



RF DIRECTIONAL  
THRULINE® WATTMETER

MODEL 43 | 4B

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INSTRUCTION BOOK PART NUMBER 920-43 | 4B REV. F

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## Safety Precautions

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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.

**WARNING**

**Keep Away From Live Circuits**

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

**WARNING**

**Shock Hazard**

Do not attempt to remove the RF transmission line while RF power is present.

**WARNING**

**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.

**WARNING**

**Safety Earth Ground**

An uninterruptible earth safety ground must be supplied from the main power source to test instruments. Grounding one conductor of a two conductor power cable is not sufficient protection. Serious injury or death can occur if this grounding is not properly supplied.

**WARNING**

**Resuscitation**

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

**WARNING**

**Remove Power**

Observe general safety precautions. Do not open the instrument with the power on.

## Safety Symbols

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### 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.

**Note:** *Calls attention to supplemental information.*

## Warning Statements

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The following safety warnings appear in the text where there is danger to operating and maintenance personnel, 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 the transmitter when connecting or disconnecting a wattmeter.

Be sure the transmission line is terminated into a load or antenna.

When a Plug-In Element is removed from the RF line socket, the line section center conductor is exposed. Do not put fingers or other objects into the Plug-In Element socket while RF power is applied.

On pages 3 and 11.

### WARNING

Always be sure transmitter power is off before disconnecting the unit from the transmission line.

On page 20.

## Caution Statements

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

### CAUTION

Do not drop the ThruLine Wattmeter or its elements or subject them to hard blows. The microammeter is shock mounted in the wattmeter housing, but its delicate mechanism may be damaged by severe impact.

On page 3.

**CAUTION**

Severe damage to the Plug-In Element or wattmeter can result from exposure to excessive RF power. Make sure the Plug-In Element installed in the wattmeter has a sufficiently high wattage rating to handle the line load when it is first applied to the RF line.

On page 4.

**CAUTION**

Use reasonable care in handling. Do not drop or subject the wattmeter or elements to hard blows as accuracy may be impaired or other damage may result.

On pages 11 and 21.

**CAUTION**

Do not apply RF power to the wattmeter in excess of the full scale range of the element.

On page 11.

**CAUTION**

When making low reflection readings using a more sensitive element, take care to insert the element so that it senses reflected power only. Do not rotate the element in the socket so that it is subjected to forward power. This can result in damage to the Plug-In Element, the microammeter, or both.

On page 16.

**CAUTION**

If other than Female N type connectors are used, limit power and frequency to the capabilities of the RF coaxial cable or connectors used. Damage to connectors or errors in reading could result.

On page 26.

## **Safety Statements**

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### **USAGE**

ANY USE OF THIS INSTRUMENT IN A MANNER NOT SPECIFIED BY THE MANUFACTURER MAY IMPAIR THE INSTRUMENT'S SAFETY PROTECTION.

### **USO**

EL USO DE ESTE INSTRUMENTO DE MANERA NO ESPECIFICADA POR EL FABRICANTE, PUEDE ANULAR LA PROTECCIÓN DE SEGURIDAD DEL INSTRUMENTO.

### **BENUTZUNG**

WIRD DAS GERÄT AUF ANDERE WEISE VERWENDET ALS VOM HERSTELLER BESCHRIEBEN, KANN DIE GERÄTESICHERHEIT BEEINTRÄCHTIGT WERDEN.

### **UTILISATION**

TOUTE UTILISATION DE CET INSTRUMENT QUI N'EST PAS EXPLICITEMENT PRÉVUE PAR LE FABRICANT PEUT ENDOMMAGER LE DISPOSITIF DE PROTECTION DE L'INSTRUMENT.

### **IMPIEGO**

QUALORA QUESTO STRUMENTO VENISSE UTILIZZATO IN MODO DIVERSO DA COME SPECIFICATO DAL PRODUTTORE LA PROZIONE DI SICUREZZA POTREBBE VENIRNE COMPROMESSA.

## **SERVICE**

SERVICING INSTRUCTIONS ARE FOR USE BY SERVICE - TRAINED PERSONNEL ONLY. TO AVOID DANGEROUS ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING UNLESS QUALIFIED TO DO SO.

## **SERVICIO**

LAS INSTRUCCIONES DE SERVICIO SON PARA USO EXCLUSIVO DEL PERSONAL DE SERVICIO CAPACITADO. PARA EVITAR EL PELIGRO DE DESCARGAS ELÉCTRICAS, NO REALICE NINGÚN SERVICIO A MENOS QUE ESTÉ CAPACITADO PARA HACERLO.

## **WARTUNG**

ANWEISUNGEN FÜR DIE WARTUNG DES GERÄTES GELTEN NUR FÜR GESCHULTES FACHPERSONAL.

ZUR VERMEIDUNG GEFÄHRLICHE, ELEKTRISCHE SCHOCKS, SIND WARTUNGSARBEITEN AUSSCHLIEßLICH VON QUALIFIZIERTEM SERVICEPERSONAL DURCHZUFÜHREN.

## **ENTRETIEN**

L'EMPLOI DES INSTRUCTIONS D'ENTRETIEN DOIT ÊTRE RÉSERVÉ AU PERSONNEL FORMÉ AUX OPÉRATIONS D'ENTRETIEN. POUR PRÉVENIR UN CHOC ÉLECTRIQUE DANGEREUX, NE PAS EFFECTUER D'ENTRETIEN SI L'ON N'A PAS ÉTÉ QUALIFIÉ POUR CE FAIRE.

## **ASSISTENZA TECNICA**

LE ISTRUZIONI RELATIVE ALL'ASSISTENZA SONO PREVISTE ESCLUSIVAMENTE PER IL PERSONALE OPPORTUNAMENTE ADDESTRATO. PER EVITARE PERICOLOSE SCOSSE ELETTRICHE NON EFFETTUARE ALCUNA RIPARAZIONE A MENO CHE QUALIFICATI A FARLA.

**RF VOLTAGE MAY BE PRESENT IN RF ELEMENT SOCKET - KEEP ELEMENT IN SOCKET DURING OPERATION.**

**DE LA TENSION H.F. PEAT ÊTRE PRÉSENTE DANS LA PRISE DE L'ÉLÉMENT H.F. - CONSERVER L'ÉLÉMENT DANS LA PRISE LORS DE L'EMPLOI.**

**HF-SPANNUNG KANN IN DER HF-ELEMENT-BUCHSE ANSTEHEN - ELEMENT WÄHREND DES BETRIEBS EINGESTÖPSELT LASSEN.**

**PUEDA HABER VOLTAJE RF EN EL ENCHUFE DEL ELEMENTO RF - MANTENGA EL ELEMENTO EN EL ENCHUFE DURANTE LA OPERACION.**

**IL PORTAELEMENTO RF PUÒ PRESENTARE VOLTAGGIO RF - TENERE L'ELEMENTO NELLA PRESA DURANTE IL FUNZIONAMENTO.**



## About This Manual

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This manual covers the operating and maintenance instructions for the following models:

4314B

## Changes to this Manual

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We have made every effort to ensure this manual is accurate. If you discover any errors, or if you have suggestions for improving this manual, please send your comments to our Solon, Ohio factory. This manual may be periodically updated. When inquiring about updates to this manual refer to the part number and revision on the title page.

## Literature Contents

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### Chapter Layout

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**Introduction** - Describes the features of the Thruline wattmeter, lists equipment supplied and optional equipment.

**Installation** - Describes how set up the Thruline wattmeter.

**Operating Instructions** - Describes procedures required for operating the wattmeter.

**Maintenance** - Lists routine maintenance tasks as well as troubleshooting for common problems. Specifications and parts information are also included.



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## **Purpose and Function**

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The Model 4314B Thru-line Wattmeter is an insertion-type RF wattmeter designed to measure power flow and load match in 50 ohm coaxial transmission lines. It is intended for use on CW, AM, FM, SSB, TV, and pulse signals only.

