OPERATOR'S MANUAL

Models ZM1 / ZM1P / ZM2N
Impedance Meters with Calculated Watts

U.S. Patent # 6,064,742

1. INTRODUCTION

The ZM Meter is specifically designed for the sound contractor and loudspeaker user. Simply connect the probes to the device under test. The ZM Meter displays ac impedance and calculated power for constant voltage (transformer coupled) loudspeaker systems.

Impedance is measured by applying a constant current to the device under test (such as a resistor, a capacitor, an inductor, a loudspeaker, or any electrical circuit) and then measuring the resulting voltage. The voltage is directly related to impedance by Ohm's law for ac voltages.

Calculated power is measured by applying a constant voltage to any load (as above) and then measuring the resulting current. The current is directly related to power.

For both impedance and calculated power, the various voltages are scaled within the ZM Meter to give readings in ohms (Ω) and Watts. For calculated watts, there are four scales for the various "constant voltage" systems, 25, 50, 70.7, and 100 volts.

The **ZM1P and ZM2N** are relay protected from amplifier output overloads up to 120VAC.

The cover of the ZM2N is detachable. Remove the hinge pin and store it in the holes provided above the hinge channel.

2. DESCRIPTION

a. Display:

The ZM Meter uses a 3½digit liquid crystal display (LCD) for the readout. The maximum digits are 1999. A decimal point is used to indicate the value multiplier. For instance, a reading of 18.90 when the function is set to ohms and the range is set to 20k, means 18.90kΩ (or 18,900Ω). The display is "out of range" when the reading is a 1 followed by a series of blanks, 1---. For example, a true 255Ω resistor would read the following impedance, at all frequencies:

Scale	Reading	Meaning
200	1	out of range
2000	254	254 ohms (Ω) - most digits, most accurate
20k	0.25	0.25 k ohms (KΩ), less accurate
Any	BAT	Low Battery – Replace, inaccurate readings possible

b. Switches:

Function: Use this switch to choose either OHMS (impedance), WATTS (calculated power) measurement or TONE (ZM1P / ZM2N only).

Range: The range switch controls both the display and the test signal applied to the load.
For impedance, the ranges are 200 ohms (Ω), 2000Ω and 20.00 k ohms (kΩ), with maximum readings of 199.9Ω, 1999Ω and 19.99 kΩ.
For calculated power, the ranges are 20 Watts, 200 Watts and 2000 Watts, with maximum readings of 19.99 Watts, 199.9 Watts and 1999 Watts.
For best accuracy, the range should be chosen to give the most digits displayed (but not an out of range condition). For example, if the real impedance is 1898Ω, then a reading of 1898Ω on the 2000Ω scale is the most accurate; on the 20kΩ scale it is 1.90kΩ, which is less accurate, and on the 200Ω scale it is 1--- or out of range.

Frequency: Four frequencies are generated in the ZM Meter - 100Hz, 330Hz, 1kHz, and 10kHz. Select a frequency for the impedance or calculated power measurement.

Voltage: Choose the "constant voltage" specification of the distributed loudspeaker sound system, 25, 50 70.7, or 100 volts. The ZM Meter changes the internal calculation multiplier for these different settings; it does not change the test signal applied to the load.

Tone - ZM2N : In the ON position, a loud, intermittent 70 Vac tone is generated at a frequency selected with the FREQUENCY switch. The 70V test tone was developed for very noisy environments to insure that the tone can be easily heard.
ZM1P: The tone is generated directly from the FUNCTION switch, TONE position at the frequency selected by the FREQUENCY switch. This tone is intermittent at 400mv. If your 70V amplifier has an RCA aux input, use the included alligator to RCA adapter cable to insert the test tone into the amplifier. While –6dBu is a typical aux input level for a 70V amplifier, check the specification for your application to make sure that it is appropriate.

When in TONE mode it is not possible to make either WATTS or OHMS measurements. Ignore any readings in the LCD display window.

