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BDX-613-2403

Thermistor Mount Efficiency Calibration

By J. W. Cable

Published May 1980

Project Report

Prepared for the United States Department of Energy
Under Contract Number DE-AC04-76-DP00613.

**Kansas City
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THERMISTOR MOUNT EFFICIENCY CALIBRATION

BDX-613-2403, Project Report, Published May 1980

Prepared by J. W. Cable

Thermistor mount efficiency calibration is accomplished by use of the power equation concept and by complex signal-ratio measurements. A comparison of thermistor mounts at microwave frequencies is made by mixing the reference and the reflected signals to produce a frequency at which the amplitude and phase difference may be readily measured.

DC/drb

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SUMMARY

The automated data acquisition system was controlled and later programmed to obtain analog data from a Hewlett-Packard power meter model HP432A and a Princeton Applied Research vector voltmeter model PAR 129. RF power is switched on and off to a reflectometer unit attached to a thermistor mount and the V_{RF} and $V_{RF} - V_{Comp}$ levels are measured with a Hewlett-Packard multimeter model HP3490A. Several sets of data are taken to eliminate some of the repeatability errors.

Data acquisition sequencing is established by pre-programmed PROMs mounted in the data system. The sequence is established first using a coupler code and a punched paper tape. The tape is condensed to subroutines and processed by a computer to change the coupler code to actual numbers in a specified format acceptable to the PROM programmer, and punched on paper tape again. This tape is then fed into the programmer that sets the PROM to the appropriate code to produce the commands to control the data sequence.

After the thermistor mount data are acquired and punched on paper tape, the data are fed into a CDC 6600 computer terminal. The data are processed by another computer program that corrects the measuring instrument zero shift and the channel gain before using the terminal invariant parameter technique to solve for the thermistor mount efficiency.

DISCUSSION

SCOPE AND PURPOSE

The calibration of thermistor mounts used in conjunction with precision microwave power measurements at Bendix Kansas City, was a tedious and laborious operation that yielded a significant amount of uncertainty.

Recent development work at the National Bureau of Standards (NBS) indicates that the use of the power equation concept will reduce sensitivity to certain connector irregularities. This concept, aided by automatic data acquisition and computer programming was recommended by the Primary Standards Laboratory (Sandia, Albuquerque), as a desirable method of increasing the speed and convenience, while reducing the uncertainty of thermistor mount calibration.

The following design goals for the thermistor mount efficiency calibration were established.

- An efficient data acquisition sequence allowing for mount stabilization and repeatability was established.
- An analysis of the acquired data, correcting for possible instrumentation errors was performed. Then, using the terminal invariant parameter technique, the mount efficiency was solved.

Mount efficiency is established by using a known calibrated mount and then comparing it to an unknown (efficiency) mount.

PRIOR WORK

A dual channel mixer was constructed as part of the existing thermistor mount efficiency calibration system to convert the 278 kHz signal from a network analyzer to a 20 kHz signal to be used in a vector voltmeter. The programmable data acquisition system for microwave calibration is used extensively in the implementation of the thermistor mount calibration system.

ACTIVITY

System Configuration

For the purpose of stability, the system was designed to be mounted in a bench top cabinet as shown in Figure 1. Power sources and amplifiers were separated from test ports to avoid heating changes in the measurement circuits. The vector voltmeter

BLANK			POWER CALIBRATION			4 TO 8 GHz AMPLIFIER		
			POWER AND FREQUENCY SWITCH					
MASTER OSCILLATOR			FREQUENCY COUNTER			2 TO 4 GHz AMPLIFIER		
			POWER METERS					
THERMISTOR MOUNT CONTROL UNIT			STAND- ARD	REFER- ENCE	BIAS	1 TO 2 GHz AMPLIFIER		
SLAVE OSCILLATOR NUMBER ONE		SLAVE OSCILLATOR NUMBER TWO	BLANK			1 TO 2.4 GHz SOURCE		
						1 TO 4 GHz LEVELING SWITCH UNIT		
DUAL CHANNEL MIXER			4 TO 8 GHz REFLECTOMETER			0.5 TO 1.0 GHz 3 TO 6 GHz 6 TO 9 GHz SOURCE		
NETWORK ANALYZER			2 TO 4 GHz REFLECTOMETER					
VECTOR VOLTMETER			1 TO 2 GHz REFLECTOMETER			0.5 TO 1.0 GHz AMPLIFIER		
			0.5 TO 1 GHz REFLECTOMETER					

HARMONIC
FREQUENCY
CONVERTER

THERMISTOR
MOUNTS

Figure 1. Equipment Setup

was placed under the network analyzer to provide more shielding from the power supplies of the dual channel mixer. Figure 2 is a basic block diagram of the operational system. The reflectometer units and the dual-channel mixer are Bendix built and will be described later. Table 1 is a parts list of the other units. A four-port device showing the source, the test port, the ratio device, and the five basic units to be attached to the test port, is shown in Figure 3.

Reflectometer Units

The reflectometer units (Figure 4) are designed to fit the next assembly frequency converter head. Power level control is achieved by feedback from coupler (Item 1) to a detector. Outputs from

Figure 2. Block Diagram

the traveling wave tube amplifiers (TWTAs) are coupled (Item 2) to the reference channel of the next assembly through 57 dB. The other output of the coupler (Item 2) may be switched to an auxiliary port or to the test port. From this circuit the reference power meter is coupled (Item 3) through 16 dB. The other output of this coupler is isolated from the test port by an isolator and a coupler (Item 4). The reflected signal from the test port is connected to the test channel of the next assembly through 10 dB. This provides the maximum amount of test signal with the least effect to the reference signal. Precision connectors were used for the final connections on the reference and test channels, and the test port. Table 2 lists the components used in the different reflectometer units.

Table 1. Equipment

Function	Unit	Frequency
Local Oscillator	HP4204A Oscillator	10 Hz to 1 MHz (Digital)
Slave Oscillators	GR1310B Oscillator	2 Hz to 2 MHz
Network Analyzer	HP8410A with 8411A Harmonic Converter 8413A Phase Gain Indicator	0.1 to 12.4 GHz
Vector Voltmeter	Princeton Applied Research 129A	0.5 Hz to 100 kHz
Counter	HP5340A Frequency Counter	10 Hz to 18 GHz
Signal Generators	HP8620A Sweep Oscillator	
	86241A Plug-in	3.2 to 6.5 GHz
	86220A Plug-in	1.3 GHz
	HP8614A Source	0.8 to 2.4 GHz
Traveling Wave Tube Amplifiers	Hughes Solid State M-W Amplifier	0.5 to 1.0 GHz
	HP489A M-W Amplifier	1.0 to 2.0 GHz
	Alfred 561A M-W Amplifier	2.0 to 4.0 GHz
	HP493A M-W Amplifier	4.0 to 8.0 GHz
Power Meters	HP432A Meter With Zero Circuit Switch With Calibration Factor Dial Modification	
Power Sensors	HP478A Thermistor Mount 200 Ω	

Data Acquisition System Operation

The automatic data acquisition system was used to improve the accuracy, speed, and the quantity of data acquired for measurements in determining thermistor mount efficiency.

First a punched paper tape was developed to control the data system. Data was recorded in the following order: (1) date, (2) serial number, (3) frequency, (4) efficiency, (5) SWR of unknown mount, (6) five sets of reference plane data, and (7) five sets of standard and unknown power meter readings and reference plane data for thermistor mounts. Table 3 identifies each data unit with specific measurements to be taken.

Figure 3. System Reference Units

The listing in program 1 (Appendix A) is a typical control tape for the data acquisition system. When the control tape is in the correct form, the controls are again analyzed and reduced to a form suitable for programming on the PROMs. Program 2 (Appendix B) is a listing of controls to place on the PROMs. This listing was formatted by a computer program called ROMCODE that converts the coded symbols to octal numbers that are acceptable to the PROMs. Program 3 (Appendix C) lists the FORTRAN program that performs the conversion. Tables 4 through 6 list the set of control codes used by the coupler controller and their octal and binary conversions. The succeeding Programs 4, 5, and 6 (Appendices D through F) are listings of paper tape to be read by a PROM programmer. Programs 7, 8, and 9 (Appendices G through I) show the PROM memory contents when programming is completed.

Figure 4. Reflectometer Unit

Table 2. Reflectometer Parts

Quantity	Part	Manufacturer
Frequency 0.5 to 1.0 GHz		
2	10 dB Directional Couplers	Narda
1	30 dB Directional Coupler	Narda
1	Latching Coaxial Switch	Hewlett Packard
2	10 dB Attenuators	Weinschel
1	30 dB Attenuator	Weinschel
1	17 dB Isolator	E and M Lab
3	Precision Connectors	Genrad
Frequency 1.0 to 2.0 GHz		
2	6 dB Directional Couplers	Micro/Fxr
1	10 dB Directional Coupler	Narda
1	Latching Coaxial Switch	Hewlett Packard
1	50 dB Attenuator	Weinschel
3	10 dB Attenuators	Weinschel
1	12 dB Isolator	E and M Lab
3	Precision Connectors	Genrad
Frequency 2.0 to 4.0 GHz		
1	10 dB Directional Coupler	Narda
2	6 dB Directional Coupler	Micro/Fxr
4	10 dB Attenuators	Weinschel
1	30 dB Attenuator	Weinschel
1	20 dB Attenuator	Weinschel
1	12 dB Attenuator	E and M Lab
1	Precision Connectors	Genrad
1	Latching Coaxial Switch	Hewlett Packard

Table 2 Continued. Reflectometer Parts

Quantity	Part	Manufacturer
Frequency 4.0 to 8.0 GHz		
1	10 dB Directional Coupler	Narda
1	6 dB Directional Coupler	Microlab/Fxr
1	20 dB Directional Coupler	Microlab/Fxr
2	10 dB Attenuators	Narda
1	10 dB Attenuator	Weinschel
1	20 dB Attenuator	Narda
1	20 dB Isolator	A and M Lab
3	Precision Connectors	Genrad
1	Latching Coaxial Switch	Hewlett Packard

Power Equation Theory

The power transferred at any point x , in a transmission line is

$$P_{gl}(x_1, t) = v(x_1, t) i(x_1, t).$$

The average power in the sinusoidal steady state is

$$P_{gl} = \text{Re} [V \cdot I].$$

The average power flow in the $+x$ direction on a loss-less transmission line is

$$P_{gl}(x) = \text{Re} [V^*(x) I(x)].$$

Where

$$V^*(x) I(x) = V^+ e^{-j\beta x} [1 + \Gamma(x)] * \frac{V^+}{R_0} e^{-j\beta x} [1 - \Gamma(x)],$$

$$= \frac{(V^+)^2}{R_0} [1 - \Gamma(x) + \Gamma^*(x) - |\Gamma|^2], \text{ and}$$

$$= \frac{(V^+)^2}{R_0} [1 - 2j \text{Im}[\Gamma(x)] - |\Gamma|^2].$$

Table 3. Data (51) Array Contents

Identification Information

Serial Numbers Data (1) Data (2)

Frequency Data (3)

Standard Efficiency Data (4)

Unknown SWR Data (5)

System Reference Plane Information

			I Component	Q Component
Short	Vector voltmeter	Phase 180°	Data (6)	Data (7)
Short	Vector voltmeter	Phase 270°	Data (8)	Data (9)
Short	Vector voltmeter	Phase 0°	Data (10)	Data (11)
Short	Offset	±120°	Data (12)	Data (13)
Short	Offset	±120°	Data (14)	Data (15)

STANDARD AND UNKNOWN THERMISTOR MOUNT INFORMATION

Meter	Power	Reference Data (V _{RF} -V _{COMP})	Data (V _{RF})	Standard Data (V _{RF} -V _{COMP})	Data (V _{RF})
Standard	Off	(16)	(17)	(18)	(19)
Standard	On	(20)	(21)	(22)	(23)
Standard Reference	Plane (I&Q)	(24)		(25)	
Unknown	Plane (I&Q)	(26)		(27)	
** *Unknown	On	(28)	(29)	(30)	(31)
** *Unknown	Off	(32)	(33)	(34)	(35)
Unknown	On	(36)	(37)	(38)	(39)
Unknown Reference	Plane (I&Q)	(40)		(41)	
Standard Reference	Plane (I&Q)	(42)		(43)	
**Standard Reference	On	(44)	(45)	(46)	(47)
**Standard Reference	Off	(48)	(49)	(50)	(51)

*Rows designated are interchanged for first cycle of calculation.

