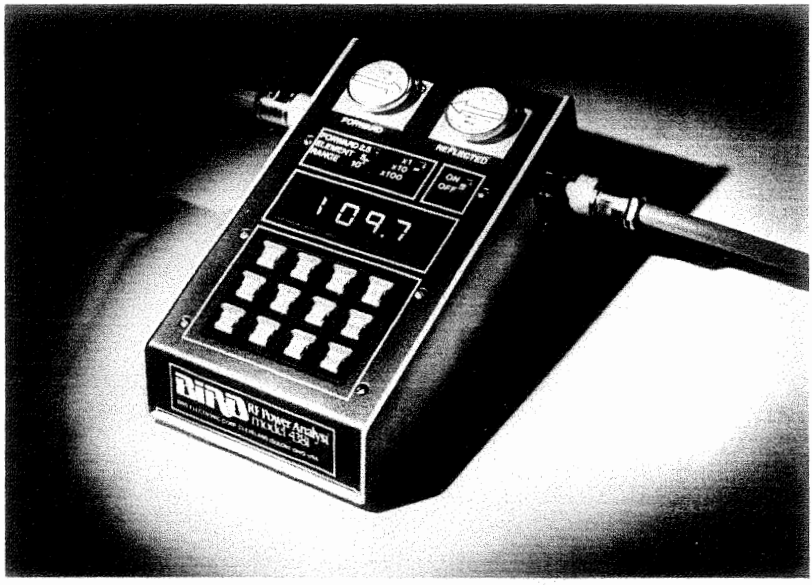
INSTRUCTION BOOK

RF Power Analyst®
Series 4380

multi-purpose Thruline® Wattmeter



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Preface

This publication not only covers the operation of the portable model 4381, but also non-portable models that are similar in operation.

Similarities, differences and installation instructions of the models 4382 thru 4388 are found in Difference Data Sheets in the back of this manual.

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INTRODUCTION

GENERAL

The Model 4381 is a multi-purpose Radio Frequency wattmeter designed around a microcomputer. A fairly extensive program stored in permanent memory controls the operation of the instrument at all times, permitting the detection and correction of various error sources and the refinement of the raw data produced by the directional detectors. Thus the instrument can compute VSWR, amplitude modulation, and various decibel variables reducing the odds of error and making such measurements consistent or repeatable regardless of who is making the measurement.

Other benefits include extended range using standard elements in some modes of operation, continuous monitoring of maximum and minimum readings, a peaking aid, and error messages.

Because of its complexity, the proper use of the 4381 is not always obvious. For this reason it is strongly advised that this manual be read in its entirety before using the device.

PURPOSE AND FUNCTION

The 4381 RF Power Analyst® is an insertion type digital RF Directional THRULINE® Wattmeter designed to measure peak or average power flow, load match, and amplitude modulation in 50 ohm coaxial transmission lines. It is intended for use with CW, AM, FM, and SSB modulation envelopes but not in narrow pulse modes. The instrument directly reads PEP or CW power in watts, milliwatts, or kilowatts in 9 ranges from 2.5 to 1000 full scale forward power or 0.25 to 100 full scale reflected power depending on the Plug-in Element. In addition it reads SWR directly over the range of 1.00 to 99.99, percent modulation directly over the range of .0 to 99.9, and return loss over the range of 0 to 36.1dB. For convenience, forward and reflected CW power can be displayed in dBm (dB above 1 milliwatt) from 6dB above to 24dB below nominal element range.

Power range and frequency band are determined by the Plug-in Elements used. Two slide switches on the front panel of the instrument are set by the user to correspond to the nominal power range of the forward element. The reflected element is assumed to have a nominal range one tenth that of the forward element. See Appendix A for setting of power ranges of panel mount units.

In any of the modes of operation described, the instrument can recall from memory the lowest or highest reading taken or tell the operator whether the newest reading is less than, equal to, or greater than the previous reading.

DESCRIPTION

The Model 4381 is housed in an aluminum calculator style case approximately 3" high by 8-1/2" deep by 6-1/4" wide (76mm x 216mm x 159mm) including connectors. See Figure 1. The line section is contained in the case and is not intended for removal. At each end of the line section are Bird Quick-Change type RF connectors which may be easily interchanged with any other Bird QC connector. See Section 5, Parts List for types available. For other Series 4380 Models see figures 1.2 and 1.3.

POWER REQUIREMENTS

Operating power for the Models 4381, 4382, 4383 and 4384 is derived from rechargeable nickel-cadmium cells inside the portable unit or from an ac operated charger-adapter which attaches to the unit via a 6 foot (1.8 meter) cord. All panel mount units (Models 4385, 4386, 4387 and 4388) are ac operated only. A voltage selector slide switch, for 115 or 230Volt operation is located on the back panel of the units.

SPECIFICATIONS

Specifications for the Power Analyst are given in Table 1. Refer to Figure 1.1, 1.2, or 1.3 for outline dimensions.

Table 1. Specifications.

Power Range[1]	
Model 4381/83/85/87	100mW to 10kW full scale
4382/84/86/88	250W to 250kW full scale
Usable Over-Range	To 120% of full scale on CW, PEP, SWR and return loss functions. To 400% of scale (PEP) on dBm and % modulation.
Frequency Range[1]	
Model 4381/83/85/87	450KHz to 2.3GHz
4382/84/86/88	2MHz to 1000 MHz
Sampling Rate	2-3 readings per second
Accuracies	
Power Readings	±5% of full scale
SWR	±10% of reading
% Modulation[2]	±5%
Return Loss	±0.3dB to corresponding SWR value (accuracy not guaranteed with components not supplied by Bird)
Modulation Frequency[3]	50-10, 000Hz
Impedance	50 ohms
Weight	
Model 4381	4.0 lbs. (1.8kg)
4382/83/84	2-1/4 lbs. (1.0kg)
Dimensions (Panel mount)	
Model 4385	19" x 6-21/32" (48.3 x 165mm)
4386/87/88	19" x 5-7/32" (483 x 133mm)
Power Requirements	
Battery - Models 4381/82/83/84	(Rechargeable Ni-Cad) Approx. 8 hours per charge
ac (Using. adapter/charger)	115V, 50-60Hz 6W or 230V, 50-60Hz 6W
ac (panel units)	115V, 50-60Hz 8W or 230V, 50-60Hz 8W switchable.

[1]Frequency band and power range is determined by Plug-in Element selected. See Bird Catalog for availability. Some modes require two elements in a 10:1 power ratio.

[2]For CW power levels greater than one third of full scale, accuracy of the % modulation mode is ±5% from 0 to 90% and +10% from 90 to 100%.

[3]For pulse modulation the minimum parameters are: 50 microseconds pulse width, 100 pps repetition rate and 1% duty cycle.

