NBSIR 81-1641

ADDENDUM TO EARTH TERMINAL MEASURMENT SYSTEM MAINTENANCE MANUAL

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Boulder, Colorado 80303

Equipment developed for

Commanding General
U.S. Army Communications Command
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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, Secretary

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Director

PREFACE

This Addendum to the Earth Terminal Measurement System Maintenance Manual, NBSIR 78-895, September 1978, documents the retrofit which adds a multiple-frequency input capability to the system. The Addendum also includes an errata page for the Maintenance Instruction Manual. This information is valid as of October 1979.

The organization of this addendum is similar to that of the Maintenance Manual in that the general system information is presented in the first sections, the instruction manuals for the retrofit are in the second sections, and the corrections to the ETMS Maintenance Manual and revised ETMS control codes are in the final sections.

This ongoing project is under the direction and guidance of Dr. D. F. Wait. The hardware modifications were accomplished in the laboratory by Mr. T. H. Bremer and Mr. G. J. Counas.

NOTICE

Certain commercial equipment, instruments, and materials are identified in this paper in order to adequately specify the required system modifications, testing procedures, etc. In no case does such identification imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the material or equipment identified is necessarily the best available for the purpose.

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EARTH TERMINAL MEASUREMENT SYSTEM
MAINTENANCE MANUAL

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This addendum to the Earth Terminal Measurement System Maintenance Manual, NBSIR 78-895, describes the equipment and maintenance procedures required to support the retrofit package for the Earth Terminal Measurement System (ETMS) developed by the National Bureau of Standards. This retrofit adds a multi-input-port relay module which provides the capability of connecting three receiver channels to the ETMS, thereby enabling measurement of pertinent earth terminal parameters at as many as three frequencies in a single measurement pass. This manual does not include measurement theory nor measurement operating procedures that are described in the Earth Terminal Measurement System Operation Manual, NBSIR 78-879.

Key Words: earth terminal; earth terminal measurement system; figure of merit; noise temperature; satellite communication.

1. GENERAL INFORMATION

1.1 Introduction

The earth terminal measurement system (ETMS) is a portable automated measurement system developed around the NBS Type IV self-balancing power meter. The system measures pertinent power ratios used in determining various performance parameters of satellite receiving earth terminals.

The ETMS connects to the IF patch panel of the earth terminal being evaluated. The retrofit module adds coaxial relays and the associated control circuitry necessary to sequentially connect the IF outputs of up to three earth terminal down-converters to the input of the ETMS. This modification to the system is compatible with the original software, so that the system can be used for a single input as originally designed. Either the original software or the updated multi-input software [1] can be used with or without connecting the relay module.

This report is an ADDENDUM to the Earth Terminal Measurement System Maintenance Manual [2].

1.2 Hardware

The hardware retrofit consists of a coaxial relay module, a 2-meter (6-ft) interconnecting control cable (see figure 4) and a relay control printed-circuit card which is installed in the ETMS control unit (figs. 2 and 3).

The coaxial relay module is interfaced to the earth terminal IF patch panel by patching up to three coaxial cables between the down-converter outputs to the relay module and a coaxial cable connecting the module to the input of the ETMS control unit. An interconnecting control cable connects the relay module to the ETMS control unit. This arrangement permits the relay module to be used as an accessory unit to the ETMS when needed. Light emitting diodes (LEDs) mounted in the relay module indicate which input is currently selected.

The relay control printed-circuit card (designated Z-800) decodes the control codes (on the control data buss) which to actuates the relay module and energizes the respective coaxial relay. Signals are supplied to light the LEDs on the relay module indicating the currently selected input.

The Z-800 relay control card also provides the necessary flag signal circuitry for computer control, and will generate a return flag regardless of whether or not the relay module is connected.

1.3 Specifications

The multi-input retrofit to the ETMS includes internal control circuitry and an accessory relay module which provides three Type-N coaxial connectors to remotely controlled relays so that the input to the ETMS can be selected at the ETMS control unit or at the computer. LED's on the relay module indicate which input is currently selected. The relay module has a built-in eyeloop to attach a cord for strain relief when suspending the module from the IF patch panel.

The ETMS can be operated either with or without the accessory relay module connected.

2. INSTALLATION AND OPERATION

2.1 Introduction

The multi-input coaxial relay module and attached control cable can be packed in the transit cases with the ETMS equipment or in the spare parts supply case for transit.

The control circuitry for this module is permanently installed within the ETMS control unit.

2.2 Unpacking and Inspection

Unpack the ETMS console and accessory relay module and inspect for shipping damages.

2.3 Initial Installation

Remove the ETMS control unit and the multi-input coaxial relay module from the transit cases. Connect the relay module control cable to J-658 on the rear of the ETMS control unit. Connect a coaxial cable from the relay module output connector to the input to the ETMS control unit and connect the ETMS simulated star output cable to number one input connector of the relay module. Connect the ETMS control unit to the ac power line and turn the power switch on.

2.3.1 Control Circuitry Check-out

Set control code 127 into the ETMS programming switches using the procedures described in section 2.3.1.1 of the Earth Terminal Measurement System Maintenance Manual and press the LOAD button. The LED located at input connector #1 should light and a mechanical click from the relay switch will probably be heard. Set control code #126 into the programming switches and press the LOAD button to select input #2. The LED at input #2 should light and the relay switche click should be heard. Repeat the procedure for programming control code #125 into the system and input #3 should be selected.

To verify that the computer control and flag circuitry are functional, the ETMS must be connected as described in section 2.3 of the Maintenance Manual. Program the computer as described in section 2.3.1.2 and execute control codes #127, #126, and #125 to select inputs #1, #2, or #3, respectively. This completes the checkout of the control circuitry.

2.3.2 RF Circuitry Checkout

Program the selected input for the simulated star output, using the procedure described in 2.2.1 above. Adjust the controls on the ETMS control

unit to obtain an indication on the ETMS output level meter as described in section 2.3.1.3 of the Maintenance Manual.

Using the programming procedures described in the section above, select and deselect the connected input, noting that the ETMS output level meter indicates whether or not an input signal has been selected. Move the input signal to the other input connectors, repeating the test to verify that each input is functioning properly.

2.4 New-Site Equipment Setup

2.4.1 Equipment Setup

Unpack and assemble the equipment as described section 2.4 of the ETMS Maintenance Manual. Locate the Input Relay Module and suspend it on a cord at the earth terminal IF patch panel so that the IF patch cables can be conveniently connected between the down-converter outputs and the relay module input connectors. Connect the relay module control cable to J-658 on the rear panel of the ETMS control unit.

After performing the ETMS system checkout described in section 2.4.5 of the Maintenance Manual, connect the coaxial cable mentioned in section 2.4.4 between the relay module output connector and the ETMS RF input. Set the down-converter frequencies and note that signal noise is present from each connected input as indicated by the ETMS output level meter. Then complete the test sequence described in section 2.4.4 of the Maintenance Manual.

3. THEORY OF OPERATION

3.1 Introduction

This section describes the theory of operation of the multi-input modification, and will refer to the Maintenance Manual for an overall description of the ETMS. Section 5 of this manual should be applied as an addendum to section 5 of the Maintence Manual entitled ETMS CONTROL/RF:

INSTRUCTION MANUAL. Section 6 of this manual describes the multi-input coaxial switching relay module which is an accessory to the ETMS.

3.1.1 Measurement Description

The measurement of the pertinent power ratios along with the real-time star location predictions is acomplished using the ETMS. The ETMS is an automated measurement system developed around the NBS Type IV self-balancing power meter [3].

3.1.2 Operational Description

The ETMS system incorporates a noise radiometer, capable of high-precision rf power measurements, which has been combined with a programmable calculator and clock. The calculator has been programmed to automatically operate the radiometer. The system is used to measure the ratio of antenna gain to system noise temperature, (G/T), of an earth terminal antenna system.

The measurement sequence first reads time from the clock and calculates the predicted azimuth and elevation required to point the antenna toward a selected radio-star. Then, as the earth rotates, the system records repeated measurements of received noise power while the radio star drifts through the beam of the antenna. This drift routine is repeated five times using a different declination angle offset from the star each time. One additional pass is made to establish a "sky background" noise level. This is accomplished by offsetting the antenna from the radio star to a quiet area in the sky.

The program then reprocesses these data using curve-fitting routines to calculate the maximum intensity of noise power (star flux) at the center of the antenna beam. The G/T ratio of the earth terminal is evaluated using measured data of the background noise temperature, the reciever system noise, and the star-flux noise temperature as seen by the antenna. Corrections are applied for atmospheric effects and antenna parameters.

The multi-input frequency retrofit is necessitated by the time required for the six star passes needed to establish a set of data based on the

rotational speed of the earth; thus making it possible to collect data at more than one frequency during a single data set. This multi-input port accessory is a three-input coaxial relay which is controlled by the computer so that measurement points may be selected sequentially from each input. When the inputs are connected to three different down-converters operating at different frequencies, data for all three frequencies are obtained; however, only one-third as many measurement points at any one frequency are recorded. Refer to the ETMS Operators Manual [1] for a rigorous analysis of the measurement theory and procedures.

