POTOMAC INSTRUMENTS INC.

INSTRUCTION MANUAL

FIELD STRENGTH METER FIM-41

7309 GROVE ROAD UNIT D FREDERICK, MD 21704 PHONE - 301-696-5550 FAX - 301-696-5553





FIELD STRENGTH METER

POTOMAC INSTRUMENTS inc. PRECISION ELECTRONIC PRODUCTS

WARRANTY FOR EQUIPMENT AND ACCESSORIES

Potomac Instruments inc. warrants each new equipment to be free of defects in material and workmanship, for a period of one (1) year after date of original shipment, except for tubes, lamps, fuses, transistors, and diodes which will be warranted for a period of ninety (90) days. Any instrument which is found within one year not to meet the foregoing standards after examination by our factory, will be repaired or at the option of Potomac Instruments replaced without charge. This warranty does not apply to equipment which has been altered, improperly handled, or damaged in any way.

CHANGES IN SPECIFICATIONS

The right is reserved to change the published specifications of equipment at any time, and to furnish merchandise in accordance with current specifications, without incurring any liability to modify equipment previously sold.

RETURNING EQUIPMENT TO THE FACTORY

Factory service is available for repair and adjustment of this instrument; however, a description of the trouble, plus the model and serial number(s) of the unit should be forwarded first, whereupon instructions for correcting the trouble or authorization for returning the equipment will be given. This applies to all units, whether under warranty or not. Shipment in an improper container may result in damaged equipment thereby voiding warranty.

TABLE CONTENTS

Paragraph

Page

SECTION 1. GENERAL DESCRIPTION

1.1	Scope of Manual	1-1
1.2	Purpose of Equipment	l-1
1.3	Equipment Specifications	1-1

SECTION 2. OPERATION

2.1	General	2-1
2.2	Operating Controls and Indicators	2-1
2.3	FIM Calibration	2–2
2.4	Measuring Field Strength	2-4
2.5	Measuring Harmonic Ratio in Decibels	2-5
2.6	R. F. Bridge Measurements. (Tuned Voltmeter)	2-6

LIST OF ILLUSTRATIONS

Figure		Page
2-1	Operating Controls and Indicators	2–3

LIST OF TABLES

Table		<u>Page</u>
1-1 1-2	Specifications: Type FIM-21 Field Strength Meter Specifications: Type FIM-41 Field Strength Meter	1-1 1-3
2-1	Operating Controls and Indicators	2-1

SECTION 1. GENERAL DESCRIPTION

1.1 Scope of Manual

This manual provides a comprehensive technical description of the operating and physical characteristics of the FIM-21 and FIM-41 Field Strength Meters. It provides sufficient information concerning the operation and func-tional theory of operation to permit effective operation of these instruments.

1.2 Purpose of Equipment

Field Strength Meters, FIM-21 and FIM-41 are light-weight portable instruments for the measurements of a wide range of radio signal intensities in the .54 to 5.0 MHz frequency spectrum. The FIM-21 covers the broadcast band (540 to 1600 KHz) while the FIM-41 covers the broadcast band and harmonic frequencies to 5.0 MHz. Both units are rugged test instruments that are equally effective for interference studies at low signal strength and for close-in measurements on high-power directional arrays. In addition, a special input jack permits the receiver to be used as a null detector for RF Bridge measurements.

1.3 Equipment Specifications

(See specifications, FIM-21, Table 1-1, FIM-41, Table 1-2)

Table 1-1. Specifications: Type FIM-21 Field Strength Meter

Frequency Range:		535 KHz to 1605 KHz
Field Intensity H	lange:	10 microvolts per meter to 10 volts per meter
Accuracy of Calib	pration:	l percent, referenced to NBS Standard Field
Accuracy of Range	e Attenuator:	2 percent over entire FI range and tuning band
Selectivity		
Bandwidth	(6 db):	7 KHz nominal with multi-pole hybrid filter
IF Rejectio	on:	75 db minimum
Image Rejec	ction:	80 db minimum
Adjacent Ch	nannel Rejection:	50 db minimum 10 KHz above and below tuned station
Panel Meter:		4" mirrored scale, logarithmic graduations 1 to 10, taut band meter movement, 2% linearity
Antenna:		Shielded loop, integral part of hinged cover

SECTION 1. GENERAL DESCRIPTION (Cont.)

