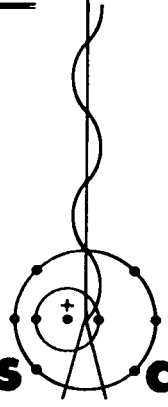
LA-5373-MS

Improvements in Hot-Wire Electroexplosive Devices



los alamos
scientific laboratory
of the University of California
LOS ALAMOS, NEW MEXICO 87544

UNITED STATES
ATOMIC ENERGY COMMISSION
CONTRACT W-7405-ENG. 36

Printed in the United States of America. Available from
National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151
Price: Printed Copy $4.00; Microfiche $0.95

LA-5373-MS
UC-45
ISSUED: October 1973

los alamos
scientific laboratory
of the University of California
LOS ALAMOS, NEW MEXICO 87544

Improvements in Hot-Wire Electroexplosive Devices

by

Richard M. Joppa

IMPROVEMENTS IN HOT-WIRE ELECTROEXPLOSIVE DEVICES

by

Richard M. Joppa

ABSTRACT

A brief investigation was conducted into several possible design improvements in hot-wire electroexplosive devices. These were: an arc-resistant header, greater bridgewire-post heat dissipation area, reacting metal bridgewires, and a secondary explosive substitute for primary explosive. Tests using an SE-1 test fixture with four header-bridgewire models showed highly promising results for raising the overall hot-wire ignition safety margins in electrostatic and rf environments without large increases in firing energy. Various electrical characteristics of the four models are given, together with electrical characteristics and function times of the devices loaded with the secondary explosive.

I. INTRODUCTION

The general objectives of this investigation were to test several concepts directed at improving the initiation safety margins of hot-wire electroexplosive devices (EEDs). The improvements investigated in this work were:

a. Header configuration designed to eliminate the possibility of initiation by pin-to-case arcing.

b. Header configuration designed to improve heat dissipation capabilities by increasing the bridgewire-post area.

c. Substitution of reacting metal bridgewire (BW) for conventional BW, with the desired goal of eliminating primary explosive materials (lead azide, styphnates, etc.) from the EED.

d. Ignition tests of potassium hexanitrodiphenylamine (KHND) which previous tests indicated as a secondary explosive possibly suitable for replacement of the primary explosives in EEDs.

II. TEST ARTICLES

The SE-1 detonator test fixture (Fig. 1.) was chosen as the primary test fixture to be used in the investigation. SE-1 size N (0.040-in. pin-to-pin spacing) was used.

Four header configurations were utilized. All used the arc-suppression concept developed in the Mk 101 detonator by Naval Ordnance Laboratory[1] as shown in Figs. 2 and 3. For convenience and lower cost, a Lucite sleeve was fabricated to serve the purpose of the aluminum charge holder (Fig. 4). The bridge element was of copper, with Mylar substrate etched in a conventional printed-circuit-board manner for convenience and low cost. Copper, of course, is not a suitable material for prolonged contact with potentially corrosive explosives, but served satisfactorily for this series of experiments.

For convenience, the four header configurations will hereafter be termed Models 1, 2, 3, and 4. Models 1 and 2 are identical except for the copper thickness, and are shown in the photograph of Fig. 5. Model 3 has a 0.003-in.-diam Pyrofuze BW and is shown in the photograph of Fig. 6. Model 4, shown in Fig. 7, is identical to Model 3, except that it has a 0.001-in.-diam Pyrofuze BW.

III. ELECTRICAL CHARACTERISTICS OF HEADER DESIGNS

A. Model 1

This header configuration has a 2.8-mil-thick (2 oz/ft^2) copper plating on a Mylar substrate. The header design is etched with mounting holes punched to mount directly to an SE-1 N-size test fixture. The header is attached by soldering to the lead wire extensions.

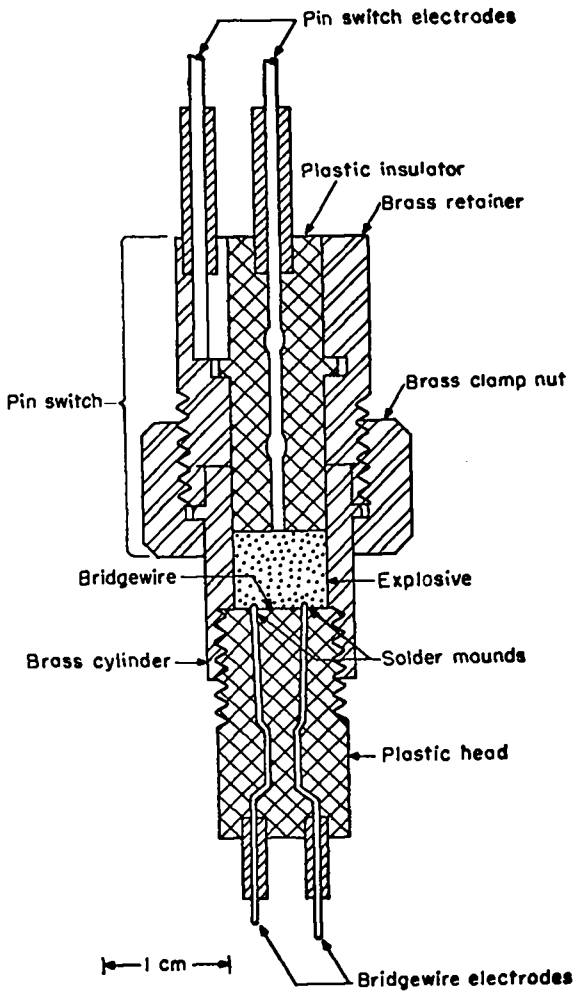


Fig. 1. SE-1 test fixture.

Typical BW resistance: 0.018 Ω (at 24°C).
direct-current carrying capacity: 10 A.
BW temperature @ 10 A: ∿ 500°F (260°C) after 30 sec (measured by temperature-sensitive Tempilaq coating).

Power dissipation capability: 1.5 W continuous (without sleeve or other SE-1 attachment); solder mounts were observed to melt, and copper surface separated from Mylar substrate at power levels above 2.5 W.

High-voltage breakdown: Occurs between serrated edge and sleeve between 1.8- and 2.0-kV dc (in air).

Thermal time constant of unloaded SE-1: ∿ 4.5 msec when measured at peak current pulses of 6 A with a transient current bridge.[2]

Minimum energy to break BW in exploding BW (EBW) mode (energy supplied by CDU): greater than 2 J (W-sec) (greater than 2 kV, 1-μF capacitor).

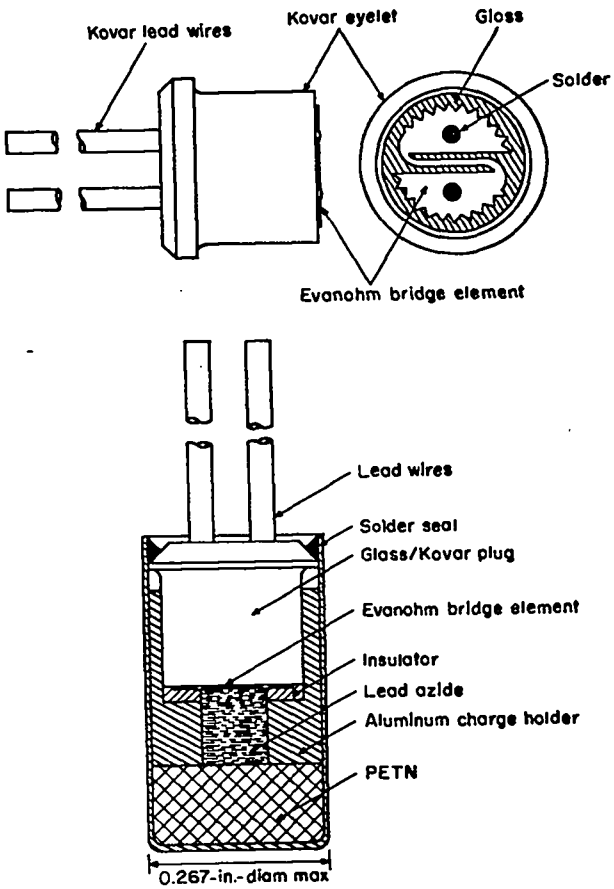


Fig. 2. Mk 101-type detonator assembly.

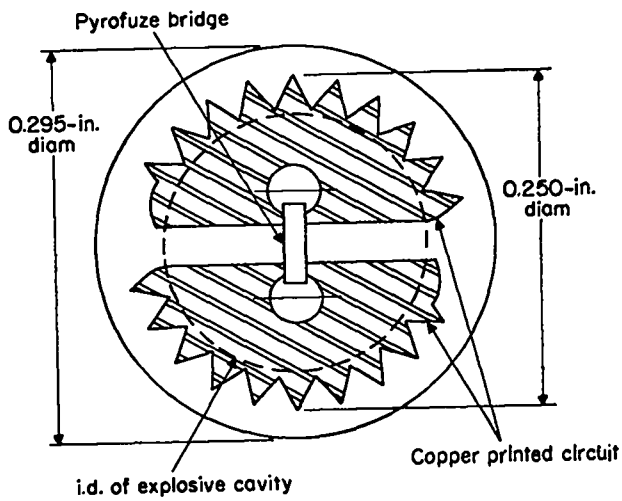


Fig. 3. Arc-dissipating bridge element.

Radio-frequency impedance characteristics: See pin-to-pin and pin-to-case impedance data in App. I.

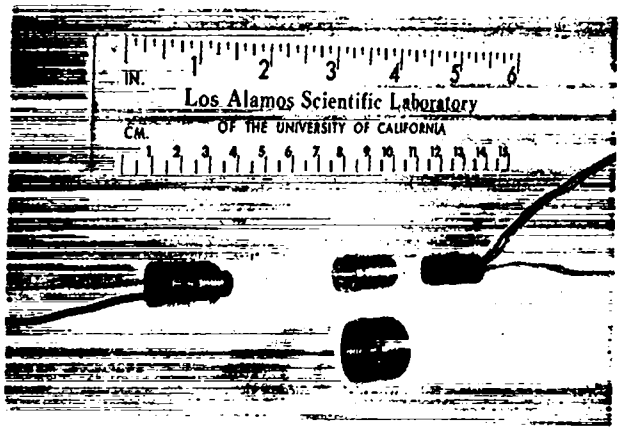


Fig. 4. SE-1 assembly.

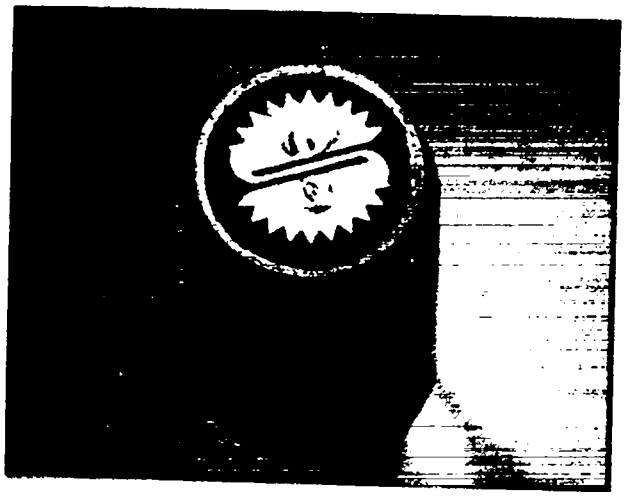


Fig. 5. Models 1 and 2.

Fig. 6. Model 3.

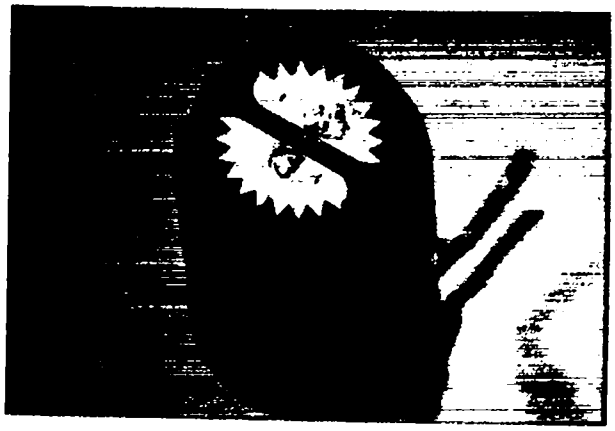


Fig. 7. Model 4.

B. Model 2

This header configuration has a 0.7-mil-thick (0.5 oz/ft^2) copper plating on a Mylar substrate. Attachment to the SE-1 fixture is as in Model 1.

Typical BW resistance: 0.046 Ω (at 23.2°C).

BW current-carrying capability: BW exhibits a temperature of 463°F (240°C) when carrying a current of 3.75 A 10 sec after current application; BW separates under dc load of 4 A.

Power dissipation capability: Approximately 0.6 W continuous (without sleeve or other SE-1 attachment). At higher power levels, BW melts (melting point of copper is ∿ 1100°C).

Note: Model 1 BW successfully carried power levels greater than header configuration could dissipate. The opposite is true for Model 2.

High-voltage breakdown: Occurs between serrated edge and sleeve between 1.8- and 2.0-kV dc (in air).

Thermal time constant of unloaded SE-1: Approximately 4.5 msec when measured at peak current pulses of 2 A with transient bridge circuit.[2]

Minimum energy to break BW in EBW mode (energy supplied by CDU): 1.12 J (1500 V, 1-μF capacitor).

Radio-frequency impedance characteristics: See pin-to-pin and pin-to-case impedance data in App. I.

C. Model 3 (0.003-in. Pyrofuze Bridgewire)

Typical BW resistance: 0.034 Ω (at 22.8°C).

BW current-carrying capability: Successfully carries 5 A in this header configuration; normally bursts at 5.75 A (Pyrofuze reaction begins at 660°C). Approximate function times at other current levels: 10 A - 5.0 msec, 15 A - 2.0 msec.

A plot of BW-current-power characteristics is shown in Fig. 8.

Power dissipation capability: Header dissipates approximately 1 W satisfactorily for a continuous current input of 4.6 A.

High-voltage breakdown: Occurs between serrated edge and sleeve between 1.8- and 2.0-kV dc (in air).

Thermal time constant of unloaded BW: Approximately 3.5-4.0 msec when measured at peak current pulse of 2 A with transient bridge circuit.

Minimum energy to break BW in EBW mode (energy supplied by CDU): 0.1922 J (620 V, 1-μF capacitor).

Radio-frequency impedance characteristics: See pin-to-pin and pin-to-case impedance data in App. I.

D. Model 4 (0.001-in. Pyrofuze BW)

Typical BW resistance: 0.257 Ω (at 23°C).

BW current-carrying capability (Pyrofuze reaction begins at 660°C): Successfully carries 600 mA; Pyrofuze reaction normally initiated at about 700 mA.

