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HANDBOOK FOR BROADBAND ISOTROPIC ANTENNA SYSTEM VOLUME I— OPERATION MANUAL

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U.S. Department of Commerce
Boulder, Colorado 80303

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PREFACE

The Handbook for the Isotropic Antenna System consists of four volumes of which this is the first. The others are:

Volume II	Statement of Work (Technical Specification and Software Description)
Volume III	Repair and Maintenance
Volume IV	Reference Data (Photographs and Schematics)

NOTICE

"Certain commercial equipment, instruments, or materials are identified in this paper. Precise identification of the product is necessary because the product is part of a system and is a part whose technical characteristics must, in the event of damage or failure, be duplicated exactly in a successful replacement part. 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."

HANDBOOK FOR
BROADBAND ISOTROPIC ANTENNA SYSTEM

VOLUME I
OPERATION MANUAL

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HANDBOOK FOR
BROADBAND ISOTROPIC ANTENNA SYSTEM

VOLUME I
OPERATION MANUAL

by
W.D. Bensema

This manual describes the equipment operation and maintenance procedures to support the broadband isotropic* antenna system developed by the National Bureau of Standards for making EMI measurements in the frequency range from 10 kHz to 18 GHz. The system uses isotropic broadband antennas, a low power microcomputer, antenna switching units, commercially available receivers, and associated cabling. The system automatically switches antenna elements, computes the total scalar sum of the existing field strength, and automatically logs time, frequency, signal strength, and system configuration. The system reduces the number of personnel required to make searches for EMI, and includes a mode for unmanned monitoring.

Key words: broadband isotropic antenna, CMOS microcomputer, data logger, EMI monitor, scanning receiver.

1.0 GENERAL INFORMATION

1.1 Introduction

The broadband isotropic antenna system is a portable automated measurement system (figure 1) developed around a low power CMOS microcomputer. The system allows rapid measurement of E-field electromagnetic radiation from 10 kHz to 18 GHz and H-field electromagnetic radiation from 100 kHz to 32 MHz.

Used in conjunction with the appropriate commercially available receiver (Singer NM 17/27, NM 37/57, or NM-67), the system operates in one of five modes. Two modes called "tuning aids" are provided to aid the operator in manual signal selection: (1) Rapid Scan switches antenna elements every 10 ms (nominal) to scan in all directions for rapidly changing signals like radar; (2) Follow Max Element, periodically samples all antenna elements (10% of the time) and then connects the element receiving the strongest signal to the receiver (90% of the

*The term isotropic, as used in this document, refers to the ability of the system to synthesize an isotropic response from several measurements rather than the pattern of a single antenna structure.

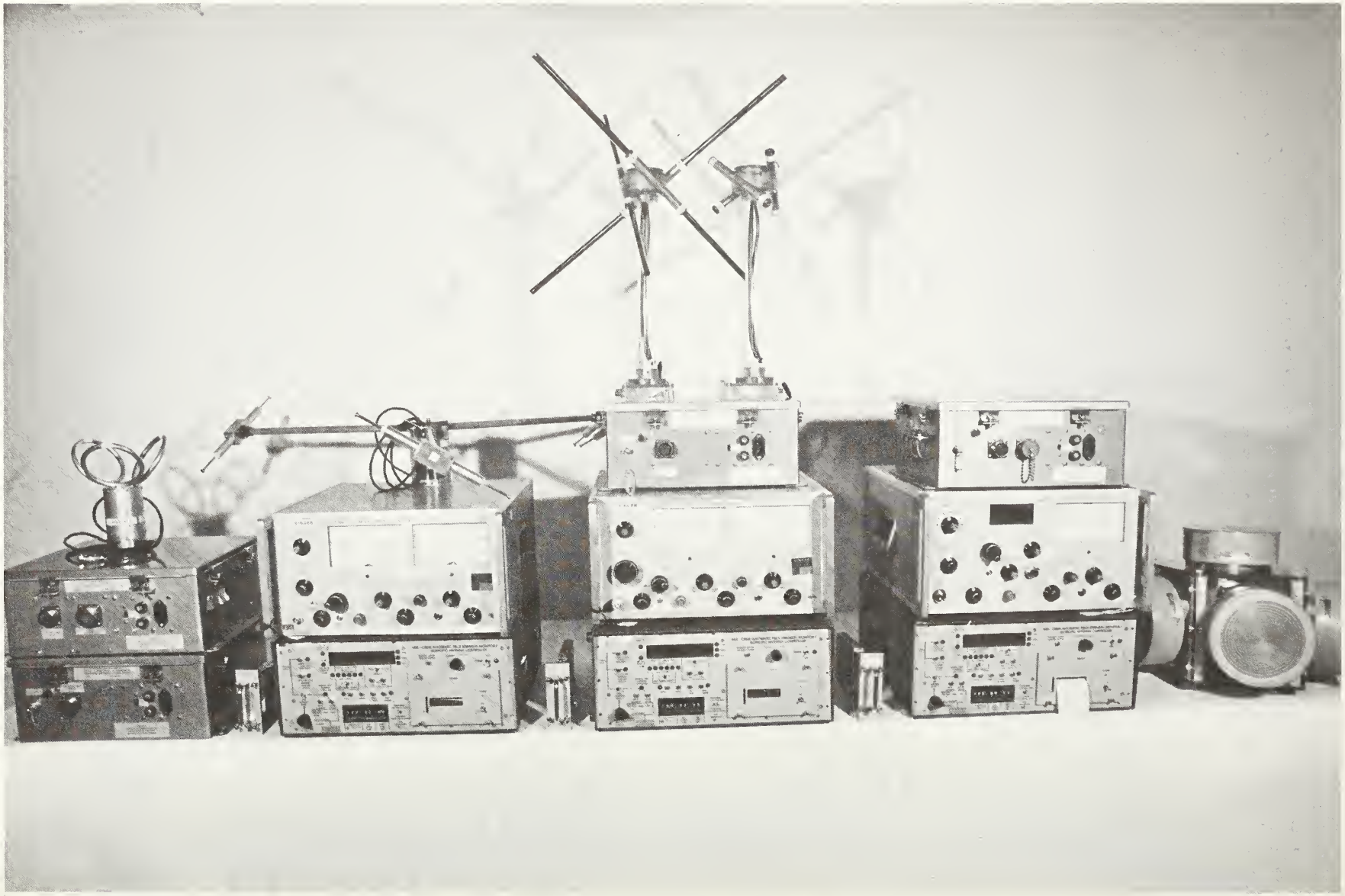

FIGURE 1 COMPLETE ISOTROPIC ANTENNA MEASUREMENT SYSTEM

time). This mode enables the operator to understand voice modulation. A third mode allows the operator to manually select antenna elements to determine relative signal strengths on each element.

After a signal has been located, a fourth mode computes the total scalar sum of the components of the field strength and displays the resultant field strength on a front panel display. If the operator wishes to permanently record this data, a fifth mode records the signal strength, frequency, time, and pertinent system parameters on a non-impact, 20 column, thermal printer.

When the receiver is placed in self-scan, a sixth mode available on the system will automatically find and record all signals present above a pre-setable threshold in the receiver band scanned. A record is made by the thermal printer.

The system also allows thumbwheel insertion of cable losses and external attenuators. Allowance is made for measuring of strong fields up to 100 V/m over most of the frequency range by optional switched insertion of an attenuator and associated automatic correction of displayed signal strength. Other system capabilities include clock set, request extra header, button for combined total and print, filtered convenience outlet, and bright indicators visible in direct sunlight.

The CMOS based controller uses a small plug-in memory that contains all the constants that pertain to a particular antenna-receiver combination. This feature allows a single controller module to serve with several antenna-receiver combinations (sequentially with memory change) thereby reducing the number of pieces of equipment (controllers) needed in the field.

1.2 Software

The software for the broadband isotropic antenna system is entirely self-contained in EPROMS plugged into the internal microcomputer. The language is 6100 assembly language, and was assembled for this machine using a FOPAL Fortran cross assembler running on a large computer. No external loading of software is required: the program is initialized and brought up whenever power is applied.

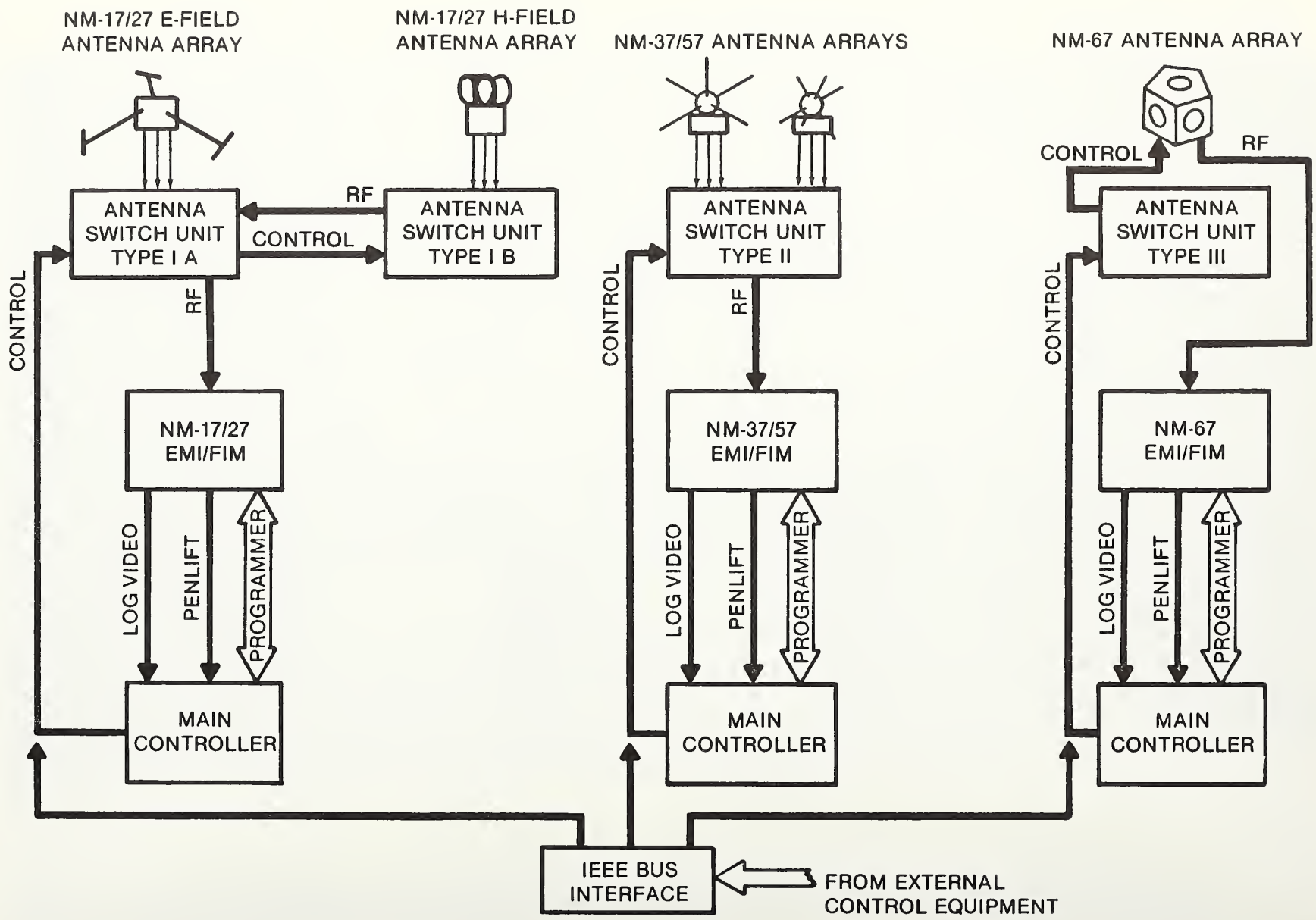

FIGURE 2. BLOCK DIAGRAM OF TYPICAL SYSTEM CONFIGURATIONS

1.3 Hardware

The broadband isotropic antenna system hardware consists of 3 major subsystems, as shown in figure 2. The measurement coverage is outlined in table 1. Note that H field measurements can be extended from 100 kHz down to 30 kHz with the use of amplitude corrections as described later.

Table 1. Measurement coverage of the broadband isotropic antenna system

System Designator	Singer Receiver Used	Electromagnetic Frequency Range	Field Component Measured
I	NM-17/27	10 kHz - 32 MHz	E
I	NM-17/27	100 kHz - 32 MHz	H
II	NM-37/57	30 MHz - 1000 MHz	E
III	NM-67	1 GHz - 18 GHz	E

E = electric field
H = magnetic field

1.4 Specifications

1.4.1 System Specifications

General system specification size: The portion of the system furnished by NBS is transported in eight foam plastic lined molded polyethylene transit cases, each occupying 0.19 cu m (6.9 cu ft). Counting three Singer transit cases of 0.16 cu m (5.5 cu ft) each, the total volume for all system transport cases is 2.03 cu m (71.7 cu ft).

The weight of each of the NBS supplied shipping containers (loaded) ranges from 25 kg (55 pounds) for the NM-67 switch box in its case, to 35 kg (76 pounds) for the controller, memory and cables in its case. Total system weight counting three controllers (eight cases) is 240 kg (529 pounds). The weight of the eight empty shipping containers and foam is about 136 kg (300 lb). The three Singer receivers and cases weigh 131 kg (289 pounds). All eleven cases with equipment weigh 371 kg (908 pounds).

Power requirements: The system will operate on either 50 or 60 Hz power line frequency and can be switched to operate from 115 VAC or 230 VAC.

Power consumption for each controller is 17 watts normally, 30 watts peak during printing. Each antenna switch box consumes 15.5 watts maximum. The three Singer receivers, NM 17/27, NM 37/57 and NM 67 consume 26 watts, 24 watts, and 125 watts, respectively. If a complete system is operating, maximum power required is 325 watts.

Environmental temperature: All components are expected to operate in the temperature range from -15°C to +50°C. The thermal printer produces increasingly faint images as the temperature drops.

Equipment mechanical dimensions: The controllers are 43 cm (17-1/2") wide by 42 cm (17") deep by 18 cm (7-1/2") high. All switch boxes are 38 cm (15.5") by 34 cm (14") by 16 cm (6.5") high. Antenna sizes vary from 22 cm (9") high by 17 cm (7") across for the 17/27 H-field antenna, up to 127 cm (52") maximum dimension across tips (extended) of the 17/27 E-field antenna.

1.4.2 Controller Specifications

1.4.2.1 Introduction

The controller is designed to display and optionally record total field strength as measured by a set of orthogonal antenna elements. Signal detection is accomplished by one of three external receivers.

The controller is capable of selecting each of the three (or six) antenna elements, sampling the resulting signal frequency and amplitude from the receiver, and displaying total field strength (square root of the sum of the squared values of the individual elements).

Most controller operations can be varied by adjusting constants in the plug-in memory. These variables will be called out in the specifications, and location and format will be given in the section on software.

1.4.2.2 Controller Modes

The controller is capable of operating in one of six modes, as follows:

1. Rapid antenna scanning. This mode connects each of the three (or six) elements to the receiver for nominally 10 ms (specified by variable

SCN). This allows the equivalent of "omnidirectional" antenna coverage while the operator manually tunes the receiver while looking for a signal. The receiver is normally placed in PEAK on this mode.

2. Follow max element antenna scanning. This mode rapidly samples all antenna elements (nominally 10 ms for the scan) and then connects the element with the strongest signal to the receiver for 90 ms. This mode aids in: (1) determining which element has the strongest signal; and (2) decreasing the amplitude variations caused by rapid scan and thereby increasing the intelligibility of any signal modulation. The receiver is normally placed in FI on this mode. Scan cycle time is programmed as parameter MFC.

On both modes 1 and 2 the log-video signal from the receiver is used. This is a wideband rapid response detector output. Both modes 1 and 2 are called automatic as opposed to manual, because the controller does the switching automatically. The signal strength display is blanked, and no signal strength readings are to be taken, because accurate readings are not practical when elements are being switched rapidly. The frequency display shows the current receiver frequency. Modes 1 and 2 are called "tuning aids" and are intended to assist the operator in locating signals.

3. Manual scanning. This mode allows the operator to manually select which antenna element is connected to the receiver by pressing the "Next Element" button. Front panel lights indicate which element is connected.

4. Total. This mode does a scalar sum (square root of the sum of the squares) of the three signals obtained from the 3 elements (or strongest 3 of 6 elements). Either automatic or manual element selection may be used. Total takes into account antenna calibration data stored in the plug-in memory, cable losses in the "standard" 9.1 meter cable, and additional cable or external attenuation factors entered on front panel thumbwheels. The resulting true field strength is displayed, along with the sample frequency. The reading is held until another operation is requested. Refer to the Operation section of this manual for methods of storing values in manual mode and diagnostics for incomplete storage.

5. Print. This is a transient mode that prints a previously computed total signal strength, and all the parameters associated with it such as frequency, the signal source selected, the antenna configuration and the time of day. If it is the first print after power up, or if an extra header is requested, a column identification or "header" is printed. Because the printer prints from the bottom up, the "header" identification is at the bottom of the columns. See the operating section on the printer for print out format decoding.

6. Max Finder. The last major mode of operation of the controller is termed max finder. When in this mode, the controller looks for and records peaks or maxima in the incoming signal amplitude level. The max finder mode can be used to either monitor a single frequency as a function of time, or to examine the output of the receiver during an automatic frequency sweep (initiated by pressing the scan button on the receiver). This mode will work with the antenna elements automatically scanned (auto) or with one element selected (manual). By selecting automatic antenna element scan, and an automatic frequency sweep, an unattended search of the selected receiver band may be obtained with omnidirectional antenna coverage, and a printed record of all desired peaks, their strength and frequency will be produced.

The threshold signal level above which a peak will be recorded is set by a front panel three digit thumbwheel, calibrated in signal strength.

A peak is defined as a maximum signal reading preceded by a signal increase and followed by a signal decrease. The minimum increase and decrease required to define a peak is determined by parameter "peaks" on the personality prom and is presently set at 6 dB. Once a peak value is determined, it is printed along with the corresponding frequency and time. As soon as a peak is determined and printed, the monitor will continue to look for the next peak. If a new peak is determined while the previous printing operation is being conducted, it will be stored until the printer can accept it. However, if more than one peak is determined while a previous printing

operation is being conducted, only the highest one will be stored and printed. This may cause some loss of data in an extremely crowded band as the printing operation takes approximately 0.3 seconds.

If an overrange condition occurs, the message ***OVERRANGE*** will be printed. When this message is encountered, more attenuation should be inserted prior to the receiver front end, and the measurement should be repeated. The overrange warning is only enabled for the log-video signal source (because of the wide bandwidth). Note that as long as the receiver is presented with a signal more than 4 dB above the meter indication, the message is continuously printed. Care should be used for unattended monitoring of single frequency to prevent using all the paper in the printer for overrange messages.

Any peak values less than the level specified by the threshold thumbwheels are not printed. The monitor will continue to print peaks until another button is pressed or the receiver frequency sweep operation terminates (determined by a pen lift signal). The numeric displays show the current frequency and signal strength. The signal value displayed and printed is a scalar sum of all antenna elements in auto mode, or the strength of the selected antenna element in manual mode. The time and frequency corresponding to the maximum signal strength are also printed. See Appendix A for the print format.

Example: Assume that the threshold is 80 dB, the minimum shoulder is 6 dB, and the following readings are made.

Time	Freq, MHz	Message Sig	Printed		
0900	10.0	55			
0900	10.6	84			
0900	10.9	81			
0900	11.1	89			
0901	11.5	67	11.1	89	09:00
0901	11.6	85			
0901	11.8	79	11.6	85	09:01

1.4.2.3 Other Controller Capabilities

1. Lamp Test. Upon application of power, the microcomputer in the controller initiates a two second test of all LED indicators and 7 segment readouts on the front panel (except for the "0 dB" light, which is lit whenever the four position selector switch in the lower left-hand corner of the front panel is in the LOG VIDEO position).

2. Clock. The controller contains a 24-hour clock. Hours and minutes can be read-out on the front panel or on the printer whenever a signal is recorded. The clock is updated every millisecond from a crystal oscillator and is good to a few seconds per day. Time may be set with hour and minute advance pushbuttons; hours and minutes advance approximately 2 per second. The clock is started by throwing the FREQUENCY/CLOCK switch to the FREQUENCY position. Time keeping is interrupted when the unit is turned off (power disconnected). After the clock is started, it will continue running unless ADV. HRS. or ADV. MIN. is pressed with the time displayed, at which time it will stop. It may then be restarted by switching back to FREQ.

3. Selecting Detector Function. The front panel monitor signal source switch is a four position switch which determines which signal line is to be sampled and how the values are processed for all modes.

   In the LOG VIDEO position, the signal from the log-video output of the receiver is sampled. The receiver function switch may be in any position. An average of several readings is taken to represent the value of the signal. This position has a quick response and tends to yield a short term average signal value. Displayed and printed values are not corrected for receiver attenuator settings. The receiver attenuator must be set to zero to achieve a correct reading.

   In the FI (field intensity) position, the signal is taken from the receiver dB readout pin. The receiver function switch should be in the FI position. When this position is used, a longer delay is inserted after selecting an antenna element, before the reading is taken (the delay is determined by parameter FIS in the personality

prom), nominally 0.6 seconds. This position has a slow response, but greater immunity to noise. Displayed and printed values are automatically corrected for receiver attenuator settings.

In the PEAK position, the signal is taken from the receiver dB readout pin. The receiver detector function switch should be in any of the peak positions with a hold time of .05 to 3.0 sec. Whenever an antenna element is selected, the monitor waits 50 milliseconds (parameter SPK in the personality prom) for the previous peak to be dumped. It then takes several samples, nominally 4 (parameter NPK in the personality prom), and chooses the maximum value. This should correspond to the maximum signal received within the sample period. This position has a fairly quick response.

In the TRUE PEAK position, the reading is the actual peak. This reading is 3 dB higher than PEAK, since the receiver scales the output of its peak detector to be equal to the FI detector for cw signals.

4. ANT. SENSITIVITY switch. To increase the usable amplitude range of this measurement system, either a variable gain antenna (17/27 E-field) or switchable attenuator (37/57 and 67) are provided. The ANT. SENSITIVITY switch inserts the appropriate amplitude correction into the computed total signal strength; and in the case of the switchable attenuators, switches it out for high sensitivity (low signal level) and in for low sensitivity (high signal level).

5. ANT ARRAY SELECT switch. Provision is made to select one of two antenna arrays, A or B. 17/27 array A is electric field (E) dipoles; array B is magnetic field (H) loops. For the 37/57, both arrays are dipoles, but array A covers from 30 MHz to 190 MHz, and array B covers from 190 MHz to 1000 MHz. For the 67 array, A is 6 spiral antennas; array B selects a seventh input connector intended for a non-NBS supplied antenna. (Non-NBS supplied antennas may be used on the 17/27 and 37/57 by connecting them directly to the receiver inputs and bringing up the controller with the NO ANT. CORRECTION FACTOR ADDED light lit. See next section).

6. NO ANT. CORRECTION FACTOR ADDED indicator light. To allow antennas other than the ones supplied and calibrated by NBS to be used with this system, provision is made to bypass (disable) the controller internal antenna calibration factors that are usually applied. To disable the internal correction, the controller AUTO/MANUAL switch must be in the MANUAL position. Hold in the NEXT ANT. pushbutton while turning on the power switch. The NO. ANT CORRECTION FACTOR ADDED indicator will be lit and the printout header will list UND (undefined) in place of the antenna identifiers.

7. Personality PROM printout. To allow inspection of all the constants stored in the plug-in memory, the contents of the personality PROM may be printed. To obtain a personality PROM dump, push the PRINT pushbutton while turning on the power switch. The PROM values are printed, 4 per line, in decimal. The first number in each line is the decimal address of the following byte. After the PROM dump, the controller will revert to normal operation.

8. Specifying the receiver and antenna characteristics. Characteristics of the specific antenna set and receiver model are stored in the personality PROM (plug-in memory). Factors include number of antenna elements, nominal antenna gain, gain correction as a function of frequency, receiver scaling factor for frequency (readout) as a function of selected band, antenna scanning rate and required settling time, etc. See table 4 for the complete format of variables and coding/decoding instructions.

