INSTRUCTION BOOK

FOR

MODEL OIB-2

HIGH FREQUENCY

OPERATING IMPEDANCE BRIDGE

USER MANUAL WIKI.COM

DELTA ELECTRONICS

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HIGH FREQUENCY

OPERATING IMPEDANCE BRIDGE

MANUFACTURED UNDER
U.S. PATENT NO.
3,249,863

THIS TECHNICAL MANUAL APPLIES ONLY TO EQUIPMENT
WITH SERIAL NUMBER 212 AND HIGHER

SAFETY WARNINGS AND CAUTIONS

WARNING

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

CAUTION

To protect the MOS/FET operational amplifier of the DC Amplifier Assembly from electrostatic discharge, the following operating and handling procedures should be observed:

1. Do not solder any connections to the DC Amplifier Assembly, A1, with the operational amplifier, A1U1, installed in the circuit.

2. Do not remove or install the operational amplifier, A1U1, with power applied, i.e., Amplifier Switch at In position.

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SPECIFICATIONS

Frequency Range:	2 MHz to 30 MHz
Through Power Rating:	1 kW with VSWR 3:1
Insertion Effect:	Equal to 5" of 150 Ohm line
Resistance Range:	-500 to +500 Ohms
Reactance Range:	-800 to +800 Ohms at 10 MHz
Resistance Accuracy:	±5% ±1 Ohm
Reactance Accuracy:	±5% ±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.
Connectors:	Input and output are Type N receptacles. 6" output clip leads supplied with bridge. External detector connector is BNC.
Physical:	9" high X 7" wide X 6-1/4" deep; 8 lbs.

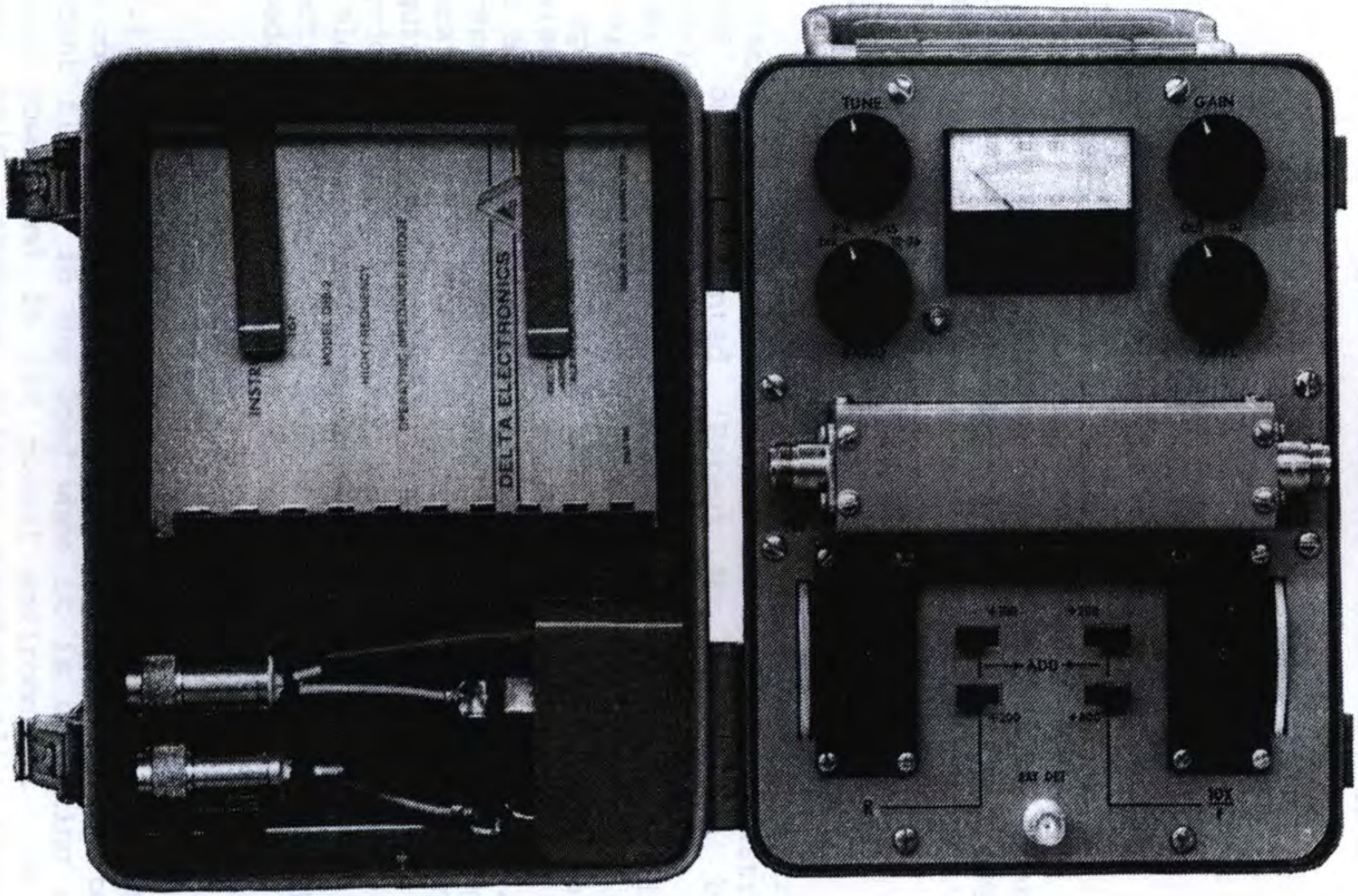


FIGURE I-I
ILLUSTRATION OF COMPLETE EQUIPMENT

INSTRUCTION BOOK

FOR

MODEL OIB-2

HIGH FREQUENCY OPERATING IMPEDANCE BRIDGE

SECTION 1

GENERAL INFORMATION

1.1 SCOPE

This instruction book describes the operation and maintenance of the Model OIB-2 High Frequency Operating Impedance Bridge manufactured by Delta Electronics, Inc.

1.2 GENERAL DESCRIPTION

The Model OIB-2 High Frequency Operating Impedance Bridge is an impedance measuring instrument based on a patented (Patent No. 3,249,863) bridge principle. 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 1,000 Watts at moderate standing wave ratios. Resistance and reactance values are read directly from two drum dials located on the front of the panel. An internal detector is provided so that when the bridge is operating in a power circuit, no other instrument is required. An external detector connector is also provided so that the Model OIB-2 may be used with a well shielded generator and receiver such as the Delta Electronics Model 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 an antenna array, its operating impedance differs from its self-impedance by the coupled impedances from adjacent radiator elements, or its image.

1.3.2 Many loads have an operating impedance which differs with applied power level. In dielectric heating applications, for example, the operating impedance of the dielectric varies substantially with applied power. 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-2 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 dielectric heating problem cited above, the Model OIB-2 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-2 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-2 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. This permits measurements in an antenna array that would otherwise require closing down the entire station.

