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A STUDY OF RF HAZARDS AT LOW AND MEDIUM FREQUENCIES TO BLASTING IN UNDERGROUND COAL MINES

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16. Abstract (Limit: 200 words)

Preliminary safe distances for blasting wiring from typical electromagnetic sources are presented. The distances are for underground coal mines and electromagnetic sources in the frequency range below 10 MHz. The distances are based on measurements performed at 3 locations in each of 3 coal mines. The measurement apparatus, measurement procedure, measurement results and the rationale used in the calculation of the safe distances are all described.

The safe distances presented are dependent on the measurement results and their interpretation. More measurements are clearly necessary to establish the validity of the suggested distances.

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FOREWORD

This report was prepared by Franklin Research Center, a division of Arvin/Calspan, Applied Physics Laboratory, 20th and Race Streets, Philadelphia, PA 19103 under USBM Contract No. J0318023. The contract was initiated under the mining research program. It was administered under the technical direction of U.S. Bureau of Mines, Safety Research Facility at Bruceton, PA with Mr. James R. Means, Jr. acting as Technical Project Officer. Mr. Joseph Gilchrist was the Contract Administrator for the Bureau of Mines. This report is a summary of the work recently completed as a part of this contract during the period February 1, 1981 to November 30, 1984. This report was submitted by the author on January 15, 1985.

ACKNOWLEDGEMENTS

This project was carried out by the personnel of the Applied Physics Laboratory of the Franklin Research Center. The mine measurements were carried out principally by the authors, Mr. Ramie H. Thompson, FRC Fellow, Dr. James Stuart, Research Scientist, and Mr. A. W. Cipkins, Technical Associate.

Thanks are due to Messrs. Harry Dobroski and James R. Means Jr. of the U.S. Bureau of Mines in providing specialized equipment and actual help in the preliminary measurements.

EXECUTIVE SUMMARY

In many underground coal mining operations the use of electromagnetic field equipment, particularly communication systems, not only increases the overall efficiency of the mining operation but can be directly linked with mine safety considerations. The use of electromagnetic field producing equipment in underground coal mining operations can only be expected to grow. Several new communication systems have already been proposed. In addition, high-frequency producing equipment for many diverse uses in mining operations are under study.

The use of these equipments in underground mining operations is hampered by the possibility of their electromagnetic fields interacting with the electric blasting cap operations commonly carried out in the mines. Such interactions can have at least two results bearing directly on mine safety:

- o premature initiation of the cap, either in its normal shot location or during hookup or transportation;
- o dudding of the cap so that normal firing operations do not cause initiation, thereby leaving unexploded high explosives after normal firing.

Since the consequences of a premature initiation could, particularly in coal mines operations, result in catastrophe involving human life, the overall approach to prediction of possible hazard must be, as far as reasonable, of a "worst case" nature.

A considerable body of work exists that deals with the overall problem for aboveground blasting operations and sources. Although some of the results of this work are directly applicable to underground mining operations, the factors of minimum distance between transmitting sources and caps, tunnel geometry, unknown electrical properties of the surrounding minerals, etc., that are inherent in underground operations limit complete application of these methods and results. Some limited theoretical investigations, tailored to a specific underground communication system, have been performed. In the end, electromagnetic hazard evaluation of the system was forced to rely on experimental data taken in a tunnel of the mine in which the communication system was to be installed.

Under the U.S. Bureau of Mines Contract HO210068 The Franklin Institute undertook a program aimed at producing a worst case model for electromagnetic energy/blasting cap interactions in underground workings. The results were presented in FIRL Report F-C3102, "Evaluation and Determination of Sensitivity of Electromagnetic Interactions of Commercial Blasting Caps," R.H. Thompson, August 1973.

