INSTRUCTION BOOK

OPERATING INSTRUCTIONS
WITH PARTS LIST

MODEL 4450
THRULINE® WATTMETER

Electronic Corporation
Cleveland (Solon) Ohio USA

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Instruction Book Part Number 920-4450-1 Rev.B

Safety Precautions

The following are general safety precautions that are not necessarily related to any specific part or procedure and do not necessarily appear elsewhere in this publication. These precautions must be thoroughly understood and apply to all phases of operation and maintenance.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must at all times observe general safety precautions. Do not replace components or make adjustments inside equipment with the high voltage supply turned on. To avoid casualties, always remove power.

DO NOT SERVICE OR ADJUST ALONE

Under no circumstances should any person reach into an enclosure for the purpose of service or adjustment of equipment except in the presence of someone who is capable of rendering aid.

CHEMICAL HAZARD

Dry cleaning solvents used to clean parts may be potentially dangerous. Avoid inhalation of fumes and also prolonged contact with skin.

RESUSCITATION

Personnel working with or near high voltages should be familiar with modern methods of resuscitation.

SAFETY SYMBOLS

WARNING
Warning notes call attention to a procedure, which if not correctly performed, could result in personal injury.

CAUTION
Caution notes call attention to a procedure, which if not correctly performed, could result in damage to the instrument.

The following safety warnings appear in the text and are repeated here for emphasis.

WARNING
Exposure to RF power radiation and the possibility of RF shock or burns exists with some operating conditions. Always be sure to turn off transmitter when connecting or disconnecting wattmeter. Be sure transmission line is terminated into a load or antenna.

WARNING
Provide adequate ventilation and observe normal precautions when using dry cleaning solvents. Many dry cleaning agents emit toxic fumes that be harmful to your health if inhaled. Avoid excessive skin contact or inhalation of the fumes when using any dry cleaning solvents.

MODEL 4450 THRULINE WATTMETER CAUTION STATEMENTS

The following equipment cautions appear in the text and are repeated here for emphasis.

CAUTION

Do not drop the Thruline Wattmeter equipment or submit it to hard blows. The voltmeter circuitry or microammeter, even though it is shock mounted, may be damaged by severe impact.

CAUTION

Clean the meter glass only when necessary and be careful not to use an excessive amount of water/detergent solution that might drip inside the housing and damage the electrical components.

This instruction book covers the model 4450 Thruline Wattmeter

This instruction book is arranged so that essential information on safety is contained in the front of the book. Reading the Safety Precautions Section before operating the equipment is strongly advised.

The remainder of this Instruction Book is divided into Chapters and Sections. Figures and tables are numbered sequentially within each chapter. At the beginning of each chapter a general overview will be given, describing the contents of that chapter.

OPERATION

First time operators should read Chapter 1 - Introduction, and Chapter 3 - Preparation for Use, to get an overview of equipment capabilities and how to install it. An experienced operator can refer to Chapter 4 - Operating Instructions. All instructions necessary to operate the equipment, are contained in this section.

MAINTENANCE

All personnel should be familiar with preventive maintenance found in Chapter 5 - Maintenance. If a failure should occur, the troubleshooting section will aid in isolating and repairing the failure.

PARTS

For location of major assemblies or parts refer to the part lists and associated drawings in the maintenance chapter.

CHANGES

Changes to this publication will be made available in supplements. To keep your instruction book accurate and up to date, it is recommended that a periodic request of the latest supplement be made. It will be supplied at no cost. When requesting updates, reference your instruction book part number and its revision level listed on the title page.

REPORTING ERRORS

It is our goal to provide our users with the information needed to operate and maintain the Thruline Wattmeter. If you should discover any errors in this publication, or if you have suggestions for improving this instruction book, please send your comments to our factory.

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Chapter 1

Introduction

Purpose and function

The Model 4450 Thruline Wattmeter is an insertion-type RF wattmeter designed to measure RF power flow and load match in 50 ohm RF coaxial transmission lines. Its primary intended use is for the test and evaluation of power line carrier equipment, although it is well suited low frequency low power RF application. When used in a 50 ohm application, with N type connectors, it has an insertion VSWR of less than 1.10 for frequencies from 25W and 0 to 100W to correspond with the range switch (S-2) settings.

This unit will not only give forward power indications with a high degree of accuracy, but also will indicate reflected power with a turn of mode switch S-1.

