INSTRUCTION BOOK

FOR

MODEL OIB-1

OPERATING IMPEDANCE BRIDGE

Manufactured under
U. S. Patent No. 3,249,863

This technical manual applies to equipment
with serial numbers 001 and higher

Delta Electronics, Inc.
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Alexandria, Virginia 22312

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CERTIFICATE OF WARRANTY

Delta Electronics, Inc. warrants to Purchaser that the product it delivers is free of defects in materials and has high standards of quality and workmanship.

This warranty applies to the period of one year from the date of delivery except for component parts purchased from other sources and assembled into the equipment by Delta Electronics, Inc. Such component parts bear only the warranty of the manufacturer thereof in effect at the time of shipment to Purchaser.

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No other warranty is expressed or implied.

SAFETY WARNING

WARNING

Dangerous radio frequency voltages may be encountered when measuring high power active circuits. Exercise care in grounding the instrument before applying power.

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SPECIFICATIONS

Frequency Range:	0.5 MHz to 2 MHz Primary Range 0.5 MHz to 5 MHz Useful Range
Through Power Rating:	5 kW with VSWR 3:1 10 kW intermittent duty below 2 MHz
Insertion Effect:	Equal to 9" of 150 Ohm line
Resistance Range:	–400 to +400 Ohms Standard –1000 to +1000 Ohms with Range Extension Option
Reactance Range:	–300 to +300 Ohms at 1 MHz Standard –900 to +900 Ohms at 1 MHz with Range Extension Option
Resistance Accuracy:	± 2% ± 1 Ohm
Reactance Accuracy:	± 2% ± 1 Ohm
RF Source:	Transmitter, transmission line, etc., or signal generator with adapting connector
Detector:	Internal for high power source. BNC connector on front panel for external detector when used with signal generator. Optional switchable amplifier for high sensitivity.
Connectors:	Input and output are large UHF receptacles (UG-357/U). Standard 12" input and output clip leads supplied with bridge. Optional 18" leads available. External detector connector is BNC.
Physical:	13-1/2" High x 10" Wide x 8" Deep, 15 Lbs.

INSTRUCTION BOOK

FOR

MODEL OIB-1

OPERATING IMPEDANCE BRIDGE

SECTION 1

GENERAL INFORMATION

1.1 SCOPE

This instruction book describes the operation and maintenance of the Model OIB-1 Operating Impedance Bridge manufactured by Delta Electronics, Inc.

1.2 GENERAL DESCRIPTION

The Model OIB-1 Operating Impedance Bridge is an impedance measuring instrument based on a patented (U.S. Patent No. 3,249,863) bridge principle and designed specifically for measurement of AM broadcast antenna impedances. It permits the measurement of impedance under power with a minimum of insertion effects on the circuit being measured. The bridge will handle a through power of up to 5,000 Watts at moderate standing wave ratios. Resistance and reactance values are read directly from two dials located on the front panel. An internal detector is provided so that when the bridge is operating in a power circuit, no other instrument is required. An input adapter and external detector connector are also provided so that the Model OIB-1 may be used with a well shielded generator and receiver such as the Delta Electronics Model RG-3 or RG-4 Receiver/Generator for low power impedance measurements.

1.3 OPERATING IMPEDANCE

1.3.1 The term "operating impedance" is defined as the complex ratio of the voltage applied to a load to the current flowing in the load when it is operating under normal power and in its normal environment. In many cases, this impedance differs substantially from the "self-impedance" or "cold impedance" of the load. In antenna systems, for example, a separate radiator has a self-impedance when operating in free space. When it is combined in a directional antenna array, its operating impedance may differ from its self-impedance by the coupled impedances from adjacent radiator elements.

1.3.2 Many loads have an operating impedance which differs with applied power level. For example, a dummy load may have an operating impedance which varies with applied power levels. A plasma load is another example of an impedance which varies with RF power. In both cases, meaningful impedance measurements must, therefore, be made at the operating power level.

1.4 DIFFERENCES BETWEEN BRIDGES

1.4.1 The Model OIB-1 differs from bridges based on classical design in that the bridge can handle a substantial power level and cause a minimum of insertion effects. This permits the direct measurement of operating impedance as defined above. For example, in the dummy load example cited above, the Model OIB-1 can be inserted directly in the circuit and the operating impedance of the load measured under normal power. Bridges of a classical design are ordinarily incapable of handling large amounts of power. They measure the cold impedance of the load. When the matching circuits are adjusted from these measurements, it is found that a satisfactory match is not obtained when power is applied.

1.4.2 In measuring the operating impedance of various elements of a complex directional antenna, the installation of a normal bridge within the antenna circuit completely disturbs the relative magnitude and phase of the currents in the various radiators. The element under measurement, therefore, does not have the normal coupled impedance, and the measurements made do not give an impedance value which can be used to adjust the feeding system of the antenna. The Model OIB-1 Operating Impedance Bridge, on the other hand, can be installed directly in the circuit of each element, each transmission line, or each matching network, and the operating impedance level throughout the system can be determined. The data thus obtained can be used to match the entire antenna system and determine the power level throughout the complete system. Another distinct advantage of the OIB-1 is that a signal generator of substantial power can be used with the bridge for making antenna impedance measurements. Unlike bridges of a classical design, almost all of the signal generator output is applied to the load. The interference effects from adjacent antennas in operation, or from strong signals on nearby frequencies, can thus be minimized.

SECTION 2

OPERATING INSTRUCTIONS

2.1 IDENTIFICATION OF CONTROLS

2.1.1 Figure 2-1 is a photograph of the front panel of the Model OIB-1 Operating Impedance Bridge. A large UHF connector is mounted in the recess on each side of the case. The connectors are identified by markings directly above them on the front panel. The connector on the right is marked IN and the connector on the left is marked OUT. In normal operation, the power source is connected to the IN connector, and the load is connected to the OUT connector.

2.1.2 The lower group of controls on the panel operate the internal variable standards. The right dial, marked R, is calibrated directly in Ohms resistance. The lever switch immediately above this dial is the resistance adder switch. When the adder switch is in the 0 (zero) position, it is inactive. When the switch is in the +100 or +200 position, the value of resistance marked adjacent to the switch is added to the reading of the R dial to obtain the load resistance.