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-2 Operating Impedance Bridge. The front panel is divided into two parts by the coupling box. A Type N connector is mounted on each end of the coupling box. The connector on the left is marked IN and the connector on the right 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 controls on the panel below the coupling box operate the internal variable standards. The left drum dial is calibrated directly in Ohms resistance. The two switches immediately to the right of this dial are the 100 Ohm and 200 Ohm adder switches. When these switches are positioned toward the drum dial, they are inactive. When they are positioned toward the center of the panel, the value of resistance marked adjacent to each switch is added to the reading of the drum dial to obtain the load resistance. The right drum dial is calibrated in Ohms of reactance at 10 MHz. The two reactance adder switches are mounted immediately to the left of this dial. They are active when they are positioned toward the center of the panel. In this position, the reactance value marked adjacent to the switch is added to the reading of the drum dial to obtain the reactance at 10 MHz. When measurements are made at frequencies other than 10 MHz, the reactance reading must be corrected by multiplying the value read by the frequency in megahertz and dividing by 10. For example, if measurements are made at 5 MHz, and the total of the adder switch and drum dial reads 250 Ohms, the actual load reactance will be:

$$(5 \text{ MHz} \times 250 \text{ Ohms})/10 \text{ MHz} = 125 \text{ Ohms}$$

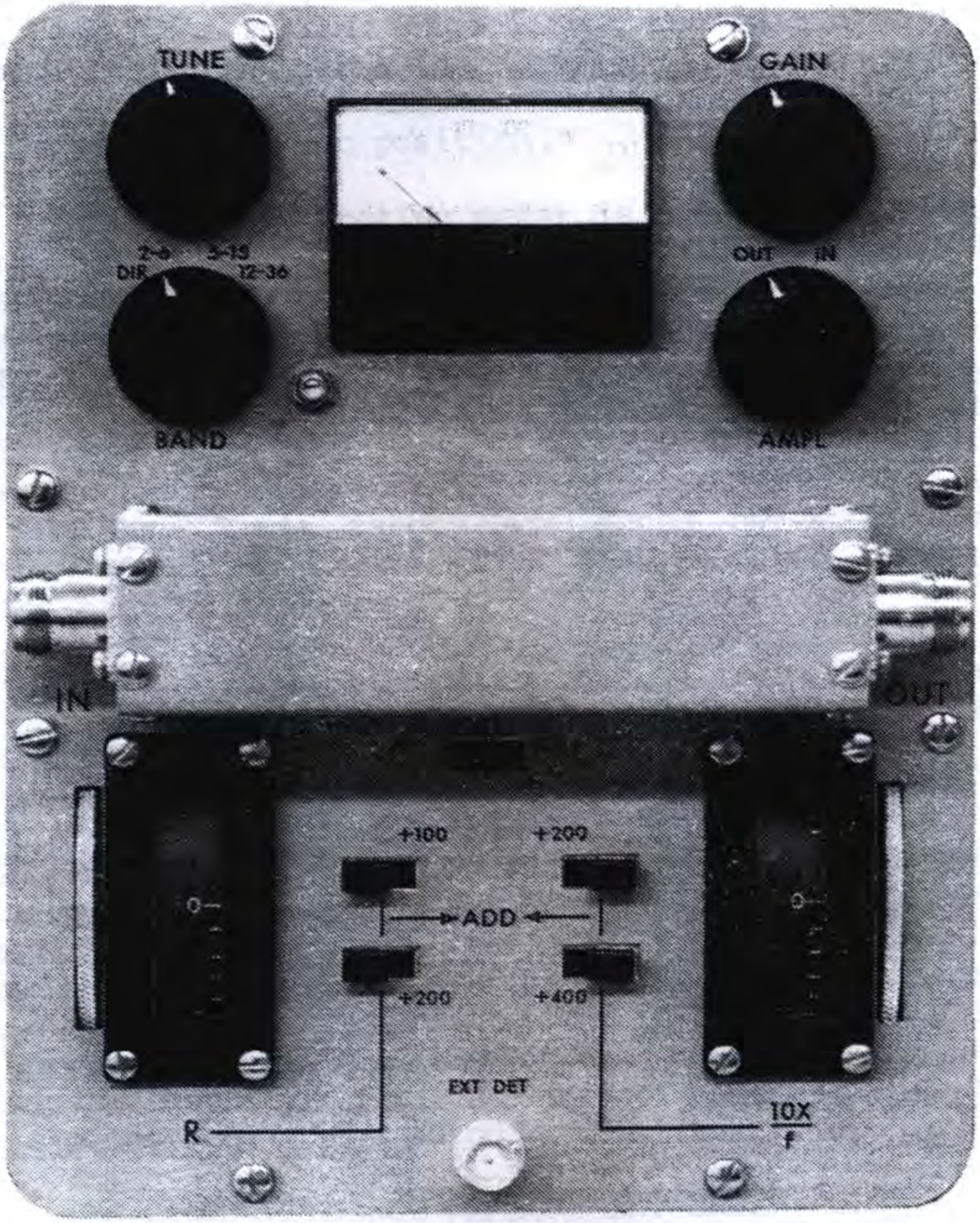


FIGURE 2-1
OIB-2 FRONT PANEL CONTROLS

The L-C switch directly beneath the coupler box 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.

2.1.3 The null indicating meter is directly above the coupling box. 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 a band switch. In the DIR position, the output of the bridge is connected directly to the meter circuit without tuning. Three other positions are provided on the dial for the frequency ranges of 2 to 6 MHz, 5 to 15 MHz, and 12 to 36 MHz. These ranges are tuned by a variable capacitor connected to the TUNE knob located directly above the band switch knob.

2.1.4 To the right of the indicating meter is a gain control which adjusts the sensitivity of the meter. The sensitivity is increased by turning this knob in a clockwise direction. Immediately below the gain knob is an amplifier switch. This switch applies power to an internal MOS/FET operational amplifier to increase the sensitivity of the meter by approximately 20 dB. When this switch is in the OUT position, the amplifier is inactive and the meter is connected directly to the bridge circuit. When the switch is in the 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.

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 of the coupling box and the end of the line toward the load is connected to the OUT connector. A power level of up to 1,000 Watts can be applied to the bridge with such connections. The controls are then adjusted as follows: Band switch in DIR position, amplifier switch in OUT position, gain control at minimum (full counterclockwise), R drum dial at zero, X drum dial at zero, L-C switch in L position, and all adder switches out (away from the center of the panel). Power is then applied to the circuit and the gain 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 further 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 drum 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 should 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

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 band switch knob is advanced to the range required for the frequency of the measurement. 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

A further sensitivity increase can be obtained by using the internal meter amplifier. The GAIN control should be turned to minimum and the amplifier switch turned to the IN position. The 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 center of the panel. A well shielded communications receiver or the receiver section of the Delta Electronics Model RG-4 Receiver/Generator can be connected by a double shielded coaxial cable to this connector and used 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 can be used as a power source and the OIB-2 used as a normal impedance bridge.