Description

The Model 4450 Thruline Wattmeter is a portable unit contained in a formed aluminum housing, with formed sheet aluminum back closure which is easily removed. The unit is equipped with a leather strap for carrying, four rubber shock feet on the base, and four rubber bumpers on the back, which allow the unit to be used standing vertically or horizontally. The meter is specially shock mounted for additional protection and has a slotted adjustment screw on the front face of the meter bezel for mechanical zeroing adjustment. Just below the meter on the front face is a mode switch for selecting power range or OFF position. On the sides of the unit are the RF connectors which are labeled for input and output.

Performance Characteristics and Capabilities

The Model 4450 Thruline Wattmeter is capable of measuring RF power up to 100 Watts in three ranges: 5, 25, and 100 Watts. These power levels are selected by adjusting the range switch and can be used for either forward or reflected power by adjusting the mode switch to RFL or FWD position. When checking reflected power greater resolution can be obtained by selecting a lower power setting on the range switch.

If necessary, the input and output connections may be reversed without loss of accuracy; however, the mode switch will be just the opposite of normal settings, i.e. RFL position will indicate forward power and FWD position will indicate reflected power.

The RF connectors are the Quick-Change (QC) type and may changed to other available QC types if necessary.

Power Requirements

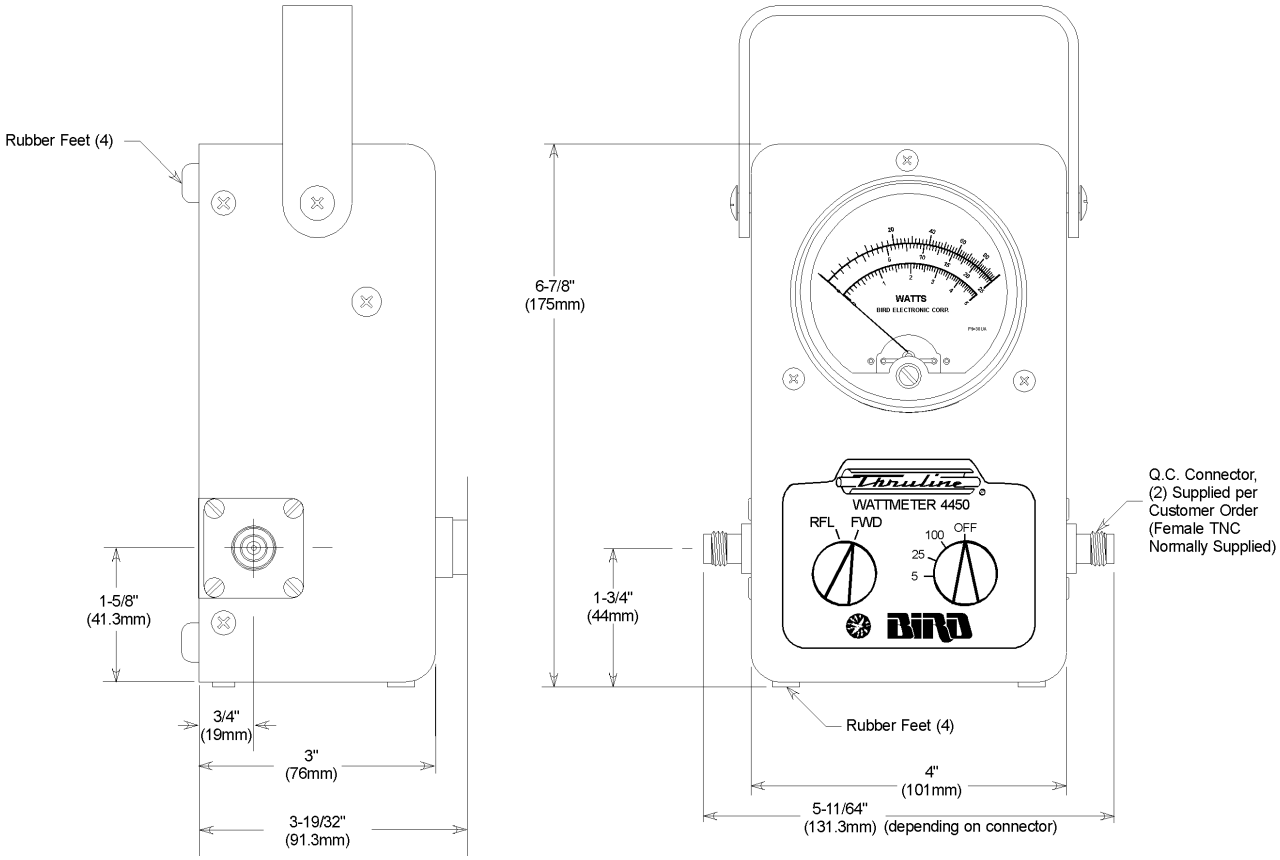
The Model 4450 Thruline Wattmeter has no batteries and requires no outside utility power source for operation other than the RF power to be measured. This makes the unit especially suited for mobile, marine, and field use.