Table 1-1. Specifications:	Type FIM-21 Field Strength Meter (Cont.)
Audio Outputs:	Front panel loudspeaker, weather treated cone Headphone jack, high and low Z (disconnects speaker)
Recorder Output:	0.4 to 4 volts DC proportional to field intensity for each attenuator range, 2000 ohm source resistance
Lights:	Frequency dial and meter; panel switch for night use
Batteries (6 required):	Standard $l\frac{1}{2}$ volt C-Z _n "D" cells or $l\frac{1}{2}$ volt Alkaline cells for extended life at very low temperatures
Battery Life:	Greater than 1000 FI readings (re- duced life with frequent use of lights and/or high speaker volume)
Environmental:	Continuous exposure -10° F to +130° F; lower temperature operation practical for "reading time" exposures
Dimensions:	8-3/4" high, ll-1/2" wide, 5-1/8" deep with cover closed; 3-7/8" deep with cover open (gripping width)
Weight:	Approximately 11-1/2 pounds
External RF Input:	535 KHz to 1605 KHz, 10 microvolts to 10 volts
RF Input Switch:	Selects loop antenna (ANT) or Panel Connector (EXT)
METER Switch:	Selects normal linear (LIN) or loga- rithmic (LOG) operation
Logarithmic Dynamic Range:	60 db compressed input range for FI meter and recorder output

SECTION 1. GENERAL DESCRIPTION (Cont.)

Table 1-2. Specifications: Type FIM-41 Field Strength Meter

Frequency Range:

Field Strength Range:

Accuracy of Calibration:

Accuracy of Range Attenuator:

Selectivity Bandwidth (6 db):

IF Rejection:

Image Rejection:

Adjacent Channel Rejection:

Harmonic Measurement:

Panel Meter:

Antenna:

Audio Outputs:

Recorder Output:

Lights:

Batteries:

.54 MHz - 5.0 MHz in two bands Band "A" .535 - 1.61 MHz Band "B" 1.58 - 5.0 MHz

10 microvolts per meter to 10 volts per meter

l percent, referenced to NBS Standard Field

2 percent over entire FI range and tuning band

7 KHz nominal with multi-pole hybrid filter

75 db minimum

80 db (min.) at 540 KHz decreasing to 50 db (min.) at 4.8 MHz

50 db minimum 10 KHz above and below tuned station

Capable of measuring harmonics in excess of 80 db below fundamental

4" mirrored scale, logarithmic graduations 1 to 10 and linear db scale; taut band meter movement, 2% linearity

Shielded loop, integral part of hinged cover

Front panel loud speaker, weather treated cone - headphone jack, high and low Z (disconnects speaker)

0.4 to 4 volts DC proportional to field strength for each attenuator range, 2000 ohm source resistance

Frequency dial and meter with panel switch for night use

Standard 1-1/2 volt $C-Z_n$ "D" cells or 1-1/2 volt. Alkaline cells for extended life at very low temperatures (six required)

SECTION 1. GENERAL DESCRIPTION (Cont.)

Table 1-2.	Specifications:	Type FIM-41	Field Strength Meter (Cont.)
Battery Life:			Greater than 1000 readings (reduced life with frequent use of lights and/or high speaker volume)
Environmental:			Continuous exposure -10 ⁰ to +130 ⁰ F; lower temperature operation practical for "reading time" exposures
Dimensions:			8-3/4" high, 11-1/2" wide, 5-1/8" deep with cover closed; 3-7/8" deep with cover open (gripping width)
Weight:			Approximately 12 pounds
External RF Inp	out:		540 KHz to 5.0 MHz, 10 microvolts to 10 volts
RF Input Switch	.:		Selects loop antenna (ANT) or Panel Connector (EXT)
METER Switch:			Selects normal linear (LIN) or loga- rithmic (LOG) operation
Logarithmic Dyn	amic Range:		60 db compressed input range for FI meter and recorder output
Accessories Ava	ilable:		Carrying/Shipping case Unipod

SECTION 2. OPERATION

2.1 <u>General</u>

The FIM-21 and FIM-41 operating controls and indicators are described in this section. Also provided are the basic operating instructions which include battery voltage testing, meter calibration, measuring field strength, and use of these instruments as null detectors for RF Bridge measurements.

2.2 Operating Controls and Indicators

All operating controls and indicators are located on the front panel of the FIM-21 and FIM-41 as shown in figure 2-1. Table 2-1 lists these controls and indicators and the associated functions.