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## **Description**

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The Model 4314B Thru-line Wattmeter is a portable unit contained in a die cast aluminum housing. The unit is equipped with a plastic strap for carrying, four rubber shock feet on the base, and four rubber bumpers on the back which allow the unit to stand vertical or lie flat in a horizontal position when used. For additional protection, the microammeter is specially shock mounted. A slotted screw is provided on the lower front face of the meter for zeroing the pointer.

The RF line section face below the meter protrudes slightly from the wattmeter housing with the Plug-In Element socket in the center. The circuit module is mounted on the line section inside the housing. It has an attached phosphor bronze spring contact finger, which protrudes through a lateral hole and into the Plug-In Element socket on the RF line section. The finger has a button on its end which makes connection with the contacts of the Plug-in Element. The silver-plated brass RF line section is precision made to provide the best possible impedance match to the coaxial RF transmission line in which the wattmeter is inserted. At each end of the line section are Bird Quick-Change type RF connectors, which may be quickly interchanged with any other Bird "QC" connectors.

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## **Performance Characteristics and Capabilities**

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To make measurements, insert a Plug-In Element into the line section socket and rotate it to either stop. Point the element arrow in the source to load direction of power flow and the meter will display a reading of forward power. Rotate the element so that the arrow is pointed in the opposite direction to obtain a reflected power reading. With known values of forward and reflected power the load match can now be determined by calculating the VSWR or by using the graphs supplied in this manual (Figure 5 on page 14 and Figure 6 on page 15).

Setting the front panel toggle switch to peak mode gives the wattmeter the capability of indicating peak pulse or envelope power.

## **Power Requirements**

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The Model 4314B can operate from two different power sources. The wattmeter comes supplied with two 9 V alkaline batteries which typically provide 20 hours of operation. An AC wall supply is also available for use with either a 115 or 230 VAC line.

## **Additional Equipment**

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The only additional equipment required by the Model 4314B is a Plug-In Element (see table below). Most of them are designed to read both average and peak power. Some are designed exclusively for peak reading application.

## Portability

The Model 4314B is a portable instrument; the housing is not designed for fixed mounting. A strap is provided for carrying purposes.

### CAUTION

Do not drop the ThruLine Wattmeter or its elements or subject them to hard blows. The microammeter is shock mounted in the wattmeter housing, but its delicate mechanism may be damaged by severe impact.

When transporting the ThruLine Wattmeter, it is best to insert the original dust plug, or a Plug-In Element with the arrow pointed down, in the measuring socket, and secure it with the catch. This will shunt the meter circuit and serve to protect it by dampening the pointer action during handling or shipping. Also, set the wattmeter controls to ON and CW modes. In this position, any unnecessary battery drain will be avoided. Handle the Plug-In Elements with care at all times as their calibration could be disturbed if they are dropped.

### 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 the transmitter when connecting or disconnecting a wattmeter.

Be sure the transmission line is terminated into a load or antenna.

When a Plug-In Element is removed from the RF line socket, the line section center conductor is exposed. Do not put fingers or other objects into the Plug-In Element socket while RF power is applied.

## Connections

The Model 4314B Wattmeter is normally supplied with two Female N type connectors which are of the Bird Quick-Change "QC" design. Other "QC" connectors are available as listed in the Replacement Parts. See "Replacement Parts" on page 31.

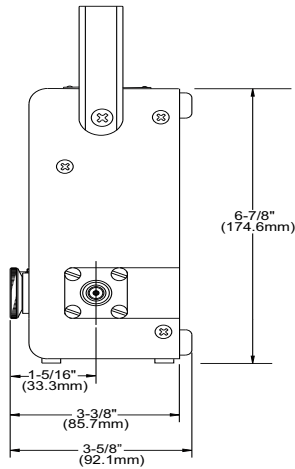
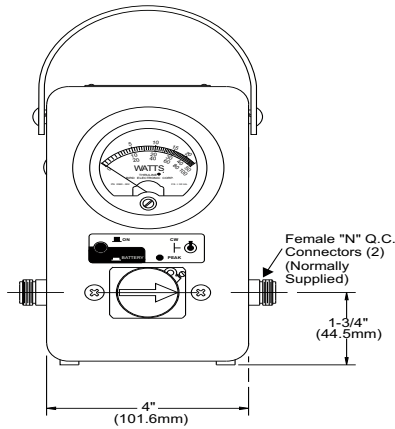
1. Insert the Model 4314B ThruLine Wattmeter in coaxial transmission lines of 50 ohms nominal impedance.

**Note:** *The signal source and load connections can be made to either side of the wattmeter with no difference in effect. Use a coaxial transmission line fitted with suitable matching RF connectors. If cables of other than 50 ohms impedance are used, a mismatch will occur which could cause serious inaccuracies in the readings.*

**CAUTION**

Severe damage to the Plug-In Element or wattmeter can result from exposure to excessive RF power. Make sure the Plug-In Element installed in the wattmeter has a sufficiently high wattage rating to handle the line load when it is first applied to the RF line.

**Figure 1 Model 4314B Outline Drawing**





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## Traveling Wave Viewpoint

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The operation of this wattmeter is based on the travelling wave concept of RF transmission. As RF power is applied to a transmission line, there is a forward wave travelling from the transmitter to the load, and a reflected wave travelling from the load to the transmitter. The closer the load is matched to the transmission line, the smaller the reflected wave will be. To determine the amount of power dissipated in a load resistor, it is necessary to determine the wattage of the forward wave and the wattage of the reflected wave. The difference between the two indicates load power.

VSWR (Voltage Standing Wave Ratio) has become a widely used tool in the traveling wave concept. The standing waves which are produced by transmission line mismatch cannot be read directly. However, the VSWR can be easily determined by the use of the VSWR Conversion Nomographs (Figure 5 on page 14 and Figure 6 on page 15), without requiring the use of unwieldy and expensive slotted line equipment. Many users find that the ratio of is more useful than VSWR.

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## Coupling Circuit

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When the wattmeter is connected into the system, the RF power is directed through the unit's line section. The air line is a short, uniform section which does not impair the impedance of the RF coaxial line into which it is inserted. When the Plug-In Element is installed in the socket of the line section, the RF waves travelling through the line produce energy in the coupling circuit of the Plug-In Element by both inductance and capacitance (Figure 2 on page 7). The inductive currents will flow according to the direction of the travelling waves producing them. Therefore, assuming that the Plug-In Element remains stationary, the coupling currents produced from the waves of one direction add in phase, while those produced from the waves of the opposite direction subtract in phase. The additive or "arrow" direction is assigned to the forward wave. The element is designed so that the wave components travelling in the opposite direction of the arrow will nearly cancel each other out, making the element highly insensitive to the reverse wave direction. Because of the highly directional characteristics of the element, the resultant direct current sensed by the microammeter indicates the power level of only the RF waves travelling in the arrow direction.

The Plug-In Element is designed so that it can be rotated 180 degrees in its socket in the line section. When it is rotated, the meter indicates the power in a direction opposite that of the initial reading. If the forward direction power is read first, the reflected direction power will be read after the Plug-In Element is rotated. The energy resulting from the inductively coupled component of the forward wave will bring about cancellation as described above.

## Peak Power Operation

---

The Model 4314B is designed to measure peak power in addition to average power. When the toggle switch is placed in peak mode, battery power energizes the amplifier system. If the AC adapter is being used, it energizes relay (K1) and disengages the batteries (Figure 3 on page 8).

The battery test circuit is energized when the push button of switch S2 is depressed. If the voltages of the two 9 V batteries are within the limits necessary to properly operate

the amplifier circuit, the pointer of the meter deflects beyond the battery test mark on the meter scale. If the pointer fails to reach the mark, the batteries need replaced. Replacement of both batteries simultaneously will assure that sufficient battery power will be available for extended periods of time (see "Maintenance" on page 21).

The amplifier circuit is designed to provide current to the meter which indicates at a steady state the peak of the power applied to resistor R5. Resistor R5 exactly matches the resistance of meter M so that the existing circuit in the Plug-In Element is loaded exactly the same as during the average reading mode (Figure 2 on page 7).