Specifications

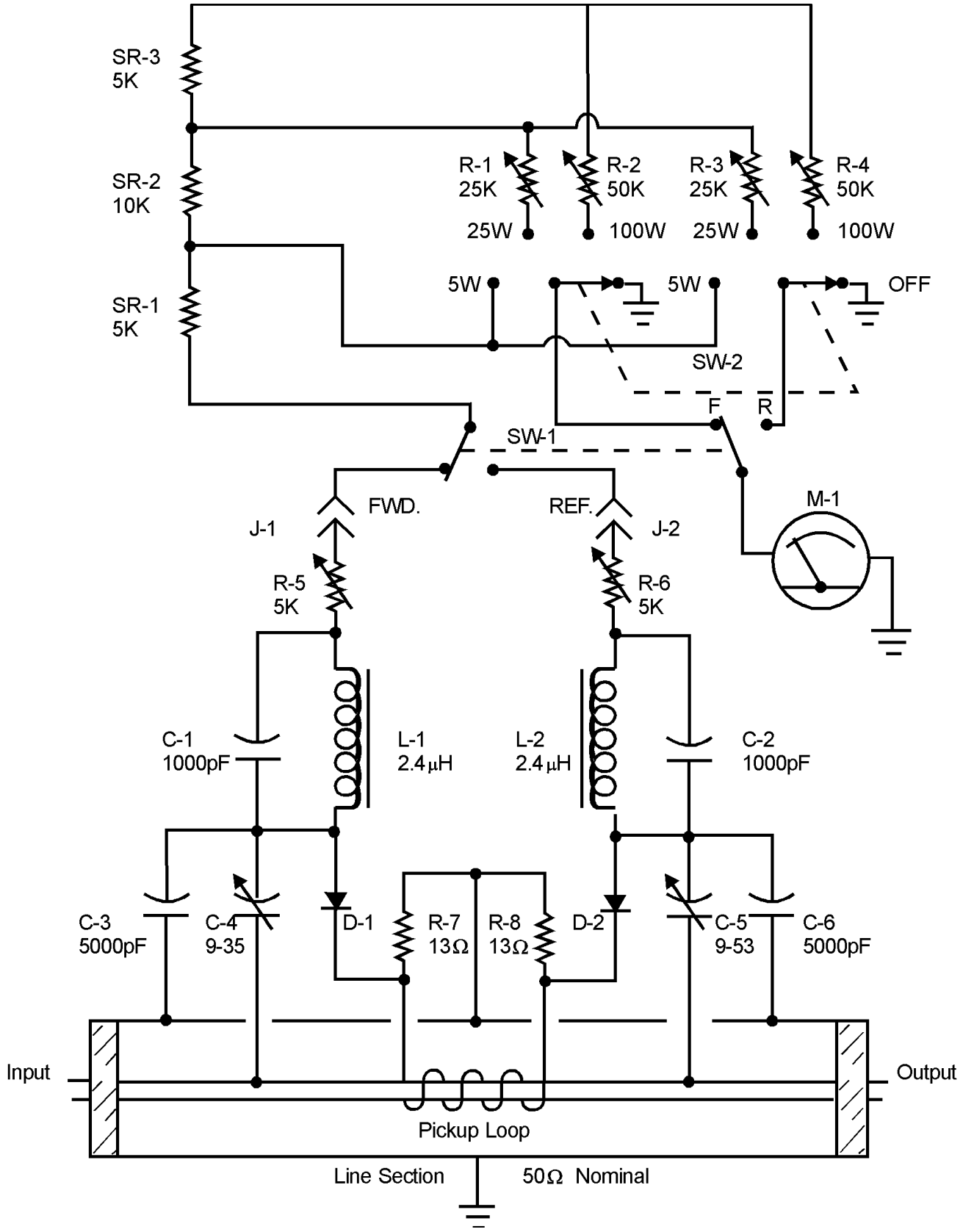
Impedance	50 ohms nominal
Power range	5/25/100 Watts
Insertion VSWR	1.10 maximum
Connectors	Bird QC type, Female N normally Supplied
Temperature Range	
Operating	+5°C to +45°C (41°F to 113°F)
Storage	-10°C to +45°C (14°F to 113°F)
Accuracy* (From 5°C to 45°C)	(Into a 50 ohm load)
30 to 535 kHz	⟨5% of full scale
20 kHz to 1 MH	⟨10% of full scale
Dimensions	3"D x $3\frac{53}{64}$"W x $6\frac{7}{8}$"H (76 x 97.2 x 175mm)
Insertion Loss	0.2 dB maximum
Directivity	25 db minimum
Weight	2lb (0.91 kg)