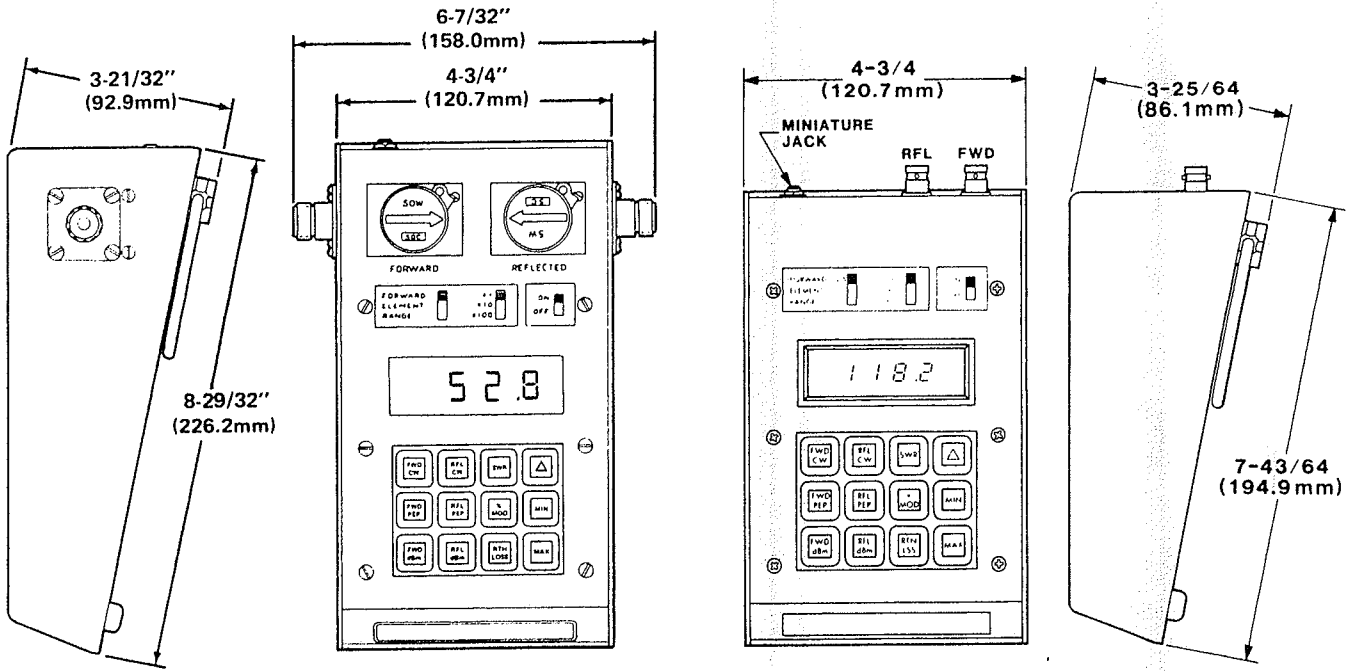


Figure 1. Configuration and Size.

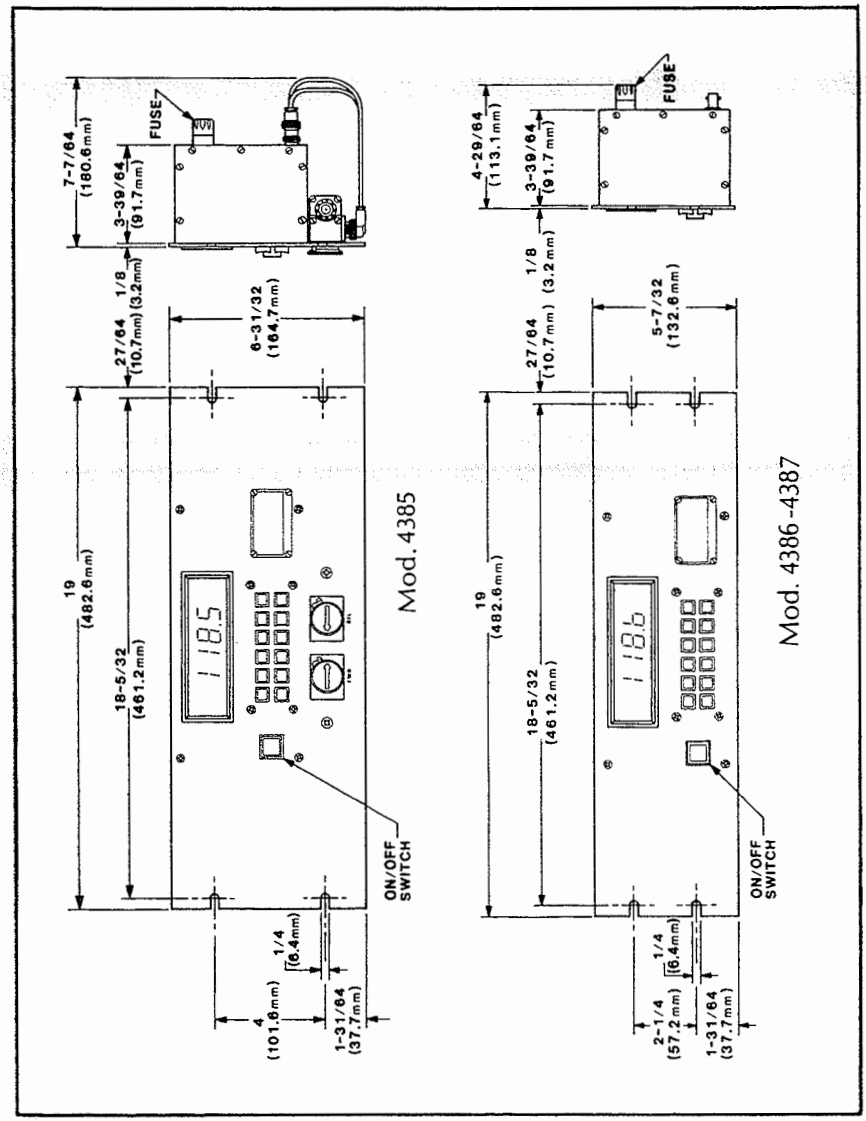


Figure 1.1 Configuration and Size.

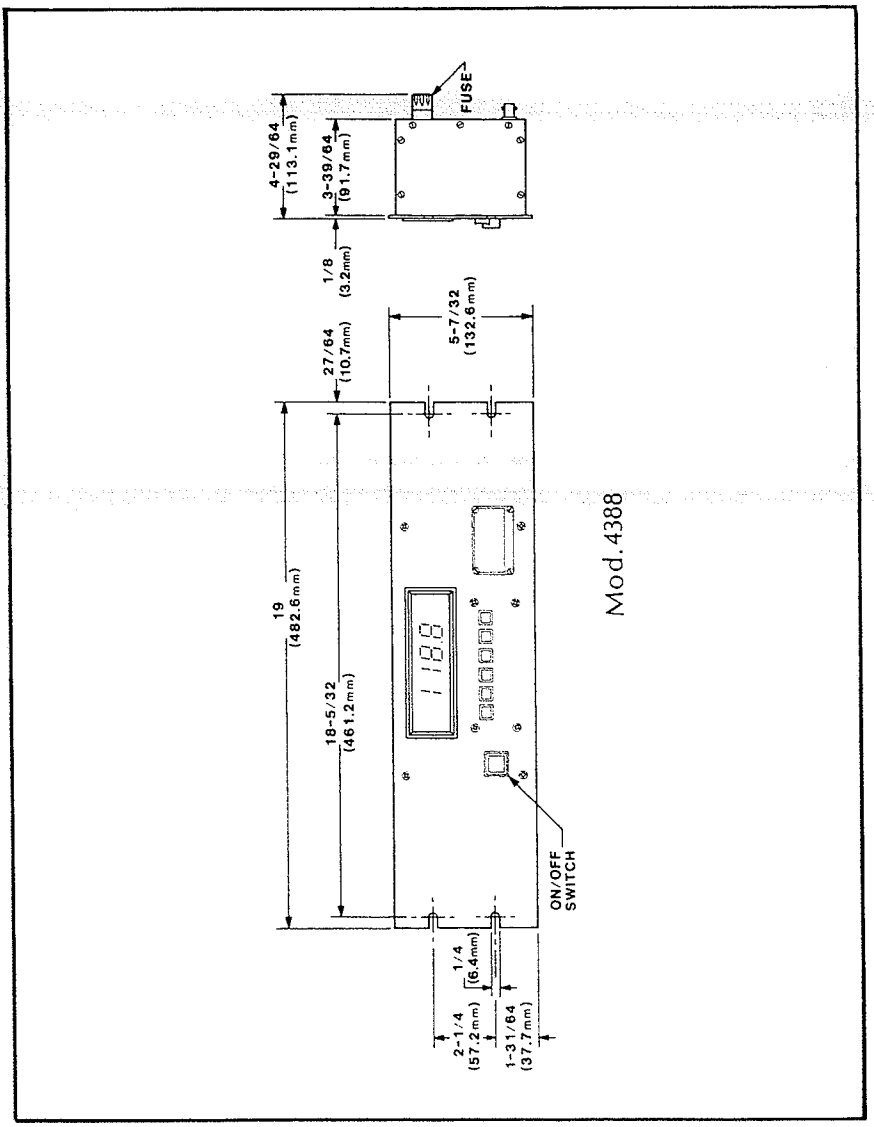


Figure 1.2 Configuration and Size.

SAFETY PRECAUTIONS

CAUTION

If an element is in one of the sockets but is not used for the measurement being taken, the meter does not monitor its output and therefore cannot alert the operator if that element is being over-ranged. Care must always be taken to insure that the unused element is not over-ranged in this manner since damage may be done to the element. Damage to the 4380 Series due to over-ranging is extremely unlikely.

CAUTION

The SWR, % modulation, and return loss modes require a stable power level for accurate results. Therefore, an abrupt power change may cause an incorrect quantity to be stored in the **MAX** or **MIN** registers.