2.5.2 When operated in this manner, the OIB-2 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-4 Receiver/Generator is specifically designed for such use. It provides over 120 dB of isolation between the generator and receiver sections and double shielded coaxial cables are provided with the unit for connection to the OIB-2.

2.6 IMPROVING PRECISION BY SUBSTITUTION METHOD

Occasionally, it will be found that accuracies better than the ±5% 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 terminal and a communications receiver 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

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 read from the dials of the bridge. The actual impedance of the load for this case is the negative of the impedance indicated.

2.8 SECOND ORDER FREQUENCY CORRECTIONS

Because of the internal lead lengths and dimensions of the coupler box, second order frequency corrections are required to realize the full accuracy of the bridge. A correction factor graph for the reactance dial reading versus frequency and a correction equation for the length of the coupler box 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:

$$k\Gamma_L W = -k\Gamma_S W \quad (1)$$

or

$$\Gamma_L = -\Gamma_S \quad (2)$$

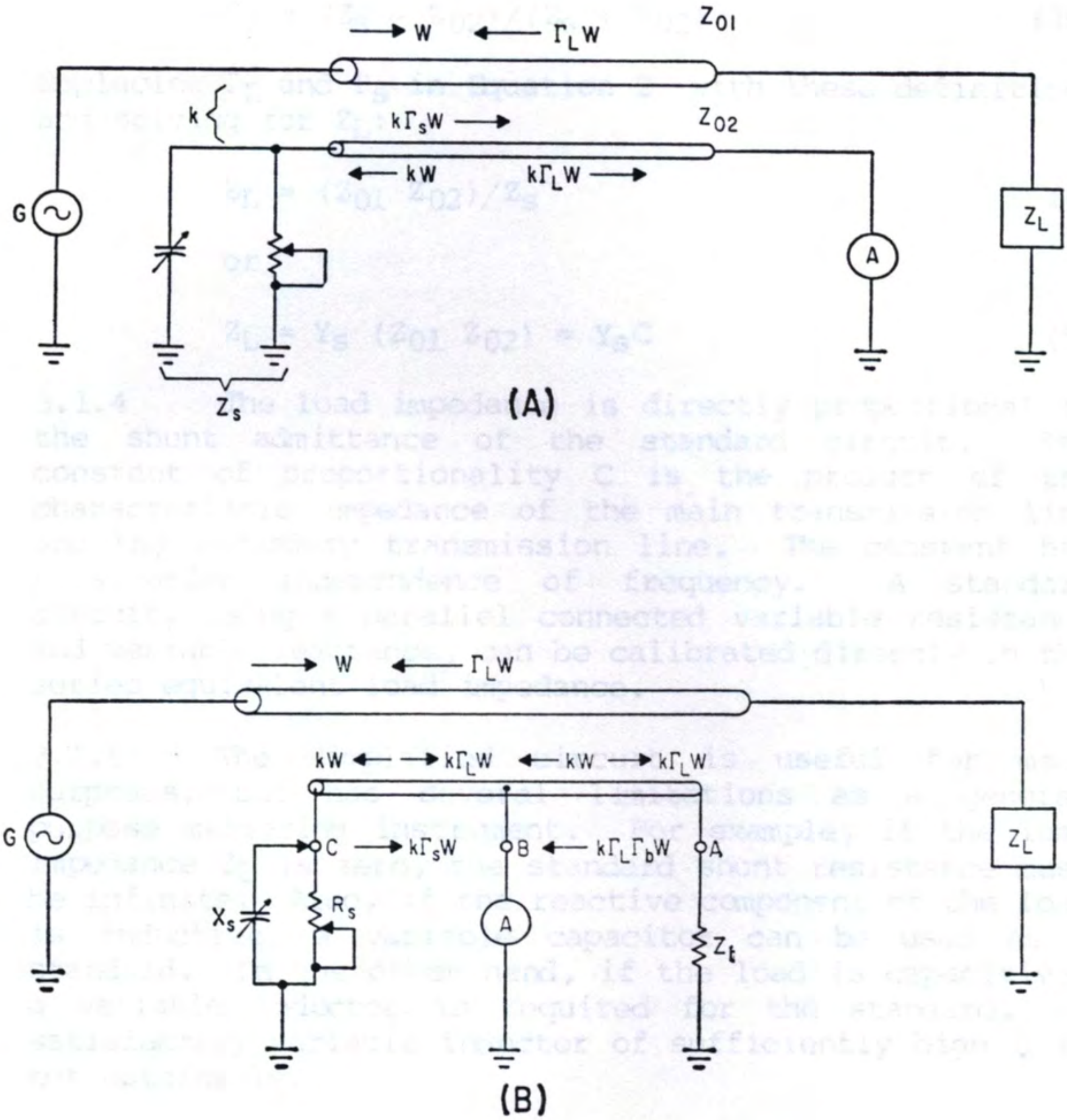


FIGURE 3-1

SIMPLIFIED SCHEMATIC DIAGRAM

The reflection coefficients Γ_L and Γ_s are:

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

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

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

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

or

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

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 $\Gamma_L W$, 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

$$Z_L = \frac{C}{2} Y_s - \frac{C}{2} Y_b \qquad (7)$$

3.1.8 This result is obtained, assuming an exact centertap 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 COUPLING BOX

Figure 3-2 is a photograph showing the coupling box with the cover removed. The main transmission line is a copper conductor suspended directly between the Type N connectors. 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 mounted on three Teflon feedthrough terminals. These three terminals are the A, B and C points shown in Figure 3-1B. Adjustable shield vanes are mounted near the ends of the secondary transmission line.

