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Technical Report

TECHNICAL REPORT
INSTRUMENTATION VALIDATION

May 1979

TELEDYNE
BROWN ENGINEERING
Cummings Research Park • Huntsville, Alabama 35807

TECHNICAL REPORT
ED79-ADTC-2334

TECHNICAL REPORT
INSTRUMENTATION VALIDATION

May 1979

Prepared For

ARMAMENT DEVELOPMENT AND TEST CENTER
EGLIN AIR FORCE BASE, FLORIDA

Contract No. F08635-77-C-0293, P00010
Data Item B004

Prepared By

ELECTRONICS DIVISION
TELEDYNE BROWN ENGINEERING
HUNTSVILLE, ALABAMA

TABLE OF CONTENTS

1. INTRODUCTION

This report is written to fulfill the requirements of Data Item B004 of Contract No. F08635-77-C-0293. The report covers the work performed under Task 7 - Validate Instrumentation of Contract Modification P00010. This work was performed during March and April 1979 at the GVT Facility at Eglin Air Force Base.

An analytic and test validation was performed on the GVT Facility instrumentation. The purpose of the test was to determine the capability of the GVT System to perform its intended mission of dynamic analysis of aircraft structures. Each element of the system was examined to determine its individual function as well as its intended and unintended interaction with every other element of the system. The system was tested for signal input accuracy, cable integrity, grounding, noise susceptibility, and output signal integrity. All components were found to be well-maintained and functioning properly. The only discrepancies found in the system relate to system analog grounding. Recommended corrective measures to eliminate these discrepancies are outlined.

With the implementation of the recommendations contained in this report, the GVT should be an excellent tool for dynamic analysis of aircraft structures and the instrumentation should provide constant, repeatable results under all test conditions.

2. WORK APPROACH

The facility validation task was broken down into the following sequence of individual tasks: Problem Definition, System Definition, Test Development, Testing, Test Results Analysis, Retest and Validation, and Recommendations for Corrective Action.

A meeting was held with GVT personnel to obtain a better understanding of the function of the system and the way it was utilized. Areas discussed included normal system configuration, test setup, problem areas encountered in testing, system performance, and test results validity. From these discussions it was determined that an independent evaluation of the ability of the system to provide accurate, repeatable, and reliable results was needed.

2.1 PROBLEM DEFINITION

Based on the requirement for an independent evaluation of the GVT instrumentation system performance, further discussions were held to determine the problems that had been experienced in the past and to try to classify these problems as to their cause and impact on system performance. The following areas were identified as potential areas for further evaluation and test:

- Noise on some transducers under some test conditions
- Lack of calibration data on
  - Input preamplifiers
  - Output power amplifiers
- Uncertainty over the effects of cable grounding
- Uncertainty over the effects of system ac power wiring
- Low-level shaker excitation with no input command when shaker amplifiers were powered from test floor.

2.2 SYSTEM DEFINITION

To properly understand the functional relationship existing between components of the GVT instrumentation, functional diagrams of the input and output signal flow were developed. These were reviewed with the GVT personnel to clarify the exact methodology used in interconnecting various elements and to obtain their insight into how various operating configurations contributed to system performance. These functional diagrams are presented in Figure 2-1 (signal input block diagram) and Figure 2-2 (excitation outputs block diagram). These diagrams were then used in defining all testing approaches and recommendations.

2.3 TEST DEVELOPMENT

A test approach was developed that would utilize the system as configured to examine the problem areas identified as well as provide an insight into any other system performance restrictions that might exist. The integrity of all input and output signals should be verified as well as the cabling. To accomplish this, four basic tests were developed, as shown in Table 2-1.

TABLE 2-1. FOUR BASIC TESTS FOR GVT

QUANTITY	COMPONENT	TEST TO BE PERFORMED
200	Cables	Short-circuit resistance, insulation resistance
32	Input Preamplifiers	Gain, frequency response, distortion
4	Power Amplifiers	Gain, frequency response, distortion
	System	Grounding and inter-rack ambient noise level

Based on the results of these tests, a full-scale examination of the system would be conducted to determine how each component contributed to the total system performance. The results of these tests are covered under test results (Section 3) and the test data are contained in the attached appendices.