When switch S1 is pressed, the DC input which is normally applied to the meter is interrupted and is applied instead to resistor R5 and differential amplifier Q1. This results in a current gain ratio of approximately 100:1. This output is applied to a resistance bridge consisting of resistors R6, R7, R8, R9, and R10. Variable resistor R8 of this bridge permits zero calibration of the amplifier circuit. Bridge output is applied to differential amplifier U1 which provides a voltage gain of about 1000:1. This ratio represents the surge of voltage from the amplifier which charges capacitor C3 and indicates the minimum pulse duration. Capacitor C3 applies a potential to differential amplifiers Q2 and Q3 as long as the capacitor remains charged. These amplifiers provide a massive current gain ratio, but unity or slightly less voltage gain. This is applied to meter M to indicate the peak power in the line. A portion of the DC output of amplifiers Q2 and Q3 is fed back to resistor R4 and to amplifier Q1. Resistor R4 is matched to resistor R5 to provide unity gain to the amplifier. This feedback circuit maintains the output from Q1 and U1 to keep capacitor C3 charged to that value which yields unity closed loop gain.

The capacitor continues to energize Q2 and Q3, to maintain the reading of the meter even though the peak of the pulse is no longer applied to the amplifier assembly input. Only the peak power is indicated even though there is a wide fluctuation of input power.

Because of capacitor leakage, diode back resistance, and transistor input current, there will be a decay in the circuit that limits the time the amplifier system will retain its output level. As the circuit decays, the meter will return to zero if no additional pulses are received at resistor R5.

**Figure 2 Schematic Diagram - Element**

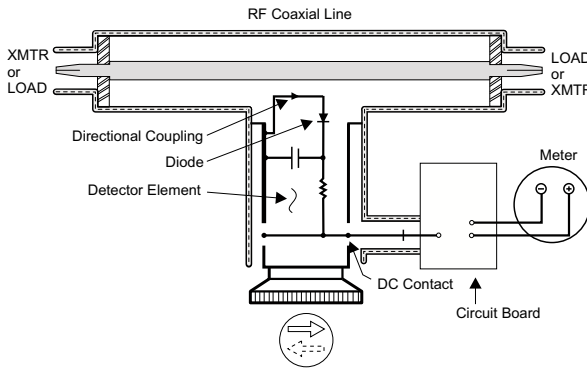
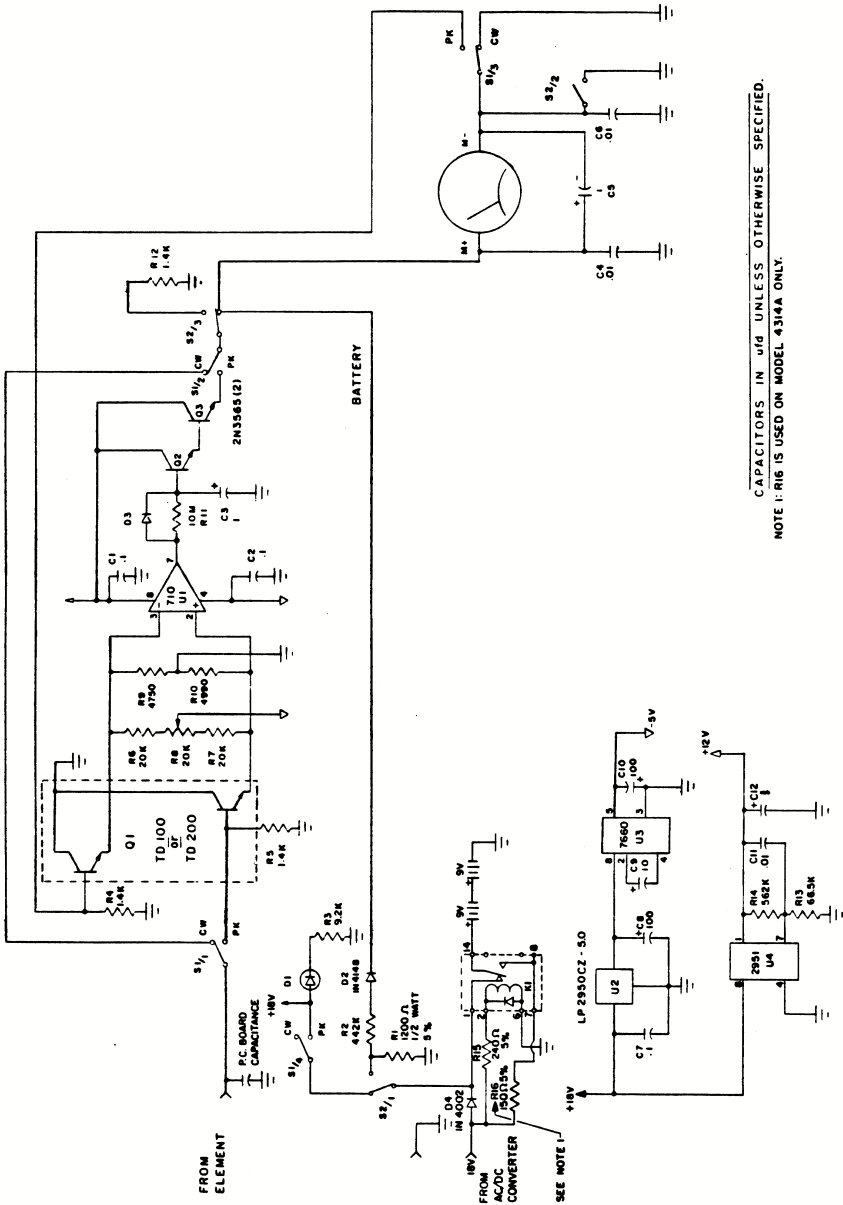


Figure 3 Model 4314B Schematic Diagram

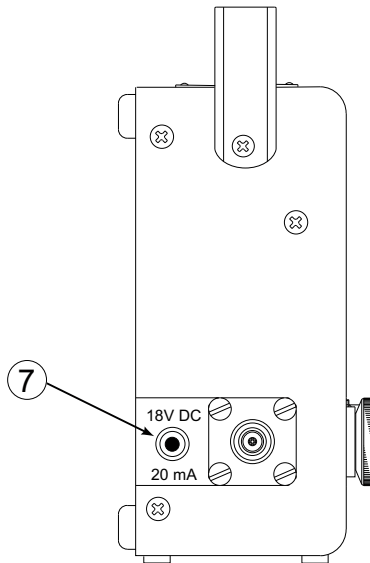
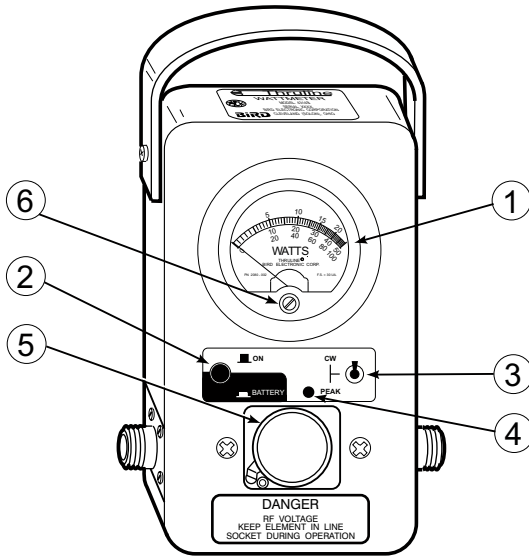


CAPACITORS IN μF UNLESS OTHERWISE SPECIFIED.  
NOTE 1: R16 IS USED ON MODEL 4314A ONLY.

# Component Description

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Figure 4 Component Diagram





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**Zero Adjust Meter**

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Before taking any readings with the wattmeter, it is necessary to zero the meter under no-power conditions.

**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 the transmitter when connecting or disconnecting a wattmeter.

Be sure the transmission line is terminated into a load or antenna. When a Plug-In Element is removed from the RF line socket, the line section center conductor is exposed. Do not put fingers or other objects into the Plug-In Element socket while RF power is applied.

**CAUTION**

Use reasonable care in handling. Do not drop or subject the wattmeter or elements to hard blows as accuracy may be impaired or other damage may result.