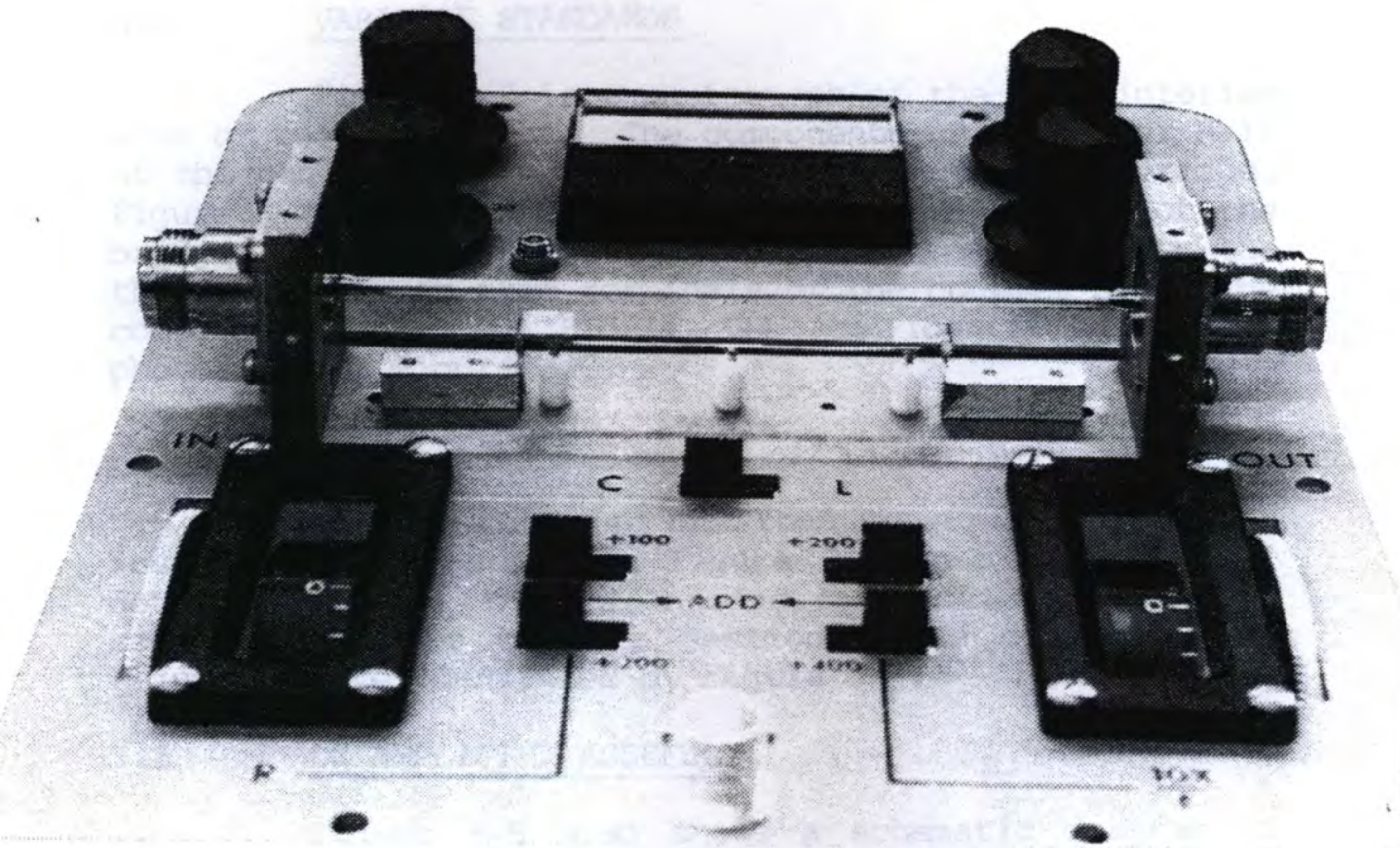


FIGURE 3-2

COUPLING BOX INTERIOR VIEW

These vanes adjust the capacitive coupling between the primary and secondary lines. This adjusts the box constant, as described above, and is a primary calibration adjustment of the bridge. These vanes veins should never be moved except when the instrument is being factory calibrated.

3.3 VARIABLE STANDARDS

Figure 3-3 is a photograph of the rear interior view of the instrument. The components on the lower half of the panel are in the standards section of the bridge. Figure 3-4 is a schematic diagram of this portion of the bridge. Terminals A, B and C on this diagram are the three Teflon insulated terminals of the coupler box. The components shown in Figure 3-4 are identified in the photograph of Figure 3-3.

3.4 NULL DETECTOR SECTION

The components on the upper half of the instrument panel shown in Figure 3-3 comprise the null detector section of the bridge. Figure 3-5 is a schematic diagram of this section. The components of Figure 3-5 are identified by Figure 3-3.

3.5 DC AMPLIFIER ASSEMBLY

Figure 3-5 also shows a schematic diagram of the DC amplifier assembly. This amplifier circuit uses a MOS/FET operational amplifier to provide approximately 20 dB gain. This assembly is mounted on a printed circuit board and secured to the back of the meter by the meter terminal bolts.