**Rows designated are again interchanged for second cycle of calculation.

Table 4. Machine Words to Octal and Binary Conversions

Control Code	Octal	Binary	Control Code	Octal	Binary	Control Code	Octal	Binary	Control Code	Octal	Binary
@00	200	10 000 000	@10	220	10 010 000	@20	240	10 100 000	@30	260	10 110 000
@0A	201	10 000 001	@1A	221	10 010 001	@2A	241	10 100 001	@3A	261	10 110 001
@0B	202	10 000 010	@1B	222	10 010 010	@2B	242	10 100 010	@3B	262	10 110 010
@0C	203	10 000 011	@1C	223	10 010 011	@2C	243	10 100 011	@3C	263	10 110 011
@0D	204	10 000 100	@1D	224	10 010 100	@2D	244	10 100 100	@3D	264	10 110 100
@0E	205	10 000 101	@1E	225	10 010 101	@2E	245	10 100 101	@3E	265	10 110 101
@0F	206	10 000 110	@1F	226	10 010 110	@2F	246	10 100 110	@3F	266	10 110 110
@0G	207	10 000 111	@1G	227	10 010 111	@2G	247	10 100 111	@3G	267	10 110 111
@0H	210	10 001 000	@1H	230	10 011 000	@2H	250	10 101 000	@3H	270	10 111 000
@0I	211	10 001 001	@1I	231	10 011 001	@2I	251	10 101 001	@3I	271	10 111 001
@0J	212	10 001 010	@1J	232	10 011 010	@2J	252	10 101 010	@3J	272	10 111 010
@0K	213	10 001 011	@1K	233	10 011 011	@2K	253	10 101 011	@3K	273	10 111 011
@0L	214	10 001 100	@1L	234	10 011 100	@2L	254	10 101 100	@3L	274	10 111 100
@0M	215	10 001 101	@1M	235	10 011 101	@2M	255	10 101 101	@3M	275	10 111 101
@0N	216	10 001 110	@1N	236	10 011 110	@2N	256	10 101 110	@3N	276	10 111 110
@0O	217	10 001 111	@1O	237	10 011 111	@2O	257	10 101 111	@3O	277	10 111 111
@40	300	11 000 000	@50	320	11 010 000	@60	340	11 100 000	@70	360	11 110 000
@4A	301	11 000 001	@5A	321	11 010 001	@6A	341	11 100 001	@7A	361	11 110 001
@4B	302	11 000 010	@5B	322	11 010 010	@6B	342	11 100 010	@7B	362	11 110 010
@4C	303	11 000 011	@5C	323	11 010 011	@6C	343	11 100 011	@7C	363	11 110 011
@4D	304	11 000 100	@5D	324	11 010 100	@6D	344	11 100 100	@7D	364	11 110 100
@4E	305	11 000 101	@5E	325	11 010 101	@6E	345	11 100 101	@7E	365	11 110 101
@4F	306	11 000 110	@5F	326	11 010 110	@6F	346	11 100 110	@7F	366	11 110 110
@4G	307	11 000 111	@5G	327	11 010 111	@6G	347	11 100 111	@7G	367	11 110 111
@4H	310	11 001 000	@5H	330	11 011 000	@6H	350	11 101 000	@7H	370	11 111 000
@4I	311	11 001 001	@5I	331	11 011 001	@6I	351	11 101 001	@7I	371	11 111 001
@4J	312	11 001 010	@5J	332	11 011 010	@6J	352	11 101 010	@7J	372	11 111 010
@4K	313	11 001 011	@5K	333	11 011 011	@6K	353	11 101 011	@7K	373	11 111 011
@4L	314	11 001 100	@5L	334	11 011 100	@6L	354	11 101 100	@7L	374	11 111 100
@4M	315	11 001 101	@5M	335	11 011 101	@6M	355	11 101 101	@7M	375	11 111 101
@4N	316	11 001 110	@5N	336	11 011 110	@6N	356	11 101 110	@7N	376	11 111 110
@4O	317	11 001 111	@5O	337	11 011 111	@6O	357	11 101 111	@7O	377	11 111 111

Table 5. ASCII Characters to Octal and Binary Conversions

ASCII Character	Octal	Binary	ASCII Character	Octal	Binary
CR	015	00 001 101	A	101	01 000 001
LF	012	00 001 010	B	102	01 000 010
SP	040	00 100 000	C	103	01 000 011
!	041	00 100 001	D	104	01 000 100
"	042	00 100 010	E	105	01 000 101
#	043	00 100 011	F	106	01 000 110
\$	044	00 100 100	G	107	01 000 111
%	045	00 100 101	H	110	01 001 000
&	046	00 100 110	I	111	01 001 001
'	047	00 100 111	J	112	01 001 010
(	050	00 101 000	K	113	01 001 011
)	051	00 101 001	L	114	01 001 100
*	052	00 101 010	M	115	01 001 101
+	053	00 101 011	N	116	01 001 110
,	054	00 101 100	O	117	01 001 111
-	055	00 101 101	P	120	01 010 000
.	056	00 101 110	Q	121	01 010 001
/	057	00 101 111	R	122	01 010 010
0	060	00 110 000	S	123	01 010 011
1	061	00 110 001	T	124	01 010 100
2	062	00 110 010	U	125	01 010 101
3	063	00 110 011	V	126	01 010 110
4	064	00 110 100	W	127	01 010 111
5	065	00 110 101	X	130	01 011 000
6	066	00 110 110	Y	131	01 011 001
7	067	00 110 111	A	132	01 011 010
8	070	00 111 000	[	133	01 011 011
9	071	00 111 001	/	134	01 011 100
:	072	00 111 010			

Table 5 Continued. ASCII Characters to Octal and Binary Conversions

ASCII Character	Octal	Binary	ASCII Character	Octal	Binary
;	073	00 111 011	]	135	01 011 101
<	074	00 111 100	↑	136	01 011 110
=	075	00 111 101	↖	137	01 011 111
>	076	00 111 110			
?	077	00 111 111			
@	100	01 000 000			

Table 6. Control Codes to Octal and Binary Conversions

Control Code	Octal	Binary
Return Control	000	00 000 000
All branches to Low Core	004	00 000 100
All branches to High Core	005	00 000 101
Prepare for Subroutine	006	00 000 110
Subroutine Return	007	00 000 111

So

$$P_{gl}(x) = \frac{(V^+)^2}{R_o} (1 - |\Gamma|^2),$$

which is independent of x because $|\Gamma| = \Gamma$ is independent of x , and if the line is loss-less the power flow is the same at every point. The power carried by the incident wave is

$$\frac{(V^+)^2}{R_o}, \text{ and } \frac{(V^+)^2 \Gamma^2}{R_o}$$

is the power reflected by the load due to mismatch.

Γ^2 is the ratio of reflected to incident power. Let

$$P_{gl}(x) = P_g^+ (1 - |\Gamma|^2).$$

The reflection coefficient at (x) is

$$\Gamma = \frac{Z_g - Z_l}{Z_g + Z_l},$$

$$\Gamma_g = \frac{Z_g - Z_o}{Z_g + Z_o}, \text{ and}$$

$$\Gamma_l = \frac{Z_l - Z_o}{Z_l + Z_o}$$

Solving for Z_g and Z_l in terms of Z_o , Γ_g , and Γ_l , then substituting into the Γ expression,

$$\Gamma = \frac{\Gamma_g - \Gamma_l}{1 - \Gamma_l \Gamma_g}$$

leaving

$$P_{gl}(x) = P_g + (1 - \left| \frac{\Gamma_g - \Gamma_l}{1 - \Gamma_l \Gamma_g} \right|^2)$$

At terminal 1 by expansion of $|\Gamma|^2$

$$P_{gl} = P_g \left(1 - \left| \frac{\Gamma_g - \Gamma_l}{1 - \Gamma_g \Gamma_l} \right|^2 \right) = P_g \frac{|1 - 2\Gamma_l \Gamma_g + \Gamma_l^2 \Gamma_g^2 - \Gamma_g^2 - 2\Gamma_l \Gamma_g + \Gamma_l^2|}{|1 - \Gamma_l \Gamma_g|^2}$$

$$P_{gl} = P_g \left[\frac{(1 - |\Gamma_g|^2)(1 - |\Gamma_l|^2)}{|1 - \Gamma_g \Gamma_l|^2} \right]$$

is the power delivered to the load; P_g is power available from the generator.

The factor

$$\frac{(1 - |\Gamma_g|^2)(1 - |\Gamma_l|^2)}{|1 - \Gamma_g \Gamma_l|^2}$$

is a function of the generator and the load. It determines the conditions for maximum power transfer and/or is the total controlling unit involving the amount of mismatch or load of total power transfer between the load and the generator. Let

$$M_{gl} = \frac{(1 - |\Gamma_g|^2)(1 - |\Gamma_l|^2)}{|1 - \Gamma_g \Gamma_l|^2} = 1 - \left| \frac{\Gamma_e - \Gamma_g^*}{1 - \Gamma_l \Gamma_g} \right|^2$$

defined as the conjugate mismatch factor. Then $P_{gl} = P_g M_{gl}$ which describes the following figure.

Replacing the load (1) with a power meter (m) will yield

where P_{gm} is the power delivered to the meter and will also be the meter-indicated power if the meter is true in reporting the power it absorbs. Substituting P_g of the meter equation into the load equation,

$$P_{gl} = \frac{M_{gl}}{M_{gm}} P_{gm}$$

In power meter calibrations using the substitution comparison method, P_{gl} would be the unknown and P_{gm} the standard. The ratio of the powers absorbed by the unknown and the standard would be:

$$\frac{P_{gl}}{P_{gm}} = \frac{M_{gl}}{M_{gm}} = K = \frac{P_{\text{unknown}}}{P_{\text{standard}}}$$

From previous equations, it can be seen that if Γ_1 and Γ_m are equal, K will be unity;

$$K = \frac{M_{gl}}{M_{gm}} = \frac{(1 - |\Gamma_g|^2)(1 - |\Gamma_l|^2)}{|1 - \Gamma_g \Gamma_l|^2} \times \frac{|1 - \Gamma_g \Gamma_m|^2}{(1 - |\Gamma_g|^2)(1 - |\Gamma_m|^2)}$$

The application of a terminal invariant parameter technique using complex signal ratio measurements is needed to exploit the relationships shown in the power equation theory. The use of such a theory and the accompanying techniques would allow the transfer of laboratory accuracies to the field user without the use of precision connectors. Low-loss, repeatable connectors are the only requirement.

The result of the operation is the calibration of thermistor mounts in efficiency rather than in calibration factor settings. Data acquisition is accomplished automatically to eliminate as much time lag as possible.

The equipment needed to perform this type of measurement is a signal generator for the frequency range desired, a four port device (reflectometer), a ratio and phase measuring device (network analyzer, connector voltmeter), arbitrary reflectors (120° apart at frequency used), and a known standard (Figure 3).