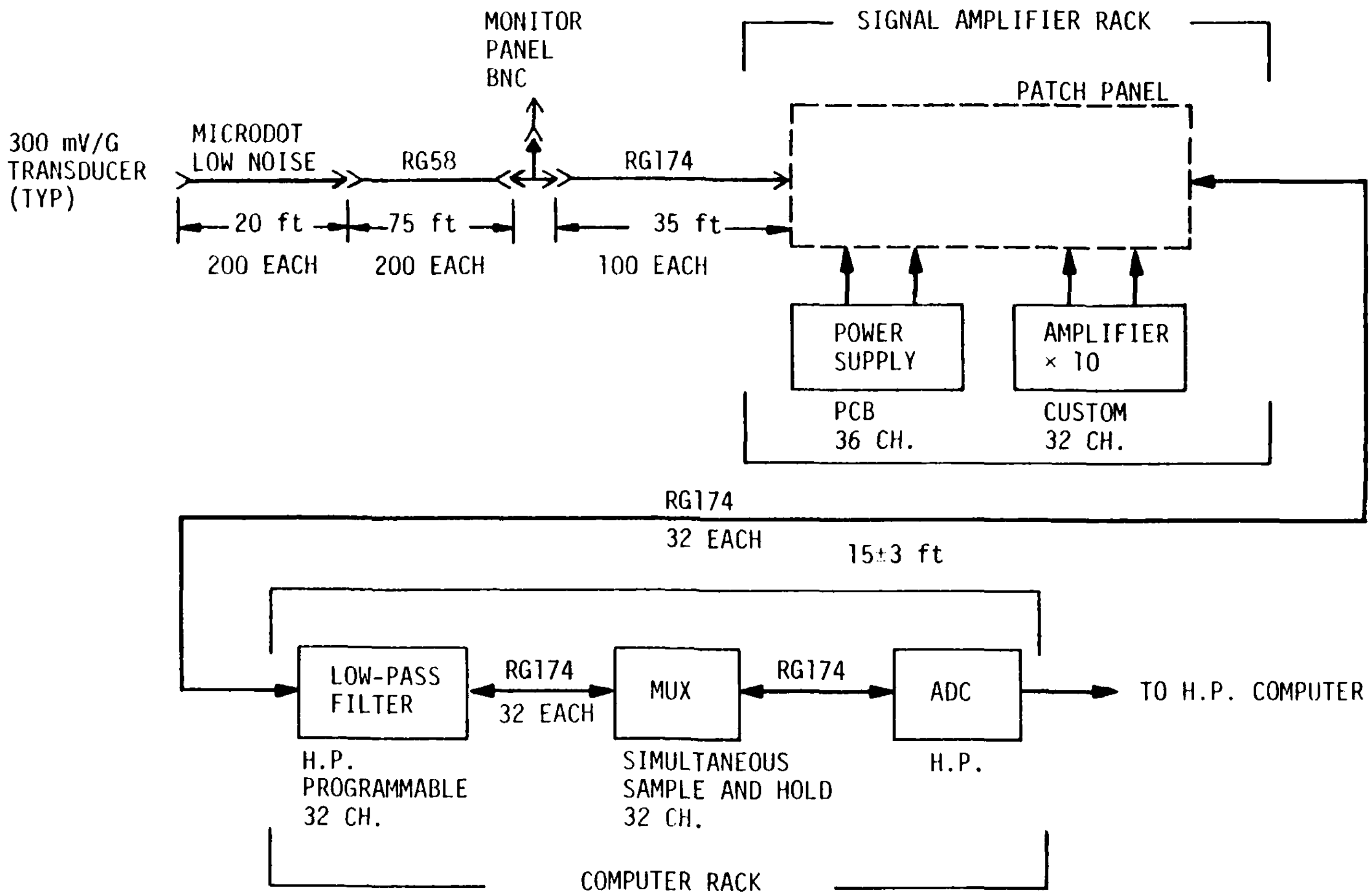


FIGURE 2-1. SIGNAL INPUT BLOCK DIAGRAM

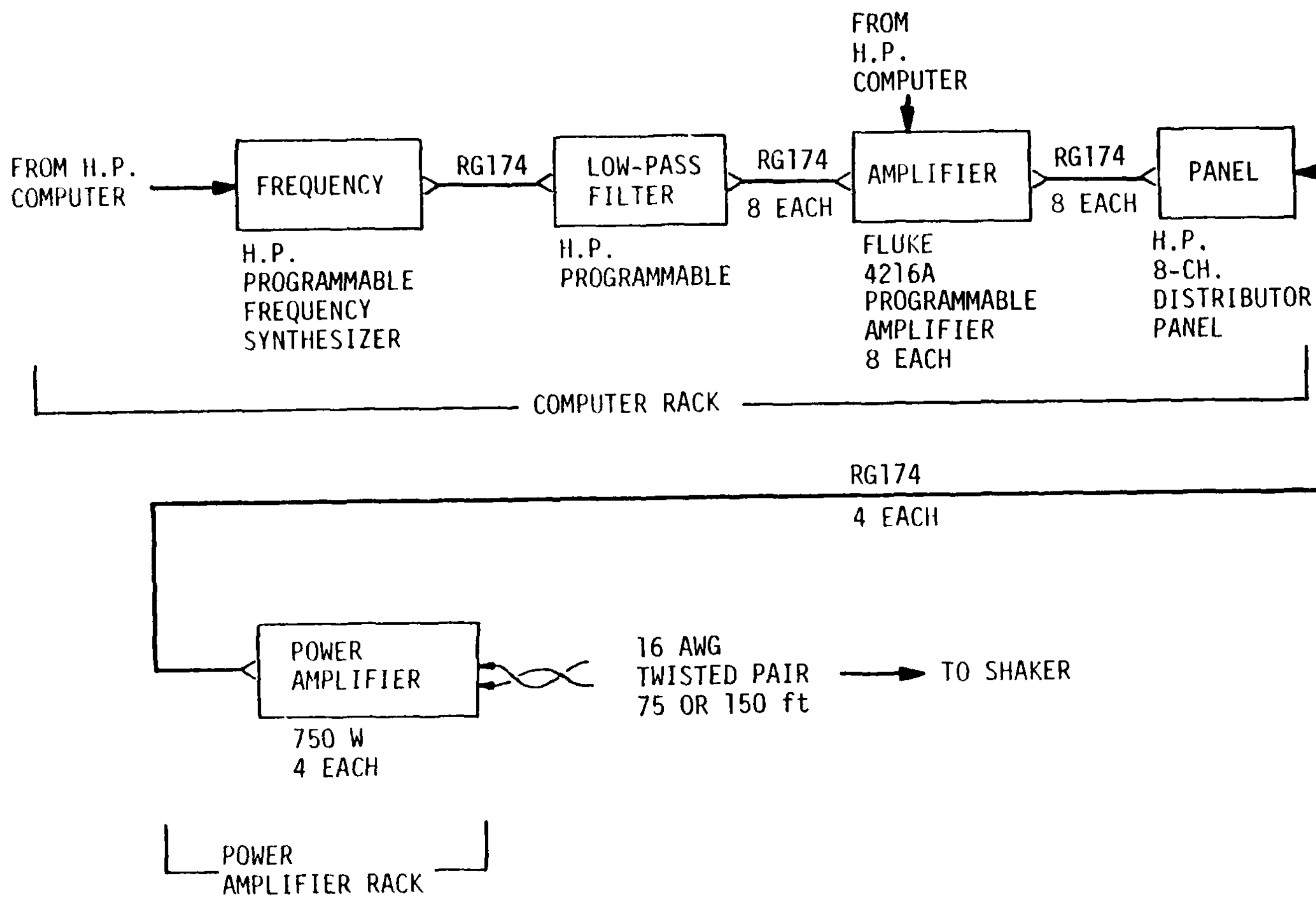


FIGURE 2-2. EXCITATION OUTPUT BLOCK DIAGTAM

3. TESTING AND TEST RESULTS

The following paragraphs discuss the detailed testing performed on the GVT instrumentation as well as the general conclusions reached about the performance of the individual components being tested.

3.1 CABLE TEST

An easily implementable and repeatable test was required to verify the integrity of all coaxial cables from the test floor to the system patch panel. After examination of the characteristics of the cable used (RG58, RG174, and Microdot Lo Noise) and the test frequencies of interest (0 to 200 Hz), it was determined that the characteristics that could be most detrimental to test results were dc resistance of the coaxial cable and insulation resistance.

The dc resistance test was conducted with one end of the cable shorted. This allowed the measurement of shield and center conductor resistance as well as all terminations (crimp and solder) in the cable run. As shown in the test results, the resistance is very repeatable from cable to cable. Table 3-1 lists the range of acceptable values for various configurations as well as those cables that are suspect and that should be examined for poor terminations.

TABLE 3-1. RANGE OF ACCEPTABLE VALUES

FROM	TO	ACCEPTABLE VALUE (ohms)	SUSPECT CABLE NO.
Floor	Patch Panel	4.3 to 5.9	3, 30, 40, 52, 86
Transducer	Patch Panel	9.0 to 10.0	40, 52
Floor	Breakout Panel	1.2 to 1.6	152

The Meggar test was conducted with the cable unterminated. This test measures the conductor-to-shield insulation resistance at 500 Vdc and will indicate shortened cables, crushed insulation, and contaminated connectors and terminations. Any value over 1 kMohm is acceptable. Cable No. 40 was found to be bad. Cables 184 to 196 exhibited a higher (1.6-ohm) resistance than cables 101 to 185, probably because a different brand of connector was used. This should present no problems with signal transmission.

Appendix A contains the test procedure and all test data taken.

3.2 INPUT PREAMPLIFIER TEST

The input preamplifiers were tested to determine their ability to accurately amplify and reproduce the transducer signal. Each amplifier was tested at 30, 300, and 600 mV input signal at the following frequencies: 2, 10, 20, 30, 40, 80, 140, and 200 Hz. The output amplitude was measured and the amplifiers were found to have a gain of 10.6 to 1 uniformly. This gain rolled off to 10.3 to 1 at 2 Hz at all amplitudes and increased to 11 to 1 at 600 mV input. These changes are insignificant to the testing being conducted.

The distortion of each amplifier was measured at 300 mV input at 20, 80, and 200 Hz and was found to be less than 0.4% for all amplifiers. This level of distortion is insignificant to the testing being conducted by the facility.

Appendix B contains the test procedure and all test data taken.

3.3 GROUNDING TEST

After preliminary investigations of system performance and discussion of previous system problems with GVT Facility personnel, it was determined that the potential existed for ground noise between components of the GVT Facility. The tests of Appendix C were conducted. These tests indicated that the primary potential difference existed between the test stand and the instrumentation. These tests also indicated that insufficient grounding existed between GVT components. As shown by the test data, addition of a ground strap reduced this noise by 66%.

Subsequent testing of ground potential differences and ground noise using the power spectral density measurement capability of the GVT computer revealed that 60-Hz ac power ground potential differences were the cause of the noise measured in the above test. Inadvertent shorting of the transducer-case-to-test-stand ground would then be the primary cause of error in GVT testing. The correction of this problem is addressed in Section 4.

3.4 POWER AMPLIFIER TEST

The power amplifiers were tested to determine their ability to accurately and repeatably provide the drive signal to the shakers at the required power levels. Each amplifier was tested at output power levels of 10, 50, and 100 W at excitation frequencies of 2, 10, 20, 30, 40, 80, 140, and 200 Hz. They were all found to have a flat response to 10 Hz, with some power amplification at 2 Hz. This amplification is not caused by the amplifier but by the dc resistance of the shaker coil at this low frequency.