9. Other. Refer to the packing list for cabling requirements. Refer to the Equipment Operation section, 2.5, for more detailed characteristics of the software, such as operational aids. Refer also to the Equipment Operation section for printer format and decoding.

2.0 INSTALLATION AND OPERATION

2.1 Introduction

Installation procedures are usually performed on arrival at each site. In short, this amounts to first unpacking the system units (controllers, antenna switch boxes, antennas and receivers), then connecting the various cables between units, verifying that the power line supply voltage selectors match the available power, and turning on the system.

2.2 Equipment Provided

Figure 1 is a photograph of the portion of the system covering from 30 to 1000 MHz. Figure 2 is the system block diagram. The system is shipped in eight transit cases, as follows:

Case No. 1, E-Field Antenna, Switch Box and cables for NM-17/27
Case No. 2, H-Field Antenna, Switch Box and cables for NM-17/27
Case No. 3, Controller, with memory for NM-17/27 and cables
Case No. 4, E-Field Antennas (2 ea), Switch Box and cables for NM-37/57
Case No. 5, Controller, with memory for NM-37/57 and cables
Case No. 6, Antenna for NM-67
Case No. 7, Switch Box and cables for NM-67
Case No. 8, Controller, with memory for NM-67 and cables

In addition to the above cases, a complete system requires three receivers, not supplied by NBS as follows:

Case No. 9, Singer-NM-17/27 receiver
Case No. 10, Singer-NM-37/57 receiver
Case No. 11, Singer-NM-67 receiver

Throughout this manual the three receivers will be referred to as Singer. They have been identified by other commercial names as Stoddart, AilTech and Eaton. This manual will use Singer throughout.

Itemized lists of the contents of each case provide a guide for repacking equipment for transit. Because there are two systems specific identification information for systems 1 and 2 is included. The first number of the two digit case number denotes which of two systems is described.

2.2.1 System 1 Packing List

Case No. 1-1 E-Field Antenna, Switch Box and cables for NM-17/27

Item	Identification
Antenna Switch Box IA	17/27E, Model 504, Serial 102 with 3 cables attached
Antenna Head Electric Field	Model 504, Serial 102
Antenna Dipole Element	#1 Model 504 Serial 102
Antenna Dipole Element	#2 Model 504 Serial 102
Antenna Dipole Element	#3 Model 504 Serial 102
Cable, 9.1m (30') coax, blue over red, with red on connector	
Cable, 9.1m (30'), 10 pin control	
Cable, AC power	
Spare fuses and pilot lamp.	

Case No. 1-2 H-Field Antenna, Switch Box and cables for NM-17/27

Item	Identification
Antenna Switch Box IB	17/27 H Model 505 Serial 102 with 3 cables attached
Antenna, Magnetic Field	Model 505 Serial 102
Cable, 3m (10'), coax red	
Cable, 3m (10'), 10 pin control	
Cable, AC power	
Spare fuses and pilot lamp.	

Case No. 1-3 Controller, with memory for NM-17/27 and cables

Item	Identification
Controller	Model 500 Serial 102
Plug-in memory for 17/27 receiver	Model 501 Serial 102
Cable, 36.6m (120'), 10 pin control	
Cable, 18.3m (60'), coax	white over red
Cable, 9.1m (30'), coax	yellow over red
Cable, 1.2m (4'), 41 pin control	
Cable, 1.2m (4'), receiver per lift	0.20" jack, both ends
Cable, 1.2m (4'), remote total and print	pushbutton to 0.25" jack
Cable, 0.9m (3'), log-video	BNC both ends
Cable, AC power	
Operation Manual, serial #102	
Spare fuses	

Case No. 1-4 E-Field Antennas (2 ea), Switch Box and cables for NM-37/57

Item	Identification
Antenna Switch Box IIA	37/57E, Model 506, Serial 102 with 3 cables attached
Antenna, 30 MHz-190 MHz	Model 506, Serial 102
Antenna Extension Element 6 each	(for 30 to 180 MHz antenna)
Antenna, 190 MHz to 1000 MHz	with 3 cables attached
Cable, 9.1m (30') coax, "standard" connector	red over white, with red on
Cable, 9.1m (30'), 10 pin control	
Cable, AC power	
Spare fuses and pilot lamps	

Case No. 1-5 Controller, with memory for NM-37/57 and cables

Item	Identification
Controller	Model 500 Serial 103
Plug-in memory for 37/57 receiver	Model 502 Serial 102
Cable, 36.6m (120'), 10 pin control	
Cable, 18.3m (60'), coax	blue over white
Cable, 9.1m (30'), coax	yellow over white
Cable, 1.2m (4'), 41 pin control	
Cable, 1.2m (4'), receiver per lift	0.20" jack, both ends
Cable, 1.2m (4'), remote total and print	pushbutton to 0.25" jack
Cable, 0.9m (3'), log-video	BNC both ends
Cable, AC power	
Operation Manual, serial #103	
Spare fuses	

Case No. 1-6 Antenna for NM-67

Item	Identification
Antenna, pentagonal, with 6 log spiral elements	Model 508 Serial 102
Spare pilot lamp	

Case No. 1-7 Switch Box and cables for NM-67

Item	Identification
Antenna Switch Box IIIA	67E, Model 508, Serial 102
Cable, 9.1m (30') coax, "standard"	Times Wire & Cable, fabric covered, P/N AE 82/1, S/N 0001
Cable, 2m (6.5'), 19 pin switch control	Large 19 pin connectors
Cable, 30', 10 pin control	
Cable, AC power	
Spare fuses	

Case No. 1-8 Controller, with memory for NM-67 and cables

Item	Identification
Controller	Model 500 Serial 104
Plug-in memory for 67 receiver	Model 503 Serial 102
Cable, 36.6m (120'), 10 pin control	
Cable, 1.2m (4'), 41 pin control	
Cable, 1.2m (4'), receiver per lift	0.20" jack, both ends
Cable, 1.2m (4'), remote total and print	pushbutton to 0.25" jack
Cable, 0.9m (3'), log-video	BNC both ends
Cable, AC power	
Operation Manual, serial #104	
Spare fuses	

2.2.2 System 2 Packing List

Case No. 2-1 E-Field Antenna, Switch Box and cables for NM-17/27

Item	Identification
Antenna Switch Box IA	17/27E, Model 504, Serial 103 with 3 cables attached
Antenna Head Electric Field	Model 504, Serial 103
Antenna Dipole Element	#1 Model 504 Serial 103
Antenna Dipole Element	#2 Model 504 Serial 103
Antenna Dipole Element	#3 Model 504 Serial 103
Cable, 9.1m (30') coax, "standard" connector	red over yellow, with red on
Cable, 9.1m (30'), 10 pin control	
Cable, AC power	
Spare fuses and pilot lamp.	

Case No. 2-2 H-Field Antenna, Switch Box and cables for NM-17/27

Item	Identification
Antenna Switch Box IB	17/27 H Model 505 Serial 103 with 3 cables attached
Antenna, Magnetic Field	Model 505 Serial 103
Cable, 3m (10'), coax red	
Cable, 3m (10'), 10 pin control	
Cable, AC power	
Spare fuses and pilot lamp.	

Case No. 2-3 Controller, with memory for NM-17/27 and cables

Item	Identification
Controller	Model 500 Serial 105
Plug-in memory for 17/27 receiver	Model 501 Serial 103
Cable, 36.6m (120'), 10 pin control	
Cable, 18.3m (60'), coax	white over yellow
Cable, 9.1m (30'), coax	blue over yellow
Cable, 1.2m (4'), 41 pin control	
Cable, 1.2m (4'), receiver per lift	0.20" jack, both ends
Cable, 1.2m (4'), remote total and print	pushbutton to 0.25" jack
Cable, 0.9m (3'), log-video	BNC both ends
Cable, AC power	
Operation Manual, serial #105	
Spare fuses.	

Case No. 2-4 E-Field Antennas (2 ea), switch box and cables for NM-37/57

Item	Identification
Antenna Switch Box IIA	37/57E, Model 506, Serial 103 with 3 cables attached
Antenna, 30 MHz-190 MHz	Model 505, Serial 103
Antenna Extension Element 6 each	(for 30 to 180 MHz antenna)
Antenna, 190 MHz to 1000 MHz	with 3 cables attached Model 507 Serial 103
Cable, 9.1m (30') coax, "standard" connector	red over blue, with red on
Cable, 9.1m (30'), 10 pin control	
Cable, AC power	
Spare fuses and pilot lamp.	

Case No. 2-5 Controller, with memory for NM-37/57 and cables

Item	Identification
Controller	Model 500 Serial 106
Plug-in memory for 37/57 receiver	Model 502 Serial 103
Cable, 36.6m (120'), 10 pin control	
Cable, 18.3m (60'), coax	white over blue
Cable, 9.1m (30'), coax	yellow over blue
Cable, 1.2m (4'), 41 pin control	
Cable, 1.2m (4'), receiver per lift	0.20" jack, both ends
Cable, 1.2m (4'), remote total and print	pushbutton to 0.25" jack
Cable, 0.9m (3'), log-video	BNC both ends
Cable, AC power	
Operation Manual, serial #106	
Spare fuses	

Case No. 2-6 Antenna for NM-67

Item	Identification
Antenna, pentagonal, with 6 log spiral elements Spare pilot lamp.	Model 508 Serial 103

Case No. 2-7 Switch Box and cables for NM-67

Item	Identification
Antenna Switch Box IIIA	67E, Model 508, Serial 103
Cable, 9.1m (30') coax, "standard"	Times Wire & Cable, fabric covered, P/N AE 82/1, S/N 0002
Cable, 2m (6.5'), 19 pin switch control	Large 19 pin connectors
Cable, 30', 10 pin control	
Cable, AC power	
Spare fuses.	

Case No. 2-8 Controller, with memory for NM-67 and cables

Item	Identification
Controller	Model 500 Serial 107
Plug-in memory for 67 receiver	Model 503 Serial 103
Cable, 36.6m (120'), 10 pin control	
Cable, 1.2m (4'), 41 pin control	
Cable, 1.2m (4'), receiver per lift	0.51cm (2'), jack, both ends
Cable, 1.2m (4'), remote total and print	pushbutton to 0.64"cm (.25") jack
Cable, 0.9m (3'), log-video	BNC both ends
Cable, AC power	
Operation Manual, serial #107	
Spare fuses.	

Since many of the cables, controllers and some other parts are interchangeable, no specific provision is made for packing spare parts for the field.

Each case containing a controller has a space for two extra plug-in memories. If one memory is carried plugged into the controller, a complete complement of memories (three) can be carried, allowing one controller to act sequentially for each of the three receivers. This reduces the number of cases required to be carried to the field by two, but with a consequential requirement that each series of frequency bands be done in sequence, and with a reduction in backup controllers and cabling.

2.3 Equipment Unpacking and Setup

2.3.1 Unpacking

The equipment is normally shipped to the measurement site in eight transit cases (11 cases including the three receivers). Unpack the equipment noting how the individual items were lodged in their individual protective foam case liners. The controller and receiver can be setup as shown in figure 1, generally with the receiver on top so the paper tape record produced by the controller will not obscure the receiver meters and controls. In bright ambient light conditions (outdoor sun), it is necessary to arrange the controller so that the operator can observe the front panel displays directly from the front, as the lighted displays have a narrow viewing angle. Placing the equipment on a table, or securely propping the controller will allow direct viewing of the front panel.

2.3.2 Equipment Setup

After unpacking the system and visually checking for damage, check the position of the 115/230 V selector card in the ac power receptacle for each controller, and the selector switch on each antenna switch box, to make sure it is set to the proper line voltage.

The selected voltage setting is visible on each selector card; slide the fuse cover back for inspection prior to plugging in the ac power card to the controller. To change the voltage, pull out the card (with a stiff wire hook, if available), turn the card over, and reinsert it, with the desired voltage showing, and with the extraction hole next to the outside. The ac convenience outlet on the back of the controller is intended for the Singer receiver. Do not draw more than 0.5 amp from this outlet or the EMI filters will overheat. This means that it cannot be used for the NM 67 receiver.

The voltage selector switch on the antenna switch box displays the ac line voltage selected directly on the switch and it is visible through a 1.4 x 0.7 cm (0.5 x 0.25") hole in the switch box near the ac line fuses. To change the selected voltage input, slide the switch up for 115 Vac, using a small blade screwdriver, or down for 230 Vac.

DO NOT CONNECT THE AC POWER TO THE ANTENNA SWITCH BOXES UNTIL THE CORRECT VOLTAGE HAS BEEN SWITCH SELECTED.

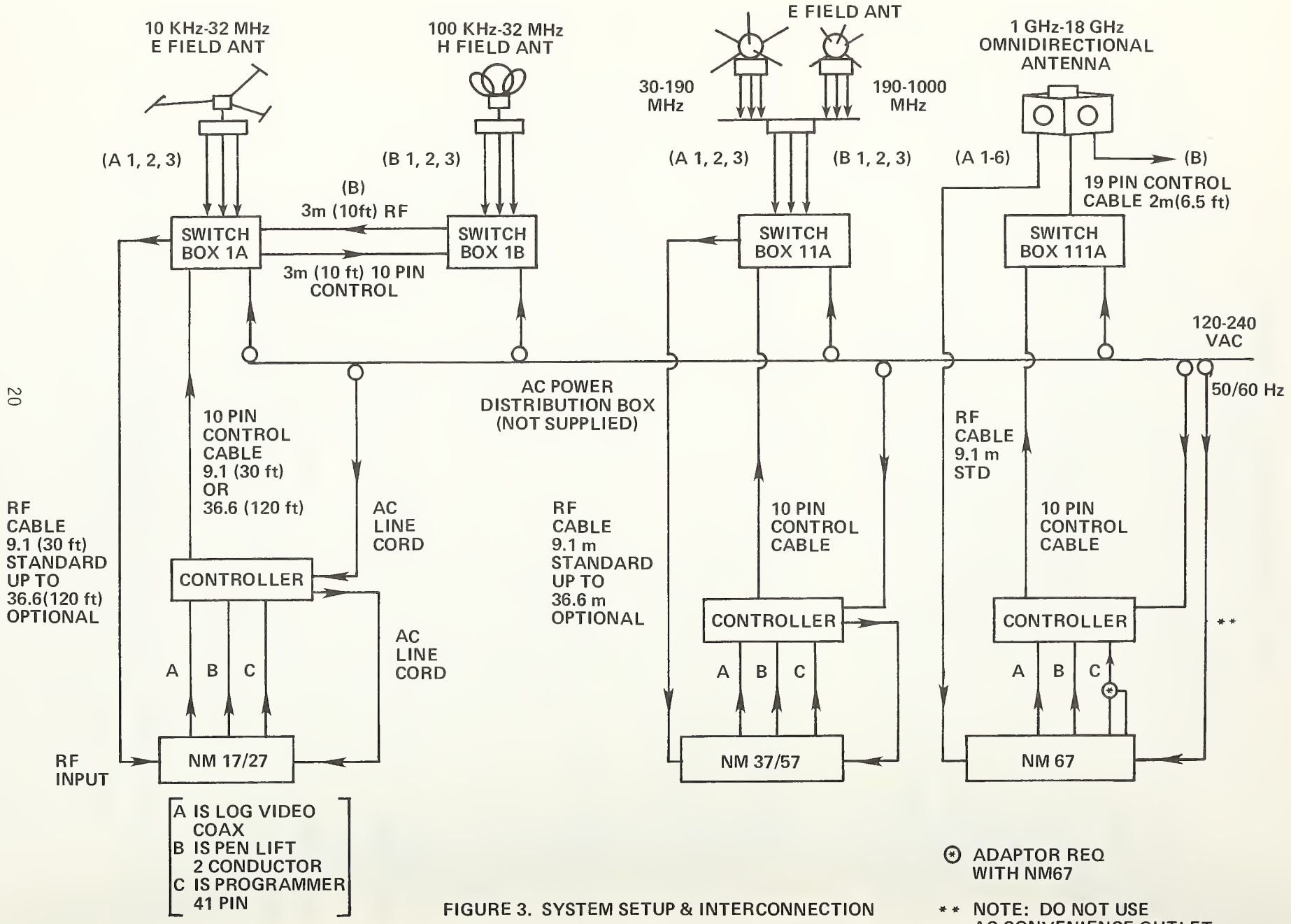

FIGURE 3. SYSTEM SETUP & INTERCONNECTION

Connect the antennas, antenna switch boxes, controller(s), receivers and cabling as shown in figure 3. The system is designed so that only a portion of the equipment (for the portion of the spectrum covered by one receiver) need be set up if desired. Refer to figure 3 to ensure that the portion or portions are completely and properly interconnected before proceeding.

Not shown on figure 3 is the remote total-and-print pushbutton on the end of a 1.2m (4') cable that may optionally be plugged into the controller(s). This cable allows the operator to keep his eyes on the receiver while requesting data print out. The remote pushbutton merely parallels the total-and-print pushbutton on the front panel.

2.3.3 Memory (Personality Module) Insertion into the Controller

This system is equipped with changeable memories (personality modules) that contain all the frequency, calibration and other information for a specific antenna-receiver combination. It is important to ensure that the intended frequency bands correspond and serial numbers match among the antennas, antenna switch boxes, receiver type, and the plug-in memory that goes in the back of the controller. For example, if it is desired to use the NM-37/57 portion of system 2, all the serial numbers should be 103 (system 1 is serial number 102 and system 2 is 103). In addition, the plug-in memory should say, for this example, "Personality Module for Singer NM 37/57 Receiver and Antenna." See the packing list for a complete listing of matching numbers. The controllers are interchangeable.

DO NOT INSERT OR REMOVE THE PLUG-IN PERSONALITY MODULE WITH THE CONTROLLER POWER TURNED ON.

The personality module plug-in memory uses CMOS components and plugs directly into the internal microcomputer backplane which carries supply voltages. Being CMOS, it is very subject to transient and static electricity damage. Permanent damage may result if the module is removed or installed with the power on. In addition, no fingers or tools should be inserted so as to touch the printed circuit board edge connector of the plug-in module (or of the socket

in the controller). The module has a sheet aluminum protective case for mechanical and electrostatic protection that should only be removed at a static protected work station.

When installing the plug-in memory personality module (with the power off), ensure that the module is right side up. Two small labels indicate "top" and "bottom."

When tightening the four thumbscrews, use only finger pressure; do not use a screwdriver, or galling of the threads and excess compression of the RFI gasket may occur. The gasket is designed to compress only to 80% of its original thickness.

2.3.4 Paper Loading into the Printer

If the thermal printer is out of paper, or if the available paper remaining indicator is near the E (Empty), install a new roll. Loosen the four thumbscrews and remove the printer front plate and attached paper magazine. Remove the black plastic roll center by pulling upward. Lightly rap the new paper roll ends on a flat surface to align the roll edges (much as is done with a deck of cards); the roll must turn easily in the magazine or the printer will not feed properly and will produce short (squashed) lines. Insert the black plastic roll center in the roll and insert this assembly into the printer magazine by pressing down (see figure 4). Be sure both the retaining springs have popped up and are holding the roll center down. Push the paper release down and insert the paper under the assembly with the printed circuit cable, and the paper should appear out the front of the printer. Ensure that the roll turns easily. If not, check for misalignment of paper, or a non-flat roll end.

Note that when the paper supply gets sufficiently low, there is a "low paper" micro-switch that will prevent the printer from returning a "ready" signal to the microcomputer in the controller, which in turn will hang up the entire system until more paper is inserted.

When inserting the loaded paper magazine, printhead, and faceplate back into the controller, use only finger pressure to tighten the four thumbscrews. Do not use a screwdriver, or galling of the threads and excess compression of the RFI gasket may occur. The printheads and faceplate assemblies are interchangeable, but serial numbers that correspond (originally) to the remainder of the printer are contained in the controller.

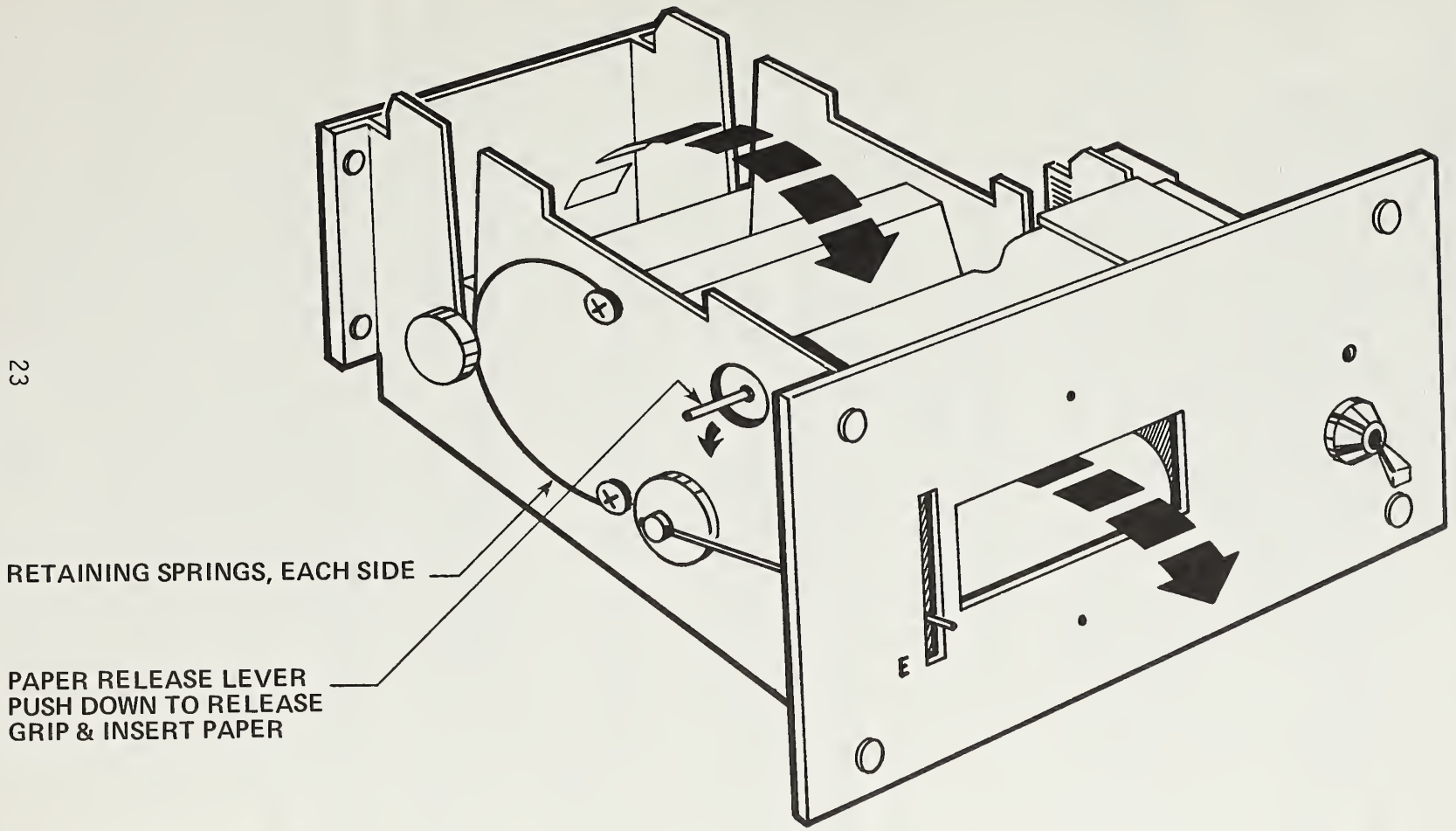

FIGURE 4. PAPER LOADING FOR THE THERMAL PRINTER MOUNTED IN THE CONTROLLER.

2.3.5 Power-Up

After it has been determined that the correct power line voltages and frequencies have been selected (see section 2.3.2 above), plug the ac power cables into the ac outlet. This applies power directly to the antenna switch boxes, as there is no ac power on-off switch on these boxes, only a voltage selector switch. As soon as the antenna switch boxes are plugged into ac power, they are on. The pilot lights on the antenna switch boxes IA, IB, and IIA, should light, as well as the pilot light on the 1-18 GHz antenna. Turn on the ac power switches on the controllers and receivers.

