Technical Report

Final Report
F-C2142

RF EVALUATIONS OF THE STRAY ELECTRICAL ENERGY INDICATOR (SEEI)

by

P. F. Mohrbach
R. R. Raksnis

January 1968

Prepared for

NASA Manned Spacecraft Center
Houston, Texas

Contract No. NAS9-7601

THE FRANKLIN INSTITUTE RESEARCH LABORATORIES
BENJAMIN FRANKLIN PARKWAY • PHILADELPHIA, PENNA. 19103

NASA CR 92106

Technical

Report

Final Report
F-C2142

RF EVALUATIONS OF THE STRAY
ELECTRICAL ENERGY INDICATOR (SEEI)

by

P. F. Mohrbach
R. R. Raksnis

January 1968

Prepared for

NASA Manned Spacecraft Center
Houston, Texas

Contract No. NAS9-7601

THE FRANKLIN INSTITUTE RESEARCH LABORATORIES
BENJAMIN FRANKLIN PARKWAY • PHILADELPHIA, PENNA. 19103

Final Report F-C2142
"RF Evaluations of the Stray
Electrical Energy Indicator (SEEI)"
Paul F. Mohrbach, Raymond R. Raksnis
The Franklin Institute Research Laboratories
January, 1968
Contract No. NAS9-7601 for
NASA Manned Spacecraft Center, Houston Texas

Dr. J. R. Feldmeier
Director of Laboratories

ABSTRACT

The RF sensitivity of 80 SEEI initiators was determined at 6 test frequencies including both CW and pulsed power and in two terminating modes. The data were compared with the SBASI initiator tested at FIRL in August of 1967, and results of both types are presented in this report. Analysis of the data indicated that the SEEI is more sensitive than the SBASI at all comparable test frequencies and modes. The largest spread in sensitivities occurs in the pin-to-pin mode at the low and moderate CW frequencies. With pulsed power the difference in the sensitivities of the two is reduced to about 2 to 1 for the pin-to-pin mode and 4 to 1 for pin-to-case. Both the SBASI and the SEEI are sensitive to pulsed power with the 50% fire levels falling approximately in the 0.02 to 0.2 watt decade for all pulsed tests and modes. The most sensitive condition occurred at 9000 MHz pulsed with the SEEI terminated for a pins-to-case excitation. At this condition a fire was produced with 0.015 watts.

Input impedance measurements conducted in the frequency band of 1.5 to 1300 MHz with CW generators showed a marked difference in pin-to-pin values of impedance. Pins-to-case values showed no great difference between the two types.

ACKNOWLEDGEMENTS

This report was prepared by the Applied Physics Laboratory, E. E. Hannum, Manager. A major contributor, other than the authors was A. W. Cipkins, Technical Associate. Inquiries pertaining to this contract should be directed to the sponsoring agency or to Mr. E. E. Hannum, Manager, Applied Physics Laboratory, The Franklin Institute Research Laboratories.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

The purpose of this work was to determine the RF sensitivity characteristics of the SEEI, which as we understand it is to serve as a stray energy indicator in circuits which may later make use of the SBASI (Single Bridgewire Apollo Standard Initiator). Test results with the SEEI are therefore compared to previous test results obtained with SBASI units which were tested here earlier this year and documented in FIRL Report No. F-B2303-9, August 1967. A photograph of the two items is shown in Figure 1-1.

Eighty SEEI units were received for the present program. The units were visually inspected, random sampled, and grouped so that information could be obtained with new units in both firing modes (pin-to-pin and pins-to-case). The outline shown in Exhibit "A" statement of work (reproduced in this report as Appendix A) allots approximately 60 new units for pin-to-pin tests and 20 new (and 40 used) units for pins-to-case tests, covering 6 test frequencies. Some flexibility, however, was followed in the actual firing of the alloted hardware. Before RF testing, all 80 units received the following preliminary tests:

1. Initial bridgewire resistance
2. Initial insulation resistance between shorted input pins and case at 6 Vdc held for 30$\pm$ 5 seconds
3. Initial pins-to-case capacitance

EEDs that were non-fires also received these measurements and the values recorded in the column marked "after" (Appendix B). Also, input impedance measurements were conducted on 3 new EEDs in both modes, at 8 selected frequencies covering 1.5 to 1300 MHz (CW only).

