part required :

(1) Type and serial number of instrument.
(2) Circuit reference.
(3) Description.
(4) MI code number.

If a part is not listed state its function, location and description when ordering.

One or more of the parts fitted to the instrument may differ from those listed in this chapter for any of the following reasons :

(a) Components indicated by † have their value selected during test to achieve particular performance limits.

(b) Owing to supply difficulties, components of different value or type may be substituted provided that the overall performance of the instrument is maintained.

(c) As part of a policy of continuous development, components may be changed in value or type to obtain detail improvements in performance.

Whenever there is such a difference between the component fitted and the one listed, always use as a replacement the same type and value as found in the instrument.

Circuit reference	*Description*	*M.I. code*
B1 to B4	Mallory TR132R 2.7V	23722-104
† D1	Selected from 1S44	28335-738
† D2	Selected from 1S923	28356-018
† D3	Selected from 1N4148	28336-678
D4	HG1005	28323-035
IC1	UC4250C	28461-306
IC2	CA3046	28461-901
R1	Met ox 10kΩ 2% ¼W	24511-610
R2	Met ox 10kΩ 2% ¼W	24511-610
R3	Met ox 220kΩ 2% ¼W	24511-643
† R4	Carb 6.8MΩ 10% 1/8W	24321-883
R5	Met ox 220kΩ 2% ¼W	24511-643
R6	Carb 1MΩ 5% 1/8W	24311-945
R7	Met ox 47kΩ 2% ¼W	24511-626
R8	Met ox 100kΩ 2% ¼W	24511-635
R9	Met ox 56kΩ 2% ¼W	24511-629
R10	Met ox 150kΩ 2% ¼W	24511-639
R11	Carb 1MΩ 5% 1/8W	24311-945
R12	Var cermet 100kΩ	25748-510
R13	Var carb 1MΩ	25615-588
R14	Met ox 330Ω 2% ¼W	24511-563
PL1	BNC bulkhead 50Ω	23443-342
SA	Log/direct	23463-266
SK1	BNC bulkhead 50Ω	23443-443
TR1	BCY71	28435-235

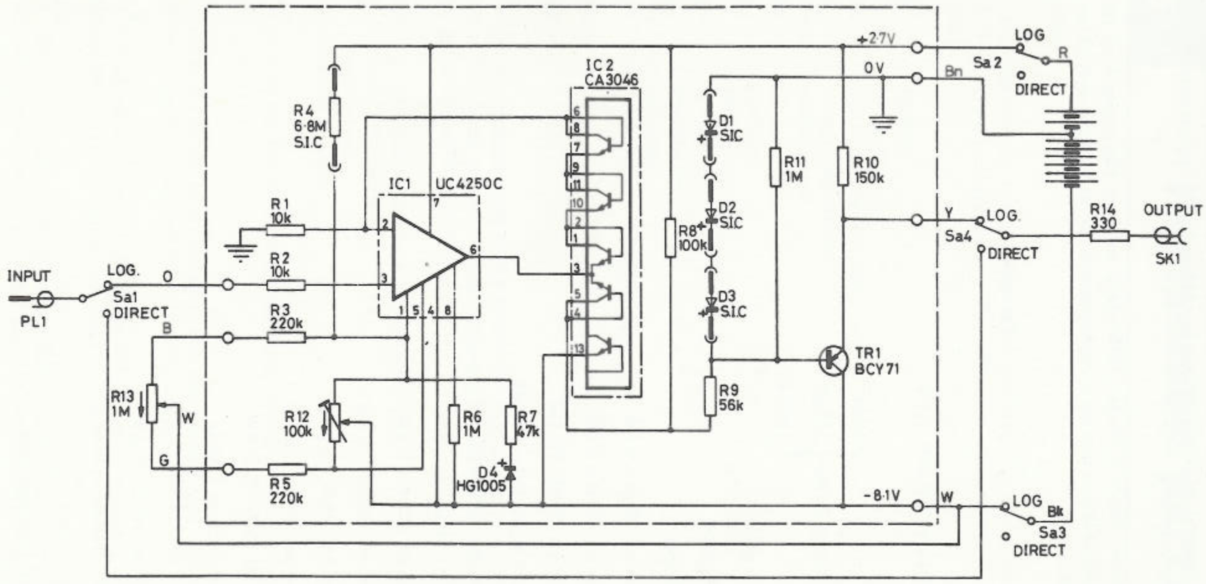

Fig. 6.1 Circuit diagram of Logarithmic Amplifier