3.1.3 Description of Multi-Input Port Update

The remote multi-input relay module contains two coaxial single-pole double-throw relays connected to provide three input ports to the ETMS radiometer. LEDs are mounted on the cover plate adjacent to each input port to indicate the currently selected port. A supporting eye-loop is built into the cover plate so that the module can be suspended from the IF patch panel to relieve the strain on the connecting coaxial cables. A coaxial cable interconnects the output of the relay module to the input of the ETMS. The coaxial relays are operated by an interconnecting 2-meter (6-ft) control cable which plugs into the rear panel of the ETMS control unit. The selective control logic and coax switch driver circuits are contained on a printed circuit board which was added to the PC card cage in the ETMS control unit. This logic decodes the control codes and generates the drive pulses to the proper coaxial relay and the handshake flag signal to the computer.

Additional spare parts included in the update are: (1) a replacement coaxial relay, (2) a spare Z-800 relay control printed circuit card, and (3) this Addendum to the ETMS Maintenance Manual which describes the modifications.

3.2 Retrofit Control Theory

3.2.1 ETMS Console Modification

The multi-input port modification to the control unit consisted of installing the Z-800 relay control PC card onto the PC card cage, modifying

the back-plane wiring as necessary, and the addition of a J-658 jack on the rear panel of the ETMS.

The control-unit data-buss lines and the CTL signal (strobe) were rerouted through the Z-800 card in order to insert buss driver buffers in the lines. The wire connecting the flag signal from the Noise-add card (Z-700) to the Z-400 PC card was removed and the Z-800 card flag circuitry connected in series with them to accommodate the multi-input port flag signal. The coax switch drivers were connected to the new J-658 jack on the rear panel.

The selective logic on the Z-800 PC card decodes the input port select control code from the data buss, and in turn enables the CTL signal. The enabled CTL signal serves three functions: (a) strobes the low 4 bits of data into the data latches, (b) initiates a one-shot which times the coaxial relay driver pulses, and (c) acts as a flag signal which is sent back to the Z-400 PC card.

3.2.2 Multi-Input Port Relay Module

The three-input relay switching module is used as an accessory to the ETMS in that the system will operate as a single-input instrument without the relay module. The module contains magnetically latched coaxial relays which provide three selectable inputs and are remotely controlled by the ETMS. The relay switching pulses and the signals to drive the LED indicators are generated by the Z-800 card and are connected to the relay module via the attached control cable and P-658.

4. TROUBLESHOOTING

4.1 Initial Checks

Initial trouble shooting, or even signal checkout, should include verifing (1) that the desired input connectors are connected to the proper down-converters, (2) that the down-converters are properly phase-locked, and (3) that both the RF input cable and the multi-input module control cable are

connected to the ETMS control unit. Follow the same procedure given in the Maintenance Manual (paragraphs 2.4.3.2 and 4.1.1) that describes turning the noise-add standard on and off and watching for the corresponding ETMS signal level meter change. If the multi-input module is suspect, remove it and connect the ETMS directly to one down-converter channel and verify that the rest of the system is functional.

Determine if the malfunction symptom is an input control signal failure or a loss of signal in an RF circuit. Then follow the appropriate troubleshooting procedure given in the ETMS Maintenance Manual.

5. ETMS CONSOLE INPUT CONTROL MODIFICATIONS-INSTRUCTION MANUAL

5.1 Digital Control Circuits

The multi-input modification involves the addition of another PC card (Z-800) and jack J-658 on the rear panel which connects the multi-input module control cable. The control circuitry for the multi-input module was designed to incorporate the necessary data, control, and flag circuits with a minimum of modification to the ETMS. However, the additional loading on the data buss necessitates inclusion of data buss drivers in these lines.

The data lines were disconnected from the multiplexers on the Z-700 board and reconnected to the data buffer outputs on the Z-800 card. The multiplexers were then connected to the inputs of the Z-800 data buffers. The CTL signal (strobe) circuit was modified the same way to include a buffer-driver in the circuit. The interconnecting wire in the flag circuit between the Z-700 board and the Z-400 board was removed and the flag circuit was connected in series through the Z-800 board, thereby including the input-port flag signal.

A one-of-ten decoder connected to the four high-order data bits decodes the input port control code which enables the CTL signal to load the data latches with the data currently on the four low-order data buss lines. The enabled strobe pulse is connected back to the flag circuit to signal the computer that the data has been received.

Data in the latches is decoded and then enabled to the appropriate relay driver circuits by a one-shot pulse which is initiated by the strobe signal. The data in the latches is also decoded by an auxillary decoder to drive LED indicators.

5.1.1 Z-800 Logic Circuit Description

Data from the multiplexers on the Z-700 board enters the Z-800 board and is buffered by IC-802 and IC-804 before being distributed to all data buss lines in the ETMS. The one-of-ten decoder, IC-801, detects when the four

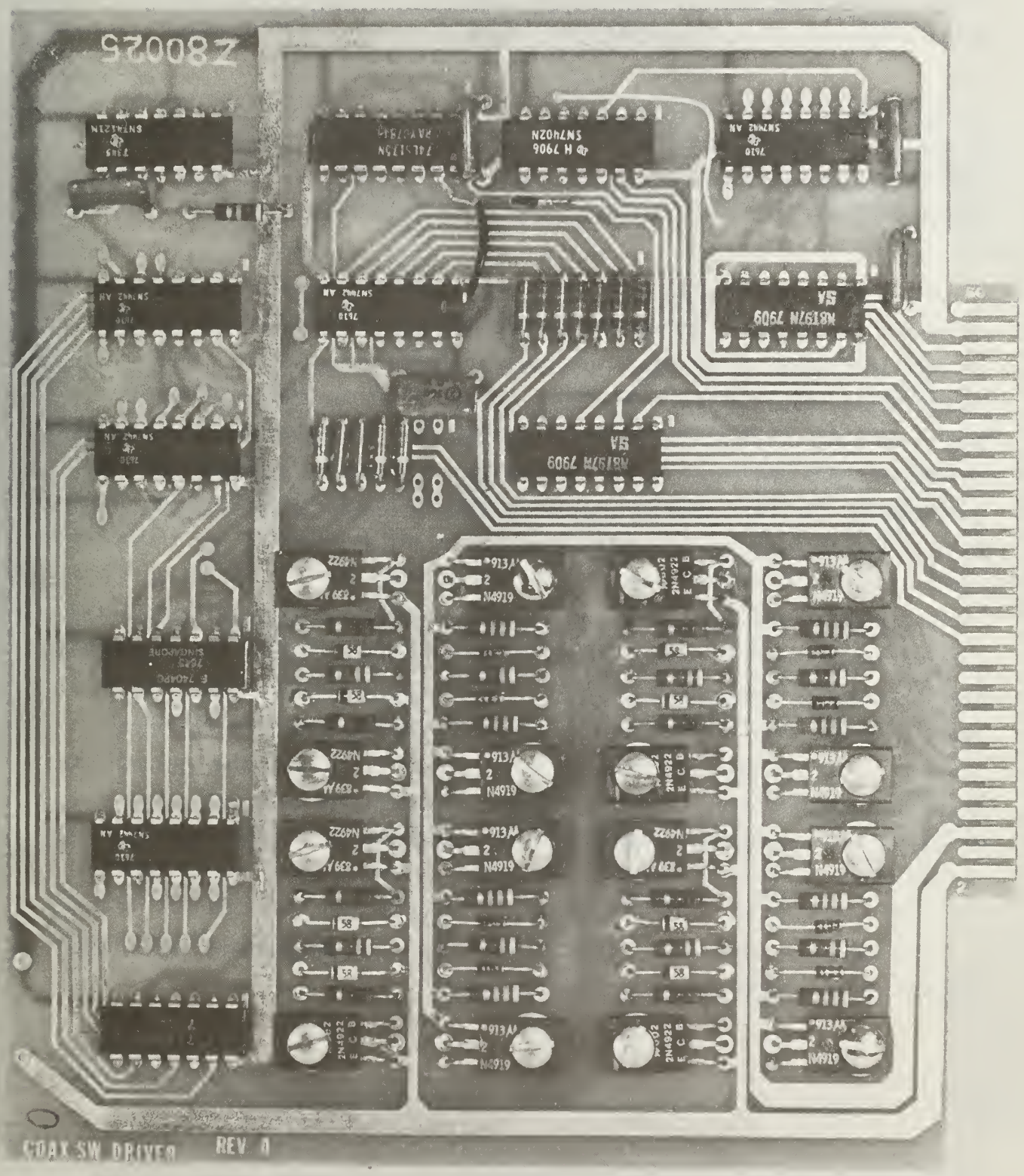


Figure 1. Z800 PC Multi-Input Port Control Card

high-order data lines (E, F, G and H) are in a low state, thus initiating a Z-800 enable signal. This low-true enable signal is combined with the low-true CTL pulse in IC-803 NOR gate to generate the Z-800 strobe pulse. The strobe pulse is ORED with the Z-700 noise-add flag in IC-803 and then inverted before being connected to the flag combining circuits on the Z-400 board.

Data on the four low-order data lines is stored in the data latches IC-805 by the Z-800 strobe pulse. The data stored in IC-805 is decoded in the auxiliary decoder, IC-811, and the decoded information is connected through current-limiting resistors to drive the external LED indicators.