* On the 5 Watt range only the lower frequency is 30 kHz for 10% accuracy and the ambient temperature is limited to 15°C to 25°C for this accuracy.

Outline Drawing



Schematic Diagram



Theory Of Operation

Traveling Wave Concept

The operation of the Model 4450 Wattmeter is based on the traveling wave concept of RF transmission. As RF power is applied to a transmission line, there is a forward wave traveling from the transmitter to the load, and a reflected wave traveling from the load to the transmitter. The closer the load is matched to the line, the smaller the reflected wave will be. To determine the watts dissipated in the load it is necessary to determine the power of the forward wave and the power of the reflected wave. The difference between the two will indicate effective power dissipation.

Traveling Wave vs Standing Wave

The interference between forward and reflected waves produces a standing wave in the coaxial system. In the standing wave concept, VSWR (voltage standing wave ratio) is a widely used implement. There is a simple relationship between forward power, reflected power, and VSWR.

$$\text{Example: VSWR} = \frac{1 + \sqrt{\left(\frac{W_r}{W_f}\right)}}{1 - \sqrt{\left(\frac{W_r}{W_f}\right)}}$$

Where: Wf = forward power and Wr = reflected power.

Since there is a definite relationship between standing wave ratio and the forward-reflected power ratio, the forward and reflected powers may be read as indicated by the Thruline meter, and conveniently converted to VSWR. The charts furnished in this instruction book may be used for this purpose.

Coupling Circuit

When the wattmeter is connected into a coaxial system, the RF power is directed through the metered line section, which is a short section of 50 ohm air line. This line section will not impair the impedance of the RF coaxial line into which it is inserted.

The main line or center conductor of this line section passes through a toroid coil, which acts as a current transformer having a one turn primary. The secondary turns of this toroid coil vary and are determined by the power range involved.

The current induced in the secondary windings of the toroid coil are fed to a resistive network which produces voltages proportional to the line current.

There is also a capacitive divider network in the line that senses the line voltage. This network produces a voltage nearly equal to voltage produced by the resistive network.

When the mode switch is in the forward position, these voltages will add in phase. This voltage is rectified and is calibrated to give an indication on the microammeter equal to forward power in the line section.

Reflected Power Reading

A coupling circuit, identical to the forward power coupling circuit, is used for the reflected power reading. This circuit is positioned so that it will sense the power in the direction opposite to the forward direction. The meter will indicate this power when the mode switch is placed in the RFL position. The energy resulting from the inductively coupled component of the forward wave will bring about cancellation as described above.

When the mode switch is in the reflected (RFL) position these voltages will oppose and almost completely cancel each other when a good 50 ohm load termination is used. This resultant voltage

will be indicated on the microammeter as the power opposite to the forward power, or reflected power.

Installation

Portability

The Model 4450 THRULINE Wattmeter is a portable unit and the housing is not designed for fixed mounting. A leather strap handle is provided on the unit for carrying purposes. When transporting the Model 4450 turn the range switch to the OFF position. This will shunt the meter movement and effectively dampen the pointer action to protect it during handling or shipping.

C A U T I O N

Do not drop the THRULINE Wattmeter equipment or submit it to hard blows. The voltmeter circuitry or microammeter, even though it is shock mounted, may be damaged by severe impact.

Connections

W A R N I N G

Exposure to RF power radiation and the possibility of RF shock or burns exists with some operating conditions Always be sure to turn off transmitter when connecting or disconnecting wattmeter. Be sure transmission line is terminated into a load or antenna.