Function times at other current levels: 10 A - 50 μsec (BW open at 100 μsec), 15 A - 40 μsec (BW open at 34 μsec).

Curve of BW temperature versus power and current input shown in Fig. 9.

Power dissipation capability: Approximately 0.09 W under continuous 600-mA current load input; power dissipation of header, based on Model 1 and Model 2 data, is greater than 1 W.

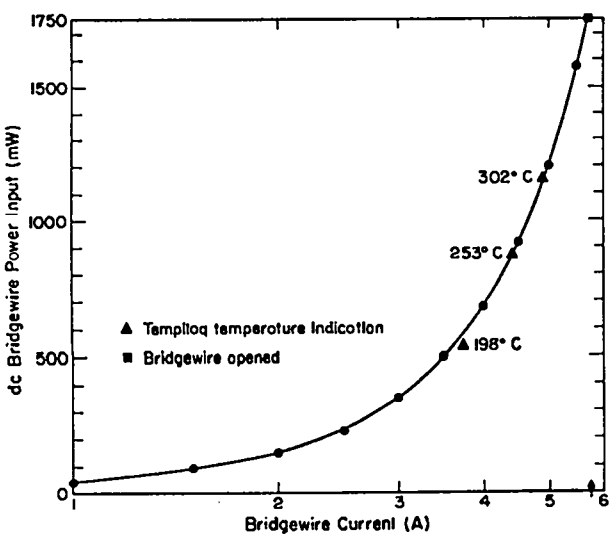


Fig. 8. Current-power characteristics of 0.003-in. Pyrofuze BW (Model 3).

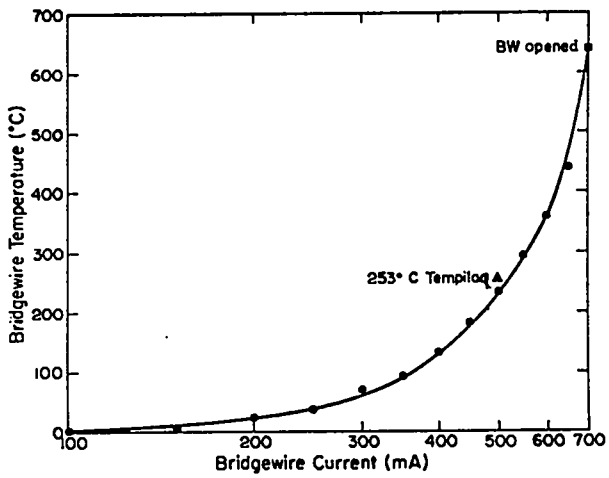


Fig. 9. Bridgewire current vs temperature Model 4, 0.001-in. Pyrofuze.

High-voltage breakdown: Occurs between serrated edge and sleeve between 1.8- and 2.0-kV dc (in air).

Thermal time constant of unloaded BW: Approximately 2.5-3.0 msec when measured at peak current pulse of 300 mA with transient bridge circuit.

Minimum energy to break BW in EBW mode (energy supplied by CDU): 0.02 J (205 V, 1-μF capacitor).

Radio-frequency impedance characteristics: See pin-to-pin and pin-to-case impedance data in App. I.

IV. CHARACTERISTICS OF REACTING BRIDGES

Various bimetallic BW composites exist. Characteristic of such composites is a violent and exothermic reaction (see Fig. 10) which is initiated at 660°C (the melting point of aluminum) and reaches a temperature between 2200°C and 2800°C. The reaction proceeds without support of oxygen, and the BW is consumed (a useful feature in EED applications where normal BWs often remain intact after initiation).

"Pyrofuze" is a registered trademark of the Pyrofuze Corporation. Pyrofuze wire is marketed by the Sigmund-Cohn Company. The Pyrofuze wire used in this investigation was 0.001 and 0.003 Hi-R.

The term "Pyrofuze reaction" is used to denote the metallic reaction (temperatures greater than 660°C). It should be noted that explosives might be ignited in the "hot-wire" mode, wherein the BW has not reached the required 660°C reaction temperature but has reached a sufficiently high temperature (350°C, for example) to ignite the explosive reaction in an EED.

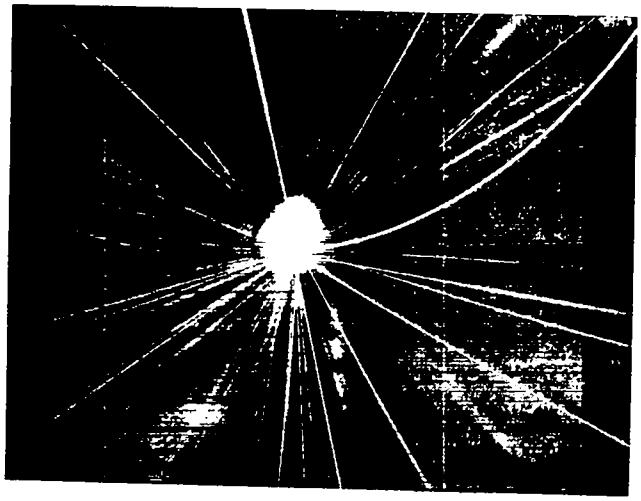


Fig. 10. Pyrofuze BW reaction.

Function times of EEDs ignited by a Pyrofuze BW are largely a function of the Pyrofuze wire size and Pyrofuze reaction itself, unless the bridge is fired in the EBW mode from a capacitor discharge unit (CDU) source. An indirect objective of the investigations conducted was to select a Pyrofuze wire size which would react in sub-millisecond times under application of direct currents on the order of 10 to 15 A. Such experiments can be performed with unloaded devices (or bare wire) to obtain representative times. The oscilloscope photographs in Figs. 11, 12, and 13 illustrate the response of various 0.001-mil Pyrofuze bridges to dc step-current application.

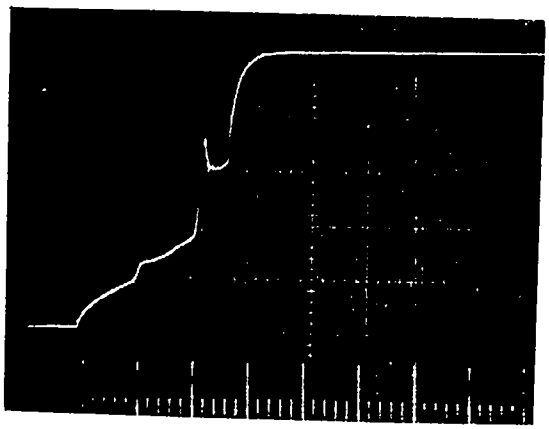


Fig. 11. Model 4 (No. 10) unloaded 0.001-in. Pyrofuze, 0.030-in. long 10 A applied, 50 μsec/cm, 5 V/cm. Pyrofuze reaction time: 50 μsec. BW open: initially 100 μsec; final 130 μsec.

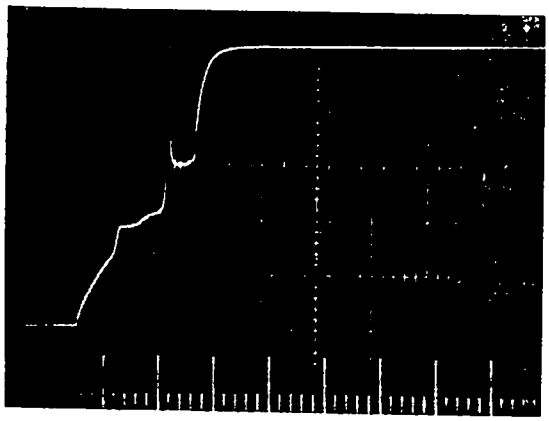


Fig. 12. Model 4 (No. 11) unloaded 0.001-in. Pyrofuze, 0.030-in. long, 15 A applied, 50 μsec/cm, 5 V/cm. Pyrofuze reaction time: 40 μsec. BW open: initially 80 μsec; final 105 μsec.

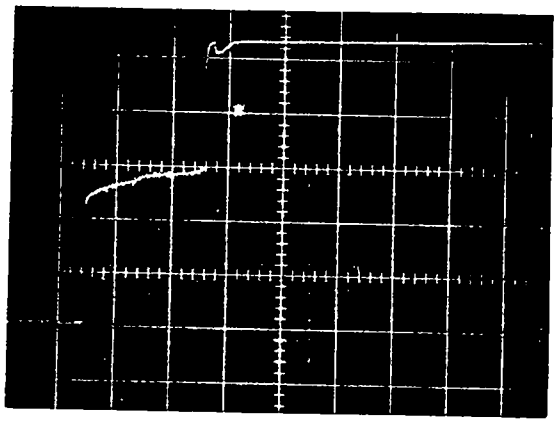


Fig. 13. Model 4 unloaded 0.001-in. Pyrofuze 0.750-in. long, 15 A applied 500 μsec/cm, 5 V/cm. Pyrofuze reaction time: unreadable--estimated at 40-50 μsec. Bridgewire open: 1250 μsec.

Note: The 0.001-in. Pyrofuze BW reaction rate can be computed as approximately 750 in./sec from these data.

V. CHARACTERISTICS OF KHND

The potassium salt of 2, 2', 4, 4', 6, 6'-hexanitrodiphenylamine (KHND) is a secondary explosive which has the following characteristics:

Molecular weight: 477.32.

Heat of combustion: 1305 kcal/mole.

Differential thermal analysis (Fig. 14).

Detonation temperature: ∿ 340°C.

Pyrolysis (Fig. 14).

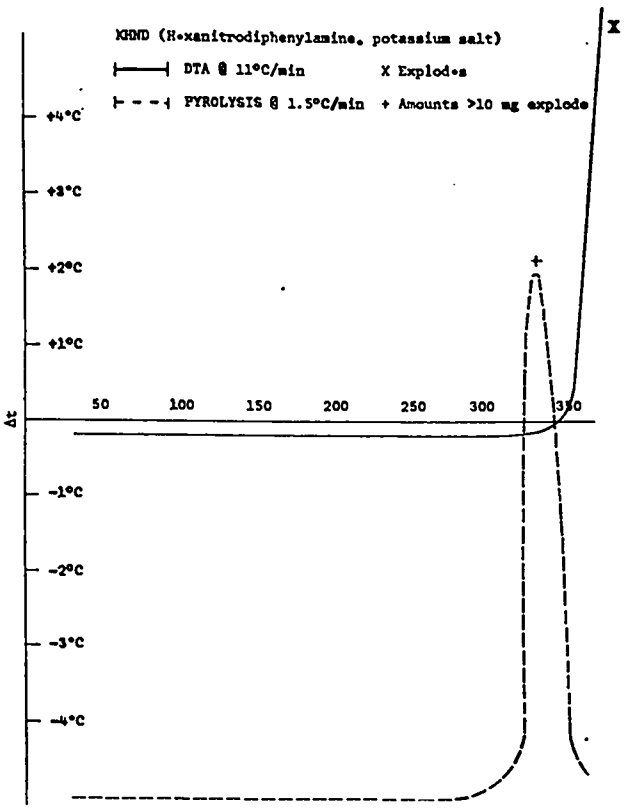


Fig. 14. Differential thermal analysis (DTA) and pyrolysis for KHND.

Impact sensitivity (compared with RDX), BRL Machine, 2.5-kg weight:

Test	Type 12	Type 12B
RDX	21.8	32.8
KHND	24.9	32.6

The spark sensitivity, as measured by WX-2, LASL Electrostatic Sensitivity Test, is as follows:

	Spark Energy to Burst 3-mil Foil (in J)	Spark Energy to Burst 10-mil Foil (in J)
KHND (Coarse 6372-74)	0.529	0.575
KHND (Fine 6372-64)	0.513	0.425
Other Secondary Explosives:		
RDX (Impact Std)	0.21	0.96
HMX (Impact Std)	0.23	1.42
PETN (Du Pont)	0.19	0.75
Tetryl (Impact Std)	0.54	3.79
TNT (Impact Std)	0.46	3.75

In general, KHND is one of the more sensitive secondary explosives (although it is less impact sensitive and spark sensitive than some others). It appears to be reasonably stable under ordinary environmental testing (e.g., the desert cycle). As opposed to many secondary explosives, a KHND deflagration is relatively easily ignited and a detonation ensues if the material is confined.

In most hot-wire EEDs, a primary explosive is located next to the BW and is initiated by the BW heating. In the case of a detonator, the force of the primary reaction is used to initiate a secondary explosive (base charge) such as PETN.

Primary explosives (lead azide, lead styphnate, etc.) are much more spark sensitive than secondaries; primary explosives also proceed rapidly to detonation (rather than deflagration). A peculiar ignition mode also appears to exist in primary explosives (particularly lead azide) which makes them undesirable from a safety viewpoint. Because of its more desirable properties, KHND was used in place of the primary explosive in EEDs during this brief investigation.[3]

VI. RESULTS OF dc FIRING TESTS

Four units each of Models 2, 3, and 4 header assemblies (mounted to an SE-1 test fixture) were loaded with two grades of KHND (6372-64 fine and 6372-74 coarse) for experimental firing tests. Previous feasibility tests[4] had shown successful 3-mil Pyrofuze ignition of both grades of KHND at densities ranging from 0.8 to 1.4 g/cm^3. The volume of the Lucite charge holder was 0.09113 cm^3. Consequently an explosive weight of 91.3 mg resulted in a density of 1 g/cm^3 and all units were loaded to this density.

Pin-to-case arc (or electrostatic) ignition tests were conducted on all models. All models were tested under standard conditions (25 kV, 500 pF capacitor, 5000 Ω in discharge path) without incident. Successively more severe tests (30-kV direct connection, Tesla coil voltages sufficient to cause air breakdown) were applied and the results were the same.

The following is a brief summary of results of dc step-current applications:

Model 2	1 g/cm³ KHND Load	Direct Current Applied	Results
# 1	fine	used in rf test	see results of rf tests (Section VII)
#7	fine	15 A	detonated
#11	coarse	15 A	detonated
#17	coarse	used in rf test	
Model 3			
# 1	fine	15 A	detonated
# 2	fine	10 A	detonated
# 3	coarse	10 A	detonated
# 4	coarse	10 A	detonated
Model 4			
# 3	fine	15 A	detonated
# 4	fine	15 A	detonated
# 5	coarse	15 A	detonated
# 7	coarse	15 A	detonated

Representative function times of the various models under the previous conditions are shown in the oscilloscope photographs of Figs. 15, 16, 17, and 18.