2.1.3 When the bridge is equipped with the optional range extension accessory, a second resistance adder switch provides resistance adders of 300 Ohms and 600 Ohms. When this adder switch is in the 0 (zero) position, it is inactive. When the switch is in the +300 or +600 position, the value of resistance marked adjacent to this switch is added to the value of the primary resistance adder switch and to the reading of the R dial to obtain the load resistance. The two adder switches may be used in any combination of settings to extend the resistance range of the bridge to 1000 Ohms.

2.1.4 The left dial is calibrated in Ohms of reactance at 1 MHz and marked X/F_{MHz}. The reactance adder switch is mounted immediately above this dial. When the adder switch is in the 0 (zero) position, it is inactive. When the switch is in the +100 or +200 position, the reactance value marked adjacent to the switch is added to the reading of the dial to obtain the reactance at 1 MHz. When measurements are made at frequencies other than 1 MHz, the reactance reading must be corrected by multiplying the value read by the frequency in megahertz. For example, if measurements are made at 1.5 MHz, and the total of the adder switch and the X dial reads 250 Ohms, the actual load reactance will be:

1.5 MHz X 250 Ohms = 375 Ohms

2.1.5 When the bridge is equipped with the optional range extension accessory, a second reactance adder switch provides reactance adders of 300 Ohms and 600 Ohms. When this adder switch is in the 0 (zero) position, it is inactive. When the switch is in the +300 or +600 position, the value of reactance marked adjacent to this switch is added to the value of the primary reactance adder switch and to the reading of the X dial to obtain the reactance at 1 MHz. The two adder switches may be used in any combination of settings to extend the reactance range at 1 MHz to ±900 Ohms. When measurements are made at frequencies other than 1 MHz, the reactance reading must be corrected by multiplying the value read by the frequency in megahertz.

FIGURE 2-1

MODEL OIB-1 OPERATING IMPEDANCE BRIDGE

2.1.6 The L–C switch between the dials in the center of the panel is for the selection of positive or negative reactance loads. If the load is inductive, the switch must be in the L position to obtain a null, and the reactance values read from the reactance dial are +j values. When the load is capacitive, the switch must be in the C position, and the reactance values are −j values. A bridge null can be obtained only when the switch is in the correct position.

2.1.7 The null indicating meter is located at the top center of the panel. A null is obtained by adjusting the resistance and reactance controls for a minimum reading on the meter. Immediately to the left of the meter is the TUNE-DIR switch. In the DIR position, the bridge is connected to the meter circuit without tuning. In the TUNE position(s), a resonant circuit is inserted between the bridge output and the meter for increased sensitivity. This circuit is tuned to the desired frequency by a variable capacitor operated by the TUNE knob to the far left of the meter. The Model OIB-1 bridges with serial numbers 001 through 1746 have one TUNE position that is applicable for the AM broadcast frequency range. The Model OIB-1 bridges with serial numbers 1747 and above have TUNE HI and TUNE LO positions that provide increased frequency coverage to beyond 2.5 MHz.

2.1.8 Immediately to the right of the meter is a switched marked FWD/REV. This switch must always be in the REV position for impedance measurements. The FWD position provides for standing wave ratio measurements as described in Section 2.8.

2.1.9 When the bridge is equipped with the optional DC Amplifier or RF Amplifier accessory, the FWD/REV switch is replaced by an AMP IN/OUT switch and the amplifier assembly is installed on the rear of the meter. When the AMP IN/OUT switch is in the OUT position, the detector circuit is connected directly to the bridge and the sensitivity control, marked SEN., controls the meter sensitivity. When the switch is in the AMP IN position, power is applied to the amplifier, the input of the amplifier is connected to the bridge circuit, and the meter is connected to the output of the amplifier. This amplifier increases the internal detector sensitivity for measurements in low power circuits.

2.1.10 To the far right of the indicating meter is a sensitivity control (SEN.) which adjusts the sensitivity of the meter. The sensitivity is increased by turning this knob in a clockwise direction.

2.2 IN-LINE IMPEDANCE MEASUREMENT UNDER POWER

WARNING

Dangerous radio frequency voltages may be encountered when measuring high power active circuits. Exercise care in grounding the instrument before applying power.

2.2.1 The simplest measurement that can be made with the bridge is the impedance level at a point along a coaxial transmission line. For this measurement, the line is interrupted, the end of the line coming from the source is connected to the IN connector and the end of the line toward the load is connected to the OUT connector. A power level of up to 5,000 Watts can be applied to the bridge with such connections. The controls are then adjusted as follows: Meter switch in DIR position, FWD/REV switch in REV position for standard bridges or amplifier switch in OUT position for bridges equipped with optional DC Amplifier or RF Amplifier accessory, gain (SEN.) control at minimum (full counterclockwise), R dial at zero, X dial at zero, L–C switch in L position, and all adder switches to 0. Power is then applied to the circuit and the gain (SEN.) control is advanced until an upscale indication on the meter is obtained. The R and X dials are then adjusted for a minimum reading on the meter.

2.2.2 If the reading on the meter is decreased when the X dial is advanced from zero, the load is inductive and a null can be obtained. If the reading is increased when the X dial is advanced from zero, the load is capacitive and the L–C switch must be changed to the C position. After a minimum has been obtained on the meter, the gain control is further advanced and additional adjustments are made on the R and X dials until a deep, sharp null is obtained. The R and X readings are noted and the X reading is corrected for frequency as described above.

2.2.3 If either the R or X dial is advanced to its maximum value before a null is obtained, it will be necessary to switch in one or more of the adder switches. When a null is obtained by the use of these switches, the values marked on the adder switches are added to the reading on the dials to obtain the load impedance.

2.2.4 Since the bridge will usually not be inserted directly into a line equipped with the proper connectors, a set of heavy clip leads is supplied for connecting the bridge into the antenna or matching network circuit. Both of the clip ground leads must be grounded when these leads are used. When measuring loads involving coaxial lines, the best accuracy is obtained by using coaxial adapters instead of the clip leads.