Note that both E-field and H-field antennas for the 17/27 receiver contain amplifiers that are powered by +24 V that is fed up the coaxial RF cable. Do not insert any attenuator or other DC short circuit across the RF coaxial cables connecting the 17/27 antennas to their respective switch box(es).

2.4 Preliminary Equipment Checkout

2.4.1 Controller

Upon application of power, the microcomputer in the controller initiates a two-second test of all LED indicators and 7 segment readouts on the front panel (except for the "0 dB" light, which is lit whenever the four position switch in the lower left hand corner is in the LOG VIDEO position). Once this light test has been initiated and terminated, it is a good indication that the microcomputer is operational.

The printer has its own 5 volt power supply; its red LED pilot light is run off of this supply.

2.4.2 Antennas, Antenna Switch Boxes and Receiver

Upon application of power, the receiver and switch box pilot lights should be lit. The pilot light for the NM-67 antenna-switch box combination is mounted on the antenna. After about one half hour of operation, the amplifiers contained in the end of the 17/27 E-field dipoles, and in the base of the H-field loop antennas, should be warm. If pilot lights are not lit, check fuses and power connections.

2.5 Equipment Operation

Refer to section 2.3.2 for equipment setup, to section 2.3.3 for memory installation (do not insert the memory with power on), section 2.3.4 for printer paper loading, and to section 2.3.5 for application of power (make sure correct voltage is selected before applying power).

2.5.1 Controls, Indicators, and Receptacles

This section contains a brief description of each of the controls, indicators, and receptacles used on the controller.

2.5.1.1 Front Panel

Paragraph letters and numbers correspond to callout on figure 5.

A. RAPID SCAN pushbutton -- (AUTO mode only) Selects RAPID SCAN mode. This is a tuning aid. The adjacent light indicates RAPID SCAN mode.

B. FOLLOW MAX ELEMENT pushbutton -- (AUTO mode only) Periodically samples all elements of the selected antenna and selects the element having the strongest signal. This is a tuning aid. The adjacent light indicates FOLLOW MAX ELEMENT mode.

C. NO ANTENNA CORRECTION FACTOR ADDED light -- This light indicates that no calibration factors for the antenna are being applied. This mode is activated by holding the NEXT ELEMENT pushbutton in while turning on the ac power. Make sure unit is in the MANUAL mode before doing this.

D. SET RECEIVER ATTENUATION TO 0 dB light -- This light being lit indicates the unit is using the log video detector of the receiver. To obtain a correct reading when this detector is used, either (1) the attenuator on the receiver must be set to 0 dB, or (2) if the attenuator is set to another position (positive values only), this value must be entered, or added to the value entered, on the external attenuator thumbwheel switch on the controller.

E. Antenna element lights -- This series of lights indicate which antenna element is connected to the receiver.

F. Signal strength display -- This is the dB μv/meter display.

G. Antenna array select switch -- Selects between the A and B antenna arrays.

H. PRINT pushbutton -- Prints the previously stored or computed information.

I. Frequency-clock display -- This is the frequency display or the time display depending on the position of switch J.

J. FREQUENCY/CLOCK DISPLAY switch -- Selects display of frequency or time of day.

K. ADV. MIN. pushbutton -- Advances minutes for setting clock.

L. GHz-MHz-kHz lights -- These lights indicate the units of the frequency display.

M. REQUEST EXTRA HEADER OUTPUT pushbutton -- Used to print out a new header at any time.

N. Intensity control -- Used to control the brightness of the LED display lights.

O. Power switch -- Applies ac power to the unit when on.

P. Printer power light -- This light indicates power is reaching the printer.

Q. Feed pushbutton -- This button advances the paper from the printer.

R. E (empty) indicator -- This indicator shows how much paper is left in the printer.

S. HIGH/LOW SENSITIVITY switch -- Used to select a pad within the antenna switch box to compensate for low/high fields. Will print an "H" or "L" on the output header to indicate high or low sensitivity. When in the low sensitivity mode, the true measured signal is compensated to account for the pad in the antenna switch box and an "L" will be printed on the header. Switching of the antenna sensitivity is automatic except in the case of the NM 17/27 E-field antenna, where the elements must be manually extended for low level fields and pushed in for high level fields.

T. MAX-FINDER pushbutton -- Prints the maximum signal strengths and corresponding time and frequency as a function of time. This may be used in conjunction with a frequency sweep. The adjacent indicator shows MAX. FINDER mode.

U. ADV. HRS. pushbutton -- Advances hours for setting clock.

V. CABLE LOSS thumbwheels -- Allows entry of correction in dB for non-standard cable loss.

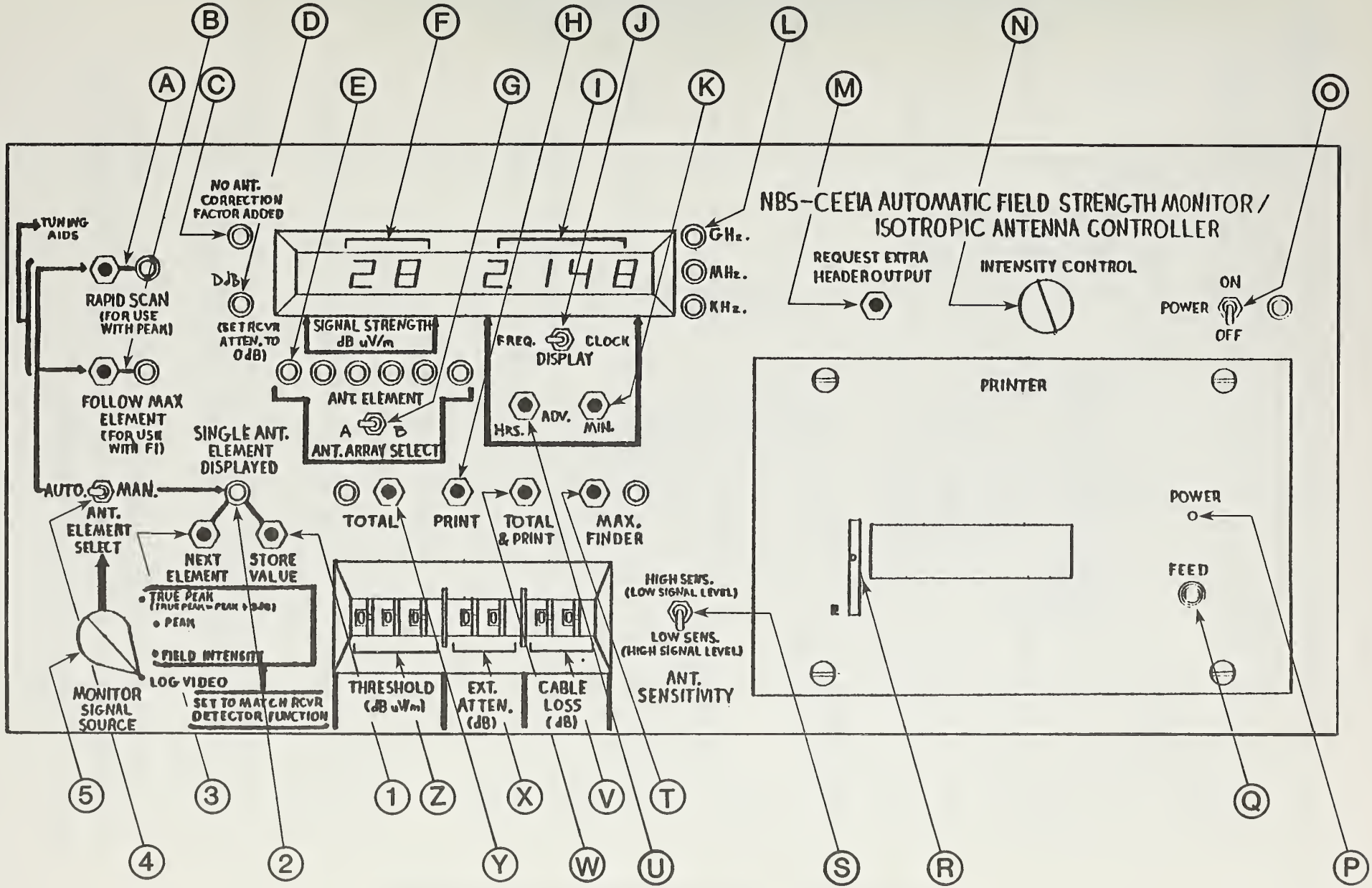

FIGURE 5. CONTROLLER FRONT PANEL OPERATING CONTROLS & INDICATORS

W. TOTAL & PRINT pushbutton -- Combines the functions of TOTAL and PRINT.

X. EXT. ATTEN. thumbwheels -- Allows entry of correction factor in dB for any additional known external attenuation between the antenna and receiver.

Y. TOTAL pushbutton -- Causes total field strength to be computed and displayed. All antenna elements are used in the computation. The adjacent indicator indicates TOTAL mode.

Z. THRESHOLD thumbwheels -- Allows entry of threshold signal for MAX-FINDER operation.

1. STORE VALUE pushbutton -- (MANUAL mode only) Stores the presently displayed value of field strength received by the selected antenna element for subsequent PRINT or TOTAL operation.

2. SINGLE ANTENNA ELEMENT DISPLAYED light -- This light indicates the display is showing the signal being picked up by a single antenna element only.

3. NEXT ANT. pushbutton -- (MANUAL mode only) Connects the receiver to the next sequential antenna element.

4. AUTO/MANUAL antenna selection switch -- Selects automatic or manual selection of antenna elements.

5. Monitor signal source selection switch -- Determines the source for the signal strength and how it is to be processed, (FI, PEAK, TRUE PEAK, LOG VIDEO).

2.5.1.2 Rear Panel

Paragraph letters correspond to callout on figure 6.

A. Convenience outlet -- Intended for the Singer NM 17/27 or NM 37/57 receivers. Do not use for NM 67.

B. To recorder penlift on receiver (0.20" jack) -- Signal from penlift jack on receiver tells MAX. FINDER mode when receiver spectrum scan is finished.

C. Personality module (plug-in memory) -- Insert the plug-in memory corresponding to the receiver-antenna model and serial number being used. Turn power OFF before inserting.

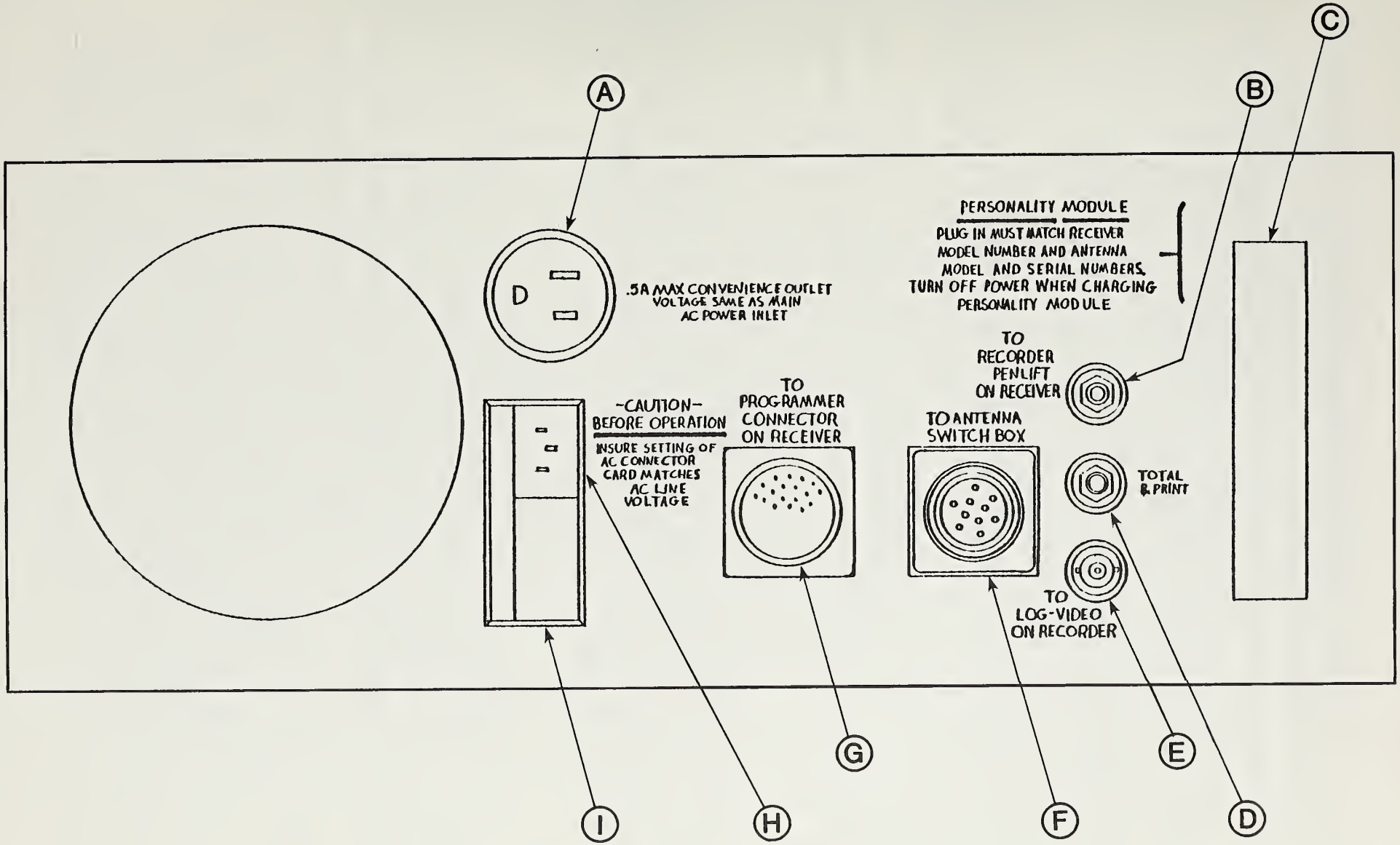

FIGURE 6. CONTROLLER REAR PANEL RECEPTACLES.

D. Total and print jack -- Provides optional alternate (parallel) pushbutton for TOTAL & PRINT on end of cable.

E. LOG VIDEO input jack (BNC) -- Accepts log video signal from the receiver.

F. To antenna switch box (10 pin cable) -- Provides control signals for selecting antenna elements and antenna sensitivity.

G. To programmer connector on receiver (41 pin cable) -- Accepts all control signals from the receiver except log-video and penlift.

H. AC power input to the controller.

I. Fuse and voltage selection card compartment -- Ensure that the voltage visible on the card matches the voltage supplied before applying power.

2.5.2 Lamp Test and Intensity Control

Upon application of power, the microcomputer in the controller initiates a two-second test of all LED indicators and 7 segment readouts on the front panel (except for the "0 dB" light, which is lit whenever the 4 position selector in the lower left hand corner is in the LOG VIDEO position).

The controller is designed to be operated in direct sunlight. The LED indicators are therefore high brilliance with a narrow cone of light output. To prevent uncomfortably high brilliance in low ambient light, an intensity control is provided to dim the LEDs.

2.5.3 Setting the Clock

The clock contents are displayed by switching the DISPLAY switch to the CLOCK position. When power is applied, the clock contents are zero. Select an operating mode with a frequent display update cycle; LOG VIDEO signal source and RAPID SCAN mode are recommended. Press the ADV. HRS. (advance hours) button and hold until the proper hour is displayed. The hours will advance approximately two per second. Then press the ADV. MIN. (advance minutes) button and hold until the proper minute is displayed. The minutes will also advance approximately two per second. The clock will start when the DISPLAY switch is switched from CLOCK to FREQ. The DISPLAY switch may be set to CLOCK at any time to display the current time. The clock will continue running unless ADV. HRS. or ADV. MIN. is pressed, or the power is turned off.

2.5.4 Selecting the Signal Source

The MONITOR SIGNAL SOURCE switch in the lower left hand corner of the front panel selects one of two signal sources from the receiver, and also adjusts the time that the controller waits before sampling. The two signal sources are the log-video BNC output on the back of the receiver and the receiver detector output as obtained from the receiver dB readout pin in the programmer connector.

The log-video output is present at all times and is independent of the position of the receiver measurement function selector switch. Log-video has a very rapid response and is used when looking at rapidly changing signals, such as obtained when the receiver is doing a spectrum scan and the controller is in MAX. FINDER mode.

The receiver detector output time constants are controlled by the (Singer) receiver function selector switch; the controller signal source switch should be set to match the receiver function selected except in the case of log-video.

2.5.4.1 LOG VIDEO

In the LOG VIDEO position, the signal from the log video output of the receiver is sampled. The receiver function switch may be in any position. This position has a quick response and tends to yield a short term average signal value. Displayed and printed values are not corrected for receiver attenuator settings. To obtain a correct amplitude reading when the LOG VIDEO detector is selected, either (1) the attenuator on the receiver must be set to 0 dB, or (2) if the attenuator is set to another position (positive values of attenuation only), this value must be entered on the EXT. ATTEN. thumbwheel switch on the controller. This is necessary because the Singer receiver does not internally correct the amplitude of the LOG VIDEO output as a function of the receiver attenuator setting; this correction must be set by the operator into the controller as mentioned in (1) or (2) above.

Because the LOG VIDEO response is so rapid, the Singer receiver amplitude output meter needle which reads FI cannot always respond. The system becomes nonlinear above 4 dB beyond the top of the signal strength meter. Signals at or above this level are considered to be an overrange. To prevent the inadvertent missing of short duration large signals a warning message is printed whenever an overrange condition occurs when using the LOG VIDEO signal. The message ***OVERRANGE*** will be printed. When this message is encountered, more

attenuation should be inserted within or prior to the receiver front end, and the measurement should be repeated.

2.5.4.2 FI (Field Intensity)

In the FI (Field Intensity) position, the signal is taken from the receiver dB readout pin. The receiver function switch should be in the FI position. When this position is used, a longer delay is inserted after selecting an antenna element, before the reading is taken (the delay is determined by parameter FIS in the personality PROM), nominally 0.6 seconds. This position has a slow response, but greater immunity to noise. Displayed and printed values are automatically corrected for receiver attenuator settings. Generally FI is used below about 30 MHz and FI or PEAK is used above 30 MHz. The real criteria is the type of signal to be measured and the level of background noise present.

2.5.4.3 PEAK

In the PEAK position, the signal is taken from the receiver dB readout pin. The receiver detector function switch should be in any of the peak positions with a hold time of 0.05 to 3.0 seconds. Whenever an antenna element is selected, the monitor waits 50 milliseconds (parameter SPK in the personality PROM) for the previous peak to be dumped. It then takes several samples, nominally 4, (parameter NPK in the personality PROM) and chooses the maximum value. This should correspond to the maximum signal received within the sample period. This position has a fairly quick response.

2.5.4.4 TRUE PEAK

The definition of the peak signal, as read out by the Singer receiver, is scaled so that it will read the same as FI for a cw signal. Because of the requirement for measuring actual peak values, a position called TRUE PEAK is supplied on the controller that simply adds 3 dB to the reading that would be obtained on PEAK.

2.5.5 External Attenuation and Cable Loss Thumbwheels

These two thumbwheels each do the same thing; whatever is dialed in is added to the computed or displayed field strength. If, for example, the operator selects LOG VIDEO and the receiver attenuator is set to +20 dB, then 20 dB should

be set on EXT ATTEN. Values are to be entered on CABLE LOSS wherever extra RF cable beyond the standard 9.1 meter (30 ft) cable is supplied. The systems are calibrated using the standard 9.1 meter cables so their loss is already taken into account in the plug-in memory calibration factors. Below 30 MHz the additional RF cable losses are generally less than 1 dB. Tables of cable loss for each color coded BNC RG-55 cable supplied for the frequency range 30 to 1000 MHz are given in Appendix A.

If cables beyond the standard 9.1 meter cable are used, find this cable in Appendix I, refer to the TRANS. LOSS FORWARD, dB column, determine the loss for the nearest frequency, round to the nearest dB, discard the negative sign, and enter (add) this loss into the CABLE LOSS thumbwheel. Remember to change it for different frequencies and cable lengths. Set CABLE LOSS to zero when using the standard 9.1 meter cable.

2.5.6 Selecting High or Low Antenna Sensitivity

An antenna sensitivity switch ("S" in figure 5) has been provided to extend the dynamic range of the system and automatically provide a correct field strength reading in each position. The ranges are approximately:

(1) NM 17/27 E-Field Probe

high sensitivity 50 μV/meter to 10 V/meter
low sensitivity 500 μV/meter to 100 V/meter
at a 10 kHz bandwidth.

(2) NM 17/27 H-field Probe
(Only one sensitivity) 10 mV/meter to 100 V/meter

(3) NM 37/57

	30 - 190 MHz	190 - 1 GHz
high sensitivity	50 μV/meter to 0.1 V/meter	100 μV/meter to 0.5 V/meter
low sensitivity	1.5 mV/meter to 2 V/meter	30 mV/meter to 2 V/meter

at a 10 kHz bandwidth.

(4) NM 67

	1 GHz*	18 GHz*
high sensitivity	500 μV/meter to 10 V/meter	20 mV/meter to 10 V/meter
low sensitivity	5 mV/meter to 100 V/meter	200 mV/meter to 100 V/meter

at a 1 MHz bandwidth

*For frequencies in between, interpolate linearly.

The switch controls an attenuator in the antenna switch box and causes an "H" or "L" to be printed on the printer header to indicate high or low sensitivity. When in low sensitivity mode, extra amplitude is mathematically added by the controller to the measured signal to compensate for the attenuator in the antenna switch box and an "L" will be printed on the header. Switching of the attenuators is automatic except in the case of the NM 17/27 E-field antenna (dipole), where the antenna elements must be manually extended for low level fields and pushed in (telescoped) for high level fields.

2.5.7 Using Tuning Aids for Locating Signals

RAPID SCAN and FOLLOW MAX ELEMENT modes are intended to be used to switch the antenna elements automatically while the operator is manually tuning the receiver, searching for signals. Each mode has some advantage. Neither mode produces accurate signal strength measurements; as a reminder of this, the signal strength display is blanked while in these two modes.

Because of the speed required in switching and sensing of signals in these modes, both modes use the log video signal. As a result of using log video, the controller will print overrange messages whenever the signal is 4 dB or more above the top of the signal strength meter. When this happens, either (1) tune off the signal, (2) increase the attenuation, or (3) choose another mode. See section 2.5.4.1, LOG VIDEO.

2.5.7.1 RAPID SCAN Mode

The AUTO/MANUAL switch must be in the AUTO position. Pressing RAPID SCAN places the controller in the RAPID SCAN mode. This mode causes the antenna elements to be sequentially selected. Each element will be connected for the time in milliseconds specified by SCN in the personality prom, plus an additional eight milliseconds machine overhead time. SCN is nominally set to two, giving a total selection time per antenna element of ten milliseconds.

During RAPID SCAN the frequency display shows the current receiver frequency; however, the signal strength display is blanked. This mode is intended for use with the receiver detector in the peak position, and for use mainly in the microwave region to catch, for example, radar signals from rotating radar antennas. As mentioned earlier, this is not a measurement mode; do not attempt to take accurate amplitude readings from the receiver signal strength meter. To make accurate amplitude readings switch to MANUAL or switch to AUTO and compute a TOTAL.

2.5.7.2 FOLLOW MAX ELEMENT Mode

The AUTO/MANUAL switch must be in the AUTO position. Pressing FOLLOW MAX ELEMENT places the controller in the FOLLOW MAX ELEMENT mode. This mode is intended to assist manual location of strong signals by automatically selecting the strongest antenna signal for most of the time. The frequency display shows the current receiver frequency. The signal strength is blanked.

This mode causes the antenna elements on the selected antenna to be periodically sampled to determine the element with the maximum signal. This element is then selected until the next periodic scan. The cycle time per scan is programmed as parameter MFC in the personality PROM. Typically, each element is sampled for three milliseconds and MFC is set for 100 milliseconds, resulting in sampling about 10% of the time with the strongest element connected 90% of the time. This mode is intended for use with the receiver detector on FI. Because longer time is spent on the strongest element, speech modulation is easier to understand on this mode.

2.5.8 Reading and Recording Field Strength for Each Antenna Element

The antenna elements are manually selected by placing the AUTO/MANUAL switch in MANUAL. The antenna element indicators show which element is currently selected. To select the desired element, press NEXT ANT. until the proper indicator is lit.

