GEND-INF--017 Vol. 9

DE82 010678

GEND-INF-017
Volume IX

FIELD MEASUREMENTS AND INTERPRETATION OF TMI-2 INSTRUMENTATION: HP-R-213

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January 1982

Published on Behalf of the GEND Group
by
EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

Prepared for the
U.S. Department of Energy
Three Mile Island Operations Office
Under DOE Contract No. DE-AC07-76IDO1570

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1. INTRODUCTION

During and following the TMI-2 accident, a number of instruments failed or were suspected of providing erroneous readings. Because of this problem, industry concerns were focused upon the behavior of instrumentation under adverse conditions. To better understand failure mechanisms, the Technical Integration Office (TIO) contracted Technology for Energy Corporation (TEC) to perform field measurements on a set of selected TMI-2 instruments to determine in-situ operating characteristics. For some instruments, these measurements were to be performed prior to removal (and replacement with new instruments) in order to have a cross reference with post-removal observations. For other instruments, an indication of the condition of the instrument (i.e., fully operational or failed) was desired.

This report provides the information gathered by TEC on the area radiation monitor HP-R-213. This detector was located at 347 feet elevation inside containment. This instrument consisted of a Victoreen Model 857-2 detector assembly connected to a Victoreen Model 856-2 panel alarm and approximately 330 feet of interconnecting cable. This instrument was believed to have failed due to a constant off-scale low radiation level indication and due to a lack of response to the manually activated checksource in the detector. As a result of this failure, the detector was a candidate for early replacement to provide long-term radiation monitoring capability inside containment.

2. INSTRUMENT LOCATION, CABLING, AND TERMINATIONS

A review of appropriate drawings from Victoreen and Burns & Roe (itemized in the Appendix in the measurement procedure, page A-5) resulted in the composite electrical diagram shown in Figure 2-1. From this information, Table 2-1 gives a list of the appropriate termination points for performing measurements in the Control Room in Cabinet 12. Also noted in Figure 2-1 are the cable lengths pulled during instrument installation (before final trimming) between each termination and/or junction point.

The detector assembly is a Victoreen Model 857-2 which is shown in Figure 2-2 along with required interfacing connections to the readout module. Figure 2-3 shows the functional layout of the detector and associated readout module. This assembly is a "medium range" device with a range of 0.1 to 10^4 mR/hr. An electrical diagram of the detector circuit is shown in Figure 2-4. As shown in Figure 2-1, the circuit is somewhat complicated by the presence of a remote alarm/meter and a second remote alarm which are used as local indicators of the radiation levels.

Since measurements were being made in the control room, there was no way to remove the effect of the remote alarm/meter (attached to the signal line) from the observed instrument response. However, since the remote alarm/meter was located outside containment, it did not experience the severe operating environments and thus was not considered to present any measurement problems. (The remote alarm was located inside containment,

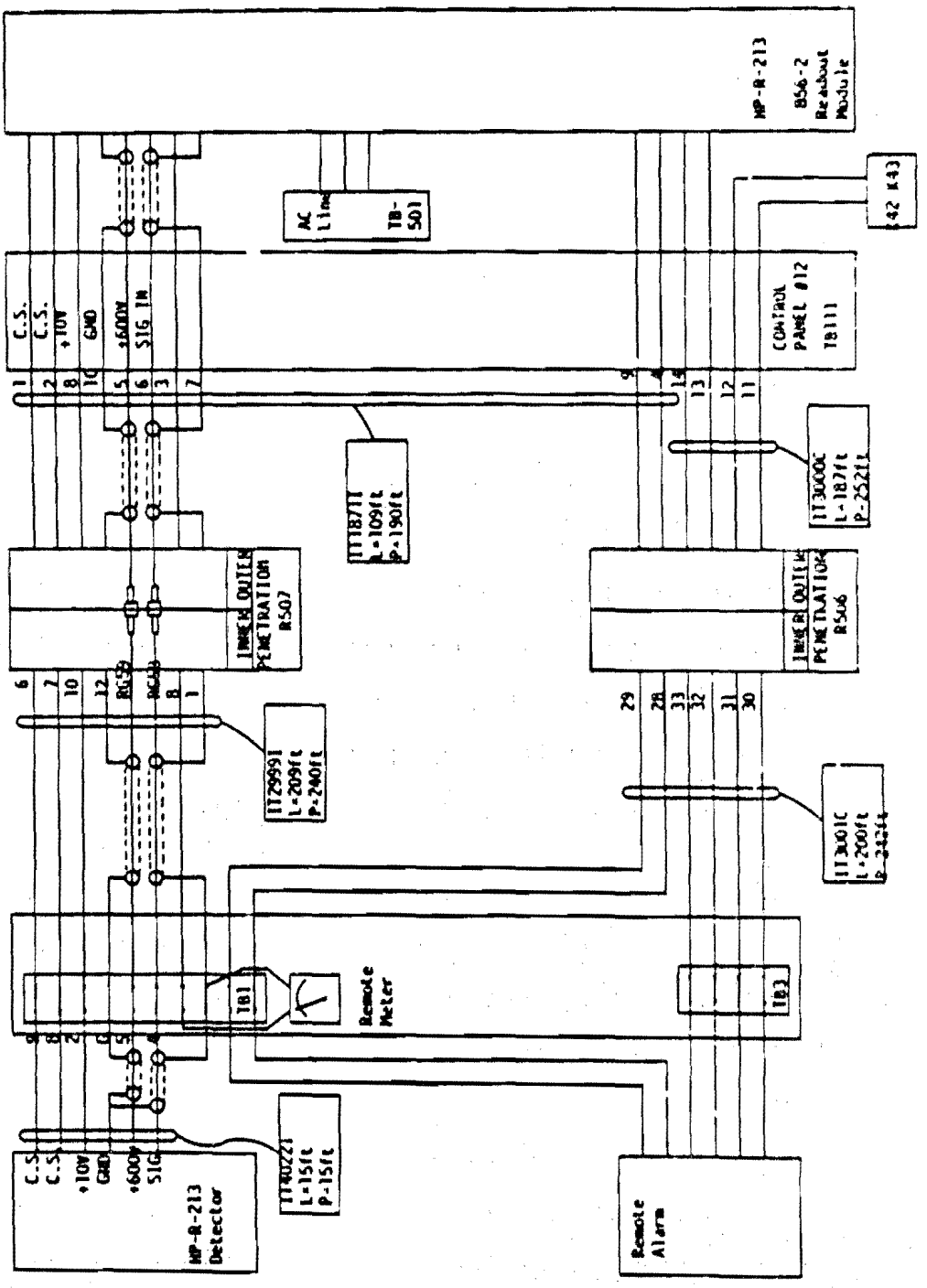


Figure 2-1. HP-R-213 Composite Electrical Diagram.

Table 2-1

TERMINATION POINTS FOR HP-R-213 MEASUREMENTS

Signal	Cabinet 12 Identification*
+10V Power Supply	TB111-8
+600V High Voltage	TB111-5
Signal In	TB111-6
Ground	TB111-10
CS**	TB111-1
CS**	TB111-2