The experimental program showed that, for blasting caps of American manufacture, the application of 40 mW of average RF power, either continuous wave or with a typical radar pulse signature, to the input impendance of the cap, either pin-to-pin or pin-to-case, could be expected to result in an initiation less than once in one thousand applications with a 95% confidence level. Thus the use of a 40 mW "no-fire" level for underground caps, a level that had been tentatively established for all American-made blasting caps, was confirmed.

Under U.S. Bureau of Mines Contract H0252015, the Applied Physics Laboratory of The Franklin Research Center undertook measurements in coal mines that, coupled with the 40 mW "no-fire" level, previously developed worst case wiring pick up antenna models, published electromagnetic mineral parameter data and a "lossy layer" model for propagation in the mine, could be used to predict safe distances for blasting operations underground. This work is reported in "RF Hazards to Blasting Caps in Coal Mines."[7] The predicted safe distances in that report for frequencies less than 10 MHz were quite large. This was the direct result of the demonstration by our measurement results that, at these frequencies, underground sources coupled well to longitudinal conductors along the drifts. Thus, the energy from the source could propogate long distances with relatively small attenuation. The analyses assumed a large coupling factor between the source and any nearby conductors, thus large values of the fields were predicted at very large distances. We recognized at the time that the assumption of very good coupling between the source and the conductors in the mine was in error but the measurements taken provided no way to produce a valid worst case estimate of smaller magnitude.

The present project was aimed directly at this difficulty. Our overall effort was directed at source frequencies of 10 MHz, or less. In this frequency regime coupling between the source and the blasting cap can be considered to be completely by magnetic induction. If the magnetic field, B, is known in the vicinity of the blasting wiring, then an upper limit on the power absorbed by a blasting cap in the wiring can be made. Since the magnetic field can be thought of as having its source in currents driven by electromagnetic equipment, and this equipment can be related to the maximum currents it can produce, we see that a knowledge of the B field in the vicinity of known currents would allow us to predict safe distances for these currents. The experimental work on this project was directed to determining the B field distribution around typical underground current carrying conductor configurations.

This overall approach to the problem is based on the observation that we are concerned only with the driven currents in the immediate vicinity of the blasting cap wiring. Currents far away will have a very much smaller effect on the total power pickup of the blasting wiring than those in the immediate vicinity. Thus, our approach takes no notice of the propagating modes of the electromagnetic field - which in any practical wire laden drift will, we believe, never be known without an extensive measurement program in that drift. We are concerned, in the 10 MHz and below frequency range, only with near field effects. We relate power pickup to the maximum driven currents in nearby loops and linear elements.

In particular, we chose loop current sources to approximate the "back pack" antennas and bandolier antennas being used for communication in coal mines. We also made measurements on a configuration approximating the conventional trolley line communcation systems.

Measurements of magnetic fields from loop and line sources were made at each of 3 locations in 3 coal mines. 1744 data points were obtained for the loop sources and 128 data points were obtained for the trolley line simulator.

Since safe distances can be readily computed from a knowledge of the magnetic field and since the "free space" magnetic field can be readily computed from a knowledge of the transmitting equipment and antenna, the parameter of concern is how much the underground environment can increase the magnetic field over its free space value. Our best estimate for this value is 5.

Our overall recommendations for blasting wiring safe distances from loop or long straight wire current sources are given in detail in Section 6 of this report. They are assumed valid for frequencies up to 10 MHz.

It should be carefully noted that the recommended distances are based on measurements performed in three locations in each of three coal mines. Although the locations and mines were selected to give a wide diversity of electrical characteristics, it is quite obvious that they can not be expected to give a statistically valid sample of all coal mines.

Further, if the safe blasting distances derived herein are to be applied to "hard rock" or metal mines we are even further from a valid statistical sample. We remark in passing, that we would expect the derived safe distances to increase somewhat in metal rich surroundings and decrease a bit in conductor poor mines.