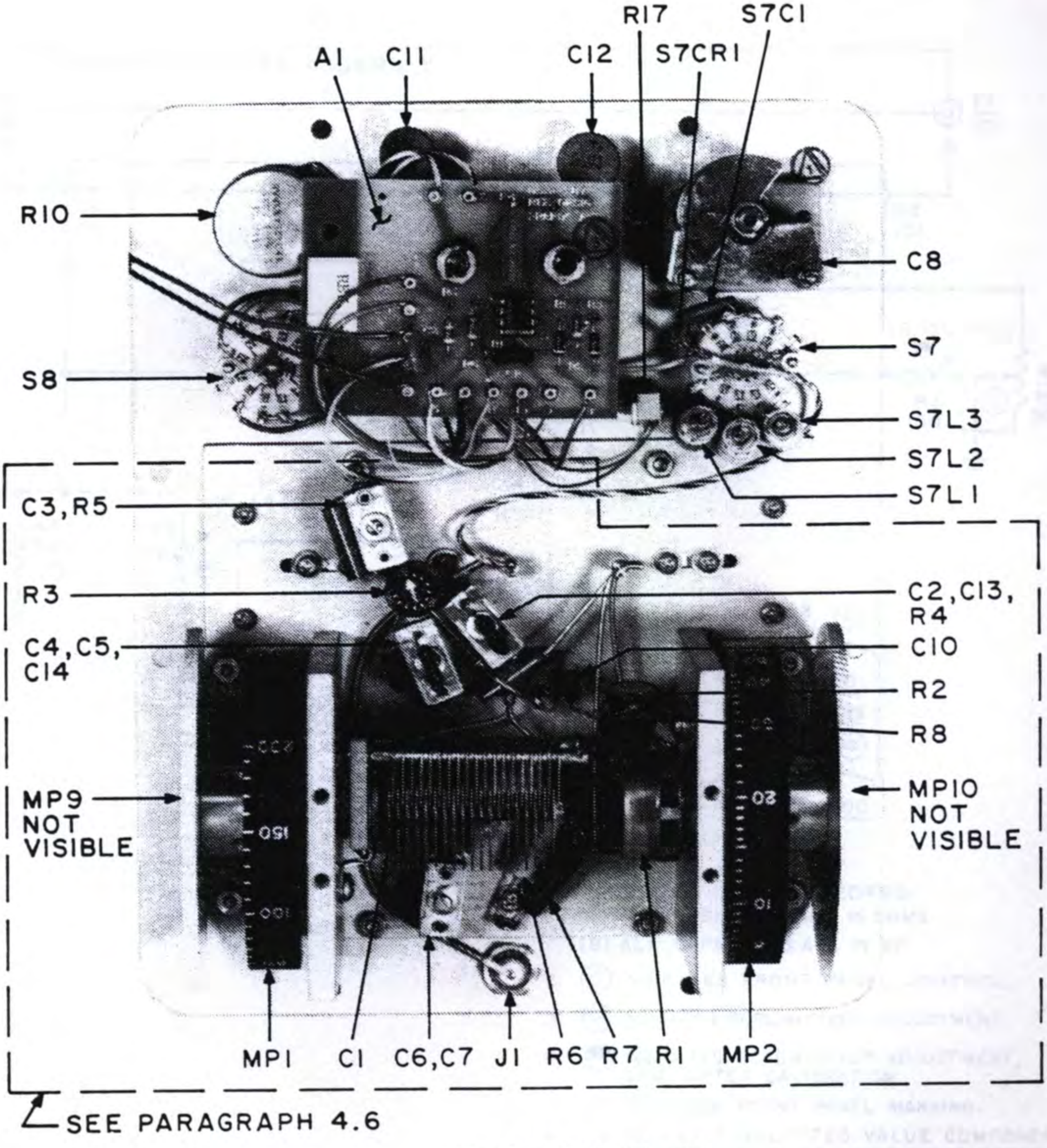
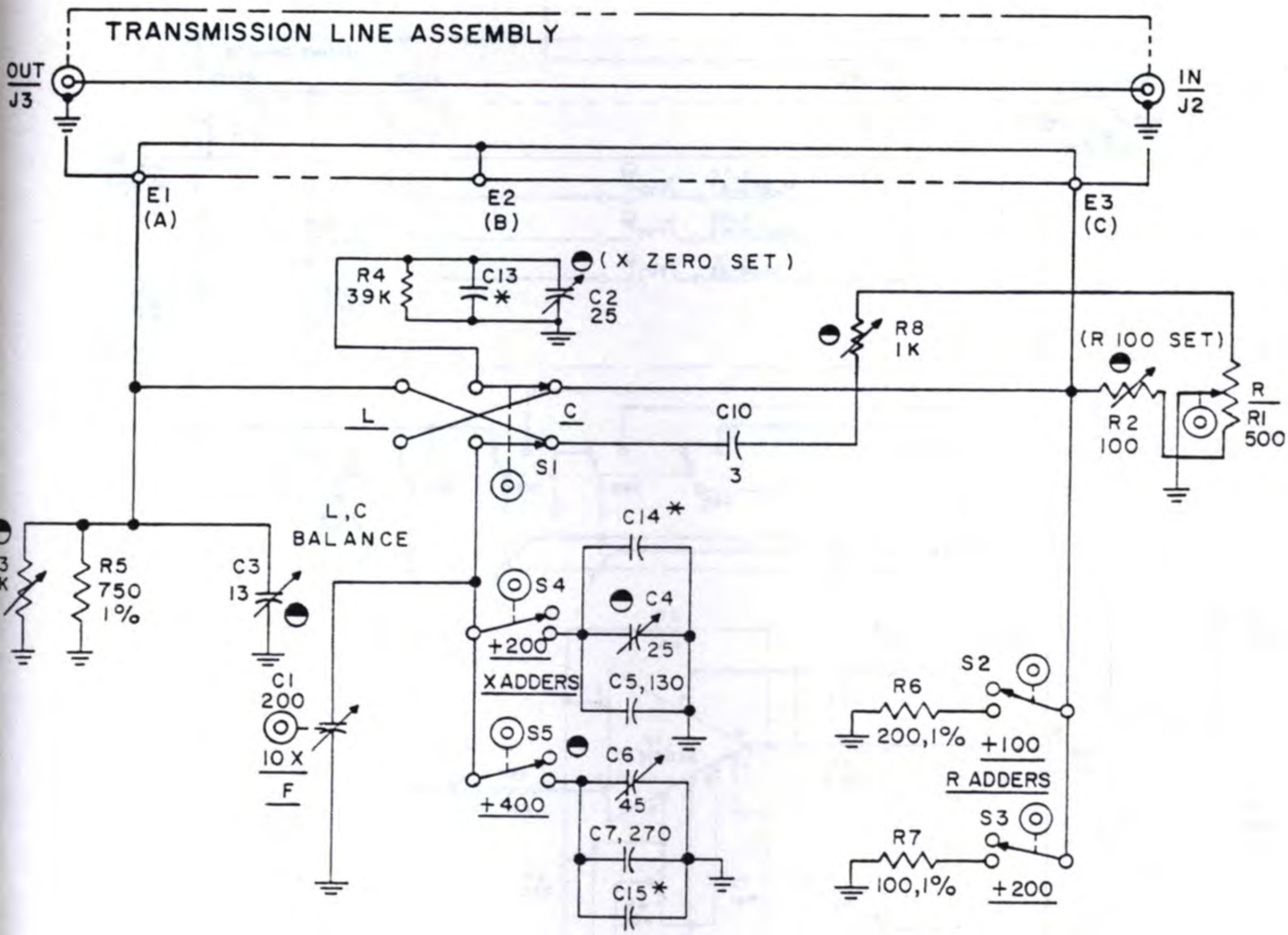