3. QUICK CHECK

To make sure the ZM Meter is operational:
1. Place the ZM Meter in OHMS Function.
a. With the LOAD leads not touching, the impedance should be "out of range" for all ranges. i.e. it should display 1--- in the 200Ω, 2000Ω and 20kΩ ranges for all frequencies.
b. With the LOAD leads connected together, the impedance should be close to zero in all ranges i.e. the last digit should be 5 or less ignoring the decimal point.
2. Place the ZM Meter in the WATTS Function
a. With the LOAD leads not touching, the power should read 0 or nearly 0 for all ranges, frequencies and system voltages.
b. With the voltage range set to 70V and the leads touching, the power should read over range (i.e. 1) for all ranges. This test will not work at 25V as it exceeds the maximum current available from the unit.

If the ZM Meter does not read close to 0 or out of range, first check to make sure the test leads are good and the contact points are not corroded. Check that "BAT" is not shown on the display.

4. BATTERY INSTALLATION

The ZM1 / ZM1P require 8 “AA” alkaline batteries. To install or replace batteries, remove the four phillips head screws on the rear cover to access the battery compartment. Remove and replace the back cover carefully to avoid damaging internal wiring.

The ZM2N requires 16 “AA” batteries. To install or replace batteries, loosen the panel fastener at the top of the battery cover plate. Lift the plate up to access the battery compartment. The ZM2N can use alkaline, NiCad or Nickel Metal-Hydride batteries. Move the BATTERY TYPE switch to the proper position – ALKaline or NICad/Nickel Metal-Hydride. The ZM2N charges whenever AC power is applied, unit turned ON or OFF.

DO NOT ATTEMPT TO CHARGE ALKALINE BATTERIES. SERIOUS INJURY AND EQUIPMENT DAMAGE CAN OCCUR.
Always replace the batteries when the "BAT" symbol appears on the display. (The ZM Meter will give incorrect readings if "BAT" is displayed)

5. OPERATION

a. To Read Impedance:

1. Turn on the ZM Meter. Set the FUNCTION switch to OHMS. The display should read 1---, the indication of very high impedance which is off scale.

2. Select the FREQUENCY, 100Hz, 330Hz, 1kHz, or 10kHz.

3. Connect LOAD leads to the device under test. ***Make sure that the object under test is disconnected from a power source, i.e. amplifier.*** Failure to do so will damage the ZM1. The ZM1P and ZM2N are relay protected from amplifier outputs up to 120VAC. If the protection relay is triggered, turn off the unit to reset the relay and disconnect the power source from the line. Note that most civilian amplifiers must be disconnected from the loudspeaker runs for best accuracy. Even with the amplifier turned off, failure to disconnect includes the output impedance of the amplifier in the calculation and can give erroneous readings.

4. Switch the range switch (200, 2000, or 20k ohms) so that the highest number of digits is displayed. Remember, 1--- is out of range.

5. The display shows impedance in ohms (Ω), or k ohms (kΩ), at the frequency selected.

b. To Read Calculated Power:

1. Calculated power applies to distributed loudspeaker systems. ***Make sure that the loudspeakers are disconnected from the power amplifier before connecting the ZM Meter.*** Failure to do so will damage the ZM1. The model ZM1P and ZM2N are relay protected against damage, however it is necessary to disconnect from the amplifier to make a measurement.

2. Turn on the ZM Meter. Place the FUNCTION switch to WATTS.

3. Select the VOLTAGE used in the distributed sound system, 25, 50 70.7 or 100 Volts.

4. Select the FREQUENCY, 100Hz, 330Hz, 1kHz or 10kHz.

5. Connect the LOAD leads to the Loudspeaker under test.

6. Switch the RANGE switch (20W, 200W, or 2000W) so that the highest number of digits is displayed. Remember, 1--- is out of range.

7. The display shows the power in watts that would be transferred to the device under test if the selected voltage at the selected frequency were to be applied.

c. Using the Tone Generator: (ZM1P and ZM2N Only)

The ZM1P and ZM2N are equipped with a test tone generator. The tone output is present on the LOAD connectors. The ZM1P output is at **Line Level** (400mv) for insertion into the Aux input of a distributed amplifier. The ZM2N output is at **Speaker Level** (70VAC) for insertion directly into the speakers, not into the amplifier.

Using the ZM1P:
1. Place the FUNCTION switch to TONE.