The three (3) low-order data bits (A, B, and C) stored in IC-805 are connected to the relay-driver decoders IC-806 and IC-808. Decoder IC-806 selects the proper relay input port, while IC-808 controls the "tree" relay to select either the double-throw zero/one input relay or the double-throw two/three* input relay. In order to automatically switch the tree relay to either the zero/one relay or the two/three relay without additional programming, the (a) input of decoder IC-808 is connected to stored data bit B, with the (b) and (c) inputs grounded.

Decoders IC-806 and IC-808 are held in the disabled state by connecting the (d) inputs to the 'not Q' output of the one-shot IC-807. These decoders are decoding "8" or greater until the Z-800 enable strobe triggers the one-shot, at which time the (d) input goes low and the proper outputs, zero through 7, are decoded low-true for the duration of the one-shot pulse. The decoded pulses are inverted and connected to the proper bi-polar relay drivers to switch the appropiate relays, thereby connecting the correct RF input port to the ETMS.

One unprogrammed decoder, IC-809, and a spare bi-polar relay driver are located on the Z-800 board, but are not used.

*Prototype unit only - otherwise input #3.

5.2 Relay Switch Driver Circuits

5.2.1 Introduction

One bi-polar relay switch driver circuit for each coaxial double-throw relay is located on the Z-800 board. Each of these drivers can furnish either a positive switching current or a negative switching current to the respective relay. These drivers are pulsed by the decoding logic, and the relays are magnetically latched.

5.2.2 Driver Circuit

The relay switch driver circuit is constructed so that the relay coil is floating, thus the circuit has the capability of connecting opposite ends of the coil to either +24 volts or ground. If the drive pulse from the decoder logic is on the base of transistor Q803, for example, Q803 will turn on, grounding the (+) lead on the relay. Grounding the (+) lead also completes the bias circuit through R805 to the base of transistor Q802, turning Q802 on and connecting the (-) lead of the relay to +24 volts thereby pulsing the relay coil in reverse polarity. Conversely, if the input pulse is on transistor Q804, Q804 will ground the (-) lead of the relay and also turn on transistor Q801 through R806, connecting the (+) lead of the relay to +24 volts.

Switch driver #1 controls the zero/one input port relay, #2 controls the two/three input relay*, and #3 controls the "tree" relay which switches between the zero/one and the two/three port relays. Switch driver #4 is a spare and is not used.

*The two/three relay is used only on the prototype.

5.3 Retrofit Modifications to ETMS Console

5.3.1 Modifications

The following itemized list of modifications is included here as a record of the modifications required by the multi-input port retrofit, and is not intended to be a complete description sufficient to install a retrofit kit. All the changes to the ETMS for this retrofit are located in the ETMS control unit.

Modifications: To add multi-input port switching to the ETMS console.

1. Enlarge the square cutout in the center of console chassis to permit addition of another PC card connector.

2. Mount the new PC card guides to the side of the card cage.

3. Fasten PC edge connector to chassis, aligning with card guides.

4. Relocate step-attenuator plate assembly and mount to chassis.

5. Reconnect step-attenuator control wires.

6. Fabricate two short coaxial leads to reconnect step-attenuator in RF circuit.

7. Cut hole in rear panel of cabinet and mount connector J-658.

8. Attach J-658 label to rear panel adjacent to cutout.

9. Extend ground-buss wires on PC pins 1 and 2, and pins 59 and 60 to the new PC edge connector and also connect to chassis ground with leads as short as possible.

10. Move data-buss lines to Z-800.

bit A. Remove all wires from J700-41 (Z400-44,J651-1).
Reconnect wires to new J800-41.
bit B. Remove all wires from J700-37 (Z400-42,J651-2).
Reconnect wires to new J800-42.
bit C. Remove all wires from J700-25 (Z400-40,J651-3).
Reconnect wires to new J800-33.
bit D. Remove all wires from J700-31 (Z400-38,J651-4).
Reconnect wires to new J800-31.
bit E. Remove all wires from J700-36 (Z400-51,J651-5).
Reconnect wires to new J800-55.
bit F. Remove all wires from J700-42 (Z400-49,J651-6).
Reconnect wires to new J800-53.
bit G. Remove all wires from J700-30 (Z400-52,J651-8).
Reconnect wires to new J800-51.
bit H. Remove all wires from J700-24 (None).
Reconnect wires to new J800-49.

11. Connect incoming data lines.

bit A. Connect wire from J700-41 to J800-43.
bit B. Connect wire from J700-37 to J800-44.
bit C. Connect wire from J700-25 to J800-38.
bit D. Connect wire from J700-31 to J800-40.
bit E. Connect wire from J700-36 to J800-56.
bit F. Connect wire from J700-42 to J800-54.
bit G. Connect wire from J700-30 to J800-52.
bit H. Connect wire from J700-24 to J800-50.

12. Flag signal circuits.

a. Remove wire between J400-50 and J700-50.
b. Connect wire from J700-50 to J800-46.
c. Connect wire from J800-48 to J400-50.

13. Control strobe (CTL).

    a. Remove all wires from J700-46 (Z400-46,J651-12).
    b. Connect wire from J800-45 to J400-46.
    c. Connect wire from J800-45 to J651-12.
    d. Connect wire from J700-46 to J800-47.

14. Power supply connections.

    a. Connect +24 volts from 20/24/36 volt power supply to J800-5 and J800-6.
    b. Connect -24 v. power supply (ground) to J800-1 and J800-2.
    c. Connect + 5 volt power supply to J800-57 and J800-58.
    d. Connect J700-22 to +5 volts on J700-57.

15. Rear panel J658 connections (switch drivers).

    a. SW-1. Connect wire fron J658-1 to J800-11.
       Connect wire from J658-8 to J800-13.
    b. SW-2. Connect wire fron J658-2 to J800-7.
       Connect wire from J658-9 to J800-9.
    c. SW-3. Connect wire fron J658-3 to J800-15.
       Connect wire from J658-10 to J800-17.
    d. SW-4. Connect wire fron J658-4 to J800-19.
       Connect wire from J658-11 to J800-21.

16. J658 LED indicator lights rear panel cabling.

    a. Connect wire from J658-5 to J800-30.
    b. Connect wire from J658-6 to J800-32.
    c. Connect wire from J658-12 to J800-34.
    d. Connect wire from J658-13 to J800-36.
    e. Connect wire from +5 volts to J658-14.

17. Miscellaneous Modifications
    a. Install capacitor on Z-100 PC board.
    b. Install capacitor on Z-400 PC board.
    c. Install capacitor on Z-400 PC board.
    d. Replace R423 with 51 ohm resistor 1/4 watt.

5.4 Troubleshooting

If trouble is suspected, check all coaxial cable connectors and I/O control cables to see that all connectors are properly locked. Determine that a signal into the ETMS yields an indication on the signal level meter, and that the signal level can be manually programmed from the ETMS console.

Connect the ETMS directly to the simulated star output, without the multi-input port module in the RF circuit, and execute the Equipment Check program to verify the ETMS integrity. Reinstall the multi-input port module and verify that the station down-converters are set to the desired frequency and properly phase-locked, and verify that a signal exists on each channel. If trouble still persists, determine if the problem is in the channel control circuitry or in one or more channels of the RF circuit. Refer to the troubleshooting chapters in the maintenance manual if the trouble is in the control circuits, or to section 6 of this addendum for information on the multi-input port accessory module RF circuits.

5.5 Parts List (Z-800 PC Board)

CATEGORY NO 1 — RESISTORS

1	Z8-R1	8	RES FXD CARB 5% 1/4W	1.0K OHM	AB	CB
2	Z8-R2		SAME AS R1	1.0K OHM		
3	Z8-R3	8	RES FXD CARB 5% 1/4W	43.0K OHM	AB	CB
4	Z8-R4		SAME AS R3	43.0K OHM		
5	Z8-R5	8	RES FXD CARB 5% 1/4W	4.3K OHM	AB	CB
6	Z8-R6		SAME AS R5	4.3K OHM		
7	Z8-R7		SAME AS R1	1.0K OHM		
8	Z8-R8		SAME AS R1	1.0K OHM		
9	Z8-R9		SAME AS R3	43.0K OHM		
10	Z8-R10		SAME AS R3	43.0K OHM		
11	Z8-R11		SAME AS R5	4.3K OHM		
12	Z8-R12		SAME AS R5	4.3K OHM		
13	Z8-R13		SAME AS R1	1.0K OHM		
14	Z8-R14		SAME AS R1	1.0K OHM		
15	Z8-R15		SAME AS R3	43.0K OHM		
16	Z8-R16		SAME AS R3	43.0K OHM		
17	Z8-R17		SAME AS R5	4.3K OHM		
18	Z8-R18		SAME AS R5	4.3K OHM		
19	Z8-R19		SAME AS R1	1.0K OHM		
20	Z8-R20		SAME AS R1	1.0K OHM		
21	Z8-R21		SAME AS R3	43.0K OHM		
22	Z8-R22		SAME AS R3	43.0K OHM		
23	Z8-R23		SAME AS R5	4.3K OHM		
24	Z8-R24		SAME AS R5	4.3K OHM		
25	Z8-R25	12	RES FXD CARB 5% 1/4W	180 OHM	AB	CB
26	Z8-R26		SAME AS R25	180 OHM		
27	Z8-R27		SAME AS R25	180 OHM		
28	Z8-R28		SAME AS R25	180 OHM		
29	Z8-R29		SAME AS R25	180 OHM		
30	Z8-R30		SAME AS R25	180 OHM		
31	Z8-R31		SAME AS R25	180 OHM		