FIGURE 3-3

COMPONENT LOCATIONS

REAR INTERIOR VIEW

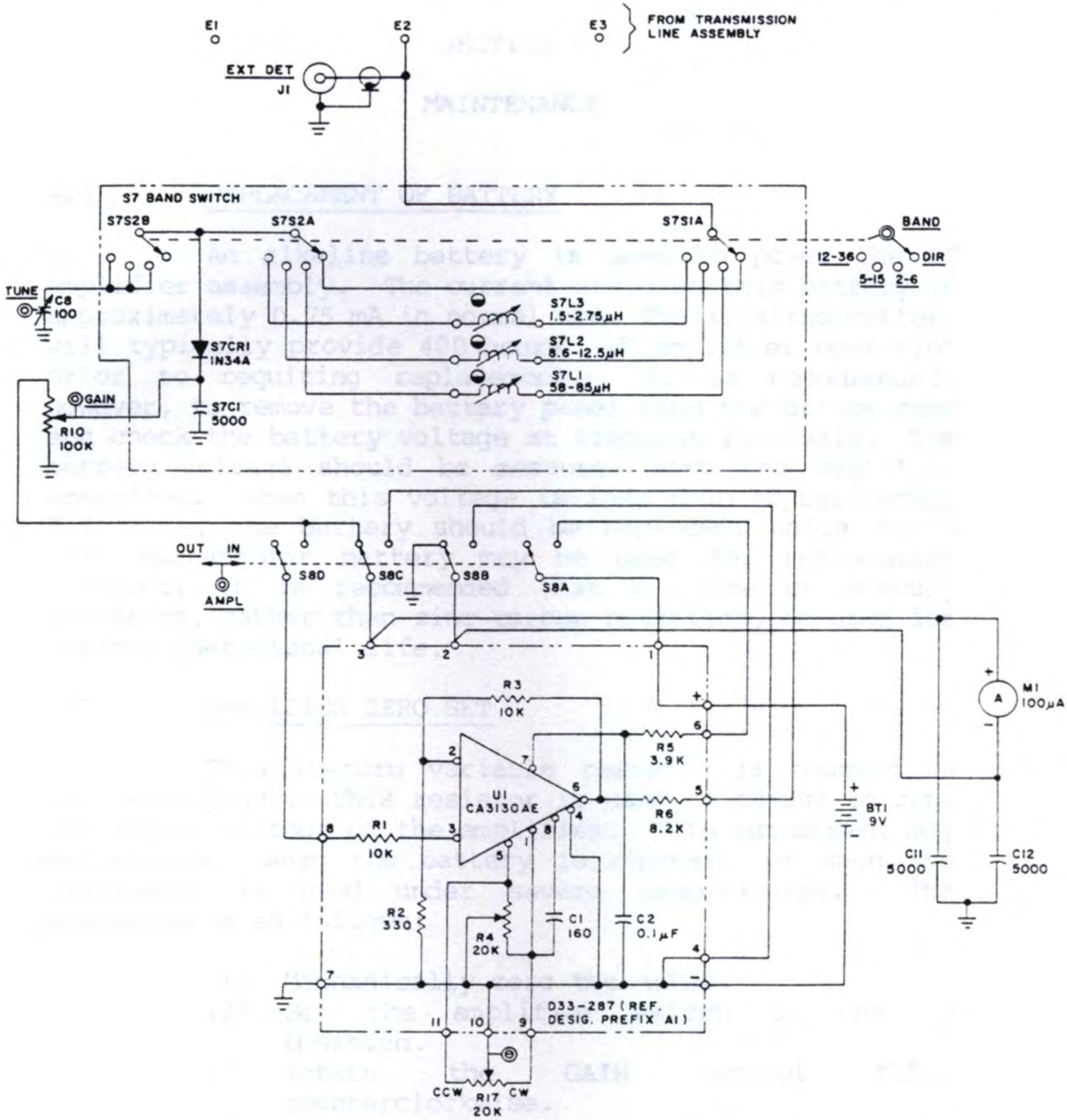


NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   (A) ALL RESISTORS ARE IN OHMS.
   (B) ALL CAPACITORS ARE IN pF.
2. ◎ INDICATES FRONT PANEL CONTROL.
3. ⊖ INDICATES SCREWDRIVER ADJUSTMENT
4. ◓ INDICATES SCREWDRIVER ADJUSTMENT, SEAL AFTER CALIBRATION.
5. X INDICATES FRONT PANEL MARKING.
6. * INDICATES SELECTED VALUE COMPONENT SOME MODELS MAY NOT HAVE CAPACITOR C13, C14 AND/OR C15.

FIGURE 3-4

STANDARDS CIRCUIT
SCHEMATIC DIAGRAM



NOTES:

1. UNLESS OTHERWISE SPECIFIED:
   (A) ALL RESISTORS ARE IN OHMS
   (B) ALL CAPACITORS ARE IN PF.
2. ◎ INDICATES FRONT PANEL CONTROL
3. ⊖ INDICATES SCREWDRIVER ADJUSTMENT
4. ◓ INDICATES SCREWDRIVER ADJUSTMENT, SEAL AFTER CALIBRATION.
5. X INDICATES FRONT PANEL MARKING

FIGURE 3-5
SCHEMATIC DIAGRAM
DETECTOR AND AMPLIFIER CIRCUIT

SECTION 4

MAINTENANCE

4.1 REPLACEMENT OF BATTERY

An alkaline battery is used to power the DC amplifier assembly. The current drain on this battery is approximately 0.75 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 or mercury batteries, rather than zinc-carbon batteries, be used for maximum operational life.

4.2 AMPLIFIER ZERO SET

This 10-turn variable resistor is mounted on the front panel. This resistor is used to adjust to zero the offset voltage of the amplifier. This adjustment may be necessary when the battery is changed, or when the instrument is used under severe temperatures. The procedure is as follows:

(1) Mechanically zero the meter.
(2) Set the amplifier switch to the IN position.
(3) Rotate the GAIN control fully counterclockwise.
(4) Adjust the meter zero variable resistor, R17, located on the front panel for a zero meter reading.

4.3 MECHANICAL ZERO SET OF DRUM DIALS

The drum dials are mounted directly on the shafts of the variable standard resistance, R1, and on the variable standard capacitance, C1, with set screws. A mechanical zero mark is engraved on the drum dials (below the zero ohm marks) for use in properly positioning these drum dials on the control shafts. In the event that the set screws become loose, the dials can be positioned on the shafts as follows: looking at the left side of the bridge (nearest the R dial) with the cover removed, the variable standard resistor is rotated clockwise until the mechanical stop of the resistor is reached. The resistor is held in this position with a screwdriver inserted in the center hole of the drum dial. The drum dial is then rotated until the mechanical zero mark is directly under the hairline of the R dial bezel. The set screw on the drum dial is then secured. The reactance drum dial can be set in the same manner, with the variable capacitance standard adjusted for minimum capacity (rotor blades are completely unmeshed from the stator plates and the internal edges of these plates perfectly parallel). Care should be taken in making these adjustments to be sure that the drum dials are positioned on the control shafts so that the drive wheel and the drum dials are properly centered on their respective panel openings.

4.4 ELECTRICAL ZERO SET

The electrical zero of these two controls can be adjusted as follows: a generator adjusted to 10 MHz is connected to the IN connector of the coupler box 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, R3, and capacitor, C2, 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.

4.5 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 R2 is then adjusted with an insulated alignment tool for a bridge balance. The resistance drum 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.

4.6 OTHER MAINTENANCE

It is recommended that no other maintenance be done on the standards section of the bridge. Normal maintenance, such as resistor testing, integrated circuit testing, or amplifier zero adjustment 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-2 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 A change in nonprecision resistors from composition to film has been made to improve the quality and reliability of all products manufactured by Delta Electronics, Inc. Fixed film resistors provide greater long term stability under the combined effects of operation and environment. The subject OIB-2 may have been manufactured prior to or during the conversion from composition to film resistors and therefore may contain only composition resistors, a combination of film and composition resistors, or only film resistors. All fixed, nonwirewound, nonprecision resistors are described in the List of Material as "Resistor, Fixed, Film, Value, 5%, Wattage" and identified by a part number derived from the MIL-R-22684 resistor type designation. These fixed film resistors directly replace fixed composition resistors and no corrections to the text or Schematic Diagrams are required for this conversion. For maintenance requirements, a film resistor as described in the Lists of Material should be used if a composition resistor is to be replaced.