**CAUTION**

Do not apply RF power to the wattmeter in excess of the full scale range of the element.

1. Rotate Plug-In Element so that the arrow points down.
2. Set wattmeter's controls to ON and CW modes.
3. Using a small screwdriver, turn the meter's zero adjust screw clockwise or counterclockwise so that the meterpointer aligns with the zero mark on the meter scale.

## Plug-In Element Selection and Insertion

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The elements determine the power range to be read on the meter scale. The major markings (50 W, 100 W, etc.) are the full scale power value for that element. Elements are also marked for frequency range. The transmitter frequency must be within the band of the element used.

- RF power measurements are made with the insertion of a Plug-In Element. Insert the element into the line section's receptacle.
- Forward power is indicated when the arrow on the element points in the direction of power flow; from transmitter to load. Reflected power measurements are made with the element rotated 180 and the arrow pointing towards the transmitter.

**Note:** *The element must be rotated fully when power measurements are being made.*

The index pin protruding from the element's body should rest against the stop on the line section in both the forward and reflected position. The small catch in the lower left hand corner of the casting face should press down on the shoulder of the Plug-In Element. This will keep the Plug-In Element in proper alignment and insure good contact with the dc pickup, the lower edge of the element and the line section body.

## Measurements

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### CW Power Measurements

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1. Set the wattmeter controls to the ON and CW modes
2. Read the appropriate meter scale corresponding to the element full-scale value.

### Peak Power Measurements

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1. Set the ON/BATTERY switch to the BATTERY mode.

**Note:** *If the pointer of the meter indicates below the battery test zone, the batteries must be replaced. See "Replacing the Batteries" on page 24.*

2. Set CW/PEAK switch to PEAK mode.
3. Read the appropriate meter scale corresponding to the element full-scale value.



## Load power

---

Where an appreciable amount of power is reflected, as with an antenna, it is necessary to subtract the reflected from the forward power to obtain the effective load power. Power delivered to and radiated by an antenna is given by:

$$W_1 = W_f - W_r$$

Where:  $W_1$  = load power

$W_f$  = ForwardPower

$W_r$  = ReflectedPower

A load closely matched to 50 ohms resulting in a VSWR of 1.2 or less, will require less than a one percent correction. A good RF load resistor, such as a Bird Termaline Load Resistor, will produce this sort of negligible or unreadable reflected power.

The Model 4314B ThruLine Wattmeter used with a Bird Termaline Load Resistor of proper power rating forms a highly useful absorption wattmeter. Since the reflected power will be negligible, it will be unnecessary to rotate the element from the forward direction.

## Determining VSWR

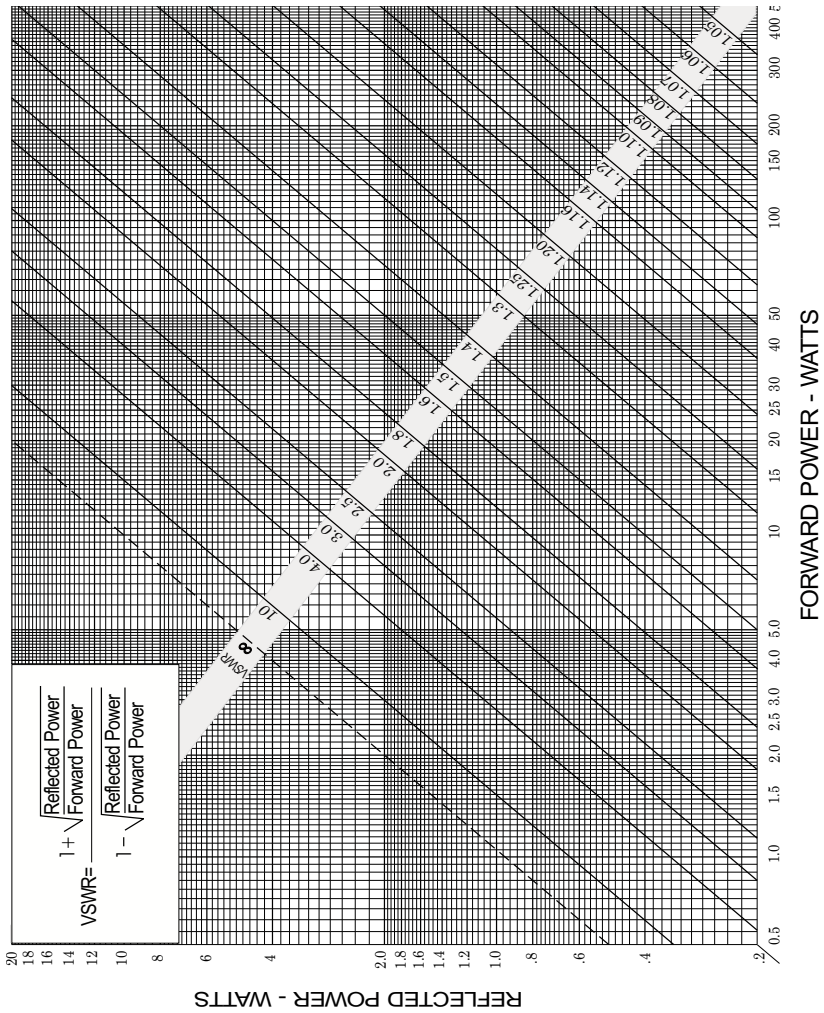
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The Model 4314B ThruLine Wattmeter is not designed to provide direct VSWR readings. In most cases, operators find that the ratio of forward to reflected power is of equal use. However, VSWR readings can be determined very easily by the use of the provided graphs as follows:

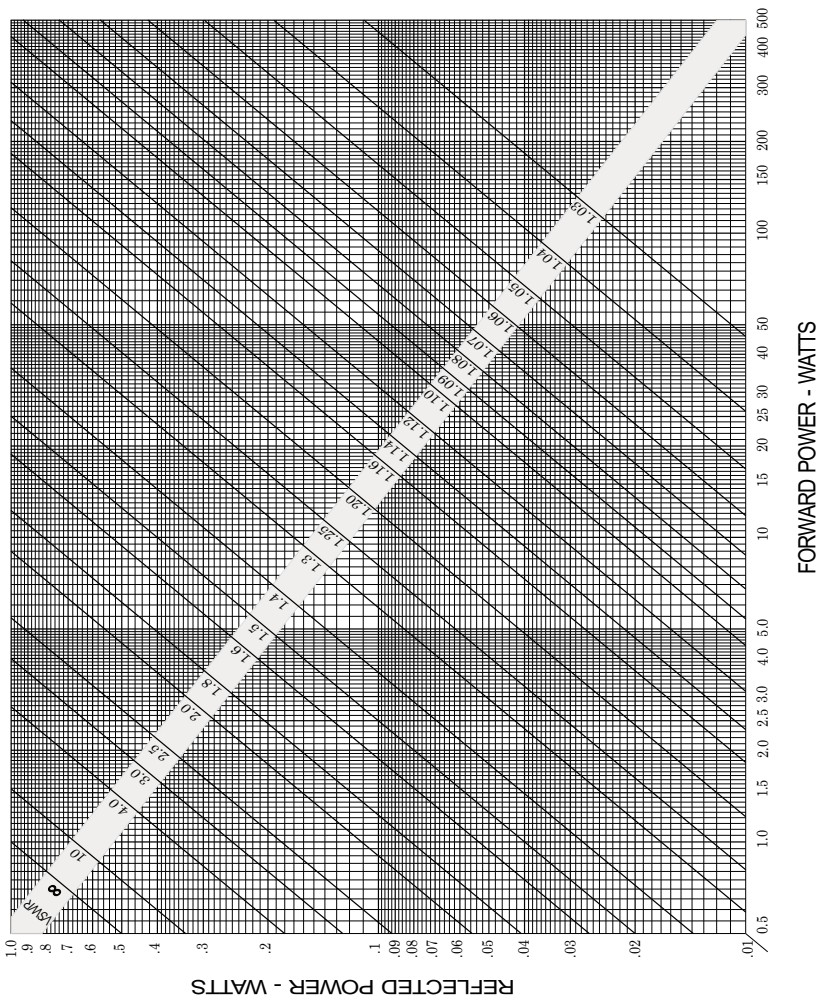
1. Determine the forward and reflected power as described above.
2. Using the appropriate VSWR Conversion Nomograph, determine the intersection of the forward and reflected power values.