*From cable IT1870I

**CS = Checksource coil positive and return contacts (exact identification not necessary).

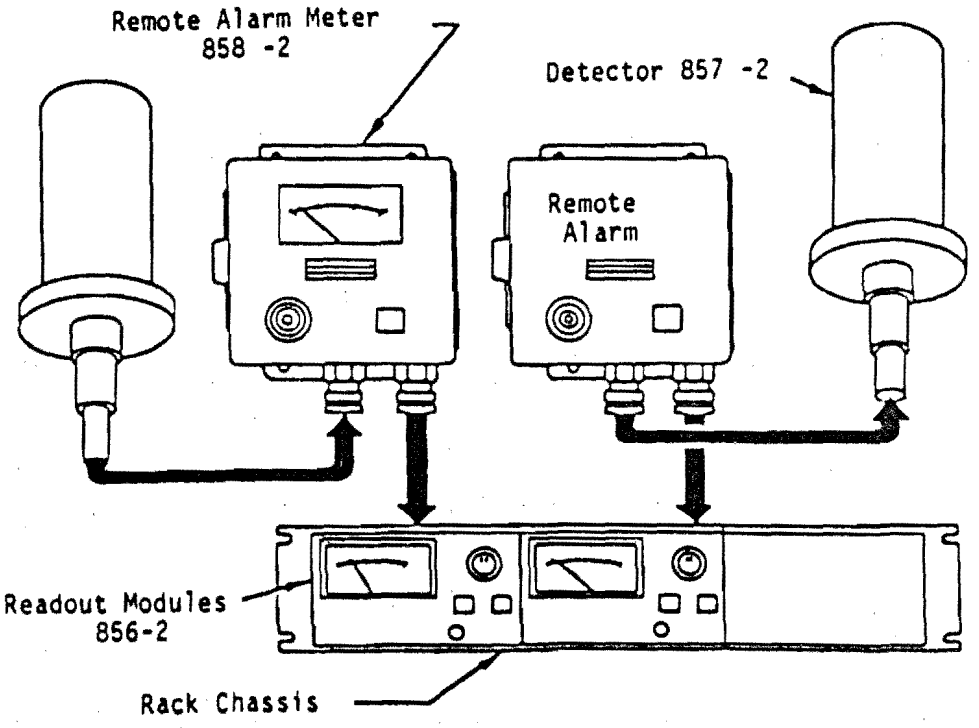


Figure 2-2. Sketch of Instrumentation for HP-R-213

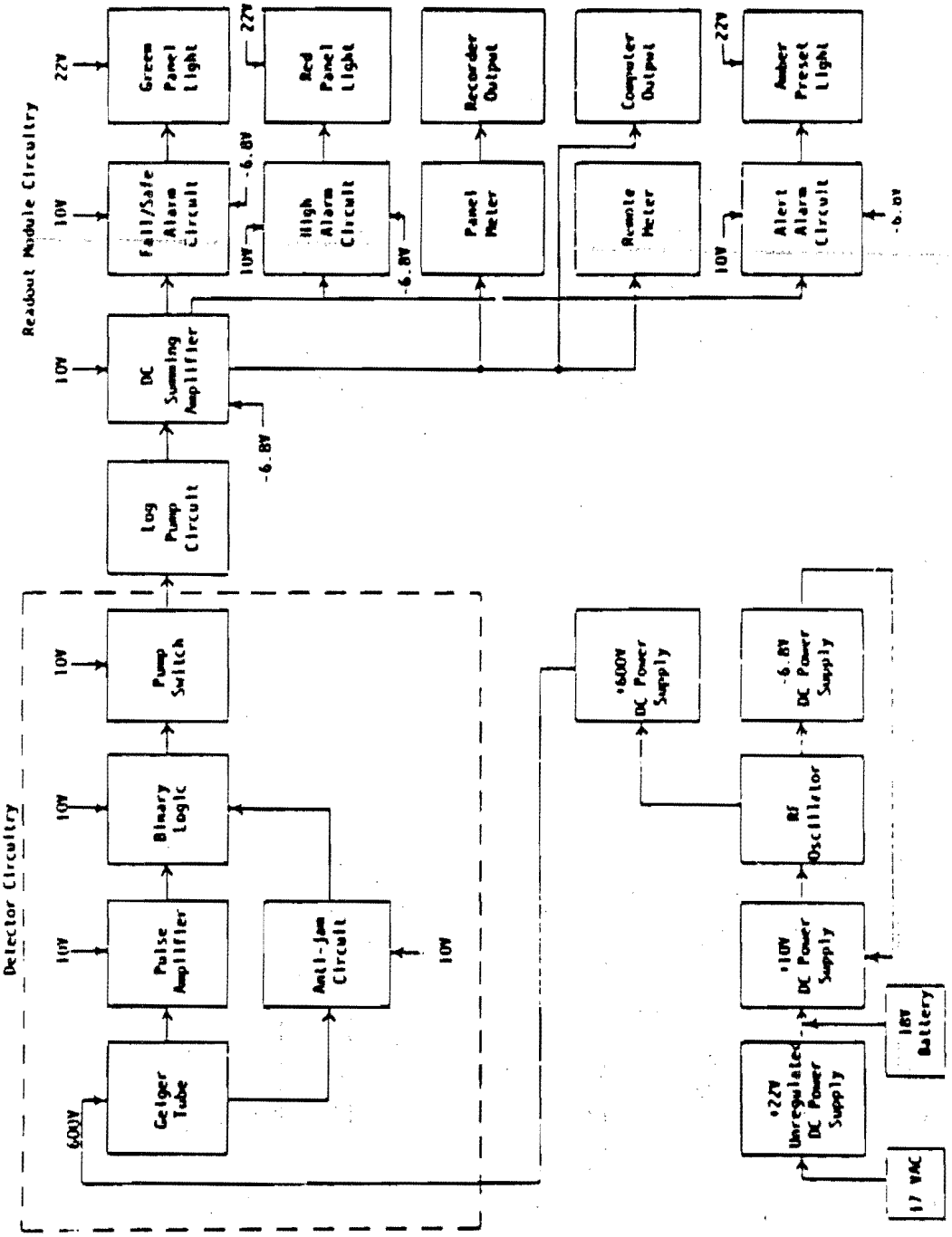


Figure 2-3 Functional Layout of Detector and Readout Module.

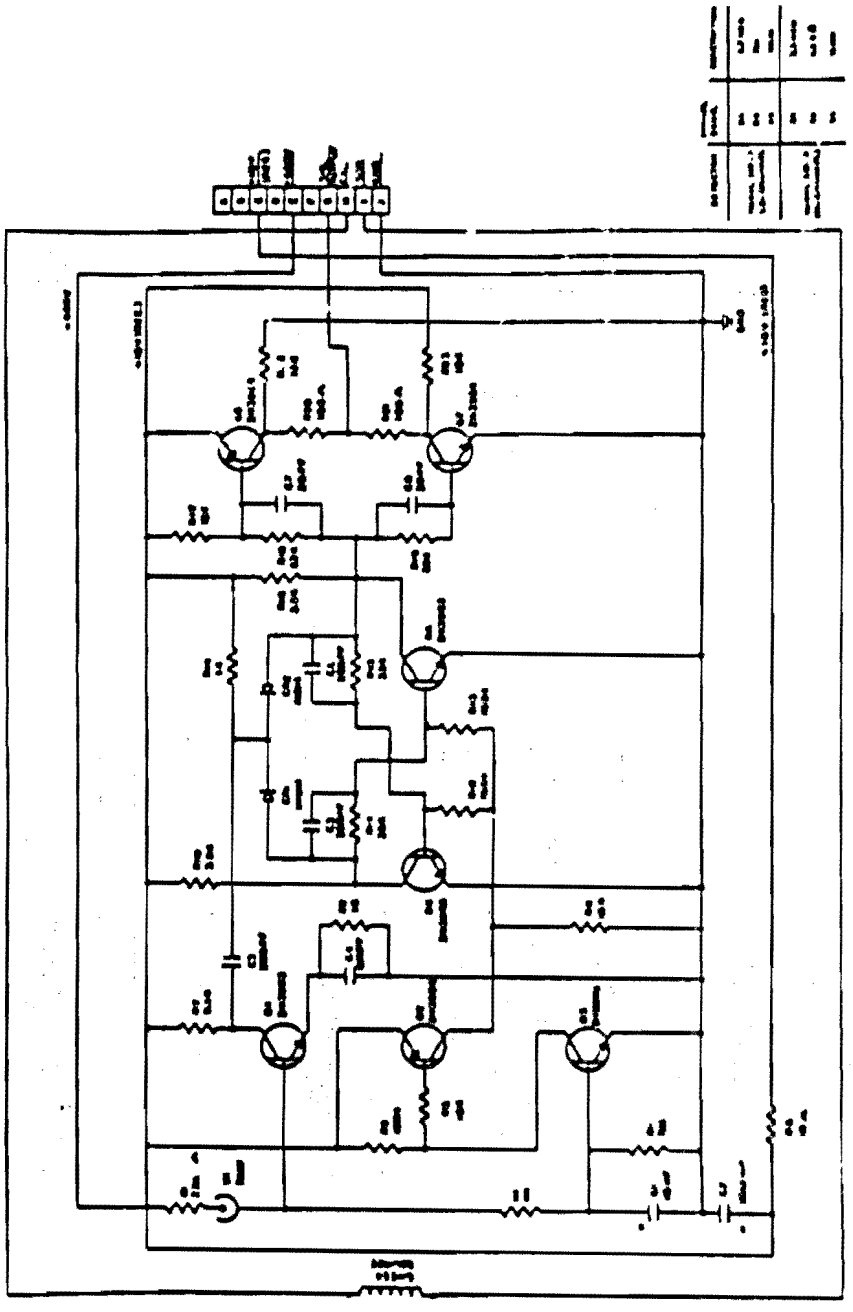


Figure 2-4. Electrical Circuit of Detector Card

but was isolated from the signal line by the remote alarm/meter circuitry.) Similarly, the Model 856-2 Readout Module, located in the control room, was not specifically considered to be a source of instrumentation problems except in its function of supplying power to the detector assembly.

3. PREPARATION OF MEASUREMENT PROCEDURES

As a result of generating the composite electrical diagram and from a review of the Victoreen Area Monitor Operation Manual, the major types of measurements to be performed were identified as:

1. Determine as-found condition of Readout Module and Remote Meter and record signal output

2. Perform passive measurements (i.e., passively monitor signals) on each electrical connection consisting of time domain waveforms, very-high frequency spectrum analysis (i.e., MHz region), and frequency spectra below 100 kHz

3. Perform resistance, capacitance, impedance, and Time Domain Reflectometry (TDR) active measurements (i.e., actively introducing a test signal).

These measurements were designed to verify the operation of the Readout Module (especially the power supplies), but the focus of the measurement was on the detector assembly, cabling, and terminations/connections to the assembly. The Appendix contains the detailed procedure which was followed during the measurement program, and a summary of measurements is presented in the next section.

4. MEASUREMENTS

Since the output of HP-R-213 was designed to cover the range of 0 to +10 volts, the signal could be directly measured without amplification. Before performing measurements, the readout of HP-R-213 indicated an off-scale low value of less than 0.1 mR/hr for the gamma dose inside containment. Activation of the checksource had no effect on the output reading. The Signal In was then recorded for approximately 10 minutes on an FM recorder and various outputs measured with a DVM. These measurements yielded the following results:

10 V power Supply @ 11.1 V

Signal IN @ 10.96 VDC

600 V Power Supply @ 599 VDC

Checksource @ 15.0 ma

The next measurements consisted of photographing the output waveforms of the checksource, Signal In, and power supplies from a storage oscilloscope. Figures 4-1 to 4-6 show the results of these time trace measurements. Along with the time traces, both high and low frequency spectra (frequency domain) were taken of the Signal In and power supplies. Figures 4-7 to 4-9 show the measured spectra over high frequency bandwidths (>1 MHz), while Figures 4-10 to 4-12 show spectra over bandwidths below 100 kHz.

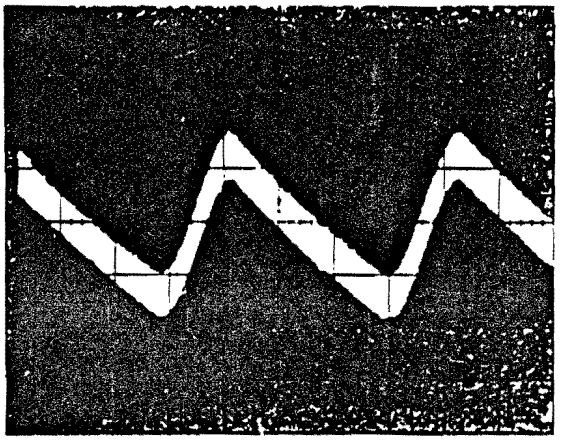


Photo #103-1

Time-2msec

Gain - 50 mV

TB111-1 to

TB111-10

Check Source

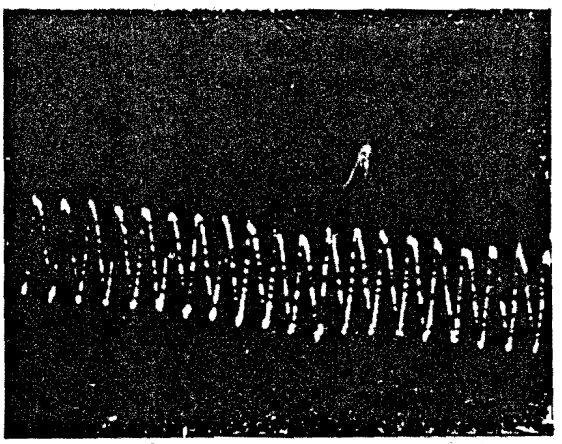


Photo #103-2

Time - 0.1 msec

Gain - 50 mV

TB111-1 to

TB111-10

Check Source

Figure 4-1. Typical Fluctuations Present on Checksource Line 1.

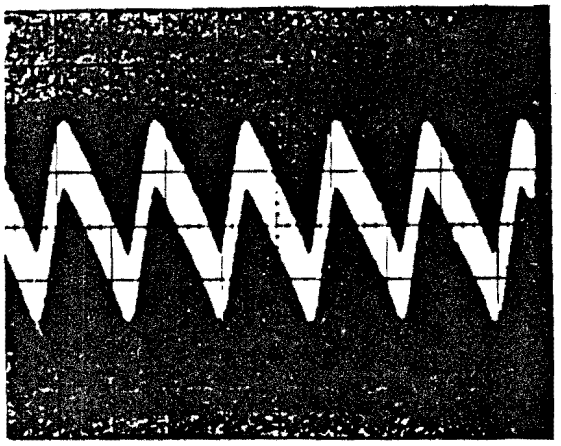


Photo #103-3

Time base - 2msec

Gain - 50 mV

TB111-2 to

TB111-10

Check Source

Figure 4-2. Typical Fluctuations Present on Checksource Line 2.