Insert the Model 4450 THRULINE Wattmeter in transmission lines of 50 ohms nominal impedance. Attachment is made through the connectors on either side of the wattmeter housing. A short length of 50 ohm coaxial transmission cable fitted with appropriate mating connectors should be used when installing the wattmeter. The input side of the wattmeter, labeled “INPUT”, must be connected to the transmitter output cable and the OUTPUT side of the wattmeter to a suitable dummy load or antenna.

The Model 4450 is normally supplied with two Female N connectors which are of the Bird Quick-Change design. These connectors may be readily and easily changed to other “QC” type connectors listed in the Replacement Parts List. These connectors are available from Bird Electronic Corporation and may be requested at time of order to facilitate connection to the user’s system.

These “QC” connectors are easily changed by removing the four 6-32 pan head machine screws from the corners of the connector flange and pulling the connector straight off. To install connectors, reverse the removal procedure making sure the center contact pin aligns properly with its mating socket.

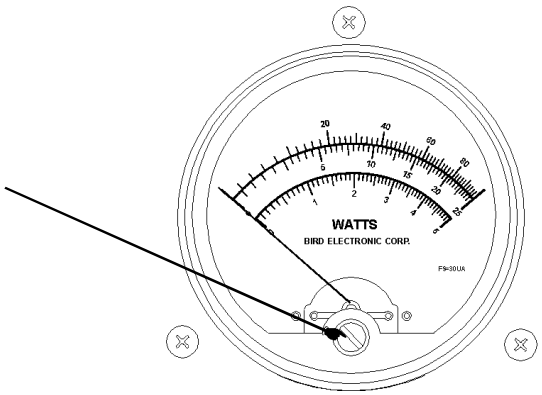
Operating Instructions

The apparent features of the Thruline equipment have been discussed in the preceding sections. As previously mentioned, no batteries or external power source is required to operate the wattmeter. A sufficient amount of power is taken from the RF transmission line to operate the unit. This power is negligible and does not affect the power output to a noticeable degree.

Preliminary Set-up

Before applying any RF power, make sure the meter pointer is exactly set on the ZERO mark of the scale. If adjustment is required, the pointer must be set on the ZERO mark under no-power conditions with the range switch set on one of the lower power ranges. Using a small screwdriver, turn the zero adjust screw on the bezel of the meter clockwise or counterclockwise as necessary until the pointer exactly aligns with the ZERO mark on the meter scale.

Figure 4-1
Zero Adjustment Screw



The range switch should be in the OFF position or at least on the 100 watt range, when power is applied. This is especially true when the amount of power being applied is unknown. After RF power is applied, the range switch may be turned to a position where a power indication is given in the upper one-third of the scale.

The mode switch should normally be in the FWD position and switched to the RFL position after a forward reading has been taken. In the RFL position a more accurate reflected power reading can be obtained by turning the range switch to a lower setting. However, with this condition care must be taken not to turn the mode switch back the the FWD position until the range switch has been returned to its original setting. Failure to do this will cause overranging of the meter and possible damage. This practice, of course, is not possible when power less than five watts is being measured.

Reverse Power Operation

The Model 4450 may be installed backward in the transmission line if necessary, i.e. transmitter output to wattmeter output and wattmeter input to load; however, the forward and reflected power indications will be reversed. Therefore when the mode switch is in the FWD position, reverse power will be indicated and the RFL position will indicate forward power. Since the line couplers and circuitry are similar, acceptable power indications are given with little, if any, change in accuracy. Reversing the unit in the transmission line should only be done when absolutely necessary since there is the potential danger of overranging the meter movement.

Load Power

Where an appreciable amount of power is reflected from a load, as with some antennas, it is necessary to subtract the reflected power reading from the forward power to obtain actual load power. RF power delivered to and dissipated in a load is given by the formula:

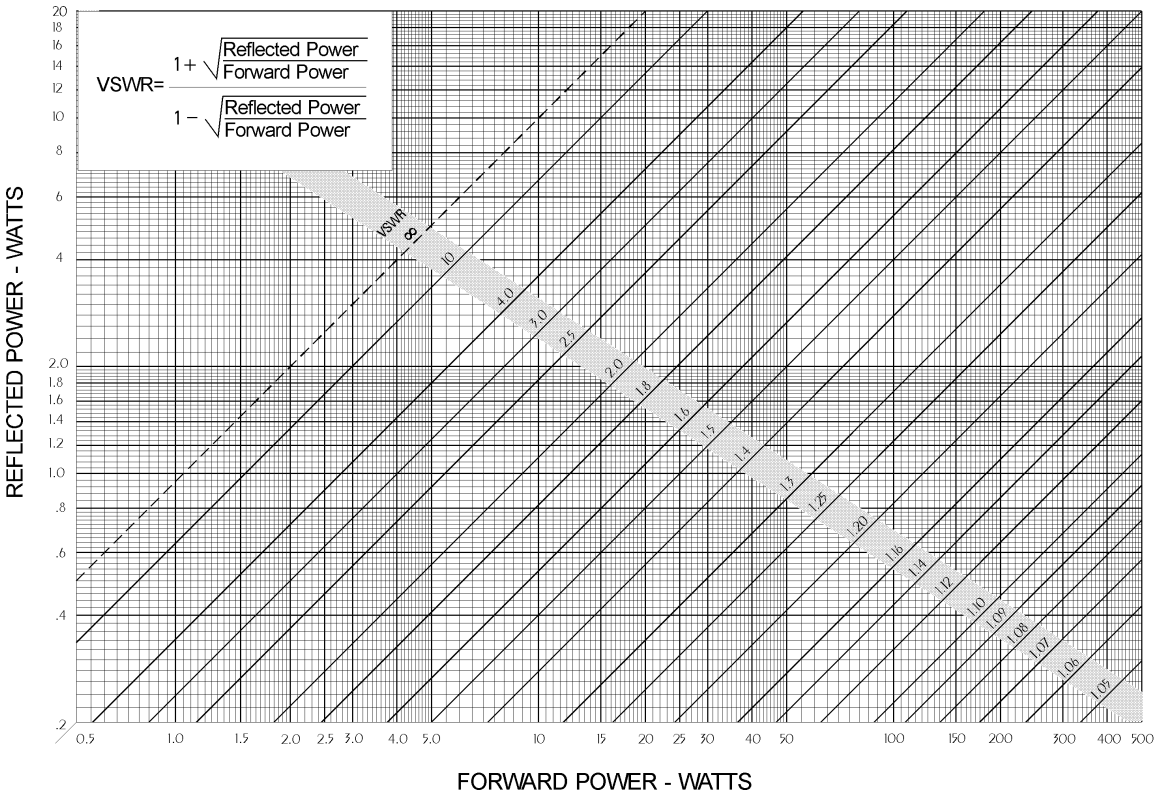
WL = watts into load = Wf - Wr

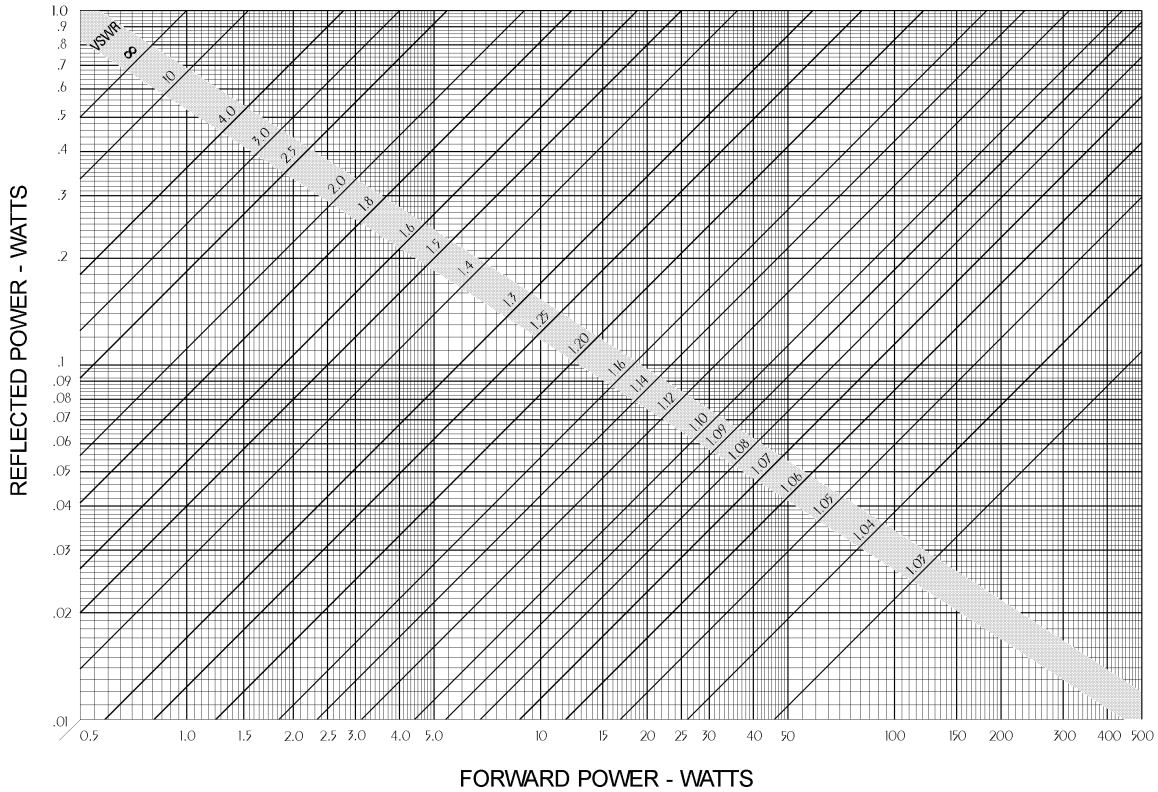
This correction is negligible (less than 1 percent) if the load is such as to have a VSWR of 1.2 to 1.0 or less. Good load resistors such as Bird TERMALINE Loads will give this negligible or unreadable reflected power.