**Note:** *The slanted line passing closest to this point indicates the VSWR.*

**Figure 5 VSWR Conversion Nomograph**



**Figure 6 VSWR Conversion Nomograph**



## Making Low Reflection Readings

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It is sometimes desirable to make more accurate low reflection readings. This can be done using a more sensitive element, provided that care is taken to prevent application of high forward power to the low-power element. This procedure is limited to use with higher power transmitters only.

1. Measure watts forward, using the proper Plug-In Element.
2. Reverse the arrow direction of the element to determine the general level of reflected power.
3. Remove the Plug-In Element.
4. Insert a lower power element which has a maximum rating of more than the reflected power indicated in the first measurement.
5. Insert the element, carefully, so that it reads reflected power only.

### CAUTION

When making low reflection readings using a more sensitive element, take care to insert the element so that it senses reflected power only. Do not rotate the element in the socket so that it is subjected to forward power. This can result in damage to the Plug-In Element, the microammeter, or both.

6. Read the reflected power on the meter in the usual manner.

**Note:** *When using the two-element method of reading low reflected power, it is not recommended using a pair of elements which has a full scale power differential of greater than 10 to 1.*

## Testing Lines, Connectors, Filters & Related Components

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Lines, connectors, filters, and related components can be tested using the Thru-line Wattmeter. The method of testing depends upon the circumstances involved for any particular test. Some of these tests are listed below:

The standing wave ratio or the reflected-power to forward-power ratio of a line can be determined by terminating the line with a good load resistor, such as a Bird Terminal Load Resistor. Proceed as described under determining VSWR. Low reflected power may be measured as described above.

Line attenuation (power lost as heat in the line) can be determined by inserting the line of unknown value between two Thru-line Wattmeters. The end of the line must be terminated by a load resistor. The attenuation of the line can be determined by comparing readings made at the two ends. Allowances must be made for normal instrument error where very small values of attenuation are involved. Some correction may be made by direct rigid connection of the Thru-line Wattmeters.

## Attenuation By Open Or Short Circuit

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Attenuation can also be determined by the open circuit method. The test set exhibits good equality between forward and reflected readings when the load connector is open or short circuited. When this is checked on an open circuit and an open-circuited length of line of unknown attenuation is connected to the load connector, the ratio shown is the attenuation in two passes along the line (down and back).

To convert the reading to decibels, divide it in half or double the line length because twice the line length is being measured (down and back). This measurement must be supplemented with a reflected power to forward power ratio check or with a dc continuity check or leakage check, since open circuits or shorts may exist part of the way along the line.

Attenuation can also be determined as described above by using a short circuit rather than an open circuit. The open circuit method is preferred because the initial equality (forward power to reflected power) is more easily achieved in an open circuit.

## Measuring Percentage Of Positive Modulation

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To measure the percentage of positive modulation in an amplitude modulation system, employ the average and peak reading characteristics of the unit since:

$$\text{PercentagePosMod} = \frac{E_{MAX} - E_{CARRIER}}{E_{CARRIER}} \times 100$$

By substitution we get:

$$\text{PercentagePosMod} = \left( \frac{\sqrt{P_P} - \sqrt{P_C}}{\sqrt{P_C}} \right) \times 100$$

Where:  $P_P$  = peak power as read with CW/PEAK switch in PEAK mode.  
 $P_C$  = carrier power as read with CW/PEAK switch in CW mode

Or:

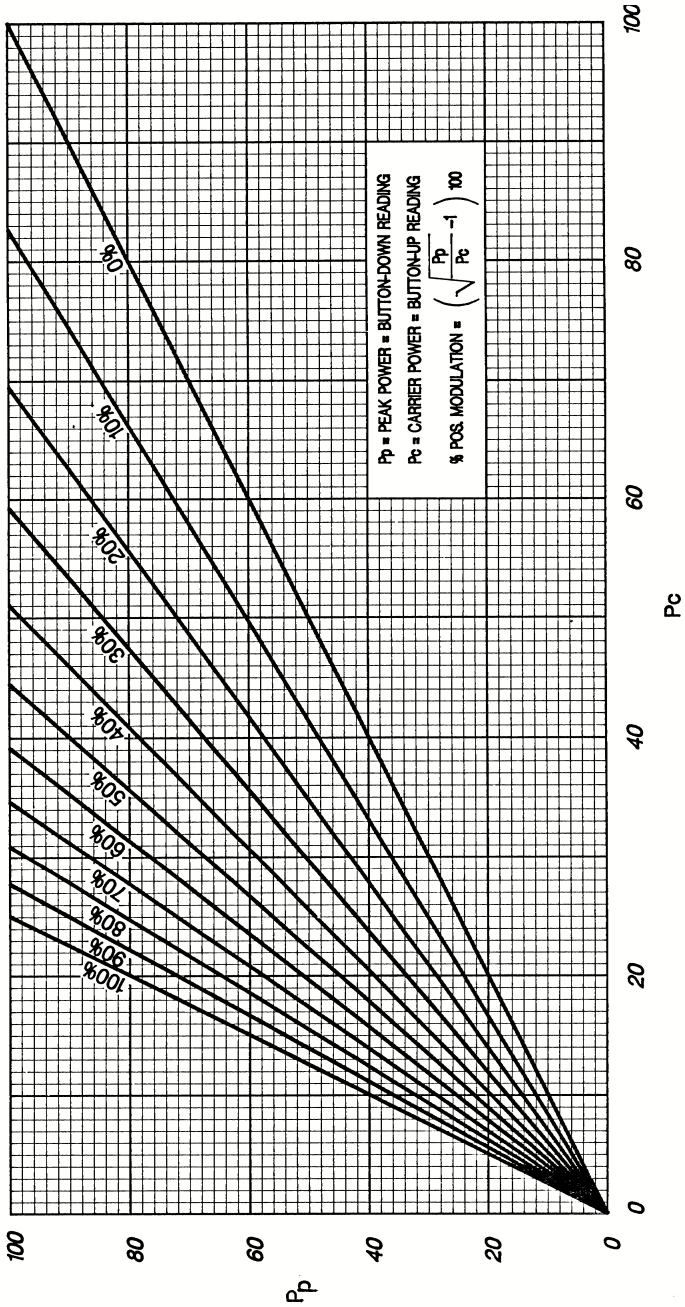
$$\text{PercentagePosMod} = \left( \frac{\sqrt{P_P}}{\sqrt{P_C}} - \frac{\sqrt{P_C}}{\sqrt{P_C}} \right) \times 100$$

And by cancellation:

$$\text{PercentagePosMod} = \left( \frac{\sqrt{P_P}}{\sqrt{P_C}} - 1 \right) \times 100$$

After determining average and peak readings, find the intersection of the carrier and peak powers on figure 7 to determine the percentage of positive modulation.

Figure 7 Graph Converting Carrier Power and Peak Power to Percent



## Performance Notes

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Although the Model 4314B ThruLine Wattmeter is equipped with Quick-Change connectors, it must be remembered that the power rating and insertion loss may be affected if other than “N” type connectors are used. Power limits must be governed by the type of connector or transmission line used. For other types of Quick-Change connectors, see Chapter 5 for the replacement parts list.

When a Model 4314B is used to match a load to a transmitter and a good match is obtained, removing the instrument will not cause any change in the conditions. A well matched 50 ohm load can be placed at the end of a 50 ohm transmission line of any length without altering conditions at the transmitter.

When the load is not well matched, like an antenna with a VSWR of 1.5 or 2.0, line length becomes critical since the length of line between a mismatched load and the source transforms the impedance of the load as seen at the source. If the adjustments for maximum power transfer were made with the Model 4314B in place, removing it shortens the line by four inches plus two connectors. This still is no cause for concern at low frequencies where four to five inches is a small fraction of a wavelength. At higher frequencies; e.g., above 100 MHz, the power output and frequency of the source may be affected.