2.3 INCREASED DETECTOR SENSITIVITY WITH TUNE CIRCUIT 1

When the power level is not high, it may be necessary to increase the sensitivity of the indicating meter in order to obtain a more accurate null. This can be done with the TUNE circuit as follows. The TUNE-DIR switch is set to the single TUNE position (Model OIB-1 bridges with serial numbers 1746 and lower) or to the TUNE HI or TUNE LO position depending upon the frequency of operation (Model OIB-1 bridges with serial numbers 1747 and higher). The TUNE LO position provides a resonant circuit tunable from 530 kHz to approximately 1100 kHz and the TUNE HI position provides a resonant circuit tunable from 1100kHz to approximately 2500 kHz. The TUNE knob is rotated for a maximum meter deflection. Measurements are then made as before with increased meter sensitivity.

2.4 USE OF INTERNAL AMPLIFIER (DC OR RF AMPLIFIER OPTION ONLY)

When the bridge is equipped with the optional DC Amplifier or RF Amplifier accessory, a further sensitivity increase can be obtained by using the internal meter amplifier. The SEN. (gain) control should be turned to minimum and the amplifier switch placed in the IN position. The SEN. (gain) control is advanced slowly to obtain an upscale reading. The TUNE control should then be adjusted for maximum deflection. Impedance measurements can now be made as described above with maximum meter sensitivity.

2.5 OPERATING WITH EXTERNAL DETECTOR

2.5.1 At very low power levels, the meter sensitivity may not be high enough even when using the tuned circuit and the internal amplifier circuit. For this condition, an external detector connector is provided at the bottom left corner of the panel. A well shielded communications receiver or the receiver section of the Delta Electronics Model RG-3 or RG-4 Receiver/Generator connects using a double shielded coaxial cable to this connector and functions as an external null detector. Impedance measurements are then made as described above using the meter on the receiver or by nulling an audible tone. For this mode of operation, a signal generator or the generator section of the Model RG-4 operates as a power source and the OIB-1 functions as a normal impedance bridge.

2.5.2 When operated in this manner, the OIB-1 is somewhat more sensitive to stray coupling than a conventional bridge. The variable standards are necessarily isolated from the primary terminals of the bridge to permit high power operation. Thus, direct coupling by induction or leakage to the generator or receiver from the antenna under measurement can cause false nulls. To test for this condition, the receiver cable is disconnected from the external detector connector and then held against the connector so the cable shield circuit is made but not the inner conductor circuit. The receiver output should be quite low. The cable is then connected normally and the R dial moved from the null position just sufficiently to duplicate the receiver output observed above. The magnitude of the R dial deviation is then a good estimate of the error caused by the leakage.

2.5.3 The Delta Electronics Model RG-3 and RG-4 Receiver/ Generators are specifically designed for operation with the OIB-1. The Receiver/Generators provide over 120 dB of isolation between the generator and receiver sections, and double shielded coaxial cables are provided with each unit for connection to the OIB-1.

2.6 IMPROVING PRECISION BY SUBSTITUTION METHOD

Occasionally, it will be found that accuracies better than the accuracy of the bridge are desired. More accurate impedance measurements can be made by installing the bridge and adjusting for a null as described above. The bridge is then removed from the circuit without disturbing the setting of the controls. A signal generator, tuned to the same frequency, is connected to the IN connector and a communications receiver is connected to the external detector connector. A variable composition resistor, such as an RV4NAYSD102 or commercial equivalent, is connected to the OUT connector. A null is then established by adjusting the X dial (which should adjust to approximately zero), and by rotating the variable resistor. The resistor is then disconnected, and its value measured on an accurate ohmmeter or a Wheatstone bridge. Very accurate resistance determinations can be made in this fashion. Accurate reactance measurements can be made using a variable capacitor across the output connector. In this case, a null is reestablished by adjusting the R control on the bridge and by varying the capacitor. When the actual load is inductive, an initial balance is obtained on the L position of the L–C switch. It will be necessary to change this switch to the C position to reestablish the null with a variable capacitor. In this case, the reactance of the capacitor after the null is reestablished will equal the inductive reactance of the load.

2.7 MEASURING NEGATIVE IMPEDANCES

2.7.1 Quite often, in complex antenna systems, it is found that one or more of the elements has a negative operating impedance; that is, the total of the coupled impedance from all other elements exceeds the self-impedance of the element, and the element actually returns power to the matching network. It is necessary to know the magnitude of this negative impedance in order to match the feed system of the element and to determine the total power in all of the elements. This can be measured by simply reversing the connections to the bridge; that is, the source is connected to the OUT connector, and the load to the IN connector. The bridge is operated in the normal manner and the impedance is read from the dials of the bridge. The actual impedance of the load for this case is the negative of the impedance indicated.

2.7.2 The R dial of the OIB-1 is calibrated below zero to about −5 Ohms. This facilitates measurement of operating resistance values near zero without the reversing technique described above.

2.8 SWR MEASUREMENTS

The null indicator meter has a standing wave ratio scale. The bridge can be used to measure the SWR on a transmission line. The bridge is connected in a normal fashion as described in Section 2.2. The reactance dial is adjusted to zero, and the resistance dial is adjusted to the Z_0 of the transmission line to be measured. The FWD/REV switch is switched to the FWD position and the meter sensitivity is adjusted for a full scale reading. The FWD/REV switch is then changed to the REV position and the SWR is read directly from the indicating meter. It will be noted that SWR measurements can be made on lines having quite a range of characteristic impedance. SWR measurements can be made with reference to a complex impedance by simply adjusting the resistance and reactance dials to that reference. In this case, the frequency dependence of the reactance dial must be accounted for as described above. (The external detector is wired directly to the output of the coupler box and does not go through the FWD/REV switch. Therefore, SWR measurements with an external detector are not possible with this bridge.)

NOTE

The SWR scale is calibrated for a linear diode characteristic. The absolute value of SWR will thus be accurate only when the readings can be obtained with the gain control near minimum (thus a large diode voltage).

2.9 HIGH Q RESISTANCE MEASUREMENT CORRECTIONS

Due to a small interaction between the resistance and reactance measuring components, a correction should be made to the resistance measurement of a high Q circuit to realize the full accuracy of the bridge. A correction equation and a correction factor graph are provided in Appendix A.