In the calibration of thermistor mount efficiency, the ratio of two mismatch factors is more useful than the value of either one.

The ratio of the signal to reference port, (Figure 3) is a bilinear transformation of the reflection coefficient seen at the test port of the four-port device (derived in the reference material). Data taken from different reflectors describe three points on a circle in the reflection plane. Now the same type of reflection data taken on the standard and the unknown thermistor mounts may be corrected for the imperfections of the measuring system. From the equation for a circle ($a^2+b^2=r^2$) a set of three equations may be set up for each thermistor mount mismatch and evaluated by applying Cramer's rule. However, the ratio of the unknown thermistor mount mismatch to the standard thermistor mount mismatch may be more accurately determined than the exact value of each mismatch by itself. As shown in the previous equations, to perform the calibration, the ratio of the mismatches and a value for the standard is all that is needed.

The equation for the evaluation of the ratio of the mismatch factors of the thermistor mounts is repeated here for the purpose of showing the evaluation routine.

$$\frac{M_{gu}}{M_{gs}} = \frac{\begin{vmatrix} \{X_1 - X_u\} & \{Y_1 - Y_u\} & \{(X_1 - X_u)^2 + (Y_1 - Y_u)^2\} \\ \{X_2 - X_u\} & \{Y_2 - Y_u\} & \{(X_2 - X_u)^2 + (Y_2 - Y_u)^2\} \\ \{X_3 - X_u\} & \{Y_3 - Y_u\} & \{(X_3 - X_u)^2 + (Y_3 - Y_u)^2\} \end{vmatrix}}{\begin{vmatrix} \{X_1 - X_s\} & \{Y_1 - Y_s\} & \{(X_1 - X_s)^2 + (Y_1 - Y_s)^2\} \\ \{X_2 - X_s\} & \{Y_2 - Y_s\} & \{(X_2 - X_s)^2 + (Y_2 - Y_s)^2\} \\ \{X_3 - X_s\} & \{Y_3 - Y_s\} & \{(X_3 - X_s)^2 + (Y_3 - Y_s)^2\} \end{vmatrix}}$$

Where $X_{1,2,3}$ and $Y_{1,2,3}$ are the system reference plane values and $X_{u,s}$ and $Y_{u,s}$ are the unknown and standard thermistor mount reference plane values. M_{gu} is the mismatch of the unknown mount compared to the system, and M_{gs} is the mismatch of the standard mount compared to the system.

The data for these equations were taken from a vector voltmeter yielding the rectangular components needed to satisfy the equation.

The network analyzer and a dual-channel mixer were used primarily to convert the 1 to 8 GHz signals to a 20 kHz signal used in the vector voltmeter. This conversion retains the same amplitude ratio and phase relationships as the original signals.

Minicomputer Interface

An interface from the 2570A Coupler Controller to a Digital Equipment Corporation PDP 11/34 was constructed to eliminate the need to transfer data via-papertape to a central site computer.

A time-share interface was incorporated into the computer - coupler/controller system. This interface allows direct communication between a computer serial terminal and the coupler/controller, as well as with a local teletype or CRT terminal. The computer may be controlled from the terminal or the coupler controller.

The coupler interface is EIA compatible with RS-232C specifications by providing data input, data output, data terminal ready, and ground terminals. It is also compatible with the HP type teleprinters. Transmission is ASCII characters, bit serial, at ten characters per second, asynchronous. Cable connections to the modem, the computer, and the terminal are shown in Figure 5.

The timeshare card has a programmable provision for turning the coupler/controller on and off. This type of interfacing capability not only allows off line punched paper tape to be fed into the computer, but also allows the computer direct access to calibration data on a real-time basis.

Evaluation Program

Thermistor mount efficiency evaluation begins with data acquisition of known parameters such as serial numbers of standard and unknown mounts (for identification); the frequency at which calibration is being performed; the efficiency of the standard mount; and the unknown mount SWR (measured at the calibration frequency before efficiency data acquisition is started). Figure 6 is a calibration program flow chart.

Pre-calibration system reference plane information is obtained by taking voltmeter quadrature data (shifting phase of the reference signal electrically then shifting phase of the test signal mechanically with airlines based on the test frequency).

Data for thermistor mount efficiency evaluation are obtained by power meters used to operate the thermistor mounts. The power

Figure 5. Serial Interconnection Wiring

meters are used to convert the RF incident power on the thermistor mount to a dc power change in the meter bridge circuits. Voltage on the RF bridge is responsive to both RF power and to ambient temperature changes.

Voltage on the compensation bridge is responsive only to ambient temperature changes. By knowing these two values, the RF power may be obtained. Power meters with the automatic bridge zeroing circuits were used; however, the bridge zeroing circuits were removed allowing a slight offset in the meters with the RF power turned off. By taking data with the power on and again with the power off, the shift may be more accurately compensated than by repetitively zeroing the bridges. Additional ambient temperature compensation is provided by a reference mount placed in a tempera-

Figure 6. Program Flow Chart

ture lag box so that any change caused by ambient air over the operating period will be insignificant. Any difference not corrected by the compensation bridge may be available for further correction. Reference plane data are then taken for the standard

and unknown mounts to be used in the mismatch correction routine in the program. Power data for the unknown mount are then taken. A mirror image data sequence is repeated to obtain additional calibration repeatability and uncertain data including system closing errors caused by system bias.

When data averaging, vector voltmeter zeroing error, channel gain, and scale factor have been compensated, individual units for the matrices are calculated (matrix-page 5 of power equation theory). The mismatch factor M_{gu}/M_{gs} is the result of two independent matrix equation components for the unknown thermistor mount and for the standard thermistor mount. After dividing the unknown thermistor mount mismatch factor by the standard thermistor mount mismatch factor, the common denominators of the matrices will cancel (not needed for ratio determination). After calculating the half of the mismatch factor that is needed, the mismatch ratio may be obtained.

Power substitution may be found by using the following formula:

$$RF \text{ Power} = \frac{V_{comp}^2 - V_{RF}^2}{4R} = \frac{1}{4R} (V_{comp} + V_{RF}) (V_{comp} - V_{RF}) \cdot V_{comp} = V_{RF};$$

when no RF power is applied. R is the resistance of the thermistor mount. The substitution power for both mounts is calculated and then the power ratio between the two mounts is found.

Multiplying the mismatch ratio, by the power ratio, times the efficiency of the standard thermistor mount, yields the mount efficiency of the unknown thermistor mount. Efficiency of the reference mount is not determined because it is used only as a check on RF power change. This entire procedure is repeated using a standard mount. The bridge balancing resistance is changed to give a different mismatch and power ratio to determine if the system is correcting for these types of changes properly. If the difference between the two calculations is greater than 0.0002, a message is printed indicating a larger than normal closing error. The final unknown thermistor mount efficiency is found by taking the difference between the two calculated efficiencies (closing error) and adding half the difference to the first unknown efficiency value.

Data for the report are stored in an array, and data for the next unknown are processed in a similar fashion. If more data are taken at the original frequency settings, system reference plane data may be bypassed. If the system is allowed to sit for any length of time between calibrations (such as two hours) new reference plane data should be taken. As many as 30 different calibrations may be processed at one time. Typical usage shows 8 to 10 is normal. Program 10 (Appendix J) is a complete listing

of the evaluation program. Program 11 (Appendix K) is a revised listing of the evaluation program modified to accept power sensor type device data.

ACCOMPLISHMENTS

An efficiency calibration system was built that uses the power equation concept (developed by NBS), and exploits automatic data acquisition. Tedious and exhaustive measurement techniques have been minimized. Time consuming calculations were reduced significantly with the aid of computer programs, and the speed and convenience with which thermistor mount calibrations can be performed was increased. The net yield is improved calibration uncertainties on thermistor mounts.

FUTURE WORK

Additional data analysis programs will be developed to use the existing system in the calibration of impedance parameters.

REFERENCES

- ¹R. D. Moyer, Terminal Invariant Parameter Determinations From Complex Signal Ratio Measurements (Development Report). Sandia Laboratories, Albuquerque: SC-DR-72 0315 May, 1972.
- ²G. F. Engen, An Introduction to the Description and Evaluation of Microwave Systems Using Terminal Invariant Parameters (National Bureau of Standards Monograph 112). U. S. Department of Commerce, Boulder, Colorado: October, 1969.
- ³F. R. Hume, Calibration of Microwave Devices Using Power Equation Concepts (Draft Report). Aerospace and Marine Products Division, North American Rockwell Corporation: C72-277/301 Contract #CST-8156 February, 1972.
- ⁴G. F. Engen, Theory of UHF and Microwave Measurements Using the Power Equation Concept (NBS Technical Note 637). U. S. Department of Commerce, Boulder, Colorado. April, 1973.
- ⁵M. P. Weidman, G. F. Engen, Application of a Non-Ideal Sliding Short to Two-Port Loss Measurement (NBS Technical Note 644). U. S. Department of Commerce, Boulder, Colorado. October, 1973.
- ⁶R. W. Beatty, Calculated and Measured S_{11} , S_{21} , and Group Delay for Simple Types of Coaxial and Rectangular Waveguide 2-Port Standards (NBS Technical Note 657). U. S. Department of Commerce, Boulder, Colorado. December, 1974.
- ⁷Hewlett Packard 2570A Timeshare Interface Operating and Service Manual. Palo Alto, California. Hewlett Packard Company, 1971.

Appendix A

CONTROL PAPER TAPE LISTING

@318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J@5M@50
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J@5M@50
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J@5M@50
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J@5M@50
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
 @318@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J@5M@50
 @4N0023@5M@50

30

31

@3I2@2E@20@5I@2E@20@30@2E@20@5I@2E@20@30@2E@20@5I@2E@20@30
@2E@20@5I@2E@20@5J@3I8@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
@4N0000@6I
@3I2@2E@20@5I@2E@20@30@2E@20@5I@2E@20@30@2E@20@5I@2E@20@30
@2E@20@5I@2E@20@5J@4N0080@6I
@3I2@2E@20@5I@2E@20@30@2E@20@5I@2E@20@30@2E@20@5I@2E@20@30
@2E@20@5I@2E@20@5J@3I8@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J
@4N0000@6I
@3I2@2E@20@5I@2E@20@30@2E@20@5I@2E@20@30@2E@20@5I@2E@20@30
@2E@20@5H@2E@20@5J@4N0080@6I
@3I2@2E@20@5I@2E@20@30@2E@20@5I@2E@20@30@2E@20@5I@2E@20@30
@2E@20@5I@2E@20@5J@3I8@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J