5.1.4 The Lists of Material for the Model OIB-2 Operating Impedance Bridge are presented as follows:

MODEL OIB-2 OPERATING IMPEDANCE BRIDGE LISTS OF MATERIAL

5.2 LIST OF MATERIAL, OIB-2 SYSTEM COMPONENTS

Reference Designation	Description	Manufacturer	Manufacturer Part No.	Delta Order No.
Unit 1	Model OIB-2 Operating Impedance Bridge	Delta	D20-2	020-0002
W1	Adapter Lead, Red	Delta	D51-2-1	051-0002-001
W2	Adapter Lead, Black	Delta	D51-2-2	051-0002-002
---	Technical Manual	Delta	D93-14	093-0014

5.3 LIST OF MATERIAL, FINAL ASSEMBLY, MODEL OIB-2 OPERATING IMPEDANCE BRIDGE

Reference Designation	Description	Manufacturer	Manufacturer Part No.	Delta Order No.
A1	Assembly, DC Amplifier	Delta	D33-287	033-0287
BT1	Battery, Alkaline, 9V	Mallory	MN1604	606-0001
C1	Capacitor, Var, Air, 200 pF	Delta	D05-61-2	005-0061-002
C2	Capacitor, Var, Mica, 4-60 pF, 175V	Arco	404	342-0010
C3	Capacitor, Var, Mica, 1-12 pF, 175V	Arco	420	342-0012
C4	Same as C2			
C5	Capacitor, Fixed, Mica, 130 pF, 5%, 500 VDC		CM05FD131J03	302-0131
C6	Capacitor, Var, Mica, 4-40 pF, 175V	Arco	422	342-0014

5.3 LIST OF MATERIAL, FINAL ASSEMBLY, MODEL OIB-2 OPERATING IMPEDANCE BRIDGE CONTINUED

Reference Designation	Description	Manufacturer	Manufacturer Part No.	Delta Order No.
C7	Capacitor, Fixed, Mica, 270 pF, 5%, 500 VDC		CM05FD271J03	302-0271
C8	Capacitor, Var, Air, 100 uF	Delta	D05-61-1	005-0061-001
C9	Unassigned			
C10	Capacitor, Fixed, Mica, 3 pF, 5%, 500 VDC	Arco	DM15-030D	302-0030
C11	Capacitor, Fixed, Ceramic, 0.005 uF, 20%, 1000V	Sprague	5GA-D50	310-0014
C12	Same as C11			
C13	Capacitor, Fixed, Mica, Selected, Type CM05			
C14	Capacitor, Fixed, Mica, Selected, Type CM05			

5.3 LIST OF MATERIAL, FINAL ASSEMBLY, MODEL OIB-2 OPERATING IMPEDANCE BRIDGE CONTINUED

Reference Designation	Description	Manufacturer	Manufacturer Part No.	Delta Order No.
C15	Capacitor, Fixed, Mica, Selected, Type CM05			
E1	Terminal	Delta	D71-12-5	071-0012-005
E2	Same as E1			
E3	Same as E1			
J1	Connector, BNC, Panel Mount		UG-1094/U	612-0023
J2	Connector, Type N		UG-58A/U	612-0006
J3	Same as J2			
M1	Meter, 100 uADC	Delta	D02-2	002-0002
MP1	Strap, Dial	Delta	D80-7-4	080-0007-004
MP2	Same as MP1			
MP3	Bezel	Jan	ET-155-3	706-0001

5.3 LIST OF MATERIAL, FINAL ASSEMBLY, MODEL OIB-2 OPERATING IMPEDANCE BRIDGE CONTINUED

Reference Designation	Description	Manufacturer	Manufacturer Part No.	Delta Order No.
MP4	Same as MP3			
MP5	Knob		MS91528-1F1B	730-0005
MP6	Same as MP5			
MP7	Knob		MS91528-1F2B	730-0006
MP8	Same as MP7			
MP9	Bearing	Delta	D80-39	080-0039
MP10	Same as MP9			
R1	Resistor, Var, Cermet, 500 Ohm	Delta	D05-8	005-0008
R2	Resistor, Var, Trimmer, 100 Ohm, 10%, 3/4W	Beckman	93PR-100 Ohm	244-0004
R3	Resistor, Var, Trimmer, 2K Ohm, 10%, 3/4W	Beckman	93PR-2K Ohm	244-0010

5.3 LIST OF MATERIAL, FINAL ASSEMBLY, MODEL OIB-2 OPERATING IMPEDANCE BRIDGE CONTINUED

Reference Designation	Description	Manufacturer	Manufacturer Part No.	Delta Order No.
R4	Resistor, Fixed, Film, 39K Ohm, 5%, 1/2W		RL20S393J	204-0393
R5	Resistor, Fixed, Film, 750 Ohm, 1%, 1W		RN70C7500F	218-7500-001
R6	Resistor, Fixed, Film, 200 Ohm, 1%, 1W		RN70D2000F	218-2000
R7	Resistor, Fixed, Film, 100 Ohm, 1%, 1W		RN70D1000F	218-1000
R8	Resistor, Var, Trimmer, 1K Ohm, 10%, 3/4W	Beckman	93PR-1K Ohm	244-0008
R9	Unassigned			
R10	Resistor, Var, Cont, 100K Ohm, 2W		RV4NAYSD104A	240-0018
R11 thru R16	Unassigned			

5.3 LIST OF MATERIAL, FINAL ASSEMBLY, MODEL OIB-2 OPERATING IMPEDANCE BRIDGE CONTINUED

Reference Designation	Description	Manufacturer	Manufacturer Part No.	Delta Order No.
R17	Resistor, Var, Wire Wound, 20K Ohm, 5%, 1W	Beckman	78LR20K	244-0040
S1	Switch, Slide, DPDT	Oak	399278-278	666-0009
S2 thru S5	Same as S1			
S7	Assembly, Switch	Delta	D33-15	033-0015
S7C1	Capacitor, Fixed, Ceramic, 0.005 uF, 20%, 1000V	Sprague	5GA-D50	310-0014
S7CR1	Diode		1N34A	410-0034-001
S7L1	Coil, RF, Var, 58-85 uH	Delta	D05-125-1	005-0125-001
S7L2	Coil, RF, Var, 8.06-12.5 uH	Delta	D05-125-2	005-0125-002
S7L3	Coil, RF, Var, 1.5-2.75 uH	Delta	D05-125-3	005-0125-003
S7S1	Switch, Rotary, 2 Sec, 4P5T	CRL	PS111	662-0013

5.3 LIST OF MATERIAL, FINAL ASSEMBLY, MODEL OIB-2 OPERATING IMPEDANCE BRIDGE CONTINUED

Reference Designation	Description	Manufacturer	Manufacturer Part No.	Delta Order No.
S8	Switch, Rotary, 1 Sec, 4PDT	CRL	PS113	662-0014

