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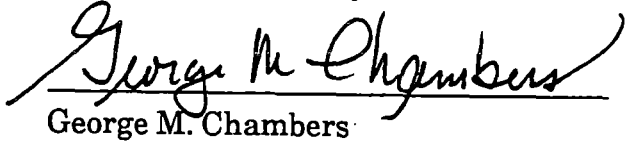
Results of Electromagnetic Interference Tests Applied to the Westinghouse Distributed Processing Family

Ahmed M. El-Antably

Approved by



George M. Chambers

July 1987

These tests were performed at the University of Michigan, Radiation Laboratory, Ann Arbor, Michigan 48111 under Shop Order BCBP-387

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ABSTRACT

This report documents the electromagnetic interference (EMI) tests performed on the Westinghouse Distributed Processing Family (WDPF™). The objective of the EMI susceptibility test was to evaluate the performance of the WDPF™ System when it was subjected to electromagnetic fields such as those generated from portable radio transceivers (walkie-talkies) or any other devices that will generate continuous wave radiated electromagnetic energy.

The EMI tests were performed as per the intent of the Scientific Apparatus Makers Association Standard PMC 33.1-1978. The WDPF™ system was subjected to field strengths of 3 volts/meter and 10 volts/meter, sweeping the entire frequency range from 20 MHz to 1 GHz, and to a field strength of 20 volts/meter over the frequency range of 20 MHz to 500 MHz.

EMI tests were performed on a standard WDPF™ cabinet containing the Distributed Processing Unit (DPU) and Q-Line input/output cards. The front and back of either the DPU or the I/O cards were separately targeted by EMI fields with the WDPF™ cabinet doors either closed or opened.

The WDPF™ was found to perform normally for EMI fields of Class 1 (3 volts/meter) and Class 2 (10 volts/meter) for frequency bands A, B, and C (that is, from 20 MHz to 50 MHz, 50 MHz to 300 MHz, and 300 MHz to 1 GHz), with the exception of EMI fields of Class 2 (10 volts/meter) increasing the output of the QAO card by an average of 4 percent from its nominal value over the frequency range from 66 MHz to 86 MHz. The operation of the WDPF™ for Class 3 (20 volts/meter) was acceptable from 20 MHz to 500 MHz, with the exception of the frequency range from 66 MHz to 86 MHz, where the output changed by 6 percent.

ACKNOWLEDGEMENTS

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SECTION 1
INTRODUCTION

Most solid state equipment is in some manner affected by electromagnetic radiation. This radiation is frequently generated by the small hand-held radio transceivers that are used by maintenance and security personnel. In addition to the continuous forms of electromagnetic energy deliberately generated, spurious radiations are caused by devices such as welders, contactors, motors, and the like.

This report covers the results of the electromagnetic interference (EMI) test on the Westinghouse Distributed Processing Family (WDPF™). The WDPF™ was tested for susceptibility to radiation of hand-held transceivers and other sources of electromagnetic radiation, such as fixed station airport radar, radio and television transmitters, vehicle radio transmitters, and various industrial electromagnetic sources. Spurious radiation sources can cause problems in the operation of the WDPF™, but they are beyond the scope of the EMI tests performed here. However, methods used to prevent effects from continuous radiation will normally reduce the effects from these sources also.

The EMI tests consisted of subjecting the WDPF™ cabinet and its main components (Distributed Processing Unit and the I/O cards) to electromagnetic fields with strengths of 3 and 10 volts/meter at frequency bands from 20 MHz to 1 GHz and of 20 volts/meter at frequencies from 20 MHz to 500 MHz. EMI tests were performed as per the intent of the Scientific Apparatus Makers Association (SAMA) Standards PMC 33.1-1978. These EMI tests were performed in a special test facility consisting of a large shielded enclosure (anechoic chamber) at the University of Michigan in Ann Arbor, Michigan. The front and back of the DPU and the I/O cards were targeted with electromagnetic radiation with the cabinet doors either closed or open. A total of 181 individual tests were made.

EMI tests performed on the WDPF™ were classified into two types as follows:

1. The modulation test: A computer was used as a controller to sweep the signal generator. Each frequency octave was divided into 40 data points with 5-second periods for each point.

2. The keying test: The signal generator output was turned on and off at 1-second intervals each, with less than 50 microseconds rise and fall time. This keying test simulates a repeated operation of a transmitter. Each frequency octave was divided to three data points.

This report describes the test setup, the test equipment, the test procedure, and the test results.

SECTION 2
SYSTEM CONFIGURATION

2.1 WDPF™ System Description

The WDPF™ System tested is configured to provide integrated modulating control, sequential control, and data acquisition for a wide variety of plant-wide system applications. The WDPF™ under test contained the following:

- WDPF™ cabinet with overall dimensions of 87.31 inches (length) × 22 inches (width) × 30 inches (depth)
- Dual DPU elements installed in a split chassis and located at the top part of the cabinet. Each DPU has its own power supply, functional processor, and process I/O interface. One processor serves as the primary with the other in stand-by mode. If the primary unit should fail, a failover signal is sent to the stand-by processor, which then scans the I/O and assumes control.
- 3 Q-crates
- One QAV G05 input card (zero to 10 volts) with pin connector for access
- One QAO G02 output card (zero to 10 volts) with pin connector for access

A Compaq personal computer (PC) was used to interact with the MAC program stored in the DPU. The software available could provide editing, monitoring, and diagnostics to the functions performed by the DPU. Appendix A provides detailed description of the WDPF™. Figures 2-1 and 2-2 show the WDPF™ system under test. Appendix B describes the DPU and the I/O cards.

2.2 System Layout

The system test configuration schematic diagram is shown in figure 2-3. It contains the DPU, the I/O boards, the personal computer, and the anechoic chamber. The figure also shows the data acquisition system, which consists of buffer amplifiers, a tape recorder, and a video recorder.

2.3 Cable Connections

Field cables of the simulated signals and the analog and digital outputs spanned 50 feet. Standard installation and wiring practices were utilized for proper connection of the shields and the grounding system. Field cables used standard 22-gauge twisted-shielded cables. A standard 15-foot RS-232 ribbon cable was used as a communication cable between the WDPF™ and the personal computer.

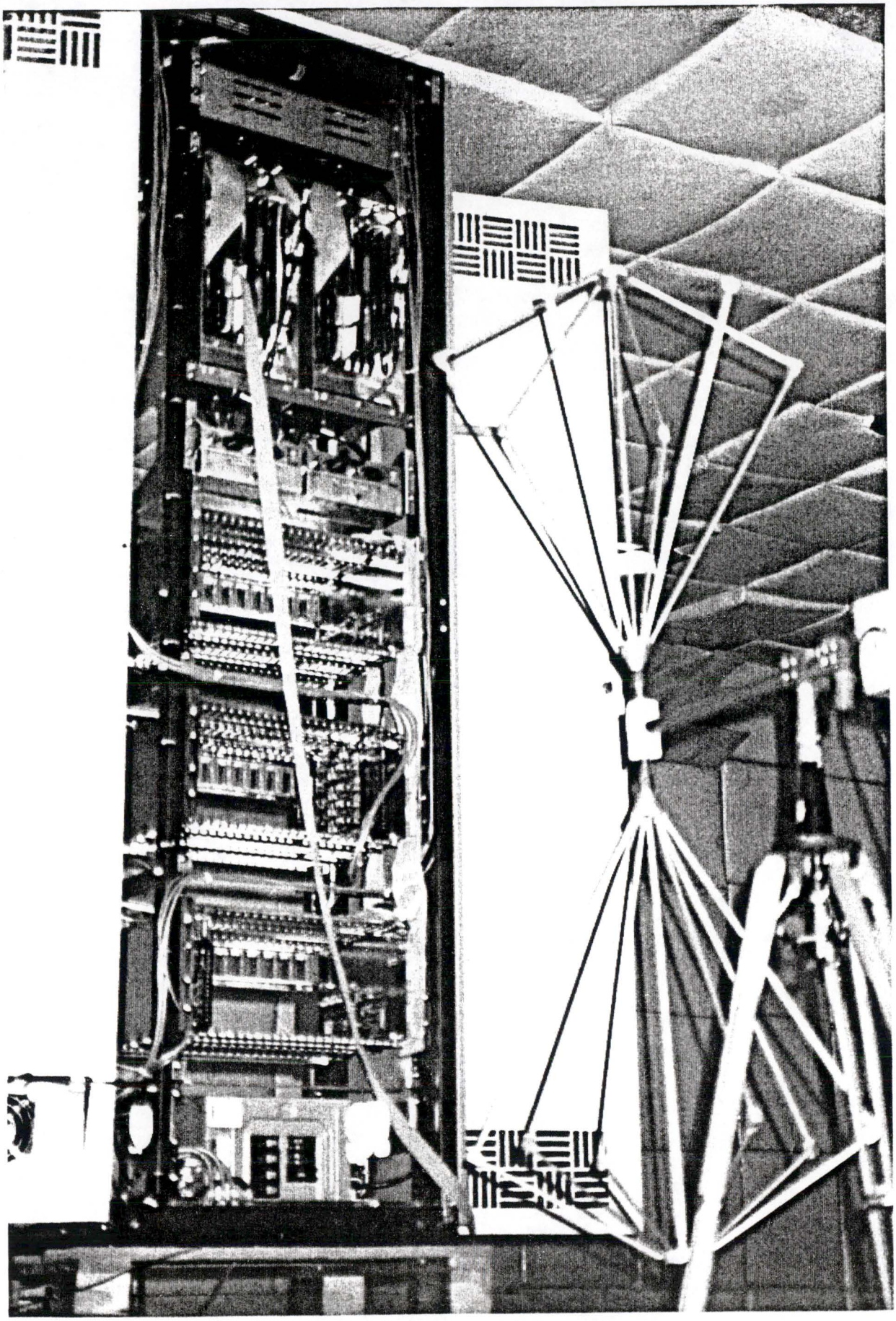


Figure 2-1. WDPF™ System Under Test Showing the Front of the DPU and the I/O Cards

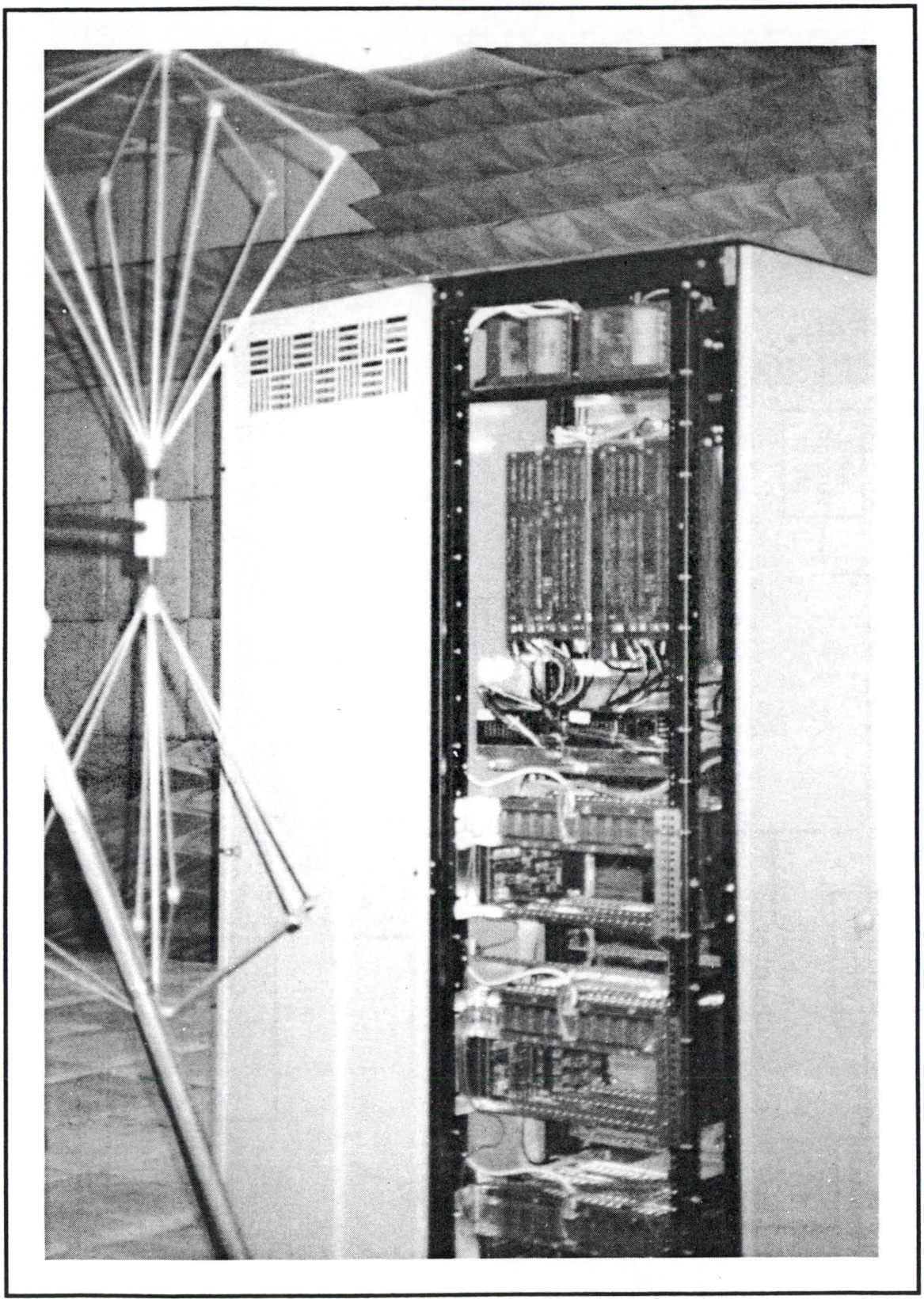


Figure 2-2. **WDPF™ System Under Test Showing the Back of the DPU and the I/O Cards**

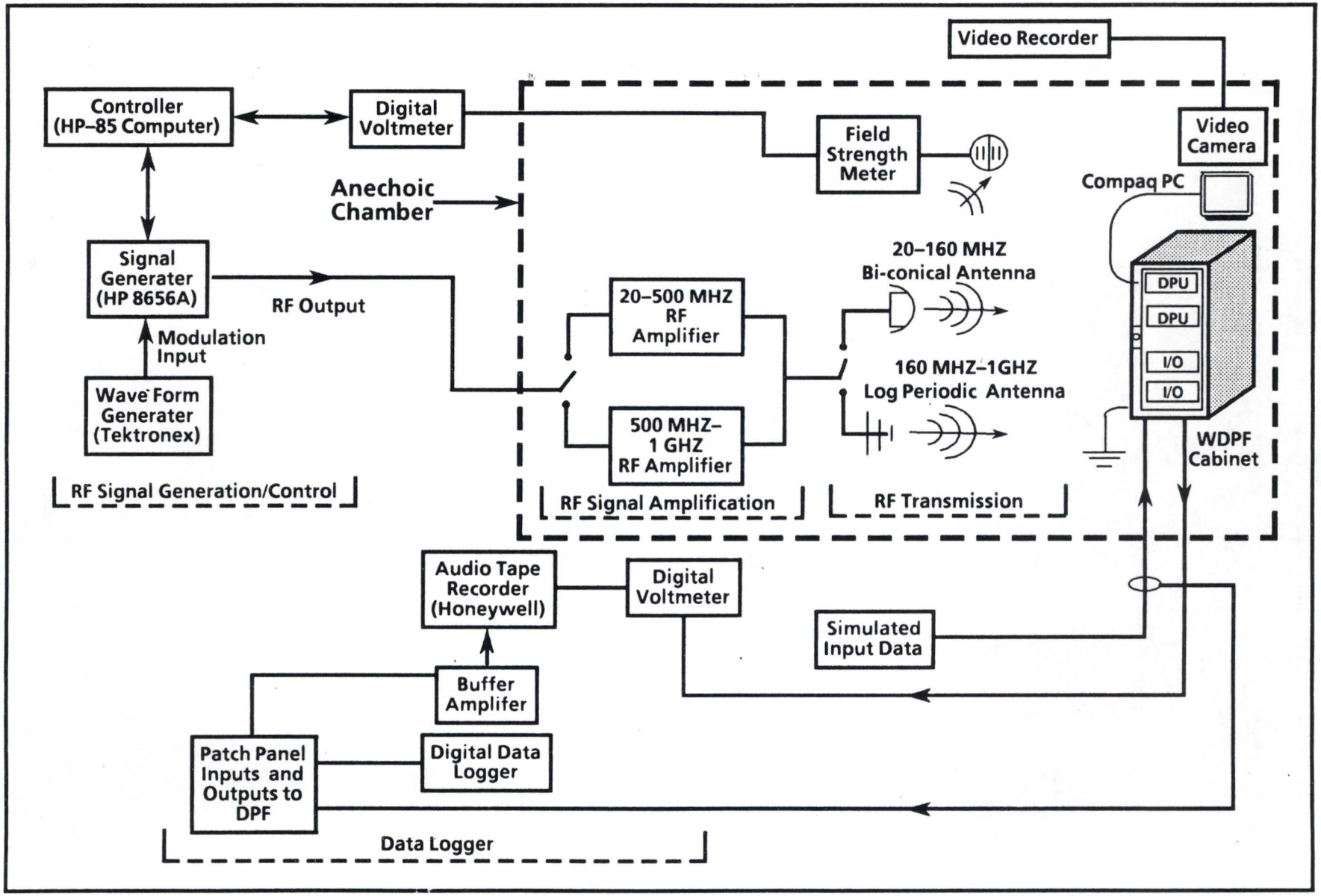


Figure 2-3. EMI Test Configuration Schematic Diagram

SECTION 3
ELECTROMAGNETIC INTERFERENCE (EMI) TEST DESCRIPTION

3.1 EMI Susceptibility Test

The purpose of the EMI susceptibility test is to evaluate the performance of the WDPF™ system when subjected to electromagnetic fields such as those generated from portable radio transceivers (walkie-talkies), or any other device that will generate continuous wave-radiated electromagnetic energy.