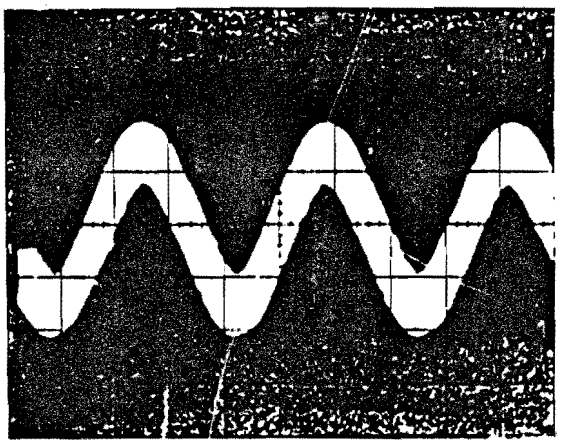


Photo #103-4

Time - 0.1 msec

Gain - 20mV

TB111-5 to

TB111-10

+600V

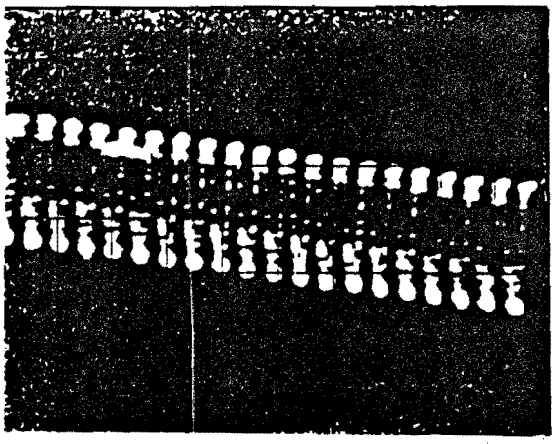


Photo #103-5

Time - 5 msec

Gain - 50mV

TB111-5 to

TB111-10

+600V

Figure 4-3. AC Variations on the 600V Power Supply.

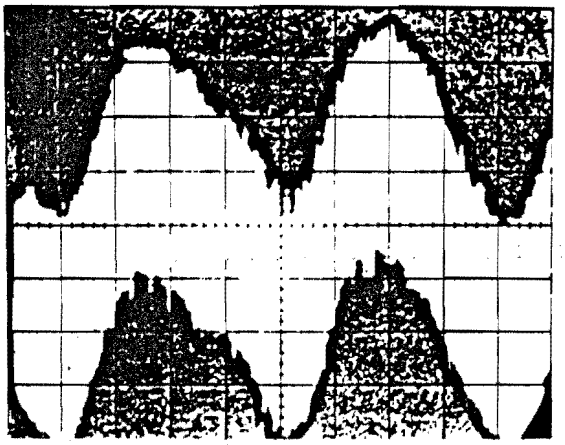


Photo #103-6

Time - 2msec

Gain - 2 mV

TB111-6 to

TB111-10

Signal

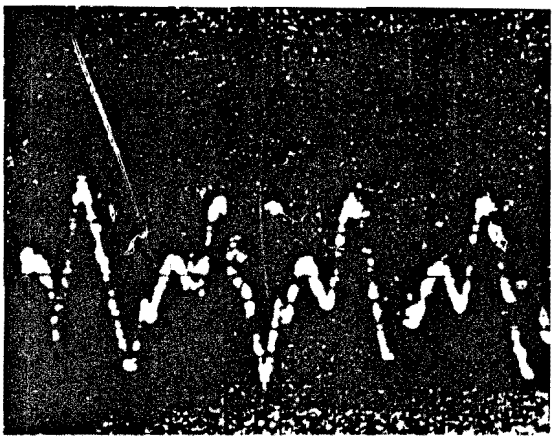


Photo #103-7

Time - 20µsec

Gain - 2 mV

TB111-6 to

TB111-10

Signal

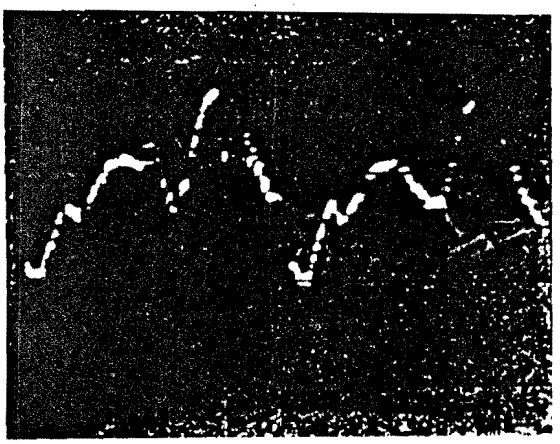


Photo #103-8

Time - 10µsec

Gain - 2 mV

TB111-6 to

TB111-10

Signal

Figure 4-4. AC Variations on the Signal Output.

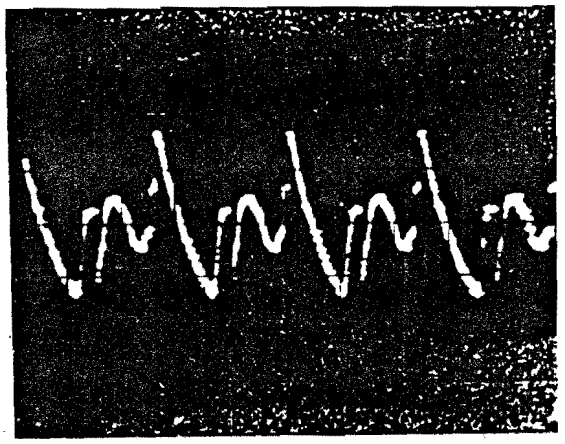


Photo #103-9

Time - 20μsec

Gain - 50 mV

TB111-8 to

TB111-10

+10V

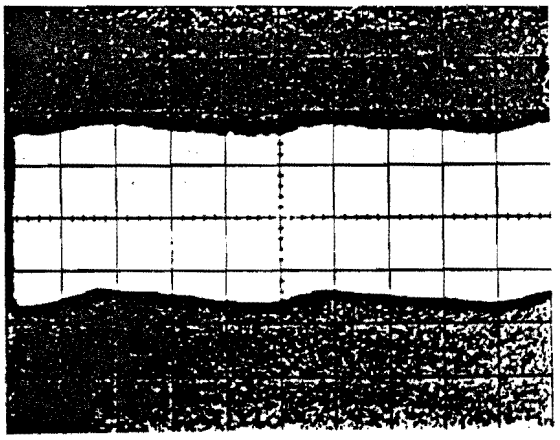


Photo #103-10

Time - 2msec

Gain - 50 mV

TB111-8 to

TB111-10

+10V

Figure 4-5. AC Variations on the 10V Power Supply.

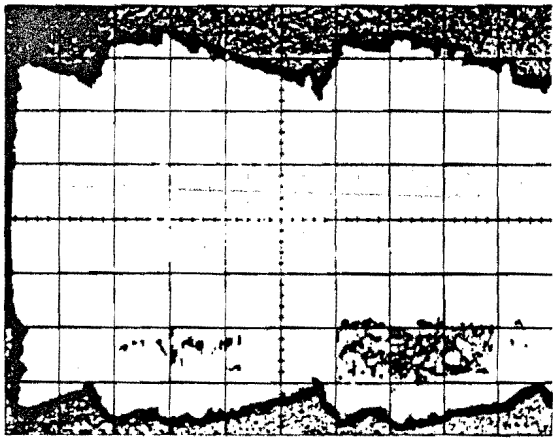


Photo #103-11

Time - 2msec

Gain - 0.1V

TB111-10 to

TB501-33

GND

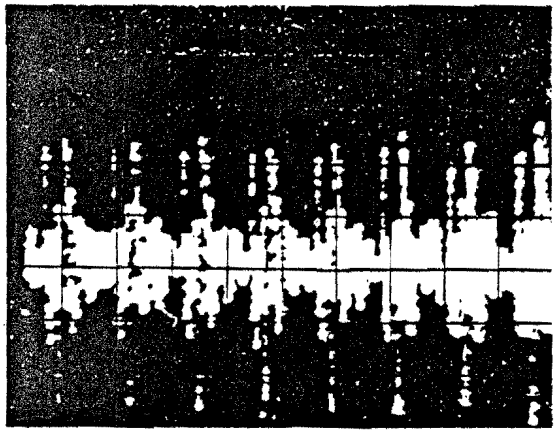


Photo #103-12

Time - 50μsec

Gain - 0.1V

TB111-10 to

TB501-33

GND

Figure 4-6. Typical Fluctuations Present Between Ground-AC Ground.

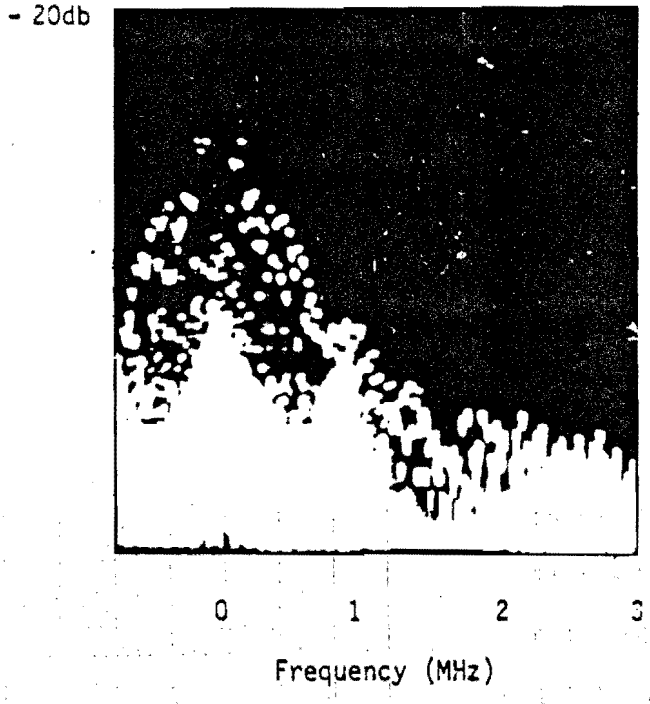


Photo #103-13

BW-1 kHz

Scan time - 1sec

Scan width - 0.5 MHz

Attn - 0

Log Ref --20db

TB111-8 to

TB111-10

+10V

Figure 4-7. High Frequency Spectrum of 10V Power Supply.

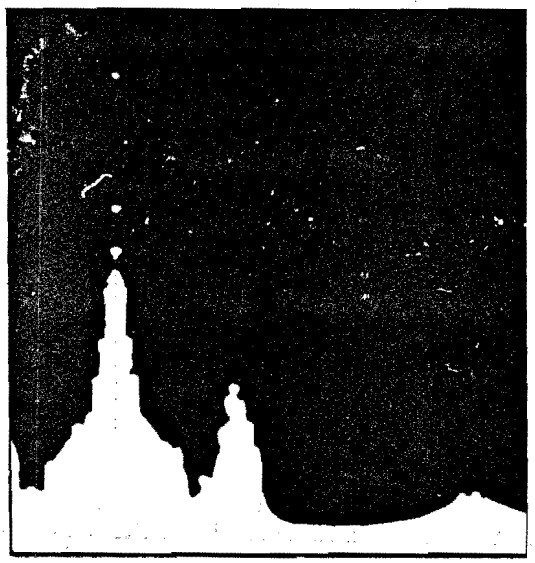


Photo #103-14

BW-1 kHz

Scan time - 1sec

Scan width - 0.5 MHz

Attn - 0

Log Ref - -20db

TB111-6 to

TB111-10

Signal In

Figure 4-8. High Frequency Spectrum of Signal Output.