Another important point in the validity of the safe distances is our use of a multiplying factor of 5 for the mine to "free space" magnetic field. As discussed in Section 5.0, this is not a worst case assumption. We had 29 of our 1744 (approximately 1.7%) measured values exceed 5. We attribute most of these to measurements near our noise level, measurements very close to conductors [and very limited in extent] or errors in measurement. There are, however, some measurements we feel were valid that did exceed a factor of 5 over the calculated free space value. We think that these "hot spots" are of very limited spacial extent and they would thus not make significant differences in our safe distance calculations. We do not know.

We recommend that further measurements of the type made here be performed in several more coal mines and, if non-coal mines are to be considered, several metal mines. The measurement apparatus should incorporate more gain to alleviate our small signal problem and the measurement procedure should be changed somewhat. Tables of values of the calculated free space pickup multiplied by 5 for each frequency/source can easily be prepared using the procedures given in Sections 6.2 and 6.3. We recommend that tables of this type be used during the measurements and any measured pickup in excess of 5 be closely investigated for its area of extent.

The measurement equipment is already in existence, the measurement procedures are documented, the software for reduction of the data has already been developed and checked out. Thus, the additional measurements and data reduction can be carried out quickly with relatively small expense.

The results of such additional measurements will result in a higher multiplying factor or confirm our recommended value of 5. The safe distance calculating procedure is structured so that a change of the multiplying factor is easy to incorporate.

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1.0 INTRODUCTION

1.1 BACKGROUND

In many underground coal mining operations the use of electromagnetic field equipment, particularly communication systems, not only increases the overall efficiency of the mining operation but can be directly linked with mine safety considerations. The use of electromagnetic field producing equipment in underground coal mining operations can only be expected to grow. Several new communication systems have already been proposed. In addition, high-frequency/high field producing equipment for many diverse uses in mining operations are under study.

The use of this equipment in underground mining operations is hampered by the possibility of their electromagnetic fields interacting with the electric blasting cap operations commonly carried out in the mines. Such interactions can have at least two results bearing directly on mine safety:

- o premature initiation of the cap, either in its normal shot location or during hookup or transportation;
- o dudding of the cap so that normal firing operations do not cause initiation, thereby leaving unexploded high explosives after normal firing.

Since the consequences of a premature initiation could, particularly in coal mines operations, result in catastrophe involving human life, the overall approach to prediction of possible hazard must be, as far as possible, of a "worst case" nature.

The general problem of predicting possible RF hazards for any electroexplosive device (EED) is best treated by reference to Appendix A of this report. Appendix A considers the general problem from a military/space agency viewpoint but blasting caps are the primitive models for most EEDs so the material is directly applicable to blasting cap problems.

In brief, the specific problem of analytically predicting possible RF hazards to blasting caps can be reduced to finding answers to the following three questions:

(1) How much power, at the frequency of concern, is necessary to function the cap?

(2) How much power is coupled to the cap by a given field existing in the vicinity of the cap and its associated wiring?

3) What fields will exist in the vicinity of the blasting cap and its wiring for a given source, physical environment, frequency and separation?

A considerable body of work[1,2,3*] exists that deals with questions (2) and (3) for aboveground blasting operations and sources. Although some of the results of this work are directly applicable to underground mining operations, the factors of minimum distance between transmitting sources and caps, tunnel geometry, unknown electrical properties of the surrounding minerals, etc., that are inherent in underground operations limit complete application of these methods and results. Some limited theoretical investigations[4,5], tailored to a specific underground communication system, have been performed. In the end, electromagnetic hazard evaluation of the system was forced to rely on experimental data taken in a tunnel of the mine in which the communication system was to be installed.

Under the U.S. Bureau of Mines Contract H0210068 The Franklin Institute undertook a program aimed at producing a worst case model for electromagnetic energy/blasting cap interactions in underground workings. The results were presented in FIRL Report F-C3102, "Evaluation and Determination of Sensitivity of Electromagnetic Interactions of Commercial Blasting Caps."[6] R.H. Thompson, August 1973.