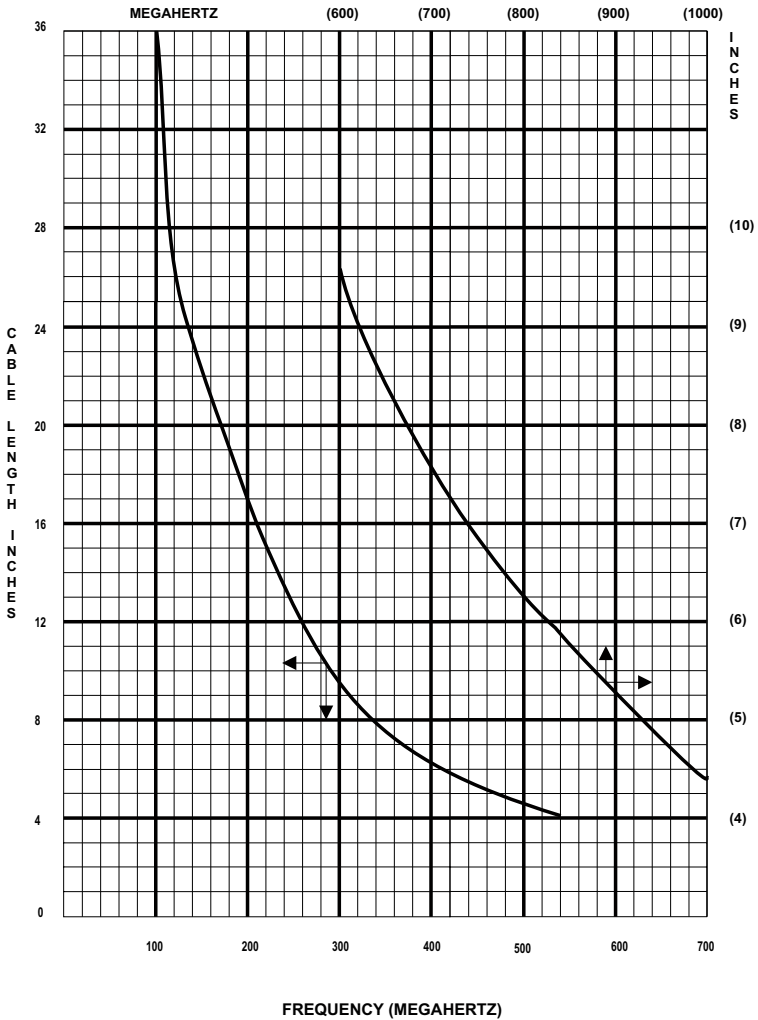
To insure that the impedance is identical on either side of  $\frac{1}{2}$  wavelength in your transmission line with the Model 4314B either in or out of the line, it is only necessary to insert or remove a  $\frac{1}{2}$  wavelength.

Make up a length of cable which, when added to the ThruLine Wattmeter, equals  $\frac{1}{2}$  wavelength at the frequency of measurement. If more than one frequency is involved, then a separate cable is needed for each frequency. Use figure 8 to determine the cable length required.

**Note:** *When using UHF Plug PL-259, the cable length is measured from tip to tip of center pin of plugs.*

**Note:** *When using other connectors, the cable length is measured from the ends of the outer conductor of the connectors.*

**Figure 8 Cable Wavelength Matching Graph**



## Shutdown

When all measurements are completed, be sure to set the CW/Peak switch to CW mode and the ON/BATTERY switch to the ON position. Leaving the unit in other switch positions will shorten battery life.

### WARNING

Always be sure transmitter power is off before disconnecting the unit from the transmission line.



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**Cleaning**

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If any of the contacts or line connectors become dirty, they should be cleaned with a good contact cleaner or dry cleaning solvent on a cotton swab stick.

It is important to keep the following surfaces clean:

- Socket bore
- Element body circumference
- Bottom rim of the socket in the line section
- DC contacts on the element

Take care not to disturb the spring finger of the DC contact when cleaning the socket bore. The spring finger can be manually adjusted. The button must be pushed out far enough to make good contact with the element body but it must not restrict the entry of the element.

Clean the meter and meter housing using a cloth moistened with a mild detergent solution. Do this only when necessary and take care not to allow water to enter any of its circuitry as damage may result.

**CAUTION**

Use reasonable care in handling. Do not drop or subject the wattmeter or elements to hard blows as accuracy may be impaired or other damage could result.

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**Preventative Maintenance**

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Care and maintenance required for the 4314B Thruline Wattmeter is primarily limited to cleaning. Keeping the Plug-In Element in the socket of the line section as much as possible serves as an effective seal against the entry of dust and dirt and to prevent damage to the meter. An aluminum dust plug may be used to cover the socket opening when the element is removed.

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**Line Section Care**

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The RF connectors on the line section should also be protected against the entry of dust and dirt by keeping them covered when the wattmeter is disconnected from the RF line.

If there is evidence of contamination inside the line section, the reachable portions should be cleaned and the interior carefully blown out.

Do not attempt to remove the RF center conductor under any circumstances. Any attempt to do so will damage the assembly.

## Inspection

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Periodic inspections should be performed at six-month intervals.

- Inspect the meter for a cracked meter glass.
- Inspect wattmeter line section for a damaged or missing latch and pivot pin assembly.
- Inspect all “QC” connectors for bent, broken, or missing pins.

## Troubleshooting

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Due to its complexity, field repair of the Model 4314B ThruLine Wattmeter is recommended only for certain malfunctions. Only those functions within the scope of normal maintenance are listed.

If a malfunction is not listed or not corrected by the listed corrective actions, notify a qualified service center for further instructions.

<b>PROBLEM</b>	<b>POSSIBLE CAUSE</b>	<b>CORRECTION</b>
No meter indication (CW or PEAK).	No radio frequency	Turn on transmitter.
	Faulty RF section assembly.	Check transmitter operational conditions, refer to operating instruction manual of equipment used..
		Check connections, interconnecting cables, and auxiliary in-line equipment.
	Arrow on element pointing in wrong direction	Rotate element so that arrow points in direction of RF power flow.
	Meter burned out or damaged	Replace meter. See “Replacing the Meter” on page 25.
	No pick-up from dc contact	Clean line section and element. See “Cleaning” on page 21.
	Defective Plug-In Element	Check element. Replace element if defective..

<b>PROBLEM</b>	<b>POSSIBLE CAUSE</b>	<b>CORRECTION</b>
No meter indication (PEAK only).	Faulty instrumentation module	Replace the input connector, see "Replacing the Meter" on page 25.
	Dead or low battery	Test battery. See "Battery Procedures" on page 24. Replace if necessary. See "Replacing the Batteries" on page 24.
		If pointer does not move from zero during the battery test, remove the batteries and measure their voltage. If less than 6.25 volts, replace the batteries. See "Replacing the Batteries" on page 24.
Erroneous or inaccurate	Low battery	Press ON/BATTERY selector switch to the BATTERY position. If the battery test indicates weak batteries, replace them with new ones. See "Replacing the Batteries" on page 24.
	Shorted or opened cable	Check connections, in-line equipment, interconnecting cables, and auxiliary in-line equipment.
	Wattmeter out of calibration	Check calibration. See "Calibrating the Wattmeter" on page 28.
Intermittent or inconsistent	Faulty transmission line, line connections, antenna, or load conditions	Inspect and correct meter operation or load.
	Dirty line section, DC contact, and/or element	Clean line section and element. See "Cleaning" on page 21.
	Sticky meter	Replace meter. See "Replacing the Meter" on page 25
High VSWR or high percentage reflected power	Bad load or poor load, antenna, or connectors.	Replace connectors. See "Replacing the Instrumentation Module" on page 26.
	Shorted or open transmission line.	Replace transmission line.
	Foreign material in line section or in RF connector bodies.	Check for foreign material and clean as required. See "Replacing the Meter" on page 25.