32	Z8-R32		SAME AS R25	180	OHM		
33	Z8-R33		SAME AS R25	180	OHM		
34	Z8-R34		SAME AS R25	180	OHM		
35	Z8-R35		SAME AS R25	180	OHM		
36	Z8-R36		SAME AS R25	180	OHM		
37	Z8-R37	1	RES FXD CARB 5% 1/4W	47.0K	OHM	AB	CB

CATEGORY NO. 2 CAPACITORS

1	Z8-C14		CAP CERAMIC MONO 50V	1.0 UF	SPRG	5C023105X025053
2	Z8-C2		SAME AS C1	1.0 UF		
3	Z8-C3		SAME AS C1	1.0 UF		
4	Z8-C4		SAME AS C1	1.0 UF		

CATEGORY NO. 3 TRANSISTORS

1	Z8-Q1	8	TRANSISTOR SILICON PNP	2N4919	MOT	2N4919
2	Z8-Q2		SAME AS Q1	2N4919		
3	Z8-Q3	8	TRANSISTOR SILICON NPN	2N4922	MOT	2N4922
4	Z8-Q4		SAME AS Q3	2N4922		
5	Z8-Q5		SAME AS Q1	2N4919		
6	Z8-Q6		SAME AS Q1	2N4919		
7	Z8-Q7		SAME AS Q3	2N4922		
8	Z8-Q8		SAME AS Q3	2N4922		
9	Z8-Q9		SAME AS Q1	2N4919		
10	Z8-Q10		SAME AS Q1	2N4919		
11	Z8-Q11		SAME AS Q3	2N4922		
12	Z8-Q12		SAME AS Q3	2N4922		
13	Z8-Q13		SAME AS Q1	2N4919		
14	Z8-Q14		SAME AS Q1	2N4919		
15	Z8-Q15		SAME AS Q3	2N4922		
16	Z8-Q16		SAME AS Q3	2N4922		

CATEGORY NO. 4 DIODES

1	Z8-D1	8	DIODE SILICON 100V	1N4153	MOT	1N4153
2	Z8-D2		SAME AS D1	1N4153		
3	Z8-D3	8	DIODE ZENER SI 36V	1N5258	MOT	1N5258A
4	Z8-D4		SAME AS D3	1N5258		
5	Z8-D5		SAME AS D1	1N4153		
6	Z8-D6		SAME AS D1	1N4153		
7	Z8-D7		SAME AS D3	1N5258		
8	Z8-D8		SAME AS D3	1N5258		
9	Z8-D9		SAME AS D1	1N4153		
10	Z8-D10		SAME AS D1	1N4153		
11	Z8-D11		SAME AS D3	1N5258		
12	Z8-D12		SAME AS D3	1N5258		
13	Z8-D13		SAME AS D1	1N4153		
14	Z8-D14		SAME AS D1	1N4153		
15	Z8-D15		SAME AS D3	1N5258		
16	Z8-D16		SAME AS D3	1N5258		

CATEGORY NO. 5 INTEGRATED CIRCUITS

1	Z8-IC1	5	INT. CRKT. 1/10 DECODE	7442N	TI	SN7442N
2	Z8-IC2	2	INT. CRKT.HEX BUSS DVR	8T97	SGNT	8T97-N
3	Z8-IC3	1	INT. CRKT. QUAD-NOR	74LS02N	TI	SN74LS04N
4	Z8-IC4		SAME AS IC2	8T97		
5	Z8-IC5	1	INT. CRKT. QUAD LATCH	74LS175N	TI	SN74175N
6	Z8-IC6		SAME AS IC1	7442N		
7	Z8-IC7	1	INT. CRKT. ONE-SHOT	74121N	TI	SN74121N
8	Z8-IC8		SAME AS IC1	7442N		
9	Z8-IC9		SAME AS IC1	7442N		
10	Z8-IC10	2	INT. CRKT. HEX INVTR	7404N	TI	SN7404N
11	Z8-IC11		SAME AS IC1	7442N		
12	Z8-IC12		SAME AS IC10	7404N		

CATEGORY NO. 10 HARDWARE

1	Z8-B1	1	PC BRD FOR COAX SW DVR		NBS	PC-Z800
2	Z8-H1	16	SCREW 4-40X1/4	1/4		
3	Z8-H2	16	NUT 4-40			
4	Z8-H3	16	LOCK WASHER STAR	4-40		

CATEGORY NO. 12 SUBASSEMBLIES

1	Z8	1	COAX SW DRIVER PC CARD	NBS	Z800

5.5.1 Parts List Additions (ETMS Console)

ADD TO CATEGORY NO. 6, ETMS Maintenance Manual page number 58.

32	Z-J648	1	CONN PC EDGE (Z-800)	60 PIN	SAME AS Z-J646
33	Z-J558	1	CONN BLUE RIBBON I/O	14 PIN	SAME AS Z-J651

ADD TO CATEGORY NO. 10, ETMS Maintenance Manual page number 60.

26	Z-H25	1	CARD GUIDE PC, FRONT	NBS
27	Z-H26	1	CARD GUIDE PC, REAR	NBS
28	Z-H27	1	MOUNT PLATE, STEP ATTNR	NBS

5.6 Wiring List

WIRING LIST
J-400 REVISED

ANALOG GND	1	2	ANALOG GND
+36 VOLTS	3	4	+36 VOLTS
+24 VOLTS	5	6	+24 VOLTS
	7	8	PGM ATNR 8+
	9	10	PGM ATNR 8-
REF ATNR-2	11	12	PGM ATNR 4+
REF ATNR-1	13	14	PGM ATNR 4-
Z500-50	15	16	PGM ATNR 2+
RF ON -2	17	18	PGM ATNR 2-
Z500-52	19	20	PGM ATNR 1+
RF ON -1	21	22	PGM ATNR 1-
	23	24	
	25	26	
	27	28	
	29	30	
	31	32	
Z500-55	33	34	
	35	36	
	37	38	Z800-31
	39	40	Z800-33
FP 49	41	42	Z800-42
FP 29	43	44	Z800-41
Z500-47	45	46	Z800-45
FP 51	47	48	FP 25
Z800-53	49	50	Z800-48
Z800-55	51	52	Z800-51
Z700-56	53	54	Z700-54
J650-20	55	56	J651-13
+5 VOLTS	57	58	+5 VOLTS
GND	59	60	GND

5.7 Wiring List

J-700 REVISED

ANALOG GND	1	2	ANALOG GND
	3	4	
+24 VOLTS	5	6	+24 VOLTS
	7	8	
	9	10	
	11	12	J654 NOISE-ADD #2
	13	14	J653 NOISE-ADD #1
S656-NC TTL-NA1	15	16	
S656-NO TTL-NA1	17	18	FP 3
S657-NC TTL-NA2	19	20	FP 1
S657-NO TTL-NA2	21	22	Z700-57
J650-16	23	24	Z800-50
Z800-38	25	26	J650-15
FP 10	27	28	FP 2
J650-11	29	30	Z800-52
Z800-40	31	32	J650-13
FP 8	33	34	FP 6
J650-12	35	36	Z800-56
Z800-44	37	38	J650-14
FP 12	39	40	FP 14
Z800-43	41	42	Z800-54
FP 14	43	44	
J650-9	45	46	Z800-47
J650-10	47	48	FP 19
FP 15	49	50	Z800-46
FP 16	51	52	Z400-45
J650-19	53	54	Z400-54
J650-17	55	56	Z400-53
+5 VOLTS	57	58	+5 VOLTS
GND	59	60	GND