The experimental program showed that, for blasting caps of American manufacture, the application of 40 mW of average RF power, either continuous wave or with a typical radar pulse signature, to the input impendance of the cap, either pin-to-pin or pin-to-case, could be expected to result in an initiation less than once in one thousand applications with a 95% confidence level. Thus the use of a 40 mW "no-fire" level for underground caps, a level that had been tentatively established for all American-made blasting caps, was confirmed.

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*Superscripts refer to numbered references of Section 8.

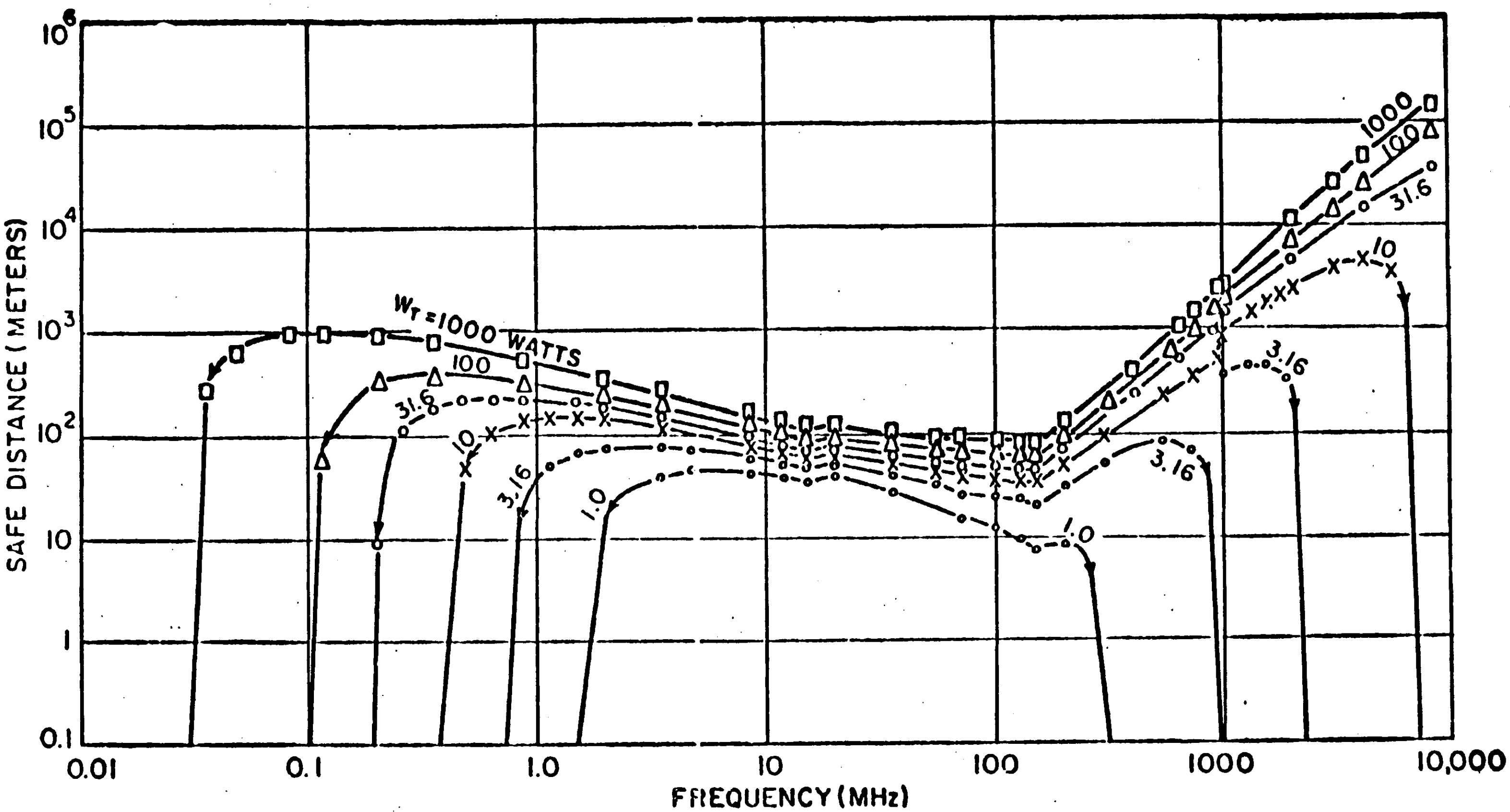


Figure 1. Safe Distances

The present project is aimed directly at this difficulty. Our overall effort was directed at source frequencies of 10 MHz, or less. In this frequency regime coupling between the source and the blasting cap can be considered to be completely by magnetic induction. If the magnetic field, B, is known in the vicinity of the blasting wiring, then an upper limit on the power absorbed by a blasting cap in the wiring can be made. Since the magnetic field can be thought of as having its source in currents driven by electromagnetic equipment, and this equipment can be related to the maximum currents it can produce, we see that a knowledge of the B field in the vicinity of known currents would allow us to predict safe distances for these currents. The experimental work on this project was directed to determining the B field distribution around typical underground current carrying conductor configurations.

This overall approach to the problem is based on the observation that we are concerned only with the driven currents in the immediate vicinity of the blasting cap wiring. Currents far away will have a very much smaller effect on the total power pickup of the blasting wiring than those in the immediate vicinity. Thus, our approach takes no notice of the propagating modes of the electromagnetic field - which in any practical wire laden drift will, we believe, never be known without an extensive measurement program in that drift. We are concerned, in the 10 MHz and below frequency range, only with near field effects. We relate worst case power pickup to the maximum driven currents in nearby loops and linear elements.