2. Select the FREQUENCY to be generated, 100Hz, 330Hz, 1kHz or 10kHz.

3. With the amplifier and ZM meter turned OFF, connect the load leads to the Aux input of the amplifier. If the amplifier has screw terminal inputs, use the alligator clip ends on the ZM meter probes to hook up. If the amplifier has an RCA Aux input connector, use the included RCA/Alligator clip adapter cable.

4. Make sure that the loudspeakers are connected to the amplifier.

5. Turn on the ZM meter. Turn on the amplifier.

6. A 400mv (-6dBu) line level intermittent tone will be generated. While this is an appropriate Aux input level for most 70V amplifiers, you should check the specifications for your amplifier. A tone at the selected frequency should now be heard on all loudspeakers connected to the amplifier.

Using the ZM2N:
1. Follow the same procedure for the ZM1P, except that the amplifier is turned off, the loudspeaker cables are disconnected from the amplifier and the ZM2N load leads are connected directly to the load, i.e. loudspeaker cables.

2. The ZM2N will output an intermittent tone at the selected frequency at 70VAC.

6. TRANSFORMER COUPLED DISTRIBUTED LOUDSPEAKER SOUND SYSTEMS

a. Description:

Connecting many loudspeakers to a single amplifier is made possible by using transformers. The transformer converts the voltage and current ratio to provide efficient power transfer from the amplifier to the loudspeakers and to permit relative level changes between different loudspeakers in a low loss manner.

Coupling transformers for loudspeaker distributed systems are called “constant voltage” transformers. They are specified by system voltage and wattage to the speaker (if that voltage were to be applied).

The constant voltage transformer method was developed to permit easy calculation and installation of distributed sound systems. The sound designer needs only to know the desired sound pressure level (SPL), and the sensitivity of the loudspeaker, SPL/watt. He may then calculate the wattage needed for a given SPL.

Each loudspeaker is then connected to the appropriate power tap on the transformer. The total power to the system is the sum of the wattage for each of the transformer power taps. The power amplifier must have this wattage, at least. The installer may change the volume level in any speaker by moving the tap on the transformer. The power to the loudspeaker changes as well.

Measurement of the distributed loudspeaker system is easily carried out with an impedance meter. However, the designer and installer have fully characterized the system using watts, not impedance. Therefore the ZM Meter has been designed to also read "power" as defined by the constant voltage transformer method. We call this power "calculated watts", because this wattage would appear at the loudspeaker only if the system voltage, such as 70.7 or 100 Volts, were applied.

b. Transformer Voltage, Power and Impedance:

Transformers simply change the ratio of voltage and current, while transferring total power (almost). The equation is:

Power at the output (to Speaker) = Power at the input, or Power at the output = (V x I) at the input, where V = voltage I = current.

If the transformer's output is connected to an impedance, the impedance at the input appears to be transformed to another value. Using ohm's law for impedance where I = V / Z, and substituting we obtain: Power at the output = (V x V/Z) input = V^2/Z input

From this equation the relationship between constant voltage, power and impedance is developed: Power at the output (P) = V^2/Z input or re-arranging, $Z = V^2/P$

For example, if we are using a 70.7 volt system, and want to supply 10 watts to the loudspeaker, then the impedance is: $Z = V^2/P$ or $(70.7)^2/10 = 5000/10 = 500$ W. (Figure 1, Page 6.)

Loudspeakers are characterized by their impedance. Impedance is simply the magnitude of the ac resistance. When a voltage is applied to the loudspeaker, current is drawn and power is dissipated as sound pressure, heat and other losses. Because the impedance value varies for different ac frequencies, the power dissipated also varies.

A single number, called the characteristic impedance, is always provided by the loudspeaker manufacturer. Usually 4Ω or 8Ω, this number is chosen because it is the closest to the actual measured impedance. The impedance is measured at a frequency that is both higher than the fundamental resonance frequency of the loudspeaker, and is the minimum value.

For transformer coupled distributed loudspeaker systems, the characteristic impedance has been used for all calculations. However, when measuring a system, the ZM Meter will read the actual impedance and often this is different by up to 20%.