CAUTION

The 4380 Series contains MOS integrated circuits which may be damaged by static electricity. Open the housing only when sure that there are no static producing materials such as carpeting or styrofoam where the work is to be done. Work on a conductive, grounded work surface touching it frequently to discharge static from your body. If a part is to be stored or shipped, wrap it in aluminum foil.

SECTION 1
INSTALLATION

1-1. GENERAL

1-2. The Power Analyst Model 4381 is completely portable and very suitable for field or laboratory use. Its power is derived from rechargeable nickel-cadmium batteries inside the unit or from an AC operated charger-adapter which attaches to the unit. All other units of the 4380 series are designed for laboratory or transmitter site use.

1-3. CONNECTIONS

1-4. The 4381 contains a short section of rigid 50-ohm coaxial air dielectric transmission line. To make measurements relating to the traveling waves in a coaxial line, that line must be disconnected at some convenient point to permit the 4381 air line to be inserted. Other units of this series use external line sections or are permanent mount panel type installations.

Although the 4381 is normally supplied with two female N-type connectors, a variety of easily interchangeable connectors are available to facilitate connecting to the user's system.

Once the Model 4380 Series is installed in the coaxial line, a Plug-in Element or a pair of Plug-in Elements must be selected which correspond to the frequency and power levels to be measured.

In order to take full advantage of the 4381's capabilities, two elements in a 10:1 ratio of power range should be used. If only one element is used, the other socket should be filled with a dust plug or a higher power element. Also, for greatest accuracy, the element(s) should be chosen having the lowest possible power range that will not result in over-ranging. Table 1-1 lists elements required for each mode of operation.

Table 1-1. Plug-In Elements Required

MODE	FORWARD	REFLECTED
FWD CW	X	
RFL CW		X
SWR	X	X*
FWD PEP	X	
RFL PEP		X
% MOD	X	
FWD dBm	X	
RFL dBm		X
RTN Loss	X	X*

*The reflected element must have a nominal power range one tenth that of the forward element.

The higher power element is placed in the socket marked **FORWARD** and its arrow pointed in the direction of forward power flow (toward antenna or load). The lower power element is placed in the socket marked **REFLECTED** and is normally pointed in the direction opposite to forward power flow. The elements are clamped in place by the hold-down catches on the face of the line section. These catches must be used to avoid error due to the element not contacting the bottom or seating plane of the socket. With the element(s) in place, set the range slide switches to correspond with the nominal power range of the elements. For example, if the forward element is a 5 watt element, the switches are set at **5** and **× 1.** For a 250 watt element they are set at **2.5** and **× 100.** Sometimes it is necessary to use milliwatts or kilowatts as the unit of measure. In other words, 1 watt becomes **10 × 100** milliwatts and 2500 watts becomes **2.5 × 1** kilowatts.

SECTION 2
THEORY OF OPERATION

2-1. DESCRIPTION OF OPERATION

2-2. Figure 2-1 is a block diagram of the major functional parts of the 4380 Series RF Power Analyst. The Mocrocomputer integrated circuit shown, controls all the other portions of the instrument, which fall into two major groups as follows.

a. Keyboard, Range Switches, and Display Group. The keyboard and range switches serve only to pass information to the computer. The display, of course, returns information from the computer to the operator. The display, which is comprised of four seven-segment LED digits, is strobed digit by digit left to right at a rate of approximately 1 digit per millisecond. This serves to conserve battery power and drive circuitry while providing scanning for the columns of the keyboard. Each time a digit is strobed, the corresponding column of the keyboard is read and if a key is pressed, the computer puts the code for that key into a memory cell. The nine white keys select which parameter is to be measured. The three colored keys simply modify the way in which the result is displayed. The range selector switches identify to the computer the nominal full scale values of the elements used. They have no effect on input sensitivity, which is constant.

b. Plug-in Elements, Analog Circuitry, and Analog-to-Digital Converter. These components are controlled solely by the computer. The Plug-in Elements in the line section provide low level positive voltages related to the instantaneous value of power. (See Figure 2-2.) The first group of solid state switches selects the forward element, the reflected element, or ground as the input to the preamplifier which boosts these signals to 0.1 to 2.0 volt range. The remaining switches shown as two groups direct the output of the preamp to the analog-to-digital converter either directly or through a peak or negative peak detector. The analog to digital converter converts the voltage to a 15 digit binary number.

2.3. Each reading output by the display is derived from as many as three different voltage readings using the circuitry described in paragraph 2-2. Once these voltages are measured, all the remaining operations are performed within the computer chip as follows:

The voltages are corrected for error due to dc drift in the analog circuitry. Each voltage is converted to square root of power using tables of stored data. Then these values are combined in a manner similar to that used mathematically by a pocket calculator to arrive at the final result in binary. This is used to update the registers containing the last value, the maximum value, or the minimum value as required. Finally the result is converted to a decimal number and placed into a register from which the display driving routine operates

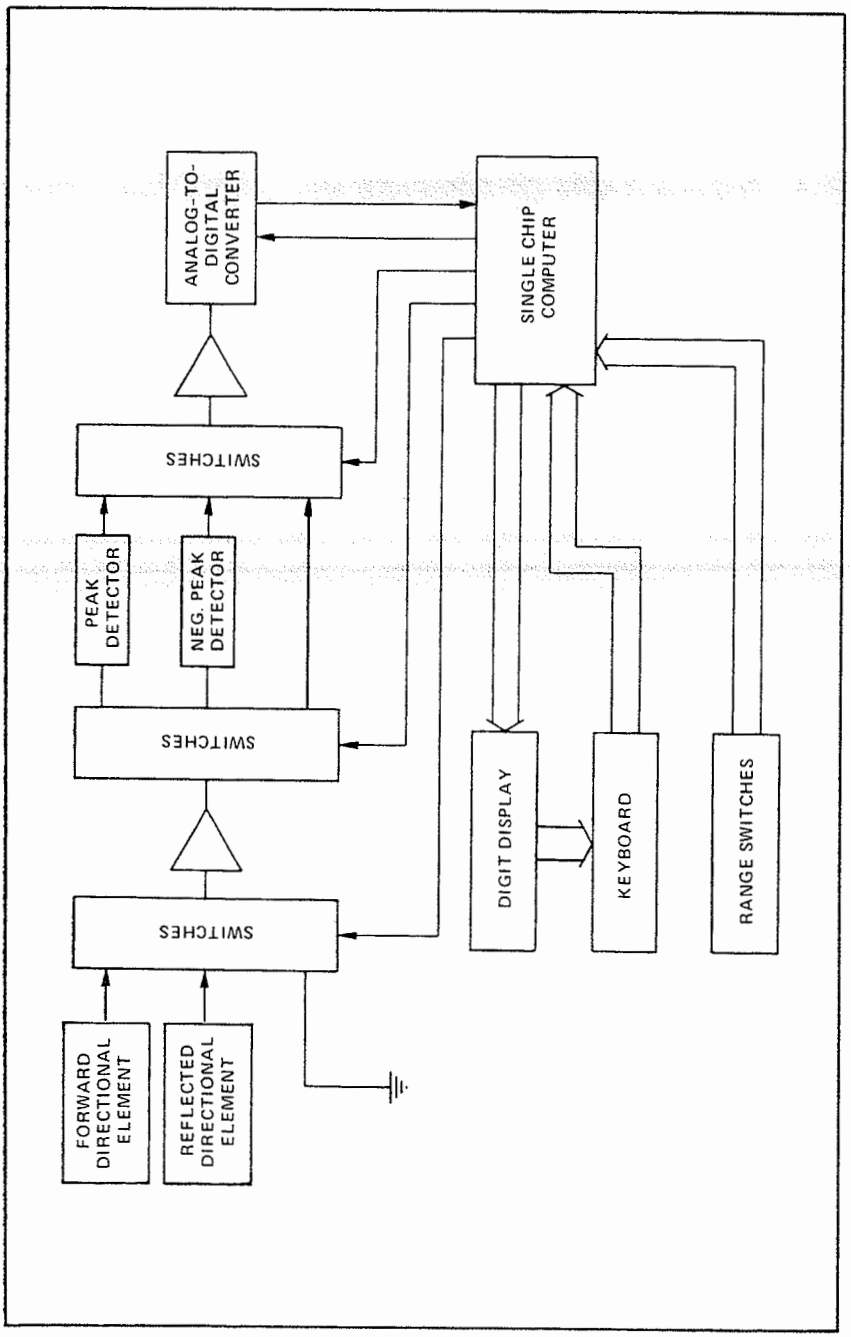
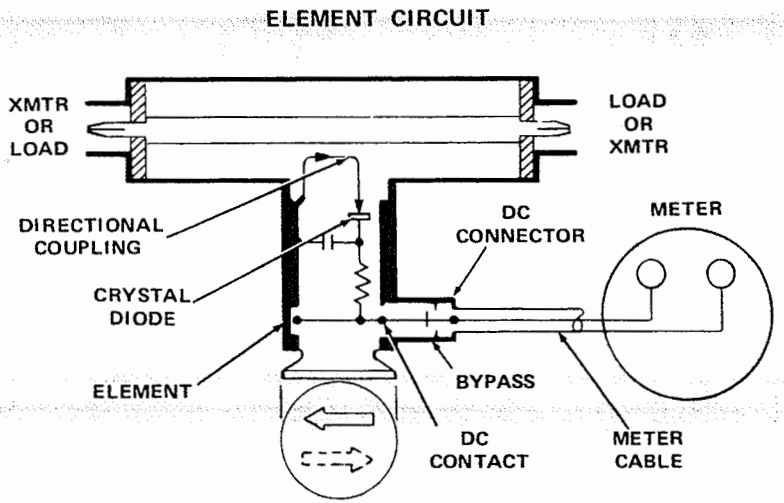