A later series of tests was conducted using the Mk 2 Mod 0 Squib (identical to that shown in Fig. 19 with the exception of a 0.003-in.-diam conventional platinum-iridum BW) containing no ignition bead (primary explosive), a flash charge of KHND (6372-74 coarse) pressed to 1 g/cm³ density, and no base charge. The objective of this test was to evaluate KHND performance in a fixed header-BW design for comparison with the Mk 2 Mod 0 performance evaluated previously.[4] The results were as follows:

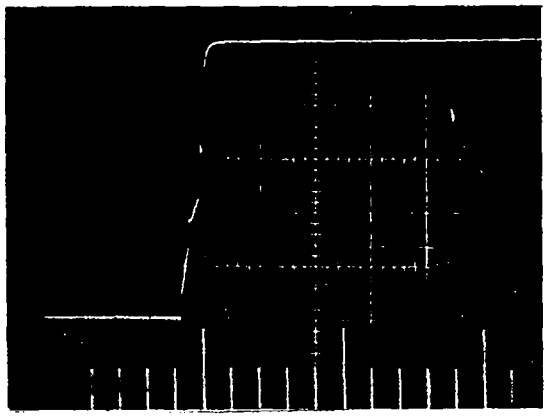


Fig. 15. Model 4 (No. 5) 0.001-in. Pyrofuze loaded with 6372-64 KHND, 15 A applied, 200 µsec/cm, 5 V/cm. Time to Pyrofuze reaction: 20 µsec (est.). Time to BW open: 80 µsec.

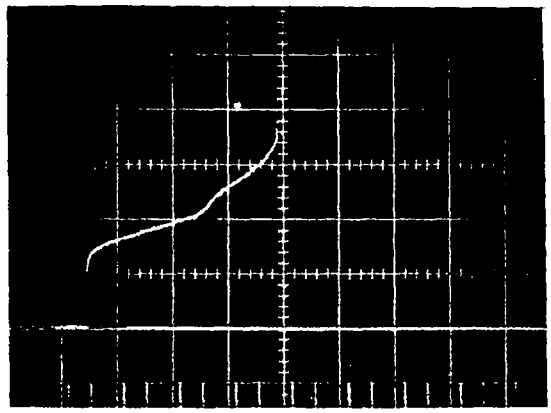


Fig. 16. Model 3 (No. 1) 0.003-in. Pyrofuze loaded with 6372-64 KHND, 0.003-in. Pyrofuze 0.030-in. long, 15 A applied, 500 µsec/cm, 0.5 V/cm. Time to Pyrofuze reaction: 1100 µsec. BW open: 1800 µsec.

#101: Detonated normally after pin-to-pin application of a direct current of 1.58 A. (Minimum all-fire current of the conventional Mk 2 Mod 0 had been previously evaluated as 1.52 A, 0.995 reliability, 95% confidence.)

#107: Was subjected to a series of pin-to-case electrostatic tests:

a. 25 kV, 500 pF, 5000 Ω: No-fire.
b. 25 kV, 500 pF, 500 Ω: No-fire.
c. Direct pin-to-case application of 25 kV: No-fire.
d. Pin-to-pin application of 1.52 A caused normal detonation.

In both #101 and #107, the BW remained intact (since the source was current-limited) as is usual with the Mk 2 Mod 0.

The principal conclusions drawn from these dc tests were:

a. The 0.001-in. Pyrofuze would successfully ignite KHND (both types) at a density of 1 g/cm³.
b. KHND can be ignited in the hot-wire mode (as illustrated by the Model 2 device and the Mk 2 Mod 0 device). Ignition temperatures are on the order of 350°C, as indicated by the higher currents required in the

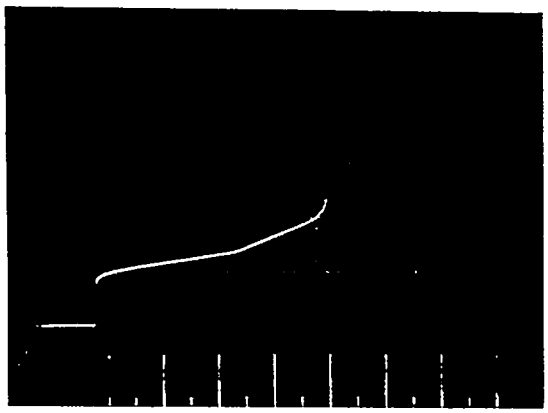


Fig. 17. Model 3 (No. 4) 0.003-in. Pyrofuze loaded with 6372-74 KHND, 10 A applied, 1000 μsec, 0.5 V/cm. Time to Pyrofuze reaction: 2700 μsec. BW open: 4200 μsec.

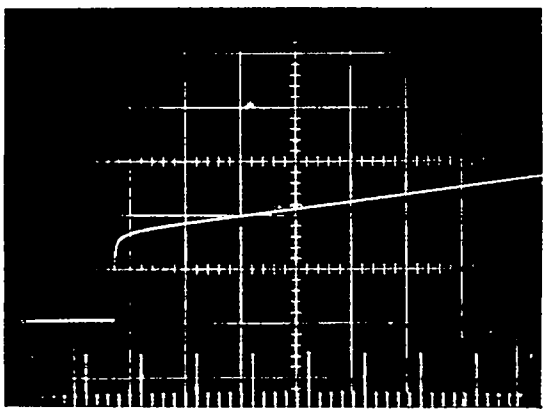


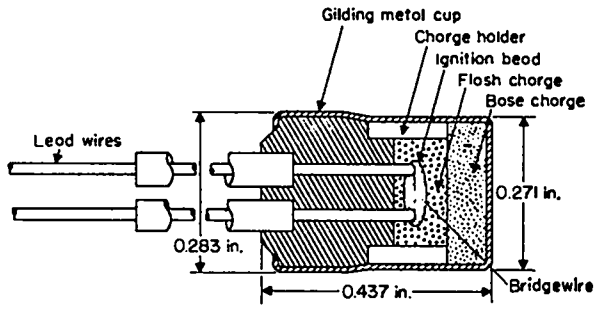
Fig. 18. Model 2 (No. 11) (non-Pyrofuze) loaded with 6372-64 KHND, 15 A applied, 0.5 msec/cm, 0.5 V/cm. Time to deflagration: greater than 4 msec.

Mk 2 Mod 0 tests when compared with currents necessary to initiate DDNP.

c. KHND has excellent dielectric strength properties, successfully withstanding approximately 250 kV/in. or 100 kV/cm in the Mk 2 Mod 0 configuration.

d. The function time of the 0.001-in. Pyrofuze BW (Model 4) was on the order of 40 μsec with 15 A applied--much faster than normally expected for a hot-wire device.

e. The Mk 101-type header and charge holder designs, together with the apparently excellent properties of KHND, can accomplish the desired purpose of dissipating high pin-to-case voltages harmlessly.



Ignition bead - ~5-mg DDNP/$KClO_3$

Flash charge - ~45-mg Black powder

Base charge - ~45-mg Black powder

Bridgewire -0.001-in. Platinum-Iridium 0.060 in. long

Fig. 19. Squib Mk 1 Mod 0.[5]

VII. RESULTS OF rf TESTS

It was previously mentioned that rf impedance of the four models (with 3/4-in. leads) was measured between 100 MHz and 8 GHz. These data are shown in the impedance data in App. I. The purpose of this measurement was to determine potentially susceptible frequencies. A test frequency of 750 MHz was selected because it was one at which the real part of the pin-to-pin and pin-to-case impedances was near 50 Ω (since rf sources of 50-Ω source impedance would be used) and also because it was the lowest frequency at which maximum use of a double-stub power matching section could be achieved. The test setup is shown in Fig. 20. The EED was "directly driven" by the rf source, maximum power transfer was achieved by tuning with the double-stub tuner (at low power levels) and net rf power was read directly.

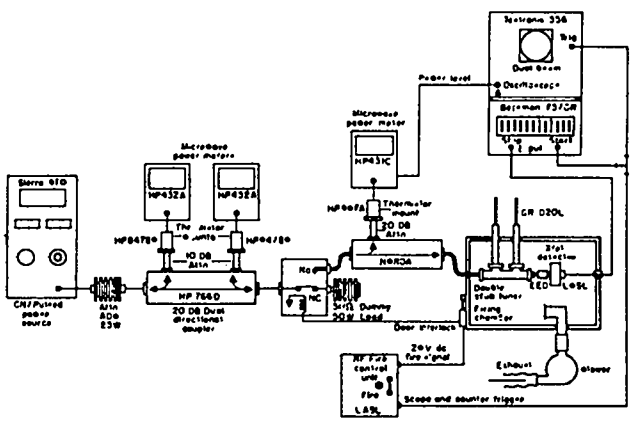


Fig. 20. Block diagram of EED rf firing system.

The rf test results can be summarized quickly. Continuous wave (CW) rf powers up to 10 W (net) were applied for up to 10 min to all four models in the pin-to-pin and pin-to-case modes without incident. This is roughly equivalent to perfect dipole coupling in an electric field of 330 V/m. The cases and brass-clamp nut became too warm to touch, but no firings resulted. Subsequent application of dc firing currents resulted in normal detonation.

The rf no-fire result was anticipated for all but the 0.001-in. Pyrofuze (Model 4). The header area was shown in preceding dc tests to be an effective heat dissipater. The combination of heat dissipation area and heat flow from the surface (due to rf skin effect) throughout the metallic volume obviously kept the BW (or other metal surface in contact with the explosive) from reaching ignition temperature (340°-350°C). The indications also are that the rf power was delivered to the entire header assembly, not just to the BW portion. In the case of the Model 4, 0.001-in. Pyrofuze BW, however, it was expected that enough power could be delivered to the BW to raise it to 350°C or to the 660°C Pyrofuze reaction point. In addition, the actual construction of the Pyrofuze wire may have aided in preventing ignition. In a Pyrofuze reaction, the aluminum center core of the wire must reach 660°C to initiate the reaction. In a dc situation this is easily achieved. In an rf situation, however, the skin effect tends to cause direct heating only of the palladium outer sheath. A combination of this effect with the immediate conduction of heat away from the surface toward a uniform distribution throughout the Pyrofuze wire may have been a factor.

As mentioned in the dc test section, several Mk 2 Mod 0 bridged headers were loaded with KHND (6372-74 coarse) explosive at a density of 1 g/cm^3. One of each of these devices was then subjected to an exposed rf direct-drive test to evaluate firing powers and to provide results for comparison with previous rf sensitivity data on the Mk 2 Mod 0 loaded with primary explosive (DDNP). The results are only quantitative since only one device was tried at each frequency; nevertheless, the KHND looks extremely attractive--especially in the pin-to-case mode. Comparisons are drawn in Figs. 21 and 22. The conventional Mk 2 Mod 0 results are based on 10 firings at each frequency. Of interest was the

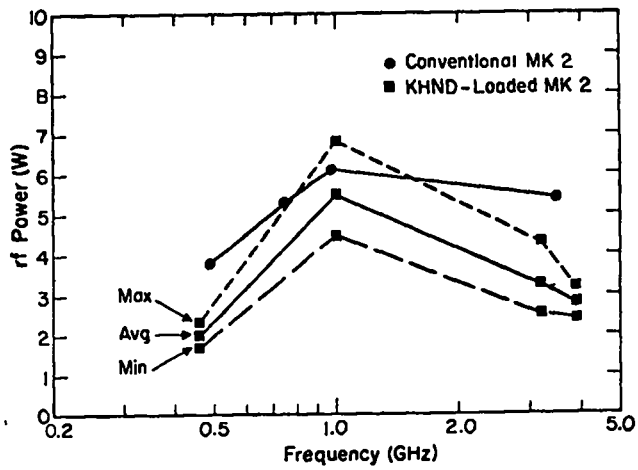


Fig. 21. rf sensitivity comparison 50-Ω source, pin-to-pin, Mk 2 Mod 0 squib.

fact that no high order KHND detonations occurred in the pin-to-case mode; only deflagration and gas pressures which ruptured the assembly resulted. Principal conclusions drawn from these tests were:

a. The properties of KHND are highly attractive when tested in the rf environment from 0.4 to 4.0 GHz.

b. The combination of design features tested in Models 1, 2, 3, and 4 (with KHND) were highly satisfactory in preventing both pin-to-pin and pin-to-case ignition in rf environments. These features are:

   1. Increased heat dissipating area of the header.
   2. Characteristics of Pyrofuze BW.
   3. KHND properties.

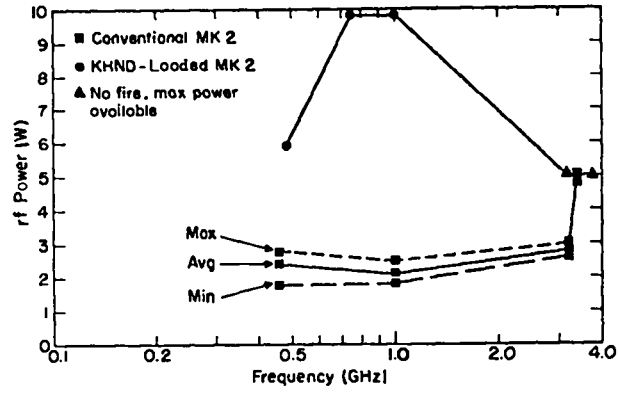


Fig. 22. rf sensitivity comparison 50-Ω source, pin-to-case, Mk 2, Mod 0 Squib.

VIII. CONCLUSIONS AND RECOMMENDATIONS

The 40-μsec ignition time for KHND, 0.001-in. Pyrofuze, and 15 A was much less than expected. It appears that hot-wire EEDs (of 0.5-A no-fire rating) could be built to function reliably in 40 μsec if 15 A were applied. Further experiments with increased currents (and anticipated decreased reaction times) should be conducted.

Further experimentation is required to determine explosive shock front propagation, etc., in relation to time of current application.

It should also be mentioned that no pressure-time history data were taken during this investigation, since ability to ignite KHND, header performance, and Pyrofuze reaction times were the primary interests.

The Pyrofuze BWs used in these experiments were cylindrical (aluminum sheathed in palladium). Other geometries, such as rectangular ribbon, thin film bridges, etc., should be explored for advantages and disadvantages in any further investigation for optimum geometries and ignition characteristics.

Further investigation into the use of Pyrofuze-type ignition appears also to be in order. Initially it was felt that the high temperature and material "throw" of the Pyrofuze reaction would be necessary to ignite a secondary explosive. In the case of KHND, it appears that hot-wire ignition alone is sufficient to cause ignition, but Pyrofuze may speed reaction times and aid in rf insensitivity. Experiments have been performed in the past showing that PETN, HMX, and RDX can be ignited with Pyrofuze. Minor experimentation mentioned earlier[4] showed that BTF (HBN) could be ignited with suitably large Pyrofuze wire (0.010-in.-diam), but attempts to ignite DATB (Lot 725) were unsuccessful.

The designs tested were highly rf-resistant. The relative contributions of the various design features to this insusceptibility should be further investigated. The properties of KHND contribute in a large measure to this insensitivity, particularly in the pin-to-case mode.