Table 2-1. Operating Controls and Indicators

Control or Indicator

Function

FUNCTION selector switch (S2)

Selects the function to be displayed on the front panel meter and connects battery.

OFF - battery disconnected from circuit, and direct connection made across meter terminals to protect meter.

BATT - battery output voltage

FI CAL TUNE - field strength of antenna input developed from detected output of receiver IF amplifier.

CAL Null - compares detector outputs from receiver and calibrating oscillator.

Selects the amount of attenuation in RF and IF stages, in 10 to 1 (20 db) ratio steps. The panel is marked with the full-scale direct-reading field strength value for each position.

CAL - applies power to calibrating oscillator, and selects 1 volt range of attenuator.

Adjusts level of audio in speaker and headphones. Switch disables audio amplifier in OUT position.

FULL SCALE selector switch (S1)

AUDIO control and switch (R3)

Table 2-1. Operating Controls and Indicators (Cont.)

Control or Indicator	Function
GAIN control (R2)	Adjusts gain of receiver by regulating gain of IF amplifier.
CAL OSC tuning control (R1)	Fine tunes calibrating oscillator. (Oscillator frequency coarse tuning is pre-set by receiver tuning control.)
RCVR tuning control (Cl)	Tunes receiver and calibrating oscillator by rotating capacitors Cl and C2. Fre- quency of receiver signal is read on dial.
FIELD-STRENGTH meter (ML)	Indicates field strength in volts per meter, in conjunction with full scale switch.
LIGHT switch (S3)	Illuminates meter and dial.
RF INPUT switch	Switches receiver input to loop antenna (ANT) or external BNC input jack (EXT).
MHz switch (FIM-41 only) (S7)	Selects frequency band:
	A54 to 1.6 MHz B. 1.6 to 5.0 MHz
METER switch (S5)	Provides either logarithmic (LOG) or linear (LIN) relation between meter reading and re- ceiver input, the former for use when the meter is to operate in conjunction with re- cording equipment or when relative measure- ments of greater than one decade are desired.

Replacement of batteries is described in the maintenance section of this manual.

2.3 FIM Calibration

The FIM should always be calibrated at the frequency of the signal to be measured. This eliminates any error due to frequency sensitive components in the circuits. Calibrate the meter as follows:

> 1. Place or hold the field strength meter in a vertical position, with the top surface in a horizontal plane. Open the cover and swing it to a vertical position.



Figure 2-1 Operating Controls and Indicators

2.3 FIM Calibration (Cont.)

- 2. Rotate the FUNCTION switch to the BATT position and see that the reading is above 5.0.
- 3. Rotate the FUNCTION switch to the FI position.
- 4. Switch LOG-LIN switch to LIN position.
- 5. Set the FULL SCALE switch to the range which covers the expected value of field strength.
- 6. Turn on the AUDIO control and tune the RECEIVER dial to the signal to be measured. Use the meter indication to obtain peak tuning, adjusting the GAIN control and FULL SCALE switch, and rotating the instrument to obtain a reading within the range of the meter. Use the audio signal to identify the station. The RCVR Tuning Control has vernier drive for 3/4th of one turn; it changes to direct drive and becomes harder to turn beyond the vernier range. Adjust it so that the desired station falls in the vernier range.
- 7. Rotate the instrument to obtain reading below 10 mV. In strong fields the meter reading may be reduced below 10 mV by holding the FIM horizontally or by changing RCVR Tuning away from the desired signal by no more than 10 KHz. (This is permissible because the receiver gain variation with frequency is very gradual.) An indistinct dip in the meter reading in Step 8 indicates inadequate reduction of the received signal, or interference.
- 8. Place the FULL-SCALE switch in the CAL position: adjust CAL OSC Tuning for highest meter reading, or an audio beat note low enough in frequency to be inaudible. (The meter reading should be 3.5-4.8 when the Gain control is properly set.)
- 9. Rotate FUNCTION switch to CAL NULL position: adjust GAIN control for lowest meter reading. The meter reading should be below 3.0.
- 10. Return FUNCTION switch to FI-CAL-TUNE. Return RCVR tuning for maximum meter reading on the desired signal. The Field Strength Meter is now calibrated at the frequency to which it was originally tuned.

2.4 Measuring Field Strength

In use, the field meter is generally held in the hand, or mounted on a tripod or unipod. Of the latter two, the unipod is preferred, since it can be easily rotated, and can remain attached to the instrument. A plate having a hole tapped for a $\frac{1}{4}$ - 20 screw is fastened to the bottom of the case, for attachment to a support.