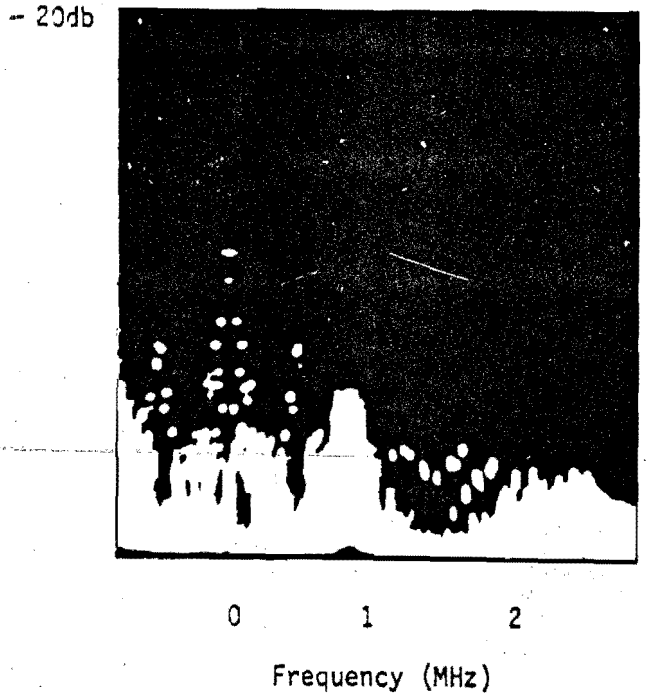


Figure 4-9. High Frequency Spectrum of 600V Power Supply.

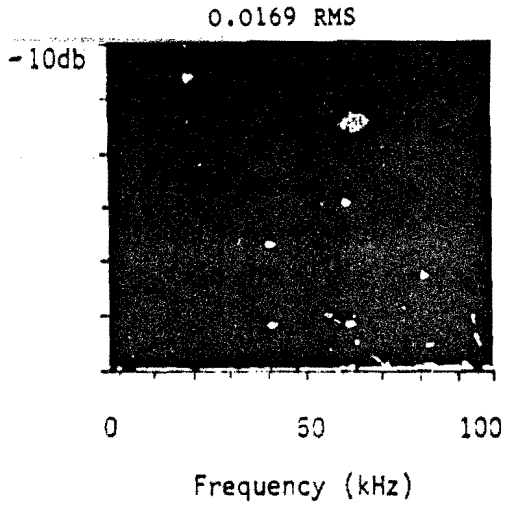


Photo #103-18

+600V

+10db Reference

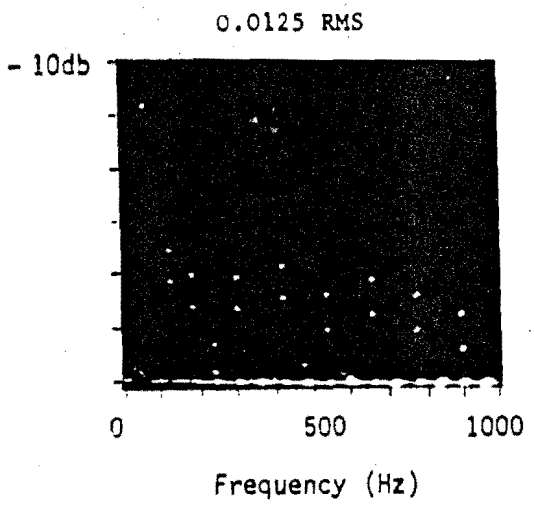


Photo #103-19

+600V

+10db Reference

Figure 4-10. Low Frequency Spectra of 600V Power Supply.

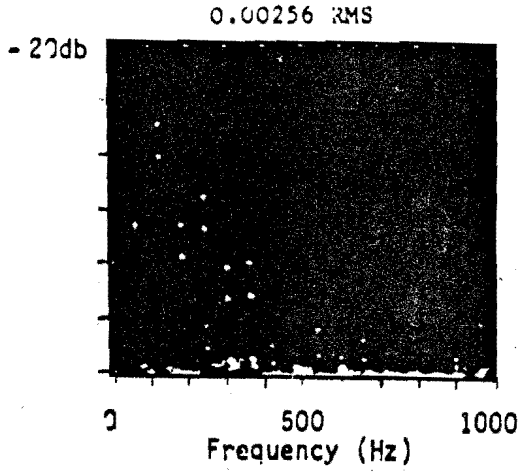


Photo #103-20

Signal In

+20db Reference

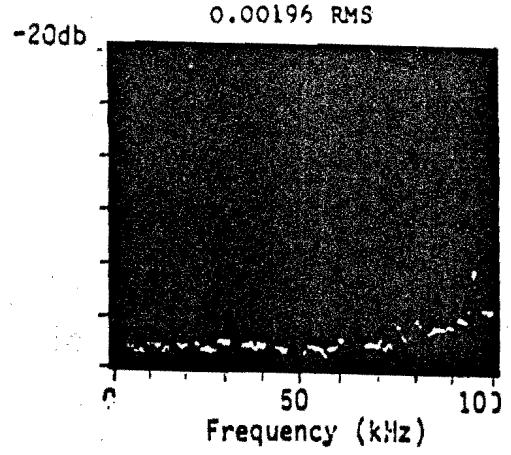


Photo #103-21

Signal In

+20db Reference

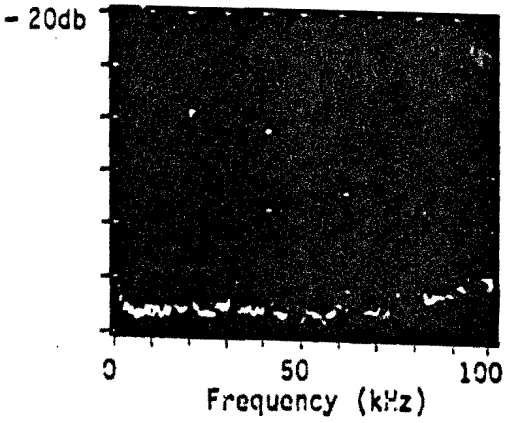


Photo #103-

Signal

+20db Reference

Figure 4-11. Low Frequency Spectra of Signal Output.

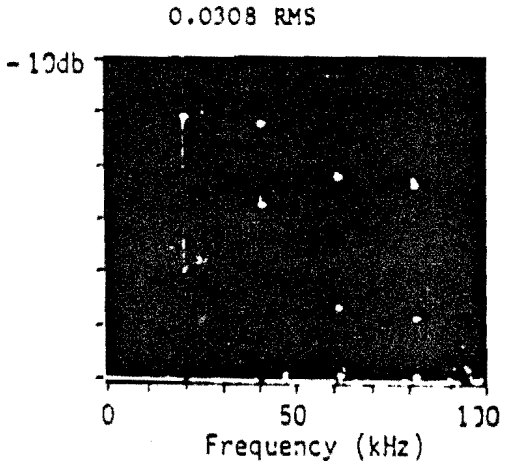


Photo #103-23

+10V

+10db Reference

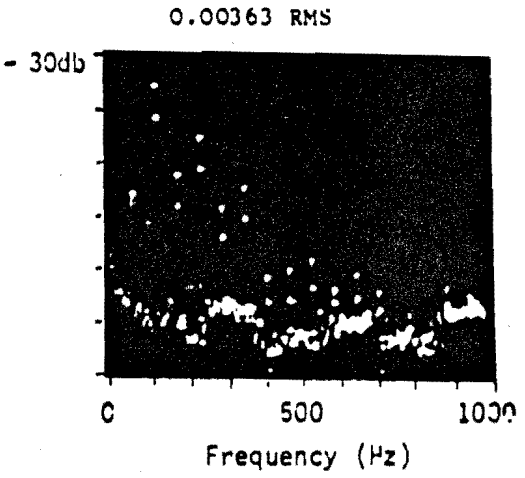


Photo #103-24

+10V

+30db Reference

Figure 4-12. Low Frequency Spectra of 10V Power Supply.

Following the frequency spectra measurements, electrical calibration was requested for the HP-R-213 readout module. During attempted calibration, a problem was identified in the readout module, but was not corrected due to other tasks requiring the attention of TMI technicians. Data from the instrument repair was then requested but not received. After attempting electrical calibration, power was removed from HP-R-213. The test fixture was removed and all signal lines from cable IT1871I to cabinet 12 were disconnected. A series of active measurements (i.e., actively introducing a test signal into the circuit) was then performed. Table 4-1 shows the results of capacitance, impedance, and DC resistance measurements on some of the field cable lines (see Appendix pages A-14 and A-16 for a complete set). A set of TDR measurements were taken on the signal lines to determine possible cable defects. These TDR traces are shown in Figures 4-13 to 4-16.

Table 4-1

CAPACITANCE, IMPEDANCE, AND RESISTANCE MEASUREMENTS

Signal	Capacitance (nF)			Impedance (ohms)			Resistance (ohms)*
	100 Hz	1 kHz	100 kHz	100 Hz	1 kHz	100 kHz	
Checksource (+) Checksource (-)	-2.8 µF	-5.8 µF	3.5	40.0	4.88	4.48	41 (41)
+600 V Ground	VAR**	10	10.5	OF+	16K	152	>2 M
Signal In	VAR	7.9	6.9	OF	OF	229	9.2K (8.6k)
+10 V Ground	96 µF	119 µF	-47	22.5	14.7	38	12.5K (8.3K)
Ground (field) Ground (cabinet)	VAR	53 µF	26.7	1.2K	960	70	--
Signal In +10 V	--	--	--	--	--	--	8.8K (7.2K)

*Values in parentheses are reverse polarity values.

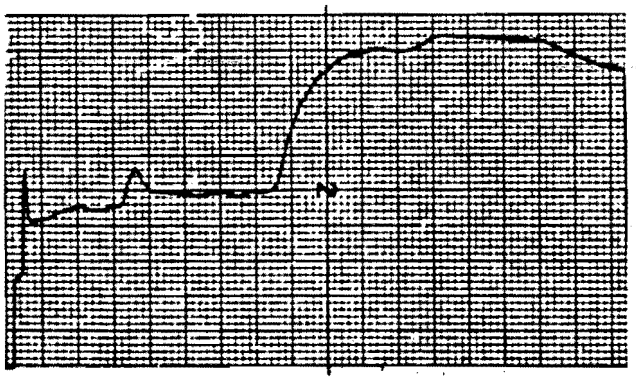
**Indicates variable response.

+ Indicates off-scale reading or excessive line noise.

STRIP CHART 103-1

TB111: 1 to 2

Signal - Check Source



Setting - 500mp/div

Range - 52.6 ft/div

15 hz filter

2nd plot begins @350 ft.