The frequency and strength are continuously sampled and displayed. The antenna system corrections, cable loss and external attenuation factors from the thumbwheels are added and the correct signal strength is displayed. To freeze a reading for printing, computing total strength, or both, press STORE VALUE. The display will show the value stored as long as STORE VALUE is held. After release, the display will again continually follow the signal, but the stored value is held internally until erased by a new value for the same antenna element, by changing the AUTO/MANUAL switch, by a successful total operation, or tuning power off.

The value displayed may be recorded (printed) by pressing PRINT. See section 2.5.9.3 PRINT and Printer Format for printer details.

2.5.9 Computing and Recording TOTAL Field Strength

The controller computes the equivalent field from the outputs of each of the three orthogonal antennas. The resultant total is then displayed to the operator. This function makes it unnecessary to rotate the receiving antenna to find the maximum signal strength.

2.5.9.1 Automatic Antenna Element Selection

For automatic antenna element sampling, the AUTO/MANUAL switch must be set to AUTO. When TOTAL is pressed, all antenna elements are sequentially selected and corresponding readings are stored. The time spent on each element is a function of the setting of the SIGNAL SOURCE switch; nominally 600 ms is used for FI which has the longest detector integration time, down to nominally 10 ms for LOG VIDEO, which has the shortest integration time. The antenna corrections are applied to the reading and the total field strength is computed. The cable loss and external attenuation factors from the thumbwheels and corrections from the high/low sensitivity switch are added, and the resulting total field strength is displayed. The receiver frequency setting during the sample is displayed. The reading is held until another operation is performed. If more than three elements are used, the strongest three of the elements are used. The indicator corresponding to the element having the strongest signal will blink. All stored element values will be reset after the TOTAL operation. A TOTAL & PRINT operation however will bypass the indication of strongest element.

2.5.9.2 Manual Antenna Element Selection

For manual antenna element sampling, the AUTO/MANUAL switch must be in MANUAL. Use NEXT ANT. and STORE VALUE buttons sequentially to store readings for all three (or six) antenna elements. Then press the TOTAL button. The total field strength is computed in the same manner as with automatic antenna element selection, except that the antenna values previously stored by store value are used for computing the total strength.

As an operator diagnostic aid, if all three (or six) element values have not been stored when TOTAL is pressed, the display will blink and the indicators for which elements have been stored will be lit (i.e., elements for which values were not stored will be dark). Since the controller cannot produce a total and is waiting for the operator to press NEXT ANT to get to the missing element(s) (and then STORE VALUE), any request for PRINT will be ignored.

2.5.9.3 PRINT and Printer Format

The values displayed by STORE VALUE or TOTAL may be printed (recorded) by pressing PRINT. The thermal "grocery tape" printer is provided to allow the recording of the majority of the measured data easily and rapidly without the use of pencil and paper.

A status block is printed before the first data line after power up, whenever any of the status values are changed and additionally whenever the REQUEST HEADER button is pushed. The header block gives the A and B antenna serial numbers (initially 102 or 103), the SENSITIVITY switch setting (H-high or L-low) and the cable loss and external attenuation thumbwheel settings in dB. Antenna model numbers (initially 504 through 508) may be looked up in the following table; enter the table using the printed frequency and setting of the ANT. ARRAY SELECT switch. Since the printer prints from the bottom up, the header is at the bottom of the column of data. See figure 7 for the printout format.

Following the status block is a data header which gives the receiver frequency signal strength, setting of ANTENNA ARRAY SELECT SWITCH, and the time.

Table 2. Determination of antenna model number given frequency and antenna array select switch setting

Frequency Range	Receiver in Use	Antenna Array Select Switch	Antenna Model No.
10 kHz to 32 MHz	NM-17/27	A (E-field)	504
100 kHz to 32 MHz	NM-17/27	B (H-field)	505
30 MHz to 190 MHz	NM-37/57	A	506
190 MHz to 1000 MHz	NM-37/57	B	507
1 GHz to 18 GHz	NM-67	A	508

```
                    KKKKK LLLR MN PP:QQ
                    (FHZ) (DB)
                    FREQ  SIG  ANT TIME
                    !!!!!!!!!!!!!!!!!!!


                      ATTEN:C      DD EXT      EE CBL
                   A. ANT #AAA          B. ANT #BBB
                 ! ! ! ! ! ! ! ! ! ! ! ! ! ! ! ! ! ! ! ! !

          (status block)
```

where:

AAA = Identification number of antenna A (0 to 225) or UND for antenna not defined (when no ANT. CORECTION FACTOR ADDED light is lit).

BBB = Identification number of antenna B (0 to 255) or UND for antenna not defined.

C = H, for high sensitivity
L, for low sensitivity
For low sensitivity, the controller adds the proper number of dB to compensate for the attenuator (pad) inserted in the antenna switch box.

DD = External attenuation (dB) set by operator.

EE = Cable loss (dB) set by operator.

(data header and data line)

where:

F = K, M, or G to indicate frequency units.

KKKKK = Frequency, including decimal point, in units specified by the data header above.

LLL = Signal field strength in dB relative to 1 microvolt per meter.

R = Monitor signal source code
T for true peak
P for peak
F for field intensity (FI)
V for log video

M = Antenna selected, A or B

N = Antenna element 1 to 6, or
A for auto compute,
M for manual compute.

PP:QQ = Time of reading, 24 hour rotation.

Figure 7. Printer printout format and explanation of system identifiers and variables. (see figure 8 for MAX FINDER format)

2.5.9.4 TOTAL & PRINT

The TOTAL & PRINT pushbutton combines the functions of TOTAL and of PRINT and additionally returns the controller to the mode previously selected. A jack on the rear panel and a 1.2 meter cable with a pushbutton on the end allow the operator to compute and record a signal with a minimum of effort while concentrating on manually tuning the receiver. TOTAL & PRINT takes the place of three separate operations, TOTAL, PRINT and return to RAPID SCAN (or FOLLOW MAX ELEMENT).

2.5.10 Using MAX. FINDER

MAX. FINDER is a mode in which the controller scrutinizes an input for peaks (maxima) in the incoming signal, hence the name MAX. FINDER. This mode can be used in several ways.

In the AUTO mode when MAX. FINDER is pressed, the antenna elements are scanned and the signal strength monitored continuously for peaks in the signal strength.

In the MANUAL mode when MAX. FINDER is pressed, the antenna element selected is monitored continuously for peaks in the signal strength.

With either the AUTO or MANUAL mode selected, the MAX. FINDER mode can be used to either monitor a single frequency as a function of time, or to examine the output of the receiver during an automatic frequency sweep (initiated by pressing the scan button on the receiver).

A peak is defined as a maximum signal reading preceded by a signal increase and followed by a signal decrease. The minimum increase and decrease required to define a peak is determined by parameter PKS on the personality PROM. Once a peak value is determined, it is printed along with the corresponding frequency and time. As soon as a peak is determined and printed, the monitor will continue to look for the next peak. If a new peak is determined while the previous printing operation is being conducted, it will be stored until the printer can accept it. However, if more than one peak is determined while a previous printing operation is being conducted, only the highest one will be stored and printed. This may cause some loss of data in an extremely crowded band. A printing operation takes approximately 0.3 seconds.

Since the receivers have a relatively rapid internal sweep, the only detector output that can follow the resultant rapid changes in amplitude is the log video output. Using log video on MAX. FINDER gives satisfactory spectrum information; however, it should be remembered that successive readings obtained on successive scans for the same station may vary a few dB since log video follows the modulation of the signal.

Also remember that since the log video output is used, the message ***OVERRANGE*** may be encountered. See section 2.5.4.1 LOG VIDEO to remedy the overrange message. Care should be used for unattended monitoring of single frequency occupancy to prevent using all the paper in the printer for overrange messages.

The THRESHOLD thumbwheels are used by the MAX. FINDER function. Any peak values less than the level specified by the THRESHOLD thumbwheels are not printed. The THRESHOLD can be set to preclude printing numerous unwanted lower level signals.

The controller will continue to print peaks until another button is pressed or the receiver frequency sweep operation termination is signaled by the receiver pen-lift output. The displays show the current frequency and signal strength. The signal value displayed and printed is a computed total of all antenna elements in AUTO mode, or the strength of the selected antenna element in MANUAL mode. Note that the values measured and printed are affected by the setting of the controller signal source. The time and frequency corresponding to the maximum signal strength are printed. See figure 8 for the print format. The following example in table 3 shows the effect of the threshold and shoulder. Assume that the threshold is 80 dB, the shoulder is 6 dB, and the following readings are made:

Table 3. Example of the operation of MAX. FINDER with threshold set at 80 dB and shoulder set at 6 dB.

Time	Freq.	Signal Strength	Lines Printed
0900	10.0	56	
0900	10.6	84	
0900	10.9	81	
0900	11.1	89	
0901	11.5	67	11.1 89 09:00
0901	11.6	85	
0901	11.8	79	11.6 85 09:01

Figure 8 shows the MAX. FINDER print format.

STOP SEARCH EE:FF

(data)

B AND B START CC:DD
MAX FINDER AAADB

where:
AAA = Threshold value selected
B = Band number, 1 to 8
CC:DD = Time that the search is started.
EE:FF = Time that MAX. FINDER is stopped

(The data header and data line format are the same as for the print command. See figure 7.)

Figure 8. Printer printout format and Explanation for the MAX. FINDER mode.

Remember, since the printer prints from the bottom up, the first entry is at the bottom of a completed paper tape, and the last entry is at the top.

2.5.11 Special Operations

There are two special operations which are initiated by holding a specified pushbutton while the power is turned on to the controller.

2.5.11.1 Personality PROM Printout

The contents of the personality PROM (plug-in memory) may be printed. This may be desired to determine the value of some parameter actually in use, or to ensure the proper memory is in place.

To obtain a personality PROM dump, ensure the controller power is off, push the PRINT pushbutton while turning the power switch on. The PROM values are printed, four per line, in decimal. The first in each line is the decimal address of the following byte. This operation will print 1024 locations if left to run. After the PROM dump, the controller will revert to normal operation. Printing can be terminated by switching the power off.

2.5.11.2 Selecting NO ANT. CORRECTION FACTOR ADDED Mode

The antenna calibration factors contained in the personality PROM (plug-in memory) may be intentionally ignored. This may be desired when using the controller to calibrate an antenna, or when using the system with an antenna other than the one characterized in the personality PROM.

To initiate the NO ANT. CORRECTION FACTOR ADDED mode, ensure the power is off and the controller is in the MANUAL mode (AUTO/MANUAL switch set to MANUAL). Then hold the NEXT ELEMENT pushbutton while turning on the power switch. The NO ANT. CORRECTION FACTOR ADDED indicator will be lit and the printout header will list UND (for undefined) in place of the antenna identification number. The controller will revert to normal mode when it is switched off.

2.6 Personality PROM (plug-in memory)

2.6.1 Introduction

Characteristics of the specific antenna set and receiver model are stored in a memory. This allows the controller to rapidly and automatically account for most all the characteristics (or personality) of a particular measurement setup. To allow the flexibility needed to cover wide ranges in frequency and to use the resultant several types of equipment with the same controller, a plug-in memory containing these variables is used. The memory is the general type known as Programmable Read-Only Memory or PROM; hence the term, personality PROM. System characterizing factors include number of antenna elements, gain correction as a function of frequency, receiver scaling factor (for correct frequency readout to the controller as a function of the selected band), antenna scanning rate, settling time, etc. Normally the operator will not need to be concerned with examining these constants. This section is included should examination become necessary.

2.6.2 Personality PROM Format

A 1024 by 8 bit PROM must be programmed to contain information on the receiver and antennas connected to the controller. The largest number that can be contained in each location is 255 decimal.

The antenna gain is approximated by a step function taking on values which are in multiples of 1 dB. The antenna gain is programmed as a nominal gain for the antenna and a deviation from nominal value for each antenna element as a function of

frequency. Calibration points are programmed as a function of frequency with a corresponding gain correction factor. For a given frequency, the antenna gain is the deviation given for the next lowest programmed frequency plus the nominal antenna gain.

All entries are stored in binary format on the PROM's. Two 512 x 8 PROM's are used. The location, symbol and function are given in table 4. Location addresses are given in both decimal and octal (PROM dump is in decimal format). The microprocessor has 4000 decimal memory locations total; the personality PROM locations begin at 1000, base 8.

Table 4. Location, symbol and function of all variables stored on the personality PROM (plug-in memory)

Location Base 10	Location Base 8	Symbol	Function
000-031	000-037	FSF	Frequency scale factors for bands 1 to 8x such that freq (Hz) = (analog freq voltage) $*10^X$
032	040	SDN	Selection time per antenna element while in rapid scan mode, milliseconds, in addition to 8 milliseconds machine overhead.
033	041	FIS	Receiver settling time for FI detection. Tenths of seconds.
034	042	SPK	Receiver dump time for peak detection, milliseconds.
035	043	NPK	Number of readings for peak detection.
036-037	044-045		Reserved.
038	046	MFC	Cycle time in follow max element mode, tenths of sec.
039	047	PKS	Minimum shoulder for peak detection, tenths of dB.
040	050	CFS	Calibration frequency scale for antenna set A, x such that freq (Hz) = (freq code) $*10^X$, where freq code = value specified for the frequency of the antenna calibration points.
041	051	BCFS	Calibration frequency scale for antenna set B.
042	052	SINGER	Offset that is added to measured signal strengths so that the resulting signal strength on the display is similar to that on the meter of the Singer machine when in the no ant. correction factor added mode, in tenths of dB.
043	053	SCD	Number of antenna elements selected between updates of frequency display.
044	054	BDADD1	Combined word attenuation when H/L switch is in low.
045	055	DBADD2	DBADD1 is the first two octal digits, while DBADD2 is the last two digits.
046-047	056-057		Reserved.
048	060	IDA	ID number of antenna A (used in printout).
049	061	IDB	ID number of antenna B (used in printout).
050-61	052-075	FRQSC	Scaling points for correction of measured frequency so PROM comparisons can be made.
062	076	NEA	Number of elements in antenna A (must be at least one).
063	077	NEB	Number of elements in antenna B (must be at least one).
064	100	NGA	Antenna A nominal gain in dB.
065	101	NGB	Antenna B nominal gain in dB.
066-067	102-103	AE1-PG	Address of element 1 calibration, antenna A.
068-069	104-105	AE2-PG	Address of element 2 calibration, antenna A.
070-071	106-107	AE3-PG	Address of element 3 calibration, antenna A.
072-073	110-111	BE1-PG	Address of element 4 calibration, antenna B.
...	...		Addresses of consecutive elements
...	...		Calibration blocks for each antenna element.

Either antenna A or B calibration may be omitted by setting the system on NO ANT. CORRECTION FACTOR ADDED. The first element of antenna A is element 1. The first element of antenna B is element (NEA+1), where NEA is the number of elements specified for antenna A.

Calibration points are stored in blocks for each antenna element. The starting address of each block is placed in the appropriate location, as shown in table 4 above. Each block is in order by frequency. Each point specifies a frequency and a gain correction factor, in dB.

Each point is stored in two 8 bit bytes. The block is terminated by two bytes containing all "one" bits. The format for each entry is FFFFFFFF AAAAAAAA. The first byte specifies the frequency in binary. The units are determined by parameter CFS. The frequency, in Hz, is the binary value FFFFFFFF, converted to decimal, followed by the number of zero's specified by CFS. Example: If CFS = 8, 2.91 GHz is represented by 10^9*2.91, or 10^8*29 (base 10) = 00011101 (base 2) = 35 (base 8).

The last byte (AAAAAAAA) specifies the gain correction factor in dB. The first bit is 0 for positive correction, 1 for negative correction. The remaining bits specify the correction value in dB.

Example: -5 dB = 10000101 (base 2) = 205 (base 8).
+5 dB = 00000101 (base 2) = 5 (base 8).

One can specify 256 frequencies for correction, with two frequency scales per receiver, one for antenna set A, and another for set B. For the NM-67, step sizes for both antenna sets are in 100 MHz, as receiver covers 1-18 GHz. For the NM-37/57, step sizes are 1 MHz up to 190 MHz and 10 MHz from 190 to 1000 MHz, as the receiver covers 30-1000 MHz. For the NM-17/27, step sizes for antenna set B are in 100 kHz. For antenna set A, step sizes are in 1 MHz, as receiver covers 0.01-32 MHz.

For more information on software, see volume II of the Handbook (Statement of Work).

3.0 NOTES ON USE OF THE SYSTEM

The Isotropic Antenna System was originally designed for surveys for high level, potentially hazardous (to electronic equipment) fields. For this reason low level sensitivity was sacrificed in order to measure fields to 100 V/meter over most of the frequency range. (In the 30 MHz - 190 MHz range, greater sensitivity was desired for certain measurement tasks and therefore the maximum field strength was limited to 2

V/meter.) However, the sensitivity of the system is such that many field strength measurement missions can be accomplished. Paragraph 2.5.6, page 33, gives the approximate useful field strength measurement ranges for the various frequency units. Note that the H-field antenna is really only useful for high level fields.

For general spectrum occupancy measurements, impulsive noise levels and band conditions below 16 MHz require that measurements be made with the FI detector function. Otherwise noise spikes and modulation peaks will give erroneous reading when the PEAK or LOG VIDEO detector function is used. This precludes use of the MAX FINDER function and frequency sweep below 16 MHz as the FI detector function has too slow a response time.

However, if you are only looking for very high level signals, e.g., greater than 100 dBμV/meter, the MAX FINDER and a frequency sweep can be used by setting the threshold to this high level. Noise peaks are now ignored since it is unlikely they will exceed 100 dBμV/meter. (Lightning generated noise is an exception which can be extremely strong if originating nearby.)

Above 16 MHz the MAX FINDER function in conjunction with the single sweep mode of the receiver is a very useful tool for making spectrum occupancy surveys. While the THRESHOLD setting function can be used to record only high level signals it is not necessary. The system, with its 6 dB shoulder detector, automatically ignores the white noise background and records signals which are about 10 dB or greater above the ambient system noise.

It should be noted that the sensitivity of the system decreases in the microwave region, starting at 1 GHz. This is a result of the type of antenna elements used in this frequency band. The sensitivity values given in par. 2.5.6 for 1 GHz and 18 GHz can be interpolated to obtain approximate system sensitivity for frequencies in between.

The MAX FINDER function can also be used to monitor channel occupancy on a single frequency. While unattended operation is possible, there is the danger that an extremely strong signal might come on frequency for an extended period. This would cause OVERRANGE to be printed out continuously using up the paper supply in short order. Therefore completely unattended operation is not advised.

4.0 CABLE ATTENUATION FACTORS

Following are 17 printouts listing rf characteristics of individual cables and cable combinations supplied with the system. Figure 9 at the end of this section lists cable loss for frequencies below 30 MHz.

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
			10 ft. Cable-solid yellow					
30.000	0.014	131.77	-0.131	-118.60	-0.131	-118.70	0.006	100.27
50.000	0.054	-39.56	-0.190	163.72	-0.190	163.62	0.055	-32.95
70.000	0.040	64.40	-0.223	84.70	-0.223	84.80	0.037	72.19
90.000	0.030	-62.17	-0.255	5.86	-0.265	5.76	0.034	-65.80
110.000	0.042	27.96	-0.295	-72.77	-0.285	-72.77	0.042	12.78
130.000	0.022	37.35	-0.317	-150.31	-0.317	-150.31	0.022	61.58
150.000	0.032	-17.77	-0.352	139.28	-0.352	139.28	0.050	-33.65
170.000	0.030	41.01	-0.380	60.61	-0.370	60.71	0.043	60.30
190.000	0.018	-17.53	-0.398	-18.01	-0.388	-18.01	0.018	-95.99
210.000	0.052	5.32	-0.429	-95.21	-0.439	-95.21	0.058	13.86
230.000	0.026	63.97	-0.455	-173.49	-0.445	-173.39	0.024	51.44
250.000	0.030	-51.87	-0.473	108.26	-0.473	108.26	0.024	-51.83
270.000	0.067	18.80	-0.497	30.05	-0.497	29.95	0.050	25.13
290.000	0.010	149.86	-0.520	-47.80	-0.520	-47.80	0.006	95.49
310.000	0.050	-15.18	-0.552	-126.34	-0.542	-126.24	0.055	-2.38
330.000	0.033	55.51	-0.563	154.88	-0.563	154.98	0.033	58.51
350.000	0.011	-30.17	-0.593	76.17	-0.593	76.07	0.020	-0.95
370.000	0.061	1.16	-0.617	-2.50	-0.617	-1.20	0.056	3.50
390.000	0.035	100.93	-0.626	-81.09	-0.626	-80.99	0.022	96.53
410.000	0.060	-28.88	-0.652	-159.72	-0.652	-159.72	0.065	-23.97
430.000	0.049	58.41	-0.671	122.06	-0.671	122.16	0.046	56.42
450.000	0.020	31.01	-0.692	43.46	-0.692	43.36	0.016	52.23
470.000	0.061	-22.64	-0.728	-33.74	-0.738	-33.64	0.066	-36.27
490.000	0.067	43.79	-0.727	-112.84	-0.727	-112.84	0.077	48.51
510.000	0.025	-121.12	-0.739	169.18	-0.749	169.18	0.030	-141.01
530.000	0.083	16.63	-0.772	90.44	-0.782	90.34	0.083	26.49
550.000	0.002	1.09	-0.771	13.09	-0.781	12.99	0.017	3.01
570.000	0.029	-15.42	-0.808	-64.95	-0.808	-64.95	0.036	0.16
590.000	0.074	32.89	-0.835	-143.48	-0.835	-143.38	0.087	21.63
610.000	0.021	140.87	-0.834	138.69	-0.834	138.49	0.031	179.17
630.000	0.078	-8.16	-0.863	61.28	-0.863	61.28	0.088	-10.95
650.000	0.041	85.76	-0.850	-17.52	-0.860	-17.52	0.037	80.70
670.000	0.057	6.82	-0.885	-95.55	-0.895	-95.55	0.061	16.48
690.000	0.034	54.51	-0.897	-174.36	-0.907	-174.36	0.037	-24.86
710.000	0.041	57.90	-0.920	108.51	-0.920	108.51	0.069	54.12
730.000	0.085	-0.03	-0.961	30.43	-0.971	30.33	0.068	-32.96
750.000	0.061	65.33	-0.954	-48.05	-0.964	-47.95	0.067	48.62
770.000	0.052	-5.37	-0.974	-125.58	-0.984	-125.68	0.047	-30.88
790.000	0.095	37.06	-1.022	157.00	-1.032	157.00	0.089	39.44
810.000	0.050	-6.66	-1.010	76.18	-1.010	76.18	0.061	-52.27
830.000	0.075	-0.33	-1.058	-1.90	-1.058	-1.90	0.073	8.80
850.000	0.079	24.23	-1.051	-80.36	-1.061	-80.46	0.041	38.23
870.000	0.043	-45.14	-1.053	-157.17	-1.073	-157.17	0.042	-36.08
890.000	0.078	19.94	-1.090	124.16	-1.110	124.06	0.102	13.25
910.000	0.051	4.22	-1.093	46.17	-1.093	46.27	0.024	74.18
930.000	0.065	-5.47	-1.167	-31.46	-1.167	-31.46	0.114	-20.75
950.000	0.070	10.49	-1.133	-108.56	-1.143	-108.66	0.075	34.35
970.000	0.036	-40.55	-1.137	173.95	-1.157	173.95	0.052	-57.02
990.000	0.083	12.02	-1.176	95.47	-1.186	95.47	0.079	2.28
1010.000	0.023	44.80	-1.167	17.36	-1.167	17.46	0.037	31.91