5.8 Wiring List

J-800

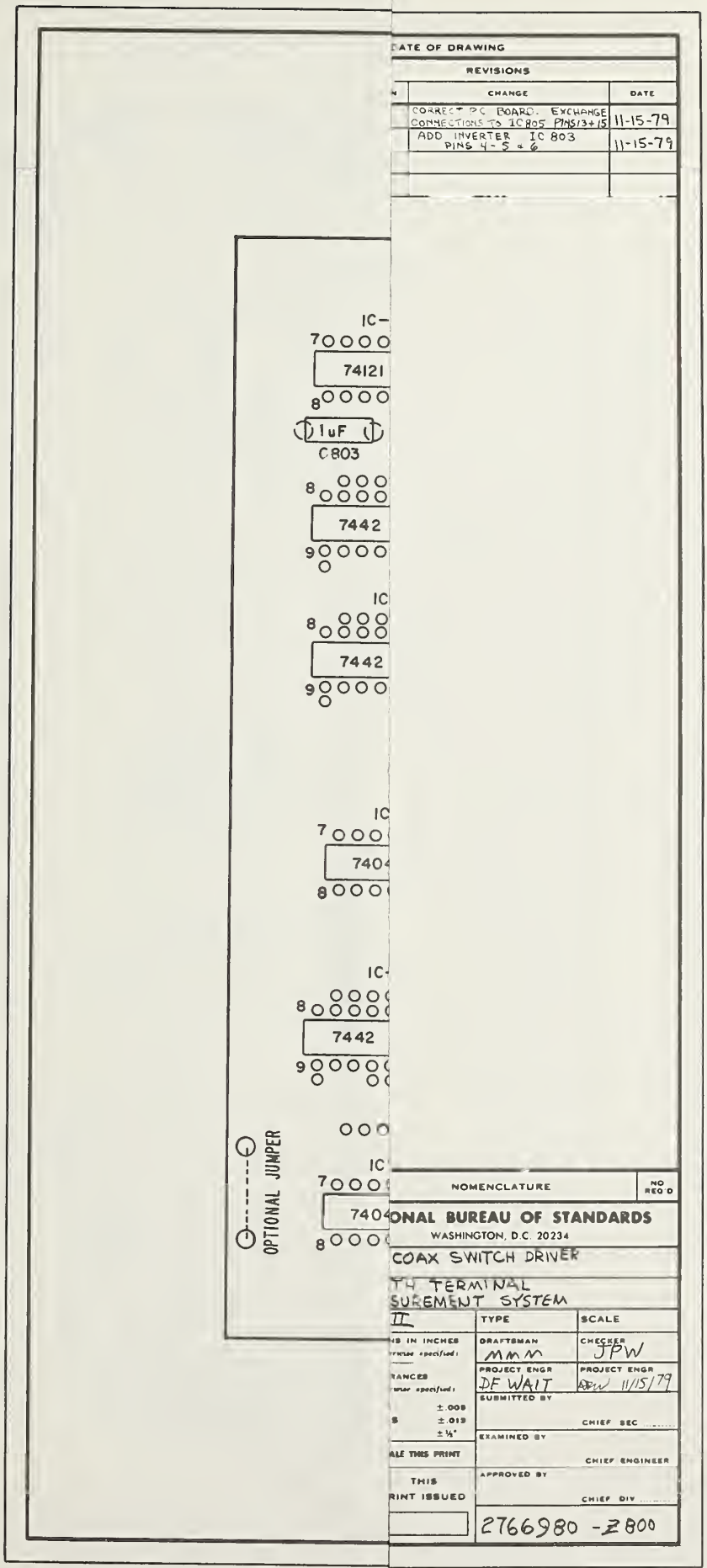
-24 VOLTS(GND)	1	2	-24 VOLTS(GND)
	3	4	
+24 VOLTS	5	6	+24 VOLTS
J658-2	7	8	
J658-9	9	10	
J658-1	11	12	
J658-8	13	14	
J658-3	15	16	
J658-10	17	18	
J658-4	19	20	
J658-11	21	22	
	23	24	
	25	26	
	27	28	
	29	30	J658-5
Z400-38,J651-4	31	32	J658-6
Z400-40,J651-3	33	34	J658-12
	35	36	J658-13
	37	38	Z700-25
	39	40	Z700-31
Z400-44,J651-1	41	42	Z400-42,J651-2
Z700-41	43	44	Z700-37
Z400-46,J651-12	45	46	Z700-50
Z700-46	47	48	Z400-50
Data bit H,No Conn	49	50	Z700-24
Z400-52,J651-8	51	52	Z700-30
Z400-49,J651-6	53	54	Z700-42
Z400-51,J651-5	55	56	Z700-36
+5 VOLTS	57	58	+5 VOLTS
GND	59	60	GND

5.9 Wiring List
J-651 REVISED

Z800-41 DATA1	1	8	Z800-51
Z800-42 DATA2	2	9	
Z800-33 DATA4	3	10	
Z800-31 DATA8	4	11	
Z800-55 DATA16	5	12	Z800-45 CTL STROBE
Z800-53 DATA32	6	13	Z400-56 MUX FLAG
GND	7	14	+5 VOLTS

5.10 Wiring List
J-658

Z800-11	1	8	Z800-13
Z800-7	2	9	Z800-9
Z800-15	3	10	Z800-17
Z800-19	4	11	Z800-21
Z800-30	5	12	Z800-34
Z800-32	6	13	Z800-36
	7	14	+5 VOLTS


DATE OF DRAWING
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DATE
CORRECT PC BOARD. EXCHANGE CONNECTIONS TO IC805 PINS 13+15
11-15-79
ADD INVERTER IC 803 PINS 4-5 & 6
11-15-79
IC-
74121
1uF
C803
7442
IC
7442
IC
7404
IC-
7442
IC
7404
OPTIONAL JUMPER
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APPROVED BY
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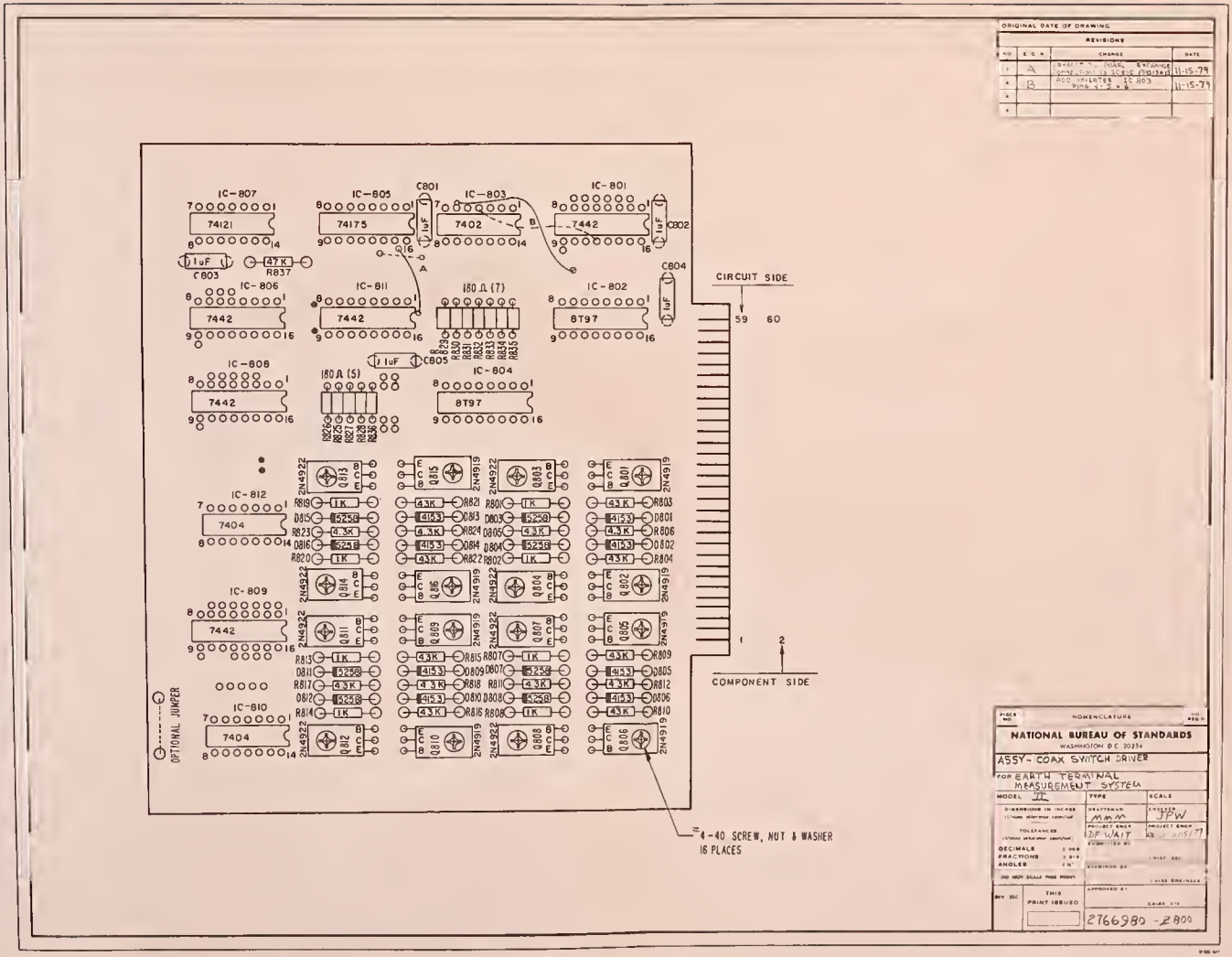
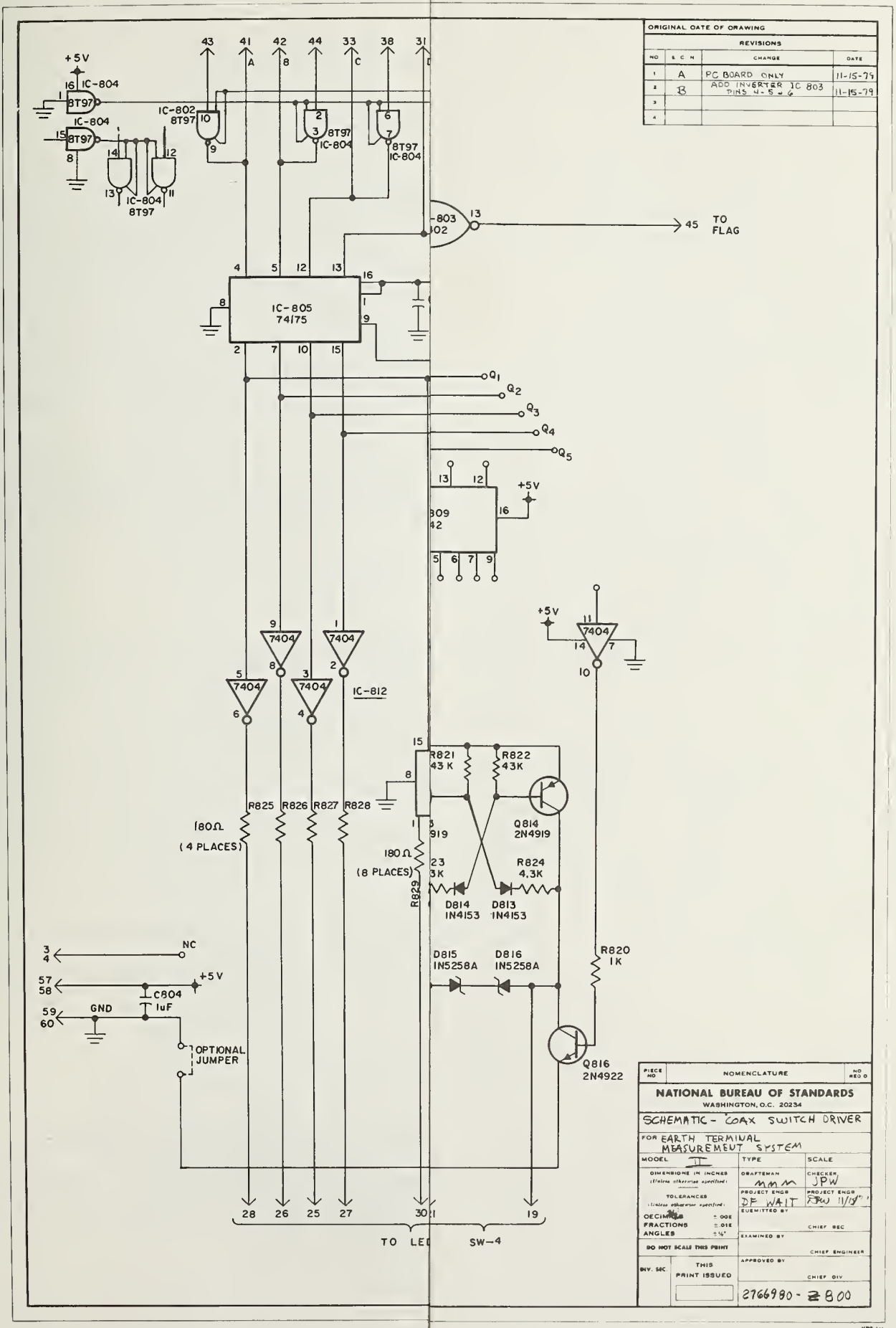