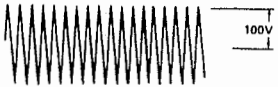
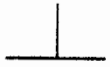
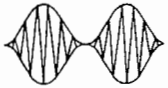
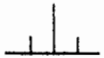
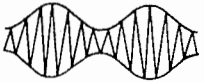
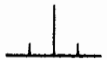
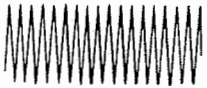
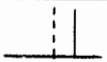
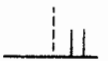
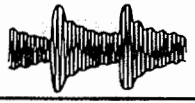
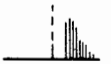
Figure 2-1. Circuit Block Diagram.



The coupling circuit which samples the traveling waves is in the Plug-in Element. The circuitry of the Element and its relationship to the other components of the THRULINE are illustrated in the schematic diagram. Energy will be produced in the coupling circuit of the Element by both mutual inductance and capacitance from the traveling RF waves of the line section. The inductive currents will, of course, flow according to the direction of the traveling waves producing them. The capacitive portion of these currents is naturally independent of the direction of the traveling waves. Therefore, assuming that the Plug-in Element remains stationary, it is apparent that the coupling currents produced from the waves of one direction will add in phase, and those produced from waves of the opposite direction will accordingly subtract in phase. The additive or "ARROW" direction is, of course, assigned to the forward wave.

The electrical values of the Element circuits are carefully balanced and so designed that the current produced from the reverse wave will cancel the other almost completely. The resultant is a directivity always higher than 30dB, which means that the Element is highly insensitive (nulled) to the "REVERSE" direction wave. Being highly directional, the THRULINE Element is sensitive (at one setting) only to one of the traveling waves which produces standing waves by interference. THRULINE measurements are therefore independent of position along standing waves.

Figure 2-2. Plug-in Element Schematic Diagram.

Transmission Type and Scope Pattern	Frequency Spectrum (C: Carrier)	PEVrms (arbitrary)	PEP = PEV^2_{rms}/Zo	Average (Heating) Power	4380 Series			Model 43
					CW Mode	PEP Mode	% MOD Mode	
Table A CW 		$\frac{100}{\sqrt{2}}$ V	100W	100W	100W	100W	0%	100W
Table B AM 100% Mod. 		$\frac{200}{\sqrt{2}}$ V	400W	150W	100W	400W	100%	100W
Table C AM 73% Mod. 		$\frac{173}{\sqrt{2}}$ V	300W	127W	100W	300W	73%	100W
Table D SSB 1 tone 		$\frac{100}{\sqrt{2}}$ V	100W	100W	100W	100W	0%	100W
Table E SSB 2 tone 		$\frac{100}{\sqrt{2}}$ V	100W	50W	25W	100W	100%	40.5W
Table F SSB Voice 		$\frac{100}{\sqrt{2}}$ V	100W	–	–	100W	–	–

Z_o = 50 ohms

PEV: Peak Envelope Voltage. Carrier (or suppressed carrier) PEV was arbitrarily chosen at 100 volts in all examples. $PEV_{rms} = PEV/\sqrt{2}$.

Figure 2-3. Readings with Various Envelopes.

SECTION 3
OPERATING INSTRUCTIONS

3-1. OPERATING MODES

3-2. The 4380 series has nine modes of operation which are selected by pressing the white keys momentarily. In addition, each mode has three output options selected by pressing the colored keys. Detailed descriptions of the modes and output options follow:

a. Reading Forward Power. (Figure 3-1.) For this measurement only a forward element is required. Install the meter and element according to the preceding paragraphs and move the power switch to **ON.** When powered up, the series 4380 always goes into the forward CW power mode. If the unit is already operating, the forward CW power mode is selected by pressing the **FWD CW** key momentarily. If the applied power exceeds 120% of the range, two right facing arrow heads (i.e., "greater-than" symbols) will be displayed. The operation of this error message does not depend on the correct setting of the range switches by the operator, nor will the meter or its elements be damaged if the switches are incorrectly set.

CAUTION

If an element is in one of the sockets but is not used for the measurement being taken, the meter does not monitor its output and therefore cannot alert the operator if that element is being over-ranged. Care must always be taken to insure that the unused element is not over-ranged in this manner since damage may be done to the element. Damage to the 4380 Series due to over-ranging is extremely unlikely.

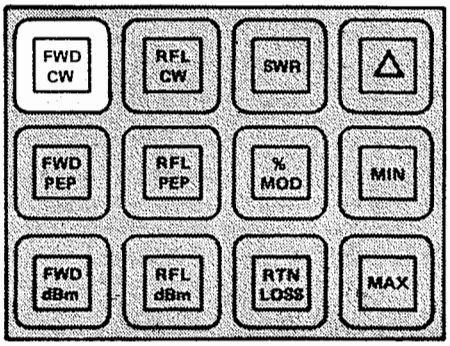


Figure 3-1. Forward Power (CW).

The series 4380 arrives at values of CW power by a method quite different from analog meters such as the Model 43 also manufactured by Bird Electronic. While the two instruments will agree when the measured wave is of constant amplitude, AM or SSB waves will result in different indications (in the CW mode). This is because the analog instrument uses the inertia of the microammeter to "time-average" the varying signal coming from the element, whereas the series 4380 uses peak and negative peak detector circuits to measure peak and minimum square root of power and combines them using the equation:

$$\text{CW Power} = \left(\frac{\sqrt{\text{Peak Power}} + \sqrt{\text{Minimum Power}}}{2} \right)^2$$

Using this technique, operation of the CW mode is predictable regardless of envelope shape (See Figure 2-3).

b. Reading Reflected CW Power. (Figure 3-2.) Operation of the reflected CW power mode is identical to that for forward CW power described above with two exceptions: the readings are taken from the element in the socket marked "reflected" and the range of the element is assumed to be 1/10 the range indicated by the range slide switches.

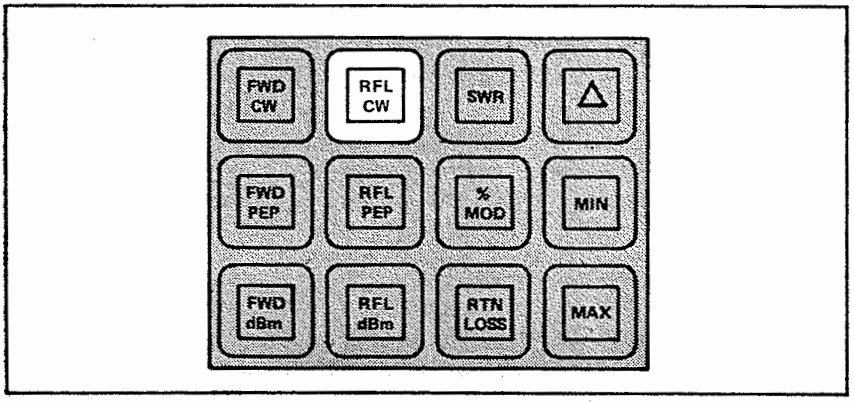


Figure 3-2. Reflected Power (CW).

c. Reading SWR. (Figure 3-3.) Two elements are required for this mode and they must have a 10 to 1 power range ratio. Press the SWR key momentarily. If the average forward power is between 10% and 120% of full scale and the average reflected power is less than 120% of the reflected element range, SWR will be displayed. If any of the above conditions are not met, an error message will be displayed. Two arrows pointing to the right — or "greater-than" symbols — indicate over-range, while two left pointing arrows — or "less-than" symbols — indicate under-range or too little power. Refer to Table 3-1.