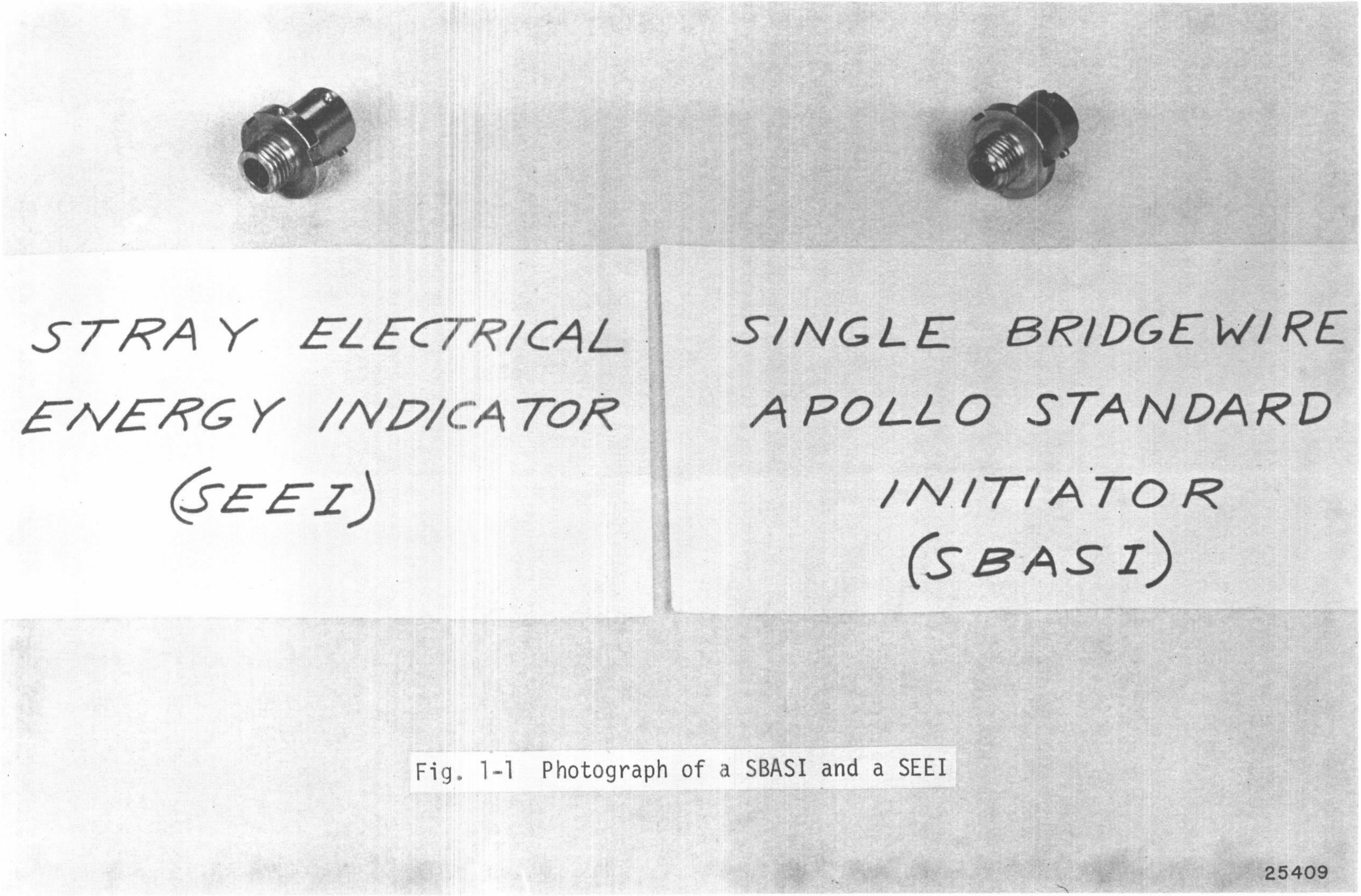


Fig. 1-1 Photograph of a SBASI and a SEEI

2. PARAMETER MEASUREMENTS ON THE SEEI

The following section describes results of these special tests. Appendix B gives detailed test results.

2.1 Visual Inspection

All 80 EEDs were inspected for burrs, bent pins, foreign matter, etc. All units were rated "ok" as a result of this inspection.

2.2 Bridgewire Resistance

The pin-to-pin resistance of all units was measured with a Keithley Model 502 milliohmmeter. All bridgewires were found intact and values ranged from 4.1 to 5.25 ohms (Note: The SBASI has bridgewire resistances that range between .85 to 1.16 ohms).

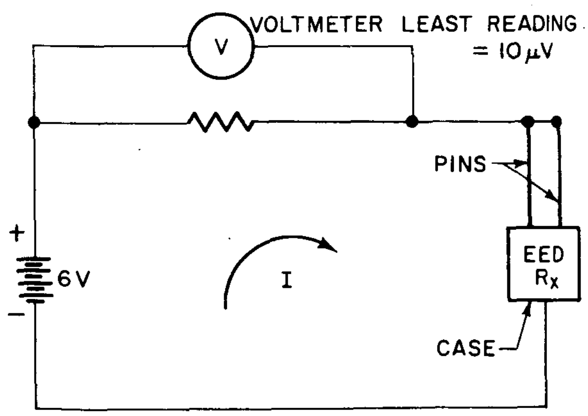
2.3 Insulation Resistance

Exhibit "A" states that this test is to be made by applying 6Vdc pins-to-case for 30 ± 5 seconds. The circuit used for this test is shown in Figure 2-1. Note that with this circuit, the current is limited to 6 microamps. During the actual testing, less than 10 microvolts was read on the voltmeter in most cases. The resistance of these were recorded as greater than 6×10^{11} ohms. One EED (FIRL #8) indicated a short in this test and a subsequent capacitance test. This EED fired when 6 volts was applied to it with no current limiting resistor.

2.4 Pins-to-Case Capacitance

The capacitance between the two input pins and the case of the SEEI was initially measured on all 80 units using a Tektronix Model 130

LC meter. This instrument measures the capacitance using a frequency of 150 kHz. Initial values ranged between 3.3 and 6.0 picofarads. Final readings on non-fired units showed only slight changes from initial values.



NOTE THAT

IF $R_x = 0$
$V = 6V$
$I = 6/10^6 = 6\mu A$

FOR $R_x > 0$
$R_x = (6-V)\,10^6/V$
$R_x \approx 6 \times 10^{11}$

WHEN $V = 10\mu V$

Fig. 2-1 Circuit for 6Vdc Insulation Resistance Test

3. RF TESTS

The 6 required test frequencies (in megahertz) were as follows:

(1) 243 CW

(2) 5400 CW

(3) 9000 CW

(4) 2700 Pulsed (1.5 μsec./1000 pps)

(5) 5400 Pulsed (0.8 μsec./400 pps)

(6) 9000 Pulsed (1.5 μsec./1000 pps)

Note that (5) represents a special pulse width and repetition rate, the usual being 1.5/1000. The SBASI (tested previously) was not tested at 5400 MHz pulsed.

Tables 3-1 to 3-4 lists the complete test results for both the SEEI and SBASI in the pin-to-pin and pins-to-case modes. Figures 3-1 and 3-2 plot the approximate 50% levels for both squibs. Considering the the normal firing mode (pin-to-pin, Figure 3-1), the SEEI is more sensitive by approximately 10 to 1 considering CW power. With pulsed power the SEEI is only approximately 2 to 1 more sensitive. In the second mode (pins-to-case, Figure 3-2) the SEEI and SBASI have almost comparable sensitivities in the 100-1000 MHz decade, considering CW power. With pulsed power the SEEI showed the highest sensitivity, with a 50% level of about 0.018 watts at 9000 MHz. The SEEI is more sensitive by about 4 to 1 over the SBASI, in the pins-to-case mode, pulsed power.

Considering both modes, these EEDs are vulnerable to pulsed power. Most probably, the high voltage "peak" of the pulsed waveform causes an internal "arc" that discharges through the explosive. The SBASI indicated almost identical sensitivities in both possible terminating modes. The SEEI was more sensitive in the pins-to-case mode.