Bridgewire sizes may be selected to achieve virtually any desired value of no-fire current by an appropriate choice of BW diameters. Use of 0.001-in. Pyrofuze wire would result in a no-fire current greater than 0.5 A and a function time of about 40 μsec when 15 A is applied.

A hot-wire EED, using only secondary explosives, and possessing greater safety margins in high rf and electrostatic environments, appears highly feasible.

REFERENCES

1. S. G. Nesbitt, "Functioning Time of 1 Amp/1 Watt Detonator," Proceedings of the Sixth Symposium on Electroexplosive Devices, San Francisco, July 1969.
2. L. A. Rosenthal, "Electrothermal Measurements of Bridgewires Used in Electroexplosive Devices," IEEE Transactions on Instrumentation and Measurement, June 1965.
3. Yu. N. Sukhushin, Yu. A. Zakharov, G. A. Rappaport, "A Study of Several Microscopic Mechanisms of the Dielectric Breakdown of Lead Azide," Izv. Tomsk, Politekh Institute, 1970, pp. 219-229.
4. R. Joppa, B. Dennis, R. Freyman, J. Todd, "Response of Airborne Electroexplosive Devices to Electromagnetic Radiation," Los Alamos Scientific Laboratory report LA-5201-MS (ASD TR 73-10), February 1973.
5. L. D. Hampton and J. N. Ayers, "Characterization of Squib, Mk 1 Mod 0; Thermal Stacking from Radar-Like Pulses," Naval Ordnance Laboratory report NOLTR 61-108, September 15, 1961.

APPENDIX I

RADIO-FREQUENCY IMPEDANCE DATA

Model 1

N Mk-101 (2 oz) #12 3/4-in. Leads Pin/Pin w/Sleeve

Impedance (ohms) -- 50.0-ohm System

FREQ	MAGN	ANGLE	REAL	IMAG	FREQ	MAGN	ANGLE	REAL	IMAG
100.000	28.13	89.0	.49	28.12	3500.000	27.89	88.4	.79	27.88
150.000	44.39	89.2	.63	44.38	3550.000	31.79	89.0	.57	31.79
200.000	63.49	88.8	1.38	63.48	3600.000	35.11	87.0	1.81	35.06
250.000	87.52	88.6	2.08	87.50	3650.000	37.64	86.0	2.62	37.55
300.000	122.86	89.4	1.37	122.85	3700.000	41.06	86.1	2.79	40.97
350.000	178.52	89.6	1.20	178.52	3750.000	45.27	85.4	3.66	45.12
400.000	311.47	86.7	18.19	310.94	3800.000	49.84	84.0	5.23	49.56
450.000	686.57	71.2	221.09	650.00	3850.000	54.18	81.7	7.82	53.61
500.000	870.82	-15.1	840.62	-227.34	3900.000	57.95	79.2	10.82	56.93
550.000	670.19	-46.0	465.62	-482.03	3950.000	62.24	77.0	14.01	60.64
600.000	383.83	-70.3	129.49	-361.33	4000.000	66.99	74.5	17.92	64.55
650.000	279.77	-79.4	51.46	-275.00	4050.000	70.48	71.4	22.49	66.80
700.000	205.04	-83.0	24.95	-203.52	4100.000	73.77	68.7	26.76	68.75
750.000	161.41	-84.1	16.70	-160.55	4150.000	75.98	68.1	28.32	70.51
800.000	131.75	-86.1	8.94	-131.45	4200.000	85.21	69.3	30.18	79.69
850.000	111.72	-86.6	6.69	-111.52	4250.000	105.63	66.8	41.65	97.07
900.000	96.19	-86.3	6.16	-96.00	4300.000	144.24	53.3	86.23	115.62
950.000	85.29	-85.8	6.31	-85.06	4350.000	159.54	12.3	155.86	34.08
1000.000	75.82	-85.5	5.89	-75.59	4400.000	74.31	-19.1	70.21	-24.34
1050.000	67.84	-86.0	4.72	-67.68	4450.000	30.67	-1.3	30.66	-.68
1100.000	60.79	-86.1	4.14	-60.64	4500.000	26.57	45.0	18.77	18.80
1150.000	52.16	-86.4	3.31	-52.05	4550.000	35.65	66.2	14.38	32.62
1200.000	45.23	-83.8	4.87	-44.97	4600.000	45.31	74.2	12.33	43.60
1250.000	39.56	-78.6	7.85	-38.77	4650.000	54.62	78.0	11.39	53.42
1300.000	34.11	-73.0	9.99	-32.62	4700.000	64.00	79.3	11.85	62.89
1350.000	33.20	-58.9	17.16	-28.42	4750.000	73.28	79.2	13.77	71.97
1400.000	40.86	-51.4	25.49	-31.93	4800.000	80.84	78.8	15.72	79.30
1450.000	44.04	-59.5	22.36	-37.94	4850.000	88.50	79.5	16.16	87.01
1500.000	46.09	-66.6	18.33	-42.29	4900.000	100.36	79.7	17.99	98.73
1550.000	42.50	-74.1	11.65	-40.87	4950.000	111.96	78.6	22.05	109.77
1600.000	36.72	-78.6	7.29	-35.99	5000.000	125.08	77.4	27.29	122.07
1650.000	31.55	-79.4	5.81	-31.01	5050.000	136.62	75.8	33.59	132.42
1700.000	27.68	-79.8	4.91	-27.25	5100.000	148.08	75.8	36.33	143.55
1750.000	24.06	-78.9	4.63	-23.61	5150.000	171.30	76.8	39.01	166.80
1800.000	21.02	-77.6	4.51	-20.53	5200.000	205.52	75.8	50.49	199.22
1850.000	18.21	-76.7	4.18	-17.72	5250.000	238.26	72.0	73.73	226.56
1900.000	14.98	-76.3	3.54	-14.55	5300.000	281.37	69.8	97.17	264.06
1950.000	11.30	-72.7	3.35	-10.79	5350.000	357.62	67.7	135.74	330.86
1999.999	7.81	-63.2	3.53	-6.97	5400.000	508.75	58.6	264.84	434.37
2000.000	7.30	-63.4	3.27	-6.53	5450.000	741.80	40.7	562.50	483.59
2050.000	4.10	-27.9	3.63	-1.92	5500.000	912.12	5.6	907.81	88.57
2100.000	5.48	39.2	4.25	3.46	5550.000	807.05	-27.7	714.84	-374.61
2150.000	12.01	62.8	5.50	10.68	5600.000	575.55	-53.1	345.70	-460.16
2200.000	24.45	70.2	8.29	23.00	5650.000	394.43	-65.0	166.80	-357.42
2250.000	54.70	66.6	21.73	50.20	5700.000	295.16	-69.6	103.12	-276.56
2300.000	163.06	22.0	151.17	61.13	5750.000	237.14	-72.8	70.02	-226.56
2350.000	97.63	-57.9	51.86	-82.71	5800.000	193.44	-74.6	51.27	-186.52
2400.000	51.23	-72.6	15.36	-48.88	5850.000	163.51	-75.6	40.58	-158.40
2450.000	34.15	-75.4	8.58	-33.06	5900.000	140.99	-76.2	33.64	-136.91
2500.000	25.26	-75.6	6.30	-24.46	5950.000	122.94	-76.9	27.93	-119.73
2550.000	19.70	-74.3	5.33	-18.97	6000.000	107.72	-77.3	23.73	-105.08
2600.000	15.73	-73.5	4.46	-15.09	6050.000	93.40	-77.8	19.68	-91.31
2650.000	12.05	-73.6	3.39	-11.56	6100.000	81.26	-76.5	19.02	-79.00
2700.000	8.83	-70.2	2.99	-8.31	6150.000	72.61	-75.5	18.14	-70.31
2750.000	6.33	-63.4	2.84	-5.66	6200.000	63.95	-74.5	17.11	-61.62
2800.000	4.08	-53.7	2.41	-3.28	6250.000	55.98	-72.6	16.75	-53.42
2850.000	2.12	-24.0	1.94	-.86	6300.000	49.09	-70.5	16.36	-46.29
2900.000	2.36	41.3	1.78	1.56	6350.000	42.28	-67.7	16.06	-39.11
2950.000	4.11	66.3	1.65	3.76	6400.000	36.13	-63.3	16.24	-32.28
3000.000	6.08	76.1	1.46	5.90	6450.000	29.22	-59.0	15.04	-25.05
3050.000	8.18	81.1	1.26	8.08	6500.000	19.87	-44.6	14.16	-13.94
3100.000	10.54	83.2	1.25	10.46	6550.000	18.95	1.3	18.95	.44
3150.000	12.58	83.2	1.50	12.49	6600.000	33.11	22.8	30.52	12.84
3200.000	14.58	84.1	1.50	14.50	6650.000	53.06	24.1	48.44	21.66
3250.000	16.78	85.2	1.39	16.72	6700.000	76.36	15.1	73.73	19.85
3300.000	18.96	85.4	1.51	18.90	6750.000	91.80	.2	91.80	.25
3350.000	21.10	85.7	1.57	21.04	6800.000	92.25	-12.3	90.14	-19.65
3400.000	23.22	86.1	1.58	23.17	6850.000	90.18	-17.7	85.94	-27.34
3450.000	25.34	86.7	1.47	25.29	6900.000	93.91	-20.8	87.79	-33.35
					6950.000	102.57	-27.9	90.62	-48.05

FREQ	MAGN	ANGLE	REAL	IMAG
7000.000	106.66	-38.0	84.08	-65.62
7050.000	00.19	-49.7	64.75	-76.46
7100.000	89.45	-58.5	46.73	-76.27
7150.000	77.63	-63.8	34.33	-69.63
7200.000	67.11	-66.9	27.10	-63.57
7250.000	62.73	-70.4	21.09	-59.08
7300.000	56.02	-73.8	15.60	-53.81
7350.000	48.25	-76.8	11.02	-46.97
7400.000	41.25	-77.0	9.31	-40.19
7450.000	35.68	-75.1	9.19	-34.47
7500.000	32.09	-72.9	9.45	-30.66
7550.000	29.69	-70.5	9.92	-27.98
7600.000	27.22	-70.0	9.30	-25.59
7650.000	24.45	-69.8	8.45	-22.95
7700.000	21.94	-68.1	8.18	-20.36
7750.000	19.68	-67.0	7.70	-18.12
7800.000	17.40	-67.2	6.74	-16.04
7850.000	14.44	-66.4	5.79	-13.23
7900.000	11.42	-63.3	5.13	-10.21
7950.000	8.72	-54.8	5.03	-7.13
7999.998	6.76	-40.9	5.11	-4.43

Model 1

N Mk-101 (2 oz) #12 3/4-in. Leads Pin/Case (Sleeve)

Impedance (ohms) — 50.0-ohm System

FREQ	MAGN	ANGLE	REAL	IMAG	FREQ	MAGN	ANGLE	REAL	IMAG
100.000	318.09	-91.6	-8.89	-317.97	2700.000	16.04	56.2	8.92	13.33
150.000	205.08	-90.3	.02	-205.08	2750.000	21.14	55.2	12.07	17.36
200.000	151.43	-88.4	4.22	-151.37	2800.000	28.31	49.4	18.43	21.48
250.000	116.23	-88.9	2.29	-116.21	2850.000	38.51	36.9	30.81	23.10
300.000	87.99	-89.6	.59	-87.99	2900.000	44.61	8.3	44.14	6.45
350.000	66.82	-88.4	1.86	-66.80	2950.000	34.54	-20.8	32.28	-12.29
400.000	48.02	-88.2	1.51	-48.00	3000.000	21.40	-36.1	17.29	-12.62
450.000	29.98	-86.7	1.71	-29.93	3050.000	12.05	-36.5	9.69	-7.17
500.000	11.87	-75.3	3.01	-11.49	3100.000	6.23	-17.1	5.96	-1.84
550.000	10.62	68.0	3.97	9.85	3150.000	5.18	29.2	4.52	2.53
600.000	39.89	78.0	8.30	39.01	3200.000	6.65	58.7	3.46	5.68
650.000	84.73	81.0	13.26	83.69	3250.000	9.11	73.1	2.65	8.72
700.000	191.50	79.5	34.96	188.28	3300.000	11.64	80.6	1.90	11.49
750.000	749.84	43.7	542.19	517.97	3350.000	14.32	85.6	1.09	14.28
800.000	442.10	-67.3	170.70	-407.81	3400.000	17.14	88.5	.45	17.14
850.000	220.40	-81.5	32.67	-217.97	3450.000	19.87	90.3	-.10	19.87
900.000	145.28	-82.8	18.19	-144.14	3500.000	22.97	92.5	-1.01	22.95
950.000	113.46	-82.5	14.75	-112.50	3550.000	27.04	93.2	-1.52	27.00
1000.000	91.27	-81.8	13.09	-90.33	3600.000	30.63	91.7	-.89	30.62
1050.000	75.20	-81.7	10.86	-74.41	3650.000	33.46	91.5	-.88	33.45
1100.000	65.21	-76.8	14.92	-63.48	3700.000	37.13	91.9	-1.25	37.11
1150.000	50.96	-70.7	16.85	-48.10	3750.000	41.57	91.9	-1.35	41.55
1200.000	51.95	-47.8	34.91	-38.48	3800.000	46.40	91.5	-1.21	46.39
1250.000	84.09	-59.5	42.68	-72.46	3850.000	51.67	90.9	-.83	51.66
1300.000	76.96	-77.0	17.26	-75.00	3900.000	57.52	90.6	-.65	57.52
1350.000	62.22	-83.5	7.06	-61.82	3950.000	66.32	90.9	-1.01	66.31
1400.000	52.32	-85.3	4.28	-52.15	4000.000	80.96	90.5	-.64	80.96
1450.000	45.31	-85.4	3.65	-45.17	4050.000	105.57	85.7	7.92	105.27
1500.000	39.61	-84.9	3.51	-39.45	4100.000	153.97	72.3	46.53	146.68
1550.000	34.69	-84.3	3.45	-34.52	4150.000	186.74	23.3	171.48	73.93
1600.000	29.29	-81.9	4.11	-29.00	4200.000	80.89	-3.2	80.76	-4.47
1650.000	25.19	-74.0	6.93	-24.22	4250.000	47.49	13.5	46.19	11.05
1700.000	24.75	-61.3	11.89	-21.70	4300.000	40.87	31.8	34.72	21.56
1750.000	27.74	-58.4	14.53	-23.63	4350.000	41.15	47.1	28.03	30.13
1800.000	28.90	-61.5	13.79	-25.39	4400.000	45.37	57.1	24.66	38.09
1850.000	28.27	-66.0	11.50	-25.83	4450.000	52.32	62.0	24.56	46.19
1900.000	25.47	-70.5	8.52	-24.00	4500.000	59.48	63.1	26.95	53.03
1950.000	22.15	-71.2	7.14	-20.97	4550.000	63.81	61.3	30.66	55.96
1999.999	19.82	-69.2	7.03	-18.53	4600.000	65.68	60.3	32.57	57.03
2000.000	17.96	-70.4	6.02	-16.92	4650.000	67.86	60.0	33.89	58.79
2050.000	15.47	-67.1	6.01	-14.26	4700.000	67.79	59.8	34.08	58.59
2100.000	13.11	-59.4	6.68	-11.28	4750.000	68.07	60.4	33.64	59.18
2150.000	12.69	-47.3	8.61	-9.33	4800.000	66.63	64.3	28.86	60.06
2200.000	13.93	-40.9	10.53	-9.12	4850.000	68.87	70.6	22.92	64.94
2250.000	15.11	-47.3	10.24	-11.11	4900.000	75.76	77.0	16.99	73.83
2300.000	12.70	-54.3	7.41	-10.31	4950.000	86.53	80.9	13.62	85.45
2350.000	9.49	-54.6	5.49	-7.74	5000.000	99.73	83.2	11.89	99.02
2400.000	6.36	-46.2	4.40	-4.59	5050.000	112.80	83.7	12.44	112.11
2450.000	4.85	-18.6	4.60	-1.54	5100.000	127.04	85.0	11.04	126.56
2500.000	5.09	12.3	4.97	1.08	5150.000	149.22	87.1	7.58	149.02
2550.000	6.52	36.2	5.26	3.86	5200.000	179.41	88.0	6.23	179.30
2600.000	8.95	48.6	5.92	6.71	5250.000	212.03	86.7	12.37	211.72
2650.000	12.24	55.3	6.97	10.06	5300.000	256.88	87.5	11.19	256.64
					5350.000	337.13	89.4	3.43	337.11