In particular, we chose loop current sources to approximate the "back pack" antennas and bandolier antennas being used for communication in coal mines. We also made measurements on a configuration approximating the conventional trolley line communcation systems.

Our overall measurement scheme was guided by the following approach to computing safe distances in the frequency band below 10MHz.

The maximum voltage induced in a loop of blasting wiring containing a cap can be written as

$$V_\ell = \int_A \frac{\partial B}{\partial t} \cdot dA \qquad (1)$$

where V_ℓ is the RMS open circuit voltage (volts),

B is the RMS magnetic field (maxwells), linking the loop, and

A is the area of the loop (meters^2)

Total worst case power to the cap (W_R) is

$$W_R = \left|\frac{V_\ell}{Z_b}\right|^2 R_{dc}$$

where W_R is the worst case power (watts), Z_b is the total impedance of the loop and,
R_{dc} is the resistance of the cap -- about 1 ohm.

If the received power is less than 40 milliwatts, we assume the cap is safe in its environment. Now, we could easily compute B at the blasting wiring location if we knew the direction, magnitude and location of all driven currents in the vicinity and the overall conductor configuration were located in free space. The actual fact is that the driven currents exist underground and there are other conductors present in the mine. The direction, magnitude and location of the driven currents can be estimated -- in a worst case sense -- from the equipment used in the mine and the conductors they drive, thus we need a correction factor that can be applied to the free space calculation of the B field that compensates -- in a worst case sense -- for the presence of the additional conductors in the mine and the presence of the minerals that make up the overall mine environment.

The determination of such a correction factor was the object of our measurements.

1.2 EARLY EFFORTS

Various loop antennas and transmission line simulating antennas were employed in late 1981 in a gallery of the U.S. Bureau of Mines Bruceton experimental mine. Measurements were taken of the variation of magnetic field with distance from the known currents in the transmitting antennas. The measurements, as expected, showed values larger than those predicted from free space calculations. The various conductor locations -- metal roof mesh, water pipes, electrical conduit, pipes, etc. -- were closely determined in the mine. A complete mockup of the mine -- constructed of wooden 2x4's was erected in an open field in Millville, N.J.