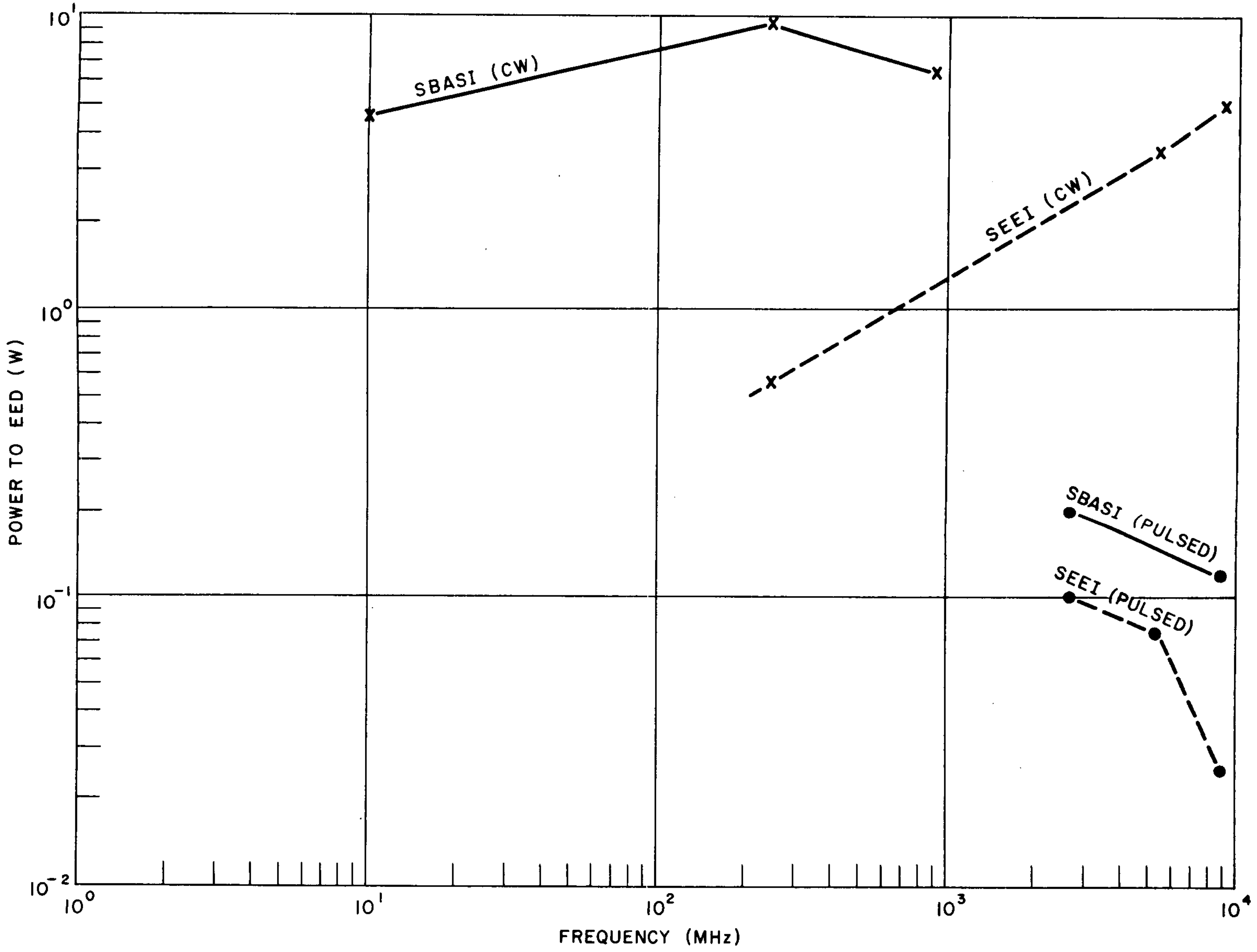


Fig. 3-1 Approximate 50% Fire Levels of the SEEI and SBASI (Pin-to-Pin Mode)