Cable dielectric - other

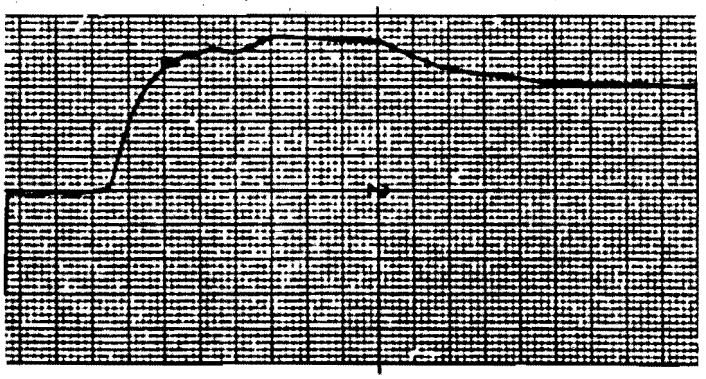
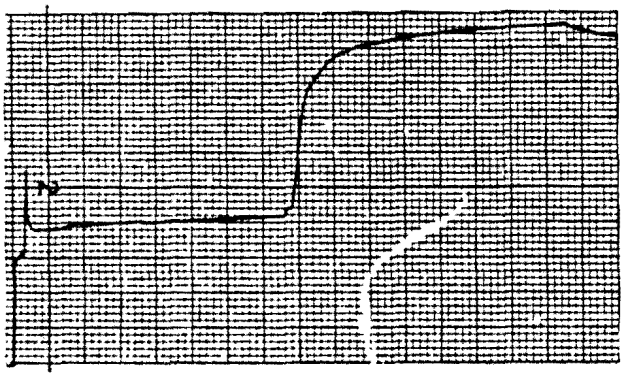


Figure 4-13. TDR Traces from the Checksource Lines.

STRIP CHART 103-2

TB111: 5 to 10

Signal - +600V



Setting - 500mρ/div

Range - 52.6 ft/div

Sensitivity - 0.25

15 hz filter

2nd plot begins @350 ft.

Cable dielectric - poly

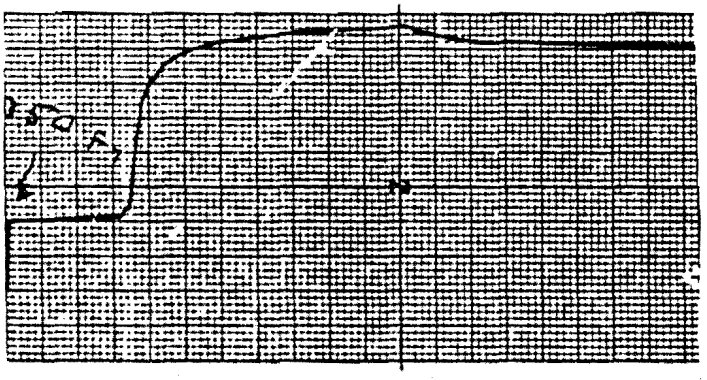
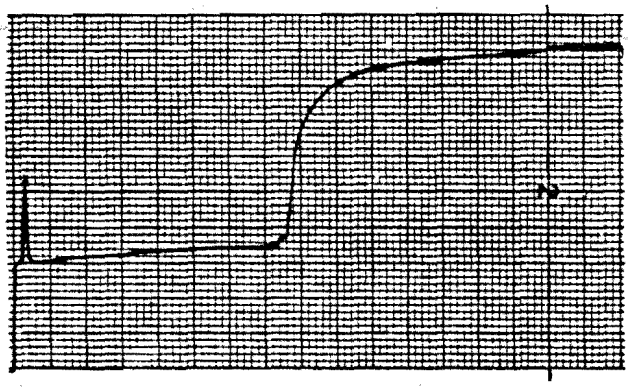


Figure 4-14. TDR Traces from the 600V Power Supply Cable.

STRIP CHART 103-3

TB111: 6 to 10

Signal: Signal In



Setting - 500mρ/div

Range - 52.6 ft/div

Sensitivity - 0.25

15 hz filter

2nd plot begins @350 ft.

Cable dielectric - poly

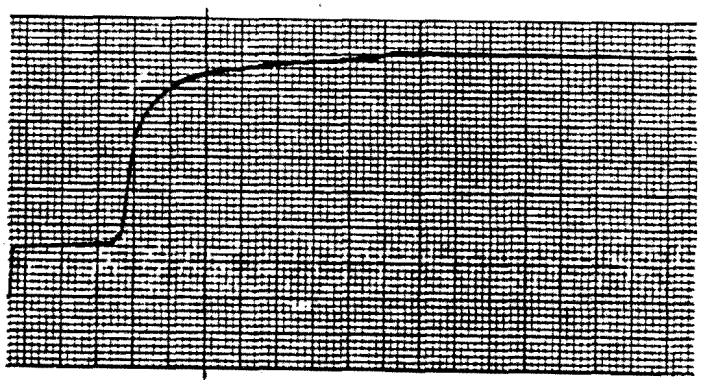
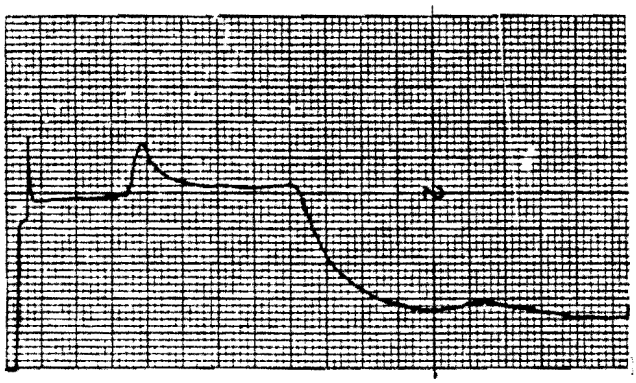


Figure 4-15. TDR Traces from the Signal-In Cable.

STRIP CHART 103-4

TB111: 8 to 10

Signal - +10V



Setting - 500mp/div

Range - 52.6 ft/div

Sensitivity - 0.25

15 hz filter

2nd plot begins @350 ft.

Cable dielectric - poly

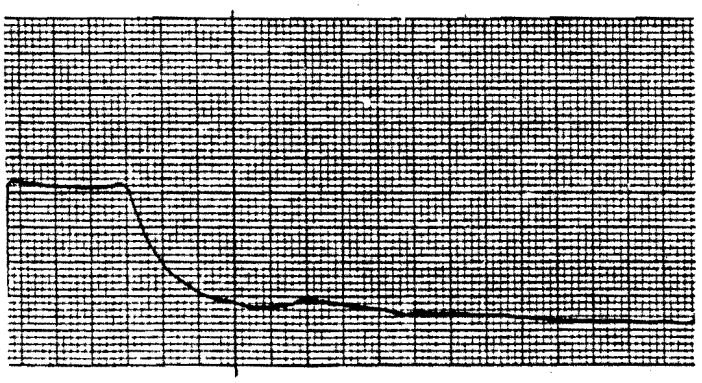


Figure 4-16. TDR Traces from the 10V Power Supply Lines.

5. SUMMARY AND INTERPRETATION OF MEASUREMENTS

This section presents a summary of the interpretation of the measurements taken on HP-R-213. This interpretation is intended to indicate the condition of the device based on observed data.

5.1 SUMMARY OF MEASUREMENTS

The 10 V power supply measurements indicated a 11.1 VDC output value, which is outside the normal variation, but probably not high enough to damage the circuitry. The 600 V power supply was measured at 599 VDC when connected to the detector assembly, which indicates this supply was working properly. The Signal In measurement produced a 10.96 VDC reading, which indicates the output is constant at very nearly the power supply level. Measurements on the checksource produced a 15 ma current load, which indicates the electrical path through the checksource coil is intact.

The time traces and frequency spectra were used to summarize the major characteristics of the measured waveforms. Results of this summary are presented in Table 5-1. Both the power supplies exhibit normal characteristics when compared to other TMI-2 measurements.

The Signal In waveform would normally be 0-10 V pulses with a frequency proportional to the radiation present. The oscilloscope photograph of

Table 5-1

CHARACTERISTICS OF MAJOR SIGNAL LINES

Signal	Frequency	Amplitude
Signal Out	0 (DC)	10.96 V
	60 Hz and Harmonics	2.5
	20 kHz and Harmonics	1.96 mV RMS
	Total Spectrum	16 mV P-P
600 V Supply	60 Hz	12.5 mV RMS
	16 kHz and Harmonics	<1 mV RMS
	20 kHz and Harmonics	16.8 mV RMS
	Total Spectrum	200 mV P-P
10 V Supply	120 Hz	3.6 mV P-P
	20 kHz and Harmonics	31 mV RMS
	Total Spectrum	150 mV P-P

the Signal In line (Figure 4-4) shows that the output has only a small AC variation from the 10.96 VDC level. These variations are mainly due to 60Hz and 20kHz low-level noise that was observed on other TMI instrument outputs. Resistance data (Table 4-1) shows a small increase in resistance among the Signal In, +10V, and Shield lines. Table 5-2 gives a comparison of the resistance data from a new detector assembly to that measured from HP-R-213. This overall increase in resistance is probably not significant since the observed changes could simply be the result of exposure to radiation and high temperatures. However, it could be the result of a degradation (but not total failure) of one of the output driver transistors (Q6 or Q7).

The capacitance and impedance data given in Table 4-1 is difficult to quantitatively interpret due to active components in the circuitry, but qualitative results are possible. Very low effective capacitance values would be expected from most signal lines except for the +10 V to ground, which has a 100 μF capacitor present. The checksource lines indicate the presence of the coil inductance (negative capacitance) which is also expected. Impedance data is reasonable and exhibits major trends expected from the circuitry such as reducing values at higher frequency for the Signal In.

The results of TDR measurements performed on the cable (shown in Figures 4-13 to 4-16) are summarized in Table 5-3. Note that the lengths identified in the table are only approximate, since no calibration of the cable resistance and material composition was performed on the TDR instrument. Some junction points were not identified by these

Table 5-2

COMPARISON OF MEASURED DETECTOR RESISTANCE

Measurement Point	New Detector*		HP-R-213	
	Polarity +	Polarity -	Polarity +	Polarity +
Signal In Shield	8.78	7.25	9.20	8.60
Signal In +10 V	8.32	6.70	8.80	7.20
Shield +10 V	7.40	11.80	8.30	12.50

*Serial numbers 111 and 1405 composite data.

Notes: (a) All values are in ohms x 10^3 unless otherwise indicated.

(b) First signal to positive terminal, second signal to negative terminal is considered Polarity +.

(c) All measurements made with a Keithley 177 DVM or 20 x 10^3 ohm scale.

Table 5-3

SUMMARY OF TDR MEASUREMENTS

Signal Lines	Distance (ft)*	Description**	Probable Cause
Checksource (+)	128	Point R Increase	Penetration R507
Checksource (-)	345	Continous R Increase	HP-R-213 Detector
600 V Supply	144	Point R Increase	Pentration R507
Ground	360	Point R Increase	Remote Meter
	371	Continuous R Increase	HP-R-213
Signal	139	Point R Increase	Penetration R507
Shield	350	Point R Increase	Remote Meter
	361	Continuous R Increase	HP-R-213 Detector
10 V Supply	134	Point R Increase	Penetration R507
Ground	376	Continuous R Increase	HP-R-213 Detector

Note: Distances are not calibrated due to lack of prior information on the cable type which prevented calibration tests.