Appendix B

PROGRAMMABLE READ ONLY MEMORY LISTING

G010 G010
 @4N0010@5M@70 240
 @4N0023@5M@70 240
 G040 G040
 @4N0042@5M@70 240
 @4N0080@5M@70 240
 @4N0000@5M@7A 010
 @4N0003@5M@7A 210
 @4N0002@5M@7B 010
 @4N0000@5M@7B 210
 G140 G140@3I8@2E@20@5I@2E@20@30@2E@20@5I@2E@20@5J 007
 G160 G160@3I2@2E@20@5I@2E@20@30@2E@20@5I@2E@20@30@2E@20@5I@2E@20@30
 @2E@20@5I@2E@20@5J 007
 G240 G240
 @6N@6I@6K 006@70 140 006@70 140 006@70 140 006@70 140 006@70 140 006@70 140@5M
 @6N@6I@6K 006@70 140 006@70 140 006@70 140 006@70 140 006@70 140 006@70 140@5M
 @6N@6I@6K 006@70 140 006@70 140 006@70 140 006@70 140 006@70 140 006@70 140@5M
 @6N@6I@6K 006@70 140 006@70 140 006@70 140 006@70 140 006@70 140 006@70 140@5M
 @6N@6I@6K 006@70 140 006@70 140 006@70 140 006@70 140 006@70 140 006@70 140@5M 000
 G010 G010@6N@6H
 006@70 160@4N0010@6N@6I@6K 006@70 160 006@70 140@4N0000@6N@6I@6K
 006@70 160@4N0010@6N@6I@6K 006@70 160 006@70 140@4N0000@6N@6I@6K
 006@70 160@4N0010@6N@6I@6K 006@70 160 006@70 140@4N0000@6N@6I@6K
 006@70 160@4N0010@6N@6I@6K 006@70 160 006@70 140@4N0000@6N@6I@6K
 006@70 160@4N0010@6N@6I@6K 006@70 160 006@70 140 000
 G210 G210@6N@6H
 006@70 160@4N0023@6N@6I@6K 006@70 160 006@70 140@4N0003@6N@6I@6K
 006@70 160@4N0023@6N@6I@6K 006@70 160 006@70 140@4N0003@6N@6I@6K
 006@70 160@4N0023@6N@6I@6K 006@70 160 006@70 140@4N0003@6N@6I@6K
 006@70 160@4N0023@6N@6I@6K 006@70 160 006@70 140@4N0003@6N@6I@6K
 006@70 160@4N0023@6N@6I@6K 006@70 160 006@70 140 000
 G010 G010@6N@6H
 006@70 160@4N0042@6N@6I@6K 006@70 160 006@70 140@4N0002@6N@6I@6K
 006@70 160@4N0042@6N@6I@6K 006@70 160 006@70 140@4N0002@6N@6I@6K
 006@70 160@4N0042@6N@6I@6K 006@70 160 006@70 140@4N0002@6N@6I@6K
 006@70 160@4N0042@6N@6I@6K 006@70 160 006@70 140@4N0002@6N@6I@6K
 006@70 160@4N0042@6N@6I@6K 006@70 160 006@70 140 000
 G210 G210@6N@6H
 006@70 160@4N0080@6N@6I@6K 006@70 160 006@70 140@4N0000@6N@6I@6K
 006@70 160@4N0080@6N@6I@6K 006@70 160 006@70 140@4N0000@6N@6I@6K
 006@70 160@4N0080@6N@6I@6K 006@70 160 006@70 140@4N0000@6N@6I@6K
 006@70 160@4N0080@6N@6I@6K 006@70 160 006@70 140@4N0000@6N@6I@6K
 006@70 160@4N0080@6N@6I@6K 006@70 160 006@70 140 000

Appendix C

READ ONLY MEMORY CODE CONVERSION PROGRAM LISTING

```

PROGRAM ROMCODE(TAPE1=32,OUTPUT=32,INPUT=32,MEMCON=32,
1DEBUG=64,TAPE2=MEMCON)
LOGICAL TTY
DIMENSION INLIN(8),LINEOUT(8),JBR(1),JBR2(1),JBR3(1),JBR4(1)
DIMENSION NCODE(63),INCOR(5),JCGL(8)
DATA JCGL/0,1,2,3,4,5,6,7/,INCOR/5*0/
DATA NCODE/ 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76,
1 77,78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90,
2 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 43, 45, 42, 47,
3 40, 41, 36, 61, 32, 44, 46, 34, 91, 93, 58, 30, 35, 64,
4 38, 94, 33, 60, 62, 92, 63, 37, 59/
C---      A      B      C      D      E      F      G      H      I      J      K      L
C      M      N      O      P      Q      R      S      T      U      V      W      X      Y      Z
C      0      1      2      3      4      5      6      7      8      9      +      -      *      /
C      (      )      $      =      ,      .      "      [      ]      :      '      #      @
C      &      +      !      <      >      \      ?      ~      ;
5      FORMAT(7A10,A2)
10      FORMAT(G3)
15      FORMAT(1X7A10,A2)
20      FORMAT(1H014,* ERRORS DETECTED -- VERBATIM CODE EXCEEDED*,
1* 5 DIGITS*)
25      FORMAT(1H15X*ROMCODE RUN *2A10,10X*(VERSION 10-09-74 S-1)*/
11H016X*MEMORY CONTENTS TABLE*/1H05X3HADR8(5X11))
30      FORMAT(1H05X*ADDRESS REVERSAL DETECTED*)
31      FORMAT(6XG3,4X5A10)
32      FORMAT(1XG3)
      LX=1      S      JER=IADR=LADR=MX=0
      ASSIGN 60 TO JBR
      ASSIGN 93 TO JBR2
      ASSIGN 40 TO JBR4
      CALL DATE(MDY)
      CALL TIME(HM)
      WRITE(2,25) MDY,HM,JCGL
      GO TO 131
40      IX=0
      DO 45 I=1,8
45      INLIN(I)=0
      READ(1,5)INLIN
      IF(EOF(1).NE.0) GO TO 91
      DO 50 I=1,72
      L=73-I
      IF(KOMSTR(INLIN,L,1,1H,1).NE.0) GO TO 55
50      CONTINUE
      GO TO 40
55      IX=IX+1
      IF(IX.GT.L) GO TO 40
      KCH=0
      CALL STRMEV(INLIN,IX,1,KCH,10)

```

```

      GO TO JBR, (60,70,85)
C---  ANALYZE @
60    IF(KCH.NE.1R) GO TO 80
65    ASSIGN 70 TO JBR
      LIM=2      $      JCDE=0
      GO TO 55
C---  BUILD @ CODE
70    KCH=NCDE(KCH)
      IF(LIM.GT.1) KCH=16*(KCH-48)
      IF(LIM.EQ.1.AND.KCH.EQ.48) KCH=64
      JCDE=JCDE+KCH
      LIM=LIM-1
      IF(LIM.LT.1) GO TO 74
      GO TO 55
74    JCDE=JCDE+64
C---  ENCODE FOR @ OR BLANK (VERBATIM)
75    ENCODE(10,10,JWRK) JCDE
      NC=3
      ASSIGN 55 TO JBR3
      GO TO 92
C---  ANALYZE BLANK (VERBATIM) CODE
80    IF(KCH.NE.1R ) GO TO 90
84    ASSIGN 85 TO JBR
      LIM=6
      NC=0
      GO TO 55
85    IF(KCH.NE.1R) GO TO 86
      IF(NC.LT.1) GO TO 65
      ASSIGN 65 TO JBR3
      GO TO 92
86    IF(KCH.NE.1R ) GO TO 87
      IF(NC.LT.1) GO TO 55
      ASSIGN 84 TO JBR3
      GO TO 92
87    LIM=LIM-1
      NC=NC+1
      CALL STRMOV(KCH,10,1,JWRK,NC)
      IF(LIM.GT.0) GO TO 55
      NC=5
      CALL STRMOV(SH*****,1,5,JWRK,1)
      JER=JER+1
      ASSIGN 84 TO JBR3
      GO TO 92
C---  ANALYZE NO CODE
90    JCDE=NCDE(KCH)
      GO TO 75
91    IF(NC.LT.1) GO TO 200
      ASSIGN 200 TO JBR3

```

```

C---      PRINT LINEOUT
92      GO TO JBR2,(93,94)
93      ASSIGN 94 TO JBR2
          GO TO 95
94      CALL STRMOV(1H\,1,1,LINEOUT,LX)
          LX=LX+1
95      CALL STRMOV(JWORK,1,NC,LINEOUT,LX)
          LX=LX+NC
          IF(LX.LT.69) GO TO 97
          PRINT 15,LINEOUT
          DO 96 I=1,8
96      LINEOUT(I)=0
          LX=1
97      LIM=0
C---      PRINT INCOR TABLE
          IF(KOMSTR(JWORK,1,1,1HG,1).NE.0) GO TO 115
          DECODE(10,32,JWORK) NADR
          NOTB=MOD(NADR,8)
          IF(NADR-IADR) 305,125,105
C          (NEW ADR NOT ON SAME LINE)
100      MX=NOTB+1
          ASSIGN 102 TO JBR4
          GO TO 130
102      IF(LADR.LT.NADR-MX) GO TO 130
          GO TO 110
105      IF((NADR-NOTB).GT.IADR) 100,110
C          (NEW ADR IS ON SAME LINE)
110      IADR=NADR      S      MX=NOTB
          GO TO 125
115      MXP=MX*6+1
          CALL STRMOV(JWORK,1,3,INCOR,MXP)
          MX=MX+1      S      IADR=IADR+1
          IF(MX.LT.8) GO TO 125
          ASSIGN 120 TO JBR4
          GO TO 130
120      MX=0
125      CONTINUE
          ASSIGN 60 TO JBR
          GO TO JBR3,(55,65,84,200)
C---      PRINT TABLE LINE & RESET
130      IF(MOD(LADR,32).EQ.0) WRITE(2,15)
          WRITE(2,31) LADR,INCOR
          LADR=LADR+8
131      DO 132 I=1,4
          K=(I-1)*12+1
132      CALL STRMOV(12H---      ---      ,1,12,INCOR,K)
          GO TO JBR4,(40,102,120)
C---      END OF INPUT

```

```

200   IF(LX.LT.2) GO TO 250
      CALL STRMOV(IH,1,1,LINEOUT,LX)
      LX=LX+1
      LX=(LX+9)/10
      PRINT 15,(LINEOUT(I),I=1,LX)
250   IF(MX.LT.1) GO TO 300
      IF(MOD(LADR,32).EQ.0) WRITE(2,15)
      WRITE(2,31) LADR,INCZR
300   IF(TTY(6L0UTPUT)) READ 5,I
      IF(JER.EQ.0) GO TO 400
      PRINT 20, JER
      STOP 77
305   PRINT 30
      STOP 76
400   CONTINUE
      END

```

Appendix D

PROM NUMBER ONE CONTROL PAPER TAPE LISTING

G010≤G010≤316≤060≤060≤061≤060≤335≤360≤250≤316≤060≤060≤062≤063≤335≤360
 ≤250≤G040≤G040≤316≤060≤060≤064≤062≤335≤360≤250≤316≤060≤060≤070≤060≤335
 ≤360≤250≤316≤060≤060≤060≤060≤335≤361≤010≤316≤060≤060≤060≤063≤335≤361
 ≤160≤316≤060≤060≤060≤062≤335≤362≤010≤316≤060≤060≤060≤060≤335≤362≤160
 ≤G140≤G140≤271≤060≤245≤257≤331≤245≤257≤277≤245≤257≤331≤245≤257≤332≤007
 ≤G160≤G160≤271≤062≤245≤257≤331≤245≤257≤277≤245≤257≤331≤245≤257≤277≤245
 ≤257≤331≤245≤257≤277≤245≤257≤331≤245≤257≤332≤007≤G250≤G250≤337≤006≤360
 ≤140≤006≤360≤140≤006≤360≤140≤006≤360≤140≤006≤360≤140≤335≤337≤006≤360
 ≤140≤006≤360≤140≤006≤360≤140≤006≤360≤140≤006≤360≤140≤335≤337≤006≤360
 ≤140≤006≤360≤140≤006≤360≤140≤006≤360≤140≤006≤360≤140≤335≤337≤006≤360...
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 ≤140≤006≤360≤140≤006≤360≤140≤006≤360≤140≤006≤360≤140≤335≤000≤G377≤