# Battery Procedures

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## Testing the Batteries

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The Model 4314B ThruLine Wattmeter uses two 9 V alkaline batteries to supply power for the peak circuitry.

1. Set the ON/BATTERY switch to the BATTERY position.

**Note:** *The meter pointer should travel to the right of the “BAT.TEST” mark.*

2. If the pointer stops below the mark, replace the batteries.

## Replacing the Batteries

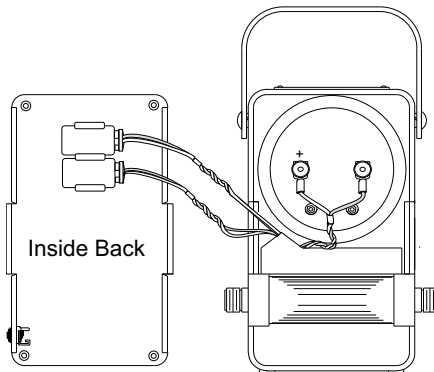
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1. Remove the back cover by unscrewing the four 8-32 Phillips flat head screws.

**Note:** *The screws are located two on each side of the meter housing near the back edge at the top and bottom of the sides.*

2. Pull the cover straight off.
3. Rotate the battery in its clip, then pull upward freeing the battery.
4. Remove the snap-on battery connector.
5. Insert the battery into the clip and replace.
6. Repeat above procedure for the other battery.

**Figure 9** *Replacing the Batteries*



## Replacing the Meter

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1. Remove the back cover by unscrewing the four 8-32 Phillips flat head screws.

**Note:** *The screws are located two on each side of the meter housing near the back edge at the top and bottom of the sides.*

2. Loosen the two 8-32 nuts securing the meter leads
3. Remove the meter leads.
4. Remove the two 10-32 oval head Phillips screws securing the meter shock ring.
5. Pull the meter and shock ring assembly out of the housing from the back.

**Note:** *If the three rubber shock mount buttons, P/N 4420-098, that the meter rests on are to be reused, be careful not to lose them. However, if the replacement shock ring, P/N 4410A261, is to be used instead, the buttons may be discarded.*

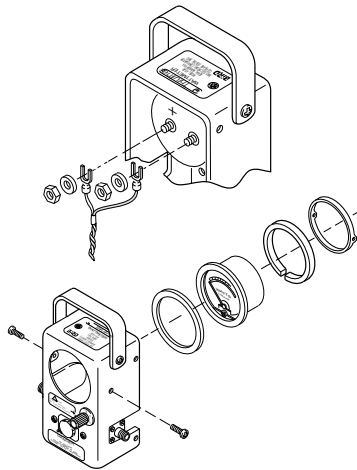
6. Remove the meter retaining ring and shock mount from the meter.
7. Replace the meter.

**Note:** *If the replacement shock ring is used, peel off the white strip covering the adhesive backing. Carefully adhere the shock ring to the front bezel flange.*

**Note:** *Be sure to observe the polarity when replacing the leads to the meter, black to negative, red to positive.*

8. Zero adjust the meter.

**Figure 10** Replacing the Meter



## Replacing the Instrumentation Module

---

1. Remove the back as above in meter replacement.

**Note:** *The instrumentation module contains the line section and circuit board chassis as an integral part.*

2. Loosen the dress nut on the CW/PEAK switch.

**Note:** *Care should be taken not to scratch the label.*

3. Remove the wire assemblies from the batteries, meter, and DC jack.

4. Remove the battery wires (item 4) first at the printed circuit board by pulling up on the slip-on connector.

5. Remove the DC jack wires (item 5).

6. Remove the meter wires (item 3) also at the printed circuit board.

**Note:** *Care should be taken not to break the wires. \*

**Note:** *Note the wire location for ease of reassembly.*

7. Remove the two oval head Phillips screws located on the front face of the unit on either side of the line section element port.

8. Pull the instrumentation module straight out from the back of the unit.

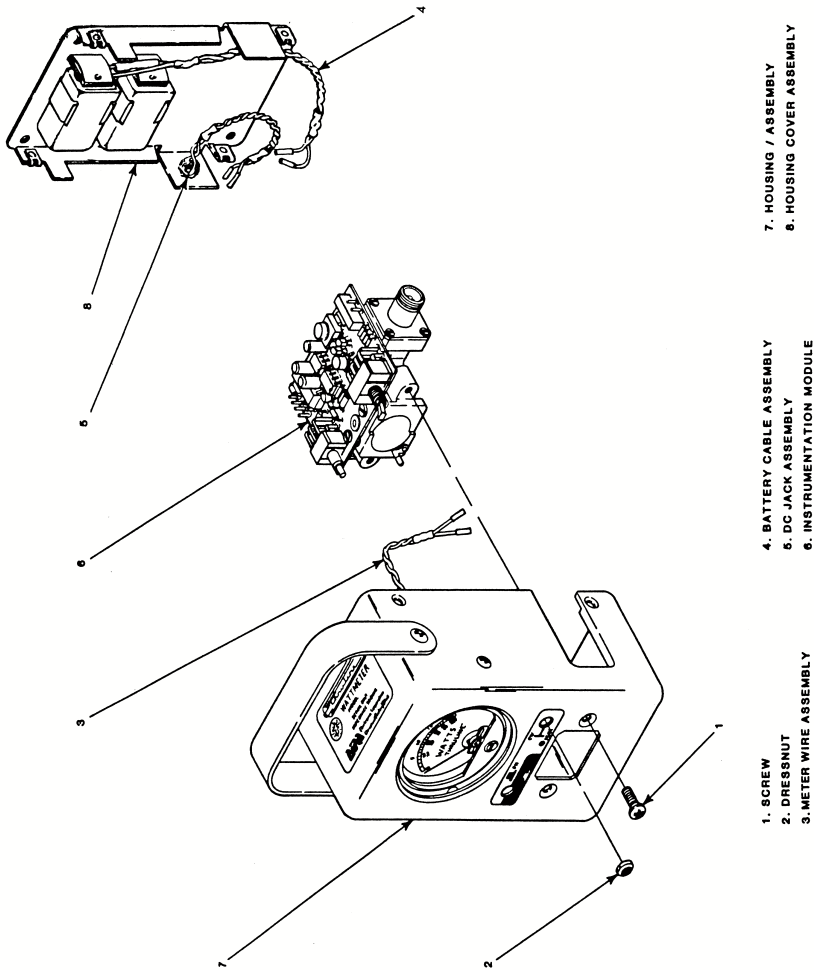
9. Replace the connector.

10. Zero adjust the meter.

### CAUTION

If other than Female N type connectors are used, limit power and frequency to the capabilities of the RF coaxial cable or connectors used. Damage to connectors or errors in reading could result.

**Figure 11 Replacing the Instrumentation Module**



## **Replacing the Quick-Change Connectors**

1. Remove the four 8-32 screws from each corner of the square flange on the connector.
2. Pulling the connector straight outward.
3. Install the new connector by reversing this procedure.

## Calibrating the Wattmeter

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Zero adjustment of the meter is the only calibration required for the 4314B. This should be done any time the meter pointer is not exactly aligned with the zero mark on the meter scale when no power is being applied. Zero adjustment must also be performed after the meter or instrumentation module has been replaced.

1. To assure that the meter reads correctly for both average and peak operation,
2. Apply direct current from a battery source to the input of the amplifier circuit (figures 5 and 6, pages 20-21).

The steady direct-current peak level should be the same as the average current level because no peaks exist in this current.

Apply a direct current and adjust as necessary so that the same reading is attained in both average and peak modes.

Install a voltage-dropping variable voltage dividing potentiometer and a battery in series with the input of the amplifier.

Make sure the resistor is set for zero output. Connect the positive (+) side of the circuit to input and the negative (-) side to ground.

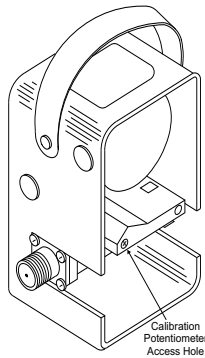
Install a voltmeter across the circuit. Slowly operate the potentiometer to adjust output to apply approximately 21 millivolts. Use a suitable resistive network.