SECTION 3

OPERATING PRINCIPLES AND CIRCUIT DESCRIPTION

3.1 THEORY OF OPERATION

3.1.1 Figure 3-1A is a simplified schematic diagram illustrating the operating principles. The circuit between the generator, G, and the load, Z_L, is interrupted by a short length of transmission line having a characteristic impedance of Z_{01}. A second section of transmission line having a characteristic impedance of Z_{02} is lightly coupled to this primary length of transmission line. The coupling coefficient between the two lines is k. Across the secondary line nearest the load is a meter circuit. Across the end of the secondary line nearest the generator is a variable standard reactance. The combination of these standards is identified as Z_s.

3.1.2 There will be two waves on the main transmission line: one direct wave carrying energy from the generator to the load, identified as W, and a reflected wave identified as $\Gamma_L W$. Quantity Γ_L is the reflection coefficient of the load impedance Z_L for the characteristic impedance of Z_{01}. Because of the coupling, k, these two waves induce waves in the secondary line. One wave is induced traveling toward Z_s, of magnitude kW, and another wave is induced traveling toward the meter of magnitude $k\Gamma_L W$. If the load impedance, Z_s, is not equal to Z_{02}, a third wave will exist on the line of magnitude, $k\Gamma_s W$. The direction of travel of this wave will be toward the meter. Γ_s is, of course, the reflection coefficient of the impedance Z_s for the characteristic impedance Z_{02}.

3.1.3 Therefore, two waves arrive at the meter circuit. They are $k\Gamma_s W$ and $k\Gamma_L W$. If these two waves are of equal magnitude and opposite time phase, the meter indication will be zero. The null condition of the bridge will be:

$$k\Gamma_L W = -k\Gamma_s W \tag{1}$$

or

$$\Gamma_L = -\Gamma_s \tag{2}$$

The reflection coefficients Γ_L and Γ_s are:

$$\Gamma_L = (Z_L - Z_{01})/(Z_L + Z_{01}) \tag{3A}$$

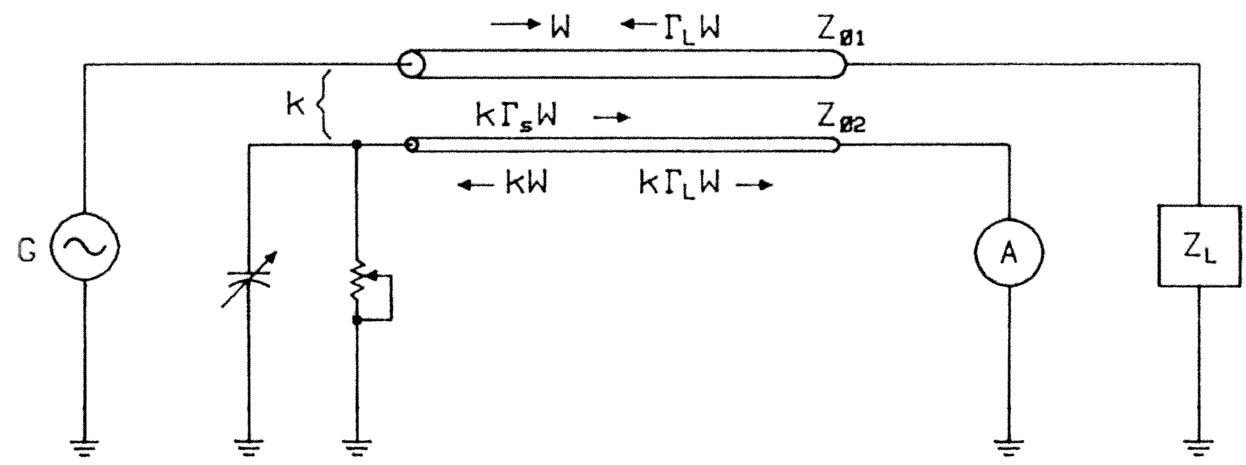
$$\Gamma_s = (Z_s - Z_{02})/(Z_s + Z_{02}) \tag{3B}$$

Replacing Γ_L and Γ_s in Equation 2 with these definitions and solving for Z_L:

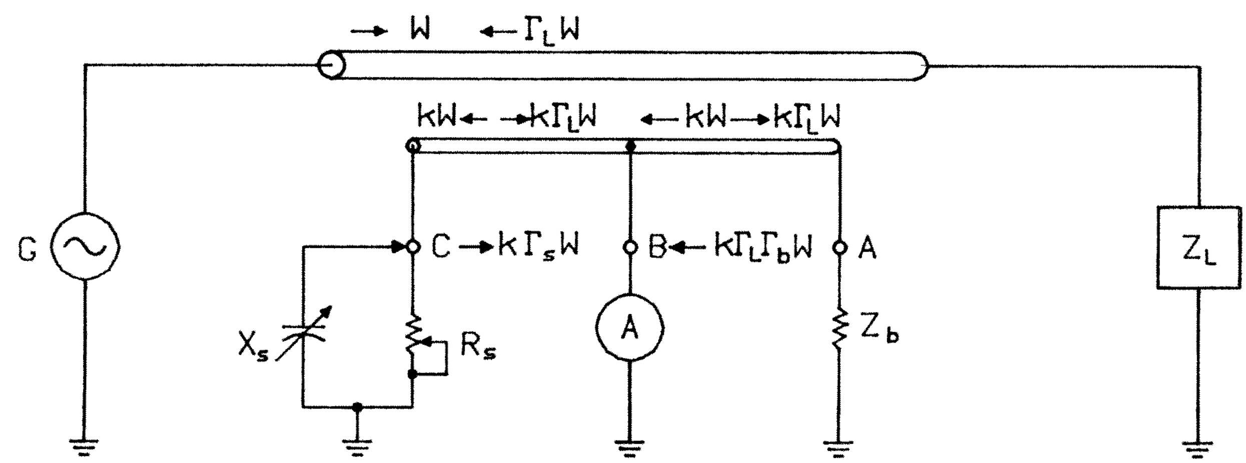
$$Z_L = (Z_{01}\, Z_{02})/Z_s \tag{4}$$

or

$$Z_L = Y_s\,(Z_{01}\, Z_{02}) = Y_s C \tag{5}$$



(A)



(B)

FIGURE 3-1

SIMPLIFIED SCHEMATIC DIAGRAM

3.1.4 The load impedance is directly proportional to the shunt admittance of the standard circuit. The constant of proportionality C is the product of the characteristic impedance of the main transmission line and the secondary transmission line. The constant has first-order independence of frequency. A standard circuit, using a parallel connected variable resistance and variable reactance, can be calibrated directly in the series equivalent load impedance.