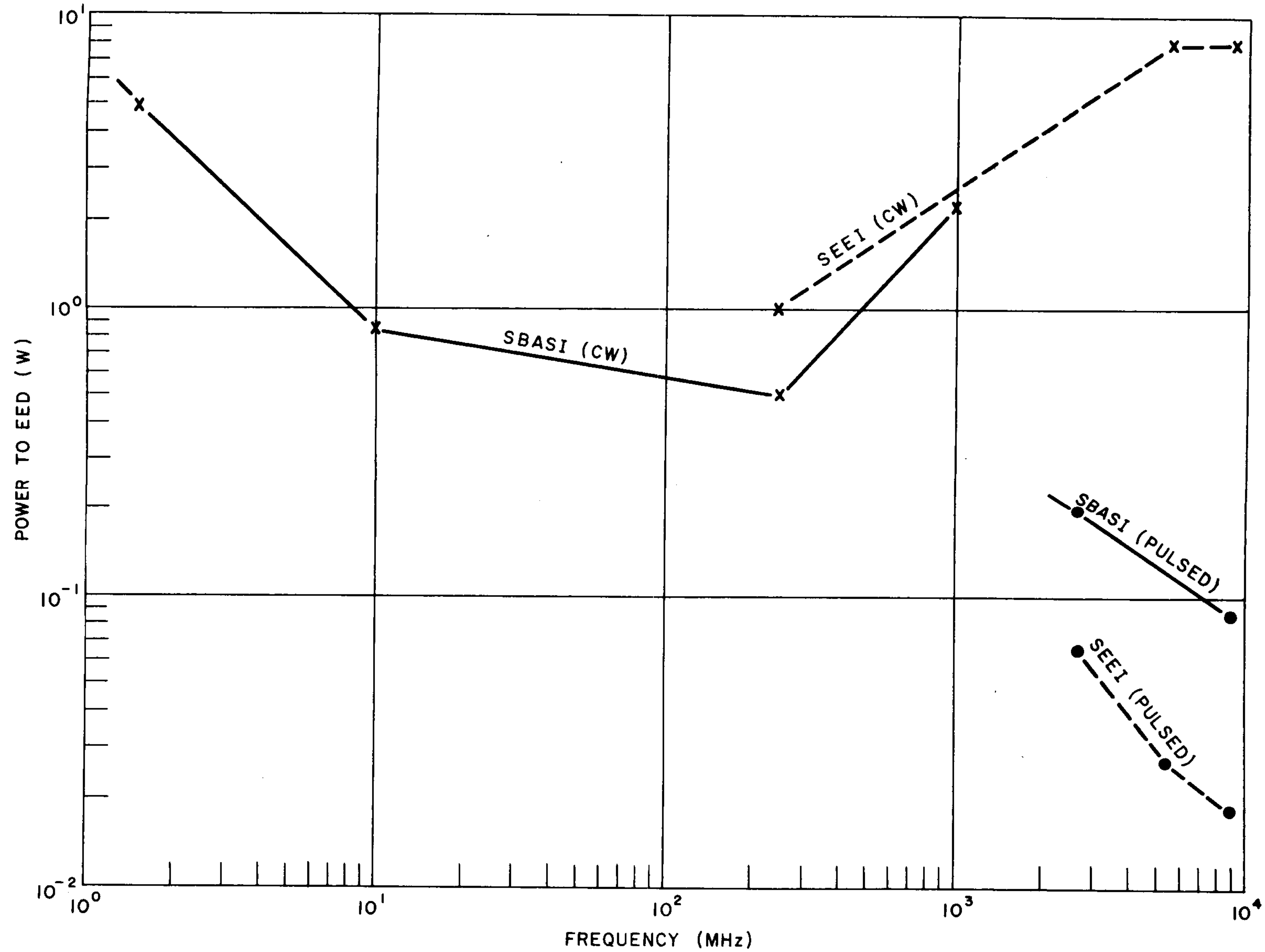


Fig. 3-2 Approximate 50% Fire Levels of the SEEI and SBASI (Pins-to-Case Mode)

TABLE 3-1 RESULTS OF PIN-TO-PIN PROBING TESTS (SEEI)

Test No.	Freq (MHz)	Power Mode	Power to EED (Watts)		Now-Fires	Fires
1789	243	CW	0.10		1	0
			0.45	mean	1	0
			0.65	.55-.60	0	2
			0.75	watts	1	2
			2.0		0	1
			5.0		0	1
1791	5400	CW	1.0		1	0
			2.0		1	0
			2.5	mean	1	0
			3.0	$\sim$3.5 watts	2	0
			4.0		0	3
1793	9000	CW	0.50		1	0
			2.5		1	0
			3.5	mean	3	1
			5.0	$\sim$5.0 watts	2	0
			5.5		0	1
			6.0		0	2
1787	2700	pulsed	.050		2	1
		1.5/1000	.065		2	1
			.075		0	1
			.100	mean	1	1
			.150	$\sim$.100 watts	0	1
			.200		0	1
			.250		0	1
			.500		0	1
1793	5400	pulsed	.050		3	0
		0.8/400	.075		2	2
			.100	mean	1	3
			.150	$\sim$.075 watts	1	1
			.250		0	1
1797	9000	pulsed	.015	mean	1	0
		1.5/1000	.020	.0225-.025	2	0
			.0225	watts	2	1
			.025		1	2

TABLE 3-2 RESULTS OF PINS-TO-CASE PROBING TESTS (SEEI)

Test No.	Freq (MHz)	Power Mode	Power to EED (Watts)		Now-Fires	Fires
1790	243	CW	0.75		1	0
			1.0	mean	2	2
			1.25	∿1.0 watts	1	0
1792	5400	CW	3.0	mean	2	0
			4.0	∿8 watts	3	0
			5.0		3	0
			Subsequent tests of misfires produced non-fires at 8 watts			
1796	9000	CW	3.5	mean	1	0
			7.5	∿8 watts	2	1
			8.0		1	0
1788	2700	pulsed 1.5/1000	.050	mean	2	0
			.075	∿.065 watts	1	2
			0.100		0	2
1794	5400	pulsed 0.8/400	.020		1	0
			.025	mean	1	0
			.030	.025-.030	1	2
			.050	watts	0	1
			.079		0	1
			.100		0	1
1978	9000	pulsed 1.5/1000	.010		1	0
			.0125	mean	3	1
			.0150	.0175-.02	2	1
			.0175	watts	2	1
			.020		0	2

TABLE 3-3 RESULTS OF PIN-TO-PIN PROBING TESTS (SBASI)

Test No.	Freq (MHz)	Power Mode	Power to EED (Watts)		Now-Fires	Fires
1736	10	CW	0.10		2	0
			3.0	mean	1	0
			4.0	4.5-5.0	1	0
			4.5	watts	1	1
			5.0		1	1
			6.0		0	1
			7.0		0	1
1737	243	CW	0.10		2	0
			5.0	mean	1	0
			8.0	9-10	3	0
			9.0	watts	0	1
			10.0		1	1
			15.0		0	1
1738	950	CW	0.10		2	0
			3.0	mean	1	0
			5.0	6-7	1	0
			6.0	watts	2	1
			7.0		0	1
			8.0		0	1
			10.0		0	1
1739	2700	pulsed 1.5/1000	0.1	mean	3	0
			0.2	0.2-0.3	2	1
			0.3	watts	0	2
			0.5		0	1
1740	9000	pulsed 1.5/1000	0.10		4	0
			0.125	mean	0	2
			0.150	~0.12 watts	0	3
			0.20		0	1
			0.30		0	1

TABLE 3-4 RESULTS OF PINS-TO-CASE PROBING TESTS (SBASI)

Test No.	Freq (MHz)	Power Mode	Power to EED (Watts)		Now-Fires	Fires
1741	10	CW	0.10		2	0
			.50	mean	1	0
			.75	.75-1.0	3	0
			1.0	watts	0	2
			2.0		0	1
			4.0		0	1
1742	243	CW	.10		2	0
			.50		1	1
			.75	mean	0	2
			1.0	∿.5 watts	0	1
			1.5		0	1
			2.0		0	1
1743	950	CW	.10		2	0
			2.0	mean	3	0
			2.25	2.0-2.25	1	2
			2.50	watts	0	1
			5.0		0	1
1744	2700	pulsed 1.5/1000	.10		2	0
			.125		0	1
			.20	mean	2	2
			.25	∿.20 watts	2	0
			.30		0	1
1745	9000	pulsed 1.5/1000	.080	mean	3	0
			.085	.085-.090	2	1
			.090	watts	0	2
			.100		0	2
1749	1.5	CW	.75		1	0
			1.0	mean	1	0
			3.8	>>5 watts	1	0
			5.0		1	0

4. INPUT IMPEDANCE

The impedance referenced at the base of the SEEI was determined in both the pin-to-pin and pins-to-case modes at 1.5, 3, 10, 100, 250, 500, 900 and 1300 MHz. Measurements were made on 3 new squibs at very low power and the results averaged. Table 4-1 shows these data as well as the previous data on the SBASI which was conducted in an identical manner. Also shown in Table 4-1 is the conductivity (G) which is obtained from (Z) by

$$G = \frac{Re(Z)}{|Z|^2} = \frac{R}{R^2 + X^2}$$

where $Z = R \pm jX$

The (Z) data from Table 4-1 is plotted in Figure 4-1 and 4-2 which relates the data to 50 ohm transmission lines. (Caution: No attempt should be made to use the value of the reflection coefficients (ρ) as indicated on Figures 4-1 and 4-2 as absolute values, since ρ will vary with respect to the characteristic impedance of the transmission line used as a reference. However, since a common base of reference has been chosen, differences in Z data between the SEEI and SBASI have some meaning.)