*TDR to terminal block test cable (15 ft) not included in distance.

**R is the abbreviation for resistance.

measurements, but this is not unusual due to the cable lengths involved and the small resistance changes that would occur at terminal block junctions.

5.2 INTERPRETATION OF MEASUREMENTS

Based upon the observation that the Signal In is at a constant level of 10.96 VDC and there are no significant resistance changes, it appears that either the Geiger tube has failed open or that several internal transistors (Q1, Q2, Q3) have failed. The result of the failure is that the output driver transistors (Q6 and Q7) are continuously asserting a high output level. It is believed that the 11.1 V level of the 10 V supply did not contribute to the failure.

6. CONCLUSIONS

Based on the measurements, data reduction, and circuit analysis of HP-R-213, there is an indication of failure of the instrument. The observed output signals and resistance measurements suggest that the Geiger tube has failed open, and that the output is constant at the power supply level. This would result in an effective "zero" input to the readout module due to an AC coupling in the receiver and would cause the readout to be off-scale low.

It is not believed that the high voltage level of the 10 V power supply contributed to the detector assembly failure.

APPENDIX

ORIGINAL FIELD PROCEDURES AND DATA SHEETS FOR HP-R-213

GENERATION CORRECTIVE MAINTENANCE SYSTEM
JOB TICKET FORM (WC Page A-1 **IEE MILE ISLAND** UNIT 2

COMPONENT DESIGNATION SYS	COMP TYPE	COMP ID	LOCATION/UNIT	JOB TYPE	JOB TICKET NUMBER	REQUEST DATE MO	DAY	YR	RECOMMENDED PRIORITY
HP	R	0213	036 00 2	CM	C56630	9	17	80	2

DESCRIBE MALFUNCTION OR MODIFICATION DESIRED: Perform attached procedure.

CAUSE OF MALFUNCTION (IF KNOWN):

ORIGINATOR'S EMP NO	ORIGINATOR'S SIGNATURE	DATE	SUPERVISOR'S EMP NO	SUPERVISOR'S SIGNATURE	DATE
06175	J.H. Brunner	9/16/80	06175	J.H. Brunner	9/16/80

WORK ORDER NUMBER LOCATION	SERIAL	QC CODE	ACCOUNT NUMBER	PLANT CONDITION SU	OP	HO	CO	RF	HS	LR	NPRD FAILURE YR	MO	DAY	START HR	MIN
0360	00187700		7876119	1	1	1	1		1	1					

MAINT MOD	WA	NUC SAFETY	WA	REG AGENCY CODE	CHG/MOD NUMBER	ENV CODE	OUTAGE CAUSE CODE	STATUS HOLD CODE
0	0	0	0			X		

ESTIMATED COMMENCE WORK MO	DAY	YR
09	17	80

WORK LOCATION OR CONTROL #
20364

Limits and Precautions:
a) Personnel

b) Equipment

c) Environment

d) Nuclear

Post Maintenance Testing required and Acceptance Criteria.

ORIGINATOR—SUPERVISOR—SUPERVISOR OF MAINTENANCE—MAINTENANCE FOREMAN—
JOB PERFORMER—MAINTENANCE FOREMAN—SUPERVISOR OF MAINTENANCE

COPY

WORK REQUEST PROCEDURE

TMI Nuclear Station

Maintenance Procedure Format and Approval

Unit No. 2

This form outlines the format and acts as a cover sheet for a maintenance procedure. Due to the limited size of the form, additional pages may be attached as required. Work Request procedure AP 1016 Section 6 should be used as a guide in preparing the maintenance procedure.

1. Procedure Title & No.:

   Cable & Detector Performance Check for HP-R-213

2. Purpose: To determine if improper reading is a cable or detector problem.

3. Description of system or component to be worked on.

   HP-R-213

4. References:

   Victoreen Manual

5. Special Tools, and Materials required.

   See attached

6. Detailed Procedure (attach additional pages as required)

   See attached

Supervisor of Maintenance recommends approval [signature] Date 9/12/80

* PORC RECOMMENDS APPROVAL

Engineering Review [signature] 9/12/80

Unit No. 1 Chairman _____ Date _____ Unit No. 2 Chairman _____ Date _____

* UNIT SUPERINTENDENT APPROVAL

Unit No. 1 _____ Date _____ Unit No. 2 _____ Date _____

* Standing Procedure _____ Supervisor of QC _____ Date

*Note: These approvals required only on Nuclear Safety Related/Radiation work permit jobs.

Technology for Energy Corporation	TITLE: IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213	NO. TP-103
		REV. 0
PROCEDURE	APPROVED M.V. Mathis, Director, Tech. Serv. Div.	DATE 9-12-80

PURPOSE: The purpose of these measurements is to gather baseline data and information in preparation for possible removal and replacement of Area Radiation Monitor HP-R-213 from the reactor building TMI Unit 2. The tests specified in this procedure are designed to assess the condition of the in-containment instrument module (gamma detector), associated cabling, and readout devices. This assessment will require the use of Time Domain Reflectometry (TDR), Impedance (Z), Spectral Analysis (frequency domain), special calibration measurements, and general oscilloscope observations (with recording) of waveforms from/to the unit under test (UUT).

PROCEDURE (ADMINISTRATIVE):

A. Limitations and Precautions

1. Nuclear Safety. Area radiation monitor HP-R-213 is part of a redundant ARM system at elevation 347'. The unit is not considered part of the engineered reactor safeguards system thus has no nuclear safety relevance.

2. Environmental Safety. Area radiation monitor HP-R-213 can be taken out-of and restored to service without producing a hazard to the environment.

3. Personnel Safety. The test described herein produces no additional personnel safety hazards other than normally associated with performing instrument calibrations and tests.

4. Equipment Protection. In the performance of each test described herein, care will be taken to insure adequate equipment protection as follows:

   a. In all cases actual test hookups to the Unit-2 instrumentation shall be made and verified by Instrumentation Personnel.

   b. All passive measurements (Spectral Analysis and Oscilloscope observations) of waveforms and signals from powered instruments shall be performed using high input impedance probes or inputs ($Z = \geq 1$ Meg ohm) to prevent loading of signals.

   c. In all Time Domain Reflectometry and Impedance measurements, power will be removed from the unit under test and low level test signals prescribed in Table 4-1 shall be utilized to perform cable

integretary measurements on the appropriate instrumentation cables by inserting test signals on appropriate conductors of Cable IT1871I (terminations shall be removed and replaced on TB111 of Cabinet 12). Should these tests reveal cable integretary problems further verification measurements will be made at TB1 of the appropriate Remote Alarm/Meter (Victoreen Model 858-3) located in the anteroom.

Table 4-1 Active Measurements

Active Signal Parameter	Time Domain Reflectometry	Impedance
Voltage	225 mV nominal (into 50 ohm base)	$\leq$ 5V rms
Frequency	---	100Hz, 1kHz, 10kHz, 100kHz
Current	$\leq$ 10mA	$\leq$ 100mA
Other	225mV, 110 picosecond pulses	---

d. In the calibration verification measurements section, baseline data on the as-found condition will be recorded prior to the performance of any adjustments or electronic calibrations.

B. Prerequisites

1. The Shift Supervisor/Shift Foreman shall be notified for concurrance prior to the performance of those measurements.

2. Instrumentation personnel shall be assigned to assist in the performance of these measurements.

3. All measurements and test instrumentation shall be in current calibration (traceable to NBS).

TEC	TITLE: IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213	NO. TP-103
		REV. 0

4. The Shift Supervisor/Shift Foreman shall be notified prior to starting and upon completion of the measurements.

C. Procedure for Performing Measurements

References:

1. Victoreen Dwg. No. 904550, Wiring Diagram Area Monitors Channels HP-R-213 & HP-R-214 (Sheet 6 of 11).
2. Instruction Manual for G-M Area Monitoring Systems, Model 855 Series Victoreen Part No. 855-10-1.
3. Burns & Roe Dwg. 3024, Sh. 304.
4. Burns & Roe Dwg. 3347, Sh. 6K.
5. Burns & Roe Dwg. 3043, Sh. 16D.
6. Burns & Roe Dwg. 3045, Sh. 26B.
7. Burns & Roe Dwg. 3045, Sh. 34.
8. Burns & Roe Dwg. 3045, Sh. 26F.
9. Burns & Roe Dwg. 3034, Sh. 34B.
10. Instruction Manual, Tektronix model 1502 Time Domain Reflectometer.
11. Instruction Manual, Hewlett Packard Model 4274 Multifrequency LCR Meter.
12. Instruction Manual, Hewlett Packard Spectrum Analyzer (Model 141T, 8553B, 8552B Modules).
13. Instruction Manual, Nicolet Model 444A-26 Spectrum Analyzer.
14. Instruction Manual, Tektronix Model 335 Oscilloscope.
15. Instruction Manual, Lockheed Store-4 Recorder.
16. Instruction Manual, Tektronix SC502 Oscilloscope.
17. TEC Composite Electrical Connection Diagram, HP-R-213 (see attached).

Victoreen Instrument Company Dwg. 904550 (Ref. 1) and B&R Drawings 3024 (Ref. 3) show the appropriate termination points for passive measurements of signals from HP-R-213 as follows:

TEC	TITLE: IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213	NO. TP-103
		REV. 0

Signal	Cable IT1871I	Cabinet 12
+10V		TB111-8
600V		TB111-5
SIG		TB111-6
GND		TB111-10
CS		TB111-1
CS		TB111-2

NOTE

Selected steps will be completed on an identical Victoreen Area Radiation Monitor Detector with attached interface connector and terminal block to characterize signals and gather baseline data before the performance of this measurement.

STEPS

1. Notify Shift Supervisor/Shift Foreman of start of test on HP-R-213.

2. Verify power is applied to HP-R-213.

J E Jones 9/18/80
Signature/Date

3. Record present signals and readings and indications on 856-2 Readout Module (Local). Record Signal-in at TB111-6, 10 and record output for 30 minutes on FM Tape Recorder. Remove recorder when finished.

TITLE	IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213	NO. TP-103
		REV. 0

Meter/Indicator/Switch	Local
mR/hr Meter Reading	< 0
Off-Operate-Alarm Function Switch	OPERATE
Fail Safe Indicator	On ___ Off ✓
High Alarm-Reset Indicator	On ___ Off ✓

J. E. Jones 9/18/80
Signature/Date

1. Using a Keithley Model 177 DMM (or equivalent) and an electrostatic voltmeter ($Z_i \geq 10^{12}$ OHMS, Range 0-2000 V, Precision = ± 1%) measure the DC voltage or current at the following test points.

   NOTE: For signal d. it will be necessary to depress Fall-Safe Check Source push button during the measurement.