Not only does the loudspeaker impedance vary with frequency, many loudspeakers contain additional drivers, such as a woofer and tweeter, and a crossover network. These modify the impedance reading considerably.

c. Voltage Standards for Constant Voltage Lines:

Four voltage standards are used: In the USA 70.7 Volts is the industrial standard; some institutional and public school facilities use 25 Volts. 100 Volts are used in most other countries with some public facilities choosing 50 Volts.

7. MEASURING A LOUDSPEAKER

Each loudspeaker type should be measured for impedance at different frequencies. These readings become the "signature" for the loudspeaker. Changes in future impedance readings will then indicate a problem. For most accurate results, measure the complete loudspeaker, that is the driver(s) mounted in the enclosure, or ceiling baffle, etc.

The ZM Meter has four signal frequencies, 100Hz, 330Hz, 1kHz, and 10kHz. Data is generally always taken at 1KHz. 330Hz is provided because it is the frequency most often used for measuring the characteristic impedance. 100Hz and 10kHz gives additional information, especially for wide range systems with multiple drivers.

When measuring calculated power with the ZM Meter, it is best to take data at 330Hz or 1kHz. This is because the impedance values at these frequencies are close to the characteristic impedance. For example, if the 8Ω speaker read exactly 8Ω at 330Hz then the calculated watts in a transformer coupled system would read correct power at 330Hz. On the other hand, if the impedance were 10Ω instead of 8Ω, then the power reading would be in error by 25%.

It is therefore recommended to always measure and write down the impedance of the loudspeaker at all frequencies. Then, for calculated power, choose the frequency that reads closest to the characteristic impedance of 4, 8 or 16Ω to help make sure a distributed sound system is correctly wired.

8. MEASURING CALCULATED WATTS

Calculated watts is the equivalent power if the system voltage, such as 70.7, were applied to the loudspeaker system. The loudspeaker system is made up of one or more transformer coupled loudspeakers (whose impedance generally varies for different frequencies). If an 8Ω loudspeaker driver had measured 8Ω, then the power reading will be accurate with the transformer. The ZM Meter reads the total calculated power. That is, the reading is the arithmetic sum of all the transformer coupled loudspeaker power ratings. For example, if 9 loudspeakers were connected to 10 watt transformer taps (9x10W=90W), and 5 loudspeakers were connected to 20 watt transformer taps (5x20W=100W), then the total calculated power would be 190 watts (90W+100W=190W).

Note that the ZM Meter has four different system voltages, 100, 70.7, 50 and 25 Volts. These voltages simply change the calculation within the ZM Meter; no such output voltages are presented to the test leads.

A large distributed loudspeaker system often uses long wire runs that modify the impedance by adding distributed capacitance and inductance. Readings of power at 10kHz will be increased due to the added capacitance.

9. MEASURING A DISTRIBUTED LOUDSPEAKER SYSTEM

The following steps are recommended for measuring and confirming a distributed loudspeaker system:

1. Measure the transformer coupled loudspeakers before installation. Use 330Hz or 1kHz and choose the frequency that results in readings agreeing closest with the transformer markings....i.e. the 5 watt transformer tap reads 5 watts with the ZM Meter. Write down the readings.

2. Calculate the total power of the loudspeaker system. To do this, add up all the wattage values of the transformer taps.

3. Measure the loudspeaker system with the ZM Meter. ***Make sure the amplifier is disconnected.*** The reading of calculated power and impedance should agree with the total power, as designed. The exact power required will depend on the length of the wire runs to the loudspeakers, as some power is lost in the runs.

Interpreting the readings:

1. If the distributed loudspeaker system ZM Meter reading is close to the intended wattage, or impedance, then the system most likely is properly connected and may be safely connected to the amplifier for further checkout and use.

2. If the distributed loudspeaker system reads very high wattage such as over 600 watts, and near 8Ω impedance with the ZM Meter, then most likely a loudspeaker is connected
directly. The transformer was left off and the loudspeaker driver terminals are directly connected to the 70 Volt line (or 25, 50, or 100 Volt line). Each loudspeaker will have to be examined to find the one with the faulty connection.

3. If the distributed loudspeaker system ZM Meter reading was less than 8Ω, and much more that the intended wattage, such as over 1000 watts, then most likely the wiring has a short circuit and damage to the amplifier could result. The wiring must be examined and repaired.