Appendix E

PROM NUMBER TWO CONTROL PAPER TAPE LISTING

G010≤G010≤350≤006≤360≤160≤316≤060≤060≤061≤060≤351≤006≤360≤160≤006≤360
≤140≤316≤060≤060≤060≤060≤351≤006≤360≤160≤316≤060≤060≤061≤060≤351≤006
≤360≤160≤006≤360≤140≤316≤060≤060≤060≤060≤351≤006≤360≤160≤316≤060≤060
≤061≤060≤351≤006≤360≤160≤006≤360≤140≤316≤060≤060≤060≤060≤351≤006≤360
≤160≤316≤060≤060≤061≤060≤351≤006≤360≤160≤006≤360≤140≤316≤060≤060≤060
≤060≤351≤006≤360≤160≤316≤060≤060≤061≤060≤351≤006≤360≤160≤006≤360≤140
≤000≤G160≤G160≤350≤006≤360≤160≤316≤060≤060≤062≤063≤351≤006≤360≤160≤006
≤360≤140≤316≤060≤060≤060≤063≤351≤006≤360≤160≤316≤060≤060≤062≤063≤351
≤006≤360≤160≤006≤360≤140≤316≤060≤060≤060≤063≤351≤006≤360≤160≤316≤060
≤060≤062≤063≤351≤006≤360≤160≤006≤360≤140≤316≤060≤060≤060≤063≤351≤006
≤360≤160≤316≤060≤060≤062≤063≤351≤006≤360≤160≤006≤360≤140≤316≤060≤060
≤060≤063≤351≤006≤360≤160≤316≤060≤060≤062≤063≤351≤006≤360≤160≤006≤360
≤140≤000≤G377≤

Appendix F

PROM NUMBER THREE CONTROL PAPER TAPE LISTING

G010≤G010≤350≤006≤360≤160≤316≤060≤060≤06+≤062≤351≤006≤360≤160≤006≤360
 ≤140≤316≤060≤060≤060≤062≤351≤006≤360≤160≤316≤060≤060≤064≤062≤351≤006
 ≤360≤160≤006≤360≤140≤316≤060≤060≤060≤062≤351≤006≤360≤160≤316≤060≤060
 ≤064≤062≤351≤006≤360≤160≤006≤360≤140≤316≤060≤060≤060≤062≤351≤006≤360
 ≤160≤316≤060≤060≤064≤062≤351≤006≤360≤160≤006≤360≤140≤316≤060≤060≤060
 ≤062≤351≤006≤360≤160≤316≤060≤060≤064≤062≤351≤006≤360≤160≤006≤360≤140
 ≤000≤G16J≤G160≤350≤006≤360≤160≤316≤060≤060≤070≤060≤351≤006≤360≤160≤006
 ≤360≤140≤316≤060≤060≤060≤060≤351≤006≤360≤160≤316≤060≤060≤070≤060≤351
 ≤006≤360≤160≤006≤360≤140≤316≤060≤060≤060≤060≤351≤006≤360≤160≤316≤060
 ≤060≤070≤060≤351≤006≤360≤160≤006≤360≤140≤316≤060≤060≤060≤060≤351≤006
 ≤360≤160≤316≤060≤060≤070≤060≤351≤006≤360≤160≤006≤360≤140≤316≤060≤060
 ≤060≤060≤351≤006≤360≤160≤316≤060≤060≤070≤060≤351≤006≤360≤160≤006≤360
 ≤140≤000≤G377≤

Appendix G

PROM NUMBER ONE MEMORY CONTENTS TABLE

MEMORY CONTENTS TABLE

ADR	0	1	2	3	4	5	6	7
000	---	---	---	---	---	---	---	---
010	316	060	060	061	060	335	360	250
020	316	060	060	062	063	335	360	250
030	---	---	---	---	---	---	---	---
040	316	060	060	064	062	335	360	250
050	316	060	060	070	060	335	360	250
060	316	060	060	060	060	335	361	010
070	316	060	060	060	063	335	361	160
100	316	060	060	060	062	335	362	010
110	316	060	060	060	060	335	362	160
120	---	---	---	---	---	---	---	---
130	---	---	---	---	---	---	---	---
140	271	060	245	257	331	245	257	277
150	245	257	331	245	257	332	007	---
160	271	062	245	257	331	245	257	277
170	245	257	331	245	257	277	245	257
200	331	245	257	277	245	257	331	245
210	257	332	007	---	---	---	---	---
220	---	---	---	---	---	---	---	---
230	---	---	---	---	---	---	---	---
240	---	---	---	---	---	---	---	---
250	337	006	360	140	006	360	140	006
260	360	140	006	360	140	006	360	140
270	335	337	006	360	140	006	360	140
300	006	360	140	006	360	140	006	360
310	140	335	337	006	360	140	006	360
320	140	006	360	140	006	360	140	006
330	360	140	335	337	006	360	140	006
340	360	140	006	360	140	006	360	140
350	006	360	140	335	337	006	360	140
360	006	360	140	006	360	140	006	360
370	140	006	360	140	335	000	---	---

Appendix H

PROM NUMBER TWO MEMORY CONTENTS TABLE

ROMCODE RUN 10/10/74 11.11.31.

(VERSION 10-00-7, S-1)

MEMORY CONTENTS TABLE

ADDR	0	1	2	3	4	5	6	7
000	---	---	---	---	---	---	---	---
010	350	006	350	160	316	050	050	051
020	060	351	006	360	160	006	350	140
030	316	060	060	060	050	351	006	360
040	160	316	060	060	051	060	351	006
050	360	160	006	360	140	316	050	060
060	060	060	351	006	360	160	316	060
070	060	061	060	351	006	360	160	006
100	360	140	316	060	060	060	060	351
110	006	360	160	316	060	060	051	060
120	351	006	360	160	006	360	140	316
130	060	060	060	060	351	006	350	160
140	316	060	060	061	060	351	006	360
150	160	006	360	140	000	---	---	---
160	350	006	360	160	316	060	060	062
170	063	351	006	360	160	006	350	140
200	316	060	060	060	063	351	006	360
210	160	316	060	060	062	063	351	006
220	360	160	006	360	140	316	060	060
230	060	063	351	006	360	160	316	060
240	060	062	063	351	006	360	160	006
250	360	140	316	060	060	060	063	351
260	006	360	160	316	060	060	062	063
270	351	006	360	160	006	360	140	316
300	060	060	060	063	351	006	360	160
310	316	060	060	062	063	351	006	360
320	160	006	360	140	000	---	---	---
330	---	---	---	---	---	---	---	---
340	---	---	---	---	---	---	---	---
350	---	---	---	---	---	---	---	---
360	---	---	---	---	---	---	---	---
370	---	---	---	---	---	---	---	---

Appendix I

PROM NUMBER THREE MEMORY CONTENTS TABLE

MEMORY CONTENTS TABLE

ACP	0	1	2	3	4	5	6	7
000	---	---	---	---	---	---	---	---
010	350	006	360	160	316	060	060	064
020	062	351	006	360	160	306	360	140
030	316	060	060	060	062	351	006	360
040	160	316	060	060	064	062	351	006
050	360	160	006	360	140	316	060	060
060	060	062	351	006	360	160	316	060
070	060	064	062	351	006	360	160	006
100	360	140	316	060	360	060	062	351
110	006	360	160	316	360	060	064	062
120	351	006	360	160	006	360	140	316
130	060	060	060	062	351	006	360	160
140	316	060	060	064	062	351	006	360
150	160	006	360	140	000	---	---	---
160	350	006	360	160	316	060	060	070
170	060	351	006	360	160	006	360	140
200	316	060	060	060	060	351	006	360
210	160	316	060	060	070	060	351	006
220	360	160	006	360	140	316	060	060
230	060	060	351	006	360	160	316	060
240	060	070	060	351	006	360	160	006
250	360	140	316	060	060	060	060	351
260	006	360	160	316	060	060	070	060
270	351	006	360	160	006	360	140	316
300	060	060	060	060	351	006	360	160
310	316	060	060	070	060	351	006	360
320	160	006	360	140	000	---	---	---
330	---	---	---	---	---	---	---	---
340	---	---	---	---	---	---	---	---
350	---	---	---	---	---	---	---	---
360	---	---	---	---	---	---	---	---
370	---	---	---	---	---	---	---	---

Appendix J

THERMISTOR MOUNT EFFICIENCY DATA EVALUATION
PROGRAM LISTING

```

C----- VERSION NO. 1 3/3/77
C-----2ND STD BRIDGE RESISTANCE VALUE 230.000 OHMS
0001 IMPLICIT DOUBLE PRECISION (A-H,O-Z)
0002 DOUBLE PRECISION MM,MMR,MMRC
0003 REAL D,READ
0004 DIMENSION DATA(51),MM(4),PW(4),DATAXT(4),DATAYT(4),
1ISCALE(8),IGAIN(7),DATAZ(12),REPORT(100),RERUN(15)
1,D(205),SH1(2),SH2(2),SH3(2),SH4(2),SH5(2),
1SA1(10),SA2(10),UA(10),DATAZ(12),DATAY(12)
1,DATE(2)
0005 DATA ISCALE/24,25,26,27,40,41,42,43/,
1IGAIN/10,12,14,24,26,40,42/
C-----READ DATE & SCALE FACTOR
0006 READ (1,120) DATE
0007 READ (1,130) SCALFR
0008 IA=0
0009 ICOUNT=1
C-----READ DATA
0010 5 CALL READ (1,205,D,NC)
C PRINT 121,DATE
C PRINT 131,SCALFR
C PRINT 160,D
0011 IF(NC.EQ.0.AND.IA.EQ.0) GO TO 115
0013 IF(NC.EQ.0) GO TO 105
0015 IF(NC.NE.205) GO TO 100
0017 STDEFF=D(4)
0018 DO 10 I=1,2
0019 SH1(I)=(D(I+5)+D(I+5+2)+D(I+5+4)+D(I+5+6)+D(I+5+8))/5D0
0020 SH2(I)=(D(I+5+10)+D(I+5+10+2)+D(I+5+10+4)+D(I+5+10+6)+D(I+5+10+8))
1/5D0
0021 SH3(I)=(D(I+5+20)+D(I+5+20+2)+D(I+5+20+4)+D(I+5+20+6)+D(I+5+20+8))
1/5D0
0022 SH4(I)=(D(I+5+30)+D(I+5+30+2)+D(I+5+30+4)+D(I+5+30+6)+D(I+5+30+8))

```

```

1/5D0
0023      SH5(I)=(D(I+5+40)+D(I+5+40+2)+D(I+5+40+4)+D(I+5+40+6)+D(I+5+40+8))
1/5D0
0024  10  CONTINUE
0025      DO 15 I=1,10
0026      SA1(I)=(D(I+55)+D(I+55+10)+D(I+55+20)+D(I+55+30)+D(I+55+40))/5D0
          C      PRINT 160, D(I+55),D(I+55+10),D(I+55+20),D(I+55+30),D(I+55+40)
0027      UA(I)=(D(I+55+50)+D(I+55+60)+D(I+55+70)+D(I+55+80)+D(I+55+90))/5D0
          C      PRINT 160,D(I+55+50),D(I+55+60),D(I+55+70),D(I+55+80),D(I+55+90)
0028      SA2(I)=(D(I+55+100)+D(I+55+110)+D(I+55+120)+D(I+55+130)+D(I+55+140
          1))/5D0
          C      PRINT 160,D(I+55+100),D(I+55+110),D(I+55+120),D(I+55+130),D(I+55+1
          C      140)
0029  15  CONTINUE
          C      PRINT 160, SH1,SH2,SH3,SH4,SH5,SA1,UA,SA2
0030      DO 20 I=1,5
0031      DATA(I)=D(I)
0032  20  CONTINUE
0033      DO 25 I=1,2
0034      DATA(I+5)=SH1(I)
0035      DATA(I+7)=SH2(I)

```

FORTRAN IV V01C-03
CORE=15K, UIC=[200,200]