3.2 EMI Test Methodology

The EMI susceptibility tests were performed as per the intent of the SAMA Standard PMC 33.1-1978 (Reference 1).

The electromagnetic environment is determined by the strength of the electromagnetic field (field strength in volts per meter). The field strength, however, is not easily measured without sophisticated instrumentation, nor is it easily calculated by classical equations and formulas because of the effect of surrounding structures or the proximity of other equipment that will distort and/or reflect the electromagnetic waves. Calibration tests were conducted on the WDPF™ to ensure that the desired field strength values had been achieved.

3.3 EMI Test Classifications

The SAMA standards classify the susceptibility tests according to field strengths and frequency bands to allow the manufacturer or user to describe the susceptibility of the instruments more accurately, because susceptibility may vary with frequency and field strength.

The classes of field strengths are shown in table 3-1; the frequency bands are shown in table 3-2. The classes of field strengths are defined as follows:

- CLASS 1: Low-level electromagnetic radiation environments, such as local radio/television stations, low power transceivers.

- CLASS 2: Moderate electromagnetic radiation environments, such as portable transceivers or mobile transceivers that can be relatively close to the equipment but not closer than 1 meter.

- CLASS 3: Open class for situations involving severe electromagnetic radiation environments. The level is subject to negotiations between the user and vendor, or as defined by the manufacturer.

Class 3 field strength was chosen to be 20 volts/meter.

Table 3-1

Class of Field Strengths

Class	Field Strength (v/m)
1	3
2	10
3	As specified

Table 3-2

Frequency Bands

Band	Frequency Range (MHz)
A	20 to 50
B	50 to 300
C	300 to 1000

The identifying nomenclature for the equipment is composed by stating the classes and bands followed by the numerical value of the maximum error of the instruments. For example, 2-abc: 0.5% span means that a system has been tested for EMI for Class 2 (10 volts/meter) and frequency bands from 20 to 1000 MHz and shows an error not greater than 0.5-percent span.

The WDPF™ was tested for EMI at field strength and frequency levels given in tables 3-3 and 3-4.

The WDPF™ was tested at frequencies from 20 to 160 MHz using the bi-conical antenna and from 160 to 990 MHz using the log periodic antenna. The frequency band from 160 to 990 MHz was divided in two bands – from 160 to 500 and 500 to 990 MHz – because two different radio frequency (RF) power amplifiers were used successively.

Table 3-3

Field Strengths Used for Testing WDPF™

Class	Field Strength (v/m)
1	3
2	10
3	20

Table 3-4

Frequency Bands Used for Testing WDPF™

Class	Frequency Range	Frequency Bands
1	20 MHz to 1 GHz	A, B, and C
2	20 MHz to 1 GHz	A, B, and C
3	20 MHz to 500 MHz	A, B, and C (up to 500 MHz)

3.4 Types of EMI Tests

The WDPF™ System was subjected to field strengths of 3 volts/meter and 10 volts/meter (fields of Classes 1 and 2) over the entire frequency range of 20 MHz to 1 GHz, and fields of 20 volts/meter over the frequency range of 20 MHz to 500 MHz.

Three types of EMI tests were performed on the WDPF™ system as follows:

1. Calibration tests: Calibration tests were performed to generate calibration data files for use in implementing the modulation and keying tests.

2. Modulation tests: A computer was used as a controller to provide automatic sweep to the signal generator to generate an RF signal with 40 data points per frequency octave, having a period of 5 seconds at each data point. The signal generators were capable of covering frequency range of 20 MHz to 1 GHz and were capable of amplitude modulation.

3. Keying test: The signal generator output was turned on and off at 1-second intervals each, with less than 50-microsecond rise and fall intervals. This test simulates the susceptibility of the WDPF™ to repeated operation of a transmitter. Three data points per frequency octave were used as per the SAMA Standard PMC 33.1-1978.

3.5 Test Location

The EMI tests were carried out in a shielded enclosure (anechoic chamber) located at the University of Michigan at Ann Arbor. The anechoic chamber is located in the radiation laboratory in the east engineering building at the University of Michigan. It is 50 feet long, 28 feet wide, and 15 feet high and has, adjacent to it, data acquisition and processing systems tailored to measure surface fields over broad frequency ranges. The illuminating antenna is at the apex of the tapered section.

The rectangular test region (or 'quiet zone') is 20 feet deep, 12 feet high, and 18 feet wide. The walls, ceiling, and floors are covered with ultra high-frequency absorbing material, the major part of which has a reflectivity of 1 percent or less for frequencies above 1.0 GHz, falling to 0.1 percent or less in 8.5 to 12 GHz region. The back wall is covered with a high-performance absorber designed to have a reflectivity of -30 db or less for frequencies of 500 MHz or higher. The ground of the anechoic chamber is covered by an aluminum sheet and the ground of the WDPF™ was solidly connected to it.

The WDPF™ cabinet, the antenna, and the field strength meter are located in the rectangular test region, and calibration and EMI measurements were performed in the quiet zone to provide the best test results. Figures 3-1, 3-2, and 3-3 show the anechoic chamber and the instruments used in the EMI test.

3.6 Test Equipment

The EMI susceptibility tests were performed using two types of antennas to cover frequency bands A, B, C (20 MHz to 1 GHz). The two frequency ranges of 20 MHz to 160 MHz and 160 MHz to 1 GHz were covered by the bi-conical and the log periodic antennas, respectively.

Two RF power amplifiers were used to cover the whole frequency range. The maximum gain of each amplifier was 40 db. The frequency range of 20 MHz to 500 MHz was covered by one amplifier and of 500 MHz to 1 GHz was covered by the second amplifier.

Other equipment used for the EMI test included a field strength meter, HP computer, digital voltmeter, signal generator, and sine wave generator. Figure 3-4 shows the equipment used to generate the EMI field and to monitor and record WDPF™ performance. Appendix C gives a list of the test equipment used in the EMI tests.

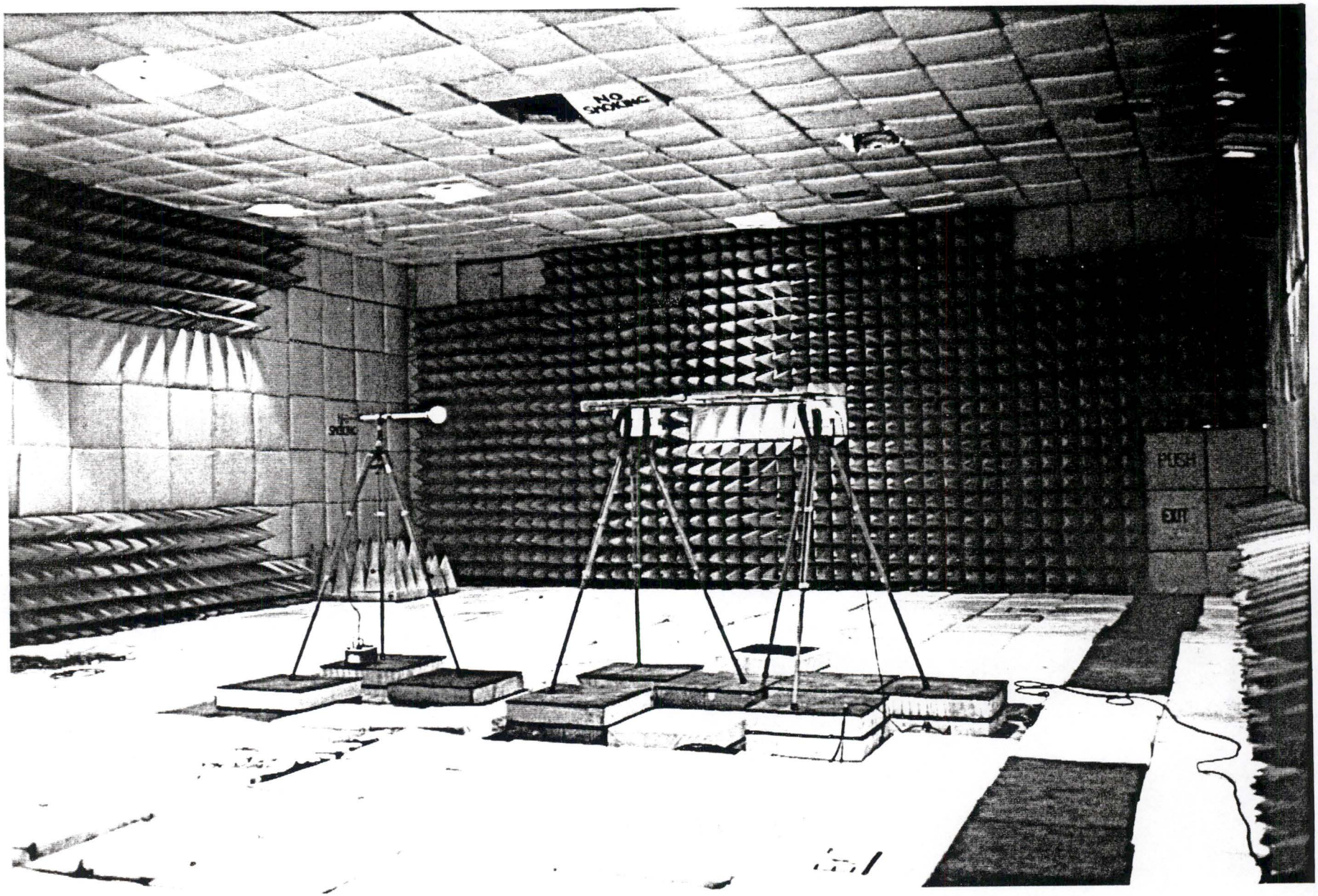


Figure 3-1. Field Strength Calibration in the Anechoic Chamber

Figure 3-2. Electromagnetic Interference Equipment Test Setup

Figure 3-3. Analog and Video Records Used for EMI Tests

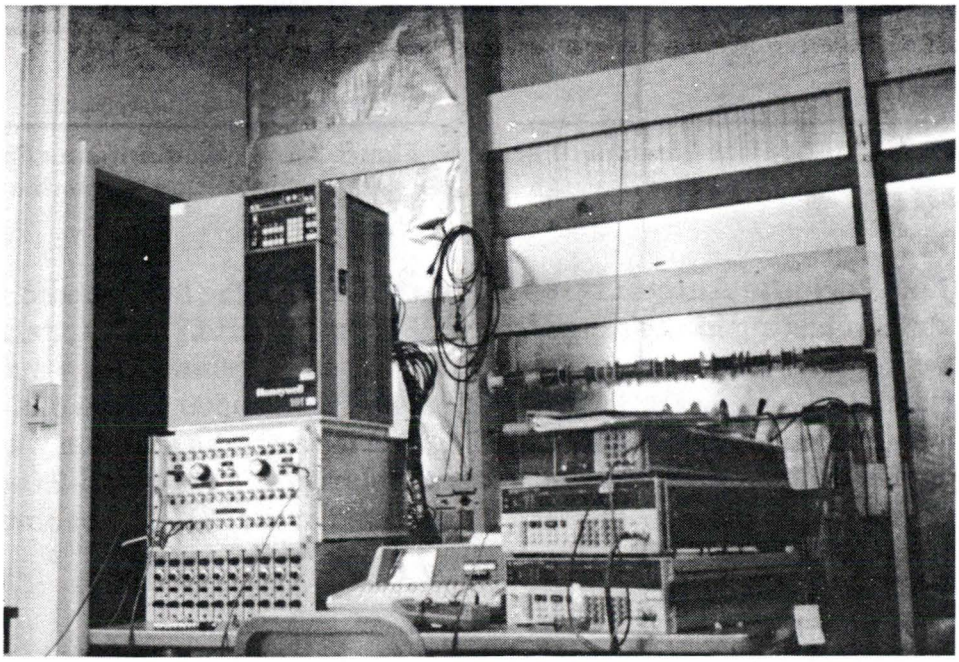


Figure 3-4. Equipment Used to Generate the EMI Field

3.6.1 Bi-Conical Antenna (20 MHz to 160 MHz) – The bi-conical antenna is perhaps the most widely used today for both EMI radiated emission and susceptibility testing in the 20 MHz to 160 MHz portion of the radio-frequency spectrum. Figure 3-5 (taken from MIL-STD-462/462B) (Reference 2) shows the bi-conical antenna in a hori-zontal polarization and measures the electric-field component of an electromagnetic wave. The antenna elements may be rotated 90 degrees to measure vertical polari-zation, if the lower elements are at least 1/2-meter above the ground. Shorter distances will capacitively load one end sufficiently to change the antenna factors. Figure 3-6 shows the antenna factors for the bi-conical antenna as appearing on page 18 of MIL-STD- 461A. Figure 3-7 shows the antenna directed at the WDPF™, both horizontal and vertical polarizations were utilized to test the WDPF™.

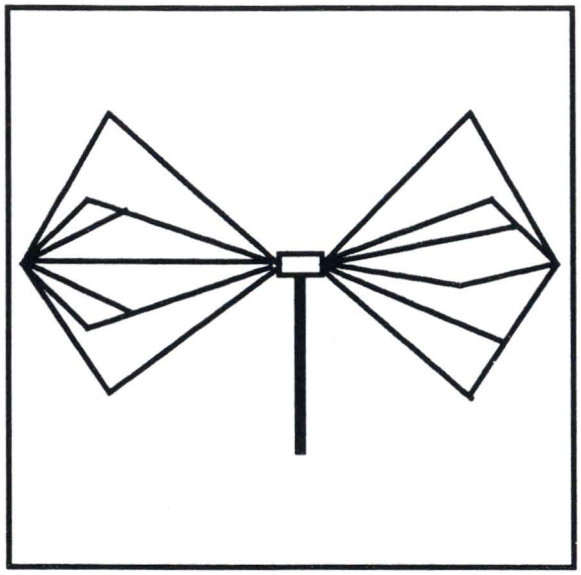


Figure 3-5. Bi-Conical Antenna (20 MHz – 160 MHz)

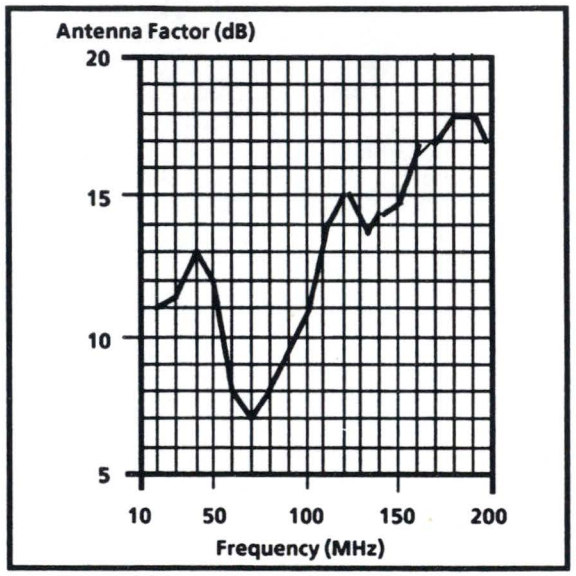


Figure 3-6. Typical Antenna Factors of a Bi-Conical Antenna

3.6.2 Log Periodic Antenna (160 MHz to 1 GHz) – The log periodic antenna was used for EMI testing in the range from 160 MHz to 1 GHz. The log periodic antenna is efficient and exhibits a higher gain. Figure 3-8 shows the log periodic antenna, which looks like a surf board with polyvinyl wrapped upon a dielectric frame which protectively covers its elements. The log periodic antenna was used in EMI testing in both the horizontal and vertical polarization. Figure 3-9 (taken from Reference 2) shows the log periodic antenna directed at the WDPF™ cabinet.

3.7 EMI Test Procedure

It was necessary to perform the calibration tests at the beginning to generate calibration data files. These calibration files were later loaded on the controller (HP computer) to control the signal generator to produce the desired EMI fields at

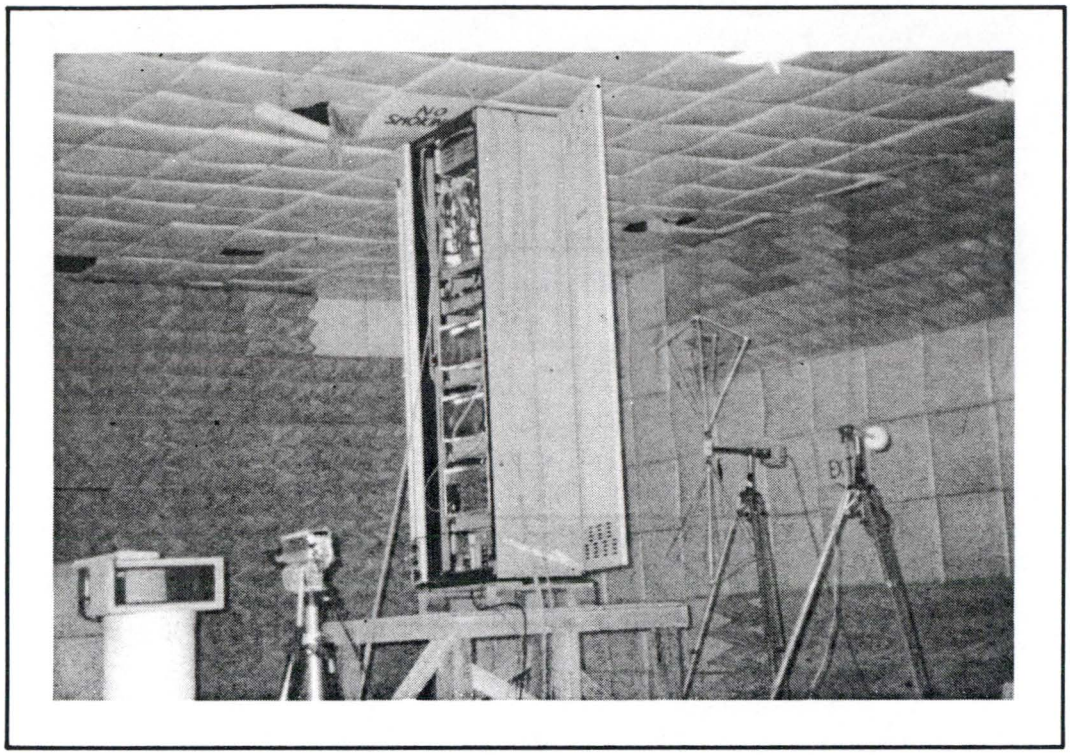


Figure 3-7. Bi-Conical Antenna (Vertical Polarization) Directed at the Front of the I/O Cards

different frequency bands to perform the modulation and keying tests on the WDPF™ system.