Check the reading of the meter.

The pointer should deviate or travel about half of full scale. Set the CW/PEAK switch to PEAK mode while watching the meter pointer. There should be no deviation of the pointer from average to peak reading.

If the pointer reads a different value for peak reading than for average reading, adjust potentiometer R8 until the two readings coincide.

**Figure 12 Calibration Potentiometer**





## Customer Service

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

If you need to return the unit for any reason, request an RMA through the Bird Technologies website (link shown below). All instruments returned must be shipped prepaid and to the attention of the RMA number.

### **Bird Service Center**

30303 Aurora Road  
Cleveland (Solon), Ohio 44139-2794  
Fax: (440) 248-5426  
E-mail: [bsc@bird-technologies.com](mailto:bsc@bird-technologies.com)

For the location of the Sales Office nearest you, visit our website at:

<http://www.bird-technologies.com>

## Specifications

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<b>Impedance</b>	50 ohms nominal
<b>Insertion VSWR</b> With "N" Connectors	1.05 Max. to 1000 MHz, 1.1 Max. to 2300 MHz
<b>Connectors</b>	Bird Quick Change "QC" Female N normally supplied*
<b>RF Power Ranges</b> Average (CW) Mode Peak-pulse or envelope-power mode	100 mW to 10 kilowatts ( 5% of full scale) 100 mW to 10 kilowatts ( 8% of full scale)
<b>Frequency Range</b>	0.45 to 2700 MHz (either mode)
<b>Pulse Parameters</b> Minimum duty factor Minimum repetition rate Minimum pulse width	1.0 x 10 <sup>-4</sup> 30 pps 0.4 microseconds at 100-2300 MHz 1.5 microseconds at 26-99 MHz 15 microseconds at 2-25 MHz
<b>Weight</b>	3 lb. (1.4 kg)
<b>Dimensions</b>	3-5/8"L x 4"W x 7"H (92.1 x 102 x 178 mm)
<b>AC Power Requirements</b> (using adapter)*	115 Vac, 10%, 60 Hz 220 Vac, 10%, 50Hz
<b>Batteries</b>	Two 9 V alkaline
<b>Battery Life</b>	20 hours of operation, typically

\*. Use only adapter supplied by Bird Electronic Corporation

## Replacement Parts

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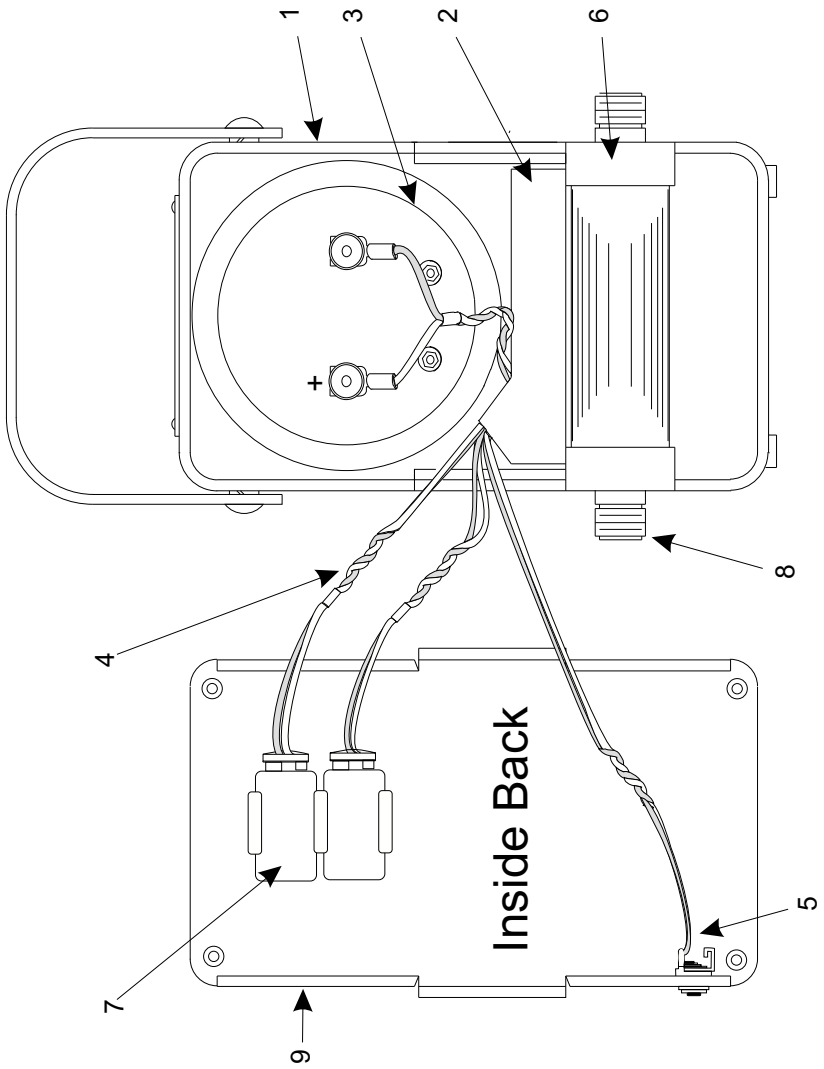
Item	Quantity	Description	Part Number
1	1	Housing assembly	4314-103
2	1	Instrumentation module	4314-202
3	1	Meter	2080-044
4	1	Battery cable assembly	4314-116
5	1	DC jack wire assembly	4314-117
6	1	Meter wire assembly	4314-119
7	2	9 V battery	5-1375
8	2	"QC" connectors	(Female N normally supplied)*
9	1	Housing cover assembly	4314-114
10	1	Dress nu	5-1670
11	1	AC to DC converter (wall supply) with interchangeable AC blades 115/230 VAC	5A1864

### \*Available QC Type Connectors

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

**Figure 13 Replacement Parts**



## LIMITED WARRANTY

All products manufactured by Seller are warranted to be free from defects in material and workmanship for a period of one year, unless otherwise specified, from date of shipment and to conform to applicable specifications, drawings, blueprints and/or samples. Seller's sole obligation under these warranties shall be to issue credit, repair or replace any item or part thereof which is proved to be other than as warranted; no allowance shall be made for any labor charges of Buyer for replacement of parts, adjustment or repairs, or any other work, unless such charges are authorized in advance by Seller.

If Seller's products are claimed to be defective in material or workmanship or not to conform to specifications, drawings, blueprints and/or samples, Seller shall, upon prompt notice thereof, either examine the products where they are located or issue shipping instructions for return to Seller (transportation-charges prepaid by Buyer). In the event any of our products are proved to be other than as warranted, transportation costs (cheapest way) to and from Seller's plant, will be borne by Seller and reimbursement or credit will be made for amounts so expended by Buyer. Every such claim for breach of these warranties shall be deemed to be waived by Buyer unless made in writing within ten days from the date of discovery of the defect.

The above warranties shall not extend to any products or parts thereof which have been subjected to any misuse or neglect, damaged by accident, rendered defective by reason of improper installation or by the performance of repairs or alterations outside of our plant, and shall not apply to any goods or parts thereof furnished by Buyer or acquired from others at Buyer's request and/or to Buyer's specifications. Routine (regularly required) calibration is not covered under this limited warranty. In addition, Seller's warranties do not extend to the failure of tubes, transistors, fuses and batteries, or to other equipment and parts manufactured by others except to the extent of the original manufacturer's warranty to Seller.

The obligations under the foregoing warranties are limited to the precise terms thereof. These warranties provide exclusive remedies, expressly in lieu of all other remedies including claims for special or consequential damages. SELLER NEITHER MAKES NOR ASSUMES ANY OTHER WARRANTY WHATSOEVER, WHETHER EXPRESS, STATUTORY, OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS, AND NO PERSON IS AUTHORIZED TO ASSUME FOR SELLER ANY OBLIGATION OR LIABILITY NOT STRICTLY IN ACCORDANCE WITH THE FOREGOING.