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
			10 ft. Cable-solid red					
30.000	0.015	125.77	-0.141	-118.50	-0.131	-118.60	0.007	108.26
50.000	0.056	-38.61	-0.200	163.82	-0.200	163.82	0.057	-32.00
70.000	0.040	63.10	-0.233	85.00	-0.233	85.00	0.037	73.70
90.000	0.035	-54.78	-0.265	6.05	-0.265	6.05	0.039	-68.98
110.000	0.040	17.14	-0.305	-72.47	-0.295	-72.47	0.040	23.91
130.000	0.017	11.70	-0.319	-149.91	-0.329	-149.91	0.013	51.55
150.000	0.023	-41.39	-0.351	139.68	-0.361	139.58	0.036	-26.05
170.000	0.036	42.96	-0.390	61.11	-0.390	61.11	0.051	60.43
190.000	0.020	-56.61	-0.408	-17.41	-0.398	-17.51	0.022	-58.22
210.000	0.041	12.36	-0.430	-94.61	-0.440	-94.71	0.048	9.21
230.000	0.032	66.37	-0.465	-172.79	-0.455	-172.79	0.029	59.16
250.000	0.031	-65.02	-0.493	109.06	-0.483	108.96	0.020	-33.03
270.000	0.072	24.34	-0.517	30.84	-0.517	30.74	0.058	23.46
290.000	0.011	179.54	-0.530	-48.00	-0.540	-46.90	0.006	37.13
310.000	0.059	-12.81	-0.561	-125.35	-0.571	-125.35	0.064	-2.80
330.000	0.017	49.50	-0.576	155.88	-0.576	155.98	0.018	55.27
350.000	0.009	-58.57	-0.603	77.17	-0.613	77.07	0.021	11.03
370.000	0.055	-2.37	-0.637	-1.29	-0.637	-1.49	0.049	5.30
390.000	0.030	112.54	-0.648	-79.70	-0.648	-79.80	0.017	94.11
410.000	0.046	-39.20	-0.671	-158.39	-0.671	-158.49	0.050	-12.30
430.000	0.053	57.25	-0.688	123.46	-0.688	123.46	0.053	59.59
450.000	0.011	106.95	-0.711	44.88	-0.711	44.78	0.037	50.68
470.000	0.061	-21.63	-0.757	-32.25	-0.757	-32.25	0.068	-30.95
490.000	0.077	64.09	-0.757	-111.35	-0.767	-111.35	0.101	44.41
510.000	0.037	-102.21	-0.775	170.86	-0.775	170.86	0.023	-98.48
530.000	0.086	34.14	-0.811	92.12	-0.811	92.02	0.093	13.35
550.000	0.003	-165.16	-0.801	14.89	-0.801	14.79	0.026	-3.35
570.000	0.042	9.41	-0.840	-63.07	-0.840	-63.07	0.048	-22.47
590.000	0.073	32.70	-0.855	-141.47	-0.865	-141.57	0.083	23.03
610.000	0.027	151.67	-0.852	140.59	-0.862	140.59	0.028	170.51
630.000	0.100	3.39	-0.899	63.35	-0.909	63.25	0.116	-6.59
650.000	0.036	102.42	-0.884	-15.39	-0.894	-15.39	0.034	53.74
670.000	0.077	4.24	-0.929	-93.36	-0.949	-93.36	0.077	3.09
690.000	0.074	66.83	-0.963	-172.26	-0.973	-172.36	0.087	-16.65
710.000	0.104	-20.78	-1.007	111.37	-1.007	111.37	0.055	-61.96
730.000	0.053	-44.27	-0.972	33.07	-0.972	32.97	0.013	-53.53
750.000	0.040	79.08	-0.981	-45.40	-0.991	-45.30	0.054	42.61
770.000	0.045	-28.85	-1.010	-122.98	-1.020	-123.08	0.058	-13.32
790.000	0.070	51.58	-1.038	159.70	-1.048	159.70	0.060	36.11
810.000	0.032	-23.66	-1.037	78.97	-1.047	78.97	0.079	-43.07
830.000	0.059	2.45	-1.075	0.97	-1.085	0.97	0.063	14.12
850.000	0.055	57.46	-1.073	-77.51	-1.083	-77.51	0.050	-11.92
870.000	0.042	-23.43	-1.095	-154.25	-1.105	-154.25	0.038	-56.03
890.000	0.071	37.52	-1.121	127.17	-1.131	127.07	0.088	6.13
910.000	0.042	5.80	-1.114	49.28	-1.124	49.38	0.013	46.47
930.000	0.068	23.96	-1.192	-28.32	-1.192	-28.32	0.094	-31.93
950.000	0.082	10.49	-1.171	-105.38	-1.191	-105.48	0.078	44.62
970.000	0.039	-27.59	-1.176	177.24	-1.196	177.24	0.047	-56.50
990.000	0.099	1.71	-1.233	98.65	-1.243	98.75	0.104	11.32
1010.000	0.011	173.11	-1.208	20.91	-1.208	21.11	0.050	-11.15

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
			30 ft. Cable-red over white					
30.000	0.019	-115.44	-0.585	-92.53	-0.585	-92.63	0.014	-82.60
50.000	0.035	-62.71	-0.783	-32.55	-0.773	-32.65	0.038	-54.86
70.000	0.049	-6.51	-0.936	27.34	-0.936	27.44	0.052	-8.15
90.000	0.035	14.24	-1.074	86.16	-1.074	86.06	0.039	55.15
110.000	0.077	82.42	-1.236	146.65	-1.226	146.75	0.081	22.49
130.000	0.025	43.34	-1.316	-152.82	-1.326	-152.72	0.030	42.88
150.000	0.027	-51.65	-1.432	-62.42	-1.442	-62.42	0.038	-27.74
170.000	0.050	2.29	-1.547	-1.59	-1.547	-1.49	0.057	-19.97
190.000	0.031	20.31	-1.635	58.72	-1.645	58.82	0.041	19.10
210.000	0.052	43.80	-1.749	120.13	-1.759	120.23	0.056	32.23
230.000	0.034	48.08	-1.834	-176.99	-1.834	-176.89	0.028	61.71
250.000	0.010	67.83	-1.929	-115.51	-1.929	-115.51	0.015	27.04
270.000	0.020	-55.15	-2.023	-54.61	-2.023	-53.31	0.017	-35.62
290.000	0.031	-12.90	-2.112	4.99	-2.112	4.99	0.029	-34.25
310.000	0.057	9.92	-2.199	66.15	-2.209	66.25	0.059	4.86
330.000	0.048	32.90	-2.284	126.34	-2.284	126.54	0.044	30.37
350.000	0.038	41.07	-2.363	-174.64	-2.363	-174.74	0.040	26.12
370.000	0.049	49.11	-2.444	-113.02	-2.444	-113.02	0.028	74.60
390.000	0.022	35.84	-2.531	-53.11	-2.531	-53.11	0.015	-140.41
410.000	0.039	-20.21	-2.601	7.52	-2.611	7.52	0.035	-30.99
430.000	0.054	7.24	-2.680	68.56	-2.680	68.76	0.051	10.30
450.000	0.060	14.26	-2.782	129.16	-2.782	129.26	0.063	10.04
470.000	0.035	30.13	-2.834	-169.24	-2.834	-169.14	0.071	-4.43
490.000	0.062	51.10	-2.907	-110.14	-2.917	-110.04	0.071	40.93
510.000	0.020	79.18	-2.970	-48.23	-2.970	-48.13	0.024	62.88
530.000	0.043	-17.46	-3.045	12.99	-3.055	13.09	0.035	-61.74
550.000	0.050	-10.11	-3.121	72.35	-3.131	73.55	0.055	-0.44
570.000	0.050	4.28	-3.196	135.41	-3.206	135.41	0.051	7.66
590.000	0.072	10.82	-3.275	-163.28	-3.285	-163.08	0.075	7.66
610.000	0.067	22.42	-3.325	-101.18	-3.335	-101.18	0.059	38.95
630.000	0.026	60.10	-3.357	-39.13	-3.367	-39.03	0.021	44.03
650.000	0.027	-49.34	-3.436	21.64	-3.456	21.74	0.038	-9.72
670.000	0.048	11.68	-3.512	83.55	-3.522	83.65	0.048	13.44
690.000	0.061	19.27	-3.589	142.14	-3.599	143.54	0.041	-0.31
710.000	0.037	0.19	-3.641	-155.02	-3.641	-154.92	0.029	-18.65
730.000	0.046	18.11	-3.703	-92.55	-3.703	-92.55	0.049	10.51
750.000	0.020	75.82	-3.774	-30.87	-3.774	-30.67	0.053	20.75
770.000	0.048	-21.53	-3.837	33.06	-3.847	32.96	0.048	-38.43
790.000	0.062	-0.61	-3.892	94.85	-3.902	94.85	0.066	-9.86
810.000	0.058	22.09	-3.972	146.84	-3.972	146.74	0.061	-2.33
830.000	0.047	1.74	-4.030	-151.96	-4.030	-150.66	0.035	26.21
850.000	0.064	24.60	-4.079	-90.48	-4.099	-90.58	0.039	44.33
870.000	0.045	36.86	-4.148	-27.82	-4.158	-27.82	0.048	19.79
890.000	0.015	-14.84	-4.212	33.17	-4.212	33.17	0.057	-9.28
910.000	0.062	8.24	-4.273	96.66	-4.273	96.76	0.057	-36.35
930.000	0.050	61.90	-4.319	159.90	-4.329	159.90	0.031	-2.20
950.000	0.117	23.63	-4.461	-137.37	-4.481	-137.47	0.112	-7.26
970.000	0.069	5.89	-4.439	-74.35	-4.459	-74.35	0.054	30.86
990.000	0.085	-13.41	-4.537	-12.03	-4.537	-12.03	0.017	19.78
1010.000	0.092	-44.86	-4.607	51.13	-4.607	51.23	0.081	-77.27

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
	30 ft.Cable-yellow over white							
30.000	0.017	-111.84	-0.585	-93.53	-0.595	-93.43	0.014	-90.64
50.000	0.037	-60.05	-0.783	-34.06	-0.783	-34.06	0.040	-54.84
70.000	0.051	-13.13	-0.947	25.33	-0.947	25.43	0.053	-6.75
90.000	0.033	25.39	-1.085	83.56	-1.085	83.46	0.034	35.30
110.000	0.053	82.92	-1.231	143.56	-1.221	143.56	0.056	15.97
130.000	0.017	17.70	-1.329	-156.62	-1.339	-156.52	0.019	24.82
150.000	0.023	-14.14	-1.432	-66.81	-1.442	-66.91	0.031	-62.34
170.000	0.036	1.68	-1.548	-6.59	-1.548	-6.59	0.042	-25.60
190.000	0.048	19.74	-1.653	53.12	-1.663	53.12	0.055	9.54
210.000	0.026	52.24	-1.743	114.01	-1.753	114.01	0.028	12.53
230.000	0.039	40.02	-1.853	176.30	-1.843	176.30	0.030	54.91
250.000	0.018	53.41	-1.939	-122.81	-1.939	-122.91	0.013	48.37
270.000	0.009	-81.81	-2.022	-61.21	-2.022	-61.31	0.010	-10.26
290.000	0.032	-20.88	-2.122	-3.51	-2.132	-3.51	0.027	-43.15
310.000	0.028	14.65	-2.200	56.98	-2.210	57.08	0.031	-12.31
330.000	0.056	42.44	-2.294	116.63	-2.304	116.73	0.050	9.92
350.000	0.052	20.61	-2.383	175.05	-2.383	175.05	0.036	45.45
370.000	0.043	52.71	-2.454	-123.83	-2.454	-123.83	0.033	46.36
390.000	0.024	69.86	-2.537	-64.60	-2.547	-64.60	0.016	107.24
410.000	0.038	-51.41	-2.623	-4.49	-2.623	-4.39	0.043	-31.97
430.000	0.043	-18.45	-2.695	56.06	-2.695	56.16	0.052	10.75
450.000	0.044	19.08	-2.783	116.11	-2.793	116.11	0.038	-8.94
470.000	0.064	23.77	-2.857	176.90	-2.867	177.00	0.073	-1.70
490.000	0.070	30.99	-2.932	-124.49	-2.942	-124.49	0.073	32.23
510.000	0.044	57.33	-2.986	-63.27	-2.996	-63.17	0.039	72.91
530.000	0.043	20.26	-3.065	-2.52	-3.075	-2.52	0.016	-141.57
550.000	0.062	-24.01	-3.145	57.56	-3.155	57.56	0.057	-13.90
570.000	0.029	3.91	-3.205	118.65	-3.205	118.75	0.029	1.52
590.000	0.053	-9.30	-3.288	179.68	-3.298	179.68	0.042	4.12
610.000	0.079	16.05	-3.361	-119.04	-3.371	-119.04	0.075	20.14
630.000	0.060	30.22	-3.392	-57.65	-3.392	-57.55	0.053	78.24
650.000	0.037	6.88	-3.460	2.58	-3.480	2.58	0.010	-40.28
670.000	0.046	-11.96	-3.539	63.98	-3.559	64.08	0.061	3.83
690.000	0.058	14.38	-3.597	123.24	-3.617	123.34	0.045	20.42
710.000	0.059	3.54	-3.678	-175.86	-3.678	-175.76	0.030	5.08
730.000	0.070	-7.77	-3.740	-113.84	-3.750	-113.94	0.050	22.78
750.000	0.035	19.32	-3.801	-52.72	-3.801	-52.62	0.031	16.36
770.000	0.031	12.41	-3.849	10.46	-3.869	10.26	0.033	19.72
790.000	0.076	-17.16	-3.932	71.84	-3.942	71.94	0.070	-36.15
810.000	0.044	16.09	-3.987	123.02	-3.997	123.02	0.067	8.08
830.000	0.057	-21.29	-4.068	-174.83	-4.068	-174.83	0.064	19.47
850.000	0.071	-3.60	-4.126	-115.25	-4.136	-115.35	0.053	31.35
870.000	0.077	48.18	-4.186	-53.32	-4.206	-53.22	0.067	15.77
890.000	0.063	-7.38	-4.240	7.13	-4.250	7.13	0.018	47.43
910.000	0.064	21.63	-4.298	69.91	-4.298	70.01	0.024	-3.17
930.000	0.080	-3.03	-4.392	132.95	-4.392	133.05	0.061	-30.02
950.000	0.046	17.61	-4.419	-165.09	-4.439	-165.09	0.044	-9.70
970.000	0.043	20.89	-4.472	-101.40	-4.482	-101.30	0.065	3.20
990.000	0.077	26.23	-4.551	-41.14	-4.561	-41.14	0.059	11.47
1010.000	0.085	27.24	-4.614	20.82	-4.624	20.92	0.065	40.71

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
	30 ft.Cable-red over yellow							
30.000	0.015	-140.14	-0.594	-93.02	-0.594	-93.12	0.011	-122.14
50.000	0.033	-76.29	-0.783	-33.24	-0.773	-33.34	0.030	-57.26
70.000	0.047	-15.44	-0.937	26.44	-0.937	26.44	0.048	-3.05
90.000	0.033	32.72	-1.075	84.86	-1.075	84.76	0.035	34.35
110.000	0.016	45.14	-1.196	145.18	-1.196	145.18	0.017	56.14
130.000	0.027	49.57	-1.305	-154.62	-1.315	-154.72	0.033	58.29
150.000	0.006	-82.26	-1.401	-64.81	-1.411	-64.81	0.015	-31.36
170.000	0.022	5.49	-1.509	-4.29	-1.509	-4.29	0.030	-18.04
190.000	0.027	19.15	-1.616	55.82	-1.616	55.72	0.041	25.08
210.000	0.039	45.66	-1.702	116.92	-1.712	116.92	0.043	34.63
230.000	0.041	60.22	-1.802	179.41	-1.802	179.41	0.039	51.75
250.000	0.034	83.51	-1.886	-119.49	-1.886	-119.59	0.031	81.81
270.000	0.007	-14.51	-1.971	-57.61	-1.971	-57.71	0.002	-46.09
290.000	0.033	-52.20	-2.051	0.39	-2.061	0.39	0.028	8.67
310.000	0.043	4.39	-2.140	61.16	-2.150	61.16	0.049	9.21
330.000	0.040	22.50	-2.224	121.15	-2.224	121.15	0.044	44.43
350.000	0.054	36.95	-2.310	179.75	-2.310	179.65	0.054	42.87
370.000	0.054	66.21	-2.370	-118.92	-2.380	-119.02	0.049	62.17
390.000	0.026	98.26	-2.456	-59.40	-2.456	-59.50	0.022	92.88
410.000	0.036	-78.00	-2.531	1.02	-2.531	0.92	0.049	6.47
430.000	0.042	4.14	-2.603	61.78	-2.603	61.78	0.049	10.81
450.000	0.038	9.18	-2.680	122.01	-2.680	121.91	0.046	14.27
470.000	0.059	19.41	-2.756	-176.88	-2.756	-176.88	0.068	13.68
490.000	0.081	40.43	-2.840	-118.20	-2.840	-118.20	0.092	50.78
510.000	0.038	96.44	-2.880	-56.56	-2.880	-56.56	0.057	58.22
530.000	0.008	102.24	-2.948	4.28	-2.958	4.28	0.028	38.78
550.000	0.041	-5.08	-3.019	64.55	-3.029	64.55	0.054	-1.40
570.000	0.048	7.15	-3.096	126.10	-3.116	126.00	0.062	10.31
590.000	0.063	16.23	-3.176	-172.88	-3.176	-172.78	0.080	0.73
610.000	0.087	36.97	-3.239	-111.29	-3.249	-111.29	0.099	27.57
630.000	0.067	64.30	-3.257	-49.59	-3.257	-49.59	0.066	68.35
650.000	0.016	95.57	-3.326	10.73	-3.336	10.73	0.046	36.20
670.000	0.063	0.94	-3.417	72.64	-3.427	72.54	0.077	2.80
690.000	0.055	23.27	-3.467	132.03	-3.477	132.13	0.051	16.37
710.000	0.057	23.68	-3.536	-166.80	-3.536	-166.80	0.052	-2.01
730.000	0.076	33.18	-3.598	-104.66	-3.608	-104.76	0.083	7.84
750.000	0.053	87.64	-3.664	-43.38	-3.674	-43.28	0.092	19.07
770.000	0.049	22.73	-3.716	20.15	-3.716	19.95	0.032	3.58
790.000	0.053	-9.94	-3.772	81.74	-3.782	81.74	0.082	-1.04
810.000	0.073	3.62	-3.868	133.39	-3.868	133.39	0.096	2.33
830.000	0.062	6.99	-3.907	-164.44	-3.917	-164.54	0.069	18.33
850.000	0.085	25.21	-3.979	-104.67	-3.989	-104.77	0.083	9.55
870.000	0.073	38.43	-4.035	-42.43	-4.045	-42.43	0.084	22.66
890.000	0.033	19.75	-4.073	18.27	-4.073	18.17	0.053	5.42
910.000	0.081	7.54	-4.146	81.48	-4.146	81.58	0.065	-34.83
930.000	0.069	5.93	-4.223	144.60	-4.233	144.50	0.093	-8.31
950.000	0.079	-4.73	-4.282	-152.99	-4.302	-153.09	0.108	-7.26
970.000	0.089	18.50	-4.318	-89.23	-4.338	-89.43	0.101	8.21
990.000	0.076	44.92	-4.387	-28.84	-4.397	-28.84	0.098	8.15
1010.000	0.056	-17.20	-4.413	34.03	-4.423	34.03	0.056	-20.17

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
			30 ft. Cable-blue over yellow					
30.000	0.014	-132.01	-0.594	-94.02	-0.594	-94.02	0.011	-113.15
50.000	0.039	-79.60	-0.793	-34.95	-0.793	-34.95	0.031	-45.74
70.000	0.044	-24.14	-0.958	24.14	-0.958	24.14	0.044	-2.66
90.000	0.035	21.54	-1.104	81.86	-1.104	81.86	0.038	37.07
110.000	0.030	64.91	-1.234	141.67	-1.224	141.67	0.034	32.13
130.000	0.011	0.32	-1.340	-158.82	-1.350	-158.72	0.017	11.37
150.000	0.002	54.51	-1.451	-69.11	-1.461	-69.61	0.011	-51.97
170.000	0.051	3.37	-1.586	-8.99	-1.576	-9.39	0.057	-30.93
190.000	0.029	3.45	-1.676	50.31	-1.676	49.91	0.040	21.81
210.000	0.039	55.83	-1.781	110.92	-1.781	110.42	0.043	16.52
230.000	0.039	46.66	-1.882	172.80	-1.872	172.50	0.037	50.22
250.000	0.015	87.37	-1.967	-126.61	-1.967	-127.01	0.024	30.08
270.000	0.013	138.42	-2.059	-65.50	-2.059	-65.90	0.014	63.86
290.000	0.025	-22.42	-2.162	-8.01	-2.162	-8.41	0.022	-32.25
310.000	0.045	3.45	-2.250	52.36	-2.260	51.96	0.055	-7.86
330.000	0.032	53.69	-2.328	111.56	-2.338	111.26	0.023	-7.08
350.000	0.046	19.62	-2.423	169.65	-2.423	169.25	0.039	39.03
370.000	0.041	84.68	-2.503	-129.64	-2.503	-129.94	0.056	20.48
390.000	0.017	94.54	-2.588	-70.62	-2.588	-70.92	0.017	29.57
410.000	0.009	-13.16	-2.660	-10.93	-2.660	-11.23	0.015	-28.91
430.000	0.050	-9.92	-2.745	49.35	-2.755	49.05	0.057	-5.26
450.000	0.065	10.58	-2.858	109.03	-2.848	108.73	0.066	-1.44
470.000	0.061	2.81	-2.912	169.48	-2.922	169.28	0.068	5.85
490.000	0.077	62.76	-3.010	-132.22	-3.020	-132.32	0.119	-2.19
510.000	0.024	49.31	-3.046	-71.06	-3.046	-71.36	0.040	17.95
530.000	0.019	26.99	-3.113	-10.92	-3.123	-11.12	0.006	15.49
550.000	0.019	16.55	-3.183	48.78	-3.193	48.48	0.025	-4.69
570.000	0.045	22.52	-3.277	109.74	-3.277	109.54	0.036	-26.23
590.000	0.048	2.97	-3.355	170.39	-3.355	170.19	0.064	-34.47
610.000	0.067	-19.86	-3.429	-128.61	-3.429	-128.81	0.038	35.01
630.000	0.070	50.59	-3.450	-67.60	-3.460	-67.60	0.061	47.08
650.000	0.033	43.61	-3.532	-7.77	-3.542	-7.97	0.020	39.24
670.000	0.049	-18.93	-3.612	53.50	-3.622	53.30	0.060	-6.00
690.000	0.065	8.23	-3.670	112.45	-3.690	112.35	0.044	5.95
710.000	0.065	-1.66	-3.762	173.04	-3.762	172.84	0.042	12.47
730.000	0.067	4.41	-3.822	-125.37	-3.822	-125.57	0.057	-3.70
750.000	0.030	44.97	-3.881	-64.64	-3.881	-64.64	0.054	-1.19
770.000	0.037	-8.24	-3.930	-1.65	-3.940	-1.75	0.013	-29.72
790.000	0.038	-29.34	-3.991	59.27	-4.011	59.17	0.062	-30.05
810.000	0.070	-13.08	-4.097	110.44	-4.097	110.24	0.084	-27.23
830.000	0.039	4.22	-4.138	171.95	-4.138	171.85	0.030	-8.78
850.000	0.069	-31.59	-4.206	-128.76	-4.226	-128.96	0.055	65.70
870.000	0.069	115.29	-4.288	-66.78	-4.308	-66.78	0.067	-32.63
890.000	0.050	49.88	-4.322	-6.85	-4.332	-7.05	0.049	33.65
910.000	0.056	40.79	-4.392	55.65	-4.392	55.65	0.044	39.17
930.000	0.054	83.88	-4.453	118.04	-4.453	117.94	0.052	34.72
950.000	0.065	42.27	-4.517	179.91	-4.537	179.81	0.040	-2.20
970.000	0.101	25.31	-4.605	-116.68	-4.625	-116.78	0.101	-14.75
990.000	0.163	50.08	-4.754	-57.24	-4.764	-57.34	0.102	-11.44
1010.000	0.098	-2.49	-4.738	5.63	-4.758	5.73	0.071	37.94