A detailed description of the EMI test implementation is given in appendix D.

3.7.1 Calibration Test Procedure – The following instruments were sent for calibration at Westinghouse Standard Laboratories: the Tetronix sine wave generator, the HP 8656A signal generator, the RF power amplifiers Model ENI 525L (25W) up to 500 MHz, and Model 63L (5W) for frequencies from 500 to 1 GHz, the dynamic amplifiers, the HP 3437A digital voltmeter, and the field strength meter.

The calibration was done to determine the desired free space field strength values of 3 volts/meter, 10 volts/meter at different frequencies from 20 MHz to 1 GHz, and 20 volts/meter from 500 MHz to 1 GHz. The calibration was done for both horizontal and vertical polarizations. These field values were stored in calibration files and are

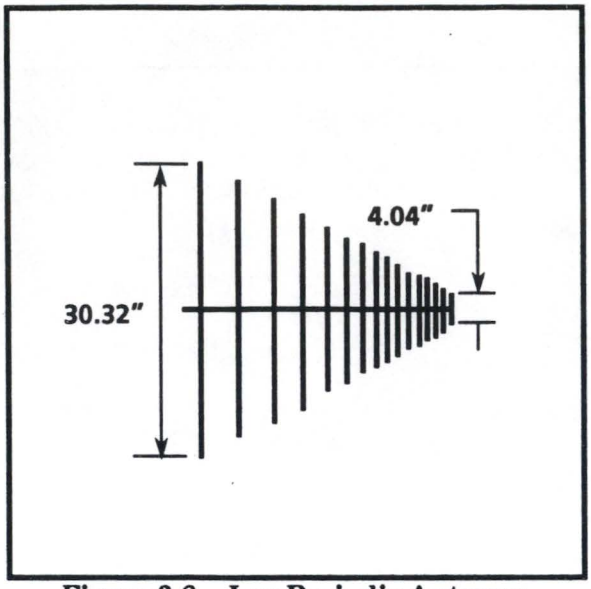


Figure 3-8. Log Periodic Antenna (160 MHz – 1 GHz)

used as reference values when the field strength meter is replaced by the WDPF™ cabinet.

Figure 3-10 shows a block diagram of the calibration setup; the power amplifier and the antenna switch have been omitted for clarity. The field strength meter faced the antenna and was positioned 1 meter from it, and no modulation was used. Both the field strength meter (FSM) and the antenna were 73 inches above the floor. The way the computer calibrates the equipment is that it steps through a file which has the frequencies of the carrier and duration of their application [specified earlier as 200 seconds per octave for 40 points, or 5 seconds for each frequency point (3 seconds on and 2 seconds off)]. For 40 data points per octave, frequency stepping was done as shown in table 3-5.

At each frequency, the computer searches for the required field strength using the field strength meter (FSM) as a feedback loop. Failure to read a specific field strength (via the digital voltmeter) results in the computer adjusting iteratively the amplitude of the signal to read the specified field strength. The amplitudes of these signals have been stored in subordinate files to be used when the WDPF™ replaces the FSM in the modulation and keying tests.

The FSM was used to sense and measure the RF field transmitted from the antenna. The FSM is fed from a dry battery to ensure minimum inter-ference effects on the power supply. The dc output of the FSM, which is proportional to the actual RF field, was fed back to a digital voltmeter which was read by the HP-85 computer.

3.7.2 Modulation Test – The modulation test was performed by replacing the FSM (used in the calibration test) by the WDPF™ cabinet in the anechoic chamber. Figure 3-11 shows a modulation test setup: the antenna was placed in the vertical

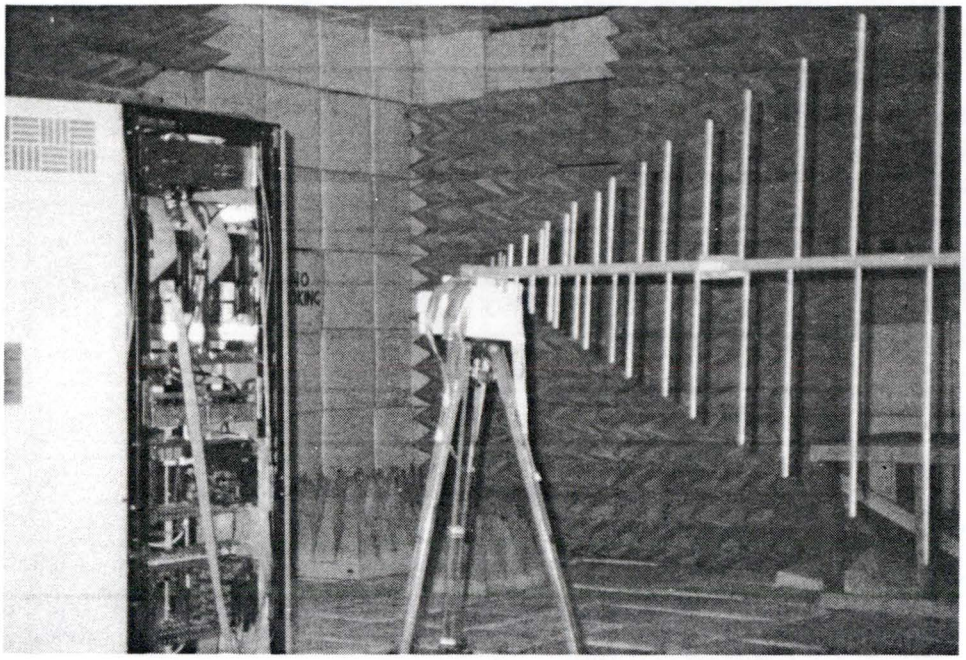


Figure 3-9. Log Periodic Antenna (Vertical Polarizations) Directed at the Front of the DPU

and horizontal polarizations and the FSM was placed at a distance of 1 meter from the cabinet and was used for reference and to ensure the existence of a RF field. Figure 3-12 shows a block diagram of the equipment used for EMI modulation tests.

A signal generator was used to produce a carrier frequency of a peak-to-peak value of 2.18 volts and frequency of 10 KHz. A sine wave generator was used to modulate (at 90 percent) the carrier frequency signal. The output of the signal generator was monitored by using an HP signal analyzer.

The calibration files generated during the calibration were used to set up the amplitude and frequency of the signal generator in order to produce a specified field strength (3, 10, or 20 volts/meter) at the WDPF™ cabinet surface. The signal generator output was fed to an RF power amplifier which had a fixed gain of 40 db. The output of the power amplifier was fed to the transmitting antenna via a special HF low-loss coaxial cable with specified length and impedance.

Table 3-5

Frequency Stepping for EMI Test

Octave Number	Frequency Range (MHz)	Frequency Step (MHz)
1	20 to 40	0.5
2	40 to 80	1
3	80 to 160	2
4	160 to 320	4
5	320 to 640	8
6	640 to 1280	16

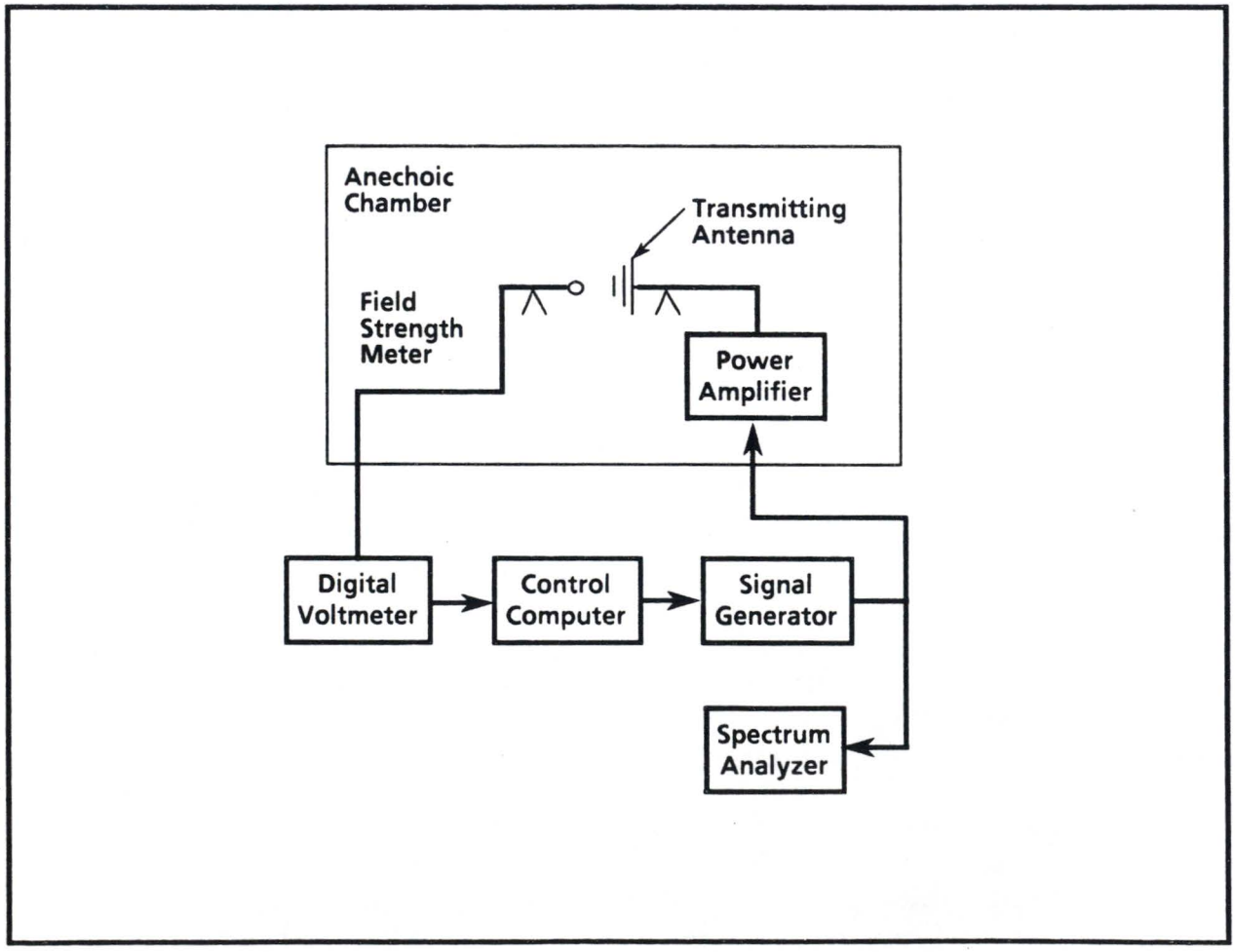


Figure 3-10. Block Diagram of the EMI Calibration Setup

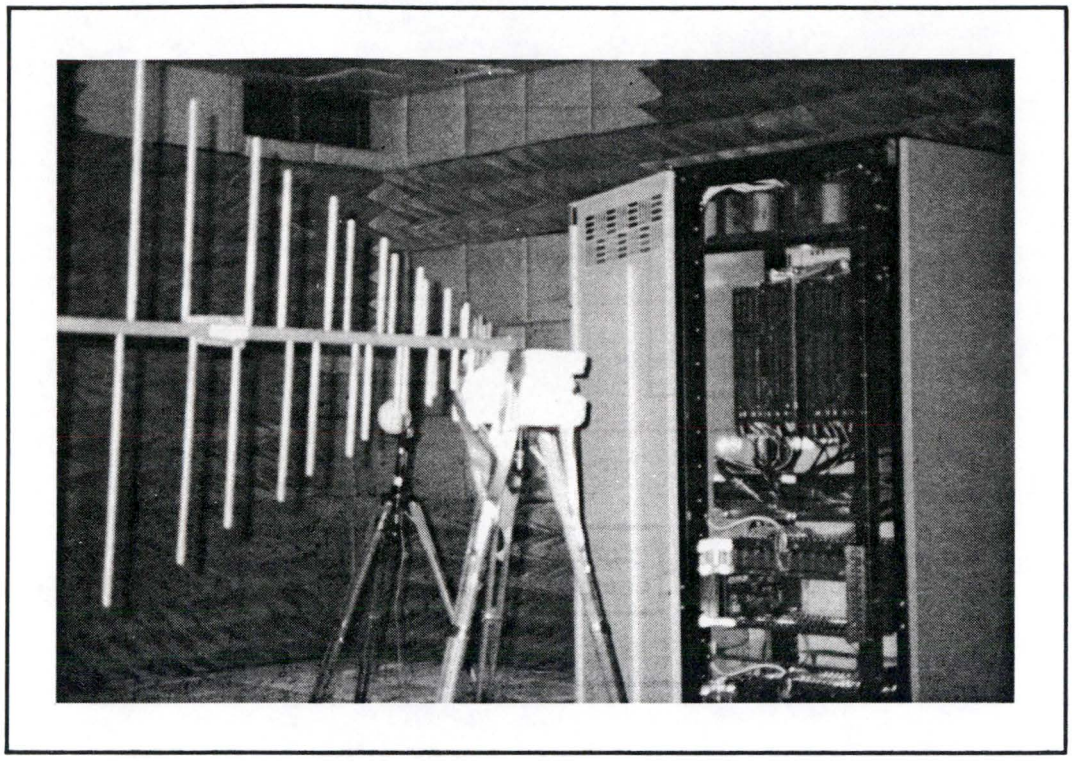


Figure 3-11. Modulation Test Photo Showing the Log Periodic Antenna and the FSM

The modulation test (EMI test) was done with the WDPF™ cabinet doors opened or closed. The front and back of the cabinet were tested with both horizontal and vertical antenna polarizations. The DPU and the I/O cards were targeted from the front and rear by the antenna. The cabinet was raised (using a specially made table) so that the I/O cards and the antenna were at the same level and both were 73 inches from the ground of the anechoic chamber. The DPU was targeted by laying the cabinet directly on the ground facing the antenna so that both the DPU and the antenna were 73 inches from the ground. Table E-1 (in appendix E) list the modulation tests (or EMI tests) performed on the WDPF™.

A Compaq portable personal computer was used to communicate with the WDPF™, to monitor the system performance when subjected to RF fields, and to detect with some diagnostics any EMI effects.

The WDPF™ cabinet, the FSM, and the personal computer were located in the quiet zone of the anechoic chamber. The four analog outputs from the I/O cards were moni-

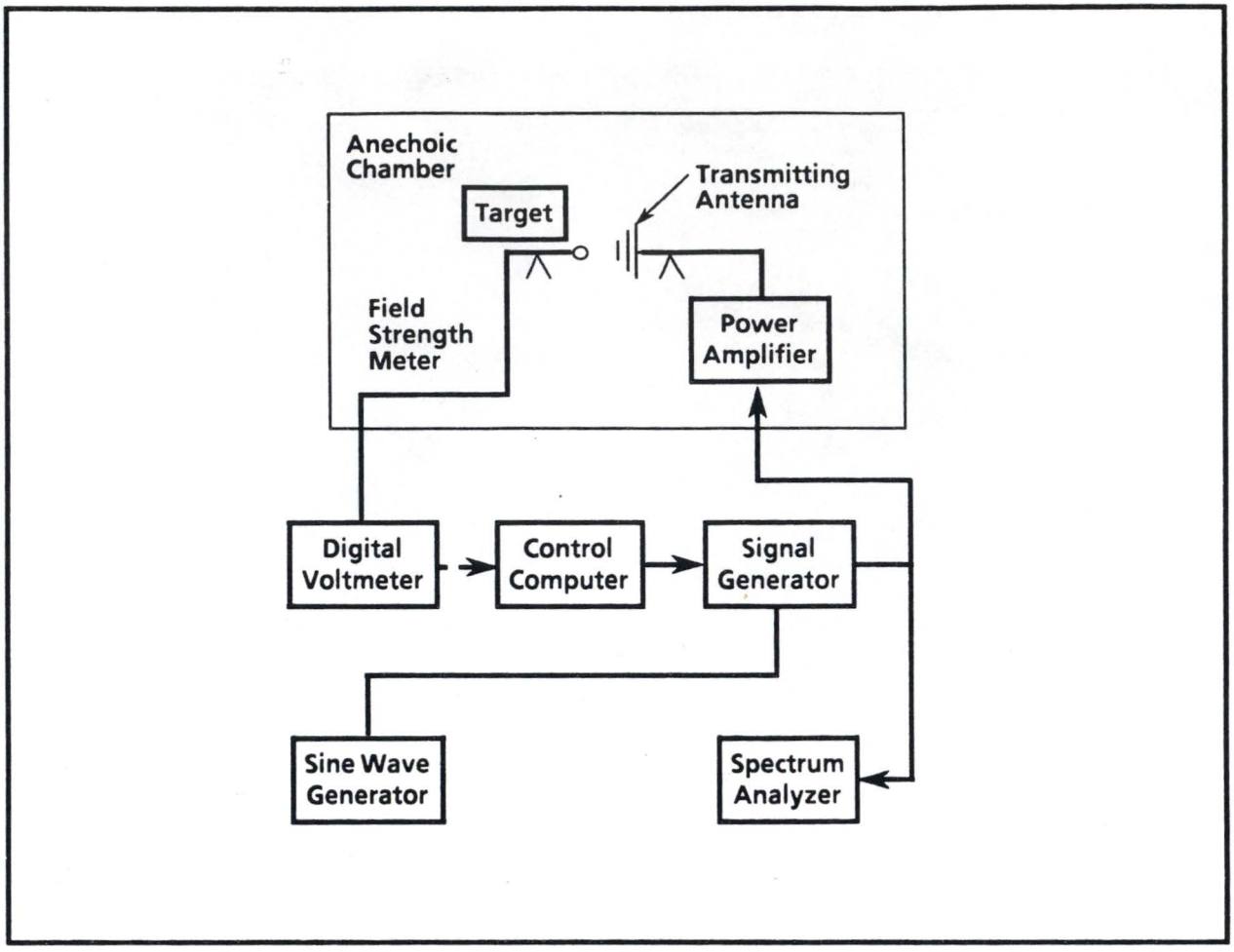


Figure 3-12. Block Diagram of the Equipment Used for EMI Modulation Tests

tored in the instrumentation room and their values were recorded on a high-quality audio tape recorder before, during, and after the application of the RF fields. The data on the monitor of the personal computer was also recorded (and observed) using a video camera located in the anechoic chamber and a video recorder and a tv monitor in the instrumentation room.