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,TMOUNT,FTN/SF=DK2:TMOUNT

```
0036      DATA(I+9)=SH3(I)
0037      DATA(I+11)=SH4(I)
0038      DATA(I+13)=SH5(I)
0039  25    CONTINUE
0040      DO 30 I=1,10
0041      DATA(I+15)=SA1(I)
0042  30    CONTINUE
0043      DATA(26)=UA(9)
0044      DATA(27)=UA(10)
0045      DO 35 I=5,8
0046      DATA(I+23)=UA(I)
0047  35    CONTINUE
0048      DO 40 I=1,10
0049      DATA(I+31)=UA(I)
0050  40    CONTINUE
0051      DATA(42)=SA2(9)
0052      DATA(43)=SA2(10)
0053      DO 45 I=5,8
0054      DATA(I+39)=SA2(I)
0055  45    CONTINUE
0056      DO 50 I=1,4
0057      DATA(I+47)=SA2(I)
0058  50    CONTINUE
0059      DO 55 I=1,15
0060      RERUN(I)=DATA(I)
0061  55    CONTINUE
          C      PRINT 160, DATA
          C-----CORRECT PAR #0# &CHANNEL GAIN
0062      W=(DATA(6)+DATA(10))/2DO
0063      WW=DSQRT((DATA(6)-W)*(DATA(6)-W)+(DATA(8)-W)*(DATA(8)-W))
0064      T=(DATA(7)+DATA(11))/2DO
0065      TT=DSQRT((DATA(7)-T)*(DATA(7)-T)+(DATA(9)-T)*(DATA(9)-T))
0066      DO 60 I=1,7
```

```

0067      J=IGAIN(I)
0068      DATA(J)=DATA(J)-W
0069      DATA(J+1)=(DATA(J+1)-T)*DABS(WW/TT)
0070  60    CONTINUE
      C-----CORRECT PAR SCALE FACTOR
0071      DO 65 I=1,8
0072      J=ISCALE(I)
0073      DATA(J)=DATA(J)/SCALFR
0074  65    CONTINUE
      C-----CALCULATE X'S, Y'S, 1 Z'S OF MATRIX
0075      M=1
0076      DO 70 I=4,7
0077      J=IGAIN(I)
0078      DO 70 L=1,3
0079      K=IGAIN(L)
0080      DATAX(M)=DATA(K)-DATA(J)
0081      DATAY(M)=DATA(K+1)-DATA(J+1)
0082      DATAZ(M)=(DATA(K)-DATA(J))*(DATA(K)-DATA(J))+
      1(DATA(K+1)-DATA(J+1))*(DATA(K+1)-DATA(J+1))
0083      M=M+1
0084  70    CONTINUE

```

```

C-----CALCULATE MISMATCH FACTOR
0085      J=1
0086      DO 75 I=1,4
0087      MM(I)=DATA(X(J)*DATAY(J+1)*DATAZ(J+2)+
1DATA(X(J+2)*DATAY(J)*DATAZ(J+1)+
1DATA(X(J+1)*DATAY(J+2)*DATAZ(J)-
1DATA(X(J+2)*DATAY(J+1)*DATAZ(J)-
1DATA(X(J)*DATAY(J+2)*DATAZ(J+1)-
1DATA(X(J+1)*DATAY(J)*DATAZ(J+2)
0088      J=J+3
0089  75   CONTINUE
C-----CALCULATE MISMATCH RATIO
0090      MMR=MM(1)/MM(2)
0091      MMRC=MM(3)/MM(4)
C-----CALCULATE POWER SUBSTITUTION
0092      K=1
0093      DO 85 J=1,17,16
0094      DO 80 I=1,4
0095      DATA(X(I)=DATA(26+J+I)
0096      DATA(26+J+I)=DATA(30+J+I)
0097      DATA(30+J+I)=DATA(X(I)
0098      IF(J.EQ.1) GO TO 80
0100      DATAY(T(I)=DATA(27+I)
0101      DATA(27+I)=DATA(31+I)
0102      DATA(31+I)=DATAY(T(I)
0103  80   CONTINUE
0104      L=0
0105      DO 85 I=1,2
0106      PW(K)=(((2D0*DATA(20+J+L)+DATA(19+J+L))*DATA(19+J+L)-(2D0*DATA(16+
1J+L)+DATA(15+J+L))*DATA(15+J+L))/((2D0*DATA(22+J+L)+DATA(21+J+L))*
1DATA(21+J+L)-(2D0*DATA(18+J+L)+DATA(17+J+L))*DATA(17+J+L)))
0107      L=L+12
0108      K=K+1

```

```

0109 85      CONTINUE
      C-----CALCULATE POWER RATIOS
0110      PWR=PW(1)/PW(2)
0111      PWRC=(86956D-5*PW(3))/PW(4)
      C-----CALCULATE THERMISTOR MOUNT EFFICIENCY
0112      EFF=MMR*PWR*DATA(4)
0113      EFFC=MMRC*PWRC*EFF
      C-----CALCULATE CLOSING ERROR
0114      CE=(STDEFF-EFFC)
0115      IA=IA+1
      C-----CORRECT EFFICIENCY FROMCLOSING ERROR
0116      EFFCOR=EFF+(CE/2D0)
      C-----CALCULATE CALIBRATION FACTOR
0117      CF=((1D0-(((DATA(5)-1D0)/(DATA(5)+1D0))*((DATA(5)-1D0)/(DATA(5)+1D
10)))))*EFFCOR
      C-----DEBUG CALCULATIONS
      C      PRINT 160, DATA, DATAZ, MM, MMR, MMRC, PW, PWR, PWRC, EFF, EFFC, CE, CF
0118      PRINT 160, EFF, EFFC, MMR, MMRC
0119      PRINT 165, CE, IA
0120      IF(DABS(CE).LT.1D-3) GO TO 90
0122      PRINT 135, IA, CE

```



```

C-----STORE FOR REPORT
0123 90 J=ICOUNT
0124 REPORT(J)=DATA(3)
0125 REPORT(J+1)=DATA(2)
0126 REPORT(J+2)=EFFCOR
0127 REPORT(J+3)=CF
0128 ICOUNT=ICOUNT+4
C-----COMPLETE CALCULATION LOOP
0129 DO 95 I=1,15
0130 DATA(I)=RERUN(I)
0131 95 CONTINUE
0132 DATA(4)=STDEFF
0133 GO TO 5
0134 100 IB=IA+1
0135 PRINT 155,IB
0136 IF(IA.EQ.0) GO TO 115
C-----PRINT REPORT
0138 105 PRINT 140,DATE, DATA(1)
0139 J=1
0140 DO 110 I=1,IA
0141 PRINT 145,(REPORT(J),REPORT(J+1),REPORT(J+2),REPORT(J+3))
0142 J=J+4
0143 110 CONTINUE
0144 115 CONTINUE
C15 CALL SECOND (SEC)
C PRINT 150, SEC
C-----FORMATS
0145 120 FORMAT (2A4)
0146 121 FORMAT (1X,2A4)
0147 125 FORMAT (I10)
0148 130 FORMAT (D15.8)
0149 131 FORMAT (1X,D15.8)
0150 135 FORMAT (42H CLOSING ERROR LIMIT EXCEEDED IN GROUP NO. ,I2,

```

```

18H CE = ,F10.6)
0151 140 FORMAT (1H1,50H ***** THERMISTOR MOUNT CALIBRATION
121H *****//7H DATE: ,2A4,1X,8H STD NO:,F7.0,
1,24X,11H CALIBRATION/,4X,
19H FREQUENCY,9X,10H SERIAL NO.,8X,10H EFFICIENCY,10X,6H FACTOR/)
0152 145 FORMAT (5X,F6.3,13X,F6.0,9X,F8.5,11X,F7.4/)
C50 FORMAT (1H1,33H VERSION NO. 1 06/24/76 CPU...,F6.1)
0153 155 FORMAT (30H INCOMPLETE DATA IN GROUP NO. ,I2)
0154 160 FORMAT (1X,4F15.6)
0155 165 FORMAT (16H CLOSING ERROR: ,D15.6,11H GROUP NO. ,I2)
0156 END

```

FORTTRAN IV STORAGE MAP

NAME	OFFSET	ATTRIBUTES	
DATA	000006	REAL*8	ARRAY (51)
MM	000636	REAL*8	ARRAY (4)
PW	000676	REAL*8	ARRAY (4)
DATAXT	000736	REAL*8	ARRAY (4)
DATAYT	000776	REAL*8	ARRAY (4)
ISCALE	001036	INTEGER*2	ARRAY (8)
IGAIN	001056	INTEGER*2	ARRAY (7)
IATAZ	001074	REAL*8	ARRAY (12)
REPORT	001234	REAL*8	ARRAY (100)
RERUN	002674	REAL*8	ARRAY (15)
D	003064	REAL*4	ARRAY (205)
SH1	004550	REAL*8	ARRAY (2)
SH2	004570	REAL*8	ARRAY (2)
SH3	004610	REAL*8	ARRAY (2)
SH4	004630	REAL*8	ARRAY (2)
SH5	004650	REAL*8	ARRAY (2)
SA1	004670	REAL*8	ARRAY (10)
SA2	005010	REAL*8	ARRAY (10)
UA	005130	REAL*8	ARRAY (10)
DATAX	005250	REAL*8	ARRAY (12)
DATAY	005410	REAL*8	ARRAY (12)
DATE	005550	REAL*8	ARRAY (2)
MMR	006364	REAL*8	VARIABLE
MMRC	006374	REAL*8	VARIABLE
READ	000000	REAL*4	PROCEDURE
SCALFR	006404	REAL*8	VARIABLE
IA	006414	INTEGER*2	VARIABLE
ICOUNT	006416	INTEGER*2	VARIABLE
NC	006420	INTEGER*2	VARIABLE
STDEFF	006422	REAL*8	VARIABLE
I	006432	INTEGER*2	VARIABLE
W	006434	REAL*8	VARIABLE

WW	006444	REAL*8	VARIABLE
DSQRT	000000	REAL*8	PROCEDURE
T	006454	REAL*8	VARIABLE
TT	006464	REAL*8	VARIABLE
J	006474	INTEGER*2	VARIABLE
DABS	000000	REAL*8	PROCEDURE
M	006476	INTEGER*2	VARIABLE
L	006500	INTEGER*2	VARIABLE
K	006502	INTEGER*2	VARIABLE
PWR	006504	REAL*8	VARIABLE
PWRC	006514	REAL*8	VARIABLE
EFF	006524	REAL*8	VARIABLE
EFFC	006534	REAL*8	VARIABLE
CE	006544	REAL*8	VARIABLE
EFFCOR	006554	REAL*8	VARIABLE
CF	006564	REAL*8	VARIABLE
IB	006574	INTEGER*2	VARIABLE

FORTRAN IV V01C-03
CORE=15K, UIC=[200,200]

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,READ.FTN/SP=DK2:READ

0001		SUBROUTINE READ(KUN,NN,A,NC)
0002		LOGICAL*1 IN,IBUF,JCH,JB,IZER,NINE,IPLUS,MINUS,JEND,JPR
0003		LOGICAL*1 ICOM,IW,IH,IY,IC,JAS,JES,L31,MASK5,MASK7,ICH
	C	LOGICAL ITY,JTY,JF4,TTY,L31
0004		DIMENSION A(1),IN(80),IBUF(30)
0005		DATA JB,IZER,NINE,IPLUS,MINUS/'40','60','71','53','55/
0006		DATA JEND,JPR,ICOM,IW,IH,IY/'5','56','54','27','10','31/
0007		DATA IC,JAS,JES/'3','52','23/
0008		DATA MASK5,MASK7/31,127/
0009	1	FORMAT(80A1)
0010	2	FORMAT(G30.0)
0011		NC=0
0012		IO=5
0013		N=NN
0014		LUN=KUN
0015		IF(KUN.LT.1) LUN=1
0017		IF(NN.LT.1)N=1
	C	IF(ITY.AND..NOT.JTY) JF4=.TRUE.
0019		ASSIGN 10 TO INPB
	C	IF(ITY) ASSIGN 10 TO INPB
	C	IF(JF4) CALL CONNEC(IO)
	C---	--- READ INPUT LINE
0020	10	L31=.FALSE.
0021		READ(LUN,1,END=44) IN
0022		JFE=0
0023		JFB=0
0024		JD=0
0025		JPER=0
0026		JEX=0
0027		JF3=0
	C---	--- EXAMINE LINE
0028		DO 15 I=1,80
	C	JCH=0