3.1.5 The simplified circuit is useful for many purposes, but has several limitations as a general purpose measuring instrument. For example, if the load impedance Z_L is zero, the standard shunt resistance must be infinite. Also, if the reactive component of the load is inductive, a variable capacitor can be used as a standard. On the other hand, if the load is capacitive, a variable inductor is required for the standard. A satisfactory variable inductor of sufficiently high Q is not obtainable.

3.1.6 **Biasing Circuit** - These limitations may be removed by adding a biasing circuit. Figure 3-1B shows a simplified schematic diagram similar to Figure 3-1A with the biasing circuit. A short length of transmission line is inserted between the generator and the load impedance to be measured, and the secondary line is lightly coupled. Three connections are brought from the secondary line, indicated by terminals A, B and C. The line between terminals C and B is used as the secondary line shown in Figure 3-1A. The line section between terminals B and A is the bias section. As before, the variable standards are parallel connected across terminal C and an RF meter circuit is connected across terminal B. A biasing impedance is connected across terminal A. The waves induced on the two secondary line sections from the direct wave W and the reflected wave LW, are shown in Figure 3-1B. The total of the waves arriving at the meter circuit is equated to zero:

$$\Gamma_s + \Gamma_L + 1 + \Gamma_L \Gamma_b = 0 \qquad (6)$$

where Γ_b is the reflection coefficient of Z_b terminating the bias line.

3.1.7 When these reflection coefficients are replaced by their defining impedance ratios, and the resulting equation is solved for Z_L, then

$$Z_L = (C/2)\, Y_s - (C/2)\, Y_b \qquad (7)$$

3.1.8 This result is obtained, assuming an exact center tap of the secondary line. Other tap ratios may be used, but they will modify this equation. Equation 7 is similar to Equation 5, except that a negative term has been added. This means that the negative of the bias admittance Y_b is effectively in parallel with the admittance of the standard Y_s. The two limitations of the circuit in Figure 3-1A are now circumvented, and the requirement for an infinite resistance standard no longer exists. When Z_L is zero, it is only necessary that Y_s and Y_b be equal. Neither is required to be zero. It is not necessary to have a variable inductor for capacitive loads. The variable capacitor standard can be switched from terminal C to terminal A. Equation 7 shows that this has the effect of reversing the sign of the susceptance of this standard.

3.2 CIRCUIT DESCRIPTION

3.2.1 Figure 3-2A is the schematic diagram for the Model OIB-1 Operating Impedance Bridge for serial numbers 1747 and higher. Figure 3-2B is the schematic diagram for the Model OIB-1 Operating Impedance Bridge for serial numbers 001 through 1746. With the exception of the TUNE circuit as described in Section 3.2.3, the schematic diagrams are identical and the following circuit description applies to all bridges. The left side of Figure 3-2A/3-2B is the schematic diagram for the Standards Circuit. The coupler box consists of a heavy rod suspended directly between the IN and OUT connector. This center conductor, along with the shielding box, forms the primary line and has a characteristic impedance of approximately 150 Ohms. The secondary line is formed by a small rod mounted from the cover of the shielding box by three shielded Teflon feed-through terminals. These terminals are the A, B and C points shown in Figure 3-1B. The shielding box should never be opened in the field since this will affect the primary calibration of the bridge.

3.2.2 The components in the Standards Circuit are selected for both their RF characteristics and long term stability. The variable R dial resistor (R1) is a special precision, low noise, cermet potentiometer. The resistance adder resistors (R4 and R5 for standard bridge; R4, R5, R9 and R10 for bridge equipped with optional range extension accessory) are high stability metal film units of values individually selected to calibrate each bridge.

3.2.3 The right side of Figure 3-2A/3-2B is the schematic diagram for the Meter Circuit. With the FWD/REV switch, S6, in the REV position and with the TUNE-DIR switch, S5, in the DIR (Direct) Position, the Meter Circuit is a straight-forward RF detector providing DC current through the SEN Control, S8, for the null meter, M1. With the TUNE-DIR set to the appropriate tune position, TUNE, TUNE HI or TUNE LO, an "L" section tuned circuit is inserted ahead of the detector for increased sensitivity. The TUNE control, C6, adjusts for a resonance peak on M1.

3.3 RF AMPLIFIER ASSEMBLY

The optional RF amplifier increases the signal to the detector for increased sensitivity with low power sources and results in a sharper, more accurate null. Figure 3-2C is the schematic diagram of the Meter Circuit with the RF amplifier option. When this assembly is installed, the FWD/REV switch is replaced by the AMP IN-OUT switch. The amplifier assembly is mounted on a printed circuit board and contained within a shielded box behind the AMP IN-OUT switch.

3.4 DC AMPLIFIER ASSEMBLY

Figure 3-2D shows the schematic diagram of the Meter Circuit with the optional DC Amplifier Assembly. This DC amplifier has been replaced on current design bridges with the RF amplifier described above. This DC amplifier circuit uses a differential amplifier to provide approximately 20 dB gain. When this assembly is installed, the FWD/REV switch is replaced by the AMP IN-OUT switch. The amplifier assembly is mounted on a printed circuit board and secured to the back of the meter by the meter terminal bolts.

SECTION 4

MAINTENANCE

4.1 GENERAL

Due to the complexity of the RF distributed circuit and the interaction of all controls, it is recommended that field maintenance not be attempted on this unit. If the unit is damaged or ceases to function, it should be returned to the factory for maintenance and calibration.

NOTE

A precision cermet potentiometer is used as a variable standard resistance in this bridge. Each of these potentiometers is carefully tested for acceptable level of electrical noise caused by contact resistance prior to installation in a bridge. However, with use and resulting mechanical wear, the potentiometer will eventually become "noisy" and obtaining sharp nulls will become difficult. In severe instances, multiple nulls will be observed. For proper operation, a "noisy" potentiometer must be replaced along with its matching R dial.