VSWR Calculations

After obtaining the forward and reflected power readings described above, the VSWR may be found by calculation as described on page 2-1 Traveling wave vs. Standing wave. Conversion nomographs to simplify determining VSWR are provided below. Simply find the numbers on the horizontal and vertical axis of the nomograph which correspond to the actual forward and reverse power readings respectively. Follow the cross lines until they intersect, and read the VSWR from the nearest slanted line.

Figure 4-2 VSWR Conversion Monograph Power Values vs. VSWR





Maintenance

General

This chapter contains operator maintenance instructions, troubleshooting and parts information.

With the relatively simple circuitry, construction, and self-contained nature of the Model 4450 Thruline equipment, only a moderate amount of maintenance is required. The major precaution for the safekeeping and maintenance of the wattmeter is handling; use reasonable care and do not drop the unit.

Any maintenance or service procedure beyond the scope of those provided in this section should be referred to a qualified service center.

Sales / Repair Facilities

U.S.A. Sales and Manufacturing

Service Group
Bird Electronic Corporation
30303 Aurora Road
Cleveland (Solon), Ohio 44139-2794
Phone: (440) 248-1200 Cable: BIRDELEC
Fax: (440) 248-5426 Telex: 706898 Bird Elec UD

Sales Facilities

For the location of the sales office nearest you, give us a call or visit our Web site at:

http://www.bird-electronic.com

Preventive Maintenance

> W A R N I N G
> Provide adequate ventilation and observe normal precautions when using dry cleaning solvents. Many dry cleaning agents emit toxic fumes that may be harmful to your health if inhaled. Avoid excessive skin contact or inhalation of the fumes when using any dry cleaning solvent

If any of the contacts or line connectors become dirty, they should be cleaned with an aerosol type cleaner that leaves no residue, or any dry cleaning solvent on a soft cloth or cotton swab stick. Clean all contact surfaces and the exposed surface of the Teflon insulators.

The housing and meter glass can be cleaned with a soft cloth and a mild detergent solution.

> CAUTION
> Clean the meter glass only when necessary and be careful not to use an excessive amount of water/detergent solution that might drip inside the housing and damage the electrical components.

Troubleshooting

Table 5-1 contains troubleshooting information for problems which can occur during normal operation. Locate the problem, review the possible causes, and perform the action listed.

PROBLEM	CAUSE	AREAS TO CHECK / CORRECTION
No meter indication	No RF power	✔ Check transmitter or transmission line
		✔
	Open or short in dc circuit	✔ Check meter leads or circuit board and related components
	Defective meter	✔ Check meter
Intermittent or inconsistent meter readings	Faulty load	✔ Check dc resistance of load
	Faulty transmission line	✔ Check line for shorts, opens, bad connections or defective connectors
	Defective connection or cold solder joints	✔ Check circuit board and related parts for bad connections
	Sticky or defective meter	✔ Check meter and replace if necessary

Repair

Although the Model 4450 is designed to be rugged and provide years of trouble-free service, occasional repair or replacement may become necessary. This section contains repair and replacement procedures.

Repairs should not be attempted by the user for the first year warranty period as this may void the warranty.

If a problem should occur in the line section or coupling circuits, the unit should be returned to the factory for repair and recalibration.