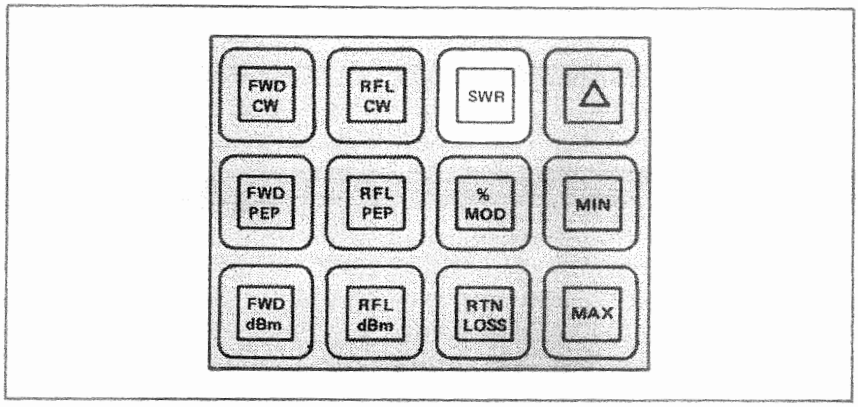


Figure 3-3. Standing Wave Ratio (SWR).

Table 3-1. Voltage Standing Wave Ratio (VSWR).

VSWR	Return Loss dB	Reflected Power %
1.01	46.1	0
1.02	40.1	.01
1.03	36.6	.02
1.04	34.2	.04
1.05	32.3	.06
1.06	30.7	.08
1.07	29.4	.11
1.08	28.3	.15
1.09	27.3	.19
1.1	26.4	.23
1.15	23.1	.49
1.2	20.8	.83
1.25	19.1	1.23
1.3	17.7	1.7
1.35	16.5	2.22
1.4	15.6	2.78
1.45	14.7	3.37
1.5	14	4
1.75	11.3	7.44
2	9.5	11.11
2.25	8.3	14.79
2.5	7.4	18.37
2.75	6.6	21.78
3	6	25
3.25	5.5	28.03
3.5	5.1	30.86
3.75	4.7	33.52

Table 3-1. Voltage Standing Wave Ratio (VSWR). (Cont.)

VSWR	Return Loss dB	Reflected Power %
4	4.4	36
4.25	4.2	38.32
4.5	3.9	40.5
4.75	3.7	42.53
5	3.5	44.44

d. **Measuring Peak Envelope Power.** (Figure 3-4). PEP power measurements are made in the same manner as the CW power readings described above, except that the **FWD PEP** and **RFL PEP** buttons are pressed and the readings are displayed directly as peak power.

NOTE

The accuracy of measurements made with modulation present which has a frequency, duty cycle, pulse width, or repetition rate **outside the range** of the instrument cannot be assured in any mode of operation.

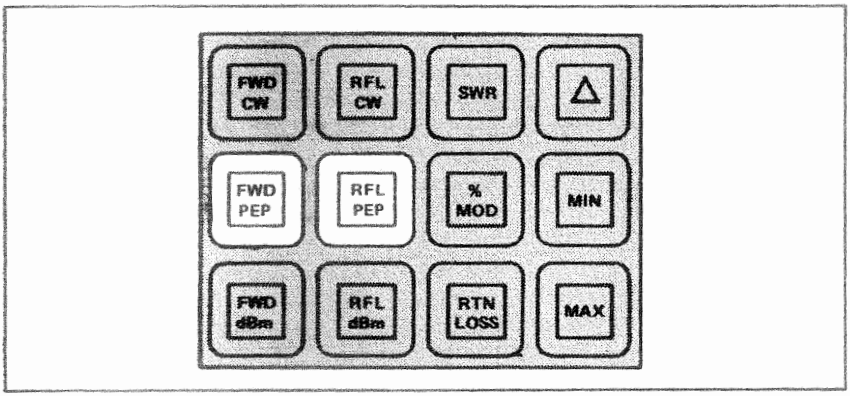


Figure 3-4. Peak Envelope Power (PEP).

e. **Measuring Amplitude Modulation.** (Figure 3-5.) Only a forward element is required for this mode. The element should be pointed in the direction of forward power and the % **MOD** key pressed. Modulation is displayed directly in percent, provided the average signal is above 10% and the **PEP** of the signal is below 400% of the element's nominal full scale. For specified measurement accuracy, the average **CW** power levels must be greater than one third of full scale. Modulation is calculated as follows:

$$\text{MODULATION} = \frac{\sqrt{\text{Peak Power}} - \sqrt{\text{Minimum Power}}}{\sqrt{\text{Peak Power}} + \sqrt{\text{Minimum Power}}} \times 100$$

and is therefore limited to the range of 0 to 99.9%. Over-modulation will be indicated as 99.9%. Refer to Table 3-2.

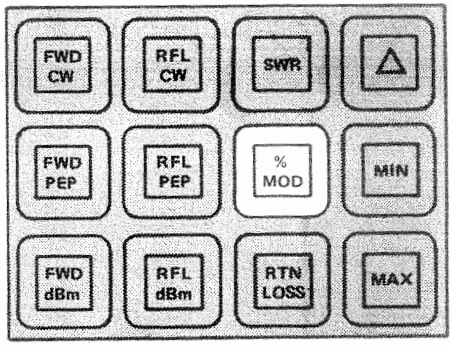


Figure 3-5. Amplitude Modulation (%).

Because of the threshold of the RF diode, a modulated signal which has a minimum power level below 0.3% of full scale will result in a high modulation reading with uncertain accuracy.

Table 3-2. Amplitude Modulation.

Peak/CW Power	% Modulation
1	0
1.1	5
1.21	10
1.32	15
1.44	20
1.56	25
1.69	30
1.82	35
1.96	40
2.1	45
2.25	50
2.4	55
2.56	60
2.72	65
2.89	70
3.06	75
3.24	80
3.42	85
3.61	90
3.8	95
4	100

f. **Measuring Power in dBm.** (Figure 3-6.) Operation of the forward and reflected dBm modes is identical to the forward and reflected CW power modes, except that the resulting reading is converted to dB above 1 milliwatt before it is displayed. It should be noted that in doing this conversion, the range set on the slide switches is assumed to be watts rather than kilowatts or milliwatts. If it is not, 30.0 must be added to all dB readings when the range is in kilowatts, or subtracted from all readings when it is in milliwatts. An error message is displayed if CW power is more than 24dB below, or peak power is more than 6dB above the nominal element range. Refer to Table 3-3.

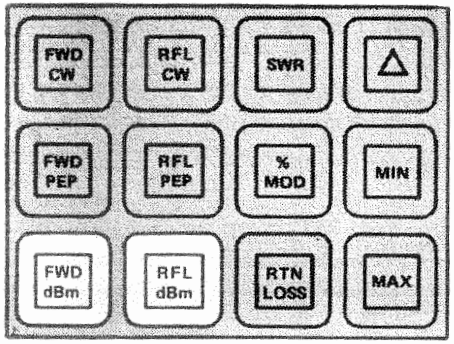


Figure 3-6. CW Power in dBm.

Table 3-3. Watts/dBm Equivalents.

Power	dBm
1 milliwatt	= 0dBm
10 milliwatts	= 10dBm
100 milliwatts	= 20dBm
1 watt	= 30dBm
2 watts	= 33dBm
4 watts	= 36dBm
10 watts	= 40dBm
20 watts	= 43dBm
40 watts	= 46dBm
100 watts	= 50dBm

g. **Measuring Return Loss, Insertion Loss, or Attenuation.** (Figure 3-7.) The measurement of return loss is the same as that of SWR except that the result is displayed in dB. In other words a reading of 21.6 indicates that reflected power is 21.6dB down from forward power.