The Z data shows considerable differences between both squibs in the pin-to-pin mode. The fact that the SEEI has a 4.5 ohm bridgewire and the SBASI a 1 ohm bridgewire is reflected in the values of Z at low frequencies.

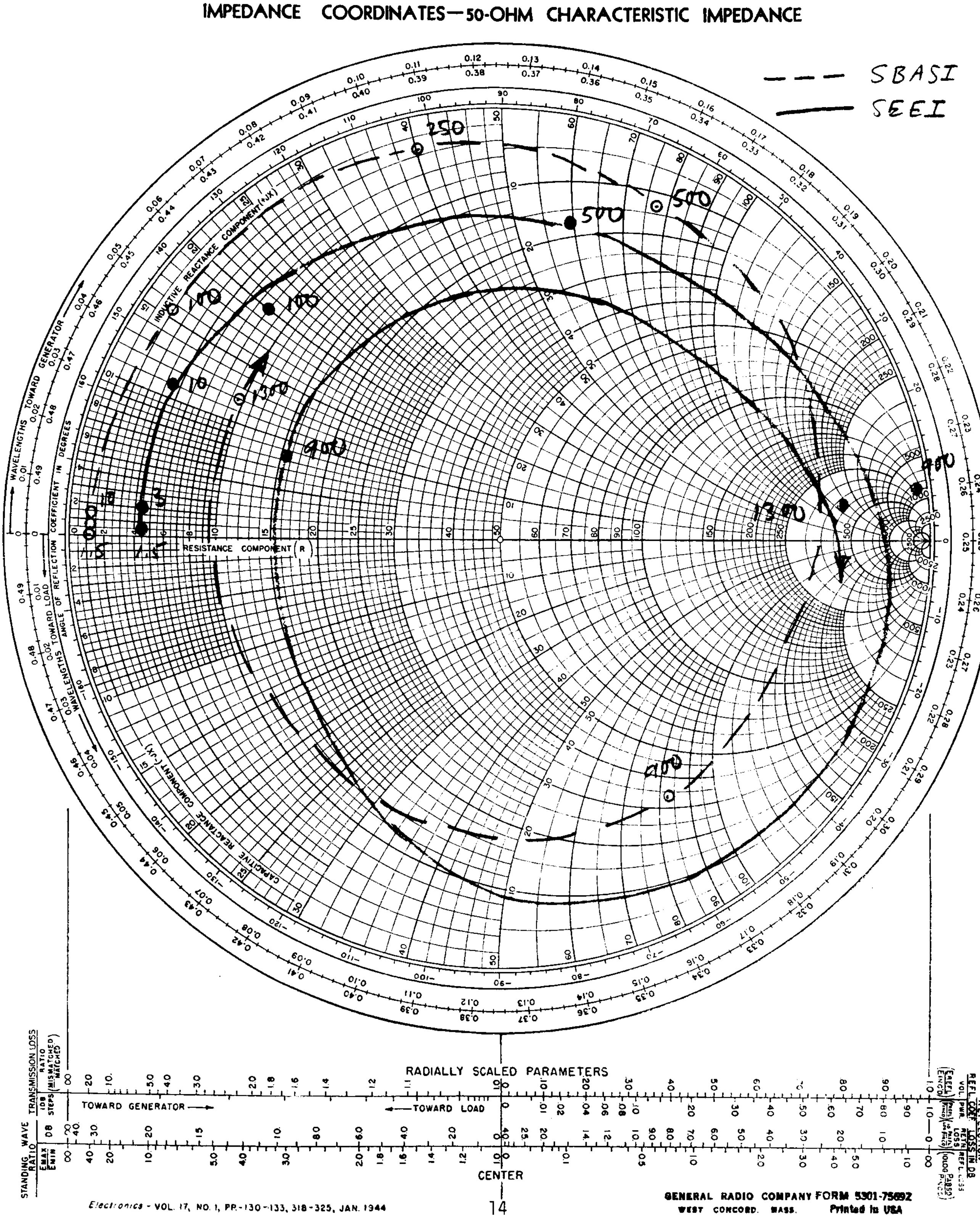
The pins-to-case Z data show only slight differences in impedance with the SEEI indicating slightly higher reflection coefficients as referenced to a 50 ohms line.

TABLE 4-1 INPUT IMPEDANCE DATA, SEEI, SBASI (AVERAGE OF THREE READINGS)

Frequency (MHz)	Pin-to-Pin				Pins-to-Case			
	Impedance (Z)		Conductivity (G)		Impedance (Z)		Conductivity (G)	
	SBASI	SEEI	SBASI	SEEI	SBASI	SEEI	SBASI	SEEI
1.5	1.1+j0	4.5+j0.5	9.09×10^{-1}	2.19×10^{-1}	727-j11,100	111-j10,600	5.87×10^{-6}	9.87×10^{-7}
3	1.12+j0.67	4.5+j2.0	6.57×10^{-1}	1.86×10^{-1}	357-j5130	583-j5150	1.35×10^{-5}	2.17×10^{-5}
10	1.14 +j1.35	4.5+j11.0	3.65×10^{-1}	$3.18 \times 10-^{2}$	160-j1760	152-j1200	5.12×10^{-5}	1.04×10^{-4}
100	1.97+j15.3	8.0+j20.0	8.28×10^{-3}	1.72×10^{-2}	16-j112	12.3-j260	1.25×10^{-3}	1.81×10^{-4}
250	3.4+j40	17.2+j59.0	2.11×10^{-3}	4.55×10^{-3}	7.25-j69	4.0-j8.65	$1.5. \times 10^{-3}$	4.40×10^{-2}
500	13+j77	15.6+j740	2.13×10^{-3}	2.80×10^{-5}	3.17-j21.5	5.0+j420*	6.71×10^{-3}	2.83×10^{-5}
900	34-j83	15.5+j8.5	4.23×10^{-3}	4.96×10^{-2}	2.82+j17.3	1.05+j16.0	9.18×10^{-3}	4.08×10^{-3}
1300	9.4+j12	356+j163	4.04×10^{-2}	2.32×10^{-3}	9.0+j75.2	3.75+j68.5	1.57×10^{-3}	7.96×10^{-4}

*Suspected to be in error.