Figure 3. Z800 PC Card Parts Layout.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NO | S C N | CHANGE | DATE
1 | A | PC BOARD ONLY | 11-15-79
2 | B | ADD INVERTER IC 803 PINS 4-5-6 | 11-15-79
+5V
IC-804
8T97
IC-802
IC-803
74LS02
TO FLAG
IC-805
74175
Q1
Q2
Q3
Q4
Q5
7404
IC-812
R821 43 K
R822 43K
R825 R826 R827 R828
180Ω (4 PLACES)
180Ω (8 PLACES)
R824 4.3K
Q814 2N4919
D814 IN4153
D813 IN4153
D815 IN5258A
D816 IN5258A
R820 1K
Q816 2N4922
NC
C804 1uF
GND
OPTIONAL JUMPER
TO LED
SW-4
NATIONAL BUREAU OF STANDARDS
WASHINGTON, D.C. 20234
SCHEMATIC - COAX SWITCH DRIVER
FOR EARTH TERMIVAL MEASUREMENT SYSTEM
2766980 - 2800

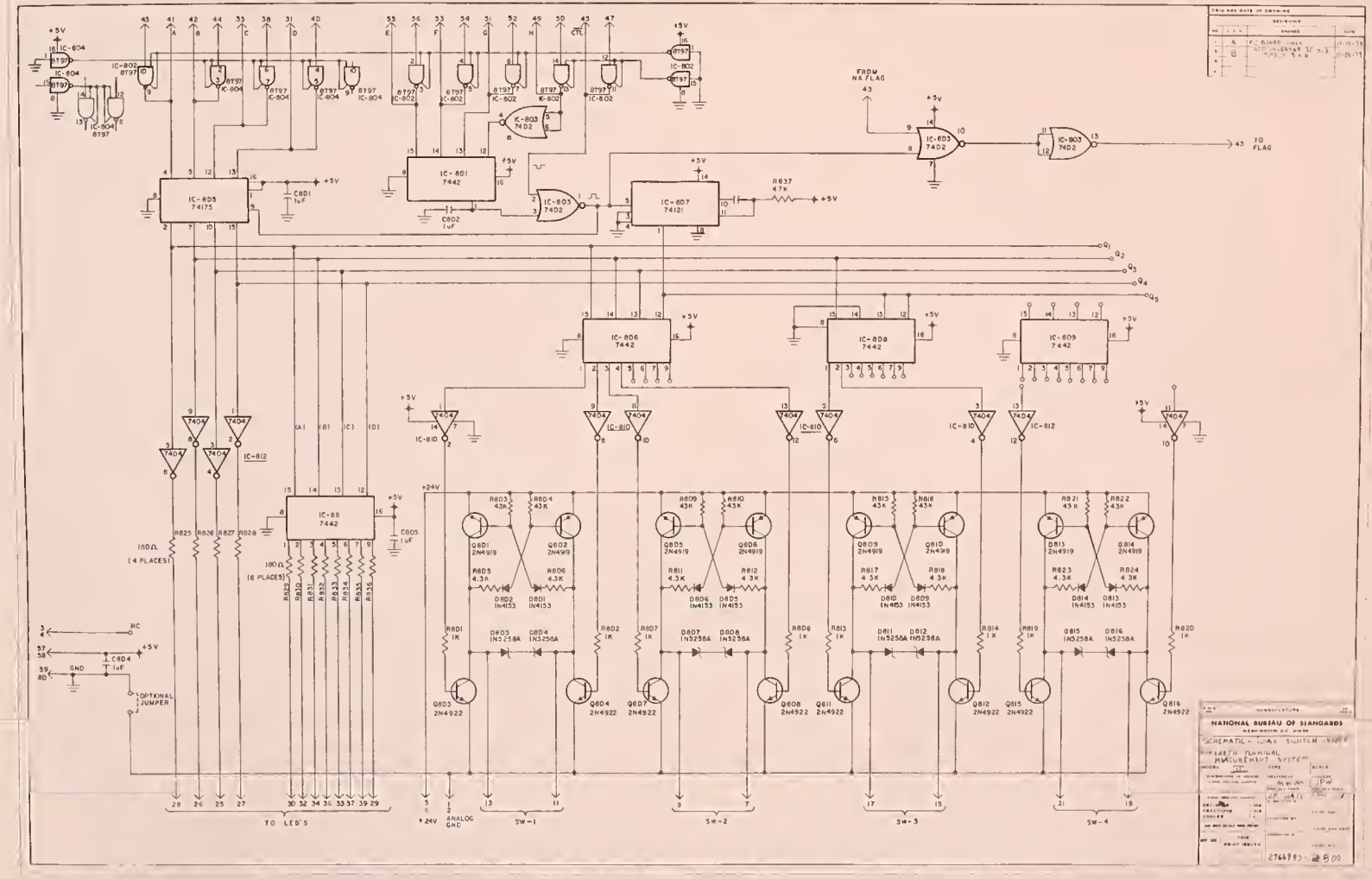


Figure 2. PC Z800 Schematic Diagram.

6. MULTI-INPUT PORT MODULE-INSTRUCTION MANUAL

6.1 Introduction

The multi-input port module, figure 4, is an accessory to the ETMS which permits connection of up to three RF inputs which may be remotely selected by the ETMS system. The module is located at the earth terminal IF patch panel near the down-converter outputs. It is connected to the ETMS via a single coaxial cable and a control cable. The ETMS can be used in the single input mode without connecting the multi-input module using either the original software or the revised software.

The ETMS control codes to select inputs one, two, or three either from the front panel or from the computer are #127, #126, and #125 respectively.

6.2 Module Description

Two magnetically latched double-throw coaxial relays connected to form a relay "tree" are mounted in a small enclosure having a support-loop on the cover. The relays connect any one of the three coaxial inputs to the output coaxial connector. The relays are controlled via a permenantly attached control cable which plugs into J-658 on the rear panel of the ETMS. LED indicators on the cover are positioned adjacent to each coaxial input to display the currently selected input.

The module does not house any electronics, only the two bi-polar relay coils and the LED indicators. All control circuitry is contained on the Z-800 PC board in the ETMS console.

6.3 Troubleshooting

If trouble with this module is suspected, check that the control cable is connected to J-658 and that the connector is properly latched. Determine whether the problem is an RF continuity problem or a control problem.