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
	30 ft. Cable-yellow over red							
30.000	0.018	-127.10	-0.595	-92.93	-0.605	-93.03	0.011	-94.39
50.000	0.030	-72.01	-0.793	-33.24	-0.793	-33.24	0.032	-61.78
70.000	0.043	-12.07	-0.957	26.54	-0.957	26.54	0.045	-6.10
90.000	0.038	34.66	-1.104	85.06	-1.104	84.96	0.039	33.50
110.000	0.016	51.82	-1.227	145.48	-1.227	145.58	0.017	36.54
130.000	0.021	52.58	-1.346	-154.32	-1.356	-154.22	0.029	45.50
150.000	0.004	108.63	-1.451	-64.10	-1.461	-64.30	0.009	-86.81
170.000	0.037	-25.93	-1.569	-3.39	-1.579	-3.59	0.046	10.24
190.000	0.042	30.25	-1.684	56.63	-1.684	56.43	0.054	12.50
210.000	0.040	38.21	-1.782	117.92	-1.782	117.72	0.044	36.70
230.000	0.037	53.64	-1.883	-179.49	-1.873	-179.59	0.033	54.90
250.000	0.031	86.85	-1.976	-118.40	-1.976	-118.50	0.030	69.92
270.000	0.015	-82.04	-2.061	-56.31	-2.061	-56.51	0.018	-2.71
290.000	0.032	-45.01	-2.161	1.79	-2.161	1.59	0.030	2.67
310.000	0.069	5.51	-2.269	62.74	-2.269	62.64	0.071	3.21
330.000	0.043	32.08	-2.334	122.74	-2.334	122.74	0.044	28.05
350.000	0.047	35.19	-2.421	-178.45	-2.421	-178.75	0.047	38.10
370.000	0.044	44.07	-2.504	-117.03	-2.494	-117.23	0.035	64.29
390.000	0.014	74.54	-2.590	-57.41	-2.590	-57.61	0.002	-0.83
410.000	0.025	-72.63	-2.662	3.04	-2.662	2.94	0.037	-8.43
430.000	0.052	2.33	-2.742	63.96	-2.752	63.86	0.054	5.91
450.000	0.048	16.11	-2.829	124.28	-2.839	124.08	0.054	-0.45
470.000	0.048	11.75	-2.894	-174.46	-2.904	-174.46	0.055	1.70
490.000	0.062	38.92	-2.979	-115.54	-2.989	-115.64	0.062	52.10
510.000	0.039	50.52	-3.039	-53.85	-3.049	-53.95	0.025	91.03
530.000	0.023	10.09	-3.114	7.19	-3.124	6.99	0.003	-35.65
550.000	0.030	-4.84	-3.185	67.57	-3.195	67.37	0.032	10.10
570.000	0.060	-20.69	-3.286	129.19	-3.296	129.09	0.073	27.41
590.000	0.046	-0.84	-3.347	-169.53	-3.347	-169.53	0.057	5.15
610.000	0.070	40.85	-3.421	-107.83	-3.431	-108.03	0.090	25.25
630.000	0.049	68.98	-3.444	-46.02	-3.454	-46.22	0.048	62.17
650.000	0.028	6.39	-3.529	14.50	-3.549	14.40	0.021	-36.34
670.000	0.065	7.25	-3.615	76.35	-3.635	76.25	0.067	-9.03
690.000	0.056	26.54	-3.674	135.80	-3.684	135.80	0.049	33.23
710.000	0.051	12.80	-3.758	-162.65	-3.758	-162.75	0.056	-31.00
730.000	0.062	26.36	-3.807	-100.50	-3.827	-100.70	0.063	1.15
750.000	0.055	110.55	-3.894	-39.07	-3.894	-38.97	0.086	25.17
770.000	0.013	81.65	-3.943	24.51	-3.943	24.31	0.053	11.08
790.000	0.034	-1.07	-3.997	86.28	-4.017	86.18	0.081	10.08
810.000	0.092	27.09	-4.104	138.17	-4.114	137.97	0.075	-19.32
830.000	0.101	-9.41	-4.198	-159.57	-4.198	-159.67	0.088	22.28
850.000	0.072	57.28	-4.223	-99.59	-4.243	-99.69	0.089	-33.05
870.000	0.102	-20.17	-4.308	-36.76	-4.318	-36.76	0.037	162.79
890.000	0.043	-63.64	-4.323	23.84	-4.333	23.74	0.048	-53.07
910.000	0.085	5.39	-4.393	86.99	-4.393	86.99	0.037	-81.22
930.000	0.037	1.35	-4.453	150.28	-4.453	150.08	0.056	3.90
950.000	0.062	-24.48	-4.540	-147.35	-4.560	-147.55	0.096	14.67
970.000	0.068	23.75	-4.572	-84.72	-4.582	-84.82	0.068	7.07
990.000	0.018	-125.22	-4.631	-22.53	-4.641	-22.63	0.039	-86.56
1010.000	0.045	-8.49	-4.679	40.10	-4.689	40.20	0.038	-5.22

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
			30 ft.Cable-blue over red					
30.000	0.013	-143.60	-0.594	-94.02	-0.604	-94.12	0.011	-126.22
50.000	0.032	-75.18	-0.793	-34.94	-0.793	-34.94	0.032	-60.08
70.000	0.046	-15.44	-0.957	24.14	-0.957	24.14	0.047	-9.21
90.000	0.042	17.18	-1.103	81.95	-1.103	81.85	0.045	38.16
110.000	0.021	53.24	-1.226	141.67	-1.236	141.67	0.019	44.94
130.000	0.036	61.36	-1.353	-158.92	-1.353	-158.82	0.044	51.42
150.000	0.009	36.52	-1.461	-69.30	-1.461	-69.60	0.013	-81.28
170.000	0.033	11.30	-1.578	-9.29	-1.578	-9.49	0.038	-36.49
190.000	0.037	17.37	-1.684	50.02	-1.684	49.82	0.044	10.17
210.000	0.018	40.15	-1.775	110.61	-1.785	110.41	0.022	28.13
230.000	0.034	55.24	-1.893	172.50	-1.883	172.40	0.031	37.75
250.000	0.042	76.46	-1.985	-126.89	-1.985	-127.09	0.034	77.14
270.000	0.019	78.03	-2.069	-65.70	-2.069	-65.90	0.016	115.89
290.000	0.020	-34.60	-2.161	-8.31	-2.171	-8.41	0.020	-23.36
310.000	0.055	4.99	-2.270	52.05	-2.270	51.95	0.053	-8.67
330.000	0.063	33.56	-2.354	111.31	-2.364	111.31	0.061	7.43
350.000	0.043	12.94	-2.425	169.45	-2.435	169.25	0.032	30.12
370.000	0.028	61.25	-2.507	-129.73	-2.507	-129.93	0.032	17.78
390.000	0.022	72.52	-2.598	-70.91	-2.598	-71.01	0.012	78.25
410.000	0.022	-53.00	-2.673	-11.06	-2.673	-11.16	0.030	-43.94
430.000	0.037	19.77	-2.746	49.02	-2.756	49.02	0.030	-14.72
450.000	0.047	11.61	-2.844	108.79	-2.854	108.79	0.043	-5.27
470.000	0.056	26.32	-2.922	169.32	-2.932	169.32	0.066	-15.58
490.000	0.099	34.11	-3.025	-132.48	-3.025	-132.48	0.096	25.85
510.000	0.035	37.85	-3.052	-71.37	-3.062	-71.37	0.038	57.82
530.000	0.005	118.80	-3.121	-11.11	-3.131	-11.21	0.020	20.26
550.000	0.043	33.63	-3.203	48.58	-3.213	48.48	0.010	-56.40
570.000	0.053	1.71	-3.297	109.62	-3.307	109.42	0.049	4.00
590.000	0.056	12.61	-3.371	170.17	-3.381	170.07	0.059	-21.58
610.000	0.086	2.88	-3.456	-128.75	-3.456	-128.95	0.070	21.96
630.000	0.048	31.41	-3.472	-67.63	-3.482	-67.53	0.053	42.39
650.000	0.035	90.29	-3.544	-8.00	-3.564	-8.10	0.046	39.82
670.000	0.054	-15.23	-3.634	53.40	-3.644	53.20	0.059	-11.07
690.000	0.057	43.17	-3.675	112.20	-3.695	112.20	0.030	34.61
710.000	0.020	19.86	-3.751	172.78	-3.761	172.68	0.020	122.31
730.000	0.089	15.15	-3.857	-125.55	-3.867	-125.65	0.089	3.03
750.000	0.028	8.94	-3.904	-64.46	-3.904	-64.46	0.036	-43.71
770.000	0.032	17.61	-3.947	-1.73	-3.957	-1.83	0.025	39.24
790.000	0.047	-14.61	-4.028	59.26	-4.038	59.16	0.068	-21.36
810.000	0.048	-3.82	-4.109	110.16	-4.119	110.16	0.093	-3.36
830.000	0.067	3.59	-4.174	171.99	-4.174	171.99	0.041	-9.38
850.000	0.084	-0.46	-4.264	-128.83	-4.274	-129.03	0.091	0.91
870.000	0.038	89.42	-4.304	-66.78	-4.324	-66.78	0.079	-69.18
890.000	0.058	-6.67	-4.345	-6.78	-4.355	-6.88	0.022	102.55
910.000	0.097	-10.75	-4.428	55.88	-4.438	55.88	0.050	-153.92
930.000	0.070	14.95	-4.476	118.31	-4.486	118.31	0.027	-11.17
950.000	0.047	15.21	-4.538	180.00	-4.548	179.90	0.042	3.97
970.000	0.045	18.49	-4.586	-116.81	-4.596	-116.91	0.039	12.18
990.000	0.122	-42.09	-4.750	-56.12	-4.760	-56.32	0.085	85.01
1010.000	0.022	73.90	-4.723	5.72	-4.733	5.72	0.073	-15.99

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
30 ft. Cable-yellow over blue								
30.000	0.014	-103.86	-0.595	-92.93	-0.595	-92.93	0.017	-96.39
50.000	0.046	-53.39	-0.793	-33.07	-0.793	-33.07	0.049	-48.06
70.000	0.052	-9.29	-0.956	26.73	-0.956	26.83	0.055	-7.18
90.000	0.041	35.67	-1.093	85.36	-1.093	85.26	0.041	28.11
110.000	0.022	57.80	-1.225	145.77	-1.225	145.77	0.023	33.56
130.000	0.026	55.58	-1.336	-153.92	-1.346	-153.92	0.032	43.72
150.000	0.024	4.60	-1.452	-64.00	-1.452	-63.90	0.032	-69.90
170.000	0.055	1.56	-1.577	-3.29	-1.577	-3.19	0.060	-20.03
190.000	0.044	26.52	-1.683	56.92	-1.673	57.02	0.049	10.16
210.000	0.042	38.35	-1.771	118.12	-1.781	118.22	0.043	33.51
230.000	0.036	28.66	-1.875	-179.11	-1.865	-178.91	0.020	61.72
250.000	0.021	22.90	-1.970	-117.82	-1.970	-117.72	0.004	44.59
270.000	0.008	-8.59	-2.051	-55.91	-2.051	-55.91	0.002	-31.52
290.000	0.038	-29.78	-2.152	2.39	-2.162	2.49	0.027	-24.71
310.000	0.052	-14.77	-2.251	63.36	-2.251	63.46	0.051	24.47
330.000	0.047	24.24	-2.334	123.44	-2.334	123.64	0.047	28.39
350.000	0.044	28.77	-2.413	-177.75	-2.413	-177.75	0.037	33.90
370.000	0.035	50.74	-2.496	-116.23	-2.486	-116.13	0.032	39.12
390.000	0.011	17.22	-2.591	-56.52	-2.591	-56.42	0.006	-67.74
410.000	0.049	-37.05	-2.673	4.00	-2.673	4.10	0.051	-36.25
430.000	0.061	0.05	-2.741	65.05	-2.751	65.15	0.052	1.44
450.000	0.040	-2.70	-2.833	125.51	-2.833	125.41	0.037	9.79
470.000	0.049	7.76	-2.904	-173.27	-2.904	-173.07	0.058	0.99
490.000	0.052	35.61	-2.976	-114.24	-2.986	-114.14	0.061	32.16
510.000	0.024	74.79	-3.037	-52.53	-3.037	-52.43	0.032	80.53
530.000	0.027	-47.76	-3.121	8.61	-3.121	8.61	0.030	-37.42
550.000	0.045	-7.42	-3.190	68.97	-3.200	69.07	0.038	-15.58
570.000	0.061	6.48	-3.288	130.70	-3.298	130.70	0.058	-5.77
590.000	0.055	3.28	-3.345	-168.03	-3.355	-167.93	0.050	6.84
610.000	0.078	28.61	-3.420	-106.23	-3.430	-106.23	0.076	40.11
630.000	0.051	66.73	-3.452	-44.31	-3.452	-44.31	0.044	74.51
650.000	0.043	3.03	-3.530	16.19	-3.550	16.29	0.014	-64.78
670.000	0.059	5.18	-3.616	78.15	-3.626	78.15	0.045	10.27
690.000	0.070	19.08	-3.678	137.62	-3.698	137.82	0.025	10.29
710.000	0.151	-54.06	-3.890	-160.91	-3.890	-160.81	0.117	88.49
730.000	0.045	40.75	-3.821	-98.21	-3.831	-98.21	0.078	5.95
750.000	0.031	73.06	-3.883	-36.81	-3.893	-36.61	0.069	28.59
770.000	0.038	-9.28	-3.941	26.91	-3.951	26.91	0.032	-14.49
790.000	0.052	-34.24	-4.018	88.68	-4.038	88.68	0.097	-6.13
810.000	0.036	-12.17	-4.081	140.53	-4.091	140.53	0.058	19.72
830.000	0.032	24.75	-4.139	-157.09	-4.139	-157.09	0.023	13.34
850.000	0.051	17.38	-4.208	-97.07	-4.218	-97.07	0.034	1.87
870.000	0.042	38.27	-4.276	-34.63	-4.286	-34.53	0.049	33.43
890.000	0.043	-13.55	-4.333	26.31	-4.333	26.31	0.020	-4.92
910.000	0.054	-3.89	-4.403	89.62	-4.403	89.62	0.050	-13.50
930.000	0.053	24.60	-4.491	153.04	-4.491	153.04	0.083	-22.12
950.000	0.059	22.53	-4.545	-144.46	-4.555	-144.56	0.077	-14.62
970.000	0.056	20.21	-4.580	-81.71	-4.590	-81.71	0.055	3.88
990.000	0.039	46.59	-4.650	-19.72	-4.650	-19.62	0.058	9.54
1010.000	0.045	-11.43	-4.701	43.01	-4.701	43.21	0.047	-11.13

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
			30 ft. Cable-red over blue					
30.000	0.021	158.02	-0.613	-94.59	-0.613	-94.69	0.020	169.57
50.000	0.022	-111.73	-0.804	-35.82	-0.804	-35.92	0.020	-99.03
70.000	0.021	-36.97	-0.970	22.87	-0.970	22.87	0.023	-19.03
90.000	0.016	18.00	-1.118	80.28	-1.118	80.18	0.022	60.39
110.000	0.032	88.16	-1.245	139.67	-1.245	139.67	0.033	11.80
130.000	0.017	27.05	-1.358	-161.21	-1.368	-161.21	0.015	54.40
150.000	0.019	107.52	-1.470	-71.69	-1.480	-71.79	0.013	178.96
170.000	0.005	57.93	-1.580	-12.00	-1.580	-12.20	0.007	-40.31
190.000	0.021	44.15	-1.686	47.01	-1.686	46.91	0.024	6.89
210.000	0.024	29.96	-1.784	107.21	-1.784	107.11	0.029	42.44
230.000	0.034	52.86	-1.883	168.70	-1.883	168.70	0.028	46.76
250.000	0.037	78.50	-1.975	-131.10	-1.985	-131.20	0.030	73.36
270.000	0.042	130.91	-2.065	-70.28	-2.065	-70.48	0.043	93.99
290.000	0.004	85.46	-2.160	-13.30	-2.160	-13.40	0.006	130.58
310.000	0.023	7.12	-2.240	46.68	-2.250	46.58	0.023	1.81
330.000	0.026	-1.55	-2.328	105.67	-2.338	105.67	0.030	63.50
350.000	0.044	27.25	-2.413	163.45	-2.423	163.35	0.042	39.78
370.000	0.059	58.72	-2.499	-136.24	-2.499	-136.44	0.056	48.34
390.000	0.045	88.61	-2.582	-77.80	-2.582	-77.90	0.040	85.83
410.000	0.017	127.23	-2.647	-18.40	-2.657	-18.40	0.015	68.50
430.000	0.024	-1.33	-2.727	41.43	-2.727	41.43	0.027	15.97
450.000	0.025	12.12	-2.818	100.86	-2.818	100.76	0.025	22.47
470.000	0.050	4.28	-2.905	161.02	-2.905	160.92	0.050	0.71
490.000	0.053	23.39	-2.969	-141.07	-2.979	-141.17	0.069	14.36
510.000	0.080	59.45	-3.035	-80.67	-3.035	-80.77	0.074	60.09
530.000	0.039	49.82	-3.095	-20.75	-3.105	-20.75	0.034	107.54
550.000	0.039	74.06	-3.173	38.46	-3.183	38.46	0.033	82.40
570.000	0.050	17.96	-3.264	99.23	-3.264	99.13	0.040	10.39
590.000	0.037	33.02	-3.328	159.51	-3.338	159.51	0.046	-28.24
610.000	0.095	20.13	-3.437	-139.82	-3.437	-139.92	0.105	0.32
630.000	0.089	42.14	-3.445	-79.11	-3.445	-79.21	0.087	38.35
650.000	0.042	14.64	-3.508	-19.79	-3.518	-19.79	0.031	72.11
670.000	0.013	0.53	-3.587	41.04	-3.597	40.94	0.066	19.99
690.000	0.014	49.58	-3.632	99.53	-3.652	99.53	0.081	45.87
710.000	0.045	43.46	-3.718	159.73	-3.718	159.63	0.023	2.28
730.000	0.069	-6.75	-3.790	-138.96	-3.800	-139.06	0.056	23.95
750.000	0.072	26.15	-3.848	-78.52	-3.858	-78.52	0.066	26.54
770.000	0.084	47.96	-3.918	-15.99	-3.938	-16.19	0.066	58.41
790.000	0.052	19.59	-3.970	44.56	-3.980	44.46	0.039	12.16
810.000	0.050	21.49	-4.029	95.20	-4.039	95.10	0.061	6.45
830.000	0.057	-2.06	-4.113	156.67	-4.113	156.67	0.070	8.58
850.000	0.069	0.10	-4.171	-144.55	-4.181	-143.35	0.068	6.54
870.000	0.072	1.35	-4.236	-83.10	-4.246	-83.10	0.071	20.41
890.000	0.063	34.23	-4.296	-23.67	-4.296	-23.67	0.086	33.22
910.000	0.045	16.38	-4.347	38.76	-4.357	38.76	0.063	18.28
930.000	0.073	41.17	-4.407	100.90	-4.407	100.80	0.024	8.96
950.000	0.057	24.59	-4.469	162.42	-4.479	162.22	0.047	-11.28
970.000	0.088	3.60	-4.546	-134.58	-4.566	-134.58	0.092	-17.72
990.000	0.080	16.70	-4.595	-75.14	-4.605	-75.14	0.074	5.94
1010.000	0.068	29.60	-4.647	-13.54	-4.657	-13.44	0.073	14.35

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
30 ft.Cable-yellow over blue(spare)								
30.000	0.017	-127.66	-0.584	-93.63	-0.584	-93.73	0.010	-93.61
50.000	0.040	-66.27	-0.773	-34.36	-0.783	-34.46	0.038	-46.87
70.000	0.060	-11.62	-0.946	24.82	-0.936	24.82	0.063	-6.39
90.000	0.046	31.01	-1.083	82.85	-1.083	82.85	0.046	26.27
110.000	0.030	41.23	-1.203	142.76	-1.193	142.76	0.032	48.72
130.000	0.028	49.17	-1.325	-157.63	-1.325	-157.63	0.035	43.05
150.000	0.032	-25.20	-1.432	-68.01	-1.432	-68.11	0.040	-53.85
170.000	0.031	-23.78	-1.539	-7.89	-1.529	-7.99	0.037	-11.48
190.000	0.040	19.24	-1.644	51.72	-1.634	51.52	0.054	10.21
210.000	0.038	38.60	-1.741	112.42	-1.741	112.32	0.045	27.54
230.000	0.038	54.00	-1.842	174.41	-1.832	174.41	0.037	42.82
250.000	0.028	95.38	-1.925	-124.80	-1.925	-125.00	0.037	47.02
270.000	0.004	-74.41	-2.011	-63.41	-2.011	-63.51	0.016	-6.20
290.000	0.043	-46.87	-2.112	-5.92	-2.112	-5.92	0.042	-11.59
310.000	0.055	-3.52	-2.200	54.55	-2.200	54.55	0.062	-2.18
330.000	0.053	44.32	-2.285	114.03	-2.285	114.13	0.052	4.37
350.000	0.033	27.80	-2.366	172.34	-2.366	172.14	0.039	7.17
370.000	0.045	56.87	-2.443	-126.74	-2.433	-126.94	0.042	34.09
390.000	0.024	75.52	-2.527	-67.72	-2.527	-67.82	0.014	47.38
410.000	0.031	-49.85	-2.595	-7.68	-2.605	-7.78	0.046	-46.19
430.000	0.052	5.90	-2.676	52.57	-2.686	52.57	0.049	-21.23
450.000	0.051	7.85	-2.764	112.49	-2.774	112.39	0.039	-7.08
470.000	0.062	9.40	-2.841	173.19	-2.841	173.19	0.068	0.32
490.000	0.082	33.65	-2.919	-128.53	-2.929	-128.43	0.088	26.56
510.000	0.043	62.60	-2.967	-67.39	-2.977	-67.39	0.049	46.40
530.000	0.042	-19.72	-3.045	-6.60	-3.055	-6.80	0.031	-81.86
550.000	0.045	2.61	-3.109	53.07	-3.119	52.97	0.032	-35.11
570.000	0.054	10.10	-3.200	114.13	-3.200	114.13	0.052	-29.48
590.000	0.044	-10.85	-3.263	174.90	-3.273	174.90	0.050	-24.92
610.000	0.056	8.57	-3.338	-123.94	-3.338	-123.94	0.060	0.37
630.000	0.049	42.66	-3.364	-62.70	-3.364	-62.60	0.041	62.26
650.000	0.051	30.90	-3.437	-2.88	-3.457	-2.78	0.021	144.26
670.000	0.052	6.88	-3.521	58.55	-3.521	58.35	0.035	3.34
690.000	0.062	31.94	-3.581	117.49	-3.591	117.39	0.044	42.37
710.000	0.183	-4.63	-3.902	178.41	-3.902	178.31	0.167	4.70
730.000	0.056	10.61	-3.730	-119.57	-3.730	-119.67	0.066	-12.38
750.000	0.052	46.95	-3.784	-58.80	-3.784	-58.80	0.056	7.87
770.000	0.094	-15.26	-3.867	4.36	-3.877	4.16	0.038	-169.59
790.000	0.044	32.98	-3.907	65.34	-3.917	65.24	0.048	4.77
810.000	0.051	-24.62	-3.984	116.81	-3.994	116.71	0.092	-16.06
830.000	0.061	17.82	-4.046	178.56	-4.046	178.46	0.035	-5.05
850.000	0.049	-9.20	-4.083	-122.06	-4.103	-122.16	0.029	15.32
870.000	0.051	8.33	-4.150	-60.06	-4.160	-60.06	0.012	21.45
890.000	0.056	59.48	-4.241	-0.08	-4.241	-0.18	0.080	22.28
910.000	0.076	-12.92	-4.284	62.88	-4.284	62.98	0.037	-67.50
930.000	0.081	-4.96	-4.358	125.76	-4.368	125.56	0.051	-48.90
950.000	0.056	-8.24	-4.413	-172.37	-4.423	-172.67	0.068	-18.80
970.000	0.102	10.42	-4.492	-109.28	-4.502	-109.28	0.079	-21.40
990.000	0.027	73.14	-4.512	-48.67	-4.512	-48.87	0.027	-51.71
1010.000	0.068	0.86	-4.565	13.25	-4.575	13.25	0.033	82.53