The amplifier distortion measured at 50 W output power at 20, 100, and 200 Hz was found to be less than 0.6%. This distortion level is insignificant to the testing being conducted. The phase shift was measured at 20, 100, and 200 Hz at 100 W output power and was found to be zero at the higher frequencies and only 7 deg at 20 Hz. This phase shift should not affect test results or excitation characteristics.

3.5 TEST RESULTS ANALYSIS

The test data contained in the appendices were examined to determine if each component was making a proper contribution to GVT instrumentation performance. The only area identified that required further investigation was system grounding. The potential difference between system components, especially between the test stand and the preamplifier rack, was much too high for good, consistent low-level signal measurement.

All other component testing verified that the equipment was functioning properly and was fully capable of performing the GVT mission.

3.6 RETEST AND VALIDATION

A retest of the input system with transducers connected was conducted to examine the effect of ground noise found in initial testing on system performance. This test was conducted in two phases: 1) ground potential measurement and 2) transducer signal impact.

The ground potential between the aircraft grounding lugs in the test floor and the legs of the test stand was measured. The potential between lugs ranged from 1 to 5 mV rms and between lugs and the test stand ranged from 7 to 12 mV rms. This measurement indicates that the test stand has no common ground and that the test stand is not connected to the grounding lugs in the floor. The structural modifications to be made to the test stand along with the recommendations made later in this report should reduce this noise to acceptable levels (1 to 3 mV rms).

The system was then configured for a power spectral density (PSD) test. An accelerometer and load cell were connected to two input amplifier channels. The transducers were held on the test floor on an isolation pad and the signal output was monitored at the transducer power supply with an oscilloscope. The noise level from both transducers was less than 1 mV peak-to-peak. The computer-run PSD test indicated that what coherent noise existed was centered at 60 Hz.

The transducer cases were individually shorted to the test stand. The noise increased to 50 mV peak-to-peak, with the primary frequency at 60 Hz and a secondary contribution at 180 Hz (third harmonic). When both cases were shorted together and then shorted to the test stand, the noise was reduced to 40 mV peak-to-peak.

With the transducer cases shorted together and to the test stand, an 8 AWG (3 No. 12 AWG) ground strap was connected between the test stand and the preamplifier rack. The noise level was reduced to 10 mV peak-to-peak with the same 60- and 180-Hz frequency content.

Based on these measurements, it was concluded that the only problem with the system was one of 60-Hz power grounding and that the system, through its PSD measurement capability, could be configured to monitor its own ground noise condition. No problems should be encountered with the present configuration as long as care is taken to ensure that all transducers are isolated from the test stand ground.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The GVT instrumentation as configured will perform accurate, repeatable tests and will provide reliable, consistent results provided all transducers are electrically isolated from the test item. As currently configured, up to 50 mV peak-to-peak of 60-Hz noise will be injected on transducer liners that are shorted to the test item or the structure.

During testing, it was demonstrated that these noise levels could be substantially reduced by revision of the system grounding. The revision to system grounding and isolation are the major recommendations derived from these test and analysis efforts. Implementation of these recommendations should remove all test anomalies.

Measures should be taken to reduce this 60-Hz noise by reducing the ground potential difference between system elements.

4.2 RECOMMENDATIONS

Only two recommendations for revisions to equipment or procedures have been identified as potential improvements to system performance. The basic system, including all cables, transducers, and electronics, was found to be sound and properly maintained. The recommendations deal with reduction of system 60-Hz ground differential voltage and with the isolation of all test transducers.

4.2.1 Transducer Isolation

It was found that accelerometers are generally installed on isolation studs; however, no attempt is made at present to verify that ground isolation is achieved. A procedure should be instituted whereby each transducer's isolation is verified with an ohmmeter prior to connection of that transducer's cable.

The load cell placed between the shaker and the test specimens is not currently isolated since it is bolted directly to the load transfer pads. A nonconductive shim should be placed between this pad and the test specimens to ensure electrical isolation. This isolation should be verified prior to connection of the load cell cable in the same manner as the transducer. If a nonisolated shaker is used, then similar precautions should be taken between the shaker and the load cell.

4.2.2 60-Hz Noise and Grounding

The 60-Hz noise can be traced to two sources: 1) the lack of a common analog ground system and 2) the lack of a common instrumentation power source. Because the GVT facility was installed in an existing facility, not all ac power is derived from a single power panel with common ground. This presents a condition wherein chassis ground differences can develop and vary according to electrical loads in other parts of the building not controlled by GVT Facility personnel. To alleviate this problem, the ac wiring servicing the GVT Facility should be revised to provide a common power distribution point for all instrumentation with no other, nonfacility equipments attached.

No consideration has been given to establishing a common analog ground for the system separate from the ac third-wire safety ground. Tests have shown (Appendix C) that ground noise can be substantially reduced by installation of an analog grounding system. The recommended grounding scheme is shown in Figure 4-1 and implemented as follows:

- A ground bus should be installed in the signal power supply and amplifier rack.
- A 6 AWG wire should be run from a welded lug on the test stand to the ground bus.
- A 6 AWG pigtail should be provided from the test stand ground lug to the test specimens.
- An 8 AWG wire should be run from the ground bus to each of the other equipment rack frames.
- A 16 AWG wire should be run from the ground bus to the ground jack on each transducer power supply.

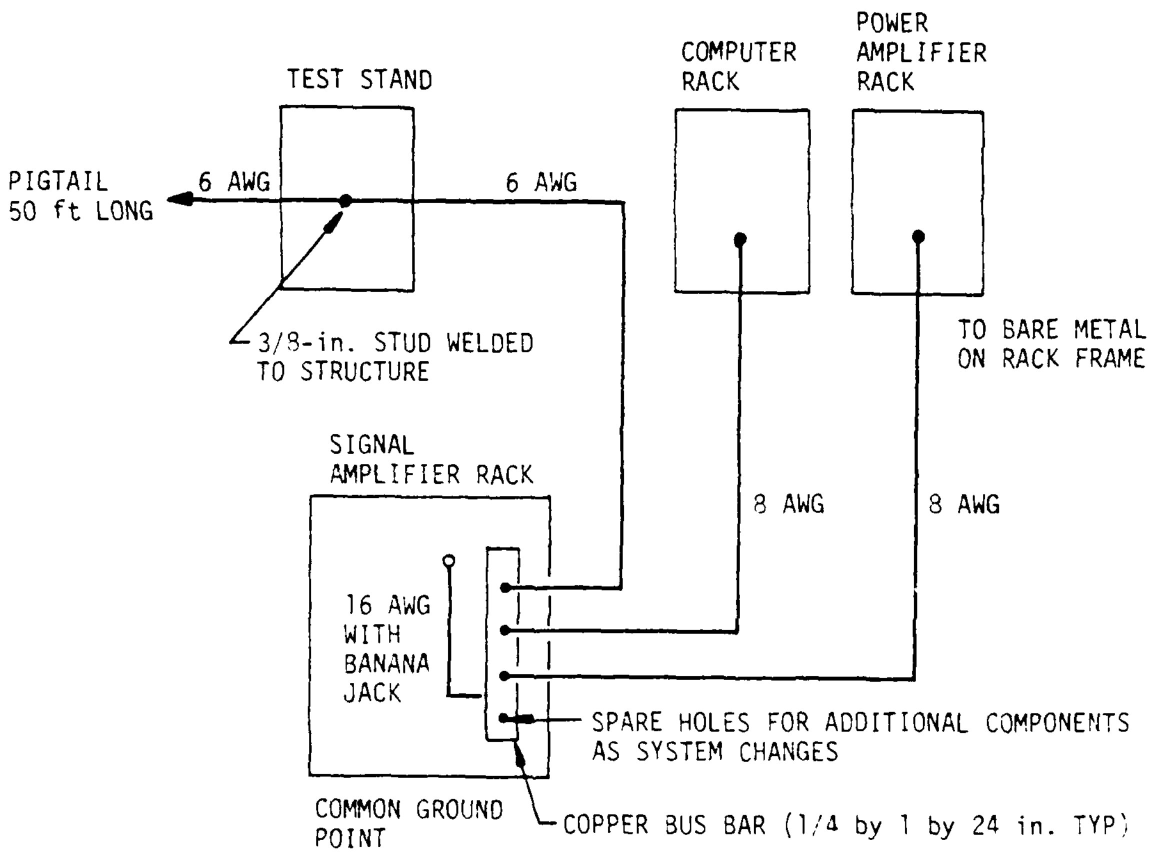


FIGURE 4-1. RECOMMENDED SIGNAL GROUND SCHEME

This grounding scheme should establish an analog ground system independent of ac third-wire grounding and substantially reduce 60-Hz noise in the system.