All conductors were simulated in this mockup. The overall idea was to determine if the conductors or the minerals of the mine contributed most to the elevated B field measurements obtained in the actual mine. Hindsight is much better than foresight. We found our aboveground measurements to be completely useless. All our measurements were contaminated by large pickups -- large in relation to our previous measurements -- from AM & FM radio stations, even though these stations were many miles away. In the main, this entire result was due to the fact that the 300 foot long conductors were excellent antennas for the commercial radio stations.

This entire phase of our effort provided no insight into our problem but did produce improvements in our source equipment and measurement techniques.

1.3 FINAL MEASUREMENTS

The measurements presented herein were aimed at the determination of B field variation -- in coal mine settings -- from known straight line and loop driven current sources. The measurements were performed at three locations in each of three mines. The individual locations were selected to provide a wide variation in local conduction density and degree of wetness.

2.0 MINE MEASUREMENT DESCRIPTIONS

2.1 THE MINES AND THE MEASUREMENT LOCATIONS

The measurements were performed in two mines close to Raton, New Mexico and a mine in Ashland, PA. In the data presented the measurement locations are given by a number 1 to 9.

The York Canyon Mines

Two underground coal mines called respectively "Main" and "Central" are in York Canyon near Raton, New Mexico. Franklin Research Center personnel made electromagnetic measurements in three locations in each of these two mines. The mines were temporarily shut down at the time of measurements with only maintenance and supervisory personnel present.

The mines are owned by the Kaiser Steel Co. The cooperation of the following people, among others, was greatly appreciated: Mr. Harry Elkin, Manager; also Fred Revera, M.A. Bertola, Paul Starkovich and Joe Romero. Help and hospitality from Mike Sepich and Larry Stolarczyk of A.R.F. Products Incorporated, manufacturers of mine-communications equipment, is also acknowledged.

(1) Location 1 was in York Canyon Main Mine, number nine left intake, in front of the entrance to cross-cut thirty-six. This was a dry location. Density of metallic conductors present was high. A three-inch steel water-pipe ran along one wall along with many heavy electric cables. Thin steel plates called "mats", approximately fifteen inches wide by fifteen feet long, with their long dimension oriented across the tunnel, were bolted to the roof at four-foot intervals. The circular antenna loops were hung with the top of the loop approximately eighteen inches below the roof. This location was about three miles in from the mine portal and close to a long-wall continuous-mining apparatus.

(2) Location 2 was not far from the previous location: York Canyon Main Mine, number nine left intake, in crosscut twenty-seven. This was a dry location. Density of metallic conductors present was medium. There was just one electric cable hung along the side of the crosscut, and no pipes. There were steel mats on the roof like those described previously. Transverse steel I-beams were used as roof supports. The antenna-loop was hung with its top two feet below the roof.

(3) Location 3 was York Canyon Main Mine, number nine left intake, in crosscut 26. This was a dry location. Density of metallic conductors present was low. There were no cables or pipes running along the side of the crosscut. Steel mats were on the roof in an

irregular pattern. The roof was held up by steel I-beams going from one side of the crosscut to the other, supported at the ends by sturdy wooden posts. These I-beams were about eight feet apart. The loop antenna was hung so its top was about two feet below the roof, in a spot fourteen feet into the crosscut from the place where it opened into the haulageway. Thirty feet from the loop in the other direction was a concrete-block wall with a small door leading to a beltway.

(4) Location 4 was York Canyon Central Mine, main intake, first south, in the haulageway between crosscuts eleven and twelve. This was a dry location. Density of conductors was medium. There were two three-inch-diameter high-voltage electric cables running along the side of the tunnel; these were the only longitudinal conductors. Steel I-beams ran across the roof every eight feet, supported by vertical logs at the tunnel sides. Between these I-beams were one or two of the "mats" described previously, running across the tunnel and bolted to the roof. The antenna-loop was hung with its top three feet below a roof mat, in the center of the haulageway.