Remove Back Cover

Follow the instructions below when removing the back cover is necessary for parts replacement or repair.

1. Withdraw four screws located on the back half of both sides.
2. Pull back cover straight off.

Circuit Board Repair or Replacement

1. Remove back cover.
2. Peel off the rubber feet located in the back half of the bottom section to gain access to flat head screws securing the line section mounting bracket.
3. Remove the two screws.
4. Pull the line section out of the back slightly and disconnect the three wires that connect to the circuit board.
5. Withdraw four pan head screws in each corner of connector flanges and pull QC connectors straight off.
6. Withdraw the four screws on the line section housing positioned near the top edge. Do not remove the screws that secure the mounting bracket to the housing. The circuit board will lift straight out of the housing with the center conductor attached.
7. Complete reassembly by reversing the procedure above. See note below.

☞ NOTE: When reassembling the circuit board and line section in the housing, position the circuit board so that the 5k calibrating potentiometers, R5 and R6, face away from the side of the housing on which the mounting bracket is attached. These controls must face outward for calibration purposes and also to maintain correct input and output configuration.

Calibration Board and Meter Removal

1. Remove the rear cover.
2. Unplug the ribbon cable connector from the calibration board.
3. Remove the two nuts that secure the calibration board to the terminals of the meter. The calibration board can now be taken out of the housing.
4. To remove the meter, unscrew the three Phillips head screws from the front face of the meter housing. The meter may now be pulled straight out of the housing. Notice the rubber shock ring on the front of the meter. It must be replaced when reassembling meter to case.

5. Reinstall the meter and calibration board by reversing the disassembly procedure. Do not tighten the meter mounting screws excessively.

Range and Mode Switch Replacement

1. Remove back cover.
2. Peel off the rubber feet located in the back half of the bottom section to gain access to flat head screws securing the line section mounting bracket.
3. Remove the two screws.
4. Pull the line section out of the back slightly and disconnect the three wires that connect to the circuit board.
5. Using a 5/64 Allen wrench, loosen the set screws in the switch knobs and remove the knobs.
6. Remove the nuts that secure the switches to the front panel with a 9/16 end wrench. Unplug the ribbon cable connector from the calibration board. The switch and cable harness assembly can now be removed from the meter housing assembly for repair or replacement. If only one switch is to be replaced, be sure to reattach the wires individually to the correct switch lugs as original.
7. To reinstall the switch assembly, simply reverse the disassembly procedure. When replacing the knobs, make sure the arrow of the knob points to the correct setting before tightening the set screws.

1	Line section assembly	4450-003
1	Mounting bracket	450-020
2	PC board mounting brackets	4450-019
1	30 uA meter	2080-063
2	Switch knobs	4110-016
1	Meter housing	4450-009
1	Carrying strap	8580-003
8	Bumper feet	5-875
1	Back cover assembly	4450-005
2	“QC” connectors	*See Below
1	PC board assembly (line section)	4450-015
1	PC board assembly (meter)	4450-014
2	RF choke (2.4 uH) (L1 & L2)	5-1546
1	Switch (2 pole, 2 position)	5-1361
1	Switch (2 pole, 4 position)	4450-026
2	N617 diodes (RCA SK3087) (D1 & D2)	5-1571
2	25 k potentiometers (R1 & R3)	5-1364-2
2	100 k potentiometers (R2 & R4)	5-1364-5
2	5k potentiometers (R5 & R6)	5-1572
2	13 ohm (R7 & R8)	5-581
1	1.8 k sensistor (SR1)	5-595-1
1	5 k sensistors (SR3)	5-595-7
1	10 k sensistor (SR2)	5-595-8
2	1000pF ceramic (C1 & C2)	5-1564-1
2	5000pF ceramic (C3 & C6)	5-1564-2
2	15-60pF variable (C4 & C5)	5-1570
1	Switch assembly (Includes both switches & wire harness)	4450-004

*Available “QC” Type Connectors

N-Female	4240-062	LT-Female	4240-018
N-Male	4240-063	LT-Male	4240-012
HN-Female	4240-268	C-Female	4240-100
HN-Male	4240-278	C-Male	4240-110
LC-Female	4240-031	UHF-Female (SO-239)	4240-050
LC-Male	4240-025	UHF-Male (PL-259)	4240-179
BNC-Female	4240-125	7/8" EIA Air Line	4240-002
BNC-Male	4240-132		

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