0029		IF(NC.EQ.N) GO TO 900
	C	CALL STRMOV(IN,I,1,JCH,10,JERR)
0031		ICH=IN(I)
0032		JCH=ICH.AND.MASK7
0033	18	IF(JCH.LT.IZER) GO TO 24
0035	19	IF(JCH.GT.NINE) GO TO 24
0037	21	IF(JFB.EQ.1) GO TO 23
	C---	--- START OF NUMBER
0039	22	JFB=1
0040		L31=.FALSE.
0041		LL=I
	C---	--- DIGIT COUNT
0042	23	IF(JD.GE.25) GO TO 50
0044		JD=JD+1
0045		IF(I.EQ.80) GO TO 331
0047		GO TO 15
	C---	TEST SYMBOLS
0048	24	IF(JCH.EQ.IPLUS) GO TO 25
0050		IF(JCH.NE.MINUS) GO TO 27
0052	25	IF(JFB.EQ.0) GO TO 22
0054		IF(JEX.NE.1) GO TO 50

0056		IF(JFE.EQ.1) GO TO 50
0058		JFE=1
0059		GO TO 23
0060	C---	TEST ALPHA
26		JCH=JCH.AND.MASK5
0061		IF(JCH.NE.JEND) GO TO 34
0063		IF(JFB.NE.1) GO TO 50
0065		IN(I)="305
0066		JEX=1
0067		GO TO 23
0068	27	IF(JCH.NE.JPR) GO TO 30
0070		IF(JPER.EQ.1) GO TO 50
0072		JPER=1
0073		IF(JFB.NE.1) GO TO 22
0075		GO TO 23
0076	30	IF(JCH.NE.JB) GO TO 33
0078		IF(JFB.NE.1) GO TO 15
0080		L31=.TRUE.
0081	31	NC=NC+1
	C---	--- END NUMBER
0082		JFB=0
0083		JEX=0
0084		JPER=0
0085		JFE=0
0086		DO 32 J=1,30
0087	32	IBUF(J)=JB
0088		LM=31-JD
	C	CALL STRMOV(IN,LL,JD,IBUF,LM,JERR)
0089		IP=LL
0090		DO 321 J=LM,30
0091		IBUF(J)=IN(IP)
0092	321	IP=IP+1
0093		IF(JF3.GT.0) GO TO 38

```

0095      DECODE(30,2,IBUF) A(NC)
0096      JD=0
0097      GO TO 15
0098  33    IF(JCH.NE.ICOM) GO TO 37
0100  331   IF(JFB.EQ.1) GO TO 31
0102      IF(JF3.EQ.2) GO TO 391
0104      IF(.NOT.L31) NC=NC+1
0106      L31=.FALSE.
0107      GO TO 15
      C--- --- CONT. EXAM .LT. IZER
0108  34    IF(JCH.NE.IW) GO TO 35
0110      IF(JFB.EQ.1) GO TO 50
0112  342   NCC=NC+1
0113      WRITE(IO,4) NCC
0114  4      FORMAT(' DATUM(',I4,')= ')
0115      GO TO INPB,(10,44)
      C--- --- HELP
0116  35    IF(JCH.NE.IH) GO TO 36
0118      IF(JFB.EQ.1) GO TO 50
0120      WRITE(IO,5)
0121      WRITE(IO,6)

```

```

      C      IF(.NOT.ITY) GO TO 356
0122      READ(LUN,7) JCH
0123      JCH=JCH.AND.MASK5
0124      IF(JCH.NE.IY) GO TO 342
0126 356    WRITE(IO,8)
0127      WRITE(IO,9)
0128      GO TO 342
0129 5      FORMAT('0--- VER. 10-20-76 S-1 ---'/
      A'OENTER NUMBERS IN FREE FORM, SEPARATING THEM WITH ONE OR MORE'//
      B' SPACES, OR WITH A COMMA.'//
      C' (DECIMAL POINTS ARE NOT REQUIRED FOR WHOLE NUMBERS. MAXIMUM'//
      D' CHARACTERS PER NUMBER IS 25. E NOTATION MAY BE USED, E.G. 2.,
      E'E-6)'/OENTER W TO FIND NEXT DATUM WANTED.'//
      F'OENTER C TO CEASE INPUT AND CONTINUE NORMAL RUN.')
0130 6      FORMAT('OENTER S TO STOP RUN, OR TO SIGNAL LAST RUN.'// (RESULTS'
      H,' MAY VARY FOR C AND S, DEPENDING ON PROGRAM DESIGN')//
      I'OENTER H TO GET THIS HELP. CONTINUE HELP? ')
0131 8      FORMAT('OSPECIAL ENTRY FEATURES---'/
      A' MULTIPLE ASSIGNMENT MAY BE USED TO ENTER A SERIES OF '//
      B' IDENTICAL NUMBERS, E.G. 5',1H*'0. ,WHICH INPUTS '//
      C' 5 NUMBERS ALL EQUAL TO 0.'//
      D'O SKIP OF DATUM ENTRY OCCURS IF A COMMA IS NOT PRECEDED '//
      E' WITH DIGITS, E.G. 5.3,,3.7, 8.2 CAUSES DATUM(2)'/
      F' TO BE SKIPPED, OR'/
      G' 3,,, 6 CAUSES DATUM(2) AND DATUM(3) TO BE SKIPPED.')
0132 9      FORMAT('OMULTIPLE SKIP OCCURS IF N',1H*', IS ENTERED, E.G. 10',
      I2H*,// CAUSES THE NEXT 10 DATUM ENTRIES TO BE SKIPPED.'//
      J'NOTE: SKIP ENTRY SHOULD BE USED ONLY IF THE PROGRAM IS '//
      H' DESIGNED TO LOOP BACK AND RETAIN PREVIOUSLY ENTERED '//
      I'. DATA, OTHERWISE RESULTS ARE UNPREDICTABLE.')
0133 7      FORMAT(A1)
0134 36     IF(JCH.NE.IC) GO TO 43
0136      IF(JFB.EQ.1) GO TO 50

```


0138		GO TO 900
0139	37	IF(JCH.NE.JAS) GO TO 26
0141		IF(JFB.NE.1) GO TO 50
0143		IF(JF3.EQ.2) GO TO 50
0145		JF3=1
0146		GO TO 31
0147	38	DECODE(30,2,IBUF) XN
0148		NC=NC-1
0149		IF(JF3.EQ.2) GO TO 40
0151		IF(N-NC-ABS(XN).GE.0) GO TO 39
0153		WRITE(10,382)
0154		GO TO 50
0155	382	FORMAT('MULTIPLIER IS TOO LARGE, THEREFORE,')
0156	39	JF3=2
0157		M=ABS(XN)+.5
0158		JD=0
0159		GO TO 15
0160	391	NC=NC+M
0161		JF3=0
0162		JD=0
0163		GO TO 15

FORTTRAN IV V01C-03
CORE=15K, UIC=[200,200]

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PAGE 004
,READ.FTN/SF=DK2:READ

0164	40	DO 41 J=1,M
0165		NC=NC+1
0166	41	A(NC)=XN
0167		JF3=0
0168		JD=0
0169		GO TO 15
0170	43	IF(JCH.NE.JES) GO TO 50
0172		IF(JFB.EQ.1) GO TO 50
0174	44	NC=-NC-1
0175		GO TO 900
	C---	--- ERROR MSG
0176	50	WRITE(IO,3) ICH,I
0177	3	FORMAT('0 ',A1,' ILLEGAL AT POSITION ',I2/' RE-ENTER BEGINNING', 1' AT')
0178		GO TO 342
0179	15	CONTINUE
0180		IF(NC.EQ.N) GO TO 900
0182		GO TO 10
	C---	--- END ROUTINE
	C900	IF(.NOT.JF4) GO TO 905
	C	CALL DISCON(IO) \$ BACKSPACE IO
0183	900	CONTINUE
0184	905	RETURN
0185		END

FORTRAN IV STORAGE MAP

NAME	OFFSET	ATTRIBUTES	
A	000020	REAL*4	PARAMETER ARRAY (1)
IN	000024	LOGICAL*1	ARRAY (80)
IBUF	000144	LOGICAL*1	ARRAY (30)
KUN	000014	INTEGER*2	PARAMETER VARIABLE
NN	000016	INTEGER*2	PARAMETER VARIABLE
NC	000022	INTEGER*2	PARAMETER VARIABLE
JCH	002636	LOGICAL*1	VARIABLE
JB	000202	LOGICAL*1	VARIABLE
IZER	000203	LOGICAL*1	VARIABLE
NINE	000204	LOGICAL*1	VARIABLE
IPLUS	000205	LOGICAL*1	VARIABLE
MINUS	000206	LOGICAL*1	VARIABLE
JEND	000207	LOGICAL*1	VARIABLE
JPR	000210	LOGICAL*1	VARIABLE
ICOM	000211	LOGICAL*1	VARIABLE
IW	000212	LOGICAL*1	VARIABLE
IH	000213	LOGICAL*1	VARIABLE
IY	000214	LOGICAL*1	VARIABLE
IC	000215	LOGICAL*1	VARIABLE
JAS	000216	LOGICAL*1	VARIABLE
JES	000217	LOGICAL*1	VARIABLE
L31	002637	LOGICAL*1	VARIABLE
MASK5	000220	LOGICAL*1	VARIABLE
MASK7	000221	LOGICAL*1	VARIABLE
ICH	002640	LOGICAL*1	VARIABLE
IO	002642	INTEGER*2	VARIABLE
N	002644	INTEGER*2	VARIABLE
LUN	002646	INTEGER*2	VARIABLE
INPB	002650	INTEGER*2	VARIABLE
JFE	002652	INTEGER*2	VARIABLE
JFB	002654	INTEGER*2	VARIABLE
JD	002656	INTEGER*2	VARIABLE
JPER	002660	INTEGER*2	VARIABLE
JEX	002662	INTEGER*2	VARIABLE
JF3	002664	INTEGER*2	VARIABLE
I	002666	INTEGER*2	VARIABLE
LL	002670	INTEGER*2	VARIABLE
J	002672	INTEGER*2	VARIABLE
LM	002674	INTEGER*2	VARIABLE
IP	002676	INTEGER*2	VARIABLE
NCC	002700	INTEGER*2	VARIABLE
XN	002702	REAL*4	VARIABLE
ABS	000000	REAL*4	PROCEDURE
M	002706	INTEGER*2	VARIABLE