(5) Location 5 was York Canyon Central Mine, first south intake, near crosscut thirteen. This was a wet location. Density of conductors was high. Because this was close to the face there were a great many longitudinal conductors, pipes and electric cables running along the sides of the tunnel. The roof, about five feet five inches high, was steel mats, oriented transversely, bolted to the roof, spaced about four feet apart. There were steel I-beams running across the roof, supported by vertical logs at the ends. These I-beams were about twenty feet apart in this tunnel. The floor was covered with puddles. Our radiofrequency apparatus was put onto duckboards. The roof dripped water everywhere. Icicles up to three feet long hung from the roof; we had to clear a small space through the icicles so we could set up the antennas to make measurements. The loop antenna was hung with its top approximately eighteen inches below the roof, one foot away from a steel I-beam which was at roof-level.

(6) Location 6 was York Canyon Cental Mine, first south intake, in the haulageway near crosscut twelve. This was a wet location. Density of conductors was medium. The only longitudinal conductors were a few electric cables and a telephone wire. There were puddles all over the floor. Water dripped from many places on the roof, and icicles hung all around. The steel roof mats were like those in location 5.

Pioneer Tunnel

This is a 70-year-old coal mine in Pennsylvania's anthracite region. The mine has three levels, three hundred vertical feet apart. All the tunnels have steel rails on the floor, and many places have electricity and compressed-air pipe. The mine was not operating, i.e. not producing coal at the time we were there. The author would like to express gratitude to George Staudenmeier, manager, and to William Whyne, foreman.

(7) Location 7 was the so-called Little Buck Gangway. There were steel rails underfoot. Two wires ran overhead, along the center of the tunnel, attached to insulators nailed to logs or to the roof. Those were the only conductors present except for water, which dripped slowly from many places on the roof, but did not form puddles on the floor. The "Little Buck" vein of anthracite coal was two or three feet wide and slanted up at about a forty-five-degree angle. Above and below this vein were layers of hard rock. The bottom layer of rock had been blasted and excavated to make the tunnel. It was ten feet wide, with a horizontal floor and a smooth, sloping rock roof which was nine feet from the floor at its highest point. The vein of coal could be seen clearly. It continued up on one side, and down on the other side of the tunnel, parallel with and just below the tunnel's slanted rock roof. In most places no roof-supports of any kind were necessary. Infrequently (about fifty-foot intervals) there were a few vertical logs at the walls, and horizontal logs across the top, to give support at places where a chute led into this gangway from levels further up. The transmitting-loops for our measurements were hung with their centers about five feet from the floor, in the middle of the tunnel.

(8) Location 7 was called "West number two Buck Mountain Gangway." There were no conductors at all here. The rails and electric wires had stopped farther back, and the roof did not drip water. The roof was twelve feet off the floor at its highest point, sharply slanted over a two-foot-wide coal seam. At the end of the gangway, where we were, the coal seam pinched down to one foot wide. In other respects this location was like the one described above. The transmitting coils were hung with center approximately four-and-a-half feet above the floor, in the center of the tunnel.

(9) Location 9 was called "West Orchard Gangway." The roof dripped much water, and there were puddles on the floor. There were rails underfoot, and spare rails, pipes, tools and metal cans were stacked against the wall. This gangway had logs against the walls about every two feet, supporting horizontal logs overhead. Evidently the roof here needed more support than the roof in the other two gangways where we took data. This gangway was about ten feet wide, seven feet high, and seventy feet long. The transmitting coils were hung about twelve feet from the face at the end of this gangway. The coils were hung in the middle of the gangway with centers about four feet from the floor. The gangway ended abruptly at a face or vertical wall where the coal seam, three feet wide here and tilted up at forty-five degrees, could be seen clearly in cross-section. There was a single electric power line overhead for lighting.