4.2.3 Cable Retest

At least once a year the test of Appendix A (Cable Continuity and Impedance) should be rerun to reverify the integrity of all cables, especially those on the test floor. This test can be run in approximately 8 hours and will identify any damaged cables.

Whenever an individual cable is suspect, the test can be run to the cable in a matter of minutes and the problem corrected before continuing testing.

4.2.4 Automatic System Checkout

In addition to the above-mentioned recommendations, an automatic pre- and post-test checkout should be considered. The H.P. computer has the capability of acquiring and testing all transducer channels automatically. This capability can be used to run a power spectral density measurement on all transducers prior to activation of the shakers. This test can be set to flag any transducer that shows a 60-Hz frequency or other component that is above the system quiescent noise level (established after all system modifications are complete). The verification can be rerun at the completion of each test or after each shaker reconfiguration, thereby verifying that no degradation in system grounding and isolation has occurred during the test. This test should be run with the programmable filter in the bypass mode.

APPENDIX A. RESISTANCE TEST

RESISTANCE TEST

The purpose of this test is to verify the integrity of all wiring from the test floor to the patch panel. Using the equipment as shown in figure 1 conduct the following test and record the results in table 1.

- o Short Circuit Resistance: Connect a shorting plug to the cable at the patch panel and measure the total resistance, shield to center conductor at the floor end of the cable. For those wires stoping at the monitor panel - install the shorting plug at that point.
- o Megohn Test: With all patches and shorting plugs removed, measure the open circuitry resistance of the wires with a megohmmeter.

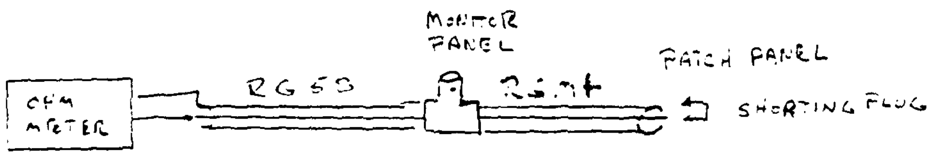


FIGURE 1

TEST EQUIPMENT

8600 A Digital Multimeter SN 585307 (Fluke)

1620 Megohmeter SN 709 (Freed)

RESISTANCE TEST

TABLE 1

FLOOR WIRE NO.	RESISTANCE WITH SHORT AT PATCH/PANEL	MEGGAR TEST (✓=∞)
1	5.5	1.4K MEG
2	4.6	✓
3	8.7	✓
4	4.6	✓
5	4.5	20K MEG
6	4.5	1.8K MEG
7	4.5	✓
8	4.5	1.4K MEG
9	4.4	✓
10	4.3	✓
11	4.4	5K MEG
12	4.9	3.2K MEG
13	4.3	✓
14	4.7	50K MEG
15	4.4	1.5K MEG
16	4.3	✓
17	4.8	✓
18	4.8	✓
19	4.9	✓
20	4.7	3.6K MEG
21	4.4	1K MEG
22	4.9	6K MEG

RESISTANCE TEST

TABLE 1

FLOOR WIRE NO.	RESISTANCE WITH SHORT AT PATCH/PANEL		MEGGAR TEST
23	4.3		✓
24	4.3		✓
25	4.3		✓
26	4.3		✓
27	5.0		1.6K MEG
28	5.2		✓
29	4.3		6K MEG
30	9.5		✓
31	4.3	9.0	✓
32	4.3	9.0	1.5K MEG
33	4.6	9.3	✓
34	4.3	9.0	✓
35	4.3	9.0	2K MEG
36	4.3	9.0	✓
37	4.3	9.0	5K MEG
38	4.3	9.0	✓
39	4.7	9.5	✓
40	6.3	11.6	low resistance
41	4.8	9.6	✓
42	4.4	9.1	✓
43	4.8	9.5	10K MEG
44	5.0	9.7	✓

RESISTANCE TEST

TABLE 1

FLOOR WIRE NO.	RESISTANCE WITH SHORT AT PATCH/PANEL		MEGGAR TEST
45	4.4	9.1	✓
46	5.7	10.4	3K MEG
47	5.1	9.8	✓
48	4.7	9.4	1K MEG
49	4.3	9.0	✓
50	4.4	9.1	✓
51	4.3	8.9	5K MEG
52	11.9	16.6	5K MEG
53	4.4	9.1	✓
54	4.9		✓
55	4.8		1K MEG
56	4.6		✓
57	4.4		✓
58	4.8		20K MEG
59	4.6		✓
60	4.6		5K MEG
61	5.9		✓
62	4.3		3K MEG
63	4.8		✓
64	4.4		✓
65	5.4		10K MEG
66	4.5		6K MEG

RESISTANCE TEST

TABLE 1

FLOOR WIRE NO.	RESISTANCE WITH SHORT AT PATCH/PANEL	MEGGAR TEST
67	4.6	2.8 K MEG
68	4.7	5K MEG
69	4.5	✓
70	4.5	4K MEG
71	4.5	✓
72	4.6	5K MEG
73	4.7	7K MEG
74	4.5	4K MEG
75	4.5	5K MEG
76	5.0	✓
77	4.5	✓
78	4.6	4K MEG
79	4.6	7K MEG
80	4.6	4K MEG
81	4.6	✓
82	5.0	✓
83	4.5	5K MEG
84	4.6	1K MEG
85	4.6	✓
86	13.7	✓
87	4.6	20K MEG
88	4.6	600 MEG

RESISTANCE TEST

TABLE 1

FLOOR WIRE NO.	RESISTANCE WITH SHORT AT PATCH/PANEL	MEGGAR TEST
89	4.6	✓
90	4.6	✓
91	4.6	✓
92	4.6	✓
93	4.5	600 MEG
94	4.6	✓
95	4.5	5K MEG
96	4.5	✓
97	4.8	✓
98	4.6	✓
99	4.5	✓
100	4.9	✓
101	1.2	✓
102	1.2	10K MEG
103	1.2	20K MEG
104	1.2	✓
105	1.2	✓
106	1.2	7K MEG
107	1.2	✓
108	1.2	1K MEG
109	1.2	3K MEG
110	1.2	✓

RESISTANCE TEST

TABLE 1

FLOOR WIRE NO.	RESISTANCE WITH SHORT AT PATCH/PANEL	MEGGAR TEST
111	1.2	10K MEG
112	1.2	1.8K MEG
113	1.2	✓
114	1.2	4K MEG
115	1.2	✓
116	1.2	✓
117	1.47	✓
118	1.2	✓
119	1.2	20K MEG
120	1.2	✓
121	1.2	✓
122	1.2	✓
123	1.2	6K MEG
124	1.16	6K MEG
125	1.52	✓
126	1.2	✓
127	1.2	✓
128	1.2	1K MEG
129	1.2	10K MEG
130	1.2	✓
131	1.2	✓
132	1.2	1.3K MEG