FREQ	MAGN.	ANGLE	REAL	IMAG	FREQ	MAGN	ANGLE	REAL	IMAG
5400.000	513.33	89.2	7.34	513.28	6700.000	29.80	5.9	29.64	3.09
5450.000	948.22	85.5	74.22	945.31	6750.000	38.92	16.6	37.30	11.11
5500.000	3394.60	46.0	2359.37	2440.62	6800.000	53.38	20.2	50.10	18.43
5550.000	1564.06	-65.0	661.72	-1417.19	6850.000	75.08	18.1	71.39	23.27
5600.000	708.96	-80.1	121.68	-698.44	6900.000	104.27	6.9	103.52	12.52
5650.000	436.00	-82.3	58.69	-432.03	6950.000	125.99	-13.2	122.66	-28.81
5700.000	313.99	-82.0	43.70	-310.94	7000.000	123.52	-34.5	101.76	-70.02
5750.000	247.54	-83.0	30.13	-245.70	7050.000	106.24	-48.3	70.70	-79.30
5800.000	200.54	-83.4	23.02	-199.22	7100.000	91.10	-55.5	51.56	-75.10
5850.000	167.77	-83.2	19.80	-166.60	7150.000	78.78	-60.5	38.82	-68.55
5900.000	143.61	-83.1	17.16	-142.58	7200.000	70.01	-64.1	30.57	-62.99
5950.000	123.63	-82.8	15.48	-122.66	7250.000	63.31	-67.7	23.97	-58.59
6000.000	107.92	-82.6	13.84	-107.03	7300.000	56.07	-72.0	17.36	-53.32
6050.000	93.20	-82.4	12.30	-92.38	7350.000	47.82	-74.4	12.89	-46.04
6100.000	81.60	-80.0	14.11	-80.37	7400.000	41.10	-74.5	11.00	-39.60
6150.000	73.36	-78.4	14.70	-71.87	7450.000	35.42	-72.0	10.93	-33.69
6200.000	65.45	-77.0	14.75	-63.77	7500.000	32.35	-68.9	11.67	-30.18
6250.000	58.22	-75.1	15.01	-56.25	7550.000	30.51	-66.5	12.17	-27.98
6300.000	52.12	-72.5	15.67	-49.71	7600.000	28.92	-66.9	11.33	-26.61
6350.000	46.78	-69.6	16.31	-43.85	7650.000	26.19	-68.8	9.48	-24.41
6400.000	42.42	-65.9	17.33	-38.72	7700.000	23.20	-69.0	8.33	-21.66
6450.000	38.21	-63.8	16.89	-34.28	7750.000	20.24	-69.4	7.12	-18.95
6500.000	31.75	-61.8	15.01	-27.98	7800.000	17.39	-69.7	6.02	-16.31
6550.000	24.41	-50.6	15.48	-18.87	7850.000	13.90	-69.2	4.94	-12.99
6600.000	21.88	-29.5	19.04	-10.78	7900.000	10.58	-65.1	4.45	-9.59
6650.000	23.91	-8.7	23.63	-3.62	7950.000	7.73	-54.7	4.47	-6.31
					7999.998	5.82	-37.0	4.65	-3.50

Model 2

N Mk-101 (0.5 oz) #3 3/4-in. Leads Pin/Pin w/Sleeve

Impedance (ohms) — 50.0-ohm System

FREQ	MAGN	ANGLE	REAL	IMAG	FREQ	MAGN	ANGLE	REAL	IMAG
100.000	29.20	89.0	.49	29.20	2300.000	56.58	-70.5	18.92	-53.32
150.000	46.15	89.2	.61	46.14	2350.000	38.80	-76.0	9.37	-37.65
200.000	66.23	88.7	1.48	66.21	2400.000	28.69	-78.2	5.89	-28.08
250.000	92.03	88.5	2.48	91.99	2450.000	22.20	-77.5	4.80	-21.68
300.000	130.87	89.3	1.52	130.86	2500.000	17.68	-76.4	4.16	-17.19
350.000	193.76	89.3	2.26	193.75	2550.000	14.19	-74.1	3.90	-13.65
400.000	354.34	85.2	29.35	353.12	2600.000	11.60	-72.4	3.52	-11.06
450.000	896.89	63.8	396.09	804.69	2650.000	8.83	-70.9	2.89	-8.35
500.000	723.05	-26.5	646.87	-323.05	2700.000	6.28	-65.5	2.60	-5.71
550.000	565.81	-52.0	348.05	-446.09	2750.000	4.29	-53.4	2.56	-3.44
600.000	346.38	-71.9	107.42	-329.30	2800.000	2.62	-30.4	2.26	-1.33
650.000	256.52	-79.6	46.09	-252.34	2850.000	2.07	24.4	1.89	.86
700.000	195.30	-83.2	22.97	-193.95	2900.000	3.50	61.0	1.69	3.06
750.000	153.70	-84.2	15.41	-152.93	2950.000	5.37	72.3	1.63	5.12
800.000	126.47	-86.1	8.68	-126.17	3000.000	7.31	78.7	1.43	7.17
850.000	108.01	-86.6	6.47	-107.81	3050.000	9.37	82.6	1.21	9.29
900.000	93.15	-86.4	5.88	-92.97	3100.000	11.67	84.3	1.15	11.61
950.000	82.73	-85.9	5.94	-82.52	3150.000	13.70	84.1	1.42	13.62
1000.000	73.67	-85.4	5.89	-73.44	3200.000	15.72	84.7	1.45	15.65
1050.000	65.98	-86.0	4.57	-65.82	3250.000	17.97	85.8	1.33	17.92
1100.000	59.12	-86.1	4.06	-58.98	3300.000	20.19	85.9	1.44	20.14
1150.000	50.70	-86.2	3.37	-50.59	3350.000	22.33	86.5	1.38	22.29
1200.000	43.98	-83.5	4.96	-43.70	3400.000	24.58	86.7	1.42	24.54
1250.000	38.46	-78.2	7.87	-37.65	3450.000	26.89	87.1	1.37	26.86
1300.000	33.49	-72.2	10.25	-31.88	3500.000	29.75	88.6	.72	29.74
1350.000	32.87	-59.2	16.85	-28.22	3550.000	33.75	89.0	.61	33.74
1400.000	40.11	-53.1	24.07	-32.08	3600.000	37.55	87.0	1.99	37.50
1450.000	42.11	-60.8	20.53	-36.77	3650.000	40.45	85.7	3.02	40.33
1500.000	43.27	-66.4	17.33	-39.65	3700.000	44.39	85.3	3.62	44.24
1550.000	40.08	-73.3	11.55	-38.38	3750.000	48.82	84.3	4.83	48.58
1600.000	34.58	-77.7	7.36	-33.79	3800.000	54.01	83.1	6.49	53.61
1650.000	29.70	-78.5	5.92	-29.10	3850.000	59.41	81.1	9.19	58.69
1700.000	25.82	-79.0	4.94	-25.34	3900.000	64.87	79.0	12.43	63.67
1750.000	22.05	-77.6	4.74	-21.53	3950.000	72.92	76.8	16.63	71.00
1800.000	18.75	-75.9	4.57	-18.19	4000.000	84.34	73.7	23.66	80.96
1850.000	15.52	-74.3	4.20	-14.94	4350.000	101.79	68.5	37.26	94.73
1900.000	11.58	-71.6	3.65	-10.99	4100.000	135.01	55.4	76.66	111.13
1950.000	7.18	-59.3	3.67	-6.18	4150.000	166.66	15.1	160.94	43.31
1999.999	4.07	-8.6	4.03	-.61	4200.000	77.89	-26.6	69.63	-34.91
2000.000	4.02	-11.7	3.94	-.81	4250.000	29.66	-15.3	28.61	-7.82
2050.000	8.82	53.2	4.93	6.58	4300.000	20.03	31.3	17.11	10.41
2100.000	19.77	68.6	7.20	18.41	4350.000	25.82	60.2	12.82	22.41
2150.000	47.76	68.2	17.75	44.34	4400.000	33.24	72.4	10.03	31.69
2200.000	156.10	88.1	137.70	73.54	4450.000	41.35	78.2	8.42	40.48
2250.000	103.52	-55.1	59.28	-84.86	4500.000	49.17	80.1	8.47	48.44
					4550.000	55.70	80.2	9.52	54.88

FREQ	MAGN	ANGLE	REAL	IMAG
4600.000	61.55	80.7	9.91	60.74
4650.000	68.39	81.7	9.89	67.68
4700.000	76.51	82.1	10.56	75.78
4750.000	85.12	81.0	13.26	84.08
4800.000	91.84	80.3	15.45	90.53
4850.000	99.94	80.4	16.72	98.54
4900.000	112.40	80.1	19.24	110.74
4950.000	124.62	78.4	25.10	122.07
5000.000	136.97	76.9	31.05	133.40
5050.000	148.38	75.3	37.55	143.55
5100.000	160.99	75.5	40.33	155.86
5150.000	187.55	76.6	43.55	182.42
5200.000	226.89	75.4	57.32	219.53
5250.000	267.48	70.9	87.60	252.73
5300.000	318.88	68.4	117.38	296.48
5350.000	420.31	65.1	176.95	381.25
5400.000	659.14	53.0	396.48	526.56
5450.000	959.56	20.3	900.00	332.81
5500.000	825.48	-21.7	767.19	-304.69
5550.000	588.02	-43.4	427.34	-403.91
5600.000	449.31	-55.8	252.73	-371.48
5650.000	342.68	-64.8	145.70	-310.16
5700.000	266.55	-70.2	90.33	-250.78
5750.000	215.59	-73.8	60.16	-207.03
5800.000	176.45	-75.6	43.90	-170.90
5850.000	149.55	-76.0	36.13	-145.12
5900.000	128.73	-76.5	29.98	-125.20
5950.000	112.12	-76.9	25.49	-109.18
6000.000	98.37	-77.1	21.90	-95.90
6050.000	85.09	-77.6	18.29	-83.11
6100.000	73.51	-76.2	17.53	-71.39
6150.000	64.84	-74.9	16.89	-62.60
6200.000	56.26	-73.4	16.11	-53.91
6250.000	48.11	-71.2	15.48	-45.56
6300.000	40.13	-67.5	15.38	-37.06
6350.000	32.51	-60.9	15.80	-28.42
6400.000	26.00	-48.5	17.21	-19.48
6450.000	21.23	-25.6	19.14	-9.18
6500.000	25.90	10.8	25.44	4.86
6550.000	45.71	21.5	42.53	16.75
6600.000	66.73	13.7	64.84	15.77
6650.000	81.86	1.3	81.84	1.83
6700.000	87.14	-11.3	85.45	-17.09
6750.000	82.77	-19.7	77.93	-27.88
6800.000	76.78	-22.0	71.19	-28.76
6850.000	76.58	-20.0	71.97	-26.17
6900.000	85.27	-18.1	81.05	-26.46
6950.000	99.66	-24.5	90.72	-41.26
7000.000	109.12	-37.3	86.82	-66.11
7050.000	108.79	-51.2	64.45	-80.08
7100.000	90.89	-59.6	45.95	-78.42
7150.000	78.32	-65.5	32.42	-71.29
7200.000	68.90	-68.9	24.85	-64.26
7250.000	61.83	-72.6	18.53	-58.98
7300.000	54.45	-75.6	13.55	-52.73
7350.000	46.59	-78.2	9.55	-45.61
7400.000	39.78	-77.7	8.47	-38.87
7450.000	34.20	-75.5	8.57	-33.11
7500.000	30.44	-72.3	9.24	-29.00
7550.000	28.34	-69.0	10.14	-26.46
7600.000	26.18	-67.4	10.06	-24.17
7650.000	23.94	-66.9	9.39	-22.02
7700.000	21.54	-65.4	8.98	-19.58
7750.000	19.44	-64.2	8.45	-17.50
7800.000	17.07	-64.6	7.31	-15.43
7850.000	14.02	-63.7	6.21	-12.57
7900.000	10.82	-58.4	5.60	-9.25
7950.000	8.13	-47.3	5.49	-6.00
7999.998	6.40	-29.0	5.60	-3.11

Model 2

N Mk-101 (0.5 oz) #3 3/4-in. Leads Pin/Case (Sleeve)