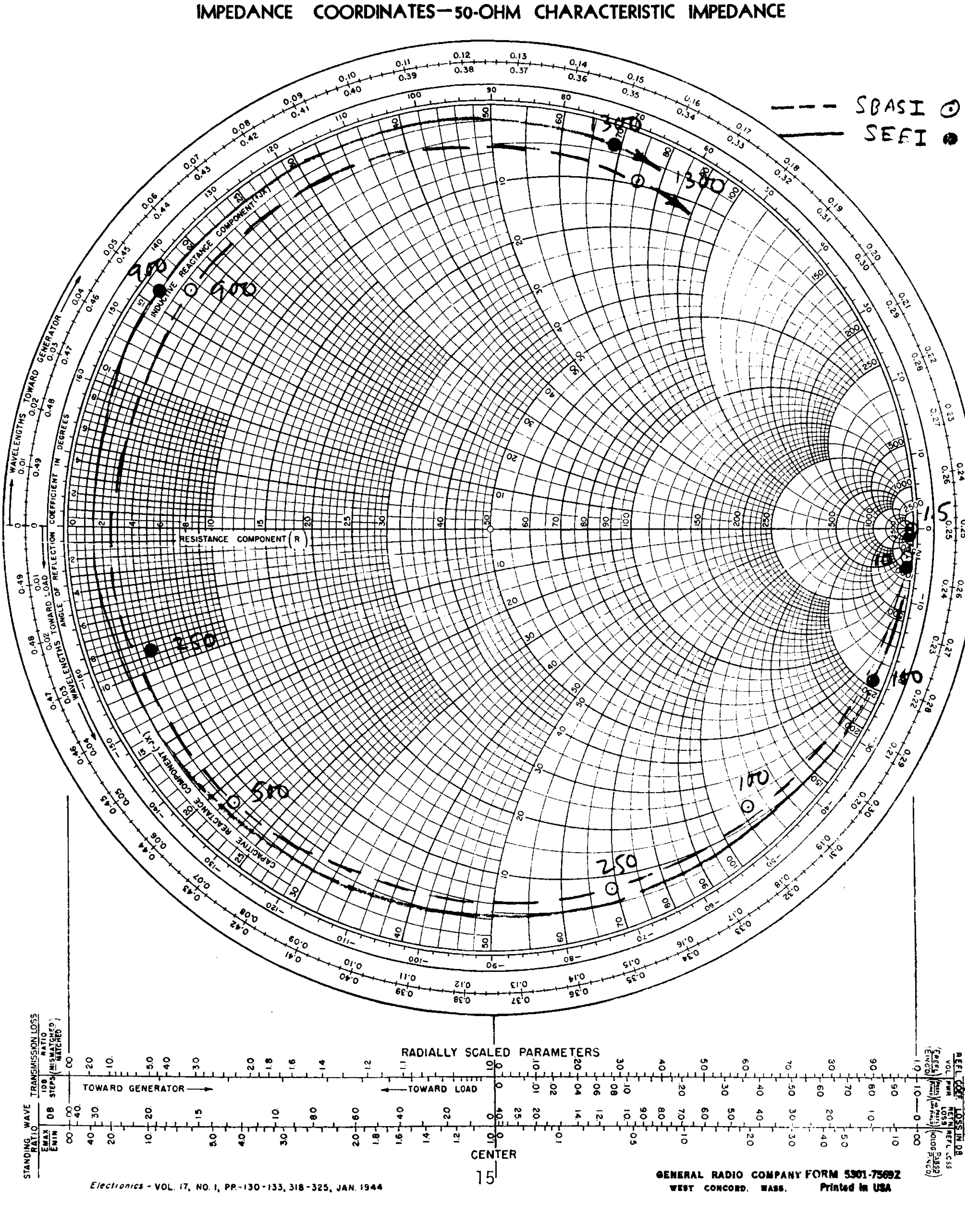
TITLE Fig. 4-1 Input Impedance, (Smith Chart) SEEI, SBASI (Pin-to-Pin Mode)



Electronics - VOL. 17, NO. 1, PP.-130-133, 318-325, JAN. 1944

GENERAL RADIO COMPANY FORM 5301-7569Z
WEST CONCORD. MASS. Printed in USA

TITLE Fig. 4-2 Input Impedance (Smith Chart) SEEI, SBASI, (Pins-to-Case Mode)



Electronics - VOL. 17, NO. 1, PP.-130-133, 318-325, JAN. 1944

GENERAL RADIO COMPANY FORM 5301-7569Z WEST CONCORD, MASS. Printed in USA

5. SUMMARY AND CONCLUSIONS

RF testing with the SEEI has shown that it is more sensitive than the SBASI at all test frequencies and modes. The largest spread in sensitivity (approx. 10 to 1) occurs with CW power in the normal bridgewire (pin-to-pin mode). However, both the SEEI and SBASI are quite sensitive to pulsed power (50% levels between 0.02 to 0.2 watts) and their spread reduces to about 2 to 1 for pin-to-pin comparisons and 4 to 1 for pins-to-case. The SEEI in the pins-to-case mode at 9000 MHz pulsed was the most sensitive condition and one EED fired with 15 milliwatts (Table 3-1).

Owing mainly to the fact that the SEEI has a 4.5 ohm bridgewire and the SBASI a 1 ohm, the impedance data were quite different in the pin-to-pin mode. In the pins-to-case mode these data show no particularly large differences.

It should be noted that the RF sensitivity tests performed in this study were of a probing nature and conducted with a minimum of test items. While this technique has proven to be effective in indicating trends; for example, at which frequency is the greatest sensitivity obtained or is one device more sensitive than another at a given frequency, the absolute values must be used with great caution. The mean firing values generated from a 40 item Bruceton test at a given condition could produce a value marked by different from the "approximate means" which we have estimated from the probing tests.