RESISTANCE TEST

TABLE 1

FLOOR WIRE NO.	RESISTANCE WITH SHORT AT PATCH/PANEL	MEGGAR TEST
133	1.2	10K MEG
134	1.2	20K MEG
135	1.2	2K MEG
136	1.2	1.6K MEG
137	1.2	✓
138	1.28	✓
139	1.2	✓
140	1.2	6K MEG
141	1.2	1.2K MEG
142	1.2	4.5K MEG
143	1.2	✓
144	1.2	✓
145	1.2	5K MEG
146	1.2	✓
147	1.2	2.2K MEG
148	1.2	✓
149	1.2	✓
150	1.2	1.6K MEG
151	1.5	✓
152	1.25 [illegible] 4-3-[illegible] [illegible]	✓
153	1.12	15K MEG
154	1.2	✓

TABLE 1

FLOOR WIRE NO.	RESISTANCE WITH SHORT AT PATCH/PANEL	MEGGAR TEST
155	1.2	7K MEG
156	1.2	20K MEG
157	1.15	5K MEG
158	1.2	✓
159	1.2	✓
160	1.2	20K MEG
161	1.24	✓
162	1.15	✓
163	1.24	✓
164	1.13	✓
165	1.16	✓
166	1.22	✓
167	1.22	✓
168	1.24	✓
169	1.13	✓
170	1.25	✓
171	1.22	✓
172	1.23	✓
173	1.25	✓
174	1.25	20K MEG
175	[illegible]	✓
176	1.23	4K MEG

RESISTANCE TEST

TABLE 1

FLOOR WIRE NO.	RESISTANCE WITH SHORT AT PATCH/PANEL	MEGGAR TEST
177	1.15	1K MEG
178	1.23	✓
179	1.2	✓
180	1.2	✓
181	1.23	✓
182	1.23	✓
183	1.24	✓
184	1.6	2.4K MEG
185	1.6	600 MEG
186	1.52	4.5K MEG
187	1.63	✓
188	1.5	✓
189	1.63	20K MEG
190	1.63	✓
191	1.62	20K MEG
192	1.6	✓
193	1.6	✓
194	1.63	✓
195	1.6	✓
196	1.62	✓

RESISTANCE TEST

TABLE 1

FLOOR WIRE NO.	RESISTANCE WITH SHORT AT PATCH/PANEL	MEGGAR TEST

APPENDIX B. INPUT PREAMPLIFIER TEST

INPUT PREAMPLIFIER TEST

The purpose of this test is to measure the gain, frequency response and distortion of the custom pre amplifiers. From the patch panel measure the performance of each amplifier channel at the following frequencies and input signal amplitudes. (Distortion at 20, 80 & 200 Hz only)

INPUT AMPLITUDE: 30 mv., 300 mv, 600 mv.

INPUT FREQUENCY (Hz)2, 10, 20, 30, 40, 80, 140, 200

AT 2 (Hz) Amplifiers were measured with SCOPE
THE VTVM RESPONSE DOESN'T GO DOWN THAT LOW

TEST EQUIPMENT
Function Gen. From System
400D VTVM SN 22965 (HP)
330B Distortion Analyzer SN 204-08440 (HP)
Scope with two vertical inputs

AMP CH # 1

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	880mv f to f	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320mv	3.2 VOLTS	6.6 VOLTS	.34%
30	320 mv	3.2 VOLTS	6.6 VOLTS	
40	320 mv	3.2 VOLTS	6.6 VOLTS	
* 80	320 mv	3.3 VOLTS	6.6 VOLTS	.3%
140	320 mv	3.25 VOLTS	6.6 VOLTS	
* 200	320 mv	3.2 VOLTS	6.6 VOLTS	.3%

AMP CH # 2

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	880 mv P to P	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.7 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 VOLTS	.36%
30	320 mv	3.2 VOLTS	6.6 v	
40	320 mv	3.2 VOLTS	6.6 v	
* 80	320 mv	3.2 VOLTS	6.6 v	.3%
140	320 mv	3.2 VOLTS	6.7 v	
* 200	320 mv	3.2 VOLTS	6.65 v	.3%

AMP CH # 3

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	320mv P to P	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320mv	3.2 VOLTS	6.6 V	.36%
30	320mv	3.2 VOLTS	6.6 V	
40	320 mv	3.2 VOLTS	6.6V	
* 80	320 mv	3.2 VOLTS	6.6V	.3%
140	320 mv	3.2 VOLTS	6.6V	
* 200	320 mv	3.2 VOLTS	6.6V	.3%

AMP CH # 4

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	880mv P to P	3.11 VOLTS	6.18 VOLTS	
10	320mv	3.2 VOLTS	6.6 VOLTS	
* 20	320mv	3.2 VOLTS	6.6v	.36%
30	320mv	3.2 VOLTS	6.6v	
40	320mv	3.2 VOLTS	6.6v	
* 80	320mv	3.2 VOLTS	6.6v	.3%
140	320mv	3.2 VOLTS	6.65v	
* 200	320mv	3.2 VOLTS	6.65v	.3%

AMP CH # 5

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	880mv P to P	3.11 VOLTS	6.18 VOLTS	
10	320mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6v	.36%
30	320 mv	3.2 VOLTS	6.6v	
40	320 mv	3.2 VOLTS	6.6v	
* 80	320 mv	3.2 VOLTS	6.6v	.3%
140	320 mv	3.2 VOLTS	6.6v	
* 200	320 mv	3.2 VOLTS	6.6v	.3%

AMP CH # 6

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	880 mv P to P	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6v	.36%
30	320 mv	3.2 VOLTS	6.6v	
40	320 mv	3.2 VOLTS	6.6v	
* 80	320 mv	3.2 VOLTS	6.6v	.3%
140	320 mv	3.2 VOLTS	6.6v	
* 200	320 mv	3.2 VOLTS	6.6v	.3%

AMP CH # 7

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6v	.36%
30	320 mv	3.2 VOLTS	6.6v	
40	320 mv	3.2 VOLTS	6.6v	
* 80	320 mv	3.2 VOLTS	6.6v	.3%
140	320 mv	3.2 VOLTS	6.65v	
* 200	320 mv	3.2 VOLTS	6.65v	.3%

AMP CH # 2

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mV	3.2 VOLTS	6.6v	.36%
30	320 mv	3.2 VOLTS	6.6v	
40	320 mv	3.2 VOLTS	6.6v	
* 80	320 mv	3.2 VOLTS	6.6v	.3%
140	320 mv	3.2 VOLTS	6.6v	
* 200	320 mv	3.2 VOLTS	6.6v	.3%

AMP CH # 9

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6v	.36%
30	320 mv	3.2 VOLTS	6.6v	
40	320 mv	3.2 VOLTS	6.6v	
* 80	320 mv	3.2 VOLTS	6.6v	.3%
140	320 mv	3.2 VOLTS	6.6v	
* 200	320 mv	3.2 VOLTS	6.6v	.3%

AMP CH # 10

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.15 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 v	.36%
30	320 mv	3.2 VOLTS	6.6 v	
40	320 mv	3.2 VOLTS	6.6 v	
* 80	320 mv	3.2 VOLTS	6.6 v	.3%
140	320 mv	3.2 VOLTS	6.6 v	
* 200	320 mv	3.2 VOLTS	6.6 v	.3%

AMP CH # 11

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6v	.36%
30	320 mv	3.2 VOLTS	6.6v	
40	320 mv	3.2 VOLTS	6.6v	
* 80	320 mv	3.2 VOLTS	6.6v	.3%
140	320 mv	3.2 VOLTS	6.6v	
* 200	320 mv	3.2 VOLTS	6.6v	.3%

AMP CH # 12

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 volts	6.55 VOLTS	.36%
30	320 mv	3.2 VOLTS	6.6 v	
40	320 mv	3.2 VOLTS	6.6 v	
* 80	320 mv	3.2 VOLTS	6.6 v	.3%
140	320 mv	3.2 VOLTS	6.6 v	
* 200	320 mv	3.2 VOLTS	6.6 v	.3%