Impedance (ohms) -- 50.0-ohm System

FREQ	MAGN	ANGLE	REAL	IMAG
100.000	315.32	-91.4	-7.48	-315.23
150.000	203.52	-90.1	-.22	-203.52
200.000	151.24	-88.3	4.39	-151.17
250.000	116.43	-88.9	2.33	-116.41
300.000	88.97	-89.7	.54	-88.96
350.000	68.48	-88.4	1.89	-68.46
400.000	50.61	-88.1	1.68	-50.59
450.000	34.37	-87.0	1.79	-34.33
500.000	18.06	-83.4	2.06	-17.94
550.000	2.47	5.9	2.46	.25
600.000	23.72	79.1	4.47	23.29
650.000	55.80	82.9	6.87	55.37
700.000	114.42	82.6	14.67	113.48
750.000	280.91	72.5	84.28	267.97
800.000	1095.00	-6.7	1087.50	-127.93
850.000	340.41	-77.0	76.76	-331.64
900.000	183.60	-81.2	28.08	-181.45
950.000	134.49	-82.1	18.58	-133.20
1000.000	102.42	-81.8	14.67	-101.37
1050.000	82.22	-81.6	11.96	-81.35
1100.000	69.85	-76.3	16.50	-67.87
1150.000	56.06	-66.9	22.00	-51.56
1200.000	69.45	-51.2	43.55	-54.10
1250.000	82.09	-72.3	24.90	-78.22
1300.000	68.60	-82.2	9.29	-67.97
1350.000	56.84	-85.2	4.73	-56.64
1400.000	48.13	-85.8	3.52	-48.00
1450.000	41.40	-85.3	3.42	-41.26
1500.000	35.48	-83.5	3.99	-35.25
1550.000	30.10	-81.1	4.66	-29.74
1600.000	24.66	-72.6	7.36	-23.54
1650.000	23.99	-57.1	13.04	-20.14
1700.000	29.18	-47.0	19.90	-21.34
1750.000	33.09	-52.4	20.19	-26.22
1800.000	33.39	-58.8	17.29	-28.56
1850.000	31.60	-65.1	13.31	-28.66
1900.000	27.58	-69.5	9.67	-25.83
1950.000	23.78	-69.8	8.23	-22.31
1999.999	21.29	-67.7	8.07	-19.70
2000.000	17.79	-69.4	6.27	-16.65
2050.000	14.97	-66.2	6.05	-13.78
2100.000	12.63	-56.5	6.97	-10.53
2150.000	12.65	-41.8	9.42	-8.44
2200.000	14.57	-36.8	11.67	-8.72
2250.000	15.69	-45.2	11.06	-11.13
2300.000	12.65	-51.8	7.82	-9.94
2350.000	9.21	-48.5	6.10	-6.90
2400.000	6.27	-32.3	5.30	-3.35
2450.000	5.90	2.0	5.90	.21
2500.000	7.58	23.6	6.95	3.04
2550.000	10.46	36.7	8.39	6.24
2600.000	14.22	42.7	10.45	9.64
2650.000	20.03	42.2	14.84	13.45
2700.000	27.50	36.2	22.19	16.24
2750.000	37.21	16.4	35.69	10.52
2800.000	38.64	-15.4	37.26	-10.25
2850.000	27.04	-42.7	19.87	-18.33
2900.000	15.91	-53.4	9.50	-12.77
2950.000	8.61	-53.0	5.19	-6.87
3000.000	3.85	-35.7	3.12	-2.25
3050.000	2.51	38.8	1.96	1.57
3100.000	5.21	76.9	1.19	5.08
3150.000	8.13	83.8	.88	8.08
3200.000	10.88	87.4	.50	10.86
3250.000	13.72	89.6	.10	13.72
3300.000	16.58	90.3	-.10	16.58
3350.000	19.24	90.6	-.21	19.24
3400.000	21.90	91.2	-.47	21.90
3450.000	24.64	91.7	-.71	24.63
3500.000	27.78	93.2	-1.55	27.73
3550.000	32.20	93.7	-2.07	32.13
3600.000	36.40	92.0	-1.28	36.38
3650.000	39.80	91.2	-.85	39.79

FREQ	MAGN	ANGLE	REAL	IMAG	FREQ	MAGN	ANGLE	REAL	IMAG
3700.000	44.44	91.2	-.94	44.43	5900.000	134.45	-82.8	16.75	-133.40
3750.000	50.20	91.0	-.87	50.20	5950.000	116.14	-82.1	15.94	-115.04
3800.000	57.23	89.9	.12	57.23	6000.000	101.61	-81.9	14.38	-100.59
3850.000	65.65	88.6	1.65	65.62	6050.000	87.77	-81.6	12.89	-86.82
3900.000	75.99	86.9	4.16	75.88	6100.000	76.27	-79.1	14.40	-74.90
3950.000	93.77	84.6	8.78	93.36	6150.000	68.11	-77.1	15.16	-66.41
4000.000	128.06	78.3	26.03	125.39	6200.000	60.37	-75.3	15.28	-58.40
4050.000	197.46	58.7	102.54	168.75	6250.000	53.12	-72.9	15.60	-50.78
4100.000	226.18	.4	226.17	1.70	6300.000	46.74	-69.9	16.04	-43.90
4150.000	93.97	-36.5	75.49	-55.96	6350.000	40.58	-66.3	16.31	-37.16
4200.000	37.28	-29.9	32.32	-18.58	6400.000	35.65	-60.6	17.50	-31.05
4250.000	21.94	8.4	21.70	3.19	6450.000	30.96	-55.2	17.65	-25.44
4300.000	24.35	41.6	18.21	16.16	6500.000	24.49	-47.5	16.53	-18.07
4350.000	30.96	54.8	17.85	25.29	6550.000	20.36	-24.0	18.60	-8.26
4400.000	36.78	60.4	18.16	31.98	6600.000	23.26	2.4	23.24	.97
4450.000	41.80	61.9	19.70	36.87	6650.000	31.07	18.9	29.39	10.07
4500.000	44.50	61.6	21.14	39.16	6700.000	42.94	28.2	37.84	20.29
4550.000	44.13	63.0	20.07	39.31	6750.000	61.01	32.3	51.56	32.62
4600.000	44.22	68.4	16.26	41.11	6800.000	88.58	30.1	76.66	44.38
4650.000	47.16	75.7	11.63	45.70	6850.000	132.08	19.4	124.61	43.80
4700.000	53.11	81.6	7.79	52.54	6900.000	176.43	-3.1	176.17	-9.53
4750.000	60.33	84.6	5.71	60.06	6950.000	181.52	-31.3	155.08	-94.34
4800.000	67.20	86.7	3.82	67.09	7000.000	149.43	-52.4	91.21	-118.36
4850.000	75.30	89.1	1.19	75.29	7050.000	118.93	-62.9	54.20	-105.86
4900.000	86.83	91.0	-1.51	86.82	7100.000	98.09	-68.7	35.60	-91.41
4950.000	100.60	91.0	-1.76	100.59	7150.000	82.20	-72.5	24.66	-78.42
5000.000	114.85	90.7	-1.49	114.84	7200.000	71.33	-75.1	18.29	-68.95
5050.000	129.50	89.3	1.53	129.49	7250.000	63.26	-78.2	12.99	-61.91
5100.000	143.17	89.4	1.58	143.16	7300.000	55.13	-81.3	8.35	-54.49
5150.000	167.01	90.8	-2.29	166.99	7350.000	46.55	-83.4	5.39	-46.24
5200.000	199.83	90.9	-3.16	199.80	7400.000	39.15	-82.6	5.06	-38.82
5250.000	237.14	89.1	3.66	237.11	7450.000	33.39	-79.8	5.93	-32.86
5300.000	284.78	89.3	3.28	284.77	7500.000	29.54	-75.6	7.35	-28.61
5350.000	371.21	91.4	-9.13	371.09	7550.000	27.57	-72.0	8.53	-26.22
5400.000	579.39	92.3	-23.75	578.91	7600.000	25.49	-70.5	8.52	-24.02
5450.000	1174.01	91.8	-36.57	1173.44	7650.000	23.13	-70.3	7.80	-21.78
5500.000	9817.07	15.7	9450.00	2659.37	7700.000	20.41	-69.1	7.29	-19.07
5550.000	1274.41	-79.1	240.23	-1251.56	7750.000	17.95	-67.4	6.88	-16.58
5600.000	624.25	-84.2	62.70	-621.09	7800.000	15.55	-66.5	6.20	-14.26
5650.000	397.13	-84.5	37.99	-395.31	7850.000	12.67	-64.0	5.55	-11.39
5700.000	290.83	-83.7	31.98	-289.06	7900.000	9.61	-57.8	5.13	-8.13
5750.000	230.59	-83.9	24.41	-229.30	7950.000	7.22	-43.6	5.23	-4.97
5800.000	186.87	-83.7	20.53	-185.74	7999.998	5.80	-21.7	5.39	-2.15
5850.000	157.56	-83.2	18.68	-156.45					

Model 3

N 0.003 Pyrofuze w/Mk-101 Header #6 3/4-in. Leads Pin/Pin w/Sleeve

Impedance (ohms) -- 50.0-ohm System

FREQ	MAGN	ANGLE	REAL	IMAG	FREQ	MAGN	ANGLE	REAL	IMAG
100.000	26.37	89.0	.46	26.37	1600.000	38.67	-78.5	7.71	-37.89
150.000	41.41	89.2	.61	41.41	1650.000	33.80	-79.2	6.31	-33.20
200.000	58.70	88.8	1.18	58.69	1700.000	30.25	-80.0	5.26	-29.79
250.000	80.39	88.7	1.87	80.37	1750.000	26.79	-79.2	5.00	-26.32
300.000	110.75	89.5	.98	110.74	1800.000	24.13	-78.6	4.75	-23.66
350.000	156.84	90.0	-.01	156.84	1850.000	21.80	-78.5	4.36	-21.36
400.000	256.85	87.7	10.46	256.64	1900.000	18.96	-78.9	3.64	-18.60
450.000	484.67	77.2	107.23	472.66	1950.000	16.02	-77.6	3.43	-15.65
500.000	921.71	13.3	896.87	212.50	1999.999	13.38	-74.8	3.52	-12.92
550.000	864.38	-26.5	773.44	-385.94	2000.000	12.66	-69.9	4.35	-11.89
600.000	472.42	-66.8	185.74	-434.37	2050.000	10.51	-64.3	4.55	-9.47
650.000	320.32	-78.0	66.80	-313.28	2100.000	8.54	-56.3	4.73	-7.10
700.000	229.29	-82.5	29.79	-227.34	2150.000	7.25	-46.0	5.04	-5.22
750.000	174.23	-83.9	18.51	-173.24	2200.000	5.32	-30.8	4.57	-2.73
800.000	139.80	-86.0	9.84	-139.45	2250.000	3.98	2.9	3.98	.20
850.000	117.79	-86.6	7.04	-117.58	2300.000	5.50	50.9	3.47	4.27
900.000	100.98	-86.4	6.29	-100.78	2350.000	10.12	70.1	3.44	9.52
950.000	88.93	-85.6	6.76	-88.67	2400.000	17.19	76.3	4.07	16.70
1000.000	78.77	-85.4	6.34	-78.52	2450.000	28.12	76.9	6.36	27.39
1050.000	70.40	-85.9	5.04	-70.21	2500.000	50.21	72.2	15.36	47.80
1100.000	62.73	-86.3	4.10	-62.60	2550.000	115.38	50.2	73.83	88.67
1150.000	53.63	-86.2	3.61	-53.71	2600.000	132.47	-35.7	107.62	-77.25
1200.000	46.45	-83.4	5.32	-46.14	2650.000	59.16	-62.8	27.00	-52.64
1250.000	40.75	-78.2	8.34	-39.89	2700.000	35.24	-68.4	12.96	-32.76
1300.000	35.45	-71.6	11.18	-33.64	2750.000	23.89	-69.6	8.34	-22.39
1350.000	35.49	-58.2	18.68	-30.18	2800.000	16.70	-69.8	5.76	-15.67
1400.000	43.74	-53.2	26.22	-35.01	2850.000	11.22	-67.8	4.24	-10.39
1450.000	45.84	-60.9	22.31	-40.04	2900.000	7.01	-60.1	3.49	-6.08
1500.000	47.35	-66.6	18.80	-43.46	2950.000	3.97	-39.9	3.05	-2.54
1550.000	44.38	-74.1	12.17	-42.68					

FREQ	MAGN	ANGLE	REAL	IMAG	FREQ	MAGN	ANGLE	REAL	IMAG
3000.000	2.83	10.3	2.78	.50	5500.000	273.70	60.4	135.35	237.89
3050.000	4.09	51.7	2.53	3.21	5550.000	335.47	53.2	200.78	268.75
3100.000	6.28	68.6	2.29	5.85	5600.000	465.44	45.6	325.78	332.42
3150.000	8.55	74.5	2.28	8.24	5650.000	690.69	17.7	657.81	210.55
3200.000	10.89	78.8	2.11	10.68	5700.000	626.42	-18.8	592.97	-201.95
3250.000	13.27	81.0	2.08	13.11	5750.000	496.13	-41.6	371.09	-329.30
3300.000	15.51	82.0	2.15	15.36	5800.000	367.79	-55.1	210.55	-301.56
3350.000	17.68	83.2	2.10	17.55	5850.000	286.03	-62.2	133.20	-253.12
3400.000	19.90	84.4	1.96	19.80	5900.000	231.47	-67.1	89.94	-213.28
3450.000	22.14	85.5	1.75	22.07	5950.000	191.48	-70.0	65.62	-179.88
3500.000	24.86	87.3	1.17	24.83	6000.000	165.09	-71.8	51.56	-156.64
3550.000	28.59	87.6	1.18	28.56	6050.000	141.79	-74.3	38.28	-136.52
3600.000	31.93	85.7	2.42	31.84	6100.000	122.22	-74.2	33.35	-117.58
3650.000	34.24	84.5	3.26	34.08	6150.000	108.75	-74.3	29.44	-104.69
3700.000	37.30	84.1	3.81	37.11	6200.000	96.81	-74.2	26.32	-93.16
3750.000	40.72	83.1	4.86	40.43	6250.000	86.84	-73.1	25.20	-83.11
3800.000	44.22	81.6	6.43	43.75	6300.000	79.14	-72.5	23.75	-75.49
3850.000	47.55	79.7	8.53	46.78	6350.000	72.98	-71.6	23.07	-69.24
3900.000	49.62	77.4	10.79	48.44	6400.000	68.31	-70.9	22.36	-64.55
3950.000	52.14	76.0	12.65	50.59	6450.000	64.04	-72.4	19.38	-61.04
4000.000	54.95	74.4	14.75	52.93	6500.000	57.39	-75.5	14.36	-55.57
4050.000	56.83	72.2	17.38	54.10	6550.000	47.98	-76.6	11.10	-46.68
4100.000	57.18	69.7	19.87	53.61	6600.000	40.06	-72.6	11.95	-38.23
4150.000	55.70	71.2	17.94	52.73	6650.000	35.00	-66.4	13.99	-32.08
4200.000	57.63	74.6	15.28	55.57	6700.000	31.06	-60.4	15.36	-27.00
4250.000	62.10	76.8	14.21	60.45	6750.000	27.15	-52.6	16.50	-21.56
4300.000	66.21	77.9	13.87	64.75	6800.000	24.96	-40.2	19.07	-16.11
4350.000	70.38	80.1	12.06	69.34	6850.000	24.71	-27.7	21.87	-11.49
4400.000	78.24	82.3	10.44	77.54	6900.000	27.67	-15.9	26.61	-7.58
4450.000	89.12	83.1	10.71	88.48	6950.000	30.99	-10.5	30.47	-5.64
4500.000	103.07	82.3	13.77	102.15	7000.000	33.45	-5.5	33.30	-3.18
4550.000	117.81	80.0	20.46	116.02	7050.000	35.90	3.3	35.84	2.06
4600.000	133.69	76.7	30.86	130.08	7100.000	44.47	12.6	43.41	9.68
4650.000	154.91	74.4	41.60	149.22	7150.000	62.23	15.2	60.06	16.31
4700.000	195.32	70.7	64.45	184.37	7200.000	90.58	5.0	90.23	7.95
4750.000	262.54	58.8	135.94	224.61	7250.000	110.60	-18.5	104.88	-35.11
4800.000	343.55	34.0	284.77	192.19	7300.000	101.24	-40.2	77.34	-65.33
4850.000	319.81	-6.1	317.97	-34.23	7350.000	83.09	-52.5	50.59	-65.92
4900.000	190.09	-33.3	158.79	-104.49	7400.000	69.53	-58.6	36.18	-59.37
4950.000	102.92	-41.1	77.54	-67.68	7450.000	59.03	-61.7	28.03	-51.95
5000.000	54.44	-33.1	45.61	-29.74	7500.000	51.72	-62.6	23.83	-45.90
5050.000	32.57	-1.0	32.57	-.54	7550.000	46.86	-62.8	21.39	-41.70
5100.000	35.10	40.5	26.71	22.78	7600.000	42.81	-63.8	18.87	-38.43
5150.000	49.97	60.4	24.66	43.46	7650.000	38.69	-65.5	16.04	-35.21
5200.000	67.61	68.0	25.29	62.70	7700.000	35.07	-66.0	14.28	-32.03
5250.000	86.35	71.2	27.83	81.74	7750.000	32.06	-66.9	12.57	-29.49
5300.000	107.41	73.0	31.35	102.73	7800.000	28.95	-68.8	10.45	-27.00
5350.000	135.59	73.6	38.28	130.08	7850.000	24.97	-70.8	8.19	-23.58
5400.000	173.62	71.5	55.08	164.65	7900.000	20.85	-71.1	6.74	-19.73
5450.000	217.15	67.1	84.57	200.03	7950.000	17.32	-68.7	6.29	-16.14
					7999.998	14.53	-64.7	6.21	-13.13