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
			60 ft. cable-blue over white					
30.000	0.036	-49.44	-1.271	125.83	-1.271	125.83	0.033	-47.99
50.000	0.047	20.11	-1.664	-148.44	-1.664	-148.54	0.042	24.97
70.000	0.016	89.03	-1.998	-61.60	-1.988	-61.60	0.012	124.89
90.000	0.010	-2.39	-2.281	22.68	-2.281	22.58	0.011	-27.61
110.000	0.038	19.15	-2.546	110.74	-2.546	110.74	0.032	25.52
130.000	0.024	15.39	-2.788	-161.72	-2.798	-161.72	0.019	53.25
150.000	0.027	6.37	-3.000	-10.02	-3.010	-11.12	0.032	-0.72
170.000	0.019	29.09	-3.220	78.71	-3.220	77.71	0.020	61.62
190.000	0.024	7.52	-3.427	166.10	-3.437	165.10	0.014	-54.45
210.000	0.017	45.48	-3.625	-103.71	-3.635	-104.71	0.020	-14.52
230.000	0.033	32.97	-3.835	-12.11	-3.825	-13.01	0.018	50.02
250.000	0.053	77.13	-4.036	77.41	-4.026	76.41	0.036	123.18
270.000	0.040	-18.83	-4.200	168.67	-4.210	167.77	0.030	22.09
290.000	0.043	21.20	-4.389	-105.72	-4.389	-106.62	0.036	50.34
310.000	0.026	49.11	-4.548	-17.71	-4.558	-18.61	0.016	70.80
330.000	0.023	9.15	-4.719	69.56	-4.729	68.96	0.028	17.53
350.000	0.040	14.91	-4.895	154.25	-4.895	153.45	0.036	50.77
370.000	0.034	49.90	-5.054	-115.53	-5.054	-116.43	0.037	48.14
390.000	0.013	48.80	-5.217	-27.93	-5.217	-28.63	0.028	20.21
410.000	0.054	41.77	-5.372	59.04	-5.372	58.34	0.043	9.89
430.000	0.036	41.86	-5.519	150.65	-5.529	149.95	0.027	33.19
450.000	0.045	17.98	-5.685	-121.44	-5.685	-122.24	0.028	0.11
470.000	0.037	5.74	-5.829	-31.54	-5.829	-32.14	0.033	-2.38
490.000	0.069	27.71	-5.994	52.31	-6.004	51.71	0.058	30.25
510.000	0.027	69.35	-6.118	142.64	-6.128	142.14	0.031	40.90
530.000	0.051	16.13	-6.269	-127.98	-6.269	-128.48	0.046	6.85
550.000	0.053	26.49	-6.404	-40.18	-6.414	-40.68	0.041	29.61
570.000	0.057	19.73	-6.552	52.83	-6.562	52.43	0.035	8.84
590.000	0.048	21.39	-6.694	141.60	-6.704	141.10	0.035	8.23
610.000	0.067	17.12	-6.833	-127.60	-6.853	-128.00	0.060	10.97
630.000	0.042	24.09	-6.932	-36.41	-6.942	-36.81	0.037	35.05
650.000	0.038	18.06	-7.071	51.56	-7.081	51.26	0.036	4.47
670.000	0.058	35.30	-7.211	141.20	-7.221	140.80	0.036	13.19
690.000	0.074	21.85	-7.345	-132.11	-7.355	-132.41	0.023	8.04
710.000	0.057	18.02	-7.475	-39.78	-7.485	-40.28	0.044	24.01
730.000	0.090	9.39	-7.625	52.08	-7.635	51.58	0.058	21.83
750.000	0.071	13.55	-7.749	142.59	-7.759	142.29	0.063	42.97
770.000	0.064	1.86	-7.873	-123.72	-7.883	-124.22	0.063	8.76
790.000	0.071	2.71	-7.996	-33.18	-8.006	-33.48	0.062	26.92
810.000	0.068	19.77	-8.127	36.41	-8.137	36.01	0.064	18.66
830.000	0.069	11.91	-8.258	128.77	-8.258	128.37	0.068	-1.99
850.000	0.102	0.79	-8.394	-143.00	-8.404	-142.20	0.069	1.99
870.000	0.071	6.51	-8.501	-50.49	-8.511	-50.69	0.078	9.78
890.000	0.072	-7.14	-8.609	38.13	-8.619	37.73	0.049	-5.99
910.000	0.077	-17.43	-8.772	132.29	-8.772	131.99	0.095	5.87
930.000	0.069	8.96	-8.854	-133.71	-8.854	-134.01	0.059	5.15
950.000	0.077	17.15	-8.968	-42.61	-8.988	-42.91	0.046	5.17
970.000	0.097	7.47	-9.102	52.98	-9.112	52.68	0.073	-3.79
990.000	0.096	9.05	-9.223	143.95	-9.233	143.75	0.058	8.70
1010.000	0.094	3.52	-9.324	-123.22	-9.274	-123.32	0.043	11.00

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
	60 ft.Cable-white over yellow							
30.000	0.043	-41.98	-1.270	127.42	-1.280	127.32	0.039	-37.71
50.000	0.056	29.24	-1.681	-145.84	-1.681	-145.84	0.054	25.75
70.000	0.017	80.17	-2.018	-57.80	-2.028	-57.80	0.011	111.17
90.000	0.045	-22.36	-2.340	27.63	-2.340	27.53	0.045	-23.21
110.000	0.040	24.86	-2.615	116.84	-2.615	116.94	0.039	21.20
130.000	0.032	33.95	-2.866	-154.63	-2.876	-154.83	0.032	40.79
150.000	0.054	14.75	-3.109	-1.43	-3.109	-0.93	0.061	8.12
170.000	0.021	3.88	-3.329	88.51	-3.329	88.91	0.022	27.72
190.000	0.056	-15.18	-3.562	177.09	-3.562	177.69	0.049	-40.18
210.000	0.058	2.70	-3.779	-91.41	-3.789	-91.01	0.055	7.73
230.000	0.017	5.64	-3.986	1.37	-3.976	1.87	0.032	-14.93
250.000	0.032	-28.50	-4.192	92.25	-4.192	92.75	0.028	-34.15
270.000	0.034	-19.88	-4.382	-175.33	-4.382	-174.93	0.026	-13.67
290.000	0.031	22.04	-4.580	-88.61	-4.590	-88.11	0.020	28.59
310.000	0.012	31.36	-4.759	0.79	-4.769	1.19	0.012	28.23
330.000	0.033	8.62	-4.949	89.46	-4.959	89.86	0.020	14.26
350.000	0.036	-2.82	-5.128	175.26	-5.138	175.56	0.024	37.61
370.000	0.030	-7.33	-5.312	-93.24	-5.312	-92.84	0.017	-9.03
390.000	0.047	-20.46	-5.490	-4.38	-5.500	-3.98	0.048	-6.30
410.000	0.037	22.29	-5.653	83.93	-5.653	84.23	0.047	20.30
430.000	0.015	8.88	-5.817	176.73	-5.827	177.13	0.034	-5.33
450.000	0.038	10.88	-5.999	-94.07	-5.999	-93.87	0.038	-13.66
470.000	0.065	8.20	-6.163	-2.80	-6.163	-2.50	0.052	4.08
490.000	0.043	5.02	-6.318	82.49	-6.328	82.69	0.029	22.48
510.000	0.044	-15.67	-6.470	174.06	-6.480	174.46	0.033	-64.93
530.000	0.055	-10.58	-6.625	-95.55	-6.625	-95.15	0.038	4.28
550.000	0.026	5.11	-6.774	-6.34	-6.784	-6.04	0.031	24.01
570.000	0.045	-61.82	-6.940	87.95	-6.950	88.25	0.051	7.73
590.000	0.031	-5.96	-7.082	178.02	-7.092	178.32	0.048	-25.61
610.000	0.031	17.05	-7.229	-89.76	-7.239	-89.56	0.032	38.44
630.000	0.029	-35.24	-7.371	2.71	-7.381	2.91	0.046	-23.69
650.000	0.044	26.20	-7.515	91.86	-7.525	92.06	0.044	-1.23
670.000	0.040	-12.95	-7.664	-177.07	-7.674	-176.87	0.022	-38.51
690.000	0.056	-37.90	-7.809	-89.62	-7.829	-89.32	0.040	-27.49
710.000	0.150	-141.99	-8.284	3.86	-8.284	4.16	0.153	134.96
730.000	0.037	54.33	-8.085	98.01	-8.095	98.21	0.060	12.91
750.000	0.029	32.37	-8.232	-171.54	-8.242	-171.34	0.050	-15.31
770.000	0.044	33.49	-8.364	-75.65	-8.374	-75.55	0.050	0.19
790.000	0.018	56.21	-8.494	16.19	-8.504	16.49	0.038	-52.57
810.000	0.049	17.37	-8.649	87.32	-8.649	87.52	0.054	-0.33
830.000	0.052	31.26	-8.786	-179.17	-8.786	-178.97	0.044	-12.86
850.000	0.034	85.82	-8.920	-89.61	-8.930	-89.41	0.052	-57.52
870.000	0.056	15.39	-9.047	4.14	-9.057	4.44	0.024	-13.16
890.000	0.056	8.14	-9.180	93.90	-9.180	94.10	0.047	-1.29
910.000	0.059	11.95	-9.313	-170.40	-9.323	-170.10	0.048	7.50
930.000	0.057	6.91	-9.450	-76.20	-9.400	-76.20	0.041	-4.84
950.000	0.042	24.01	-9.569	17.40	-9.489	17.40	0.041	6.19
970.000	0.060	4.57	-9.678	114.10	-9.668	114.30	0.047	-13.42
990.000	0.061	-25.89	-9.803	-153.16	-9.773	-153.06	0.063	-37.62
1010.000	0.045	17.00	-9.909	-60.49	-9.869	-60.29	0.042	-15.68

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
run#2 60ft. Cable-white over yellow								
30.000	0.042	-41.41	-1.270	127.42	-1.280	127.42	0.039	-38.09
50.000	0.057	29.57	-1.681	-145.74	-1.681	-145.84	0.054	25.85
70.000	0.017	77.67	-2.028	-57.80	-2.028	-57.70	0.011	114.10
90.000	0.045	-21.33	-2.340	27.73	-2.340	27.63	0.046	-23.63
110.000	0.041	24.51	-2.625	117.04	-2.615	117.04	0.039	21.73
130.000	0.034	32.66	-2.866	-154.63	-2.886	-154.53	0.032	42.54
150.000	0.057	15.30	-3.119	-1.03	-3.119	-1.03	0.063	8.37
170.000	0.023	0.89	-3.339	88.91	-3.339	88.81	0.022	29.06
190.000	0.058	-15.95	-3.572	177.69	-3.572	177.59	0.050	-39.34
210.000	0.059	1.58	-3.789	-90.81	-3.799	-91.01	0.055	8.68
230.000	0.018	-3.24	-3.996	2.07	-3.986	1.97	0.032	-16.69
250.000	0.033	-31.06	-4.202	92.85	-4.202	92.75	0.029	-32.89
270.000	0.034	-21.24	-4.392	-174.63	-4.392	-174.83	0.027	-11.98
290.000	0.029	22.15	-4.590	-87.81	-4.590	-87.91	0.021	25.77
310.000	0.011	23.72	-4.770	1.59	-4.780	1.49	0.013	21.59
330.000	0.033	7.64	-4.959	90.16	-4.959	90.16	0.021	12.67
350.000	0.035	-2.34	-5.138	175.95	-5.148	175.85	0.024	33.18
370.000	0.030	-9.74	-5.322	-92.35	-5.322	-92.55	0.019	-13.63
390.000	0.048	-19.63	-5.510	-3.58	-5.510	-3.58	0.048	-7.87
410.000	0.037	21.96	-5.663	84.73	-5.673	84.73	0.045	18.05
430.000	0.016	2.35	-5.828	177.62	-5.838	177.52	0.034	-10.15
450.000	0.038	10.60	-6.009	-93.17	-6.009	-93.37	0.039	-17.39
470.000	0.064	7.55	-6.184	-1.99	-6.184	-1.99	0.051	2.20
490.000	0.044	1.13	-6.340	83.39	-6.340	83.39	0.025	16.79
510.000	0.044	-16.89	-6.491	175.07	-6.501	174.97	0.034	-68.63
530.000	0.054	-12.66	-6.645	-94.54	-6.645	-94.54	0.035	3.11
550.000	0.025	-0.56	-6.784	-5.33	-6.794	-5.23	0.028	26.07
570.000	0.046	-63.35	-6.960	87.76	-6.970	87.76	0.049	8.39
590.000	0.029	-8.78	-7.102	179.03	-7.112	179.03	0.046	-25.54
610.000	0.029	15.43	-7.249	-88.76	-7.249	-88.76	0.030	39.76
630.000	0.029	-37.68	-7.381	3.71	-7.391	3.71	0.045	-24.26
650.000	0.042	25.78	-7.535	92.97	-7.545	92.97	0.041	-1.11
670.000	0.040	-14.05	-7.683	-175.86	-7.693	-175.96	0.021	-42.19
690.000	0.056	-38.43	-7.829	-88.32	-7.849	-88.32	0.038	-28.30
710.000	0.150	-140.49	-8.305	5.17	-8.305	5.07	0.152	136.26
730.000	0.036	54.75	-8.105	99.41	-8.115	99.31	0.058	13.16
750.000	0.028	32.56	-8.261	-170.24	-8.261	-170.34	0.048	-15.08
770.000	0.043	34.00	-8.383	-74.25	-8.403	-74.45	0.047	-0.53
790.000	0.016	52.05	-8.513	17.60	-8.523	17.50	0.037	-56.15
810.000	0.048	16.61	-8.668	88.72	-8.668	88.72	0.050	-0.24
830.000	0.050	31.97	-8.805	-177.67	-8.815	-177.77	0.040	-12.18
850.000	0.031	88.49	-8.949	-88.01	-8.959	-88.11	0.048	-58.56
870.000	0.054	15.86	-9.066	5.74	-9.086	5.64	0.021	-10.01
890.000	0.054	8.07	-9.199	95.50	-9.209	95.40	0.045	3.24
910.000	0.058	12.33	-9.343	-168.81	-9.283	-168.81	0.047	12.11
930.000	0.056	8.35	-9.480	-74.61	-9.400	-74.81	0.040	0.17
950.000	0.041	24.01	-9.488	18.89	-9.588	18.79	0.041	10.55
970.000	0.059	5.70	-9.678	115.80	-9.668	115.60	0.046	-10.05
990.000	0.062	-24.57	-9.803	-151.46	-9.773	-151.56	0.062	-35.38
1010.000	0.045	16.71	-9.909	-58.79	-9.969	-58.79	0.042	-12.22

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
	60 ft.Cable-white over red							
30.000	0.043	-41.46	-1.270	128.11	-1.270	128.11	0.041	-38.46
50.000	0.049	28.86	-1.663	-144.64	-1.673	-144.74	0.045	21.76
70.000	0.006	83.55	-2.010	-56.31	-2.000	-56.21	0.004	-133.51
90.000	0.043	-5.81	-2.310	29.64	-2.310	29.64	0.043	-42.23
110.000	0.032	2.91	-2.587	119.25	-2.577	119.35	0.026	41.34
130.000	0.025	27.09	-2.828	-151.83	-2.838	-151.73	0.024	40.57
150.000	0.047	18.87	-3.069	1.57	-3.069	1.37	0.054	8.46
170.000	0.020	16.61	-3.290	91.80	-3.280	91.70	0.013	79.37
190.000	0.032	-7.49	-3.505	-179.20	-3.505	-179.20	0.031	-25.11
210.000	0.044	8.62	-3.721	-87.30	-3.731	-87.40	0.045	21.30
230.000	0.022	30.91	-3.925	5.88	-3.915	5.88	0.027	0.97
250.000	0.029	3.31	-4.121	97.16	-4.121	97.16	0.019	-44.60
270.000	0.048	-3.53	-4.311	-170.03	-4.321	-170.23	0.028	8.19
290.000	0.035	26.74	-4.510	-82.82	-4.510	-82.92	0.023	28.19
310.000	0.019	-12.57	-4.681	6.88	-4.691	6.88	0.022	-11.37
330.000	0.040	19.40	-4.869	95.84	-4.879	95.94	0.036	-4.21
350.000	0.038	-0.47	-5.049	-177.85	-5.049	-178.05	0.023	9.89
370.000	0.042	-9.65	-5.227	-85.95	-5.227	-86.05	0.033	-80.34
390.000	0.024	-2.41	-5.380	1.87	-5.390	3.17	0.015	-12.99
410.000	0.038	50.47	-5.545	91.86	-5.545	91.86	0.027	11.76
430.000	0.027	-4.27	-5.707	-174.97	-5.717	-174.87	0.019	-15.12
450.000	0.032	34.87	-5.879	-85.42	-5.879	-85.42	0.026	-28.12
470.000	0.043	16.75	-6.036	6.17	-6.036	6.17	0.033	-1.01
490.000	0.036	38.81	-6.192	91.83	-6.202	91.93	0.015	32.50
510.000	0.038	6.54	-6.343	-176.24	-6.353	-176.04	0.024	-61.14
530.000	0.041	13.07	-6.487	-85.44	-6.497	-85.34	0.024	28.67
550.000	0.048	26.11	-6.639	4.16	-6.649	4.26	0.027	110.80
570.000	0.048	6.37	-6.807	97.64	-6.807	97.74	0.039	-16.71
590.000	0.060	1.18	-6.958	-170.72	-6.958	-170.62	0.041	0.27
610.000	0.047	37.09	-7.089	-78.21	-7.099	-78.21	0.043	58.25
630.000	0.042	24.32	-7.213	14.68	-7.213	14.68	0.020	-43.48
650.000	0.041	36.68	-7.350	104.32	-7.370	104.32	0.000	-85.91
670.000	0.052	8.92	-7.498	-164.36	-7.518	-164.36	0.012	59.67
690.000	0.041	40.94	-7.639	-76.49	-7.649	-76.39	0.038	77.49
710.000	0.178	-39.44	-8.131	18.41	-8.141	18.41	0.153	90.81
730.000	0.045	42.41	-7.918	111.88	-7.938	111.78	0.071	22.95
750.000	0.070	2.36	-8.078	-157.12	-8.078	-157.02	0.047	-26.57
770.000	0.028	-8.28	-8.191	-61.02	-8.201	-61.02	0.052	46.90
790.000	0.051	49.15	-8.332	31.22	-8.342	31.22	0.058	6.62
810.000	0.046	-2.58	-8.464	102.96	-8.474	102.86	0.056	-17.88
830.000	0.064	20.61	-8.595	-163.34	-8.595	-163.24	0.022	-36.79
850.000	0.066	5.36	-8.718	-73.24	-8.738	-73.34	0.041	12.81
870.000	0.050	2.07	-8.844	20.75	-8.854	20.75	0.020	-32.94
890.000	0.073	13.28	-8.993	110.89	-8.993	110.89	0.060	16.60
910.000	0.071	9.83	-9.120	-153.09	-9.120	-152.99	0.034	8.89
930.000	0.080	24.97	-9.253	-58.48	-9.263	-58.48	0.051	-12.29
950.000	0.071	2.48	-9.371	35.49	-9.291	35.49	0.058	3.25
970.000	0.052	20.24	-9.493	132.60	-9.473	132.50	0.070	-0.81
990.000	0.075	-10.44	-9.604	-134.37	-9.574	-134.27	0.068	-33.12
1010.000	0.067	11.83	-9.714	-41.32	-9.674	-41.22	0.055	12.63

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
			60 ft.Cable-white over blue					
30.000	0.027	-90.79	-1.304	125.16	-1.304	125.16	0.015	-80.41
50.000	0.020	29.32	-1.709	-149.42	-1.719	-149.52	0.022	-9.30
70.000	0.015	97.64	-2.069	-62.99	-2.069	-62.89	0.020	141.05
90.000	0.002	-147.56	-2.361	21.00	-2.371	21.00	0.003	41.34
110.000	0.033	106.65	-2.650	108.88	-2.650	108.88	0.027	-37.69
130.000	0.022	76.02	-2.897	-164.01	-2.907	-164.01	0.024	28.97
150.000	0.016	23.73	-3.120	-12.51	-3.120	-13.51	0.021	-0.27
170.000	0.026	64.70	-3.350	76.01	-3.360	75.01	0.031	72.93
190.000	0.015	80.24	-3.570	163.01	-3.570	162.01	0.012	98.70
210.000	0.025	63.34	-3.786	-107.00	-3.786	-107.90	0.010	32.75
230.000	0.035	53.82	-4.003	-15.60	-3.993	-16.40	0.033	42.53
250.000	0.033	79.81	-4.196	73.70	-4.196	72.80	0.026	90.34
270.000	0.015	-37.11	-4.380	164.60	-4.380	163.80	0.010	77.70
290.000	0.035	71.81	-4.569	-110.02	-4.579	-110.82	0.030	11.78
310.000	0.038	54.43	-4.756	-22.21	-4.756	-23.01	0.024	119.10
330.000	0.022	42.05	-4.927	64.98	-4.937	64.28	0.026	57.66
350.000	0.022	44.49	-5.106	149.37	-5.106	148.47	0.021	44.81
370.000	0.038	56.33	-5.274	-120.73	-5.274	-121.53	0.033	48.40
390.000	0.013	78.04	-5.446	-33.31	-5.456	-34.01	0.027	59.92
410.000	0.042	48.15	-5.613	53.37	-5.613	52.67	0.027	43.81
430.000	0.045	88.24	-5.775	144.69	-5.775	144.19	0.049	46.69
450.000	0.047	64.32	-5.936	-127.64	-5.936	-128.34	0.031	55.95
470.000	0.032	21.97	-6.096	-37.81	-6.096	-38.41	0.027	16.90
490.000	0.064	38.83	-6.269	46.94	-6.279	46.44	0.063	38.46
510.000	0.026	67.94	-6.396	135.94	-6.406	135.44	0.042	58.56
530.000	0.058	54.55	-6.559	-134.96	-6.559	-135.56	0.011	1.41
550.000	0.069	35.38	-6.720	-47.43	-6.730	-47.93	0.078	44.70
570.000	0.075	33.52	-6.863	45.23	-6.873	44.83	0.046	79.01
590.000	0.030	14.82	-7.006	134.00	-7.006	133.60	0.053	12.36
610.000	0.092	22.43	-7.184	-135.31	-7.184	-135.91	0.080	29.00
630.000	0.067	75.55	-7.265	-44.70	-7.275	-45.10	0.071	49.61
650.000	0.078	-1.48	-7.434	43.55	-7.454	43.15	0.067	11.14
670.000	0.057	10.21	-7.564	132.82	-7.574	133.62	0.060	14.14
690.000	0.060	5.29	-7.687	-140.67	-7.707	-140.97	0.036	25.54
710.000	0.057	-1.37	-7.837	-48.56	-7.837	-48.96	0.052	37.19
730.000	0.087	16.83	-7.994	43.04	-8.004	42.64	0.084	17.71
750.000	0.067	24.54	-8.117	133.17	-8.117	132.97	0.069	34.03
770.000	0.069	-7.54	-8.273	-133.02	-8.283	-133.52	0.100	-2.71
790.000	0.051	40.30	-8.352	-42.76	-8.362	-43.06	0.059	11.91
810.000	0.046	36.70	-8.502	26.70	-8.502	26.40	0.064	-7.09
830.000	0.051	24.73	-8.636	118.73	-8.636	118.33	0.059	3.63
850.000	0.055	-2.26	-8.748	-151.96	-8.778	-152.36	0.064	13.19
870.000	0.067	39.62	-8.894	-61.13	-8.914	-61.43	0.068	15.84
890.000	0.085	20.82	-9.038	27.31	-9.048	27.01	0.060	6.61
910.000	0.075	12.99	-9.163	121.40	-9.163	121.20	0.084	3.77
930.000	0.058	27.17	-9.265	-144.72	-9.265	-145.02	0.058	6.81
950.000	0.071	22.38	-9.391	-53.82	-9.411	-54.12	0.059	13.45
970.000	0.076	7.45	-9.514	41.49	-9.474	41.39	0.078	-4.85
990.000	0.089	8.04	-9.655	132.56	-9.575	132.26	0.066	7.41
1010.000	0.080	-4.21	-9.715	-134.80	-9.675	-134.90	0.054	-4.89