AMP CH # 13

Excitation Frequency/ Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 v	.36%
30	320 mv	3.2 VOLTS	6.6 v	
40	320 mv	3.2 VOLTS	6.6 v	
* 80	320 mv	3.2 VOLTS	6.6 v	.3%
140	320 mv	3.2 VOLTS	6.6 v	
* 200	320 mv	3.2 VOLTS	6.6 v	.3%

AMP CH # 14

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 v	.36%
30	320 mv	3.2 VOLTS	6.6 v	
40	320 mv	3.2 VOLTS	6.6 v	
* 80	320 mv	3.2 VOLTS	6.6 v	.3%
140	320 mv	3.2 VOLTS	6.6 v	
* 200	320 mv	3.2 VOLTS	6.6 v	.3%

AMP CH # 15

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 v	.36%
30	320 mv	3.2 VOLTS	6.6v	
40	320 mv	3.2 VOLTS	6.6v	
* 80	320 mv	3.2 VOLTS	6.6v	.3%
140	320 mv	3.2 VOLTS	6.65v	
* 200	320 mv	3.2 VOLTS	6.65v	.3%

AMP CH # 16

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320	3.2 VOLTS	6.6 VOLTS	
* 20	320 mV	3.2 VOLTS	6.6 VOLTS	.34%
30	320 mv	3.2 VOLTS	6.6v	
40	320 mV	3.2 VOLTS	6.6v	
* 80	320 mv	3.2 VOLTS	6.6v	.3%
140	320 mv	3.2 VOLTS	6.6v	
* 200	320 mv	3.2 VOLTS	6.6v	.3%

AMP CH # 17

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 VOLTS	.34%
30	320 mv	3.2 VOLTS	6.6v	
40	320 mv	3.2 VOLTS	6.6v	
* 80	320 mv	3.2 VOLTS	6.6v	.3%
140	320 mv	3.2 VOLTS	6.6v	
* 200	320 mv	3.2 VOLTS	6.6v	.3%

AMP CH # 18

Excitation Frequency/ Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mV	3.2 VOLTS	6.6 VOLTS	.34%
30	320 mv	3.2 VOLTS	6.6 V	
40	320 mv	3.2 VOLTS	6.6 V	
* 80	320 mv	3.2 VOLTS	6.6 V	.3%
140	320 mV	3.2 VOLTS	6.6 V	
* 200	320 mV	3.2 VOLTS	6.6 V	.3%

AMP CH # 19

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 volts	
* 20	320 mv	3.2 VOLTS	6.6 volts	.34%
30	320 mv	3.2 VOLTS	6.6v	
40	320 mv	3.2 VOLTS	6.6v	
* 80	320 mv	3.2 VOLTS	6.6v	.37%
140	320 mv	3.2 VOLTS	6.6v	
* 200	320 mv	3.2 VOLTS	6.6v	.3%

AMP CH #20

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.55 VOLTS	
* 20	318 mv	3.2 VOLTS	6.55 VOLTS	.34%
30	320 mv	3.2 VOLTS	6.55v	
40	320 mv	3.2 VOLTS	6.6v	
* 80	320 mv	3.2 VOLTS	6.6v	.3%
140	320 mv	3.2 VOLTS	6.55v	
* 200	320 mv	3.2v	6.55v	.3%

AMP CH # 21

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.55 volts	.34%
30	320 mv	3.2 VOLTS	6.6v	
40	320 mv	3.2 VOLTS	6.6v	
* 80	320 mv	3.2 VOLTS	6.6v	.37%
140	320 mv	3.2 VOLTS	6.6v	
* 200	320 mv	3.2 VOLTS	6.6v	.37%

AMP CH #22

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 VOLTS	.34%
30	320 mv	3.2 VOLTS	6.6v	
40	320 mv	3.2 VOLTS	6.6v	
* 80	320 mv	3.2 VOLTS	6.6v	.3%
140	320 mv	3.2 VOLTS	6.6v	
* 200	320 mv	3.2 VOLTS	6.6v	.3%

AMP CH # 23

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 volts	.34%
30	320 mv	3.2 VOLTS	6.6 V	
40	320 mv	3.2 VOLTS	6.6 v	
* 80	320 mv	3.2 VOLTS	6.6 v	.3%
140	320 mv	3.2 VOLTS	6.6 v	
* 200	320 mv	3.2 VOLTS	6.6 V	.3%

AMP CH #24

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 VOLTS	.34%
30	320 mv	3.2 VOLTS	6.6 V	
40	320 mv	3.2 VOLTS	6.6 V	
* 80	320 mv	3.2 VOLTS	6.6 V	.3%
140	320 mv	3.2 VOLTS	6.6 V	
* 200	320 mv	3.2 VOLTS	6.6 V	.3%

AMP CH #25

Excitation Frequency/ Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 VOLTS	.34%
30	320 mv	3.2 VOLTS	6.6 v	
40	320 mv	3.2 VOLTS	6.6 v	
* 80	320 mv	3.2 VOLTS	6.6 v	.3%
140	320 mv	3.2 VOLTS	6.65 v	
* 200	320 mv	3.2 VOLTS	6.65 v	.3%

AMP CH # 26

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 VOLTS	.34%
30	320 mv	3.2 VOLTS	6.6 V	
40	320 mv	3.2 VOLTS	6.6 V	
* 80	320 mv	3.2 VOLTS	6.6 V	.3%
140	320 mv	3.2 VOLTS	6.6 V	
* 200	320 mv	3.2 VOLTS	6.6 V	3%

AMP CH # 27

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 VOLTS	.34%
30	320 mv	3.2 VOLTS	6.6 V	
40	320 mv	3.2 VOLTS	6.6 V	
* 80	320 mv	3.2 VOLTS	6.6 V	.3%
140	320 mv	3.2 VOLTS	6.6 V	
* 200	320 mv	3.2 VOLTS	6.6 V	.3%

AMP CH # 28

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 VOLTS	.36%
30	320 mv	3.2 VOLTS	6.6 v	
40	325 mv	3.2 VOLTS	6.6 v	
* 80	320 mv	3.2 VOLTS	6.6 v	.3%
140	320 mv	3.2 VOLTS	6.6 v	
* 200	320 mv	3.2 VOLTS	6.65 v	.3%

AMP CH #29

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 VOLTS	.34%
30	320 mv	3.2 VOLTS	6.6V	
40	320 mv	3.2 VOLTS	6.6V	
* 80	320 mv	3.2 VOLTS	6.6V	.3%
140	320 mv	3.2 VOLTS	6.65V	
* 200	320 mv	3.2 VOLTS	6.65V	.3%

AMP CH # 30

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.55 VOLTS	
* 20	320 mv	3.2 VOLTS	6.55 VOLTS	.34 %
30	320 mv	3.2 VOLTS	6.55 v	
40	320 mv	3.2 VOLTS	6.6 v	
* 80	320 mv	3.2 VOLTS	6.6 v	.3%
140	320 mv	3.2 VOLTS	6.6 v	
* 200	320 mv	3.2 VOLTS	6.6 v	.3%

AMP CH # 31

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 VOLTS	.34%
30	320 mv	3.2 VOLTS	6.6 v	
40	320 mv	3.2 VOLTS	6.6v	
* 80	320 mv	3.2 VOLTS	6.6v	.3%
140	320 mv	3.2 VOLTS	6.6 v	
* 200	320 mv	3.2 VOLTS	6.6V	.3%

AMP CH # 32

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2	311 mv	3.11 VOLTS	6.18 VOLTS	
10	320 mv	3.2 VOLTS	6.6 VOLTS	
* 20	320 mv	3.2 VOLTS	6.6 VOLTS	.34%
30	320 mv	3.2 VOLTS	6.6 v	
40	320 mv	3.2 VOLTS	6.6v	
* 80	320 mv	3.2 VOLTS	6.6v	.3%
140	320 mv	3.2 VOLTS	6.6v	
* 200	320 mv	3.2 VOLTS	6.6 v	.3%

AMP CH #____

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2				
10				
* 20				
30				
40				
* 80				
140				
* 200				

AMP CH #____

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2				
10				
* 20				
30				
40				
* 80				
140				
* 200				

AMP CH #____

Excitation Frequency/Hz	Output with 30 mv Input %	Output With 300mv Input	Output With 600mv Input	Distortion * @ 300 mv IN
2				
10				
* 20				
30				
40				
* 80				
140				
* 200				

APPENDIX C. GROUNDING TEST

GROUNDING TEST

The purpose of this test is to investigate the adequacy of the system A.C. ground. Configure the system as shown in figure 2 . With the H. P. system running, make the following A.C. Voltage measurements.