TEC

TITLE IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213

NO. TP-103

REV. 0

SIGNAL	CABINET 12	TEST LEAD	READING
a.	TB111-8 TB111-10	(+) (-)	(10V) 11.1 V
b.	TB111-6 TB111-~~7~~10	(+) (-)	(SIG IN) 10.96 (CS OUT) 10.95 (CS IN)
*c.	TB111-5 TB111-10	(+) (-)	(600V) 599 V
**d.	TB111-1 (open field side) TB111-1 (cabinet side)	(+) (-)	(≤500 mA est.) 15.02 ma { -1.95 ma reference

*Use electrostatic voltmeter
**Link closed after measurement

Signature/Date 9/18/80

TEC TITLE: IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213 | NO. TP-103 | REV. 0

5. Using a Tektronix Model SC502 (or equivalent) oscilloscope observe the waveform at the following test points:

SIGNAL	CABINET 12	PARAMETER			
a.	TB111-1 TB111-10	CS	Photo 103-1 Time Base 2MS Vert Gain 50MV	Photo 103-2 Time Base 0.1MS Vert Gain 20MV	Photo ____ Time Base ____ Vert Gain ____
b.	TB111-2 TB111-10	CS	Photo 103-3 Time Base 5MS Vert Gain 50MV	Photo ____ Time Base ____ Vert Gain ____	Photo ____ Time Base ____ Vert Gain ____
*c.	TB111-5 TB111-10	+600V	Photo 103-4 Time Base 0.1MS Vert Gain ____	Photo 103-5 Time Base 5MS Vert Gain 50MV	Photo ____ Time Base ____ Vert Gain ____
d.	TB111-6 TB111-10	SIG	Photo 103-6 Time Base 2MS Vert Gain 2MV	Photo 103-7 Time Base 20MS Vert Gain 2MV	Photo 103-8 Time Base 10MS Vert Gain 2MV
e.	TB111-8 TB111-10	+10V	Photo 103-9 Time Base 20MS Vert Gain 50MV	Photo 103,10 Time Base 2MS Vert Gain 50MV	Photo ____ Time Base ____ Vert Gain ____
f.	TB111-10 TB501-33	GND ACGND	Photo 103-11 Time Base 2MS Vert Gain .1V	Photo 103-12 Time Base 50MS Vert Gain .1V	Photo ____ Time Base ____ Vert Gain ____

*Decouple DC Voltage.

Sync the oscilloscope and photograph the waveform using up to three time base and vertical gain settings. (The necessity of 3 photographs will be determined by visual analysis by the field engineer.) Mark the back of the photographs with the instrument tag number and parameter measured.

TSH 9/18/80
Signature/Date

TEC	TITLE: IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213	NO. TP-103
		REV. 0

6. Using a Hewlett-Packard Spectrum Analyzer (Models 141T, 8553B, and 8552, or equivalent) perform an analysis of the following signals for spectral content:

SIGNAL	CABINET 12	PARAMETER	PHOTO #
a.	TB111-8 TB111-10	+10V GND	103-13 *
b.	TB111-6 TB111-~~9~~ 10	SIG IN GND	103-14 *
*c.	TB111-5 TB111-10	+600V GND	103-15 *

103-17 * *

103-16 * *

*Decouple DC voltage max input to Spectrum Analyzer (50VDC)

Before photographing each scope display adjust analyzer for best spectral resolution. Record critical analyzer parameters e.g., RF bandwidth, RF bandwidth and sweep speed on rear of photograph as well as parameter analyzed.

	SPECTRUM IDENT	FREQUENCY	AMPLITUDE	REMARKS	
BANDWIDTH	SCAN WIDTH	INPUT ATTEN	SCAN TIME	LOG REF 10db Log	LINEAR SENS
* 1 KHz	.5 mHz/DIV	0	1 SEC	-20	0
* * 1 KHz	.2 mHz/DIV	0	1 SEC	-20	0

Signature/Date 9/18/80

TEC	TITLE: IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213	NO. TP-103
		REV. 0

7. Using the Nicolet Model 444 FFT Analyzer (or equivalent) perform FFT analysis of signals from the following test points:

SIGNAL	CABINET 12	PARAMETER	PHOTO #	
*a.	TB111-5 TB111-10	+600V GND	103-18	103-19
b.	TB111-6 TB111-~~X~~10	SIG IN GND	103-20	103-21, 103-22
c.	TB111-8 TB111-10	+10V GND	103-23	103-24

*Decouple DC voltage input to Spectrum Analyzer (50VDC Max input)

If PSD plots from any one of the three signals show high or unusual amplitudes, utilize the zoom feature to provide finer resolution and obtain PSD data in the frequency band of interest.

T S 9/18/80
Signature/Date

8. Inside Cabinet 12 perform usual electronic calibrations using applicable instrument shop procedures. Attach a copy of the instrument shop calibration data sheet and identify any significant adjustments in the space below:

TEC

TITLE IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213

NO. TP-103

REV. 0

Procedure Step	Remarks
See attached instrument shop procedure data sheet.	

Instrument Shop Procedure No. _____

_____
Signature/Date

9. Remove all power from HP-R-213 (Tag Open TB501 links 31, 32, and 33 per procedure AP 1002).

9/18/70
Signature/Date

10. Open links for all field wires from Cable IT1871I at TB111 (Cabinet 12).

TERMINAL	SIGNAL IDENT.
TB111-1 (Blue)	C.S.
TB111-2 (Orange)	C.S.
TB111-3 (White)	Rem. Meter
TB111-4 (Yellow) IT3000C	HI N.C.
TB111-5 (RG 59/U, 72 OHM)	600V
TB111-6 (RG 58/U, 50 OHM)	SIG IN
TB111-7 (RG 58/U, 50 OHM)	Shield (for signal)
TB111-8 (Red)	+10V
TB111-9 (Green) IT3000C	Alert N.C.
TB111-10 (Blk) (RG 59/U, 72 OHM)	GND Shield

Signature/Date 9/14/90

11. Using the Hewlett-Packard Model 4274 (or equivalent) Impedance Bridge measure the capacitance and impedance of the following test points:

TEC TITLE: IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213

NO. TP-103

REV. 0

TEST POINT	FROM*		TO*	
	CABLE	WIRE COLOR/TYPE [TB111-X]	CABLE	WIRE COLOR/TYPE [TB111-X]
a.	IT1871I	Blue (1)	IT1871I	Orange (-2)
b.	IT1871I	RG 59/U Center(-5)	IT1871I	RG 59/U Shield (-10)
c.	IT1871I	RG 58/U Center(-6)	IT1871I	RG 58/U Shield (-7)
d.	IT1871I	Red (-8)	IT1871I	Black (-10)
e.	IT1871I	Black (-10)(Field Side)	IT1871I	TB111-10 (Cabinet)

*Numbers in parentheses refer to TB111 terminal numbers (field side).

Record the data required below:

Test Point*	Capacitance			Impedance		
Frequency	100 Hz	1 kHz	100 kHz	100 Hz	1 kHz	100 kHz
a. TB111-(1/2)	~2.8 nf	~5.8 nf	3.5 nf	40 Ω / 4°	40.8 Ω / 34°	440 Ω / -10°
b. TB111-(5/10)	~2 to 36 nf	10 nf	10.5 nf	OF	16K / -90°	152 Ω / -85°
** c. TB111-(6/7)	5 to 12 pf	7.9 pf	6.9 pf	OF	OF	229 K / -91° BAD DATA
d. TB111-(8/10)	96 nf	119 nf	-47 nF	22.5 Ω / -49°	14.7 Ω / -5°	38 Ω / 60°
†e. TB111-(10/10)	~2 to 6 nf	53 nf	26.7 nf	1.2 KΩ / -8°	960 Ω / -17°	70 Ω / -58°

*Numbers in parentheses refer to TB111 FROM/TO terminal numbers on field side.

†Field side/Cabinet side across open link.

** RUN TB111-6/10 ~12 nf / 12.6 nf / 13 nf 4.8K / 1.5 Ω 4.4K / -20° 121 Ω / -86°

Signature/Date

TEC	TITLE: IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213	NO. TP-103
		REV. 0

12. Using the Tektronix Model 1502 (or equivalent) TDR unit perform TDR measurements on the five test points given in Step 11. Record data below:

Test Point	High R @ N ft.	Low R @ N ft.	Instrument Settings Ampl Range Mult	Strip Chart Number
a. TB111-(1/~~2~~)				103-1
b. TB111-(~~5~~/10)				103-2
* c. TB111-(~~6~~/7)	10			103-3
d. TB111-(~~8~~/10)				103-4
e. TB111-(~~10~~/10)				103-5

* TB111 TERMINAL #7 MISSING CABLE FIELD SIDE FOUND TERMINAL #7 CABLE IS CONNECTED TO TB111 TERM #10

J T Sell 9/18/80
Signature/Date

13. Using the Keithley Model 144 (or equivalent DMM) perform resistance measurements on the Test Points specified and record value in space provided.

TEC

TITLE: IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213

NO. TP-103

REV. 0

All Reading 20K Scale.

TEST POINT	FROM LINK (field side)	TO LINK (field side)	POLARITY From = +; To = - RESISTANCE	POLARITY From = -; To = + RESISTANCE
a.	TB111-1	TB111-2	41Ω	41Ω
b.	TB111-1	TB111-5	~~OL~~	~
c.	TB111-1	TB111-6	~	~
d.	TB111-1	TB111-X10	~	~
e.	TB111-1	TB111-8	~	~
f.	TB111-1	TB111-10	~	~
g.	TB111-2	TB111-5	~	~
h.	TB111-2	TB111-6	~	~
i.	TB111-2	TB111-X10	~	~
j.	TB111-2	TB111-8	~	~
k.	TB111-2	TB111-10	~	~
l.	TB111-5	TB111-6	~	~
m.	TB111-5	TB111-X10	~	~
n.	TB111-5	TB111-8	~	~
o.	TB111-5	TB111-10	~	~
p.	TB111-6	TB111-X10	9.2K	8.6K
q.	TB111-6	TB111-8	8.4K	7.2K
r.	TB111-6	TB111-10	9.2K	8.6K
s.	TB111-X10	TB111-8	8.3K	12.5K
~~t.~~	~~TB111-X10~~	~~TB111-10~~		
~~u.~~	~~TB111-8~~	~~TB111-10~~		

NOTE:
Close all links on TB111 (opened in Step 10) when finished with this step.