3.7.3 Keying Test – The WDPF™ is susceptible to repeated operation of a transmitter. The keying test was used to evaluate the WDPF™ in this mode. To simulate keying of a transceiver, the SAMA Standard PMC 33.1 requires that the source signal be switched between zero and 100 percent of the continuous wave amplitude. The switched signal must have an on and off duration of at least 1 second each and rise and fall times no greater than 50 microseconds. In addition, at least three keying cycles per frequency octave are required.

Manual sweep was utilized and the test was performed at three frequencies (data points) per octave. The keying test frequencies (in MHz) are shown below:

22	180
28	240
34	308
45	384
60	440
70	496
86	656
110	832
140	

The keying test was performed in a manner similar to the modulation test. A relay, relay/switch, a function generator, and a dc power supply were added to the test equipment used for the modulation test. The relay was fed from a dc power supply and driven by a function generator at 0.5 Hz pulse, which activated the relay/switch. When the relay switch had been activated, the modulated output of the signal generator was fed to the transmitting antenna via the RF power amplifier.

The output of the function generator turned the signal on for 1 second, then off for 1 second. The signal was manually applied for 1 minute at each chosen data point, which resulted in 30 cycles (of RF field) on and off. The rise and fall times of the on and off cycling were less than 50 microseconds. The RF transmitted signal during the keying test was 90 percent modulated at 10 KHz.

Figure 3-13 shows a block diagram of the equipment used for the EMI keying tests.

The keying test was applied for two configurations, as follows:

1. The front of the DPU was targeted by the antenna and the two doors of the WDPF™ cabinet were left open. The RF field strength was 10 volts/meter and the keying frequencies were from 22 to 832 MHz using horizontal and vertical polarizations.

2. The back of the DPU was targeted by the biconical antenna (both horizontal and vertical polarizations) and the cabinet doors were left closed. The field strength was 20 volts/meter and the keying frequencies were from 22 to 140 MHz.

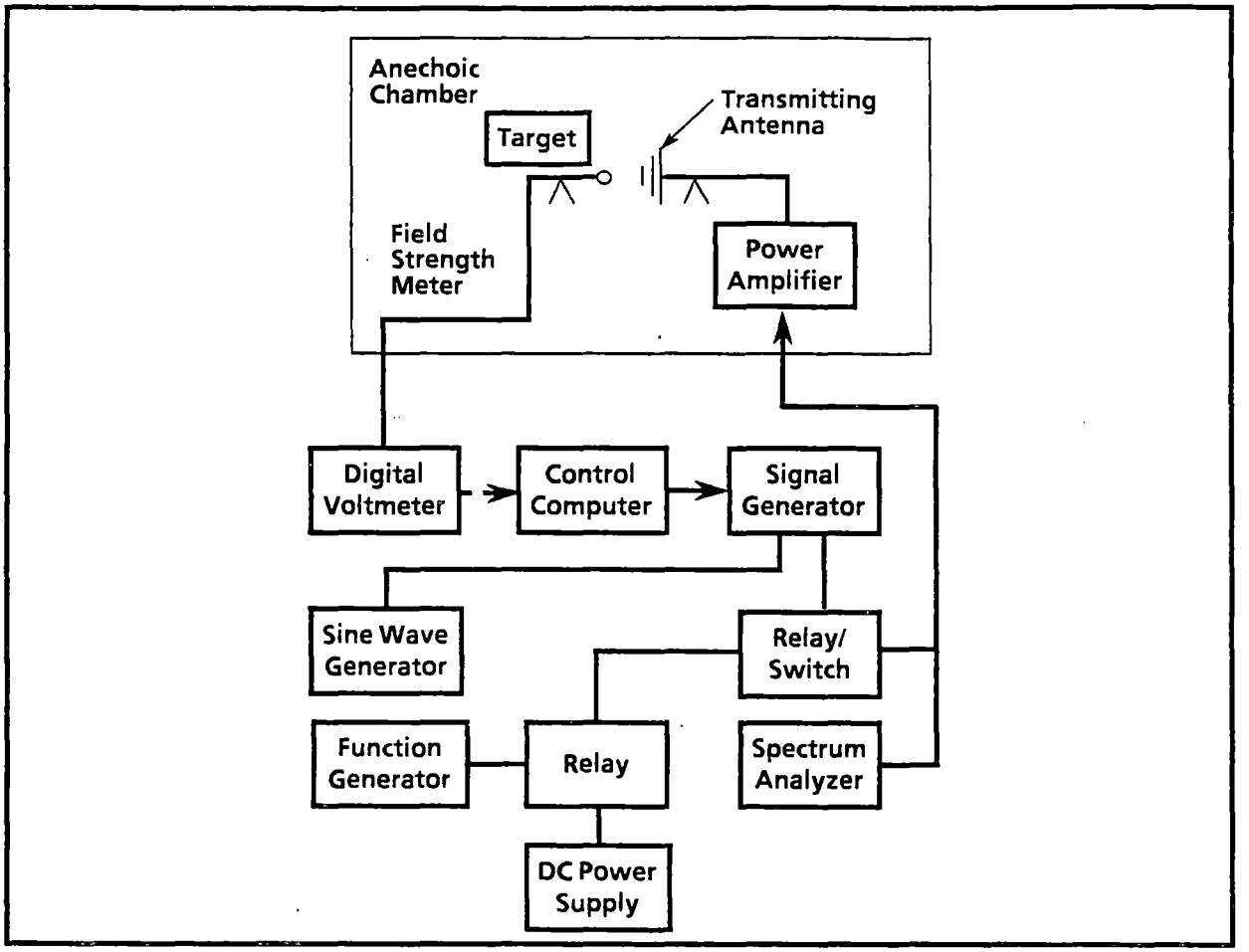


Figure 3-13. Block Diagram of the EMI Keying Test Setup

SECTION 4
EMI TEST SETUP AND MONITORING

4.1 EMI Test Setup

The EMI test setup for the WDPF™ consisted of the cabinet which contained the DPU and the I/O cards. Field cables spanning 50 feet were used to connect the cabinet to a patch panel located at the instrumentation room outside the anechoic chamber. The analog signals were taken from the patch panel and fed to a high-quality tape recorder via buffer amplifiers. The video camera used to record the output on the personal computer monitor screen was connected to a video recorder in the instrumentation room using a high-frequency 50-foot coaxial cable. The output of the camera was connected to a tv monitor for observation and was recorded by a 1-inch professional video recorder. Figure 3-4 shows the test equipment setup (patch panel, tape recorder, signal generator, data acquisition and monitoring system).

4.1.1 System Connections – The system connections were implemented through the patch panel. The QAV input card has six inputs; four were used for the test. The QAV is a voltage card, and four independent power supplies (zero to 10 v) were used to simulate input from four RTDs. Twisted-shielded cables were used to connect the input of the QAV card (from a pin connector) to the patch panel. The four outputs from the QAO card (in the WDPF™ cabinet) were connected to the patch panel in the measurement room using twisted-shielded cables. The shields were grounded on the cabinet side only and were left floating on the measurement end to avoid ground loops. The field connections to the I/O terminations are shown in detail in appendix F.

The routing configuration and the separation of the field connection cables were implemented according to standard nuclear power plant practices.

The WDPF™ has a very powerful software programming package called MAC™-4000. A number of hardware items provided communications between the MAC™ program loader and the MAC™-4000 as follows: an IBM or Compaq personal computer with disk operating system software (DOS version 2.1 or later), a 384 kb memory expansion board, a serial port configured as COM1, a 15-foot communication ribbon cable for the COM1 port PC with a 25-pin D-connector.

The ribbon cable was connected to the communication interface port on the MAC™-4000. The PC and the cable were in the anechoic chamber in the quiet zone, just behind the WDPF™ cabinet.

4.1.2 Simulated Input Signals to the WDPF™ – To achieve the best EMI test results, normal operating conditions of the WDPF™ must be replicated. These

conditions were replicated by simulating temperature signals with separate dc power supplies.

The WDPF™ has two I/O cards: the analog high level input point QAV G05 PC card and the analog output QAO G02 PC card. The input card QAV and the output card QAO each have six inputs and six outputs. Four of these inputs and outputs were used to simulate temperatures in the following loops:

1. Selection of low temperature loop (LO SEL)
2. Selection of high temperature loop (HI SEL)
3. Summation of temperature loop (SUM)
4. Delta difference of temperature loop (DELTA)

Figures 4-1 and 4-2 show diagrams representing the four loops. The temperature ranges in these loops were as follows:

Temp 1 from zero to 100°C
Temp 2 from zero to 100°C
Temp 3 from zero to 100°C
Temp 4 from zero to 100°C
LO SEL from zero to 100°C
HI SEL from zero to 100°C
SUM from zero to 200°C
DELTA from -100°C to +100°C

The input to the QAV card is zero to 10 volts and represents zero to 100°C. Four power supplies were used to simulate 10°C, 40°C, 60°C, and 90°C to the four inputs of the QAV card. The four outputs of the QAO card are the low temperature select (LO SEL), the high temperature select (HI SEL), the temperature summation (SUM), and the temperature difference (DELTA). These output values are 10°C, 90°C, 50°C,

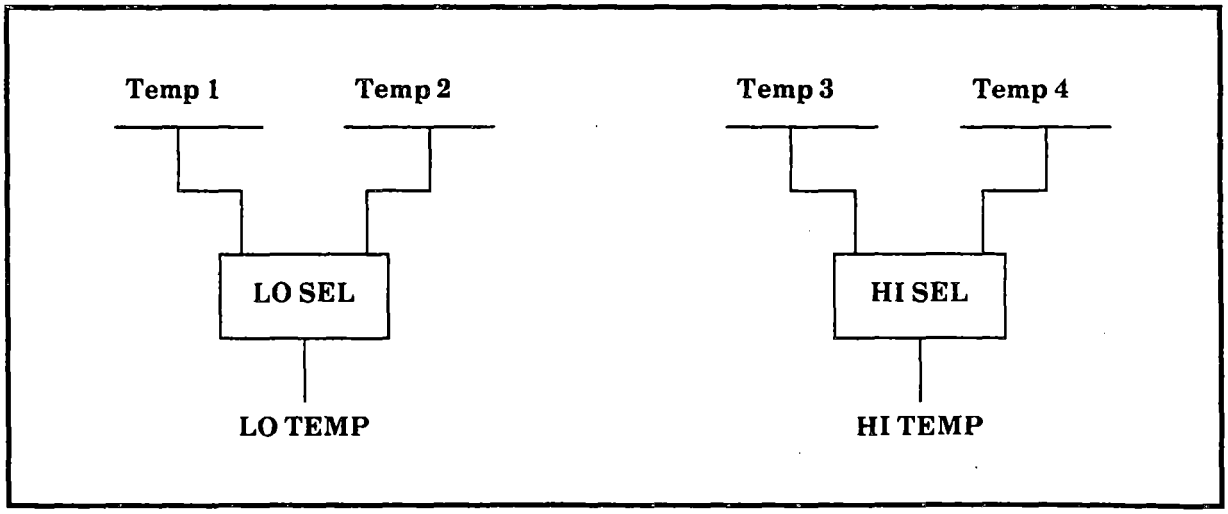


Figure 4-1. Diagram of LO SEL and HI SEL Loops

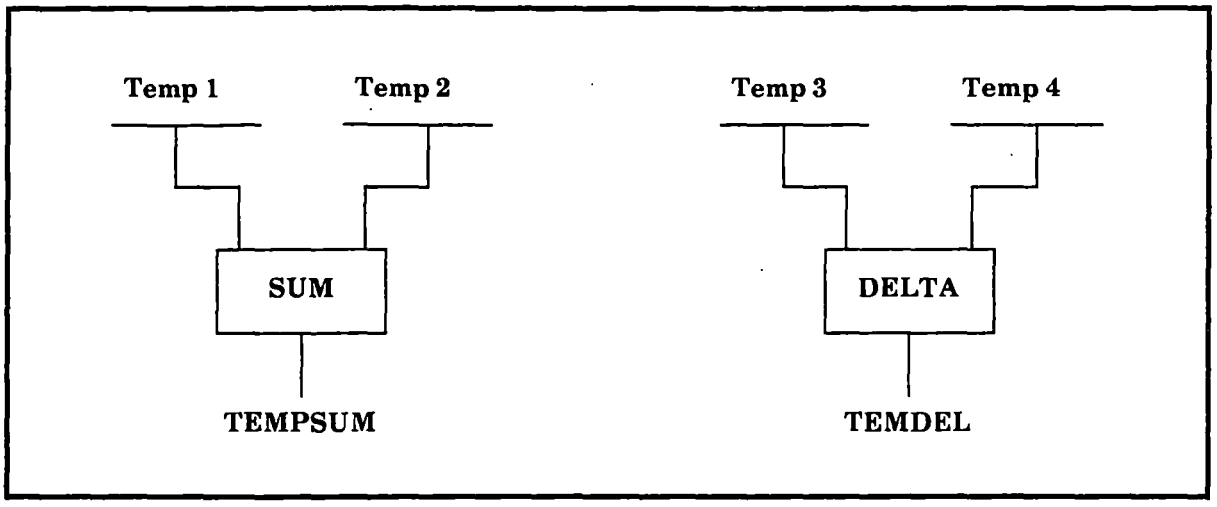


Figure 4-2. Diagram of SUM and DELTA Loops

and 30°C, which could be measured on the output card QAO terminals as 1 volt, 9 volts, 2.5 volts, and 6.5 volts, respectively. Appendix F shows the wiring diagrams for QAV and QAO cards. The output terminals of QAO were taken to a terminal box (patch panel, shown in figure 3-4) in the measurement room using twisted-shielded cables, and all four outputs were recorded using a 14-channel Honeywell recorder.

4.1.3 Analog Outputs and Data Acquisition System – The four analog outputs from the QAO card were connected to the patch panel (in the measurement room). The data acquisition system was used to record all analog outputs during each test. It consisted of an audio tape recorder and visi-recorder with eight channels for recording the output. The tape recorder was interfaced to the patch panel via buffer dynamic amplifiers. The visi-recorder, used for monitoring, was directly connected to the patch panel.

A 14-channel high-quality FM audio tape recorder (figure 3-4) was used to record the four outputs of the system. The tapes were calibrated before recording, using a standard calibration procedure. The input of the tape recorder was set for a ten-to-one attenuation level, and the tape speed was 1.87 inches per second. The differential outputs of the system were fed through buffer amplifiers, which also converted the signals from differential to single-ended outputs. Each signal was fed through one buffer amplifier. Figure 4-3 shows a typical connection for an analog output channel.

4.2 EMI Test Monitoring

The tests were monitored in compliance with the acceptance criteria outlined in section 5. The analog output signals, the PC display monitor, and the communication cable were monitored before, during, and after each test to ensure that the

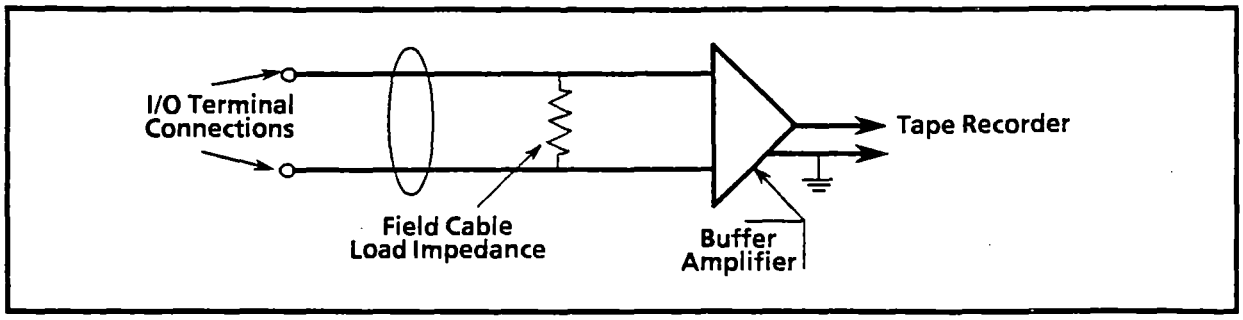


Figure 4-3. Diagram of an Analog Output Channel Recording Connection

system and its input/output remained functional and accurate throughout the electromagnetic interference test.

The tape recorder was calibrated before recording and was run for 2-minute intervals before and after testing. The recorded outputs were also measured with a digital voltmeter, and any observed effects were noted on data sheets. The data sheets included information on the WDPF™ part tested, the antenna or configuration, the field strength, the beginning and end of the recording footage, and remarks and test observations. Figure 4-4 is a sample EMI test data sheet.

Log sheets were also used during EMI testing. The log sheet shows the test set, date, test time, beginning and end of the recording footage, and the gain and frequency setting for each buffer amplifier. Figure 4-5 is a sample log sheet. The data sheets were compared to the log sheets to ensure compatible record keeping.