On models having external line sections, attenuation or insertion loss can be measured directly using this function if two line sections are used. The first line is inserted at the source end of the device being measured and its DC

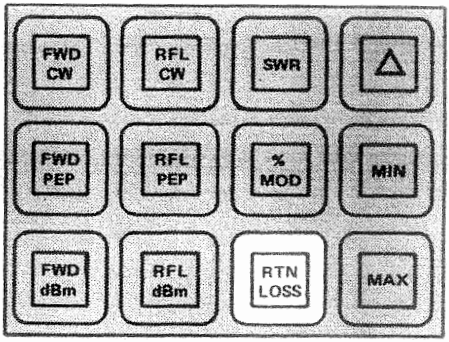


Figure 3-7. Return Loss, Insertion Loss, or Attenuation.

output connected to the "forward" input jack. The second line is inserted at the load end of the device and connected to the "reflected" input jack. Both elements are in this case pointed in the direction of forward power flow. If the two elements do not have a ten to one ratio a correction factor must be added to or subtracted from the "return loss" reading (See Table 3-4), depending on the ratio of the elements.

Table 3-4. Correction Factors.

Ratio of Elements	Added dB	Ratio of Elements	Added dB
1:1	−10	100:1	10
2:1	−7	200:1	13
2.5:1	−6	250:1	14
4:1	−4	400:1	16
5:1	−3	500:1	17
10:1	0	1000:1	20
20:1	3	2000:1	23
25:1	4	2500:1	24
40:1	6	4000:1	26
50:1	7	5000:1	27

h. Monitoring Maximum and Minimum Readings. (Figure 3-8). While operating in any of the modes discribed, the 4380 Series will continuously keep track of the highest and lowest reading obtained. This action begins after ten reading cycles to allow time for the peak detectors to settle from the previous mode. To recall the maximum or minimum reading, hold the **MAX** or **MIN** key depressed. When these keys are released, the meter goes back to displaying the current value of the parameter being measured. Recalling maximum or minimum does not stop the meter from continuing to monitor the current value and updating the minimum and maximum registers. To clear the minimum and maximum register, the mode key must be pressed again or a

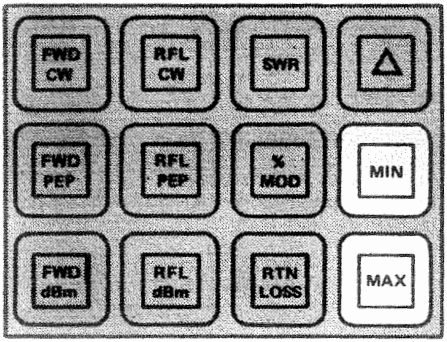


Figure 3-8. Maximum or Minimum Readings.

new mode selected. For example, if CW power deviations are to be monitored, the series 4380 is installed as described at the beginning of this section and turned on, then the power source is turned on and allowed to stabilize. Once the system has stabilized, and **FWD CW** key is pressed to clear the **MAX** and **MIN** registers. At any time during test the **MAX** and **MIN** keys can be used to recall the maximum and minimum values without affecting the test. However, pressing **FWD CW** or changing modes will clear the registers.

CAUTION

The SWR, % modulation, and return loss modes require a stable power level for accurate results. Therefore, an abrupt power change may cause an incorrect quantity to be stored in the **MAX** or **MIN** registers.

i. Using the Peaking Aid. (Figure 3-9.) The peaking aid is useful for making adjustments to optimize any of the parameters which the series 4380 measures. After the mode is selected, the delta (Δ) key is pressed momentarily. This blanks the least significant digit of the display, and replaces it with right facing arrow head if the measured quantity is increasing and a left facing arrow head if it is decreasing. If there is no change, the digit is left blank. To find a peak, begin making the adjustment in whichever direction produces a right facing arrow head and continue slowly in that direction until the arrow head turns around. At this point the peak has been reached. To check to make sure the peak has not been passed, press the **MAX** key to read the highest value read and release it to read the current value. The two should be the same. Desired minimum levels (e.g. of reflected power or SWR) are found in a similar manner.

Another method, which does not require watching the rapidly changing display, is to run through equipment adjustments from one extreme to the

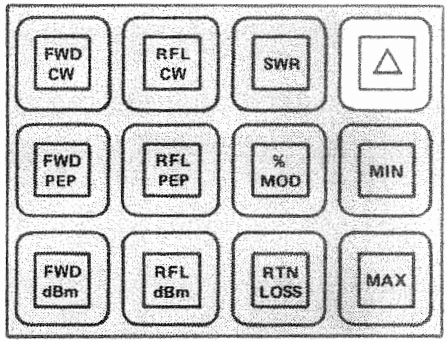


Figure 3-9. Peaking Aid (Δ).

other — even with eyes closed — then push the **MIN** memory button to display the optimum achievable value, and tune your gear to match it. The same easy procedure is available for desired maximum levels, by use of the **MAX** memory button. This is even faster than tweaking with an analog display meter, since one need not pass the signal dip (or peak) several times to be certain the optimum condition has been reached: The memory shows exactly what MIN or MAX value to aim for (Figure 3-8).

j. Battery Care. With average use, the nickel-cadmium batteries in the 4381/82/83/84 will power the unit for eight hours before recharging is required. The units will maintain rated accuracy until battery voltage drops to the point at which operation stops altogether. When this happens the display will show a constant random number or go blank. Recharging is accomplished by connecting AC power to the unit via the adapter provided. This takes approximately 14 hours when the unit is turned off, or 24 hours when it is operating.

We recommend that the 4380 Series power meters are not left connected to the battery charger and the batteries charged for longer than fourteen hours per charge. When all the batteries have reached a full charge the voltage may increase to a level where the meter will not operate. If this should happen the power meter can be made operational by turning the power switch on for approximately 30 seconds, turning it off, and on again. Over charging the batteries will not cause damage to the power meter or the batteries.

To prolong the life of the batteries, it is recommended that they be allowed to completely discharge periodically before recharging. If the batteries lose the ability to hold a charge they can be replaced with standard C-size nickel-cadmium batteries. However, other types of batteries are not usable because of their higher voltages. See Section 4 for important precautions regarding static electricity when opening the housing.

k. Operating on AC Power. For AC power operation, the 4381 is simply connected to an AC receptacle using the adapter provided. The correct AC voltage is marked on the adapter. The meter may be operated in this manner with the batteries removed if desired.

SECTION 4
MAINTENANCE INSTRUCTIONS

4-1. GENERAL

4-2 Due to its complexity, repair of the series 4380 in the field is recommended only for certain malfunctions.

CAUTION

The 4381 contains MOS integrated circuits which may be damaged by static electricity. Open the housing only when sure that there are no static producing materials such as carpeting or styrofoam where the work is to be done. Work on a conductive, grounded work surface touching it frequently to discharge static from your body. If a part is to be stored or shipped, wrap it in aluminum foil.

4-3. LINE SECTION PROBLEMS

4-4. Worn or Damaged Connectors. This problem can result in high standing waves. Inspect the connectors visually and replace if required.

4-5. Worn Element Seats. The element seat is not plated as manufactured so visual inspection is of little value in detecting this problem. A badly worn seat will cause an element to read 1 or 2% higher than it does in a new line section with power held constant. Remedy by replacing the line section. See Paragraph 4-25 for disassembly.

4-6. Intermittent Contact. Touching or slightly rotating the element causes large changes in the reading. Clean the contacts on the element and in the sockets of the line section with a mild cleaning solvent such as alcohol. If the contacts in the line section are recessed too far, bend them out slightly with a small screwdriver. Take care not to bend them out so far as to interfere with the insertion of the element.

4-7. Loose Catches. If a catch is loose, the element can be rotated easily and may rock slightly under light finger pressure, resulting in loss of accuracy. This problem can usually be repaired by bending the catch slightly. If not, the line section must be replaced.

4-8. No Output From One Socket. This can result either from a poor contact as described above, or a faulty connection, or short between the line section and the MCU and analog PC board. Check with a VOM and repair.

4-9. BATTERY PROBLEMS

4-10. Short Life. If the batteries lose their ability to hold a full charge, they should be replaced with new batteries available from Bird. Note that any C-size nickel-cadmium battery may be used but the use of other types of batteries may destroy the instrument. See Paragraph 4-25 for disassembly.