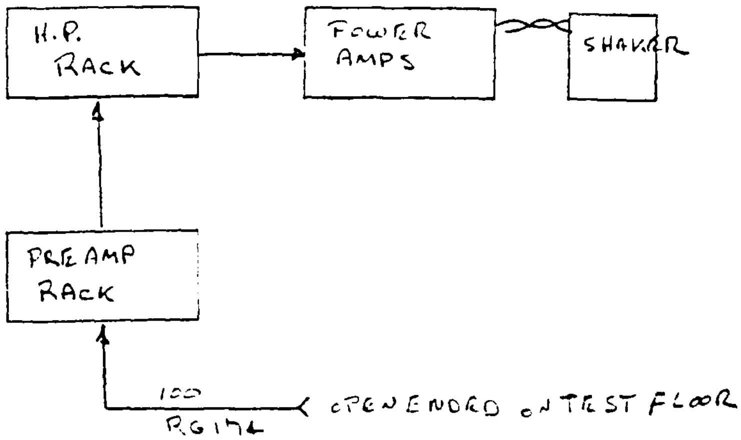
	VOLTAGE	
H.P. Rack to Preamp Rack	11.5 MILL-VOLTS	
H.P. Rack to Power Amp Rack	1.6 MV	
H.P. Rack to Test Stand	34 mv	
Preamp Rack to Power Amp Rack	4.7 mv	
Preamp Rack to Test Stand	36 mv	
Power Amp Rack to Test Stand	39 mv	7.7 mv D.C.

Connect a ground strap between the following points and repeat the measurements.

	VOLTAGE	
H.P. Rack to Preamp Rack	3.8 mv	22 mv D.C.
H.P. Rack to Power Amp Rack	1.2 mv	1.4 mv D.C.
H.P. Rack to Test Stand	11 MV	10 MV D.C.
Preamp Rack to Power Amp Rack	2.9 mv	very low D.C
Preamp Rack to Test Stand	9.3 mv	no D.C.
Power Amp Rack to Test Stand	1.1 mv	3.6 D.C

GROUND TEST

FIGURE 2



TEST CONDITIONS

- Sine Sweap Ø to 200 Hz
- All Power Amps On
- All Shakers @ ½ Power
- All input and power supplies connected through patch panel

TEST EQUIPMENT

8600A Digital Multimeter SN 565307 (Fluke)

APPENDIX D. POWER AMPLIFIER TEST

POWER AMPLIFIER TEST

The purpose of this test is to determine the frequency response, distortion, and phase shift of the power amplifiers. Connect the equipment as shown in figure 3 and measure each amplifier performance at the following fequencies and power settings.

Input frequency 2, 10, 20, 30, 40, 80, 140, 200 output power (WATTS) 10, [redacted] 60, [redacted] 100 measure the amplifier distortion with shaker loaded to .5 and 1g. at 20, 100 and 200 Hz

TEST EQUIPMENT

Function Gen.

400D VTVM

330B Distortion Analyzer

Scope

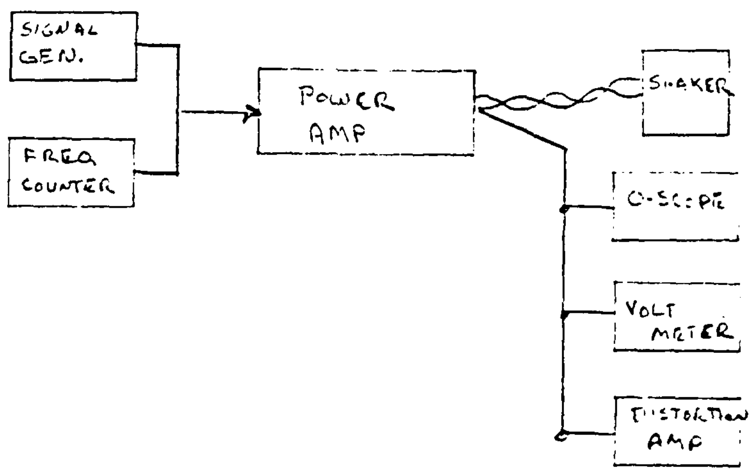


TABLE 3

SN 1392

INPUT FREQUENCY	OUTPUT POWER: 10 WATTS	50 [redacted] WATTS	100 [redacted] WATTS
2	3.11 volts	5.65 volts	8.1 volts
10	4.6 volts	8.7 volts	11.6 volts
20	4.8 volts	9.2 volts	12.5 volts
30	4.8 volts	9.0 volts	12.5 volts
40	4.7 volts	9.0 volts	12.5 volts
80	4.8 volts	9.2 volts	12.5 volts
140	4.8 volts	9.0 volts	12.5 volts
200	4.8 volts	9.0 volts	12.5 volts

INPUT FREQUENCY	DISTORTION @ 50 [redacted]	100 [redacted]	PHASE SHIFT @ [redacted] [redacted]
20	.3 to .4%	.4%	7°
100	.32%	.4%	0°
200	.3%	.35%	0°

SN 1370

TABLE 3

INPUT FREQUENCY	OUTPUT POWER 10 WATTS	50 [redacted] WATTS	100 [redacted] WATTS
2	2.7 volts	5.4 VOLTS	7.4 VOLTS
10	4.1 volts	8.2 VOLTS	11.0 VOLTS
20	4.4 volts	8.7 VOLTS	12.0 VOLTS
30	4.4 volts	8.7 VOLTS	12.0 VOLTS
40	4.3 volts	8.7 VOLTS	12.0 VOLTS
80	4.4 volts	8.7 VOLTS	12.0 VOLTS
140	4.4 volts	8.7 VOLTS	12.0 VOLTS
200	4.4 volts	8.7 VOLTS	12.0 VOLTS

INPUT FREQUENCY	50 DISTORTION @ [redacted]	[redacted]	100 PHASE SHIFT @ [redacted] [redacted]
20	.4%	.4%	7° phase sh
100	.34%	.35%	0°
200	.34%	.3%	0°

TABLE 3

SN 138 D

OUTPUT POWER

INPUT FREQUENCY	10 WATTS	50 [redacted] WATTS	100 [redacted] WATTS
2	2 7 VOLTS	5.6 VOLTS	7.7 VOLTS
10	40 VOLTS	8.4 VOLTS	11.5 VOLTS
20	4.2 VOLTS	8.8 VOLTS	12.0 VOLTS
30	4.2 VOLTS	8.8 VOLTS	12.0 VOLTS
40	4.2 VOLTS	8.8 VOLTS	12.0 VOLTS
80	4.2 VOLTS	8.8 VOLTS	12.0 VOLTS
140	4.2 VOLTS	8.8 VOLTS	12.0 VOLTS
200	4.2 VOLTS	8.8 VOLTS	12.2 VOLTS

INPUT FREQUENCY	DISTORTION @ 50 [redacted]	100 [redacted]	PHASE SHIFT @ [redacted] [redacted]
20	.6 to .7%	.4%	7°
100	.3%	.35%	0°
200	.3[illegible]	.32%	0°