Model 3

N 0.003 Pyrofuze w/Mk-101 Header #6 3/4-in. Leads Pin/Case (Sleeve)

Impedance (ohms) — 50.0-ohm System

FREQ	MAGN	ANGLE	REAL	IMAG	FREQ	MAGN	ANGLE	REAL	IMAG
100.000	322.38	-91.6	-8.73	-322.27	1200.000	41.30	-58.1	21.83	-35.06
150.000	207.03	-90.1	-.37	-207.03	1250.000	63.02	-40.6	47.85	-41.02
200.000	153.19	-88.4	4.40	-153.12	1300.000	86.19	-55.9	48.29	-71.39
250.000	117.02	-88.8	2.48	-116.99	1350.000	74.42	-75.6	18.55	-72.07
300.000	88.29	-89.4	.86	-88.28	1400.000	60.68	-81.8	8.67	-60.06
350.000	66.33	-88.5	1.76	-66.31	1450.000	52.04	-83.1	6.24	-51.66
400.000	46.60	-88.2	1.46	-46.58	1500.000	46.08	-84.3	4.58	-45.85
450.000	27.07	-85.9	1.94	-27.00	1550.000	41.04	-85.5	3.19	-40.92
500.000	8.41	-57.0	4.58	-7.06	1600.000	35.96	-86.5	2.19	-35.89
550.000	17.81	69.5	6.25	16.67	1650.000	30.54	-86.0	2.12	-30.47
600.000	53.27	75.5	13.38	51.56	1700.000	25.91	-81.0	4.06	-25.59
650.000	112.89	76.9	25.54	109.96	1750.000	23.89	-72.8	7.06	-22.83
700.000	280.01	71.8	87.43	266.02	1800.000	24.38	-67.4	9.36	-22.51
750.000	954.65	-27.5	846.87	-440.62	1850.000	25.21	-68.0	9.46	-23.36
800.000	299.79	-73.5	84.96	-287.50	1900.000	23.62	-72.2	7.23	-22.49
850.000	183.37	-82.1	25.10	-181.64	1950.000	20.93	-73.5	5.96	-20.07
900.000	130.40	-83.2	15.38	-129.49	1999.999	18.80	-71.5	5.97	-17.82
950.000	105.07	-83.0	12.74	-104.30	2000.000	16.13	-69.7	5.58	-15.14
1000.000	85.97	-82.6	11.10	-85.25	2050.000	14.61	-65.4	6.08	-13.28
1050.000	71.68	-82.7	9.12	-71.09	2100.000	13.24	-61.4	6.35	-11.62
1100.000	61.37	-79.1	11.65	-60.25	2150.000	12.60	-54.3	7.36	-10.23
1150.000	48.56	-74.7	12.84	-46.83					

FREQ	MAGN	ANGLE	REAL	IMAG	FREQ	MAGN	ANGLE	REAL	IMAG
2200.000	12.00	-50.8	7.56	-9.30	5100.000	223.37	32.8	187.70	121.09
2250.000	11.79	-49.2	7.70	-8.92	5150.000	231.57	20.9	216.41	82.42
2300.000	10.33	-53.3	6.18	-8.28	5200.000	211.43	7.2	209.77	26.46
2350.000	8.22	-52.3	5.03	-6.51	5250.000	169.40	-1.6	169.34	-4.80
2400.000	5.88	-45.2	4.14	-4.17	5300.000	137.50	-3.1	137.30	-7.34
2450.000	4.35	-24.9	3.95	-1.83	5350.000	111.58	1.9	111.52	3.70
2500.000	3.93	5.0	3.92	.34	5400.000	98.85	13.1	96.29	22.34
2550.000	4.50	33.7	3.75	2.50	5450.000	101.25	27.5	89.84	46.68
2600.000	6.03	51.0	3.80	4.69	5500.000	120.25	37.1	95.90	72.56
2650.000	8.11	60.6	3.98	7.07	5550.000	145.06	42.7	106.64	98.34
2700.000	10.22	66.4	4.10	9.36	5600.000	189.62	44.9	134.37	133.79
2750.000	12.71	69.9	4.36	11.94	5650.000	251.80	41.6	188.28	167.19
2800.000	15.89	72.0	4.90	15.11	5700.000	341.27	33.7	283.98	189.26
2850.000	19.21	73.2	5.56	18.38	5750.000	503.93	18.1	478.91	156.84
2900.000	23.57	72.0	7.30	22.41	5800.000	634.58	-20.5	594.53	-221.87
2950.000	28.30	68.7	10.27	26.37	5850.000	462.27	-52.0	284.37	-364.45
3000.000	34.55	63.5	15.43	30.91	5900.000	326.14	-66.0	132.42	-298.05
3050.000	42.19	52.3	25.78	33.40	5950.000	242.96	-72.1	74.51	-231.25
3100.000	43.91	36.0	35.55	25.78	6000.000	195.34	-74.3	52.73	-188.09
3150.000	37.17	21.9	34.47	13.89	6050.000	163.72	-76.2	39.11	-158.98
3200.000	32.60	15.9	31.35	8.94	6100.000	140.35	-76.6	32.57	-136.52
3250.000	26.83	17.1	25.63	7.91	6150.000	123.97	-77.2	27.44	-120.90
3300.000	26.80	21.3	24.98	9.73	6200.000	109.00	-78.1	22.53	-106.64
3350.000	24.54	12.6	23.95	5.36	6250.000	96.79	-77.6	20.80	-94.53
3400.000	18.00	8.0	17.82	2.52	6300.000	87.64	-77.2	19.46	-85.45
3450.000	12.14	21.7	11.28	4.49	6350.000	80.10	-76.9	18.09	-78.03
3500.000	10.94	51.9	6.75	8.61	6400.000	74.45	-76.7	17.11	-72.46
3550.000	13.93	73.1	4.05	13.33	6450.000	69.42	-78.3	14.14	-67.97
3600.000	17.76	80.8	2.84	17.53	6500.000	62.04	-81.9	8.72	-61.43
3650.000	21.34	85.3	1.74	21.26	6550.000	51.78	-83.7	5.72	-51.46
3700.000	25.35	88.2	.81	25.34	6600.000	43.31	-80.2	7.37	-42.68
3750.000	29.30	88.9	.58	29.30	6650.000	37.65	-75.6	9.34	-36.47
3800.000	33.06	89.4	.33	33.06	6700.000	33.02	-70.6	10.95	-31.15
3850.000	36.72	89.8	.14	36.72	6750.000	28.66	-63.9	12.62	-25.73
3900.000	40.33	90.5	-.36	40.33	6800.000	25.85	-53.7	15.31	-20.83
3950.000	44.84	91.7	-1.31	44.82	6850.000	24.67	-42.0	18.33	-16.50
4000.000	51.54	93.1	-2.76	51.46	6900.000	25.38	-29.8	22.02	-12.62
4050.000	59.01	91.7	-1.75	58.98	6950.000	28.53	-18.8	27.00	-9.22
4100.000	66.70	89.3	.82	66.70	7000.000	34.82	-13.3	33.89	-8.00
4150.000	74.67	87.6	3.09	74.61	7050.000	41.76	-13.7	40.58	-9.89
4200.000	87.42	86.0	6.12	87.21	7100.000	48.69	-19.5	45.90	-16.24
4250.000	109.42	80.2	18.70	107.81	7150.000	51.51	-28.0	45.46	-24.22
4300.000	135.95	63.5	60.64	121.68	7200.000	50.76	-35.6	40.97	-29.30
4350.000	122.44	37.0	97.75	73.73	7250.000	46.90	-42.5	34.57	-31.69
4400.000	79.35	27.8	70.21	36.96	7300.000	41.54	-45.8	28.96	-29.79
4450.000	58.41	39.2	45.26	36.91	7350.000	35.86	-46.0	24.93	-25.78
4500.000	57.23	55.3	32.62	47.02	7400.000	31.92	-41.8	23.78	-21.29
4550.000	62.80	63.8	27.73	56.35	7450.000	30.23	-35.1	24.73	-17.38
4600.000	69.89	68.3	25.83	64.94	7500.000	30.49	-29.4	26.56	-14.97
4650.000	78.77	71.7	24.68	74.80	7550.000	32.92	-25.2	29.79	-14.01
4700.000	90.51	73.6	25.59	86.82	7600.000	35.73	-26.1	32.08	-15.72
4750.000	103.57	72.8	30.66	98.93	7650.000	37.31	-30.1	32.28	-18.73
4800.000	115.84	71.7	36.43	109.96	7700.000	37.41	-34.3	30.91	-21.07
4850.000	130.47	70.3	43.95	122.85	7750.000	36.[illegible]	-39.1	28.32	-23.05
4900.000	153.50	67.7	58.30	141.99	7800.000	34.49	-44.5	24.61	-24.17
4950.000	176.60	61.8	83.40	155.66	7850.000	30.79	-48.7	20.31	-23.14
5000.000	203.63	53.0	122.46	162.70	7900.000	26.67	-51.6	16.58	-20.98
5050.000	218.95	42.6	161.13	148.24	7950.000	22.47	-52.0	13.84	-17.70
					7999.998	19.27	-49.8	12.43	-14.72

Model 4

N 0.001 Pyrofuze w/Mk-101 Header #9 3/4-in Leads Pin/Pin w/Sleeve

Impedence (ohms) -- 50.0-ohm System

FREQ	MAGN	ANGLE	REAL	IMAG	FREQ	MAGN	ANGLE	REAL	IMAG
100.000	28.43	88.6	.69	28.42	800.000	132.33	-86.1	8.96	-132.03
150.000	44.88	88.9	.85	44.87	850.000	112.31	-86.6	6.75	-112.11
200.000	64.28	88.5	1.72	64.26	900.000	96.69	-86.3	6.27	-96.48
250.000	88.81	88.3	2.58	88.77	950.000	85.89	-85.6	6.52	-85.64
300.000	125.02	89.1	2.01	125.00	1000.000	76.23	-85.3	6.25	-75.98
350.000	182.44	89.3	2.36	182.42	1050.000	68.25	-85.8	5.02	-68.07
400.000	320.80	85.8	23.66	319.92	1100.000	61.10	-85.8	4.44	-60.94
450.000	713.57	66.7	282.03	655.47	1150.000	52.38	-85.9	3.76	-52.25
500.000	835.34	-15.6	804.69	-224.22	1200.000	45.21	-83.0	5.48	-44.87
550.000	649.27	-43.7	469.53	-448.44	1250.000	39.59	-76.7	9.13	-38.53
600.000	382.36	-69.9	131.64	-358.98	1300.000	34.68	-68.7	12.57	-32.32
650.000	279.06	-78.9	53.81	-273.83	1350.000	36.67	-54.7	21.19	-29.93
700.000	208.24	-82.9	25.78	-206.64	1400.000	46.70	-53.7	27.64	-37.65
750.000	161.54	-84.3	16.06	-160.74	1450.000	47.10	-63.2	21.24	-42.04