2.4 <u>Measuring Field Strength (Cont.)</u>

The field meter should always be operated in a vertical position when making field strength measurements.

After calibrating as described in the previous section, proceed as follows:

- 1. Set the FULL SCALE switch to the range approximating the signal strength expected.
- 2. With the FUNCTION switch set at FI, rotate the unit to orient the loop antenna and obtain maximum deflection on the panel meter, changing the position of the FULL SCALE switch if necessary to keep the panel meter indication on scale.
- 3. Read the field intensity directly from the panel meter, using the position of the FULL SCALE switch as a guide. For example, with the FULL SCALE switch on 100 mv, a full scale reading of 10 on the meter means 100 millivolts per meter, and a reading of 5.6 indicates a field strength of 56 millivolts per meter.
- 4. Multiply the reading obtained in step 3 by the K factor for the operating frequency given on the calibration certificate for the instrument. This procedure is followed when it is necessary to make full use of the specified accuracy of the field meter.
- 5. To de-energize the field meter, rotate the FUNCTION switch to the OFF position. This disconnects the batteries from the circuit. Closing the cover also removes the battery power.

2.5 <u>Measuring Harmonic Ratio in Decibels</u>

Field Strength Ratios may be measured directly in decibels by reading the db scale of the meter in conjunction with the FULL-SCALE range indicator. Since each step of the FULL-SCALE switch corresponds to one (1) decade or twenty (20) db, the ratio is determined by the following formula:

$$db_1 - db_2 + N \ge 20 = Ratio in db$$

where:

db1 = Harmonic field strength
db2 = Fundamental field strength
N = Number of FULL SCALE steps between fundamental
and harmonic

2.5 Measuring Harmonic Ratio_in_Decibels (Cont.)

Example:

Let us say that we want to measure the field strength and the second and third harmonic suppression of a transmitter with an operating frequency of 1500 KHz.

- Measure field strength of fundamental as outlined in section 2.4 of this manual; note db scale. Example: 560 mV/M & 5 db.
- 2. Measure field strength of second harmonic as above at 3.0 MHz. Example: 0.35 mV/M & 9 db.
- 3. Measure field strength of third harmonic as above at 4.5 MHz. Example: 79 uV/M & 2 db.

Calculate harmonic suppression:

 $db_1 - db_2 + 20 \times N = ratio (db)$ second harmonic suppression = 9-5 + 60 = 64 db third harmonic suppression = 2-5 + 80 = 77 db

It is not the purpose of this manual to describe the techniques of locating radial measurement points and plotting the field data required by the FCC. For this type of information, and for a more detailed description of operating techniques, the user is referred to the current edition of the NAB Handbook.

2.6 R. F. Bridge Measurements (Tuned Voltmeter)

The receiver section of the FIM-21 and FIM-41 may be used as a tuned voltmeter for applications such as R. F. Bridge null detection. As a tuned voltmeter, these instruments exhibit an imput impedance of 2500 ohms shunted by less than 2 picofarads.

To use the FIM as a relative indicator of RF voltage, proceed as follows:

1.	RF INPUT switch	switch	to EXT position
2.	METER switch	LOG or for RF	LIN - the LOG mode is helpful null detection work
3.	FUNCTION switch	set to	FI-CAL TUNE
, 4•	FULL SCALE switch	set to for me	10V position or as required ter indication

2.6 R. F. Bridge Measurements (Tuned Voltmeter) (Cont.)

Connect RF source to EXT RF input on FIM front panel. Adjust RCVR tuning for desired frequency and highest reading: adjust FULL SCALE switch for an on-scale reading.

To calibrate the FIM for absolute voltage measurements; set RCVR tuning to desired frequency with signal source connected to EXT RF input switch settings as in steps 1, 3 & 4 above. The LOG-LIN switch must be set to the LIN position for absolute readings. Switch the RF INPUT switch to ANY and calibrate meter as described in Section 2.3. Return RF INPUT switch to EXT and read meter. The correct voltage is obtained by correlating the meter indication and the FULL SCALE attenuator setting as previously described.

IMPORTANT NOTE

When operating the FIM as a tuned voltmeter, it is necessary to guard against severe overload at the EXT RF input. For this reason, start all measurements in the 10V FULL SCALE switch position. The maximum input level which can be applied to EXT input without causing damage is 25 volts RMS.