10. MEASURING THE IMPEDANCE OF RESISTORS, CAPACITORS, INDUCTORS, NETWORKS

a. Resistors:

Resistor measurements are easily carried out. Simply connect the test leads to the resistor, apply any frequency and read the display. Note that for carbon and film resistors, the readings are essentially the same for all frequencies. For high value wire wound resistors, the readings at 10kHz may have some inductive reactance and raise the impedance reading slightly.

b. Capacitors:

The impedance of capacitors, called capacitive reactance, may be read by the meter. The reactance varies inversely with frequency; for example, the reactance at 10kHz will be ten times less than the reactance at 1kHz. The equation is:

$Z_c = 1/(6.28fC)$, where f = frequency in Hertz and C = Capacitance value in Farads

c. Inductors:

The impedance of inductors, called inductive reactance, may be read by the meter. The reactance varies directly with frequency; for example the reactance at 10kHz will be ten times more than the reactance at 1kHz. The equation is:

$Z_l = 6.28fL$, where f = frequency in Hertz and L = Inductance value in Henry's

Note that the ZM Meter can be used to determine the capacitor's or the inductor's value. Simply apply a given frequency to the part, read the impedance, and then look up the value on the graph. (Figure 2, Page 6.)

For example if at 1kHz a capacitor reads 160Ω impedance, then looking at the graph for 160 and intersecting with 1kHz, the capacitor value read 1.0 micro-farad.

d. Network impedance:

The ZM Meter will accurately measure the impedance of networks, made up of inductors, resistors, and capacitors. The impedance value given is the "magnitude" of the complex impedance; the ZM Meter does not separate the "real" from the quadrature ("imaginary") components.

It is pointed out that networks made up of capacitors and inductors have impedance values that differ greatly from the impedance of each individual component. For further information please review the many texts covering ac network theory.

The loudspeaker is a complex network. It is made up of voice coil wire resistance, voice coil inductance, electro-mechanical motional impedance, acoustical resonances, and sometimes a crossover network made up of inductors, capacitors, and resistors. The ZM Meter accurately reads the magnitude of this very complex network.

e. Transformer Impedance:

The ZM Meter will properly measure the impedance of a load coupled through a transformer. Therefore, always make sure there is a resistor (or a loudspeaker driver) connected to the transformer.

Note that the impedance of the load is modified by the turns ratio of the transformer. The equation is: $Z = (N_1/N_2)^2 Z_l$, where N_1 is the number of turns on the secondary, N_2 is the number of turns on the primary, and Z_l is the impedance of the load.

To measure the impedance of a transformer used for coupling loudspeakers, always make sure that the loudspeaker driver is connected.

11. ACCURACY AND RESOLUTION

The ZM Meter is inherently accurate due to the physics employed, namely a constant current source for measuring impedance, and a constant voltage source for measuring calculated power. Connecting a load to the meter modifies slightly the current and the voltage values as measured by the meter resulting in a maximum error of ± 2% for impedance and ± 3% for calculated watts for the ZM1/1P and ± 1% for impedance and ± 2% for calculated watts for the ZM2N.

The ZM Meter has been factory calibrated at 1,000 ohms on the 2K scale for impedance, and at 316 watts on the 2000 watt scale for calculated watts. Precision resistors used for the other scales assure that the ZM Meter will be typically ± 2%. The LCD permits 3½ digits of resolution. For maximum accuracy make sure that all the digits have a value. Note that the resolution diminishes for fewer digits, even though truncation appears to improve the accuracy. (Figure 3, Page 7.)

12. INJECTION SIGNALS

The ZM Meter presents a current or a voltage to the load and then measures the voltage or the current respectively to determine the impedance or the calculated watts.

For impedance, the ZM Meter presents a 42 Volt peak-to-peak signal to resistors in series with the load under test. The resistors are 2MΩ, 200kΩ, or 20kΩ for the 20kΩ, 2000Ω, and 200Ω impedance scales respectively. Note that the open circuit voltage appearing on the test jacks is limited to about 4 volts peak-to-peak.