4.2.1 **Video Recording of the PC Monitor** – The PC monitor (in the anechoic chamber) was observed in the instrumentation room by using a video camera and a tv monitor. The PC monitor picture was also recorded using a professional (1-inch tape) video recorder. All video tape footage was systematically entered on the log sheets and has been kept for future use.

4.2.2 **Analog Output Voltage Measurements** – The four analog output voltage signals were continuously monitored before, during, and after the EMI test using a digital voltmeters to ensure that the accuracy of the output voltage was not degraded and that any observations were recorded on the data sheets.

EMI TEST FORWDPF SYSTEM
UNIVERSITY OF MICHIGAN
RADIATION LAB, MICHIGAN

SAMA STANDARD
PMC 33-1-1978

Procedure Rev._____
Date:_____
Test #:_____

TEST DATA

FIELD:_____ FREQUENCY:_____
ANTENNA:_____ POLARIZATION:_____
CONFIGURATION:_____ CALIBRATION FILE #:_____

PRE TEST

DATA LOGGER DATA VERIFICATION * PRINT OUTPUT #_____
SYSTEMS STATUS: DPU_____QAW____QAO_____PC_____DATA LINK_____
INPUT VALUES: CHANNELS #1_____#2_____#2_____#4_____
MEASURED OUTPUTS: CHANNELS #1_____#2_____#3_____#4_____
LOOPS: #1_____#2_____
REMARKS AND OBSERATION:_____

TEST

TAPE RECORDER FOOTAGE: BEGINS_____END_____SET #_____
SPEED_____TIME_____
SYSTEMS STATUS: DPU_____QAW____QAO_____PC_____DATA LINK_____
INPUT VALUES: CHANNELS #1_____#2_____#2_____#4_____
MEASURED OUTPUTS: CHANNELS #1_____#2_____#3_____#4_____
LOOPS: #1_____#2_____
REMARKS AND OBSERATION:_____

POST TEST

DATA LOGGER DATA VERIFICATION * PRINT OUTPUT #_____
SYSTEMS STATUS: DPU_____QAW____QAO_____PC_____DATA LINK_____
INPUT VALUES: CHANNELS #1_____#2_____#2_____#4_____
MEASURED OUTPUTS: CHANNELS #1_____#2_____#3_____#4_____
LOOPS: #1_____#2_____
REMARKS AND OBSERATION:_____

TEST PERFORMED BY:_____
TEST VERIFIED BY:_____

NOTES:

Figure 4-4. Sample EMI Test Data Sheet

TAPE RECORDER: ____

TAPE RECORDER LOG SHEET

SET	DATE	TIME	LOOP CONDITIONS						RECORDING																				REMARKS
			PUMPS				TEMP	PRESS	TAPE NO	START	STOP	IPS	MIN	GROUP	CHANNELS														
			1	2	3	4									1	2	3	4	5	6	7	8	9	10	11	12	13	14	

Figure 4-5. Tape Recorder Log Sheet

SECTION 5
ACCEPTANCE CRITERIA

The acceptance criteria for the EMI tests is defined as follows:

> *The WDPF™ system shall continue to operate satisfactorily with proper data transfer and within the specified accuracy at an electromagnetic field of 3 volts/meter for the frequency bands of 20 MHz to 1 GHz with cabinet doors closed; that is, Class 1-A, B, C.*

SECTION 6
TEST RESULTS

6.1 Description

The results of the EMI tests on the WDPF™ are based on the acceptance criteria defined in section 5. The observations of the analog signal recording showed no interference effects on the continuous operation of the DPU or input/output signals (analog/digital), and the WDFP™ functioned normally. Tables 6-1 and 6-2 show the EMI test results. The detailed description of these EMI test results is given in the following subsections.

6.2 EMI Test Results

6.2.1 Modulation Tests – The modulation tests are as follows:

- 3 volts/meter field strength
  - Front (or back) of the DPU with cabinet doors open (or closed). No interference effects were observed on the WDPF™ performance for frequency bands A, B, and C (that is, from 20 MHz to 1 GHz). Test results are given in table E-1 (appendix E).
  - Front (or back) of the I/O cards with cabinet doors open (or closed). No interference effects were observed on the WDPF™ performance. Table E-1 (appendix E) contains details of the test results and adherence to the acceptance criteria.
- 10 volts/meter field strength
  - Front (or back) of the DPU with cabinet doors open (or closed). The DPU performed properly except in the range from 66 to 74 MHz where the DPU was affected by interference. Table 6.1 contains compliance to passed/failed criteria and table E-1 (appendix E) contains details of each EMI test for frequency bands A, B, and C (that is, from 20 MHz to 1 GHz).
  - Front (or back) of the I/O cards with cabinet doors open (or closed). The I/O cards performed properly except in the range from 66 to 86 MHz where the output was affected by interference. Table 6-2 contains compliance to passed/failed criteria and table E-1 (appendix E) contains details of each EMI test for frequency bands A, B, and C (that is, from 20 MHz to 1 GHz).

Table 6-1
EMI Test Results for the DPU

		Modulation Tests (cabinet doors open)						Modulation Tests (cabinet doors closed)					
		Vertical Polarization			Horizontal Polarization			Vertical Polarization			Horizontal Polarization		
		Frequency Band[a]			Frequency Band			Frequency Band			Frequency Band		
		A	B	C	A	B	C	A	B	C	A	B	C
Class 1 3 V/m	DPU(Front)	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
	DPU(Back)	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Class 2 10 V/m	DPU(Front)	Passed	OK/Except ["B" signal 66-74 MHz][d]	Passed	Passed	Passed	Passed	Passed	OK/Except [66-74MHz][b]	Passed	Passed	OK/Except [66-74 MHz][b]	Passed
	DPU(Back)	Passed	Passed	Passed	Passed	OK/Except [66-74 MHz][b]	Passed	Passed	Passed	Passed	Passed	OK/Except [66-74 MHz][b]	Passed
Class 3 20 V/m	DPU(Front)	Passed	OK/Except ["B" signal at 66-86 MHz][d]	Passed[c]	Passed	OK/Except [66-74 MHz][b]	Passed[c]	Passed	OK/Except [66-74MHz][b]	Passed[c]	Passed	OK/Except [66-74 MHz][b]	Passed[c]
	DPU(Back)	Passed	OK/Except [66-74 MHz][b]	Passed[c]	Passed	OK/Except ["B" signal at 66-86 MHz][d]	Passed[c]	Passed	OK/Except[e]	Passed[c]	Passed	OK/Except [66-74 MHz][b]	Passed[c]

a. Frequency band
A = 20 MHz – 50 MHz
B = 50 MHz – 300 MHz
C = 300 MHz – 1 GHz
N/T = Not tested

b. The output of the WDPF™ changed during this frequency range by an average of 2 to 6%.

c. N/T from 500 MHz to 1 GHz

d. "B" is a flag raised by WPDF™ to indicate that the signal is outside its specified high or low limit.

e. Output (O/P) signals are degraded to "B" 66-86 MHz. O/P goes to zero at 74 MHz.

Table 6-2
EMI Test Results for I/O Cards

		Modulation Tests (cabinet doors open)						Modulation Tests (cabinet doors closed)					
		Vertical Polarization			Horizontal Polarization			Vertical Polarization			Horizontal Polarization		
		Frequency Band			Frequency Band			Frequency Band			Frequency Band		
		A	B	C	A	B	C	A	B	C	A	B	C
Class 1 3 V/m	I/O(Front)	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
	I/O(Back)	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
Class 2 10 V/m	I/O(Front)	Passed	OK/Except 66-74 MHz[b]	Passed	Passed	OK/Except [66-74 MHz][b]	Passed	Passed	OK/Except [66-82MHz][b]	Passed	Passed	OK/Except [66-74 MHz][b]	Passed
	I/O(Back)	Passed	Passed	Passed	Passed	OK/Except [71-86 MHz][b]	Passed	Passed	Passed	Passed	Passed	OK/Except [76 MHz][b]	Passed
Class 3 20 V/m	I/O(Front)	Passed	OK/Except [66-74 MHz][b]	Passed[c]	Passed	OK/Except [66-74 MHz][b]	Passed[c]	Passed	OK/Except [66-74MHz][b]	Passed[c]	Passed	OK/Except [70-78 MHz][b]	Passed[c]
	I/O(Back)	Passed	Passed	Passed[c]	Passed	Passed	Passed[c]	Passed	Passed	Passed[c]	Passed	OK/Except [76 MHz][b]	Passed[c]

a. Frequency Band
'A = 20 MHz – 50 MHz
B = 50 MHz – 300 MHz
C = 300 MHz – 1 GHz
N/T = Not tested

b. The output of the WDPF™ changed during this frequency range by an average of 2 to 6%.

c. N/T from 500 MHz to 1 GHz

- 20 volts/meter field strength

  - Front (or back) of the DPU with cabinet doors open (or closed). The DPU performed properly except in the range from 66 MHz to 86 MHz where the DPU was affected by interference. The output was temporarily lost at 74 MHz when the back of the DPU was targeted by the bi-conical antenna in the vertical polarization (test number 109, table E-1). Table 6-1 contains compliance to passed/failed criteria and table E-1 (appendix E) contains details of each EMI test for the frequency bands A, B, and C.

  - Front (or back) of the I/O cards with cabinet doors open (or closed). The I/O cards performed properly except in the range from 66 MHz to 78 MHz where the output was affected by interference. The output changed by an average of 6 percent from its nominal value due to EMI from 66 to 78 MHz. Table 6-1 contains compliance to passed/failed criteria and table E-1 (appendix E) contains details of each EMI test for the frequency bands A, B, and C (that is, 20MHz to 1 GHz).

    Grounding the cabinet doors (by solidly connecting them to the ground facility) may minimize the disturbance effects reported in the results. These effects could be created by the holes in the doors acting as short antennas.

6.2.2 Keying Test – The keying test is as follows:

- 10 volts/meter field strength

  - Front (or rear) of the DPU with cabinet doors open (or closed). The keying test was performed manually for frequency ranges from 28 MHz to 832 MHz with horizontal and vertical polarizations of the bi-conical and log periodic antennas. The WDPF™ performed normally except at 66, 70, and 86 MHz where the output was affected by interference. Table E-2 (appendix E) contains details of each keying test.

SECTION 7
CONCLUSION

The experimental evidence in this report shows that the WDPF™ system remained fully functional within the required specified accuracy and met the acceptance criteria specified in section 5. The EMI test conclusively demonstrated that the WDPF™ continued to operate normally when subjected to the following:

- EMI fields of Class 1 (3 volts/meter) field strength for frequency bands A, B, and C (that is, from 20 MHz to 1 GHz)
- EMI fields of Class 2 (10 volts/meter) field strength for frequencies above 75 MHz to 1 GHz
- EMI fields of Class 3 (20 volts/meter) field strength for frequencies above 86 MHz to 1 GHz

No changes in the design of the WDPF™ are necessary, in particular:

- The processors of the DPU and the Compaq PC continued to operate undisturbed.
- The analog and digital (contact input/output) signals were continuous and accurate.
- The output to the Compaq display monitor was continuous and accurate.

In summary, the EMI test program convincingly demonstrated that the WDPF™ system performance did not degrade even when subjected to abnormal electrical conditions which exceed those that can be reasonably postulated.

SECTION 8
REFERENCES

The following references were used in this document:

1. "Electromagnetic Susceptibility of Process Control Instrumentation," Scientific Apparatus Manufacturer's Association (SAMA) Standard PMC 33.1-1978.

2. White, Donald R. J., Duff, William G., Hill, James S., "Electromagnetic Interference and Compatibility," Gainesville, VA, 1971.

3. Nasrallah, C. N., "Noise, Fault, Surge, and Radio Frequency Interference Test Report," WCAP-11340, November 1986.

APPENDIX A

GENERAL DESCRIPTION OF THE WDPF™

Introduction

This appendix is extracted from the WDPF™ Manual (published by Westinghouse Automation Division). The Westinghouse Distributed Processing Family (WDPF™) is a digital system designed to provide integrated modulating control, sequential control, and data acquisition for a wide variety of plant-wide system applications. The WDPF™ can handle all levels of complexity, from small systems to large data highway-based plant-wide systems.

WDPF™ is expandable to a maximum of 254-drop, highway-based, plant-wide system. The architecture of the WDPF™ communication system permits all drops on the WDPF™ data highway to have transparent access to any other drop's process point values without communications overhead. The 2-megabound data highway broadcasts 16,000 analog values or 256,000 packed digital values, or any combination every second, which ensures that this global data base is always current.

The instantaneous, transparent access to a current distributed global data base permits the WDPF™ system to execute, in one drop, control loops that use process values generated elsewhere in the system. More importantly, this data base access and transparency allows the distribution of functions, which would normally reside in one control processor, into many independent drops. Since each drop operates in parallel and can concentrate on its assigned function without interruption, system performance never degrades, regardless of other events that may be occurring simultaneously. Drops performing functions such as CRT graphic updates, control loop processing, alarm reporting, historical data collection, and log printing, all respond as fast during plant upsets as they do under steady-state conditions.

Features of WDPT™

Key features of a WDPF™ system include the following:

- Standard hardware building blocks
- Distributed global data base
- Guaranteed update of 16,000 analog values or 256,000 packed digital values or any combination, every second
- No traffic director
- Every expandability to 254 drops
- Passive axial and fiber optic highways

- Optional redundancy
- Combined control and data acquisition
- No host computer needed
- CRT displays in under 1 second
- Custom graphics
- Problem-oriented languages

Configuration

A typical WDPF™ system consists of a selection of various drops linked by the data highway. The drops which were tested for EMI are as follows:

- Distributed processing unit (DPU), which performs data acquisition and control functions and interfaces to the process
- Gateway, which interfaces WDPF™ to other computers or other non-Westinghouse PCs
- WDPF™ hardware building blocks, which for the WDPF™ system consist of three sets of hardware: the data highway, the functional processor, and the I/O interface. These sets of hardware are used as building blocks for the system

Data Highway

Communications to and from the data highway are provided by the data highway controller (DHC) subsystem. The DHC is common to all drops and consists of a shared memory, a modem, and a data base manager (custom bit-slice micro-processor). The shared memory is used as the interface between the DHC and the functional processor and performs the specific tasks associated with a particular type of drop. It provides transparent communication between the DHC and the rest of the WDPF™ system.

The DHC sub system frees each drop's functional processor to concentrate on its assigned task, which eliminates the need for communication software. All data transferred to and from shared memory appear to the functional processor as part of its internal data base, independent of origin.

Functional Processor

The functional processor performs the specific functions associated with the drop (man-machine interface, logs historical storage, control loop processing, and the like. The functional processor obtains and stores data from the memory shared between it and the DHC, it then communicates with other hardware such as mass memory, process I/O, and peripherals.

Communications

The WDPF™ system provides communications among the drops via the DHC subsystem. Communication takes place either by periodic broadcast of process data or on a demand request.

Periodic Broadcast

Every 100 M.Sec, each drop (up to 254 drops) has access to the highway, allowing it to broadcast the process values stored in its shared memory (15 analogs, or 31 digitals, or 15 32-bit digital registers), in addition to their point identifiers and status. In turn, each drop listens to broadcasts made by other drops about process points of interest to it, and pulls them off the highway to store them in its shared memory.

All process variables are broadcast at least every second, but since each drop has access to the highway every 100 M.Sec, a drop can broadcast and update the key process points as frequently as every 100 M.Sec, if conditions warrant.

Demand Request

At the conclusion of each periodic broadcast cycle, the remaining time in each 100 M.Sec time slice is available on a demand basis for other communication, such as downloading of programs, transfer of English description of points, and so forth.

Diagnostics

Extensive on line diagnostics exist in each DHC to ensure its integrity, as well as that of the whole system. Failed drops are automatically bypassed. Alarms indicating such failures are displayed on the operator's alarm console.

Combined Data Acquisition and Control

The DPU provides, in one drop, both control and data acquisition functions. This eliminates the duplication of sensors, so often needed by systems that perform only one or the other. These dual drop functions also permit easy integration of systems that start with data acquisition only and which add control later, or vice versa. WDPF™ also provides, in one system, an integrated approach to modulating and sequential control, as well as to data acquisitions.

Process I/O

WDPF™ systems use the Westinghouse Q-line family of process I/O cards for the accumulation and dissemination of data. The Q-line cards provide maximum flexibility and long life, while incorporating state-of-the-art technology.

The Q-line process I/O cards provide the WDPF™ system with its process and instrumentation interface. The input cards process and interface most standard field process inputs (such as current, voltage, millivolts). These input cards enable system monitoring of temperature levels, speed, and pressure. The sequence of events input card provides resolution to 1 millisecond.

The output cards provide system control of a large variety of field process and instrumentation devices. Current outputs (zero-20 MA) and digital contact outputs

are available. These output cards control positioning motors, solenoids, valve drives, relays, and analog-driven instrumentation, and many more plant devices.