Furthermore, if the intended use of the SEEI is to replace the SBASI in systems tests where the entire assembly is irradiated and success or failure based on whether or not the SEEI fires, then a work of caution is in order. Because of the great differences in impedances (pin-to-pin mode primarily) a system could be a poor match for the SEEI and a good match for the SBASI, thus, even though the SEEI is more sensitive it might *not* fire in such a system whereas the SBASI *would fire*.

APPENDIX A

Exhibit "A"

Statement of Work

Exhibit "A"

STATEMENT OF WORK

Scope

The purposes of this work will be to estimate the radio frequency (rf) sensitivity of the Stray Electrical Energy Indicator (SEEI). These devices will be supplied as GFE to GAEC for use on LM vehicles as a Radio Frequency (RFI) detector. Therefore knowledge of the unit's sensitivity threshold for various frequencies is mandatory.

General Requirements

Visual inspection and checkout measurements such as electrical bridgewire resistance, insulation resistance, etc., will be taken and recorded on each unit prior to any actual tests to be conducted and, when appropriate, after each test.

This test will be a probing test using 80 units to examine rf sensitivity at six frequencies.

Detailed Requirements

The suggested procedure to be followed is outlined below:

a. Randomly separate the units into six groups of ten each.

b. Information concerning inspection and electrical measurements of each group will be recorded on data sheets and will include but not necessarily be limited to: Group designation, bridgewire resistance, insulation resistance, pin-to-case capacitance, visual inspection and any pertinent remarks. The following tests will be conducted on each unit prior to any rf testing, and when appropriate upon completion of each test.

(1) Visual Inspection - Each initiator shall be visually inspected for burrs, bent pins, foreign matter or any apparent defect. Any abnormalities, whether considered a defect or not, shall be recorded.

(2) Bridgewire Resistance - The resistance of the bridgewire shall be measured and recorded using an instrument having an accuracy equal or greater than the Alinco Circuit Tester.

(3) Insulation Resistance - The resistance between the shorted initiator pins and the body of the initiator shall be measured for each initiator by applying a voltage not greater than six volts d-c for no longer than 30 ± 5 seconds.

(4) Pins-to-case Capacitance - The capacitance between both pins shorted together and the case shall be measured and recorded.

(5) Impedance Measurements - These measurements will be made pin-to-pin and pin-to-case over the range of 1 to 1300 MHz. The data shall be recorded.

c. After the tests described in Paragraph b. have been completed on all units and the data recorded, a probing type of test shall be conducted. Ten units will be exposed at each frequency. For this test rf energy shall be applied through the bridgewire (pin-to-pin) for a maximum of five minutes. Specifically, the tests shall be conducted under the following conditions:

Frequency	Signal Type	Number of Units
240	CW	10
2700	Pulsed	10
5400	Pulsed (0.75 μsec @ 400 PRF)	10
9000	Pulsed	10
5400	CW	10
9000	CW	10

The data from this test, along with any other pertinent firing data, such as functioning time and firing pulse duration and current applied shall be systematically recorded. Based on the information collected a curve will be plotted of power level to fire versus frequency for the pin-to-pin mode.

d. The tests outlined in Paragraph c. will be repeated using five unexposed units and five exposed units left from the Paragraph c. tests. The rf energy is to be applied between shorted bridgewire pins and initiator case for this test. Other conditions shall remain the same.

e. Post-firing examination and measurements on "non-fires" are to be performed as outlined in Paragraph b. The information shall be recorded as before.

f. The Franklin Institute shall return the units when advised by NASA.

g. A detailed test report which documents the results of all tests, including equipment and procedures used, and other pertinent data including recommendations, and conclusions will be written upon the completion of the program.

APPENDIX B

PRE-FIRING TEST DATA SHEETS

PRE-FIRING DATA SHEET

TEST GROUP: 1

DATE: 12/67

$* = >6x10^{11}$

INITIATOR SERIAL NO.	VISUAL INSPECTION		BRIDGEWIRE RESISTANCE (OHMS) A-B		BRIDGEWIRE RESISTANCE (OHMS) C-D		INSULATION RESISTANCE (OHMS)		INNER BRIDGE CAPACITANCE ($\mu\mu F$)		PINS TO CASE CAPACITANCE ($\mu\mu F$)		BRIDGE TO BRIDGE RESISTANCE (OHMS)		REMARKS
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	
1	O.K		4.5				*				4.3				
2	O.K.		4.2				*				4.5				
3	O.K.		5.0				*				5.0				
4	O.K.		4.5				*				4.5				
5	O.K.		5.0				5V $.2x10^6$				5.5				
6	O.K.		4.9				*				4.5				
7	O.K		4.4				*				4.2				
8	O.K.		3.5				6V 0				0				
9	O.K.		4.9				*				4.6				
10	O.K.		4.75				*				5.2				

PRE-FIRING DATA SHEET

TEST GROUP: 2

DATE: 12/67

* = $>6x10^{11}$

INITIATOR SERIAL NO.	VISUAL INSPECTION		BRIDGEWIRE RESISTANCE (OHMS) A-B		BRIDGEWIRE RESISTANCE (OHMS) C-D		INSULATION RESISTANCE (OHMS)		INNER BRIDGE CAPACITANCE (MMF)		PINS TO CASE CAPACITANCE (MMF)		BRIDGE TO BRIDGE RESISTANCE (OHMS)		REMARKS
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	
11	O.K.		4.95				*				4.8				
12	O.K.		4.75				*				4.5				
13	O.K.		5.25				*				4.3				
14	O.K.	O.K.	4.15	4.2			*	*			4.2	5.0			
15	O.K.	O.K.	4.6	4.8			*	*			4.5	6.0			
16	O.K.		4.4				.35mV $1.7x10^{10}$				5.4				
17	O.K.		4.2				*				4.2				
18	O.K.		4.25				*				4.2				
19	O.K.		4.4				*				4.5				
20	O.K.		4.1				*				4.5				