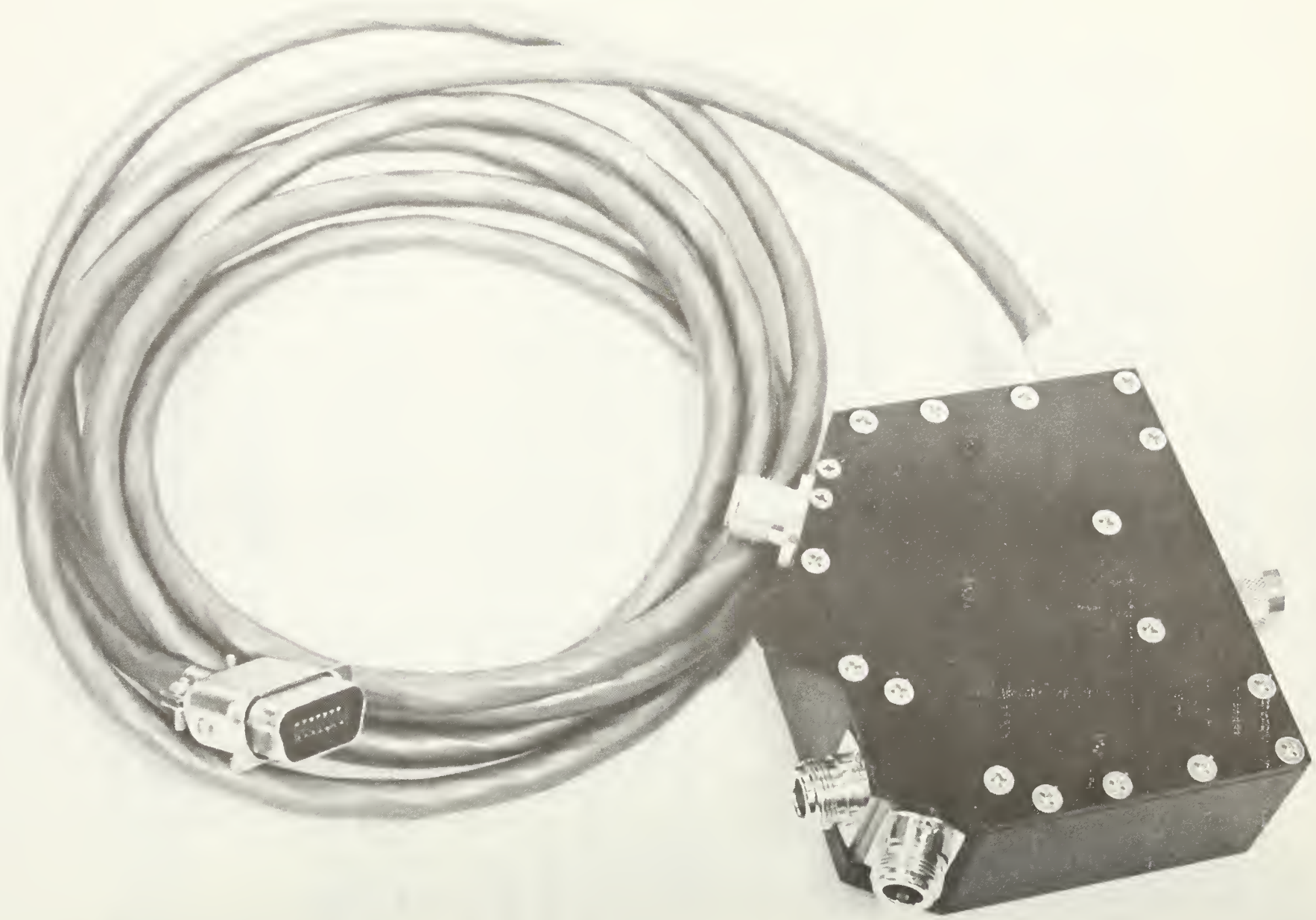


Figure 4. Multi- Input Relay Module.

If the symptom is loss of RF signal, check the coaxial cables and connectors and verify whether a signal is present at the output of the down-converter. Determine if the loss of signal is common to all input channels or is only in a single channel. Check any suspect channel by connecting the questionable input to the simulated star output and observing the signal level on the ETMS.

If the problem is related to control of the relays, follow the guidelines given in section 5 in this addendum and the troubleshooting sections of the ETMS Maintenance Manual.

6.4 Parts List Multi-Input Port Module

CATEGORY NO. 3			DIODES		
1	T1-D1	3	LED DIODE	TI	
2	T1-D2		SAME AS D1		
3	T1-D3		SAME AS D1		

CATEGORY NO. 6			CONNECTORS		
1	TI-J1	1	COAXIAL ADAPTER	TYPE N	UG 57B/U
2	T1-J2	1	COAXIAL ADAPTER	TYPE N	UG 30D/U

CATEGORY NO. 8			SWITCHES			
1	T1-S1	2	RELAY SWITCH,COAXIAL	TYPE N	HP	8665
2	1-S2		SAME AS S1			

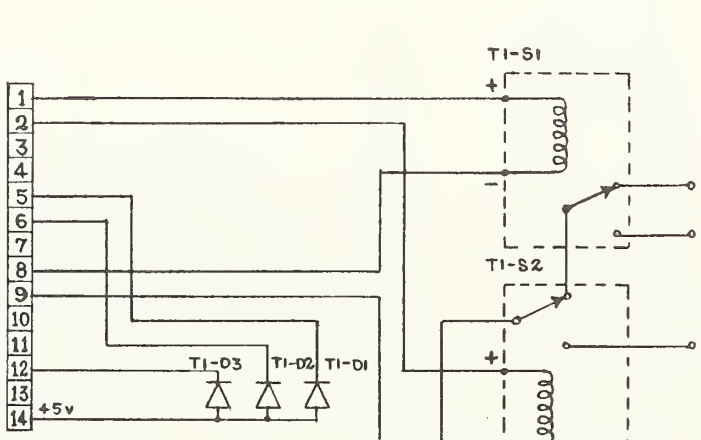
CATEGORY NO. 10			HARDWARE	
1	T1-H1	1	BASE PLATE, MODULE	NBS
2	T1-H2	1	COVER, MODULE	NBS
3	T1-H3	1	ESCUTCHEN,MODULE	NBS
4	T1-H4	4	SCREW,FLATHEAD 3/8X6-32	
5	T1-H5	4	SCREW,FLATHEAD 3/8X4-40	
6	T1-H6	8	SCREW,FLATHEAD 1/2X4-40	
7	T1-H7	1	CABLE STRAP, 3/8 IN.	

6.5 Wiring List

Relay Module Control Cable

	P-658	MULTI-INPUT MODULE
	1	SWITCH # 1 (+)
	2	SWITCH # 2 (+)
*	3	SWITCH # 3 (+)
	4	
	5	LED (INPUT # 1)
	6	LED (INPUT # 2)
	7	
	8	SWITCH # 1 (-)
	9	SWITCH # 2 (-)
*	10	SWITCH # 3 (-)
	11	
	12	LED (INPUT # 3)
*	13	LED (INPUT # 4)
	14	+5 VOLTS TO +LED'S

* These items used on prototype only.



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	PROJECT ENGR	PROJECT ENGR

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FIGURE 5. Multi-Input Relay Module Schematic Diagram