DO NOT attempt to break the seal on the potentiometer for cleaning purposes.

4.2 MECHANICAL STOP SET OF DIALS

The resistance and reactance dials directly control the variable standard resistance, R1, and the variable standard capacitance, C1, respectively. A mechanical stop mark is engraved on the dials (below the zero ohm marks) for use in properly positioning these dials on the control shafts. In the event that the dials are removed or the screws become loose, the dials can be positioned on the shafts as follows. Rotate the variable standard resistor clockwise until the mechanical stop of the resistor is reached. The resistance dial is then positioned so the mechanical stop mark is directly below the R dial indicator. The set screw on the resistance dial is then secured. The reactance dial can be set in the same manner, with the variable capacitance standard adjusted fully clockwise to its mechanical stop and the dial's mechanical stop mark aligned with the X dial indicator.

4.3 ELECTRICAL ZERO SET

The electrical zero of these two controls can be adjusted as follows. A generator adjusted to 1 MHz is connected to the IN connector of the bridge and a short circuit is connected across the OUT connector. An external detector is used. The R and X dials are set to the zero Ohm position; the L−C switch is set to L; the resistor, R6 (R zero set), and capacitor, C4 (X zero set), are then adjusted by an insulated alignment tool for a bridge balance. Since the instrument panel must be removed from the case for this adjustment, it is extremely important that both the signal generator and the null detector are well shielded. The instrument panel is then remounted in the case and the results of this adjustment checked.

4.4 RESISTANCE RANGE SET

If an accurate 100 Ohm high frequency resistor is available, the resistance dial 100 Ohm calibration can be set. This is done by connecting the bridge, as described above, with the 100 Ohm resistor across the OUT connector. The X dial is adjusted for zero and the R dial is adjusted to 100 Ohms. Resistor R3 (R 100 set) is then adjusted with an insulated alignment tool for a bridge balance. The resistance dials are individually calibrated and engraved at the factory for each bridge. If the zero and 100 Ohm dial points are properly adjusted as described above, other dial points should be quite accurate.

4.5 REPLACEMENT OF BATTERY (RF AMPLIFIER OPTION ONLY)

An alkaline battery is used to power the RF Amplifier Assembly. The current drain on this battery is approximately 4 mA in normal use. The alkaline battery will typically provide 400 hours of amplifier operation prior to requiring replacement. It is recommended, however, to remove the battery panel from the bridge case and check the battery voltage at frequent intervals. The battery voltage should be measured with the amplifier energized. When this voltage is less than approximately 7.5 Volts, the battery should be replaced. While any 9 Volt rectangular battery may be used for replacement purposes, it is recommended that alkaline batteries (Mallory MN1604 or equivalent), rather than zinc-carbon batteries, be used for maximum operational life.

4.6 REPLACEMENT OF BATTERY (DC AMPLIFIER OPTION ONLY)

4.6.1 A 10.5 volt alkaline battery powers the differential DC Amplifier. With current drain on this battery of approximately 0.7 mA, the battery will provide approximately 150 hours of operation. Check the battery at frequent intervals for proper operating voltage. The battery voltage should be measured with the amplifier on. When this voltage is less than approximately 8.5 volts, the battery should be replaced.

4.6.2 To replace the amplifier battery, the bridge must be removed from its case. To do this, remove the twelve 6-32 screws from around the edges of the panel and the four 8-32 screws on each side of the case. Remove the bridge from the case, being careful not to move or damage the components or interconnecting straps. Insert the new battery (Duracell PC177A or equivalent) with polarity as marked on the circuit board. To conserve battery life, always return the AMP IN/OUT switch to the OUT (down) position whenever use of the amplifier is not required.

4.7 AMPLIFIER ZERO ADJUSTMENT (DC AMPLIFIER OPTION ONLY)

Should the meter not indicate zero with the amplifier turned on and no signal applied, adjust the amplifier zero trimpot located on the front panel.

4.8 OTHER MAINTENANCE

It is recommended that no other maintenance be done on the standards section of the bridge. Normal maintenance, such as resistor testing or amplifier circuit testing can be performed on the null detector section of the bridge without jeopardizing the accuracy of the bridge.

SECTION 5

LIST OF MATERIAL

5.1 INTRODUCTION

5.1.1 Maintenance parts in the OIB-1 are identified by reference designations. These designations are used on the photographs, schematic diagrams, and lists of material to identify the components. The component reference designation is also marked adjacent to the component on the printed circuit assembly. The letter(s) in the reference designation identifies the class of item such as a resistor, integrated circuit, or transistor or identifies a subassembly such as printed circuit assembly. The number differentiates between parts or subassemblies of the same class.

5.1.2 Reference designations for the parts of a subassembly consist of the part's standard reference designation preceded by the reference designation for the subassembly. For example, reference designation A1R2 identifies resistor number 2 on subassembly number 1. When all of the prefixes are identical on a schematic diagram or printed circuit board, they may be omitted for brevity and a note to that effect is placed on the drawing or circuit board.

5.1.3 The lists of material for the Model OIB-1 Operating Impedance Bridge are presented as follows:

MODEL OIB-1 OPERATING IMPEDANCE BRIDGE LISTS OF MATERIAL

TABLE OF CONTENTS

5.2 LIST OF MATERIAL, OIB-1 SYSTEM COMPONENTS

Ref Des	Description	Manufacturer	Manufacturer Part No.	Delta Order No.
Unit 1	Model OIB-1 Operating Impedance Bridge	Delta	D20-1	920-0001
W1, W2	Adapter Leads, 12" (Standard)	Delta	D51-3-1	051-0003-001
W1, W2	Adapter Leads, 18" (Optional)	Delta	D51-3-2	051-0003-002
---	Adapter, BNC to Large UHF	Delta	D81-13	081-0013
---	Technical Manual	Delta	D93-15C	093-0015