4-11. Unit Will Not Operate at All Under Battery Power. This condition probably results from a bad connection. Check all battery connections with a VOM and repair the bad connection.

4-12. POWER SUPPLY PROBLEMS

4-13. No Output. If the power supply has no output, it must be replaced. Its output should be about 10 volts dc with no load.

4-14. KEYBOARD PROBLEMS

4-15. Key Does Not Make Contact. If only one key is not working, the problem is in the keyboard. Replace the keyboard. See Paragraph 4-25 for disassembly.

4-16. Row or Column Not Working. This is likely to be caused by an open or short circuit inside the keyboard or between the keyboard and the computer chip. Remedy by locating short or open and correcting it.

4-17. DISPLAY PROBLEMS

4-18. One Segment on One Digit Out. This can only be caused by a defective LED display, its socket, or an open connection where the socket is soldered to the PC board. Switch displays to isolate the problem.

4-19. Entire Digit Malfunction. This is usually caused by a fault in the drive circuitry to the digit. If the keyboard is malfunctioning, check for a short or an open on the MCU and analog PC board between the computer chip and the 26 pin connector. Otherwise check the two PNP transistors just below the digit.

4-20. Same Segment on All Digits Malfunctioning. This problem can only be caused by a defective 7447 driver IC or a short or open between the driver and the displays.

4-21. No Decimal Point or All Decimal Points. The decimal point is driven by a PNP transistor near the 7447 IC. A short or open on either side of this transistor can cause the problem.

4-22. Strange Counting Sequence. If this happens, there is a problem in the binary coded decimal signal coming from the computer chip to the driver IC. Isolate the problem and repair. The 7447 IC may be at fault.

4-23. OTHER DISORDERS

4-24. For problems more complex than those listed above, it may be necessary to return the meter to Bird for analysis or to replace one or both circuit boards. A call or telegram to the Bird Customer Service Department will help determine the best solution to these problems.

CAUTION

The 4380 Series contains MOS integrated circuits which may be damaged by static electricity. Open the housing only when sure that there are no static producing materials such as carpeting or styrofoam where the work is to be done. Work on a conductive, grounded work surface touching it frequently to discharge static from your body. If a part is to be stored or shipped, wrap it in aluminum foil.

4-25. DISASSEMBLY (Models 4381, 4382, 4383 and 4384).

4-26. Opening the Case. Remove four pan head screws in the corners of the bottom of the case. Pull the front panel forward and downward. As soon as the case is opened, remove all the batteries to reduce the chances of damage if a short circuit is made accidentally. Disconnect the three wires coming from the line section at the connectors on the MCU and analog PC board. When reconnecting, black goes to the terminal marked "GND," white to the terminal marked "FWD," and gray to the terminal marked "RFL."

4-27. Removing the Line Section. Remove the eight pan head screws holding the QC connectors and remove the connectors. Remove the four oval head screws which hold the line section to the sides of the case. Using finger pressure, spread the case open just enough to pull the line section straight up and out.

4-28. Removing the Line Section PC Board. Remove the four pan head screws holding the PC board to the line section. Pull the board straight away from the line. Note the positions of the two flat spacers and white teflon beads for reassembly.

4-29. Removing the MCU and Analog PC Board. Remove the two oval head screws near the upper corners of the keyboard. Pull the board straight away from the front panel assembly. Use care when reassembling to properly align the connectors so as not to bend the contacts in the receptacle.

4-30. Removing the Power and Control PC Board. Remove the remaining four screws on the front panel. The power and control PC board will drop free.

4-31. DISASSEMBLY (Models 4385, 4386, 4387 and 4388)

4-32. Remove from Relay Rack. Removing the Line Section (on Model 4385 only) Remove the RF Cables. Remove the two oval head machine screws that hold the Line Section to the back of the panel.

4-33. Opening the Case. Remove the pan head screws around the box. Pull the center box section away from the box sides. Disconnect the three wires coming from the BNC jacks at the connectors on the MCU and analog PC board. When reconnecting, black goes to the terminal marked "GND", white to the "FWD", and gray to the "RFL" terminal.

4-34. AC Disconnection. Disconnect the AC wires from the PC board by pulling the black 4-pin female plug away from the pins on the PC Board (unpolarized plug). Slide the switch terminal wires off the back of the power switch. Replace either wire on the common (C) terminal; the other wire on the NC or NO terminal (The switch will function correctly either way).

4-35. Removing the PC Boards. Remove the screws around the keyboard and pull the keyboard away from the panel. The MCU board is freed by removing the two screws attaching it to the power and control PC Board (large board) Note particularly the orientation of the small board, and use care when re-aligning the multi-pin connector.

4-36. Calibration. Recalibration of the 4380 Series is a uncomplicated procedure. However, if done incorrectly significant errors could result. The 4380 Series Wattmeter samples the incoming dc signal. During the time the signal is not being sampled the input impedance is higher. This tends to modulate the source of current used for calibration. As a result any current meter placed in series will average the current during sampling and the current during the not-sampled time and show a low reading.

The preferred method of calibration is to use a regulated voltage source of 5 volts or greater and an adjustable resistance. Adjust this combination so that it produces the correct current into a microammeter and resisitor combination having the same total impedance as the power meter impedance (see figure). Then substitute the 4380 Series meter for the microammeter and resistor, and adjust it to read full scale on the FWD CW function. Note the static electricity precautions in the instruction manual before opening the digital power meter for calibration. There is only one calibration trimmer in the 4380 Series meters. If the CWD CW function is calibrated all other functions will be calibrated simultaneously.

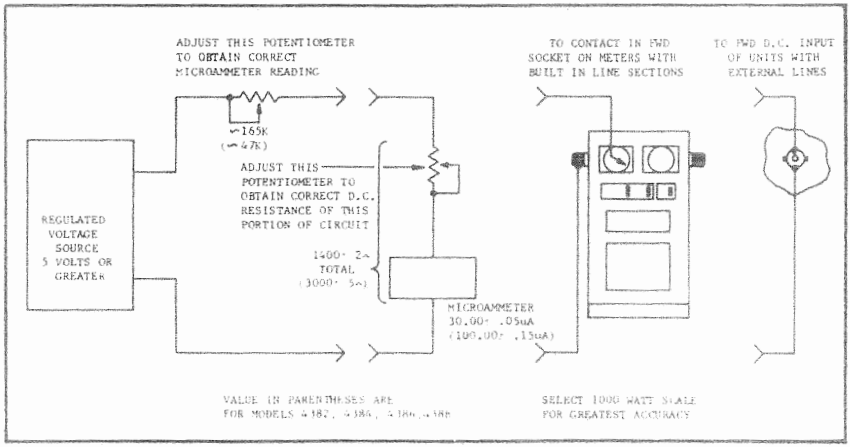


Figure 4.1 Calibration Diagram

SECTION 5
PARTS LIST

5-1. GENERAL

5-2. The parts listed in this section are those recommended for replacement by the manufacturer. Do not disassemble beyond the instructions of Section 4, Maintenance since replacement parts other than those described are not available.

MODEL 4381 PARTS LIST

Qty Reqd	Description	Part Number
1	Line Section Assembly (less PC Board)	4381-005
1	PC Board Assembly (for Line Section)	4381-015
4	Batteries	5-1230
1	Battery Holder	5-1238
1	Converter/Charger (115V)	5-1242
1	Converter/Charger (230V)	5-1257
1	Power Supply Jack	5-736
1	Key Board	4381-026
2	3 Position Switch	5-1216
1	2 Position Switch	5-1215
4	LED Digit	5-1221
1	Control and Power PC Board Assembly	4381-017
1	MCU Chip	4381-035
1	MCU and Analog PC Board Assembly	4381-016-1
2	QC Connector — Female N	4240-062
	Other QC Connectors Available	
	Male N	4240-063
	Female HN	4240-268
	Male HN	4240-278
	Female C	4240-100
	Male C	4240-110
	Female UHF (SO-239)	4240-050
	Male UHF (PL-259)	4240-179
	Female BNC	4240-125
	Male BNC	4240-132
	Female LC	4240-031
	Male LC	4240-025
	Female LT	4240-018
	Male LT	4240-012
	7/8" EIA Air Line	4240-002

SECTION 5
PARTS LIST (Continued)