TABLE 3

SN 140

INPUT FREQUENCY	10 WATTS	OUTPUT POWER 50 [redacted]	100 [redacted]
2	2.9 volts	6.0 volts	7.9 volts
10	4.2 volts	8.8 volts	11.5 volts
20	4.4 volts	9.2 volts	12.2 volts
30	4.4 volts	9.2 volts	12.0 volts
40	4.4 volts	9.2 volts	12.0 volts
80	4.4 volts	9.2 volts	12 0 volts
140	4.4 volts	9.2 volts	12.2 volts
200	4.4 volts	9.2 volts	12.2 volts

50 100

INPUT FREQUENCY	DISTORTION @ [redacted]	[redacted] PHASE SHIFT @ [redacted]	[redacted]
20	.4%	.5%	7°
100	.4%	.6%	0°
200	.3%	.46%	0°

APPENDIX E. FREQUENCY SYNTHESIZER CALIBRATION RECORD

PERFORMANCE TEST CARD

Hewlett-Packard Model 3320A/B
Frequency Synthesizer

Serial No. 1532A01586

Test Performed By H.J. Frey

Date 4-12-79

Frequency Accuracy

Vernier Out			
1 MHz	.999990 MHz	1.000000	1.000010 MHz
12.22 MHz	12.219878 MHz	12.219992	12.220122 MHz
1.10 MHz	1.099989 MHz	1.099999	1.100011 MHz
00.01 MHz	99.99900 µs	100.00007	100.00100 µs
Vernier In			
00.0150 MHz	14.000 kHz	15.095	16.000 kHz
12.9999 MHz	12.9989 MHz	12.999986	13.0009 MHz
1000 kHz Range		1.300000	
100 kHz Range		130000	
10 kHz Range		13000	
1000 Hz Range		1.300	

Harmonic Distortion

Not checked

10 kHz	______	> - 60 dB
129.9 kHz	______	> - 50 dB
150 kHz	______	> - 50 dB
1299 kHz	______	> - 40 dB
4 MHz	______	> - 40 dB
7 MHz	______	> - 40 dB
12.99 MHz	______	> - 40 dB

Spurious	______	> - 60 dB or - 110 dBm
Signal to Phase Noise	______	> - 40 dB

Not checked

3320A Amplitude Accuracy

50 Ohm load	0.9 V rms	______	1.1 V rms
Open circuit	1.8 V rms	______	2.2 V rms

3320B Amplitude Accuracy

50 Ohm load	4.975 V rms	5.01	5.025 V rms
Open circuit	9.95 V rms	10.04	10.05 V rms

Frequency Response

3320A	- 0.8 cm	______	+ 1 cm
3320B, 0.01 Hz–10 Hz	- 0.2 cm	+0.1	+ 0.2 cm
3320B, 10 Hz–13 MHz	6930 µV dc	6970 to 7034	7070 µV dc

Adjusted Errors: Adjusted Errors: (Para. 5-22(e)): C in the formula A = B + C - D

12.99 MHz	.01 MHz	1299 kHz	1 kHz	129.9 kHz	.1 kHz	12.99 kHz	.01 kHz	1299 Hz	10 Hz
-2.15	C	.86	-.14	-.14	-.14	-.14	2.43	-.14	2.43

CALIBRATION RECORD
TELEDYNE BROWN ENGINEERING

INSTRUMENT	OWNER	DATE
Frequency Synthesizer	USAF	4-12-79
MANUFACTURER H.P	MODEL 3320B	SERIAL NUMBER 1532A01586
TECHNICIAN H.J. Frey	DATE OF LAST CALIBRATION New	NEXT DUE DATE
AMBIENT TEMPERATURE 70°F	HUMIDITY 48%	PROCEDURE Manufactures

ADJUSTMENT REQUIRED - - REMARKS

☐ YES
☒ NO

PARTS REQUIRED - - REMARKS

☐ YES
☒ NO

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DATA

NOMINAL READING OF ITEM BEING CALIBRATED A	INITIAL READING OF CALIBRATING EQUIPMENT B	ALGEBRAIC ERROR SUBTRACT B FROM A + C	− D	SPECIFIED ACCURACY OF ITEM BEING CALIBRATED % E	ACCEPTABLE ERROR F	ALGEBRAIC ERROR GREATER THAN ACCEPTABLE ERROR YES G	NO H	FINAL READING AFTER REPAIR OR ADJUSTMENT I
1 Hz	1000018 usec							
2 Hz	499996 usec							
5 Hz	200000 usec		Instrument meets manufactures Specs					
10 Hz	100000 usec		with the following exceptions:					
20 Hz	50001 usec		Harmonic Distortion, Spurious, and					
30 Hz	33333 usec		Signal-to-Phase Noise not checked					
40 Hz	25000 usec		due to lack of proper test					
50 Hz	20001 usec		equipment.					
60 Hz	16666 usec							
80 Hz	12500 usec							
100 Hz	10000 usec							
120 Hz	8333 usec							
140 Hz	7142 usec							
200 Hz	5000 usec							

EQUIPMENT USED

DESCRIPTION, CALIBRATION DATE AND AGENCY		DESCRIPTION CALIBRATION DATE AND AGENCY	
5245L Counter	504-03969	6-2-79	TBE
545B Scope	100779	6-7-79	TBE
L Plug-In	022439	9-20-79	TBE
885AB Diff. Voltmeter	195	9-6-79	Fluke
931B RMS Diff. Voltmeter	1391	5-3-79	Fluke
11049A Thermal Converter	416-00238	7-31-79	HP
355D VHF Attenuator	219-01743	6-8-79	TBE
3400A RMS Voltmeter	1213A19105	10-12-79	TBE

FORM 7035, REV. NOV. 1978

I Certify that this Calibration is Traceable to and Compatible with National Bureau of Standards Measurement.

R. L. Hackett

Supervisor
Calibration Laboratory

Attenuator Accuracy, 3320B (Para. 5-24(d)): D in the formula A = B + C - D

+ 15.00 dBm	0.998 V dc	.999	1.002 V dc
+ 5.00 dBm	0.996 V dc	1.000	1.004 V dc
- 5.00 dBm	0.994 V dc	.999	1.006 V dc
- 15.00 dBm	0.992 V dc	.998	1.008 V dc
- 25.00 dBm	0.990 V dc	.995	1.010 V dc
- 35.00 dBm	0.988 V dc	.997	1.012 V dc
- 45.00 dBm	0.986 V dc	.998	1.014 V dc
- 55.00 dBm	0.984 V dc		1.016 V dc
- 65.00 dBm	0.982 V dc		1.018 V dc

Attenuator Frequency Response, 3320B Record Readings (Para. 5-26(d)): B in the formula A = B + C - D

Record Readings (Step d):

	12.99 MHz	.01 MHz	1299 kHz	1 kHz	129.9 kHz	12.99 kHz	1299 Hz
+ 15		.999	.999	.999	.999	1.000	.999
+ 5		1.001	1.001	1.001	1.001	1.001	1.001
- 5		1.001	1.000	1.000	1.000	1.000	1.000
- 15		1.001	1.001	1.001	1.001	1.001	1.001
- 25		1.000	1.000	1.001	1.000	1.000	1.000
- 35		1.000	1.000	1.000	1.000	1.000	1.000
- 45		1.000	1.000	1.001	1.000	1.000	1.001
- 55							
- 65							

Calculated Error (Para. 5-26(h)): A in the formula A = B + C - D

	12.99 MHz	.01 MHz	1299 kHz	1 kHz	129.9 kHz	12.99 kHz	12.99 Hz	Tolerance
+ 15		0	.86	-.14	-.14	-.86	-.14	± 5 mV
+ 5								± 5 mV
- 5								± 12 mV
- 15								± 12 mV
- 25								± 23 mV
- 35								± 23 mV
- 45								± 23 mV
- 55								± 45 mV
- 65								± 45 mV

DATE
FILMED

5-8