Appendix K

POWER SENSOR/THERMISTOR MOUNT COMBINED DATA EVALUATION PROGRAM LISTING

```

0001      PROGRAM PSENSR
          C----- POWER SENSOR PROGRAM
          C----- VERSION # 4 10/31/78 - JWC - PWR RATIO TEST FOR TMOUNTS
          C----- VERSION NO. 3      3/13/78
          C-----2ND STD BRIDGE RESISTANCE VALUE 230.000 OHMS
0002      IMPLICIT DOUBLE PRECISION (A-H,O-Z)
0003      DOUBLE PRECISION MM,MMR,MMRC
0004      REAL D,READ
0005      DIMENSION DATA(51),MM(4),PW(4),DATAXT(4),DATAYT(4),
          1ISCALE(8),IGAIN(7),DATAZ(12),REPORT(100),RERUN(15)
          1,D(205),SH1(2),SH2(2),SH3(2),SH4(2),SH5(2),
          1SA1(10),SA2(10),UA(10),DATA(12),DATAY(12)
          1,DATE(2)
0006      DATA ISCALE/24,25,26,27,40,41,42,43/,
          1IGAIN/10,12,14,24,26,40,42/
          C-----READ DATE & SCALE FACTOR
0007      READ (1,120) DATE
0008      READ (1,130) SCALFR
0009      IA=0
0010      ICOUNT=1
          C-----READ DATA
0011      5      CALL READ (1,205,D,NC)
          C      PRINT 121,DATE
          C      PRINT 131,SCALFR
          C      PRINT 160,D
0012      IF(NC.EQ.0,AND,IA.EQ.0) GO TO 115
0014      IF(NC.EQ.0) GO TO 105
0016      IF(NC.NE.205) GO TO 100
0018      STDEFF=D(4)
0019      DO 10 I=1,2
0020      SH1(I)=(D(I+5)+D(I+5+2)+D(I+5+4)+D(I+5+6)+D(I+5+8))/5D0
0021      SH2(I)=(D(I+5+10)+D(I+5+10+2)+D(I+5+10+4)+D(I+5+10+6)+D(I+5+10+8))
          1/5D0

```

0022		SH3(I)=(D(I+5+20)+D(I+5+20+2)+D(I+5+20+4)+D(I+5+20+6)+D(I+5+20+8))
		1/5D0
0023		SH4(I)=(D(I+5+30)+D(I+5+30+2)+D(I+5+30+4)+D(I+5+30+6)+D(I+5+30+8))
		1/5D0
0024		SH5(I)=(D(I+5+40)+D(I+5+40+2)+D(I+5+40+4)+D(I+5+40+6)+D(I+5+40+8))
		1/5D0
0025	10	CONTINUE
0026		DO 15 I=1,10
0027		SA1(I)=(D(I+55)+D(I+55+10)+D(I+55+20)+D(I+55+30)+D(I+55+40))/5D0
	C	PRINT 160, D(I+55),D(I+55+10),D(I+55+20),D(I+55+30),D(I+55+40)
0028		UA(I)=(D(I+55+50)+D(I+55+60)+D(I+55+70)+D(I+55+80)+D(I+55+90))/5D0
	C	PRINT 160,D(I+55+50),D(I+55+60),D(I+55+70),D(I+55+80),D(I+55+90)
0029		SA2(I)=(D(I+55+100)+D(I+55+110)+D(I+55+120)+D(I+55+130)+D(I+55+140
		1))/5D0
	C	PRINT 160,D(I+55+100),D(I+55+110),D(I+55+120),D(I+55+130),D(I+55+1
	C	140)
0030	15	CONTINUE
	C	PRINT 160, SH1,SH2,SH3,SH4,SH5,SA1,UA,SA2
0031		DO 20 I=1,5
0032		DATA(I)=D(I)
0033	20	CONTINUE

```

0034      DO 25 I=1,2
0035      DATA(I+5)=SH1(I)
0036      DATA(I+7)=SH2(I)
0037      DATA(I+9)=SH3(I)
0038      DATA(I+11)=SH4(I)
0039      DATA(I+13)=SH5(I)
0040  25    CONTINUE
0041      DO 30 I=1,10
0042      DATA(I+15)=SA1(I)
0043  30    CONTINUE
0044      DATA(26)=UA(9)
0045      DATA(27)=UA(10)
0046      DO 35 I=5,8
0047      DATA(I+23)=UA(I)
0048  35    CONTINUE
0049      DO 40 I=1,10
0050      DATA(I+31)=UA(I)
0051  40    CONTINUE
0052      DATA(42)=SA2(9)
0053      DATA(43)=SA2(10)
0054      DO 45 I=5,8
0055      DATA(I+39)=SA2(I)
0056  45    CONTINUE
0057      DO 50 I=1,4
0058      DATA(I+47)=SA2(I)
0059  50    CONTINUE
0060      DO 55 I=1,15
0061      RERUN(I)=DATA(I)
0062  55    CONTINUE
0063      C      PRINT 160, DATA
0064      C-----CORRECT PAR #0# &CHANNEL GAIN
0063      W=(DATA(6)+DATA(10))/2D0
0064      WW=DSQRT((DATA(6)-W)*(DATA(6)-W)+(DATA(8)-W)*(DATA(8)-W))

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0065      T=(DATA(7)+DATA(11))/2D0
0066      TT=DSQRT((DATA(7)-T)*(DATA(7)-T)+(DATA(9)-T)*(DATA(9)-T))
0067      DO 60 I=1,7
0068      J=IGAIN(I)
0069      DATA(J)=DATA(J)-W
0070      DATA(J+1)=(DATA(J+1)-T)*DABS(WW/TT)
0071  60    CONTINUE
      C-----CORRECT PAR SCALE FACTOR
0072      DO 65 I=1,8
0073      J=ISCALE(I)
0074      DATA(J)=DATA(J)/SCALFR
0075  65    CONTINUE
      C-----CALCULATE X'S, Y'S, 1 Z'S OF MATRIX
0076      M=1
0077      DO 70 I=4,7
0078      J=IGAIN(I)
0079      DO 70 L=1,3
0080      K=IGAIN(L)
0081      DATAX(M)=DATA(K)-DATA(J)
0082      DATAY(M)=DATA(K+1)-DATA(J+1)
0083      DATAZ(M)=(DATA(K)-DATA(J))*(DATA(K)-DATA(J))+

```



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1(DATA(K+1)-DATA(J+1))*(DATA(K+1)-DATA(J+1))
0084      M=M+1
0085  70    CONTINUE
C-----CALCULATE MISMATCH FACTOR
0086      J=1
0087      DO 75 I=1,4
0088      MM(I)=DATA(X(J)*DATAY(J+1)*DATAZ(J+2)+
1DATA(X(J+2)*DATAY(J)*DATAZ(J+1)+
1DATA(X(J+1)*DATAY(J+2)*DATAZ(J)-
1DATA(X(J+2)*DATAY(J+1)*DATAZ(J)-
1DATA(X(J)*DATAY(J+2)*DATAZ(J+1)-
1DATA(X(J+1)*DATAY(J)*DATAZ(J+2)
0089      J=J+3
0090  75    CONTINUE
C-----CALCULATE MISMATCH RATIO
0091      MMR=MM(1)/MM(2)
0092      MMRC=MM(3)/MM(4)
C-----CALCULATE POWER SUBSTITUTION
0093      K=1
0094      DO 85 J=1,17,16
0095      DO 80 I=1,4
0096      DATA(X(I)=DATA(26+J+I)
0097      DATA(26+J+I)=DATA(30+J+I)
0098      DATA(30+J+I)=DATA(X(I)
0099      IF(J.EQ.1) GO TO 80
0101      DATAYT(I)=DATA(27+I)
0102      DATA(27+I)=DATA(31+I)
0103      DATA(31+I)=DATAYT(I)
0104  80    CONTINUE
0105      L=0
0106      DO 85 I=1,2
0107      FW(K)=(((2D0*DATA(20+J+L)+DATA(19+J+L))*DATA(19+J+L)-(2D0*DATA(16+
1J+L)+DATA(15+J+L))*DATA(15+J+L))/(((2D0*DATA(22+J+L)+DATA(21+J+L))*

```

```

1DATA(21+J+L)-(2D0*DATA(18+J+L)+DATA(17+J+L))*DATA(17+J+L)))
0108      L=L+12
0109      K=K+1
0110  85   CONTINUE
      C-----CALCULATE POWER RATIOS
0111      IF(D(109).EQ.0.0) PW(2)=PW(2)*(UA(7)+UA(3))/.8
0113      IF(D(109).EQ.0.0) PW(3)=PW(2)
0115      PWR=PW(1)/PW(2)
0116      PWRC=(86956D-5*PW(3))/PW(4)
      C-----CALCULATE THERMISTOR MOUNT EFFICIENCY
0117      EFF=MMR*PWR*DATA(4)
0118      EFFC=MMRC*PWRC*EFF
      C-----CALCULATE CLOSING ERROR
0119      CE=(STDEFF-EFFC)
0120      IA=IA+1
      C-----CORRECT EFFICIENCY FROMCLOSING ERROR
0121      EFFCOR=EFF+(CE/2D0)
      C-----CALCULATE CALIBRATION FACTOR
0122      CF=((1D0-(((DATA(5)-1D0)/(DATA(5)+1D0))*((DATA(5)-1D0)/(DATA(5)+1D
10)))))*EFFCOR
      C-----DEBUG CALCULATIONS

```

```

      C      PRINT 160, DATA, DATAZ, MM, MMR, MMRC, PW, PWR, PWRC, EFF, EFFC, CE, CF
0123      PRINT 160, EFF, EFFC, MMR, MMRC
0124      PRINT 165, CE, IA
0125      IF (DABS(CE).LT.2D-3) GO TO 90
0127      PRINT 135, IA, CE
      C-----STORE FOR REPORT
0128  90      J=ICOUNT
0129      REPORT(J)=DATA(3)
0130      REPORT(J+1)=DATA(2)
0131      REPORT(J+2)=EFFCOR
0132      REPORT(J+3)=CF
0133      ICOUNT=ICOUNT+4
      C-----COMPLETE CALCULATION LOOP
0134      DO 95 I=1,15
0135      DATA(I)=RERUN(I)
0136  95      CONTINUE
0137      DATA(4)=STDEFF
0138      GO TO 5
0139 100      IB=IA+1
0140      PRINT 155, IB
0141      IF (IA.EQ.0) GO TO 115
      C-----PRINT REPORT
0143 105      PRINT 140, DATE,      DATA(1)
0144      J=1
0145      DO 110 I=1, IA
0146      PRINT 145, (REPORT(J), REPORT(J+1), REPORT(J+2), REPORT(J+3))
0147      J=J+4
0148 110      CONTINUE
0149 115      CONTINUE
      C15      CALL SECOND (SEC)
      C      PRINT 150, SEC
      C-----FORMATS
0150 120      FORMAT (2A4)

```

0151	121	FORMAT (1X,2A4)
0152	125	FORMAT (I10)
0153	130	FORMAT (D15.8)
0154	131	FORMAT (1X,D15.8)
0155	135	FORMAT (42H CLOSING ERROR LIMIT EXCEEDED IN GROUP NO. ,I2, 18H CE = ,F10.6)
0156	140	FORMAT (1H1,50H ***** POWER SENSOR/MTR CALIBRATION 121H *****//7H DATE: ,2A4,1X,8H STD NO:,F7.0, 1,24X,11H CALIBRATION/,4X, 19HFREQUENCY,9X,10H SERIAL NO.,8X,10HEFFICIENCY,10X,6HFACTOR/)
0157	145	FORMAT (5X,F6.3,13X,F6.0,9X,F8.5,11X,F7.4/)
	C50	FORMAT (1H1,33H VERSION NO. 1 06/24/76 CPU...,F6.1)
0158	155	FORMAT (30H INCOMPLETE DATA IN GROUP NO. ,I2)
0159	160	FORMAT (1X,4F15.6)
0160	165	FORMAT (16H CLOSING ERROR: ,D15.6,11H GROUP NO. ,I2)
0161		END

BDX-613-2304

THERMISTOR MOUNT EFFICIENCY CALIBRATION,
J. W. Cable, Project, May 1980

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SPECIAL PROJECTS: Calibration

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