PRE-FIRING DATA SHEET

TEST GROUP: 3

DATE: 12/67

$* = >6x10^{11}$

INITIATOR SERIAL NO.	VISUAL INSPECTION		BRIDGEWIRE RESISTANCE (OHMS) A-B		BRIDGEWIRE RESISTANCE (OHMS) C-D		INSULATION RESISTANCE (OHMS)		INNER BRIDGE CAPACITANCE (MMF)		PINS TO CASE CAPACITANCE (MMF)		BRIDGE TO BRIDGE RESISTANCE (OHMS)		REMARKS
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	
21	O.K		4.8				*								
22	O.K		4.4				*								
23	O.K		4.15				*								
24	O.K		4.8				1V $5x10^6$								
25	O.K	O.K	4.65	4.6			1.7mV $3.5x10^9$	13mV $4.6x10^8$							
26	O.K		4.7				*								
27	O.K	O.K	4.4	4.4			*	*							
28	O.K		4.15				*								
29	O.K		4.5				*								
30	O.K	O.K	4.5	4.5			*	*							

PRE-FIRING DATA SHEET

TEST GROUP: 4

DATE: 12/67

$* = >6x10^{11}$

INITIATOR SERIAL NO.	VISUAL INSPECTION		BRIDGEWIRE RESISTANCE (OHMS) A-B		BRIDGEWIRE RESISTANCE (OHMS) C-D		INSULATION RESISTANCE (OHMS)		INNER BRIDGE CAPACITANCE ($\mu\mu F$)		PINS TO CASE CAPACITANCE ($\mu\mu F$)		BRIDGE TO BRIDGE RESISTANCE (OHMS)		REMARKS
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	
31	tight O.K.		4.5				3.5mV $1.7x10^{9}$				5.7				
32	O.K.		4.55				*				4.5				
33	O.K.		4.0				*				4.7				
34	O.K.		4.6				.3mV $2x10^{10}$				5.3				
35	O.K.		4.85				*				4.5				
36	O.K.		5.1				*				4.5				
37	O.K.		4.25				*				4.3				
38	O.K.		4.2				*				4.4				
39	O.K.		4.35				.5mV $1.2x10^{10}$	$12.0x10^{9}$			4.4				
40	O.K.		5.15				*				4.5				

PRE-FIRING DATA SHEET

TEST GROUP: 5

DATE: 12/67

$* = >6x10^{11}$

INITIATOR SERIAL NO.	VISUAL INSPECTION		BRIDGEWIRE RESISTANCE (OHMS) A-B		BRIDGEWIRE RESISTANCE (OHMS) C-D		INSULATION RESISTANCE (OHMS)		INNER BRIDGE CAPACITANCE (µµF)		PINS TO CASE CAPACITANCE (µµF)		BRIDGE TO BRIDGE RESISTANCE (OHMS)		REMARKS
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	
41	O.K.		4.6				*				4.5				
42	O.K		5.0				1.5mV $4x10^9$				5.1				
43	O.K.	O.K.	5.1	5.2			*	*			4.6	6.0			
44	O.K		4.8				*				4.6				
45	O.K.		4.8				*				4.6				
46	O.K.		4.6				*				4.8				
47	O.K.		4.8				*				4.9				
48	O.K.		4.3				*				4.7				
49	O.K.	O.K.	4.8	4.8			*	*			4.2	4.8			
50	O.K.	O.K.	4.65	4.7			6mV $1x10^9$	1.9mV $3.1x10^9$			5.2	6.2			

PRE-FIRING DATA SHEET

TEST GROUP: 6

DATE: 12/67

$* = >6x10^{11}$

INITIATOR SERIAL NO.	VISUAL INSPECTION		BRIDGEWIRE RESISTANCE (OHMS) A-B		BRIDGEWIRE RESISTANCE (OHMS) C-D		INSULATION RESISTANCE (OHMS)		INNER BRIDGE CAPACITANCE ($\mu\mu F$)		PINS TO CASE CAPACITANCE ($\mu\mu F$)		BRIDGE TO BRIDGE RESISTANCE (OHMS)		REMARKS
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	
51	O.K.		4.6				*				5.0				
52	O.K.		4.8				*				4.7				
53	O.K.		4.6				*				5.0				
54	O.K.		5.0				*				5.0				
55	O.K.		4.2				*				5.0				
56	O.K.		4.5				2 mu $3x10^9$				6.0				
57	O.K.	O.K.	5.1	5.1			*				5.7	5.0			
58	O.K.		4.85				*				5.0				
59	O.K.		4.2				*				6.0				
60	O.K.		4.3				*				6.0				

PRE-FIRING DATA SHEET

TEST GROUP: 7

DATE: 12/67

* = $>6 \times 10^{11}$

INITIATOR SERIAL NO.	VISUAL INSPECTION		BRIDGEWIRE RESISTANCE (OHMS) A-B		BRIDGEWIRE RESISTANCE (OHMS) C-D		INSULATION RESISTANCE (OHMS)		INNER BRIDGE CAPACITANCE (μμF)		PINS TO CASE CAPACITANCE (μμF)		BRIDGE TO BRIDGE RESISTANCE (OHMS)		REMARKS
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	
61	O.K.	O.K.	4.2	4.2			*	*			4.7	5.0			
62	O.K.	O.K.	4.1	4.1			*	*			5.0	4.9			
63	O.K.	O.K.	4.5	4.5			*	*			4.8	5.2			
64	O.K.		4.25				*				4.5				
65	O.K.		4.6				*				4.8				
66	O.K.		4.4				*				5.5				
67	O.K.		4.6				*				5.4				
68	O.K.		4.8				*				5.2				
69	O.K.		4.6				*				5.2				
70	O.K.		4.85				*				5.0				

TEST GROUP: 8

DATE: 12/67

$* = >6x10^{11}$

INITIATOR SERIAL NO.	VISUAL INSPECTION		BRIDGEWIRE RESISTANCE (OHMS) A-B		BRIDGEWIRE RESISTANCE (OHMS) C-D		INSULATION RESISTANCE (OHMS)		INNER BRIDGE CAPACITANCE (μμF)		PINS TO CASE CAPACITANCE (μμF)		BRIDGE TO BRIDGE RESISTANCE (OHMS)		REMARKS
	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	BEFORE	AFTER	
71	O.K.		4.5				*				5.0				
72	O.K.		4.35				*				6.0				
73	O.K.		4.5				*				5.0				
74	O.K.		5.0				*				5.0				
75	O.K.		4.75				*				6.5				
76	O.K.	O.K.	4.5	4.5			1.3mu $46x10^9$	*			6.2	10.0			
77	O.K.		4.8				*				6.0				
78	O.K.		4.9				*				5.3				
79	O.K.		4.85				*				4.7				
80	O.K.	O.K.	4.6	4.6			*	*			4.7	4.7			