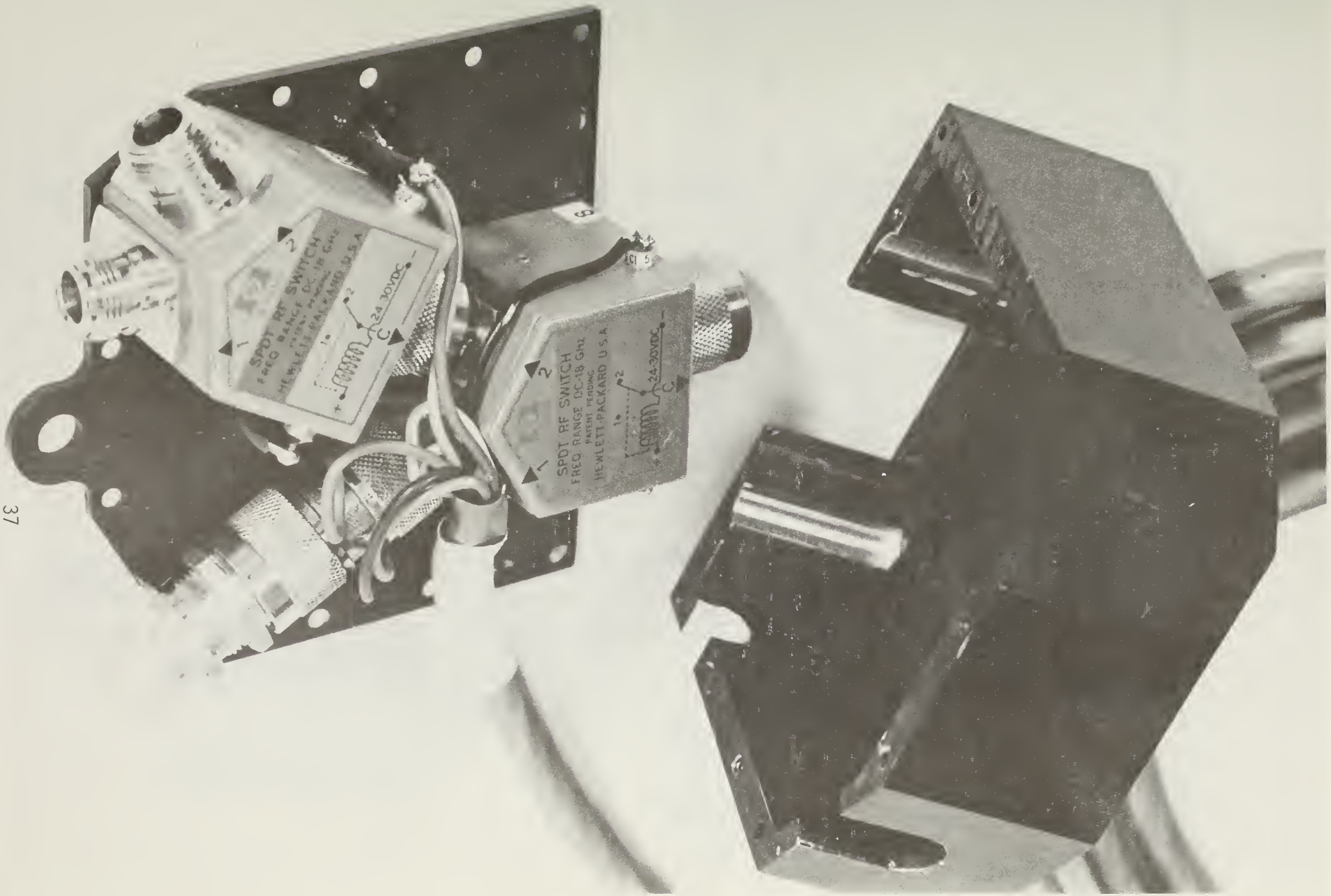

Figure 6. Relay Module Parts Location.

6.6 Spare Parts Additions

Please store the following items in the spare parts supply case, and add these to the spare parts list on page 203 of the maintenance manual.

Add to spare parts:

1. Z80O PRINTED CIRCUIT BOARD
2. T1-S1/T1-S2 COAXIAL SWITCH
3. ETMS INSTRUCTION MANUAL ADDENDUM

7. REFERENCES

[1] Wait, D. F., ETMS Operations Manual, NBSIR 78-879, (Dec. 1977).

[2] Wakefield, J. P., ETMS Maintenance Manual, NBSIR 78-895, (Sept. 1978).

[3] Larsen, N. T., A new self-balancing D-C substitution rf power meter, IEEE Transactions on Instrumentation and Measurement IM-25, No. 4, 343-347 (Dec. 1976).

8. ETMS CONTROL CODES

Program Switches and WBYTE

CODE	FUNCTION
24	DVM AUTO RANGE
27	DVM 0.1 RANGE
28	DVM 1.0 RANGE
29	DVM 10.0 RANGE
30	DVM 100.0 RANGE
31	DVM 1000.0 RANGE
32	DVM DC VOLTS FILTER OUT
33	DVM DC VOLTS FILTER IN
34	
35	DVM RATIO-NOT USED IN ETMS
48	PROG ATTNR 15 dB
49	PROG ATTNR 14 dB
↓	" " ↓ "
62	PROG ATTNR 1 dB
63	PROG ATTNR 0 dB
64	RF OFF/6 dB STEP IN
65	RF ON/6 dB STEP OUT
66	6 dB STEP IN
67	6 dB STEP OUT
68	RF OFF
69	RF ON
80	NOISE ADD ON
81	NOISE ADD OFF
82	NOISE ADD #2 ON
83	NOISE ADD #2 OFF
84	NOISE ADD #1 ON
85	NOISE ADD #1 OFF
100	INPUT CHANNEL #11 DVM
101	INPUT CHANNEL #10 DVM
102	INPUT CHANNEL # 9 DVM
103	INPUT CHANNEL # 8 DVM
104	INPUT CHANNEL # 7 DVM
105	INPUT CHANNEL # 6 DVM
106	INPUT CHANNEL # 5 DVM
107	INPUT CHANNEL # 4 DVM
108	INPUT CHANNEL # 3 DVM
109	INPUT CHANNEL # 2 DVM
110	INPUT CHANNEL # 1 DVM
111	INPUT CHANNEL # 0 DVM
124	INPUT #4
125	INPUT #3
126	INPUT #2
127	INPUT #1

9. REVISIONS AND ERRATA FOR ETMS MAINTENANCE MANUAL

9.1 Revisions and Retrofit

Please make the following additions to your ETMS MAINTENANCE MANUAL:

Page vi

a. Add on line 5.9:

ALSO see revisions in Addendum, Paragraphs 5.5 and 5.5.1.

b. Add on line 5.10:

ALSO see revisions in Addendum, paragraphs 5.6 through 5.10.

Page vii

Place the following notation at bottom of page vii:

NOTE: See Addendum for Retrofit and Revisions to add multiple input-Port switching to the ETMS.

Page viii

a. Paragraph #10, add:

10.3 Cable Wiring List (Multi Input Port) Addendum, Paragraph 6.5.

b. In Appendix C, change "page 211" to read "Addendum, Paragraph 8.0."

c. Add the following items to bottom of page viii:

Addendum Figure 1. Multi-input port control pc card Z800
Addendum Figure 2. Z800 schematic diagram
Addendum Figure 3. Z800 pc card parts layout
Addendum Figure 4. Multi-input relay module
Addendum Figure 5. Relay module schematic
Addendum Figure 6. Relay module parts layout

Page 58

Add note to end of Category # 6:

NOTE: See additional items in Addendum, Paragraph 5.5.1, Category #6.

Page 60

Add note to end of Category #10:

NOTE: See additional items in Addendum, Paragraph 5.5.1, Category #10.

Page 72

Add notation to bottom of page 72:

NOTE: See Z800 P.C. Card Parts List i Addendum, Paragraph 5.5, Categories #1 through #12.

Page 74

Place large note across Table J-400:

Revised - see Addendum, Paragraph 5.6.

Page 76

Place large note across Table J-700:

Revised - see Addendum, Paragraph 5.7.

Page 77

Make the following three notations on page 77:

a. Top of page 77:

NOTE: See Addendum, Paragraph 5.8 for Wiring Table J-800.

b. Place note across Table J-651:

Revised - See Addendum, Paragraph 5.9.

c. Bottom of page 77:

NOTE: See Wiring Table J-658 in Addendum, Paragraph 5.10.

Page 90

Add note to top of page 90:

NOTE: Z800 P.C. card (coaxial switch driver) schematic and parts layout are included in Addendum, Figure #2 and #3.

Page 203

Add to spare parts list:

1 - Z800 P.C. card
1 - Coaxial relay (T1-S1, S2)
1 - Addendum - Maintenance Manual Update

Page 211

Place large note across Table on page 211:

NOTE: See Addendum to ETMS MAINTENANCE MANUAL, Paragraph 8.0, for revised and corrected ETMS Control Codes.

9.2 Errata to ETMS MAINTENANCE MANUAL

Please make the following corrections to your ETMS MAINTENANCE MANUAL.

Page 13

Control codes should read:

Code 82 Noise - Add #2 ON
Code 83 Noise - Add #2 OFF
Code 84 Noise - Add #1 ON
Code 85 Noise - Add #1 OFF

Page 16

Top of page first sentence should read:

---Codes 83 and 82 (NA#2),--
---or 85 and 84 (NA#1),--

Page 49

Table 1 should read:

82_{10}	NC	ON
83_{10}	NC	OFF
84_{10}	ON	NC
85_{10}	OFF	NC

Page 50

Revise Table II as follows:

a. Change all J1 to J653.
Change all J2 to J654.
Change all J10 to J656.
Change all J20 to J657.

b. And in the paragraph below table; also change S10 to S-656 and S20 to S-657.

c. Change table entries as follows:

82_{10}	NC	NC	ON +24V +4V	ON
83_{10}	NC	NC	OFF +0.5V +0.7V	OFF
84_{10}	ON +24V +4V	ON	NC	NC
85_{10}	OFF +0.5V +0.7V	OFF	NC	NC

Page 54

Step #8, second sentence - change "External" to "ETMS" and the control code to #69.

Page 55

Step #13: change control code to #69.

Page 76

J-700 wiring list: correct J-700-40 to connect to FP 4.

Page 117

J-352 wiring list: connect J-352 pins 44, 45 and 46 to ground.

Page 161

Figure 30.

a. Connect an external potentiometer (20 Kohms) across R6.

b. Connect an external potentiometer (20 Kohms) across R36.

c. Reverse polarities shown for C10 and C40.

Page 193

I/O Cable Wiring List

Connect J-352 pins 44, 45 and 46 to ground. (Not Y100-3).

END of ERRATA as of October 1979

NBS-114A (REV. 2-8C)

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5. AUTHOR(S)

John P. Wakefield

6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions)

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10. SUPPLEMENTARY NOTES

☐ Document describes a computer program, SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This addendum to the Earth Terminal Measurement System Maintenance Manual, NBSIR 78-895, describes the equipment and maintenance procedures required to support the retrofit package for the Earth Terminal Measurement System (ETMS) developed by the National Bureau of Standards. This retrofit adds a multi-input-port relay module which provides the capability of connecting three receiver channels to the ETMS, thereby enabling measurement of pertinent earth terminal parameters at as many as three frequencies in a single measurement pass. This manual does not include measurement theory nor measurement operating procedures that are described in the Earth Terminal Measurement System Operation Manual, NBSIR 78-879.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Earth terminal; earth terminal measurement system; figure of merit; noise temperature; satellite communication

13. AVAILABILITY

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