Electrical Specifications

Electrical specifications for the WDPF™ are as follows:

- Voltage - 115 Vac, ±10% or 230 Vac ±10%
- Frequency - 60 or 50 HZ
- Phase - Single

APPENDIX B

SYSTEM AND ANALOG INPUT/OUTPUT CARD DESCRIPTIONS

This appendix contains descriptions of the following:

- Distributed Processing Unit
- QAV - Analog Input Card
- QAO - Analog Output Card

Distributed Processing Unit

Product Overview

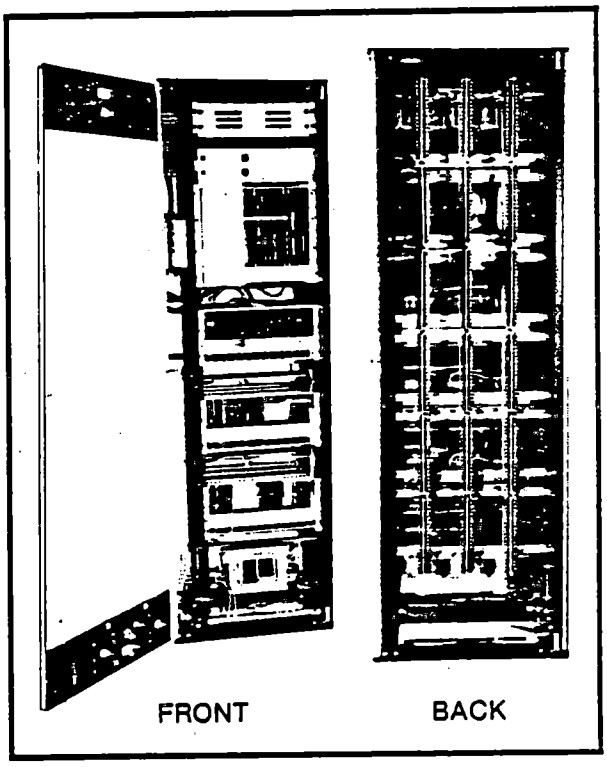
The Distributed Processing Unit (DPU) consists of a 16-bit functional processor with floating-point hardware to perform both the data acquisition and Direct Digital Control (DDC) functions in a WDPF™ System, and a standard Data Highway Controller (DHC) to communicate with the WDPF™ Data Highway.

Raw process data are converted to engineering units and limit checked by the functional processor prior to providing data to the DHC for broadcasting to the rest of the WDPF™ System. These converted process values are then used in control loops that run in the functional processor of the DPU to control the plant. Control programs can continue to execute at the DPU in the event of a Data Highway or DHC failure.

FEATURES

Features of the DPU which contribute to its versatility include:

- Combined data acquisition and control
- WDPF™ highway capability
- Powerful 16-bit processor with floating-point hardware
- Memory mapped I/O
- Sequence of events
- Process values in engineering units
- Distributed global data base
- PROM based and RAM based with bubble backup
- Optional redundancy
- All process variables updated every second
- System runs independent of Data Highway and controllers



Distributed Processing Unit (DPU)

DATA ACQUISITION

The DPU functional processor accesses the process I/O cards via a memory mapped I/O bus. Each Q-Line input card continuously receives plant information and stores it in digital form for immediate access.

The functional processor accesses these inputs, converts the data to engineering units, and performs limit checking.

A Sequence of Events capability consisting of Q-Line cards and associated software in the DPU can be provided in each DPU. This determines the sequence

in which a predetermined set of digital inputs changes state anywhere in the WDPF™ System, with a real-time resolution of less than two milliseconds.

DISTRIBUTED GLOBAL DATA BASE

Process variables and Data Acquisition System (DAS) point values are stored in the Data Highway shared memory, along with their tag or point names, English descriptions, and other attributes. Other WDPF™ Drops may obtain this data in their shared memory without interacting with the DPU.

CONTROL

DDC control programs are executed sequentially without interrupts to ensure security of control and data acquisition functions.

The control programs can use process values which are obtained locally or elsewhere in the WDPF™ System, completely transparently. The DHC allows for this by obtaining all values not local to the DPU and storing them in shared memory by listening on the highway for values needed by the functional processor.

These programs use standard WDPF™ algorithms and are written using the interactive editor for the high level Problem Oriented Language available on the Engineer's Console.

CRT-based, soft manual/automatic (M/A) stations, available on the Operator's/Alarm Console, permit operator control.

Hardwired manual backup for control loops can be provided with an Operator Interface Module (OIM) that may be mounted in a local Operator's/Alarm Console.

The DPU will continue to run in the absence of the Data Highway. Final output to the field hardware is made by the functional processor using the memory mapped I/O bus and storing the digital data to be output in the appropriate Q-Line card output register. The Q-Line card then outputs the register in the form compatible with field hardware.

REDUNDANT PROCESSOR FEATURES

For critical applications, a DPU can be furnished in a redundant configuration. In this arrangement, dual DPU elements are installed in a split chassis. Each portion has its own power supply, functional processor, DHC, and process I/O interface.

One processor serves as the primary with the other in stand-by mode. If the primary unit should fail, a failover signal is sent to the stand-by processor, which then scans the I/O and assumes control.

PARAMETERS

Each drop can process any one of the following or an equivalent mix. Processing includes scanning, converting to engineering units, and limit checking.

- 360 analog inputs
- 544 digital inputs
- 544 SOE inputs
- 144 pulse inputs
- 144 analog outputs
- 544 digital outputs

Each drop can execute a number of control loops, depending on the complexity of the loop and the number of algorithms (including ISA algorithms). Each control loop has a soft M/A station, and/or if desired, a hard M/A station.

QAV — Analog Input Card

Process I/O

GENERAL INFORMATION

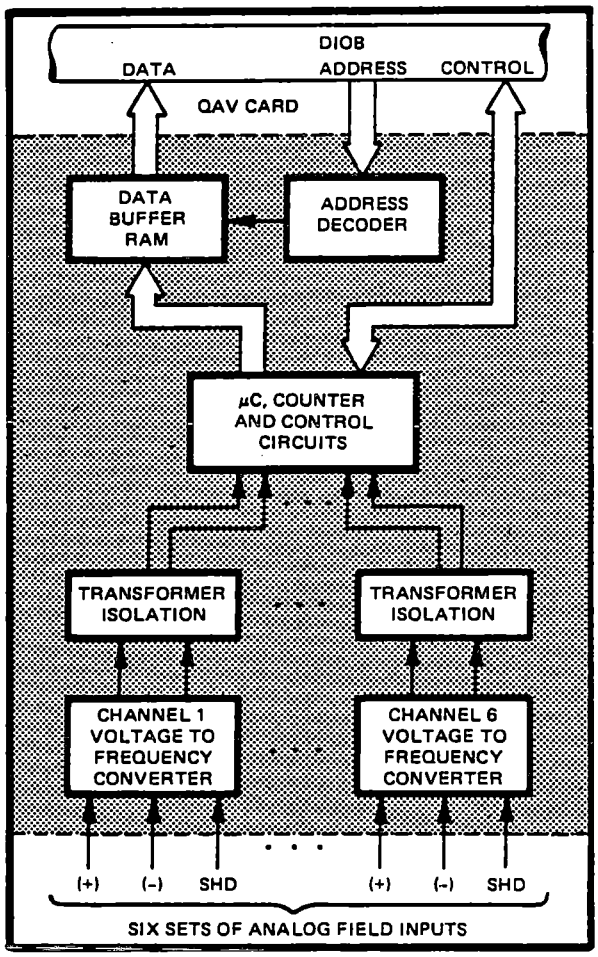
The QAV card processes six analog inputs, each with its own individually isolated, Voltage-to-Frequency converter. The frequency output of each converter is processed by a common controller. The controller converts each of the six variable frequency signals to a parallel, 13-bit word, corrects offset and gain, and places the value in its own dedicated register. The buffer-stored data is multiplexed via the or DIOB to the CPU or microprocessor upon QAV card addressing.

The QAV card is available in five groups (G01 through G05), providing a variety of analog input signal ranges. The QAV provides the following features:

- Auto-zero and Auto-gain corrections.
- Each channel individually isolated.
- On-card RAM buffer memory for storing conversion results.
- Open thermocouple detection (G01 through G03).
- Auto-conversion check.
- Jumper selectable 50/60 Hz operation.

FUNCTIONAL DESCRIPTION

After power-up, an auto-zero cycle occurs as the QAV card begins analog signal conversion. Upon cycle completion, a bit is set indicating digital data is valid. The analog signal is conditioned, amplified, and converted to a frequency pulse train. The pulses are counted, adjusted for offset and gain, and placed in buffer memory.



QAV Card Block Diagram

Each channels voltage-to-frequency conversion and input selection is supervised by a common microcomputer (µC) controller. This controller converts the selected variable frequencies to parallel, 13-bit words. These 13-bit resultant values are stored in a common RAM buffer memory for subsequent transfer to the DIOB.

Optionally, in a multicard environment, all conversions can be synchronized. Also, line frequency

tracking is available with the Time Base A/D (QTB) card.

PERFORMANCE SPECIFICATIONS

Power Supply

- Primary: 12.4 to 13.1 Vdc, 13.0 Vdc nominal
- Backup: 12.4 to 13.1 Vdc
- Current: 1.0 A nominal, 1.2 A maximum

Card Group Characteristics

- G01: −5 to +20 mV at a maximum 500 Ω source impedance, with open thermocouple detection.
- G02: −12.5 to +50 mV at a maximum 500 Ω source impedance, with open thermocouple detection.
- G03: −25 to +100 mV at a maximum 1 kΩ source impedance, with open thermocouple detection.
- G04: −12.5 to +50 mVdc at a maximum 500 Ω impedance.
- G05: −25 to +100 mVdc at a maximum 1 kΩ source impedance.

Point Sampling Rate

- 60 Hz: 4 per second
- 50 Hz: 3.4 per second

Resolution

3 bits with polarity.

Input Impedance

0^7 Ω's/V, 10^3 Ω's/V in overload.

Reference Accuracy

±0.1%, ±10 μV, ±LSB at 99.7% confidence (per SAMA Standard PMC 20)

Input Channel Sampling Period

- 60 Hz: 0.20 seconds
- 50 Hz: 0.24 seconds

Auto Calibration Interval

- 60 Hz: Once every 8.0 seconds
- 50 Hz: Once every 9.4 seconds

Normal Mode Rejection

60 dB at 50 or 60 Hz with QTB card line frequency tracking (30 dB without QTB card).

Common Mode Rejection

120 dB at dc and power line frequency with QTB card line frequency tracking (100 dB without QTB card).

Electrical Environment

- IEEE Surge Protected
- Common Mode Voltage: 500 Vdc or peak ac

QAO — Analog Output Card

Process I/O

GENERAL INFORMATION

The QAO card accepts four 12-bit digital signals via the DIOB and individually converts the data to analog field outputs. Each two-wire output (plus shield) has an isolated, digital-to-analog (D/A) converter. Several output ranges are provided for unipolar or bipolar voltage outputs. A light-emitting diode (LED) is used to indicate power-on status.

FUNCTIONAL DESCRIPTION

Digital data from the DIOB is fed to a 4-word by 12-bit memory. The data is periodically multi-plexed to the appropriate point register and presented to the D/A converter. The resultant analog value is buffered and provided at the card edge for transmission to the field process.

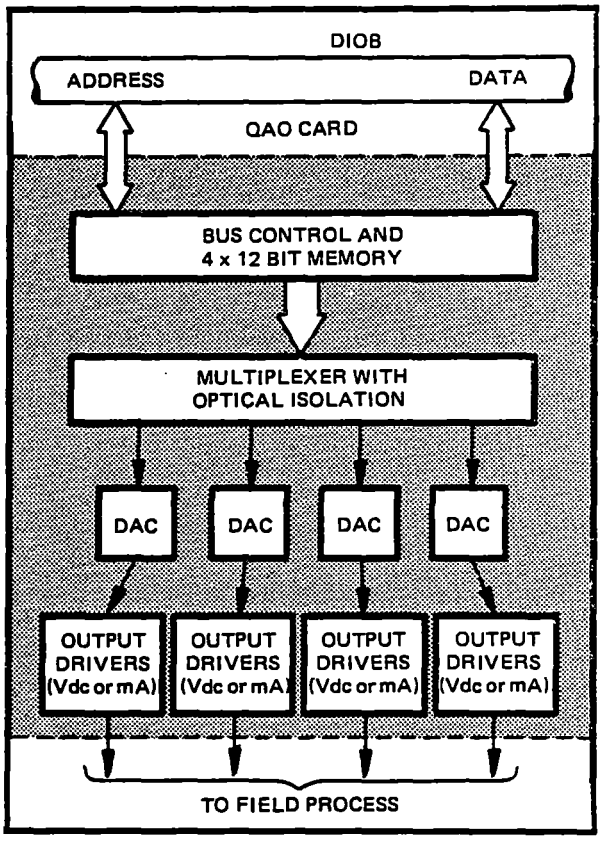
PERFORMANCE SPECIFICATIONS

Power Supply

- Primary: 12.4 Vdc minimum, 13.0 Vdc nominal, 13.1 Vdc maximum
- Backup: 12.4 Vdc minimum, 13.1 Vdc maximum
- Current: 1.3 A maximum

Card Group Characteristics

- G01: 0 to 20.475 mA, 4 points, internally powered
- G02: 0 to 10.2375 Vdc, 4 points
- G03 −10.24 to +10.235 Vdc, 4 points



QAO Block Diagram

- G04: 0 to 5.1187 Vdc, 4 points
- G05: −5.12 to +5.1175 Vdc, 4 points
- G06: −10.24 to +10.235 Vdc single channel 1 point (point 0 only)
- G07: 0 to 20.475 mA, externally powered with 40 Vdc supply, 4 points
- G08: −10.24 to +10.235 Vdc, only one point, high speed synchronized conversion

Input Characteristics

- Resolution: 12 bits (including polarity in bipolar groups)
- Throughput: G01 through G07 — 1.4 msec to 7.4 msec delay G08 — 0.5 to 1.2 msec (G08 should not be written to again for 1.5 msec)

Output Characteristics

- G01, 7 Loading: 0 to 1 kΩ
- G02, 3, 4, 5, 6, 8 Loading: 0 to 20 mA output current with 500 Ω minimum load resistance, short circuit protected
- Reference Accuracy: ±0.05 percent (per SAMA Standard PMC 20)
- Temperature coefficient: 40 ppm of span/°C for voltage outputs, 50 ppm of span/°C for current outputs.
- Adjustments: two potentiometers (per point) for gain and offset are provided.

Electrical Environment

- IEEE Surge Protected (except G08)
- Common mode voltage: 500 Vdc or peak ac (line frequency)

APPENDIX C

LIST OF TEST EQUIPMENT USED IN EMI TESTS

Description	Equipment/Model No.	Test Use
Oscilloscope	Tektronix Model 7704A	Monitor analog data
Differential amplifier	Dynamics model 7526	Analog data buffering signal conditioning to tape recorder
Line voltage regulator	Topaz model 70303	Test setup
Isolation transformer	Topaz model 91001	Test setup
Dual power supply	Tektronix model 5010 0-30V dc	Simulation
Digital multimeter	Fluke model 8502A	Monitor
Potentiometer	–	RTD simulation
Tape recorder	Honeywell model 101 Visicorder	Record, playback
Power amplifier	ENI model 240L	EMI signals
Sine wave generator	Wave Tek model 134	EMI signals
Function generator	Tecktronic model 5010	EMI signals
Bi-conial antenna	Eaton	EMI signals
Log periodic antenna	University of Michigan	EMI signals
Field strength meter	–	EMI signals
Computer	Hewlett-Packard model 9085	EMI signals
Signal generator	Hewlett-Packard model 8658A	EMI signals
Digital voltmeter	Hewlett-Packard model 3437A	EMI signals
Spectrum analyzer	Hewlett-Packard model 182C	EMI signals
Power meter	Hewlett-Packard model 432A	EMI signals

APPENDIX D

ELECTROMAGNETIC INTERFERENCE TEST PROCEDURE FOR WDPF™

Revision No. (0)

1 Introduction

This test procedure is similar to the EMI test procedure given in Reference 3.

This procedure details the Electromagnetic Interference (EMI) tests to be applied to a test configuration representative of a variety of plant equipment arrangements as described in section 4, subsection 4.1.2, of this WCAP. Tests are to be conducted per the intent of SAMA Standard PMC 33.1-1978, level a, b, and c, and bands A, B, and C, (Reference 1).

The test configuration is documented in subsection 2.3 of this WCAP, which become part of these test records as modified by this procedure.

Caution: Test facility regulations are to be followed with regard to personnel safety in radiation fields.

2 Preparation For Test

2.1 Prepare the test configuration simulation connections. Record all supportive test observations including test equipment, description, calibration date, and calibration due date in a "Permanent Record Book."

2.2 Locate the test cabinet and the Compaq personal computer (PC) unit in EMI quiet zone in the anechoic chamber and route field cabling to simulation and test monitor/recording. Connect input equipment in the measurement room and verify system operability as follows:

Switch on the power to the WDPF™, the DPUs, and the Compaq PC. Use the Compaq to down load the operating program in the DPU. Switch on the inputs in the measurements room. Load the monitor program in the Compaq and observe the Compaq screen to check for the correct WDPF™ output values at different operating modes.

Cabinet ground bus is to be connected to facility ground plane via short bonding cables (routed in conduit if necessary). Power line earth grounds should be included in ground plane connections. Equipment ac power is routed below the ground plane and/or flex conduit shielded to the respective equipment under test.

2.2.1 Connect the analog tape recorder and record for 6 minutes.

a. Record the four outputs of the WDPF™. Play back the above recorded measured data and verify calibration of playback data system.

b. Recalibrate, if necessary, and make a "reference" cross calibration. Measured and recorded values should agree within ±0.5 percent.

2.2.2 With equipment in normal operating condition, measure radiated field strength and spectrum emanating from the WDPF™ cabinet at 1 meter from all four sides and above.

3 EMI Test Procedure Sequence

3.1 With DPU and Compaq PC in the "screen" room and simulated field connections and recorders outside and using output measurements and monitor observation, verify "normal" condition of systems per calibration values.

3.2 Verity tape recorder connections.

3.3 Connect EMI antenna source; verify readiness of tape recorder data system. Enter identifying records in tape recorder log.

3.4 Target the antenna to the DPU (or I/O cards) and position the FSM for field measurement. Check the input and output values using the monitor program. Check the video camera and the video monitor and recorder.

3.5 Run the tape recorder for 2 minutes for pretest data, applying EMI source for the time duration of the field level and frequency sweep, and stop the recorder after a 2-minute post-test period. Record all observed effects if any on DPU (or I/O).

3.6 Observing the Compaq screen and the data monitor for system continuity, note and record observations.

3.7 If observation indicates an anomaly during the test, tape-recorded data should be played back on the Visicorder and observations recorded before proceeding.