FREQ	MAGN.	ANGLE	REAL	IMAG
1500.000	47.17	-69.9	16.24	-44.29
1550.000	43.03	-76.0	10.41	-41.75
1600.000	37.44	-79.5	6.81	-36.82
1650.000	32.69	-79.9	5.74	-32.18
1700.000	29.06	-80.6	4.77	-28.66
1750.000	25.62	-79.5	4.67	-25.20
1800.000	22.93	-78.4	4.60	-22.46
1850.000	20.46	-78.1	4.21	-20.02
1900.000	17.57	-78.0	3.64	-17.19
1950.000	14.40	-76.3	3.41	-13.99
1999.999	11.56	-71.6	3.66	-10.96
2000.000	10.16	-69.0	3.64	-9.48
2050.000	7.31	-56.7	4.01	-6.11
2100.000	5.37	-31.9	4.55	-2.84
2150.000	4.61	6.7	4.58	.54
2200.000	7.35	49.0	4.82	5.55
2250.000	13.54	65.5	5.62	12.32
2300.000	24.91	70.5	8.38	23.49
2350.000	48.96	65.5	20.34	44.53
2400.000	118.03	34.8	96.97	67.29
2450.000	104.60	-42.2	77.44	-70.31
2500.000	54.03	-64.8	23.54	-48.63
2550.000	35.06	-69.8	12.08	-32.91
2600.000	25.14	-71.7	7.87	-23.88
2650.000	18.45	-72.3	5.62	-17.58
2700.000	13.52	-70.2	4.59	-12.72
2750.000	10.03	-65.9	4.10	-9.16
2800.000	6.96	-61.3	3.34	-6.10
2850.000	4.21	-48.6	2.78	-3.16
2900.000	2.51	-9.2	2.48	-.40
2950.000	3.07	41.5	2.30	2.03
3000.000	4.90	64.9	2.08	4.44
3050.000	7.00	74.2	1.91	6.74
3100.000	9.36	78.4	1.88	9.17
3150.000	11.40	79.3	2.11	11.21
3200.000	13.47	81.0	2.11	13.31
3250.000	15.65	82.2	2.12	15.50
3300.000	17.79	83.4	2.05	17.68
3350.000	19.93	84.0	2.08	19.82
3400.000	21.97	84.5	2.09	21.87
3450.000	24.20	85.3	1.96	24.12
3500.000	26.84	87.1	1.36	26.81
3550.000	30.70	87.3	1.43	30.66
3600.000	34.06	85.1	2.88	33.94
3650.000	36.44	83.8	3.93	36.23
3700.000	39.59	83.1	4.75	39.31
3750.000	43.04	81.6	6.27	42.58
3800.000	46.56	79.7	8.36	45.80
3850.000	49.50	77.0	11.11	48.24
3900.000	51.26	74.2	13.96	49.32
3950.000	52.22	72.0	16.16	49.66
4000.000	52.62	71.9	16.38	50.00
4050.000	53.75	72.2	16.43	51.17
4100.000	54.41	72.4	16.48	51.86
4150.000	55.94	75.3	14.21	54.10
4200.000	60.00	78.5	11.98	58.79
4250.000	66.48	80.3	11.22	65.53
4300.000	73.48	81.4	10.97	72.66
4350.000	81.45	81.5	11.98	80.57
4400.000	92.56	82.2	12.57	91.70
4450.000	110.65	81.3	16.75	109.37
4500.000	137.22	77.5	29.64	133.98
4550.000	174.96	68.2	64.84	162.50
4600.000	226.61	48.4	150.59	169.34
4650.000	223.45	11.3	219.14	43.65
4700.000	127.72	-16.5	122.46	-36.28
4750.000	63.81	-12.9	62.21	-14.21
4800.000	43.44	14.7	39.11	10.29
4850.000	41.82	46.0	29.05	30.08
4900.000	53.24	62.0	24.98	47.02
4950.000	66.83	69.0	23.93	62.40
5000.000	80.51	72.2	24.61	76.66
5050.000	93.72	73.5	26.66	89.84
5100.000	107.56	75.4	27.05	104.10
5150.000	128.47	77.0	28.81	125.20
5200.000	154.58	76.3	36.57	150.20
5250.000	182.93	74.8	49.95	175.98
5300.000	218.59	72.6	65.33	208.59
5350.000	275.63	70.2	93.26	259.37
5400.000	375.15	63.6	166.99	335.94
5450.000	514.29	50.9	324.22	399.22
5500.000	672.78	27.2	598.44	307.48
5550.000	750.18	-1.3	750.00	-16.46
5600.000	667.59	-33.8	554.69	-371.48
5650.000	458.94	-53.8	271.09	-370.31
5700.000	332.74	-62.6	153.32	-295.31
5750.000	261.15	-67.6	99.61	-241.41
5800.000	209.68	-70.7	69.43	-197.85
5850.000	175.22	-71.3	56.05	-166.02
5900.000	149.68	-72.3	45.56	-142.58
5950.000	129.84	-73.1	37.79	-124.22
6000.000	114.17	-73.7	32.08	-109.57
6050.000	99.01	-73.7	27.83	-95.02
6100.000	87.26	-72.0	26.90	-83.01
6150.000	78.95	-70.5	26.37	-74.41
6200.000	70.99	-69.1	25.34	-66.31
6250.000	64.53	-67.2	25.05	-59.47
6300.000	58.97	-65.2	24.78	-53.52
6350.000	54.59	-63.1	24.71	-48.68
6400.000	50.74	-61.6	24.15	-44.63
6450.000	45.63	-61.6	21.73	-40.14
6500.000	38.38	-61.5	18.29	-33.74
6550.000	29.22	-55.1	16.73	-23.97
6600.000	24.06	-35.8	19.51	-14.09
6650.000	25.18	-11.4	24.68	-4.96
6700.000	32.11	6.0	31.93	3.34
6750.000	44.73	15.4	43.12	11.91
6800.000	62.22	16.1	59.77	17.29
6850.000	84.08	10.0	82.81	14.55
6900.000	108.98	-3.4	108.79	-6.38
6950.000	119.92	-21.6	111.52	-44.09
7000.000	115.36	-37.7	91.31	-70.51
7050.000	101.47	-49.5	65.92	-77.15
7100.000	88.63	-57.2	48.00	-74.51
7150.000	77.09	-62.0	36.18	-68.07
7200.000	68.75	-65.0	29.05	-62.36
7250.000	62.32	-68.6	22.78	-58.01
7300.000	55.68	-72.3	16.97	-53.03
7350.000	48.20	-74.9	12.55	-46.53
7400.000	41.56	-75.2	10.58	-40.19
7450.000	36.22	-74.0	9.99	-34.81
7500.000	32.32	-72.4	9.78	-30.81
7550.000	29.68	-69.7	10.30	-27.83
7600.000	27.19	-69.3	9.59	-25.44
7650.000	24.28	-69.4	8.54	-22.73
7700.000	21.26	-67.9	7.98	-19.70
7750.000	18.68	-65.5	7.75	-16.99
7800.000	16.22	-64.2	7.07	-14.68
7850.000	13.43	-60.6	6.59	-11.71
7900.000	10.73	-53.7	6.36	-8.64
7950.000	8.81	-40.6	6.69	-5.73
7999.998	7.74	-24.9	7.02	-3.26

Model 4

N 0.001 Pyrofuze w/Mk-101 Header #9 3/4-in. Leads Pin/Case (Sleeve)

Impedance (ohms) -- 50.0-ohm System

FREQ	MAGN	ANGLE	REAL	IMAG
100.000	313.77	-91.5	-8.00	-313.67
150.000	201.56	-90.0	.15	-201.56
200.000	149.06	-88.4	4.26	-149.02
250.000	114.09	-88.7	2.51	-114.06
300.000	86.82	-89.6	.57	-86.82
350.000	65.94	-88.4	1.79	-65.92
400.000	47.44	-88.1	1.59	-47.41
450.000	30.12	-86.8	1.66	-30.08
500.000	12.49	-78.3	2.53	-12.23
550.000	8.84	67.2	3.43	8.14
600.000	36.24	79.2	6.81	35.68
650.000	77.00	81.6	11.24	76.17

FREQ	MAGN	ANGLE	REAL	IMAG
700.000	165.80	80.4	27.64	163.48
750.000	538.29	57.2	291.80	452.34
800.000	569.77	-59.3	291.02	-489.84
850.000	248.37	-80.4	41.26	-244.92
900.000	156.44	-82.4	20.63	-155.08
950.000	120.51	-82.7	15.36	-119.53
1000.000	94.86	-82.5	12.41	-94.04
1050.000	77.33	-82.4	10.17	-76.66
1100.000	65.44	-77.8	13.79	-63.96
1150.000	51.46	-70.6	17.09	-48.54
1200.000	52.42	-49.7	33.89	-39.99
1250.000	80.25	-57.8	42.82	-67.87
1300.000	78.00	-74.0	21.44	-75.00
1350.000	63.97	-82.2	8.68	-63.38
1400.000	53.78	-84.4	5.29	-53.52
1450.000	46.64	-84.7	4.35	-46.44
1500.000	41.00	-84.7	3.82	-40.82
1550.000	36.10	-84.6	3.39	-35.94
1600.000	30.70	-83.8	3.33	-30.52
1650.000	25.52	-78.1	5.24	-24.98
1700.000	23.46	-64.4	10.12	-21.17
1750.000	26.79	-57.4	14.45	-22.56
1800.000	28.74	-61.3	13.82	-25.20
1850.000	28.40	-67.1	11.04	-26.17
1900.000	25.02	-71.5	7.92	-23.73
1950.000	21.67	-72.0	6.70	-20.61
1999.999	19.53	-69.7	6.79	-18.31
2050.000	16.69	-67.1	6.48	-15.38
2100.000	15.17	-64.5	6.52	-13.70
2150.000	13.60	-60.8	6.64	-11.87
2200.000	12.86	-55.7	7.25	-10.62
2250.000	11.78	-53.5	7.01	-9.47
2300.000	10.66	-51.9	6.58	-8.39
2350.000	8.90	-50.8	5.62	-6.90
2400.000	7.00	-46.1	4.85	-5.04
2450.000	4.82	-31.3	4.12	-2.51
2500.000	4.04	2.5	4.03	.18
2550.000	5.05	30.5	4.35	2.56
2600.000	6.79	49.1	4.45	5.13
2650.000	9.29	58.6	4.83	7.93
2700.000	12.53	62.8	5.72	11.15
2750.000	15.81	64.6	6.79	14.28
2800.000	20.12	64.6	8.64	18.16
2850.000	26.17	62.0	12.27	23.12
2900.000	34.23	55.4	19.43	28.17
2950.000	45.69	38.5	35.74	28.47
3000.000	46.20	9.9	45.51	7.96
3050.000	33.19	-12.7	32.37	-7.32
3100.000	20.21	-20.0	18.99	-6.91
3150.000	12.88	-7.5	12.77	-1.69
3200.000	11.16	17.9	10.62	3.42
3250.000	11.71	32.3	9.90	6.26
3300.000	13.83	44.8	9.24	9.18
3350.000	14.21	47.1	9.68	10.40
3400.000	13.67	53.1	8.22	10.93
3450.000	13.86	65.2	5.82	12.57
3500.000	15.80	76.0	3.81	15.33
3550.000	18.65	83.5	2.13	18.53
3600.000	22.68	87.4	1.04	22.66
3650.000	26.25	87.3	1.25	26.22
3700.000	29.26	88.3	.87	29.25
3750.000	32.96	89.4	.37	32.96
3800.000	37.11	89.4	.38	37.11
3850.000	41.41	89.2	.55	41.41
3900.000	45.86	88.8	.97	45.85
3950.000	50.40	88.7	1.17	50.39
4000.000	57.04	89.1	.87	57.03
4050.000	67.30	88.9	1.26	67.29
4100.000	81.36	85.0	7.07	81.05
4150.000	100.04	77.5	21.73	97.66
4200.000	123.29	60.8	60.16	107.62
4250.000	117.11	30.2	101.17	58.98
4300.000	68.64	15.6	66.11	18.46
4350.000	44.77	28.6	39.31	21.44
	40.71	48.5	27.00	30.47

FREQ	MAGN	ANGLE	REAL	IMAG
4400.000	44.24	61.6	21.04	38.92
4450.000	50.90	69.9	17.48	47.80
4500.000	58.92	73.7	16.55	56.54
4550.000	66.33	75.0	17.21	64.06
4600.000	73.25	75.8	18.02	71.00
4650.000	81.75	76.8	18.68	79.59
4700.000	93.01	77.3	20.51	90.72
4750.000	108.90	75.1	27.00	101.37
4800.000	116.64	73.0	34.18	111.52
4850.000	130.06	70.3	43.80	122.46
4900.000	148.52	65.7	61.13	135.35
4950.000	163.83	57.2	88.77	137.70
5000.000	168.48	47.2	114.45	123.63
5050.000	156.53	39.7	120.51	99.90
5100.000	137.55	38.0	108.40	84.67
5150.000	130.80	41.2	98.44	86.13
5200.000	130.69	47.4	88.48	96.19
5250.000	140.78	54.1	82.52	114.06
5300.000	161.71	60.0	80.86	140.04
5350.000	204.44	63.9	89.94	183.59
5400.000	276.45	63.6	122.85	247.66
5450.000	389.85	58.4	204.30	332.03
5500.000	578.61	43.4	420.31	397.66
5550.000	813.45	15.6	783.59	218.36
5600.000	857.01	-28.8	750.78	-413.28
5650.000	538.51	-57.1	292.19	-452.34
5700.000	363.42	-65.9	148.63	-331.64
5750.000	279.20	-71.3	89.55	-264.45
5800.000	223.51	-74.0	61.62	-214.84
5850.000	184.64	-76.2	44.09	-179.30
5900.000	155.79	-77.3	34.37	-151.95
5950.000	133.35	-78.1	27.59	-130.47
6000.000	116.09	-78.3	23.58	-113.67
6050.000	100.40	-78.4	20.24	-98.34
6100.000	88.04	-76.6	20.39	-85.64
6150.000	79.69	-75.2	20.34	-77.05
6200.000	71.79	-74.4	19.31	-69.14
6250.000	64.24	-72.7	19.12	-61.33
6300.000	58.33	-70.8	19.19	-55.08
6350.000	53.28	-68.6	19.43	-49.61
6400.000	49.73	-66.6	19.73	-45.65
6450.000	45.41	-66.8	17.87	-41.75
6500.000	38.50	-67.8	14.55	-35.64
6550.000	29.94	-62.3	13.92	-26.51
6600.000	24.53	-47.1	16.70	-17.97
6650.000	23.70	-28.1	20.90	-11.17
6700.000	26.54	-12.3	25.93	-5.65
6750.000	32.33	.8	32.32	.47
6800.000	42.42	6.6	42.14	4.84
6850.000	55.72	6.5	55.37	6.26
6900.000	71.60	-1.2	71.58	-1.53
6950.000	81.19	-13.6	78.91	-19.12
7000.000	83.09	-26.7	74.22	-37.35
7050.000	77.92	-36.2	62.89	-46.00
7100.000	70.78	-43.2	51.56	-48.49
7150.000	64.14	-46.6	44.09	-46.58
7200.000	58.89	-48.3	39.21	-43.95
7250.000	55.03	-51.0	34.62	-42.77
7300.000	51.24	-52.6	31.10	-40.72
7350.000	47.13	-53.8	27.83	-38.04
7400.000	44.16	-54.0	25.93	-35.74
7450.000	40.87	-54.1	23.97	-33.11
7500.000	39.13	-53.6	23.22	-31.49
7550.000	37.54	-54.5	21.80	-30.57
7600.000	35.29	-56.8	19.31	-29.54
7650.000	32.26	-59.3	16.48	-27.73
7700.000	28.88	-60.1	14.38	-25.05
7750.000	25.82	-61.1	12.46	-22.61
7800.000	22.78	-62.4	10.55	-20.19
7850.000	18.87	-62.5	8.70	-16.75
7900.000	15.12	-52.2	7.58	-13.09
7950.000	11.78	-52.7	7.14	-9.37
7999.998	9.52	-40.4	7.25	-6.17

HK:315(210)