5.3 LIST OF MATERIAL, FINAL ASSEMBLY, MODEL OIB-1 OPERATING IMPEDANCEBRIDGE, D20-1

Ref Des	Description	Manufacturer	Manufacturer Part No.	Delta Order No.
A1*	Assembly, DC Amplifier	Delta	D33-54	033-0054
A1**	Assembly, RF Amplifier	Delta	D33-145	033-0145
A2	Tuning Assembly (SN≥1747)	Delta	D33-510-1	033-0510-001
A2C1	Capacitor, Fixed, Ceramic, 0.01μF	Sprague	5GAS-S10	310-0021
A2CR1	Diode		1N34A	410-0034-001
A2L1	Inductor, Var, Tuning	Delta	D63-74-1	063-0074-001
A2L2	Inductor, Var, Tuning	Delta	D63-74-2	063-0074-002
BT1*	Battery, Alkaline, 10.5V	Duracell	PC177A	606-0002
BT1**	Battery, Alkaline, 9V	Duracell	MN1604B	606-0001
C1	Capacitor, Variable	Jackson Brothers	4507/2/MOD/LH/532	340-0004
C2	Capacitor, Variable, 100-500 pF	Sprague Elmenco	GME50401304MH	342-0001
C2.5	Capacitor, Fixed, Mica, 750 pF	Elmenco	DM19-751J03	304-0751-001
C3	Same as C2			
C3.5	Capacitor, Fixed, Mica, 1600 pF	Elmenco	DM19-162J03	304-0162
C4	Capacitor, Variable, 4.5-100 pF	Delta	D05-60-1	005-0060-001
C5	Capacitor, Variable, 7-60 pF	Sprague	GMA20400	
C6	Capacitor, Variable, 13.5-320 pF, (SN ≤ 1746)	Delta	D05-59-3	005-0059-003
C6	Capacitor, Variable, 10-365 pF, (SN ≥ 1747)	Delta	D05-165-1	005-0165-001
C7	Capacitor, Fixed, Ceramic, 6800 pF NPO (SN≤ 1746)	Murata Erie Centralab	RPE113COG682-J100V CN30A682J	312-0027
C8	Capacitor, Fixed, Ceramic, 0.01 μF	Sprague	5GA-S10	310-0017
C9+	Capacitor, Variable, 275-970 pF	Sprague Elmenco	GME10601306M	342-0004
C10+	Same as C9			

* Applicable if bridge equipped with DC Amplifier accessory

** Applicable if bridge equipped with RF Amplifier accessory

\+ Applicable is bridge equipped with Range Extension accessory

5.3 LIST OF MATERIAL, FINAL ASSEMBLY, MODEL OIB-1 OPERATING IMPEDANCEBRIDGE, D20-1

Ref Des	Description	Manufacturer	Manufacturer Part No.	Delta Order No.
C12+	Capacitor, Fixed, Mica, 2400 pF	Elmenco	DM19-242J03	304-024
CR1	Diode		1N34A	410-0034-001
J1	Connector, BNC, Panel Mount		UG-1094/U	612-0023
J2	Connector, RF	TRU	3527	612-0027
J3	Same as J2			
L1	Coil, Antenna (SN ≤ 1746)	Miller	A-123-A	352-0023
M1	Meter, 100 uADC	Delta	D02-3	002-0003
R1	Potentiometer, 500 ohm	Delta	D05-8	005-0008
R2	Resistor, Fixed, Film, 121 Ohm, 1%, 3/4W		RN70C1210F	218-1210-001
R3	Potentiometer, 500 Ohm		RV4NAYSD501A	240-0003
R4	Resistor, Fixed, Film, 8.25 Ohm, 1%, 3/4W		RN70D82R5F	218-0825
R5	Resistor, Fixed, Film, 150 Ohm, 1%, 3/4W		RN70D1500F	218-1500
R6	Same as R3			
R7	Resistor, Fixed, Film, 274 Ohm, 1%, 3/4W		RN70D2740F	218-2740
R8	Potentiometer, 100k Ohm, Logarithmic Taper	Allen Bradly	JA1N200P104AA	240-0020
R9+	Resistor, Fixed, Film, 26.1 Ohm, 1%, 3/4W		RN70D26R1F	218-0261
R10+	Resistor, Fixed, Film, 52.3 Ohm, 1%, 3/4W		RN70D52R3F	218-0523
S1	Switch, Lever, DP3T	Electroswitch	1452	666-0001
S2	Same as S1			
S3	Same as S1			
S4	Switch, Lever, DP2T	Electroswitch	1458	666-0002
S5	Same as S1			

* Applicable if bridge equipped with DC Amplifier accessory

** Applicable if bridge equipped with RF Amplifier accessory

\+ Applicable is bridge equipped with Range Extension accessory

5.3 LIST OF MATERIAL, FINAL ASSEMBLY, MODEL OIB-1 OPERATING IMPEDANCEBRIDGE, D20-1

Ref Des	Description	Manufacturer	Manufacturer Part No.	Delta Order No.
S6+	Same as S1			
S7+	Same as S1			

* Applicable if bridge equipped with DC Amplifier accessory

** Applicable if bridge equipped with RF Amplifier accessory

\+ Applicable is bridge equipped with Range Extension accessory

5.4 LIST OF MATERIAL, DC AMPLIFIER ASSEMBLY, D33-54

Ref Des	Description	Manufacturer	Manufacturer Part No.	Delta Order No.
A1R11	Resistor, Variable, 10K Ohm, 10%	Bourns	271-1-103M	244-0032
A1R12	Resistor, Variable, 100K Ohm, 10%	Bourns	3068P-1-104	244-0049
A1R13	Resistor, Fixed, Film, 47 Ohm, 5%, 1/4W		RL07S470J	202-0470
A1R14	Same as A1R13			
A1R15	Resistor, Fixed, Film, 270K Ohm, 5%, 1/4W		RL07S274J	202-0274
A1R16	Same as A1R15			
A1TR1	Transistor		2N335	420-0335
A1TR2	Same as A1TR1			