3.8 Confirm that pretest calibrations are retained ±0.5 percent. Verify that display data supports the calibration data. Record any discrepancies.

3.9 With system confirmed to be in pretest condition, proceed to next test.

4 EMI Test Class 1

4.1 With the DPU front of the cabinet as the target of the test facility antenna, test per sequence 3 above at 3volts/meter horizontal field over frequency band A, 20 to 50 MHz.

4.2 Repeat 4.1 above except band B, 50 to 300 MHz.

4.3 Repeat 4.1 above except band C, 300 to 1000 MHz.

4.4 Repeat 4.1 through 4.3 except doors front and back open. If no observable effect, go to sequence 5, Class 2 test.

4.5 Repeat 4.1 through 4.3 except vertical field.

5 EMI Test Class 2

5.1 With the DPU front of the cabinet as the target of the test facility antenna, test per sequence 3 at 10 volts/meter horizontal field over frequency band A, 20 to 50 MHz.

5.2 Repeat 5.1 above, except band B, 50 to 300 MHz.

5.3 Repeat 5.1 above, except band C, 300 to 1000 MHz.

5.4 Repeat 5.1 through 5.3 except vertical field.

6 Repeat sequence 5 except with cabinet doors front and back in open position.

7 Repeat sequences 5 through 6 except cabinet doors front and back in closed position.

8 Repeat sequences 5 through 6 except CPU back targeted by the antenna.

9 Repeat sequences 5 through 6 except cabinet doors front and back in open position.

10 EMI Test, I/O Cards

10.1 Rearrange antenna and cabinet to target the test field upon the front of the I/O cards and repeat respective test fields and spectrums 4 through 9 (including skip to sequence 5, Class 2 level if "no effect" per 4.4).

11 EMI Class 3 (Optional)

Note: This testing is to be conducted based on having completed tests at Class 2 field levels with minimal effect on system performance (doors closed) to determine operating margins.

11.1 Repeat testing of the DPU and the I/O cards with field and equipment orientations above except field strength to be 20 volts/meter.

11.2 If equipment performance effect is noted under any door closed condition, reduce field level to determine effect threshold level between 10 and 20 volts/meter.

12 Modifications

In the event of unacceptable performance effects at level 1 or 2 field exposures, experimental effort will be undertaken to isolate and/or shield the affected component or components. If possible, duplicate the observed effect with a communication transceiver for subsequent factory testing of production equipment including possible modifications thereof to minimize such effects.

APPENDIX E

LIST OF ELECTROMAGNETIC INTERFERENCE TESTS

The following tables are included in this appendix:

- Table E-1 Electromagnetic Interference Modulation Tests
- Table E-2 Electromagnetic Interference Keying Tests

Table E-1
Electromagnetic Interference Modulation Tests

Test No.	Field	Frequency Band	Antenna	Polarization	Target	Cabinet Doors	Test Results
EMI 1	3 V/m	20-160 MHz	Bi-conical	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 2	3 V/m	20-160 MHz	Bi-conical	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 3	3 V/m	160-500 MHz	Log periodic	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 4	3 V/m	160-500 MHz	Log periodic	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 5	3 V/m	500-1 GHz	Log periodic	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 6	3 V/m	500-1 GHz	Log periodic	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 7	3 V/m	20-160 MHz	Bi-conical	Vertical	DPU (Cabinet Back)	Open	No interference
EMI 8	3 V/m	20-160 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Open	No interference
EMI 9	3 V/m	160-500 MHz	Log periodic	Vertical	DPU (Cabinet Back)	Open	No interference
EMI 10	3 V/m	160-500 MHz	Log periodic	Horizontal	DPU (Cabinet Back)	Open	No interference
EMI 11	3 V/m	500-1 GHz	Log periodic	Vertical	DPU (Cabinet Back)	Open	No interference
EMI 12	3 V/m	500-1 GHz	Log periodic	Horizontal	DPU (Cabinet Back)	Open	No interference
EMI 13	3 V/m	20-160 MHz	Bi-conical	Vertical	DPU (Cabinet Front)	Closed	No interference
EMI 14	3 V/m	20-160 MHz	Bi-conical	Horizontal	DPU (Cabinet Front)	Closed	No interference
EMI 15	3 V/m	160-500 MHz	Log periodic	Vertical	DPU (Cabinet Front)	Closed	No interference
EMI 16	3 V/m	160-500 MHz	Log periodic	Horizontal	DPU (Cabinet Front)	Closed	No interference
EMI 17	3 V/m	500-1 GHz	Log periodic	Vertical	DPU (Cabinet Front)	Closed	No interference
EMI 18	3 V/m	500-1 GHz	Log periodic	Horizontal	DPU (Cabinet Front)	Closed	No interference

Table E-1 (cont)
Electromagnetic Interference Modulation Tests

Test No.	Field	Frequency Band	Antenna	Polarization	Target	Cabinet Doors	Test Results
EMI 19	3 V/m	20-160 MHz	Bi-conical	Vertical	DPU (Cabinet Back)	Closed	No interference
EMI 20	3 V/m	20-160 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Closed	No interference
EMI 21	3 V/m	160-500 MHz	Log periodic	Vertical	DPU (Cabinet Back)	Closed	No interference
EMI 22	3 V/m	160-500 MHz	Log periodic	Horizontal	DPU (Cabinet Back)	Closed	Output (O/P) changes by 1% from 66 to 74 MHz
EMI 23	3 V/m	500-1 GHz	Log periodic	Vertical	DPU (Cabinet Back)	Closed	No interference
EMI 24	3 V/m	500-1 GHz	Log periodic	Horizontal	DPU (Cabinet Back)	Closed	No interference
EMI 25	3 V/m	20-160 MHz	Bi-conical	Vertical	I/O (Cabinet Front)	Open	No interference
EMI 26	3 V/m	20-160 MHz	Bi-conical	Horizontal	I/O (Cabinet Front)	Open	No interference
EMI 27	3 V/m	160-500 MHz	Log periodic	Vertical	I/O (Cabinet Front)	Open	No interference
EMI 28	3 V/m	160-500 MHz	Log periodic	Horizontal	I/O (Cabinet Front)	Open	No interference
EMI 29	3 V/m	500-1 GHz	Log periodic	Vertical	I/O (Cabinet Front)	Open	No interference
EMI 30	3 V/m	500-1 GHz	Log periodic	Horizontal	I/O (Cabinet Front)	Open	No interference

Table E-1 (cont)
Electromagnetic Interference Modulation Tests

Test No.	Field	Frequency Band	Antenna	Polarization	Target	Cabinet Doors	Test Results
EMI 31	3 V/m	20-160 MHz	Bi-conical	Vertical	I/O (Cabinet Back)	Open	No interference
EMI 32	3 V/m	20-160 MHz	Bi-conical	Horizontal	I/O (Cabinet Back)	Open	No interference
EMI 33	3 V/m	160-500 MHz	Log periodic	Vertical	I/O (Cabinet Back)	Open	No interference
EMI 34	3 V/m	160-500 MHz	Log periodic	Horizontal	I/O (Cabinet Back)	Open	No interference
EMI 35	3 V/m	500-1 GHz	Log periodic	Vertical	I/O (Cabinet Back)	Open	No interference
EMI 36	3 V/m	500-1 GHz	Log periodic	Horizontal	I/O (Cabinet Back)	Open	No interference
EMI 37	3 V/m	20-160 MHz	Bi-conical	Vertical	I/O (Cabinet Front)	Closed	No interference
EMI 38	3 V/m	20-160 MHz	Bi-conical	Horizontal	I/O (Cabinet Front)	Closed	No interference
EMI 39	3 V/m	160-500 MHz	Log periodic	Vertical	I/O (Cabinet Front)	Closed	No interference
EMI 40	3 V/m	160-500 MHz	Log periodic	Horizontal	I/O (Cabinet Front)	Closed	No interference
EMI 41	3 V/m	500-1 GHz	Log periodic	Vertical	I/O (Cabinet Front)	Closed	No interference
EMI 42	3 V/m	500-1 GHz	Log periodic	Horizontal	I/O (Cabinet Front)	Closed	No interference
EMI 43	3 V/m	20-160 MHz	Bi-conical	Vertical	I/O (Cabinet Back)	Closed	No interference
EMI 44	3 V/m	20-160 MHz	Bi-conical	Horizontal	I/O (Cabinet Back)	Closed	No interference
EMI 45	3 V/m	160-500 MHz	Log periodic	Vertical	I/O (Cabinet Back)	Closed	No interference
EMI 46	3 V/m	160-500 MHz	Log periodic	Horizontal	I/O (Cabinet Back)	Closed	No interference
EMI 47	3 V/m	500-1 GHz	Log periodic	Vertical	I/O (Cabinet Back)	Closed	No interference
EMI 48	3 V/m	500-1 GHz	Log periodic	Horizontal	I/O (Cabinet Back)	Closed	No interference

Table E-1 (cont)
Electromagnetic Interference Modulation Tests

Test No.	Field	Frequency Band	Antenna	Polarization	Target	Cabinet Doors	Test Results
EMI 49	10 V/	20-160 MHz	Bi-conical	Vertical	DPU (Cabinet Front)	Open	O/P signals are degraded to bad[a] signals from 66 to 74 MHz
EMI 50	10 V/m	20-160 MHz	Bi-conical	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 51	10 V/m	160-500 MHz	Log periodic	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 52	10 V/m	160-500 MHz	Log periodic	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 53	10 V/m	500-1 GHz	Log periodic	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 54	10 V/m	500-1 GHz	Log periodic	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 55	10 V/m	20-160 MHz	Bi-conical	Vertical	DPU (Cabinet Back)	Open	No interference
EMI 56	10 V/m	20-160 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Open	O/P changes by 2% from 66 to 74 MHz
EMI 57	10 V/m	160-500 MHz	Log periodic	Vertical	DPU (Cabinet Back)	Open	No interference
EMI 58	10 V/m	160-500 MHz	Log periodic	Horizontal	DPU (Cabinet Back)	Open	No interference
EMI 59	10 V/m	500-1 GHz	Log periodic	Vertical	DPU (Cabinet Back)	Open	No interference
EMI 60	10 V/m	500-1 GHz	Log periodic	Horizontal	DPU (Cabinet Back)	Open	No interference

a. Bad is a flag that is used by the WDPF™ to indicate that the signal has increased (or decreased) beyond the specified limits.

Table E-1 (cont)
Electromagnetic Interference Modulation Tests

Test No.	Field	Frequency Band	Antenna	Polarization	Target	Cabinet Doors	Test Results
EMI 61	10 V/m	20-160 MHz	Bi-conical	Vertical	DPU (Cabinet Front)	Closed	O/P changes by 2% from 66 to 74 MHz
EMI 62	10 V/m	20-160 MHz	Bi-conical	Horizontal	DPU (Cabinet Front)	Closed	O/P changes by 2% from 66 to 74 MHz
EMI 63	10 V/m	160-500 MHz	Log periodic	Vertical	DPU (Cabinet Front)	Closed	No interference
EMI 64	10 V/m	160-500 MHz	Log periodic	Horizontal	DPU (Cabinet Front)	Closed	No interference
EMI 65	10 V/m	500-1 GHz	Log periodic	Vertical	DPU (Cabinet Front)	Closed	No interference
EMI 66	10 V/m	500-1 GHz	Log periodic	Horizontal	DPU (Cabinet Front)	Closed	No interference
EMI 67	10 V/m	20-160 MHz	Bi-conical	Vertical	DPU (Cabinet Back)	Closed	No interference
EMI 68	10 V/m	20-160 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Closed	O/P changes by 2% from 66 to 74 MHz
EMI 69	10 V/m	160-500 MHz	Log periodic	Vertical	DPU (Cabinet Back)	Closed	No interference
EMI 70	10 V/m	160-500 MHz	Log periodic	Horizontal	DPU (Cabinet Back)	Closed	No interference
EMI 71	10 V/m	500-1 GHz	Log periodic	Vertical	DPU (Cabinet Back)	Closed	No interference
EMI 72	10 V/m	500-1 GHz	Log periodic	Horizontal	DPU (Cabinet Back)	Closed	No interference

Table E-1 (cont)
Electromagnetic Interference Modulation Tests

Test No.	Field	Frequency Band	Antenna	Polarization	Target	Cabinet Doors	Test Results
EMI 73	10 V/m	20-160 MHz	Bi-conical	Vertical	I/O (Cabinet Front)	Open	O/P changes by 2% from 66 to 74 MHz
EMI 74	10 V/m	20-160 MHz	Bi-conical	Horizontal	I/O (Cabinet Front)	Open	O/P changes by 4% from 66 to 74 MHz
EMI 75	10 V/m	160-500 MHz	Log periodic	Vertical	I/O (Cabinet Front)	Open	No interference
EMI 76	10 V/m	160-500 MHz	Log periodic	Horizontal	I/O (Cabinet Front)	Open	No interference
EMI 77	10 V/m	500-1 GHz	Log periodic	Vertical	I/O (Cabinet Front)	Open	No interference
EMI 78	10 V/m	500-1 GHz	Log periodic	Horizontal	I/O (Cabinet Front)	Open	No interference
EMI 79	10 V/m	20-160 MHz	Bi-conical	Vertical	I/O (Cabinet Back)	Open	No interference
EMI 80	10 V/m	20-160 MHz	Bi-conical	Horizontal	I/O (Cabinet Back)	Open	O/P changes by 4% from 71 to 86 MHz
EMI 81	10 V/m	160-500 MHz	Log periodic	Vertical	I/O (Cabinet Back)	Open	No interference
EMI 82	10 V/m	160-500 MHz	Log periodic	Horizontal	I/O (Cabinet Back)	Open	No interference
EMI 83	10 V/m	500-1 GHz	Log periodic	Vertical	I/O (Cabinet Back)	Open	No interference
EMI 84	10 V/m	500-1 GHz	Log periodic	Horizontal	I/O (Cabinet Back)	Open	No interference

Table E-1 (cont)
Electromagnetic Interference Modulation Tests

Test No.	Field	Frequency Band	Antenna	Polarization	Target	Cabinet Doors	Test Results
EMI 85	10 V/m	20-160 MHz	Bi-conical	Vertical	I/O (Cabinet Front)	Closed	O/P changes by 4% from 66 to 82 MHz
EMI 86	10 V/m	20-160 MHz	Bi-conical	Horizontal	I/O (Cabinet Front)	Closed	O/P changes by 2% from 66 to 74 MHz
EMI 87	10 V/m	160-500 MHz	Log periodic	Vertical	I/O (Cabinet Front)	Closed	No interference
EMI 88	10 V/m	160-500 MHz	Log periodic	Horizontal	I/O (Cabinet Front)	Closed	No interference
EMI 89	10 V/m	500-1 GHz	Log periodic	Vertical	I/O (Cabinet Front)	Closed	No interference
EMI 90	10 V/m	500-1 GHz	Log periodic	Horizontal	I/O (Cabinet Front)	Closed	No interference
EMI 91	10 V/m	20-160 MHz	Bi-conical	Vertical	I/O (Cabinet Back)	Closed	No interference
EMI 92	10 V/m	20-160 MHz	Bi-conical	Horizontal	I/O (Cabinet Back)	Closed	O/P changes by 2% at 76 MHz
EMI 93	10 V/m	160-500 MHz	Log periodic	Vertical	I/O (Cabinet Back)	Closed	No interference
EMI 94	10 V/m	160-500 MHz	Log periodic	Horizontal	I/O (Cabinet Back)	Closed	No interference
EMI 95	10 V/m	500-1 GHz	Log periodic	Vertical	I/O (Cabinet Back)	Closed	No interference
EMI 96	10 V/m	500-1 GHz	Log periodic	Horizontal	I/O (Cabinet Back)	Closed	No interference

Table E-1 (cont)
Electromagnetic Interference Modulation Tests

Test No.	Field	Frequency Band	Antenna	Polarization	Target	Cabinet Doors	Test Results
EMI 97	20 V/m	20-160 MHz	Bi-conical	Vertical	DPU (Cabinet Front)	Open	O/P signals are degraded to bad signals from 66 to 86 MHz
EMI 98	20 V/m	20-160 MHz	Bi-conical	Horizontal	DPU (Cabinet Front)	Open	O/P changes by 3% from 66 to 74 MHz
EMI 99	20 V/m	160-500 MHz	Log periodic	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 100	20 V/m	160-500 MIz	Log periodic	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 101	20 V/m	20-160 MHz	Bi-conical	Vertical	DPU (Cabinet Back)	Open	O/P changes by 2% from 66 to 74 MHz
EMI 102	20 V/m	20-160 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Open	O/P signals are degraded to bad signals from 66 to 86 MHz
EMI 103	20 V/m	160-500 MHz	Log periodic	Vertical	DPU (Cabinet Back)	Open	No interference
EMI 104	20 V/m	160-500 MHz	Log periodic	Horizontal	DPU (Cabinet Back)	Open	No interference
EMI 105	20 V/m	20-160 MHz	Bi-conical	Vertical	DPU (Cabinet Front)	Closed	O/P changes by 2% from 66 to 74 MHz
EMI 106	20 V/m	20-160 MHz	Bi-conical	Horizontal	DPU (Cabinet Front)	Closed	O/P changes by 6% from 66 to 74 MHz
EMI 107	20 V/m	160-500 MHz	Log periodic	Vertical	DPU (Cabinet Front)	Closed	No interference
EMI 108	20 V/m	160-500 MHz	Log periodic	Horizontal	DPU (Cabinet Front)	Closed	No interference