For calculated watts, the ZM Meter presents a 0.6 Volt peak-to-peak output signal to resistors in series with the load under test. The resistors are 0.25, 2.5, and 25 ohms for the 2000 watt, 200 watt, and 20 watt scales respectively. The short circuit output current appearing on the test jacks is limited to about 100 milliamperes.

13. LINE / TONE INPUT (ZM2N Only)

A line/tone input jack is provided to feed special test signals to the system. For example, you can input a polarity test signal with a Gold Line Model APT2 polarity tester. This will insure that all loudspeakers are wired in the correct polarity.

NOTES:

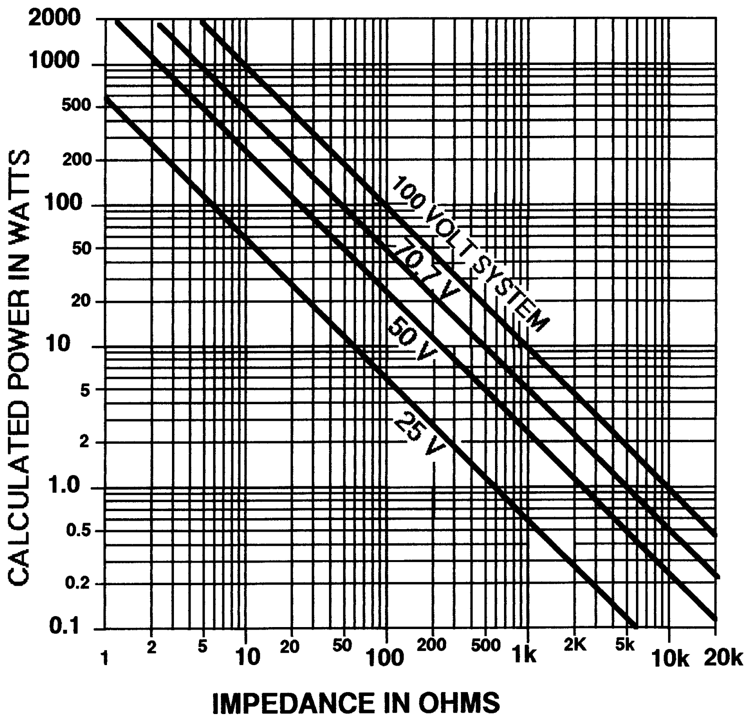

FIG 1. IMPEDANCE, VOLTAGE, AND WATTS FOR CONSTANT VOLTAGE SYSTEMS

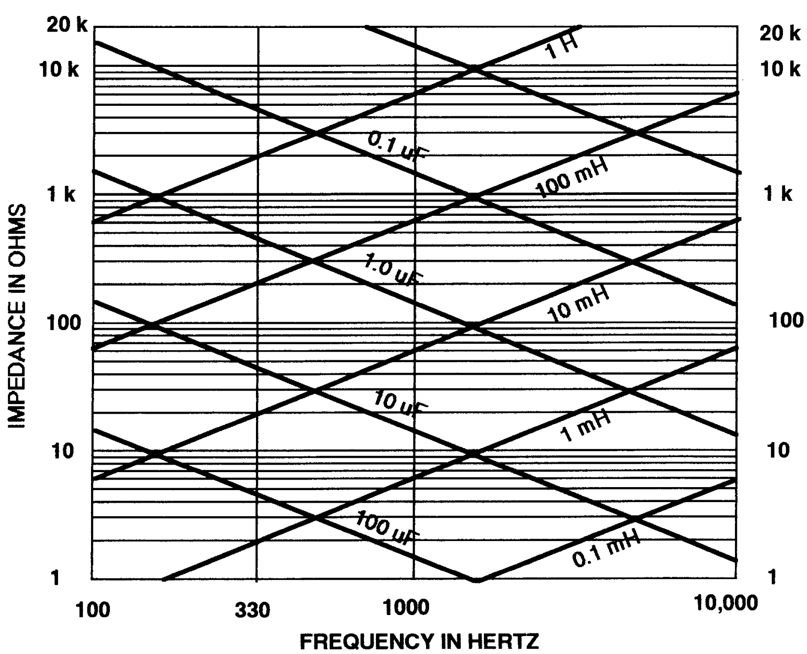

Fig 2: IMPEDANCE OF CAPACITORS AND INDUCTORS

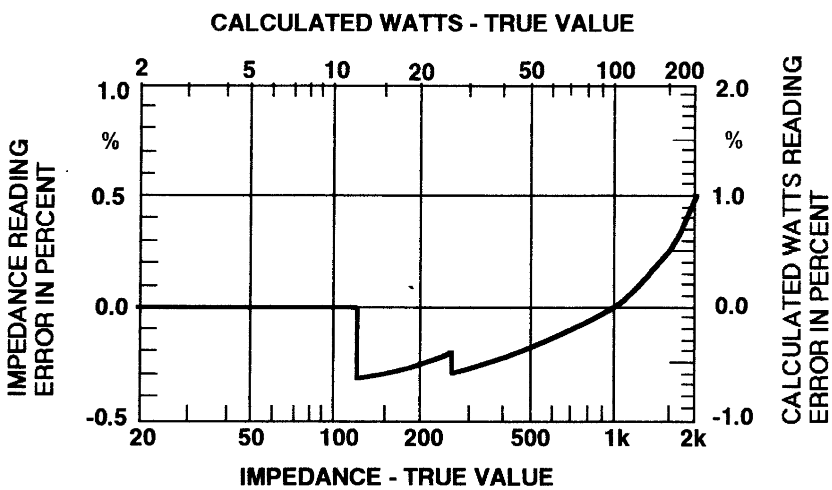

FIG 3: ACCURACY OF THE ZM-1 READING.

Add 0.5% to readings in other ranges.

NOTES:

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.
-

Pursuant to Part 15 of the FCC rules, any changes or modifications not expressly approved by Gold Line may cause harmful interference and void the FCC authorization to operate the equipment.

WARRANTY and Factory Service

GOLD LINE products are proudly made in the USA and are covered by a one year limited warranty. For details of this warranty, consult the enclosed warranty registration card or your local dealer.

GOLD LINE Customer Service will help you get the most from your new analyzer. For answers to questions regarding use of the unit, or for information not covered in this manual, please write us. If you are experiencing difficulties with your analyzer, please consult your dealer regarding factory service. If factory service is needed, you may call or fax us between 9:00am and 4:30pm US Eastern Time or send us an e-mail for instructions and a return authorization.