5.5 LIST OF MATERIAL, RF AMPLIFIER ASSEMBLY, D33-145

Ref Des	Description	Manufacturer	Manufacturer Part No.	Delta Order No.
A1C1	Capacitor, Fixed, Ceramic, 0.01 μF, 50V	Centralab	CK103	310-0037
A1C2	Capacitor, Fixed, Poly Film, 0.1 μF, 100 VDC/63 VAC	REI	MKT1822410015	330-0001
A1C3	Same as A1C1			
A1C4	Same as A1C2			
A1C5	Capacitor, Fixed, Poly Film, 1 μF, 100 VDC/63 VAC	REI	MKT1822510015	330-0006
A1CR1	Diode		1N34A	410-0034-001
A1R1	Resistor, Fixed, Film, 1K Ohm, 5%, 1/4W		RL07S102J	202-0102
A1R2	Resistor, Fixed, Film, 47K Ohm, 5%, 1/4W		RL07S473J	202-0473
A1R3	Same as A1R2			
A1R4	Resistor, Fixed, Film, 6.8K Ohm, 5%, 1/4W		RL07S682J	202-0682
A1R5	Resistor, Fixed, Film, 820 Ohm, 5%, 1/4W		RL07S821J	202-0821
A1U1	Integrated Circuit, IF Amp	RCA	CA3002	540-0006

APPENDIX A

HIGH Q RESISTANCE MEASUREMENT CORRECTION

Because of a light interaction between the resistance and reactance measuring components, a correction must be made to the resistance measurement of a high Q circuit (low resistance and high reactance) to realize the full accuracy of the bridge. The correction factor, C_R, can be computed from the following equation:

$$C_R = (X)(F)(0.009 - 0.00014R)$$

Where:

X is dial reactance before frequency correction,
F is measurement frequency, and
R is dial resistance.

Example:

10 – j100   Bridge Dial Readings at 680 kHz (frequency F = 0.68 MHz)

$$C_R = -100F\,[0.009 - 0.00014\,(10)]$$
$$= -100F\,[0.009 - 0.0014]$$
$$= -100F\,[0.0076] = -0.76\,F$$

Correcting for frequency F = 0.68 MHz

$$C_R = -0.76\,(0.68) = -0.52$$

True Resistance: 10 – 0.52 = 9.48 Ohms

Note that the correction is negative for capacitor loads and positive for inductor loads.

The correction equation has been plotted for reactance readings up to 200 ohms in Figure A-1. The correction can be read directly from this figure. The example above is illustrated by the dotted lines on the graph. The correction read from the graph must be multiplied by the frequency in MHz. These corrections are usually not significant for resistances above about 50 Ohms.

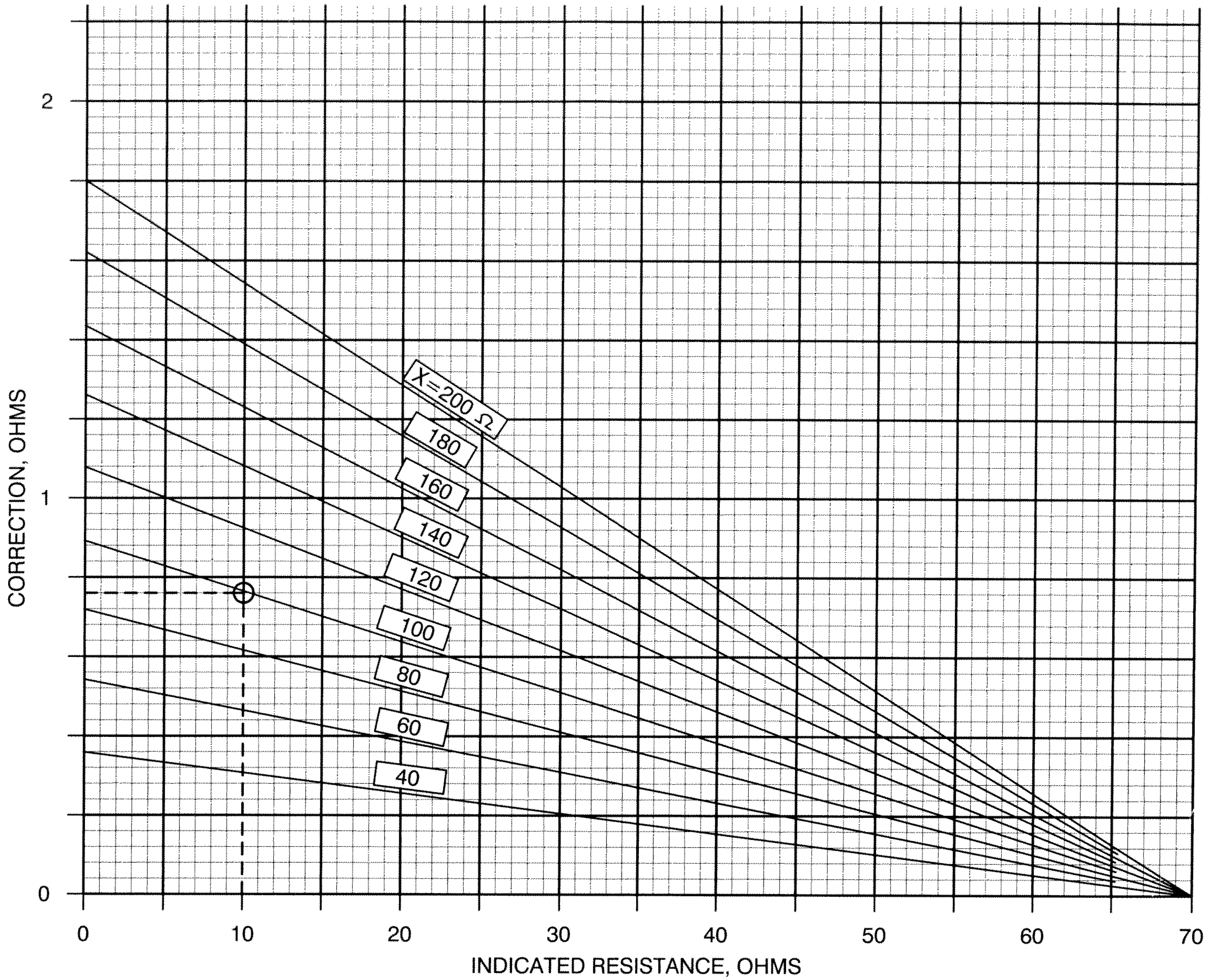


FIGURE A-1

CORRECTION FACTOR