5.4 LIST OF MATERIAL, DC AMPLIFIER ASSEMBLY, D33-287 CONTINUED

Reference Designation	Description	Manufacturer	Manufacturer Part No.	Delta Order No.
A1U1	IC, Operational Amplifier	RCA	CA3130AE	540-0008

APPENDIX A

SECOND ORDER FREQUENCY CORRECTIONS

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SECOND ORDER FREQUENCY CORRECTIONS

A.1 INTRODUCTION

Because of the internal lead lengths and dimensions of the coupler box, second order frequency corrections are required to realize the full accuracy of the bridge. These corrections fall in two categories:

(1) Second order frequency corrections for the reactance dial reading

(2) Corrections for the length of the coupler box

A.2 SECOND ORDER REACTANCE CORRECTIONS

If the connecting leads in the bridge had no inductance and the coupler box could be built with zero dimensions, the reactance could be computed as explained in Section 2 for all frequencies. Since these conditions are not possible, it is necessary to make second order corrections on the reactance dial reading at higher frequencies. The true circuit reactance can be obtained from the dial reading by the following equation:

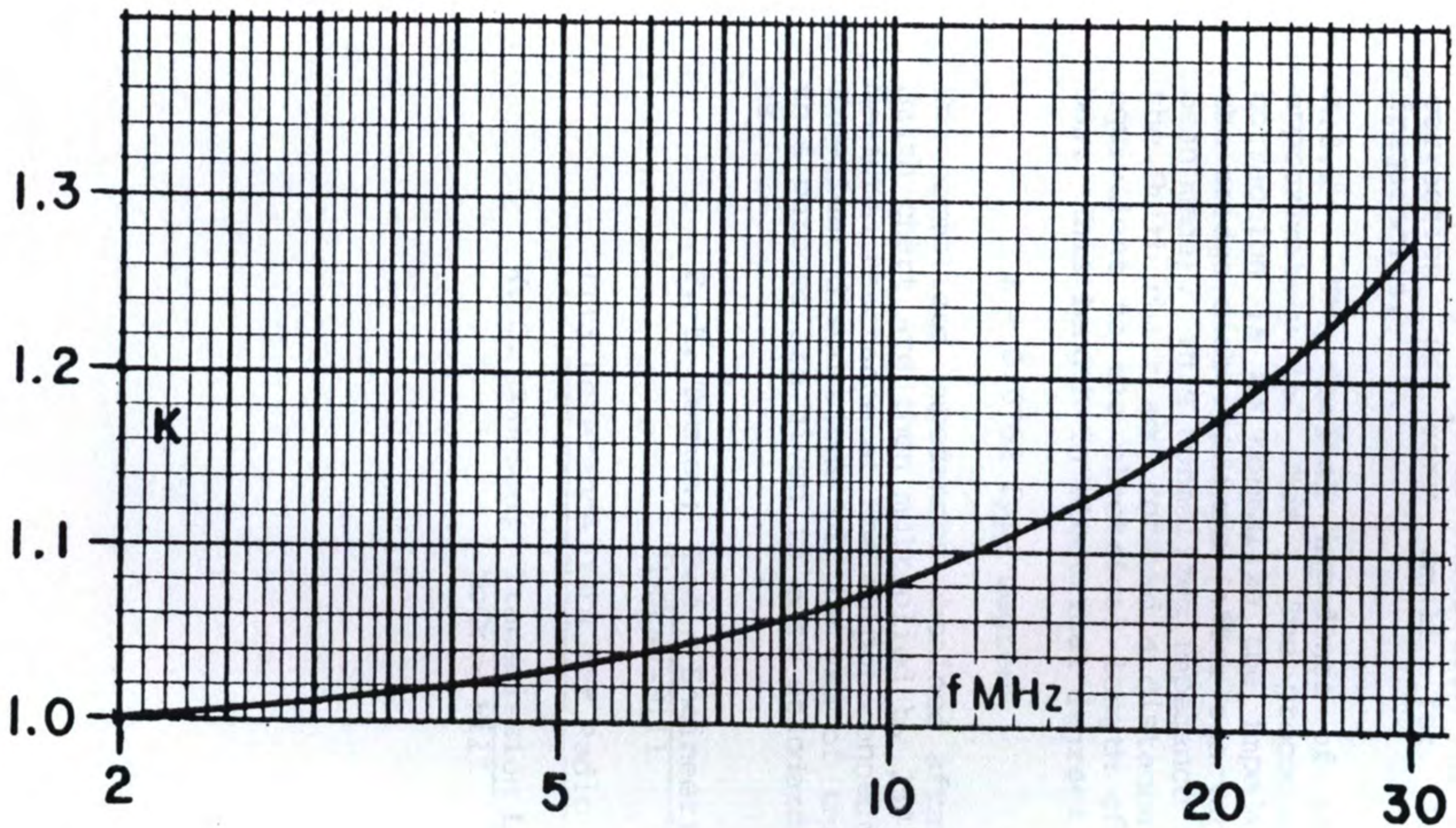
$$X = 0.1\ f_{MHz}\ D + 0.001\ (f^2 - 2f)\ D \qquad (8)$$

D = reactance dial reading

The frequency squared term accounts for the inductance of the connecting leads within the bridge and the dimensions of the secondary line within the coupling box. The equation can be reduced to:

$$X = 0.1\ f_{MHz}\ D\ K \qquad (9)$$

The factor, K, is a second order correction factor which can be applied to the reactance derived by the method explained in Section 2. Figure A-1 is a plot of this correction factor. The circuit reactance can be determined by the method in Section 2 and multiplied by the factor K, read from the graph on Figure A-1 for the measuring frequency.



X = .1 fMHz DK

D = DIAL READING

FIGURE A-1

SECOND ORDER REACTANCE
DIAL FREQUENCY CORRECTION

A.3 COUPLER BOX LENGTH CORRECTION

A.3.1 The bridge essentially measures impedance at the center of the coupling box. Although the distance from this point to the output connector is only 2-1/2", some measurements at the high frequency end of the range of the bridge require correction for this length. This correction is very small for low and moderate frequencies.

A.3.2 The nominal impedance of the coupler box is approximately 150 Ohms. The procedure for making the correction is to normalize the impedance obtained from the bridge dial readings (after reactance correction has been made). This normalized impedance is then plotted on the Smith chart and rotated a distance towards the load equivalent to the electrical length of half the coupler box. This length in electrical degrees is:

$$\ell = 0.0762 \; f_{MHz} \text{ degrees} \qquad (10)$$

The normalized impedances obtained after rotation on the Smith chart are then multiplied by 150 Ohms to give the measured reactance at the output connector of the bridge. Excellent discussions of the use of the Smith chart for this purpose are given in most standard references, such as:

F. E. Terman; Radio Engineering Handbook
McGraw-Hill

ITT; Reference Data for Radio Engineers

W. C. Johnson; Transmission Lines and Networks
McGraw-Hill