Enter your serial#______________Date of purchase__________________

NOTES:

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SPECIFICATIONS

Load / Output Connectors:	Banana Jacks
Display:	3 ½ Digit LCD
Accuracy (Typical):	Impedance ± 3% Wattage ± 2%
Test Frequencies:	100Hz, 330Hz, 1kHz, 10kHz
Voltage Ranges:	25Vac Some U.S. schools & institutions. 50Vac International. 70.7Vac U.S. Industrial standard. 100Vac International.
Impedance Measurement Ranges:	0 - 199.9 Ω (200Ω range) 0 - 1999 Ω (2000Ω range) 0 - 19.99 kΩ (20KΩ range)
Wattage Measurement Ranges:	0 - 19.99 watts (20 watt range) 0 - 199.9 watts (200 watt range) 0 - 1999 watts (2000 watts range)
Tone Generator - ZM1P:	400mv (-6dBu) - ½ sec. cycle
ZM2N:	70 Vac rms - ½ second cycle
Line / Tone Input - ZM2N Only:	¼" Phone TS 10k ohms
Power Requirement - ZM1/ZM1P:	Eight "AA" alkaline batteries
ZM2N:	16 "AA" alkaline, nicad, nickel metal-hydride batteries, 115VAC or 220VAC. Fuse - ¼A or 1/8A (¼ x 1¼ Fast Acting)
Expected Battery Life - ZM1/ZM1P:	Impedance mode: 35 hrs continuous Calculated watts mode: 23 hrs continuous
ZM2N:	Impedance mode: 70 hrs continuous Calculated watts mode: 50 hrs continuous
Approvals:	Emissions: - EN 55022 B - FCC Class B Immunity: - EN 55024 B
Size (W x H x D), Weight – ZM1/ZM1P:	3¼" x 8" x 2¼", 12oz.
ZM2N:	10¼" x 5" x 9½, 5 lbs.

GOLD LINE MANUFACTURED IN U.S.A. SINCE 1961

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