TS A 9/18/80
Signature/Date

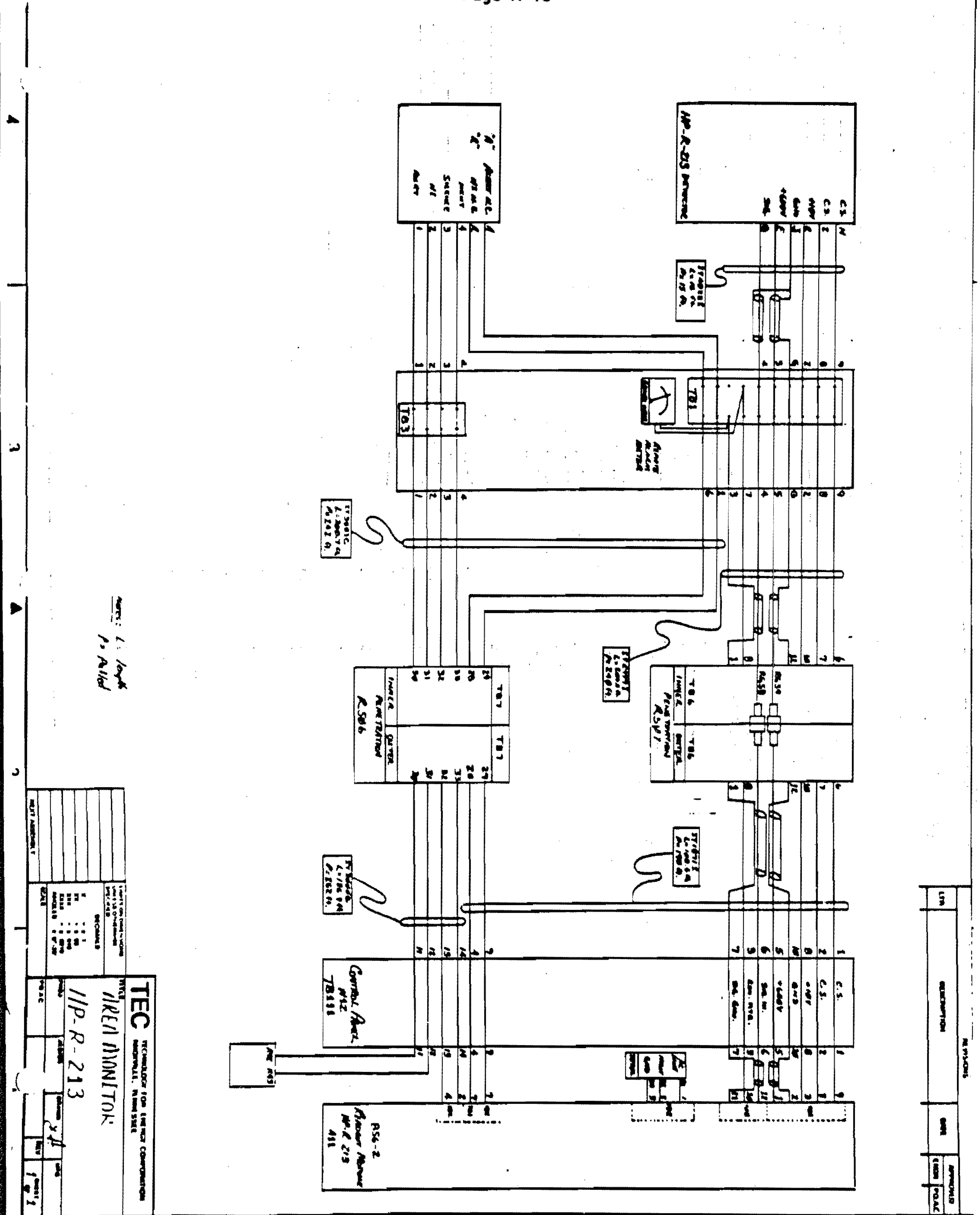
TEC	TITLE: IN-SITU MEASUREMENTS OF CABLES AND SIGNALS FROM AREA RADIATION MONITOR HP-R-213	NO. TP-103
		REV. 0

15. Notify Shift Supervisor/Shift Foreman of end of test on HP-R-213.

I hereby certify that this Test Procedure has been completed as written and that all data has been correctly entered and filed as requested.

TEC Representative _____ 9/18/80
Signature/Date

Instrumentation David A Burns 9/18/80
Signature/Date


TEC
TECHNOLOGY FOR ENERGY CORPORATION
KNOXVILLE, TENNESSEE
AREA MONITOR
HP-R-213
TB1
TB3
TB6
TB7
Inner
Outer
Penetration
Control Panel
C.S.
+HV
GND
+600V
SHLD.
Notes: L: length
R: Allied

JOB TICKET (WORK REQUEST)
REVIEW – CLASSIFICATION – ROUTING CONTROL FORM

JOB TICKET NUMBER C5663

1. Does work represent a change or modification to an existing system or component? If yes, an approved change modification is required per AP 1021. C/M No. N/A Yes ____ No ✓

2a. Does work requires an RWP? Yes ____ No ✓

2b. Is an approved procedure required to minimize personnel exposure? Yes ____ No ✓

3a. Is work on a QC component as defined in GP 1008? Yes ____ No ✓

3b. If 3a is yes does work have an effect on Nuclear Safety? If 3b is yes, PORC reviewed Superintendent approved procedure must be used. Yes ____ No ✓

4. Agreement that a PORC reviewed, Superintendent epproved procedure is not required for this work because it has no effect on nuclear safety. (Applies only if 3a is Yes and 3b is No).

N/A
UNIT SUPERINTENDENT ____ DATE ____

5a. Is the system on the Environmental Impact list in AP 1026? Yes ____ No ✓

5b. If 5a is YES, is an approved procedure required to limit environmental impact? Yes ____ No ____

6. Agreement that 5b is No. (Required only if 5a is Yes).

N/A
UNIT SUPT./SUPV. OF OPERATIONS ____ DATE ____

7. Plant status or prerequisite conditions required for work. (Operating and/or shutdown)

8. QC Dept. review, if required in item No. 3.

NA
QC SUPERVISOR ____ DATE ____

9. Does work require code inspector to be notified? Yes ____ No ____

10. Supervisor of Maintenance approval to commence work:

[signature] Date 9/17/80

11. Maintenance Foreman Assigned: ____

12. Code Inspector Notified. Name: ____ Date ____

13. Shift Foreman's approval to commence work: [signature] Date 9/17/80

____ Initial if Shift Foremen signature is not required.

TMI-154 2-80

GENERATION CORRECTIVE MAINTENANCE SYSTEM

CM STATUS ACTIVITY FORM

COMPONENT DESIGNATOR				LOCATION UNIT	JOB TYPE	WORK AUTHORIZATION NUMBER	REQUEST DATE		
SYS	COMP. TYPE	COMP. ID.	LOOP				MO	DAY	YR
5 8		12	16	17 22	23 24	28 32	33		38
HP	F	0213		036002	CM	C5663	09	16	80

TXN CD	ACT 4	ECM NUMBER 47 51
1		
804	A	

TXN CD	ACT 4	PRTY 66	RESP. LOCATION OR CONTRACTOR 67 71	PRTY	ASSISTING CONTRACTOR	PRTY	ASSISTING CONTRACTOR
1							
805	A		2036N				

TXN CD	ACT 4	PURCHASE REQUISITION NUMBER 59 66	PURCHASE ORDER NUMBER 67 73
1			
807	A		

TXN	ACT 4	STATUS HOLD CODE 39 40	START DATE 41 45	RELEASE DATE 47 52	% COMPL 53 55	S/M APPROVAL TO COMMENCE WORK MO DAY YR 56 61	FIELD WORK COMPLETION DATE MO DAY YR 62 67
1							
810	A						

01	OUTAGE HOLD
02	PART HOLD
03	QUALITY CONTROL PART HOLD
04	QUALITY CONTROL PROCEDURE HOLD
05	OPERATIONS HOLD
06	CHANGE MODIFICATION HOLD
07	ENGINEERING HOLD
08	PLANNING HOLD
50	MANPOWER NOT AVAILABLE
51	AT PORC
52	AT QUALITY CONTROL
53	AT UNIT SUPERINTENDENT
54	AT READING
55	POST MAINTENANCE TEST HOLD
56	AT ALARA

TMI 199 5 80

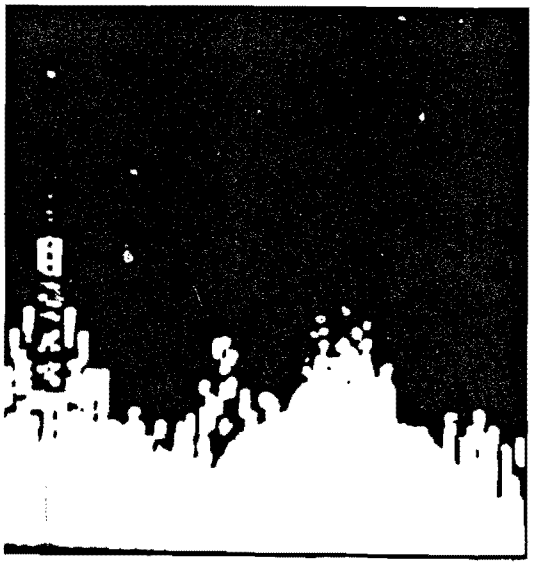


Photo #103-16

BW-1 kHz

Scan time - 1sec

Scan width - 0.2 MHz

Attn - 0

Log Ref - -20db

TB111-5 to

TB111-10

+600V

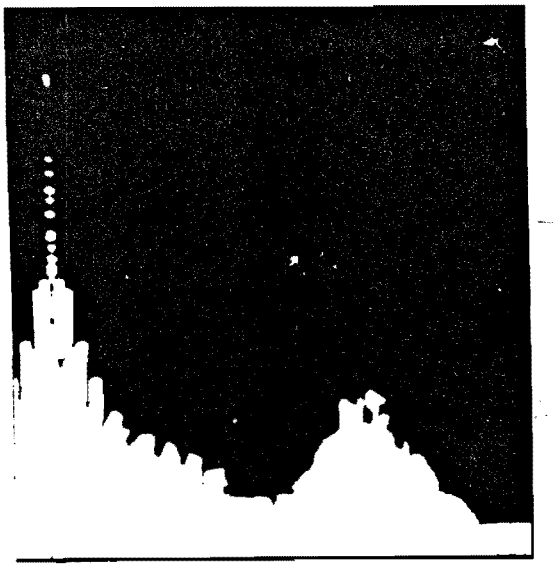


Photo #103-17

BW-1 kHz

Scan time - 1sec

Scan width - 0.2 MHz/div

Attn - 0

Log Ref - -20db

TB111-6 to

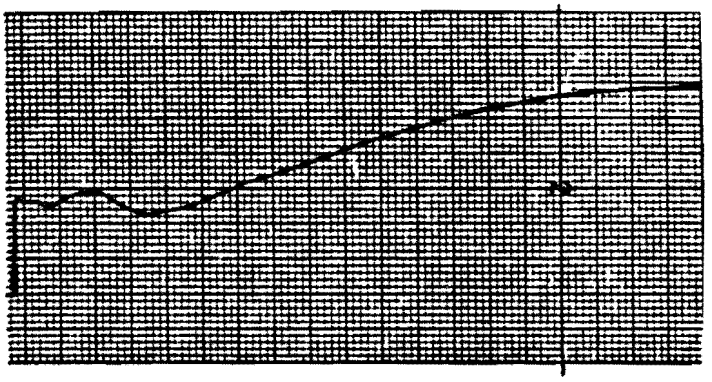
TB111-10

Signal In

STRIP CHART 103-5

TB111: 10 to 10

Signal - GND



Setting - 500mρ/div

Range - 52.6 ft/div

Sensitivity - 0.25

15 hz filter

2nd plot begins @350 ft.

Cable dielectric - other