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
30ft +30ft Cables-red & yellow over white								
30.000	0.040	-44.20	-1.261	126.02	-1.271	125.92	0.037	-44.26
50.000	0.039	19.17	-1.665	-148.24	-1.665	-148.24	0.036	15.81
70.000	0.002	138.15	-2.010	-61.21	-2.000	-61.11	0.005	-134.34
90.000	0.017	-3.29	-2.301	23.27	-2.301	23.27	0.020	-46.31
110.000	0.120	22.30	-2.654	111.34	-2.654	111.34	0.111	13.88
130.000	0.030	30.72	-2.827	-160.73	-2.837	-160.73	0.027	29.32
150.000	0.040	11.27	-3.060	-7.62	-3.060	-8.62	0.042	-0.99
170.000	0.026	-8.44	-3.279	81.10	-3.279	80.30	0.012	94.01
190.000	0.021	-33.15	-3.497	168.80	-3.497	167.90	0.027	-21.53
210.000	0.066	23.52	-3.727	-100.92	-3.727	-101.72	0.055	-20.39
230.000	0.038	52.11	-3.922	-9.00	-3.922	-9.90	0.040	42.06
250.000	0.011	6.79	-4.119	80.58	-4.109	79.88	0.016	28.50
270.000	0.037	-13.11	-4.301	172.07	-4.311	171.17	0.031	-0.36
290.000	0.019	26.98	-4.490	-102.21	-4.500	-103.01	0.020	2.98
310.000	0.037	2.96	-4.681	-14.03	-4.681	-14.73	0.016	-101.94
330.000	0.055	4.71	-4.870	73.61	-4.880	73.01	0.056	-13.85
350.000	0.053	15.62	-5.044	158.43	-5.034	157.63	0.042	34.87
370.000	0.038	73.16	-5.203	-111.33	-5.193	-112.03	0.040	40.71
390.000	0.003	-152.96	-5.368	-23.41	-5.368	-24.11	0.021	55.56
410.000	0.040	36.41	-5.533	63.74	-5.533	63.14	0.042	16.40
430.000	0.028	37.35	-5.691	155.46	-5.701	154.96	0.024	42.38
450.000	0.060	9.81	-5.878	-116.47	-5.878	-116.97	0.024	-38.17
470.000	0.063	-6.93	-6.038	-26.32	-6.038	-26.82	0.055	0.29
490.000	0.063	33.74	-6.182	57.73	-6.192	57.13	0.062	34.65
510.000	0.027	32.37	-6.313	148.36	-6.323	148.06	0.012	65.23
530.000	0.026	-14.07	-6.467	-122.00	-6.467	-122.50	0.014	-0.75
550.000	0.047	40.52	-6.624	-34.08	-6.634	-34.58	0.049	13.92
570.000	0.049	21.24	-6.762	59.05	-6.772	58.65	0.016	10.06
590.000	0.059	10.89	-6.928	147.99	-6.928	147.69	0.031	-11.72
610.000	0.053	23.78	-7.060	-120.86	-7.070	-121.36	0.058	12.46
630.000	0.042	23.54	-7.174	-29.58	-7.184	-29.98	0.028	75.48
650.000	0.053	23.98	-7.323	58.75	-7.343	58.45	0.035	-12.93
670.000	0.041	34.23	-7.461	148.63	-7.471	148.23	0.044	13.30
690.000	0.057	-8.34	-7.599	-124.42	-7.619	-124.82	0.039	-6.19
710.000	0.040	12.32	-7.741	-32.15	-7.741	-32.35	0.037	24.79
730.000	0.050	4.22	-7.873	60.05	-7.883	59.65	0.040	28.61
750.000	0.065	13.00	-8.020	150.77	-8.020	150.47	0.019	3.31
770.000	0.053	-10.70	-8.145	-115.40	-8.155	-115.90	0.056	13.94
790.000	0.043	18.06	-8.266	-24.59	-8.276	-24.89	0.041	-11.53
810.000	0.056	-16.36	-8.401	45.47	-8.411	45.07	0.029	5.07
830.000	0.040	10.25	-8.542	137.73	-8.552	137.43	0.061	4.55
850.000	0.052	27.47	-8.671	-133.89	-8.681	-134.29	0.054	20.71
870.000	0.067	30.84	-8.814	-41.21	-8.834	-41.41	0.068	12.07
890.000	0.090	9.79	-8.937	47.66	-8.947	47.26	0.018	-11.22
910.000	0.042	-9.06	-9.050	142.07	-9.060	141.77	0.046	21.41
930.000	0.014	40.48	-9.183	-123.59	-9.193	-123.89	0.044	-22.30
950.000	0.110	-8.20	-9.369	-32.27	-9.379	-32.67	0.032	-62.44
970.000	0.060	21.06	-9.420	63.41	-9.370	63.11	0.059	-12.07
990.000	0.043	25.70	-9.563	154.80	-9.473	154.50	0.069	-10.47
1010.000	0.056	-64.07	-9.617	-112.21	-9.577	-112.41	0.078	20.34

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
30ft. +60 ft. Cables-r/w and w/y								
30.000	0.046	1.88	-1.943	-14.27	-1.943	-14.27	0.044	-3.10
50.000	0.016	-176.55	-2.560	101.38	-2.560	101.38	0.018	14.94
70.000	0.042	-23.08	-3.096	-144.45	-3.096	-144.45	0.044	25.91
90.000	0.007	167.29	-3.560	-32.72	-3.560	-32.62	0.022	-1.50
110.000	0.100	8.51	-4.025	84.76	-4.025	84.86	0.072	-11.27
130.000	0.042	37.36	-4.385	-158.44	-4.385	-158.44	0.039	38.61
150.000	0.025	34.87	-4.720	56.78	-4.730	55.98	0.030	15.54
170.000	0.034	-9.90	-5.078	175.41	-5.078	174.61	0.047	-8.16
190.000	0.007	-84.41	-5.417	-69.29	-5.417	-70.19	0.030	-21.87
210.000	0.057	-2.72	-5.759	51.47	-5.759	50.67	0.053	-16.38
230.000	0.024	43.96	-6.064	175.88	-6.054	175.28	0.034	-11.42
250.000	0.034	1.93	-6.370	-64.35	-6.370	-65.05	0.030	-30.25
270.000	0.033	16.75	-6.660	56.97	-6.660	56.17	0.021	6.08
290.000	0.016	-15.85	-6.961	170.49	-6.961	169.79	0.020	-2.00
310.000	0.045	8.80	-7.249	-70.03	-7.249	-70.73	0.028	57.19
330.000	0.036	12.48	-7.520	45.26	-7.530	44.66	0.015	-18.88
350.000	0.041	13.28	-7.807	157.54	-7.807	156.74	0.028	18.82
370.000	0.029	43.37	-8.069	-81.84	-8.059	-82.44	0.019	-8.56
390.000	0.024	45.59	-8.339	34.55	-8.339	33.95	0.041	-7.42
410.000	0.016	40.24	-8.588	152.24	-8.588	151.64	0.037	-10.41
430.000	0.035	23.73	-8.842	-85.10	-8.842	-85.60	0.041	2.29
450.000	0.055	10.39	-9.105	31.13	-9.125	31.73	0.031	-17.15
470.000	0.063	-14.89	-9.352	151.60	-9.372	150.90	0.042	5.78
490.000	0.053	23.05	-9.593	-95.33	-9.603	-95.83	0.023	11.31
510.000	0.050	16.87	-9.825	25.73	-9.835	25.33	0.037	-50.81
530.000	0.031	12.09	-10.057	143.97	-9.987	143.87	0.021	3.90
550.000	0.047	17.92	-10.225	-98.96	-10.245	-98.96	0.034	24.47
570.000	0.044	40.63	-10.430	26.03	-10.420	25.93	0.046	14.28
590.000	0.061	19.11	-10.729	145.39	-10.689	145.29	0.043	-28.94
610.000	0.036	27.33	-10.867	-92.78	-10.917	-92.88	0.029	27.23
630.000	0.049	-6.87	-11.114	29.53	-11.144	29.53	0.054	-16.73
650.000	0.047	25.76	-11.364	145.85	-11.374	145.75	0.031	-0.17
670.000	0.041	28.38	-11.525	-92.42	-11.595	-92.42	0.022	-22.97
690.000	0.048	8.17	-11.793	22.59	-11.743	22.59	0.033	-39.96
710.000	0.062	97.88	-12.338	146.28	-12.268	146.28	0.149	134.69
730.000	0.042	32.36	-12.180	-90.19	-12.220	-90.19	0.058	13.37
750.000	0.062	14.78	-12.424	30.74	-12.474	30.94	0.054	-10.64
770.000	0.044	-11.89	-12.623	158.53	-12.593	158.63	0.041	0.73
790.000	0.056	-5.34	-12.847	-81.12	-12.817	-81.02	0.046	-33.31
810.000	0.055	-21.03	-13.081	8.87	-13.031	8.87	0.041	13.51
830.000	0.055	6.83	-13.232	132.47	-13.252	132.67	0.043	-22.04
850.000	0.060	52.31	-13.486	-109.17	-13.486	-109.07	0.050	-49.72
870.000	0.067	20.10	-13.638	15.13	-13.618	15.43	0.026	10.73
890.000	0.083	11.69	-13.882	133.32	-13.852	133.42	0.048	8.52
910.000	0.042	-4.69	-14.103	-100.72	-14.083	-100.42	0.052	9.72
930.000	0.019	25.39	-14.212	25.87	-14.202	26.07	0.045	10.12
950.000	0.109	-7.88	-14.484	149.78	-14.484	149.98	0.035	0.89
970.000	0.064	14.25	-14.679	-82.40	-14.669	-80.70	0.053	-7.64
990.000	0.045	3.84	-14.902	40.22	-14.872	40.52	0.065	-23.30
1010.000	0.066	-61.74	-15.010	165.14	-15.070	165.54	0.038	-7.00

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG

30ft+30ft+60ft-r/w;y/w;w/y

30.000	0.030	33.95	-2.604	-156.93	-2.614	-157.03	0.029	22.72
50.000	0.040	-35.79	-3.458	-14.06	-3.458	-14.16	0.043	-6.19
70.000	0.009	39.70	-4.158	128.09	-4.158	128.09	0.010	51.14
90.000	0.032	66.58	-4.796	-95.73	-4.796	-95.63	0.038	-0.20
110.000	0.109	11.82	-5.428	49.50	-5.418	49.50	0.047	-65.76
130.000	0.041	25.70	-5.896	-166.65	-5.896	-166.25	0.035	34.20
150.000	0.027	-10.49	-6.351	108.18	-6.361	107.78	0.041	-6.47
170.000	0.035	-10.80	-6.829	-105.20	-6.829	-105.60	0.026	20.90
190.000	0.024	15.47	-7.295	37.41	-7.295	36.81	0.038	-22.31
210.000	0.039	25.82	-7.742	-173.40	-7.742	-173.80	0.033	8.93
230.000	0.035	37.97	-8.163	-19.63	-8.153	-20.03	0.034	-3.41
250.000	0.031	12.64	-8.569	128.45	-8.569	128.05	0.029	-24.43
270.000	0.023	11.83	-8.961	-79.72	-8.961	-80.12	0.017	-5.52
290.000	0.019	-0.83	-9.361	59.09	-9.361	58.59	0.021	3.05
310.000	0.041	3.55	-9.750	-153.43	-9.750	-153.83	0.023	18.45
330.000	0.044	6.09	-10.109	-10.93	-10.129	-11.23	0.005	66.10
350.000	0.046	9.13	-10.477	127.24	-10.497	126.74	0.029	22.46
370.000	0.032	54.14	-10.758	-83.34	-10.758	-83.84	0.021	-2.03
390.000	0.017	94.72	-11.150	61.06	-11.150	60.86	0.042	-11.60
410.000	0.028	32.49	-11.437	-153.77	-11.527	-153.97	0.047	-7.81
430.000	0.034	30.80	-11.843	-1.38	-11.813	-1.38	0.035	-6.81
450.000	0.057	14.49	-12.162	142.51	-12.212	142.11	0.039	-11.96
470.000	0.055	-11.06	-12.453	-68.58	-12.523	-68.78	0.037	-3.22
490.000	0.057	24.97	-12.842	69.46	-12.832	69.16	0.024	10.18
510.000	0.043	27.23	-13.181	-140.76	-13.181	-141.16	0.031	-46.38
530.000	0.012	-1.57	-13.474	6.99	-13.484	6.79	0.023	15.93
550.000	0.046	35.45	-13.722	150.63	-13.742	150.33	0.039	30.44
570.000	0.057	16.53	-14.034	-54.39	-14.124	-54.69	0.053	8.66
590.000	0.063	17.87	-14.427	94.69	-14.387	94.29	0.037	-16.00
610.000	0.044	28.15	-14.667	-115.49	-14.717	-115.89	0.028	12.85
630.000	0.052	10.23	-15.010	36.21	-14.940	35.91	0.052	-17.82
650.000	0.049	28.54	-15.263	-179.95	-15.273	179.75	0.032	-11.04
670.000	0.041	23.64	-15.527	-29.21	-15.597	-29.51	0.020	-28.78
690.000	0.061	-5.33	-15.799	112.70	-15.849	112.40	0.030	-38.31
710.000	0.064	14.55	-16.464	-95.00	-16.494	-95.30	0.150	131.84
730.000	0.048	6.40	-16.385	59.43	-16.425	59.03	0.056	16.33
750.000	0.069	11.91	-16.726	-151.67	-16.676	-151.87	0.053	-6.74
770.000	0.048	-13.09	-17.025	6.94	-16.995	6.44	0.044	-7.51
790.000	0.045	16.58	-17.245	157.43	-17.215	157.23	0.039	-36.23
810.000	0.060	-10.74	-17.585	-95.63	-17.535	-95.93	0.044	12.85
830.000	0.036	11.88	-17.829	57.84	-17.849	57.54	0.039	-20.47
850.000	0.053	27.25	-18.082	-154.15	-18.082	-154.55	0.047	-46.39
870.000	0.070	27.54	-18.339	-1.17	-18.419	-1.37	0.029	14.04
890.000	0.089	12.76	-18.682	144.84	-18.652	144.44	0.042	6.02
910.000	0.045	-18.60	-18.902	-58.02	-18.882	-58.32	0.053	12.44
930.000	0.018	47.28	-19.113	99.17	-19.203	98.77	0.046	9.44
950.000	0.108	-8.69	-19.485	-107.13	-19.485	-107.43	0.041	17.44
970.000	0.056	20.30	-19.678	52.30	-19.668	52.00	0.050	-5.98
990.000	0.047	17.33	-20.001	-155.78	-19.971	-156.08	0.061	-21.96
1010.000	0.051	-65.82	-20.210	-2.06	-20.270	-2.26	0.044	-11.64

FREQUENCY	REFLECTION INPUT (S11)		TRANS. LOSS FORWARD (S21)		TRANS. LOSS REVERSE (S12)		REFLECTION OUTPUT (S22)	
MHZ	MAG	ANG	DB	ANG	DB	ANG	MAG	ANG
recheck calibration								
30.000	0.041	1.98	0.006	0.05	0.006	-0.05	0.033	-0.91
50.000	0.043	-38.94	0.000	0.05	0.000	-0.05	0.037	-25.09
70.000	0.033	-63.31	-0.003	-0.04	-0.003	-0.04	0.037	-49.63
90.000	0.025	-81.50	-0.005	-0.03	-0.005	-0.03	0.028	-77.01
110.000	0.015	-86.38	-0.003	-0.01	0.007	-0.01	0.012	-83.63
130.000	0.013	-48.77	0.009	0.08	-0.001	0.08	0.013	-21.19
150.000	0.017	-49.96	0.000	0.09	0.000	0.09	0.022	7.49
170.000	0.013	-15.89	0.001	0.01	0.001	0.11	0.027	-24.09
190.000	0.019	-33.38	0.003	0.09	0.013	0.09	0.027	-53.58
210.000	0.015	-68.82	0.010	-0.02	0.000	0.08	0.016	-74.61
230.000	0.003	-19.78	0.001	-0.01	0.011	0.09	0.014	-42.69
250.000	0.019	-8.35	0.009	0.07	0.009	-0.03	0.021	-53.58
270.000	0.026	-48.09	0.007	0.09	0.007	-0.01	0.020	-79.90
290.000	0.020	-81.04	0.008	0.00	-0.002	0.10	0.015	-89.91
310.000	0.011	-87.75	0.008	-0.00	0.008	0.10	0.024	-91.18
330.000	0.019	-76.50	0.006	0.09	-0.004	0.09	0.020	-93.32
350.000	0.022	-65.87	-0.005	0.09	0.005	-0.01	0.019	-93.34
370.000	0.030	-73.68	-0.005	0.09	-0.005	-0.01	0.014	-100.86
390.000	0.031	-88.22	-0.004	-1.42	-0.004	0.08	0.012	-52.11
410.000	0.029	-100.68	0.003	0.07	0.003	-0.03	0.027	-60.37
430.000	0.020	-110.71	0.013	0.08	0.003	0.08	0.022	-82.34
450.000	0.015	-53.65	0.007	0.04	0.007	-0.06	0.023	-29.23
470.000	0.036	-50.05	-0.001	-0.12	-0.001	-0.02	0.053	-45.21
490.000	0.052	-96.10	-0.021	0.14	-0.031	0.14	0.068	-96.67
510.000	0.046	-141.14	0.005	0.26	-0.005	0.26	0.051	-147.60
530.000	0.022	-173.32	0.015	0.04	0.005	0.04	0.017	171.72
550.000	0.007	-100.97	0.018	0.11	0.008	0.01	0.010	-79.91
570.000	0.022	-74.37	0.004	0.10	-0.006	0.10	0.021	-72.56
590.000	0.048	-97.68	-0.008	0.14	-0.008	0.14	0.043	-88.47
610.000	0.067	-139.30	-0.008	0.27	-0.018	0.27	0.069	-125.08
630.000	0.057	-175.13	0.030	0.25	0.030	0.25	0.052	-169.01
650.000	0.016	157.96	0.029	0.13	0.009	0.13	0.008	171.30
670.000	0.026	-119.09	0.016	0.24	0.006	0.24	0.038	-91.12
690.000	0.036	-152.50	0.023	0.23	0.013	0.23	0.061	-129.79
710.000	0.025	-170.39	0.023	0.07	0.023	0.07	0.063	-165.82
730.000	0.023	-156.42	0.022	0.06	0.022	0.06	0.049	158.55
750.000	0.020	-175.51	0.021	0.00	0.011	0.10	0.021	113.31
770.000	0.014	-138.37	0.013	0.12	0.013	0.12	0.007	-92.16
790.000	0.022	-158.49	0.026	0.11	0.026	0.01	0.044	-161.22
810.000	0.030	168.94	0.023	-0.10	0.023	-0.10	0.062	147.13
830.000	0.019	145.55	0.011	-0.07	0.011	-0.07	0.056	98.26
850.000	0.014	147.28	0.009	-0.04	-0.001	-0.04	0.032	53.54
870.000	0.006	159.70	0.019	-0.02	-0.001	0.08	0.007	24.73
890.000	0.016	-119.68	0.017	0.08	0.017	0.08	0.017	138.48
910.000	0.038	-155.99	0.013	0.04	0.003	0.04	0.023	102.10
930.000	0.046	175.10	0.003	0.05	0.003	-0.05	0.030	38.72
950.000	0.031	134.11	0.003	0.12	-0.017	0.02	0.027	-17.40
970.000	0.006	111.33	0.018	0.02	-0.002	0.12	0.020	-53.81
990.000	0.021	-130.54	0.008	0.03	-0.002	0.03	0.019	-75.01
1010.000	0.042	-166.73	0.015	0.03	0.005	0.13	0.018	-134.21

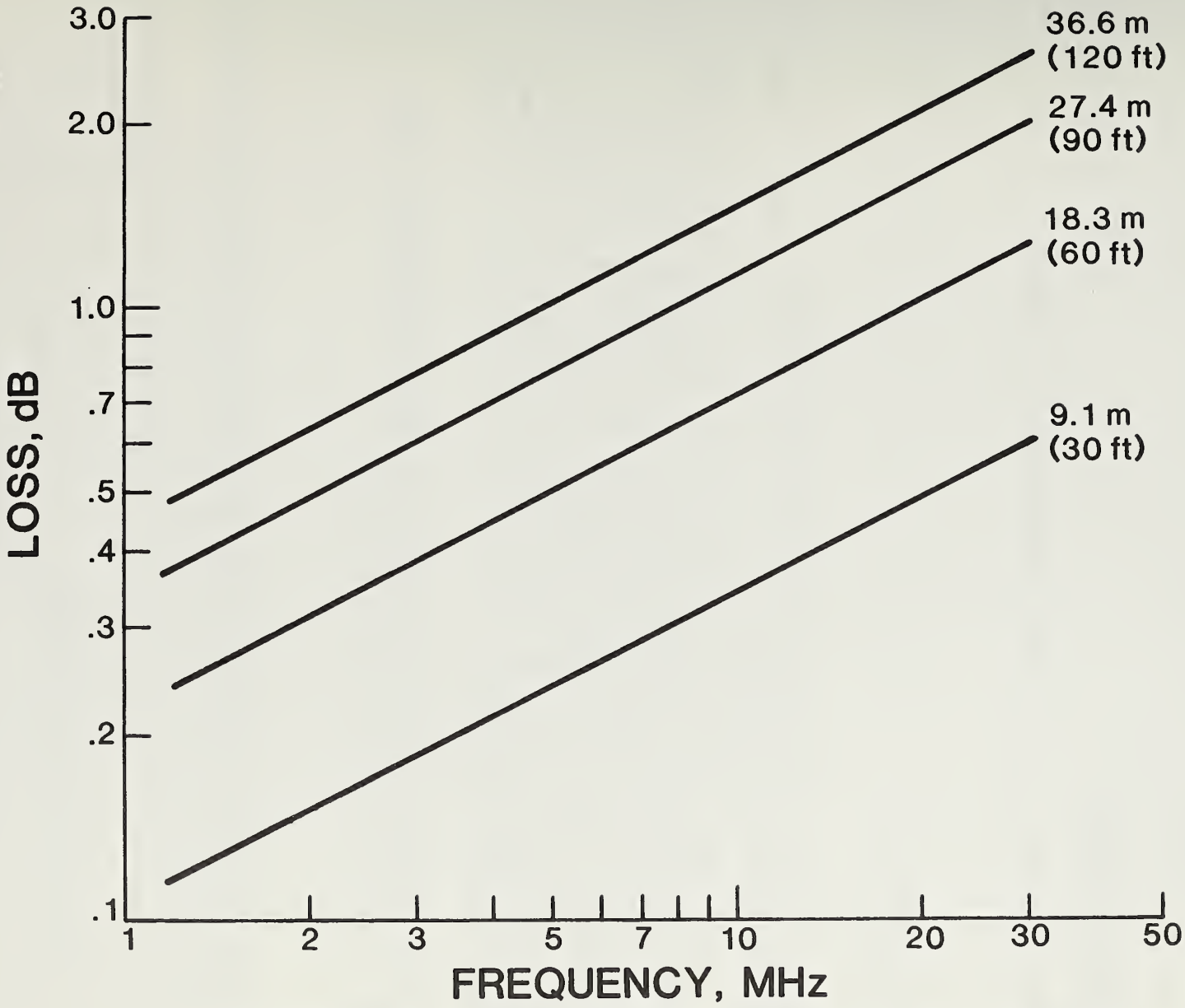

FIGURE 9. CABLE LOSS BELOW 30 MHz

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

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W. D. Bensema

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☐ 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 manual described the equipment operation and maintenance procedures to support the broadband isotropic* antenna system developed by the National Bureau of Standards for making EMI measurements in the frequency range from 10 kHz to 18 GHz. The system uses isotropic broadband antennas, a low power microcomputer, antenna switching units, commercially available receivers, and associated cabling. The system automatically switches antenna elements, computes the total scalar sum of the existing field strength, and automatically logs time, frequency, signal strength, and system configuration. The system reduces the number of personnel required to make searches for EMI, and includes a mode for unmanned monitoring.

*The term isotropic as used in this document, refers to the ability of the system to synthesize an isotropic response from several measurements rather than the pattern of a single antenna structure.

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

broadband isotropic antenna; CMOS microcomputer; data logger; EMI monitor; scanning receiver.

13. AVAILABILITY

☒ Unlimited

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