Models 4385 thru 4388 Common Parts

Qty Req'd	Description	Part Number
1	Fuse 1/8A - 3AG, 250V, Slo-Blo	5-721-8
1	Switch - 115/230V Selector	5-1088
2	BNC Connector, Bulkhead	5-1234
1	Filter, Power Line	5-1275
1	Transformer	5-1276
4	LED (Digit) Display	5-1278
1	Switch, Rotary - Display Values	5-1280
1	Switch, Pushbutton - Power On-Off	5-1284
1	Cord, Power Supply Export	5-1287
1	Cord, Power Supply Domestic	5-1286
1	MCU Board 4385 & 4387	4381-016-1
	4386	4381-016-2
	4388	4388-003
	Part Special for Model 4385 Only	
1	Line Section, Dual - THRULINE	4522-002
	Part Common to Models 4385 thru 4387	
2	Keyboard Module (6 keys)	5-1277
	Part Special for Model 4388 Only	
2	Keyboard Module (3 keys)	5-1314

DIFFERENCE DATA SHEETS
For
MODEL 4380 SERIES
RF Power Analyst®
Instruction Book

Covering

Model 4382, 4383 and 4384
Console Units

And

Models 4385, 4386, 4387 and 4388
Panel Mount Units

DIFFERENCE DATA SHEETS
MODEL 4382
Instructions

The 4382 is a RF Power Analyst® for high power systems using rigid coaxial lines. The operation of the 4382 is nearly the same as the 4381 with a few important differences.

The 4382 uses a remotely mounted dual port line section and Bird high power elements having a full scale output of 100 micro amps dc. A pair of RG58/U cables connects the line section to the 4382. When selecting elements use two elements with a ten to one power ratio just as with the 4381. Place the higher power element in either socket of the line section with the arrow on its nameplate facing in the direction of power flow. Connect the RG58/U cable from this socket to the input marked "forward" on the rear of the 4382. Place the lower power element in the line with its arrow facing opposite the direction of power flow. Connect the cable from this socket to the input marked "reflected" on the 4382.

MODEL 4383
Instructions

The 4383 is a RF Power Analyst® for high power systems using rigid coaxial lines. The operation of the 4383 is nearly the same as the 4381 with a few important differences.

The 4383 uses a remotely mounted duel port line section. A pair of RG58/U cables connects the line section to the 4383. When selecting elements use two elements with a ten to one power ratio just as with the 4381. Place the higher power element in either socket of the line section with the arrow on its nameplate facing in the direction of power flow. Connect the RG58/U cable from this socket to the input marked "forward" on the rear of th 4383. Place the lower power element in the line with its arrow facing opposite the direction of power flow. Connect the cable from this socket to the input marked "reflected" on the 4383.

MODEL 4384
Instructions

The 4384 is a rack mounted RF Power Analyst® for high power systems using rigid coaxial lines. The operation of the 4384 is nearly the same as the 4381 with a few important differences

The 4384 uses a remotely mounted dual port line section and Bird high power elements having a full scale output of 100 mocro amps dc. A pair of RG58/U cables connects the line section to the 4384. When selecting elements use two elements with a ten to one power ratio just as with the 4381. Place the higher power element in either socket of the line section with the arrow on its nameplate facing in the direction of power flow. Connect the RG58/U cable from this socket to the input marked "forward" on the rear of the 4384. Place the lower power element in the line with its arrow facing opposite the direction of power flow. Connect the cable from this socket to the input marked "reflected" on the 4384

DIFFERENCE DATA SHEETS
MODEL 4385
Instructions

The 4385 is a rack mounted variation of the 4381 RF Power Analyst®. The two models are nearly the same in operation with a few important differences.

The 4385 has no batteries since it is powered by the ac line. Before connecting the ac line cord always be sure that the power selector switch is in the correct position for the power to be used. In the "115" position the power meter will accept 100 to 130 Vac, 47 to 63 Hz. In the "230" position it will accept 200 to 260 Vac over the same range or frequency. AC power is fused with a 1/8 AMP time delay fuse. On the front panel of the power meter is a square push button power switch.

The 4385 uses a single rotary switch found behind the nameplate to set the full scale power range. Elements are first selected just as with the 4381. Then the rotary switch is set according to the table on the back of the nameplate.

MODEL 4386
Instructions

The 4386 is a rack mounted RF Power Analyst® for high power systems using rigid coaxial lines. The operation of the 4386 is nearly the same as the 4381 with a few important differences.

The 4386 uses a remotely mounted dual port line section and Bird high power elements having a full scale output of 100 micro amps dc. A pair of RG58/U cables connects the line section to the 4386. Care must be taken to ensure that the rack that the power meter is mounted in and the outer conductor of the coaxial line are both at ground potential or reading errors will result. When selecting elements use two elements with a ten to one power ratio just as with the 4381. Place the higher power element in either socket of the line section with the arrow on its nameplacte facing in the direction of power flow. Connect the RG58/U cable from this socket to the input marked "forward" on the rear of the 4386. Place the lower power element in the line with its arrow facing opposite the direction of power flow. Connect the cable from this socket to the input marked "reflected" on the 4386. Finally remove the nameplate from the front panel of the power meter and set the rotary switch under it to correspond to the forward element power according to the table on the back of the nameplate.

Before connectng ac power to the Wattmeter, make sure the slide switch on the rear panel is set correctly for the voltage available. In the "115" position the 4386 will accept 100-130 Vac 47-63 Hz. In the "230" position it will accept 200-260 Vac at the same frequencies. AC power is fused with a 1/8 AMP time delay fuse. On the front panel of the unit is a push button power switch.

DIFFERENCE DATA SHEET
MODEL 4387
Instructions

The 4387 is a rack mounted RF Power Analyst® for high power systems using rigid coaxial lines. The operation of the 4387 is nearly the same as the 4381 with a few important differences.

The 4387 uses a remotely mounted dual port line section. A pair of RG58/U cables connects the line section to the 4387. Care must be taken to ensure that the rack that the power meter is mounted in and the outer conductor of the coaxial line are both at ground potential or reading errors will result. When selecting elements use two elements with a ten to one power ratio just as with the 4381. Place the higher power element in either socket of the line section with the arrow on its nameplate facing in the direction of power flow. Connect the RG58/U cable from this socket to the input market "forward" on the rear of the 4387. Place the lower power element in the line with its arrow facing opposite the direction of power flow. Connect the cable from this socket to the input marked "reflected" on the 4387. Finally remove the nameplate from the front panel of the power meter and set the rotary switch under it to correspond to the forward element power according to the table on the back of the nameplate.

Before connecting ac power to the Wattmeter, make sure the slide switch on the rear panel is set correctly for the voltage available. In the "115" position the 4387 will accept 100-130 Vac 47-63 Hz. In the "230" position it will accept 200-260 Vac at the same frequencies. AC power is fused with a 1/8 AMP time delay fuse. On the front panel of the unit is a push button power switch.

MODEL 4388
Instructions

The 4388 is a rack mounted RF Power Analyst® for high power systems using rigid coaxial lines. The operation of the 4388 is nearly the same as the 4381 with a few important differences.

The 4388 uses a remotely mounted dual port line section and Bird high power elements having a full scale output of 100 micro amps dc. A pair of RG58/U cables connects the line section to the 4388. Care must be taken to ensure that the rack that the power meter is mounted in the outer conductor of the coaxial line are both at ground potential or reading errors will result. When selecting elements use two elements with a ten to one power ratio just as with the 4381. Place the higher power element in either socket of the line section with the arrow on its nameplate facing in the direction of power flow. Connect the RG58/U cable from this socket to the input marked "forward" on the rear of the 4388. Place the lower power element in the line with its arrow facing opposite the direction of power flow. Connect the cable from this socket to the input marked "reflected" on the 4388. Finally remove the nameplate from the front panel of the power meter and set the rotary switch under it to correspond to the forward element power according to the table on the back of the nameplate.

Before connecting ac power to the Wattmeter, make sure the slide switch on the rear panel is set correctly for the voltage available. In the "115" position the 4388 will accept 100-130 Vac 47-63 Hz. In the "230" position it will accept 200-260 Vac at the same frequencies. AC power is fused with a 1/8 AMP time delay fuse. On the front panel of the unit is a push button power switch.

LIMITED WARRANTY

All products manufactured by Seller are warranted to be free from defects in material and workmanship for a period of one (1) 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 (10) 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. 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.

MODELS COVERED IN THIS INSTRUCTION BOOK

4381	4383	4385	4387
4382	4384	4386	4388