Table E-1 (cont)
Electromagnetic Interference Modulation Tests

Test No.	Field	Frequency Band	Antenna	Polarization	Target	Cabinet Doors	Test Results
EMI 109	20 V/m	20-160 MHz	Bi-conical	Vertical	DPU (Cabinet Back)	Closed	O/P signals are degraded to Bad signals from 66 MHz to 86 MHz; O/P goes to zero temporarily at 74 MHz
EMI 110	20 V/m	20-160 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Closed	O/P changes by 6% from 66 to 74 MHz
EMI 111	20 V/m	160-500 MHz	Log periodic	Vertical	DPU (Cabinet Back)	Closed	No interference
EMI 112	20 V/m	160-500 MHz	Log periodic	Horizontal	DPU (Cabinet Back)	Closed	No interference
EMI 113	20 V/m	20-160 MHz	Bi-conical	Vertical	I/O (Cabinet Front)	Open	O/P changes by 2% from 66 to 74 MHz
EMI 114	20 V/m	20-160 MHz	Bi-conical	Horizontal	I/O (Cabinet Front)	Open	O/P changes by 2% from 66 to 74 MHz
EMI 115	20 V/m	160-500 MHz	Log periodic	Vertical	I/O (Cabinet Front)	Open	No interference
EMI 116	20 V/m	160-500 MHz	Log periodic	Horizontal	I/O (Cabinet Front)	Open	No interference
EMI 117	20 V/m	20-160 MHz	Bi-conical	Vertical	I/O (Cabinet Back)	Open	No interference
EMI 118	20 V/m	20-160 MHz	Bi-conical	Horizontal	I/O (Cabinet Back)	Open	No interference
EMI 119	20 V/m	160-500 MHz	Log periodic	Vertical	I/O (Cabinet Back)	Open	No interference
EMI 120	20 V/m	160-500 MHz	Log periodic	Horizontal	I/O (Cabinet Back)	Open	No interference

Table E-1 (cont)
Electromagnetic Interference Modulation Tests

Test No.	Field	Frequency Band	Antenna	Polarization	Target	Cabinet Doors	Test Results
EMI 121	20 V/m	20-160 MHz	Bi-conical	Vertical	I/O (Cabinet Front)	Closed	O/P changes by 2% from 66 to 74 MHz
EMI 122	20 V/m	20-160 MHz	Bi-conical	Horizontal	I/O (Cabinet Front)	Closed	O/P changes by 6% from 70 to 78 MHz
EMI 123	20 V/m	160-500 MHz	Log periodic	Vertical	I/O (Cabinet Front)	Closed	No interference
EMI 124	20 V/m	160-500 MHz	Log periodic	Horizontal	I/O (Cabinet Front)	Closed	No interference
EMI 125	20 V/m	20-160 MHz	Bi-conical	Vertical	I/O (Cabinet Back)	Closed	No interference
EMI 126	20 V/m	20-160 MHz	Bi-conical	Horizontal	I/O (Cabinet Back)	Closed	O/P changes by 2% at 76 MHz
EMI 127	20 V/m	160-500 MHz	Log periodic	Vertical	I/O (Cabinet Back)	Closed	No interference
EMI 128	20 V/m	160-500 MHz	Log periodic	Horizontal	I/O (Cabinet Back)	Closed	No interference

Table E-2
Electromagnetic Interference Keying Tests

Test No.	Field	Frequency Band	Antenna	Polarization	Target	Cabinet Doors	Test Results
EMI 129	10 V/m	180 MHz	Log periodic	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 130	10 V/m	240MHz	Log periodic	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 131	10 V/m	308 MHz	Log periodic	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 132	10 V/m	324 MHz	Log periodic	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 133	10 V/m	440 MHz	Log periodic	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 134	10 V/m	496 MHz	Log periodic	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 135	10 V/m	656 MHz	Log periodic	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 136	10 V/m	832 MHz	Log periodic	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 137	10 V/m	832 MHz	Log periodic	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 138	10 V/m	656 MHz	Log periodic	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 139	10 V/m	180 MHz	Log periodic	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 140	10 V/m	240 MHz	Log periodic	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 141	10 V/m	308 MHz	Log periodic	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 142	10 V/m	384 MHz	Log periodic	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 143	10 V/m	440 MHz	Log periodic	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 144	10 V/m	496 MHz	Log periodic	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 145	10 V/m	22 MHz	Bi-conical	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 146	10 V/m	28 MHz	Bi-conical	Horizontal	DPU (Cabinet Front)	Open	No interference

Table E-2 (cont)
Electromagnetic Interference Keying Tests

Test No.	Field	Frequency Band	Antenna	Polarization	Target	Cabinet Doors	Test Results
EMI 147	10 V/m	34 MHz	Bi-conical	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 148	10 V/m	45 MHz	Bi-conical	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 149	10 V/m	66 MHz	Bi-conical	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 150	10 V/m	70 MHz	Bi-conical	Horizontal	DPU (Cabinet Front)	Open	O/P signals are degraded to bad signals due to interference
EMI 151	10 V/m	86 MHz	Bi-conical	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 152	10 V/m	110 MHz	Bi-conical	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 153	10 V/m	140 MHz	Bi-conical	Horizontal	DPU (Cabinet Front)	Open	No interference
EMI 154	10 V/m	22 MHz	Bi-conical	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 155	10 V/m	28 MHz	Bi-conical	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 156	10 V/m	34 MHz	Bi-conical	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 157	10 V/m	45 MHz	Bi-conical	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 158	10 V/m	60 MHz	Bi-conical	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 159	10 V/m	70 MHz	Bi-conical	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 160	10 V/m	86 MHz	Bi-conical	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 161	10 V/m	110 MHz	Bi-conical	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 162	10 V/m	140 MHz	Bi-conical	Vertical	DPU (Cabinet Front)	Open	No interference
EMI 163	20 V/m	22 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Closed	No interference
EMI 164	20 V/m	28 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Closed	No interference

Table E-2 (cont)
Electromagnetic Interference Keying Tests

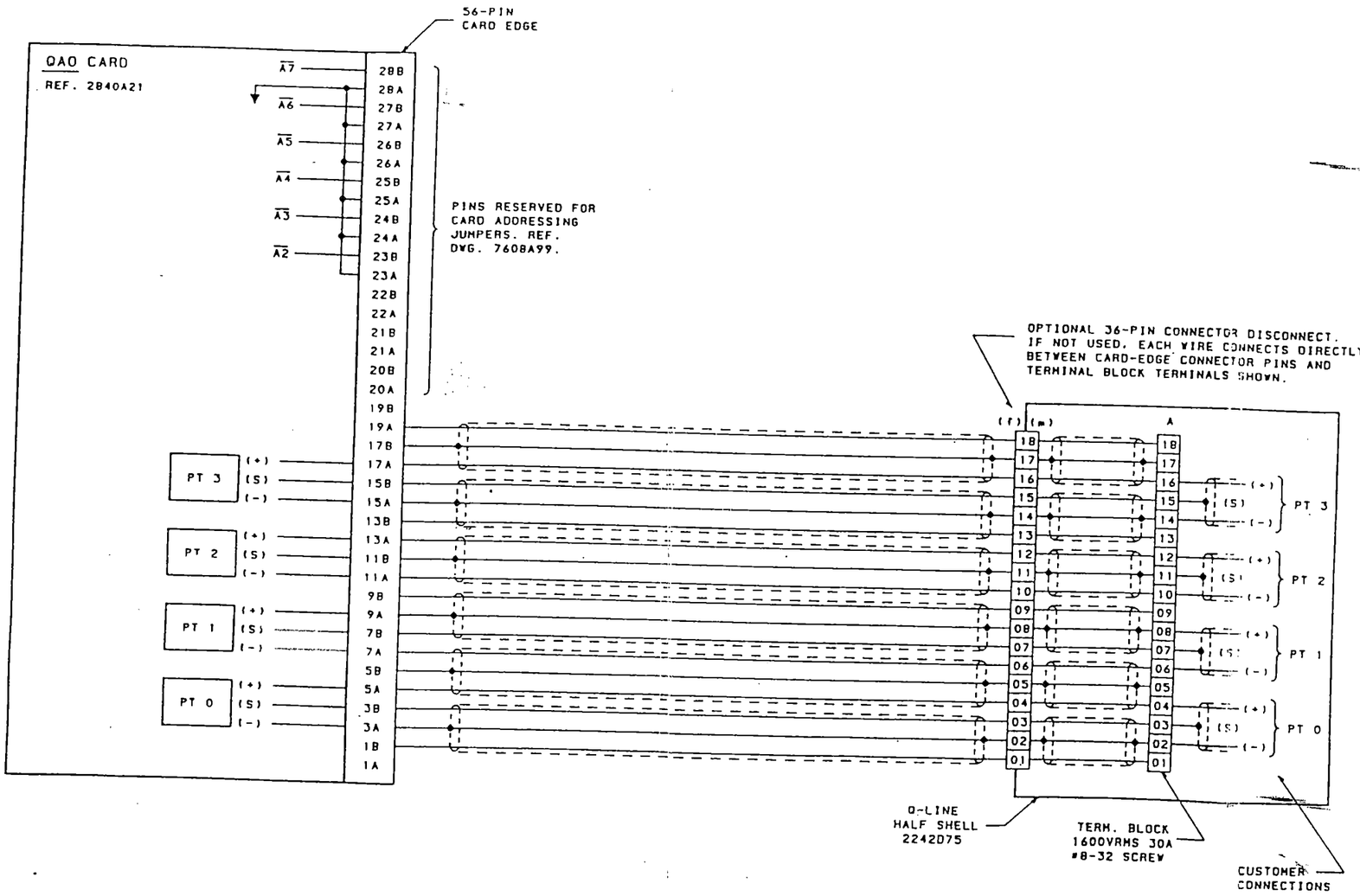
Test No.	Field	Frequency Band	Antenna	Polarization	Target	Cabinet Doors	Test Results
EMI 165	20 V/m	34 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Closed	No interference
EMI 166	20 V/m	45 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Closed	No interference
EMI 167	20 V/m	60 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Closed	No interference
EMI 168	20 V/m	66 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Closed	O/P signals are degraded to bad signals due to interference
EMI 169	20 V/m	70 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Closed	O/P changes by 6%
EMI 170	20 V/m	86 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Closed	O/P changes by 2% due to interference
EMI 171	20 V/m	110 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Closed	No interference
EMI 172	20 V/m	140 MHz	Bi-conical	Horizontal	DPU (Cabinet Back)	Closed	No interference
EMI 173	20 V/m	22 MHz	Bi-conical	Vertical	DPU (Cabinet Back)	Closed	No interference
EMI 174	20 V/m	28 MHz	Bi-conical	Vertical	DPU (Cabinet Back)	Closed	No interference
EMI 175	20 V/m	34 MHz	Bi-conical	Vertical	DPU (Cabinet Back)	Closed	No interference
EMI 176	20 V/m	45 MHz	Bi-conical	Vertical	DPU (Cabinet Back)	Closed	No interference
EMI 177	20 V/m	66 MHz	Bi-conical	Vertical	DPU (Cabinet Back)	Closed	O/P changes by 2% due to interference
EMI 178	20 V/m	70 MHz	Bi-conical	Vertical	DPU (Cabinet Back)	Closed	No interference
EMI 179	20 V/m	86 MHz	Bi-conical	Vertical	DPU (Cabinet Back)	Closed	No interference
EMI 180	20 V/m	110 MHz	Bi-conical	Vertical	DPU (Cabinet Back)	Closed	No interference
EMI 181	20 V/m	140 MHz	Bi-conical	Vertical	DPU (Cabinet Back)	Closed	No interference

APPENDIX F

FIELD CONNECTIONS TO THE I/O CARDS

The following figures are included in this appendix:

- Figure F-1. Standard Termination Schematic Analog Input Cards - QAV/QAW
- Figure F-2. Standard Termination Schematic Analog Output Card - QAO



CABLES

7855A53607: CARD EDGE TO TERMINAL BLOCK A (RIGHT H.S.)
7855A53608: CARD EDGE TO TERMINAL BLOCK A (LEFT H.S.)
5258A23 (QB002E): CARD EDGE TO 36-PIN CONNECTOR

Figure F-2. Standard Termination Schematic Analog Output Card - QAO

SI
APERTURE
CARD

Also Available On
Aperture Card

9304210007-01

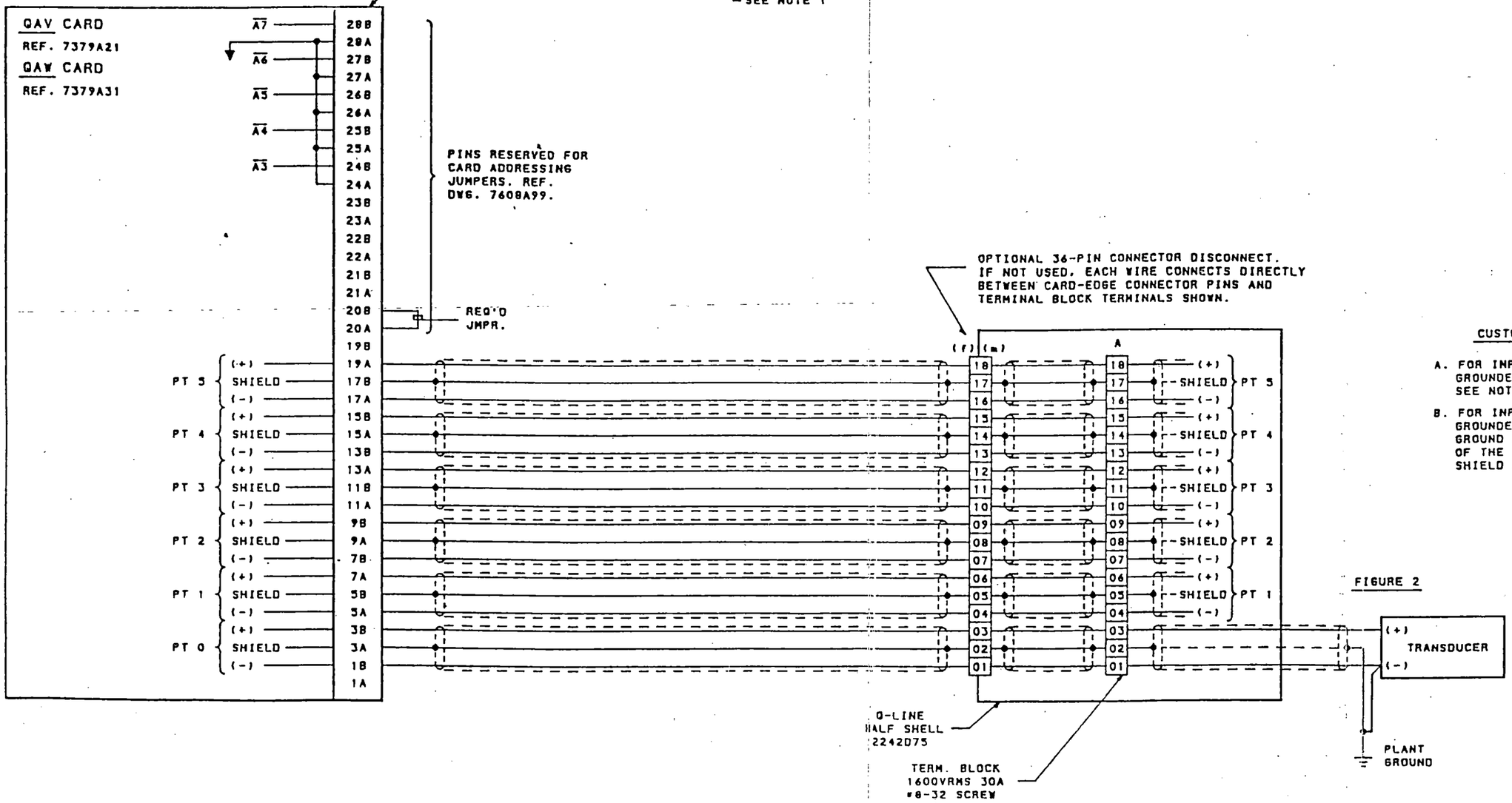
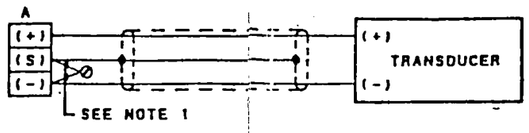


FIGURE 1



NOTE 1: IF THE INPUT SIGNAL IS TO BE GROUNDED AT THE COMPUTER (RATHER THAN AT THE TRANSDUCER OR ELSEWHERE IN THE PLANT), INSERT A NO.6 SCREW AND NUT IN THE HOLE LOCATED NEAR THE SHIELD TERMINAL ON TERMINAL BLOCK A. THEN ADD TWO JUMPERS, AS SHOWN IN FIGURE 1. (SIX HOLES, LOCATED NEXT TO TERMINALS 2,5, 8,11,14 & 17 OF TERMINAL BLOCK A, HAVE BEEN DRILLED IN THE HALF-SHELL METAL FOR THIS PURPOSE).

SI
APERTURE
CARD

Also Available On
Aperture Card

CUSTOMER CONNECTIONS

A. FOR INPUTS THAT ARE TO BE GROUNDED AT THE COMPUTER, SEE NOTE 1 AND FIGURE 1.

B. FOR INPUTS THAT ARE TO BE GROUNDED AT THE SIGNAL SOURCE, GROUND BOTH THE NEGATIVE SIDE OF THE SIGNAL AND THE CABLE SHIELD AS SHOWN IN FIGURE 2.

FIGURE 2

CABLES

3A33607: CARD EDGE TO TERMINAL BLOCK A (RIGHT H.S.)
3A33608: CARD EDGE TO TERMINAL BLOCK A (LEFT H.S.)
8A25 (Q8002E): CARD EDGE TO 36-PIN CONNECTOR

GENERAL NOTE

THE INPUT CIRCUITS OF EACH CHANNEL OF THE QAV AND QAW CARDS ARE GALVANICALLY ISOLATED AND COMPLETELY FLOATING IN ORDER TO PROVIDE HIGH COMMON-MODE REJECTION AND TO FACILITATE A FLEXIBLE SYSTEM GROUNDING SCHEME.

Figure F-1. Standard Termination Schematic
Analog Input Cards - QAV/QAW

930421000 7-02