2.2 APPARATUS

Measurement of the B field was performed using a circular loop antenna source at frequencies of approximately 0.175, 0.5, 1.0, 5.0 and 10.0 MHz in each mine location. Measurements were also made using a rectangular loop 1 by 10 meters at approximate frequencies of 0.175, 0.5 and 1.0 MHz.

All circular loops were one-half meter in diameter. At the lower frequencies (175 KHz, 500 KHz, 1 MHz) a loop with fifteen turns was used, with appropriate matching-circuits which were different for each frequency. At 5 MHz a two- turn loop was used, and at 10 MHz a one-turn loop. Typical antenna currents varied from 10 to 12 amperes (peak to peak) in each turn.

Current flowing in the antennas was measured by a clip-on current probe, Hewlett-Packard type 1110A. Peak-to-peak current, displayed on the oscilloscope described below, was entered by hand in a notebook. The transfer impedance of this current probe was 1 ohm, so that voltages displayed on the oscilloscope were of equal magnitude to currents enclosed by the probe jaws.

The mobile transmitter which drove the antennas consisted of a low-power oscillator (General Radio 1211-B serial number 1215, or Hewlett-Packard 204B serial number 416-08150) and a 35-watt RF power amplifier (E.N.I. 440LA serial number 141). The change in transmitter current due to the reflected impedance of the clip on current probe used to measure the current was investigated by observing the change in pickup coil output when the clip on probe was removed and reattached to the transmitting antenna lead. The pickup coil was positioned on axis at 1 meter from the 10 MHz transmitting loop antenna and aligned for maximum output as indicated on the oscilloscope. In this configuration some slight change in the observed pickup could be observed when the clip on probe was attached to the transmitting antenna; however, the effect was transient and, to the best of our observation, no change in amplitude could be detected. We estimate that we would be able to resolve a 2 percent change.

The electromagnetic-field sensor consisted of a one-turn pickup loop of 10 cm diameter, with a 160-ohm load paralleled by the 50 ohm measurement cable leading to the oscilloscope. The loop can thus be considered to be loaded with 38.1 ohms. The small size and low "Q" eliminated resonance effects over the entire frequency band of interest. The coaxial cable, terminated in its characteristic impedance, carried the pickup signal without reflections to a small battery-powered oscilloscope (Leader LBO-308S, serial number 1080193). Peak-to-Peak voltage, displayed on this oscilloscope, was entered by hand in a notebook. It should be noted that all data recorded were the maximum voltage observed on the scope when the pickup loop was oriented in various directions. Thus, the recorded datum is associated with the maximum B field magnitude at the measurement point irrespective of B field direction.

The low-frequency transmitting-antenna, a 15-turn loop, is shown in Figure 2. Figure 3 shows the apparatus for measurement of RF current on the single-turn 10-MHz loop.

The rectangular loop or long wire antenna was one meter high and ten meters long, with the lower conductor right on the ground or floor of the tunnel. This long-wire running down the center of the tunnel was intended to serve as a model or mockup of a trolley wire carrying radiofrequency signals. The RF magnetic field was then measured at points near the center of this wire, far enough from the ends that this mockup might be approximated theoretically by a wire of infinite length carrying uniform current. Naturally this long-wire could only be used at the lower frequencies (0.175, 0.5, 1 MHz) where the current was approximately uniform over its length. The B field measurements were made using the same 10 cm probing loop described above. Preliminary measurements were made in every case to insure that the current in the rectangular loop was approximately uniform.

2.3 APPARATUS CHECK OUT

In order to determine if the source antennas and the measurement apparatus were functioning properly we performed all anticipated measurements aboveground in conductor free environments. These check out measurements were performed on an open field here in Philadelphia outside our laboratory and again on the grounds of the Bruceton experimental mine.

The pickup results were very close to those calculated by free space assumptions.

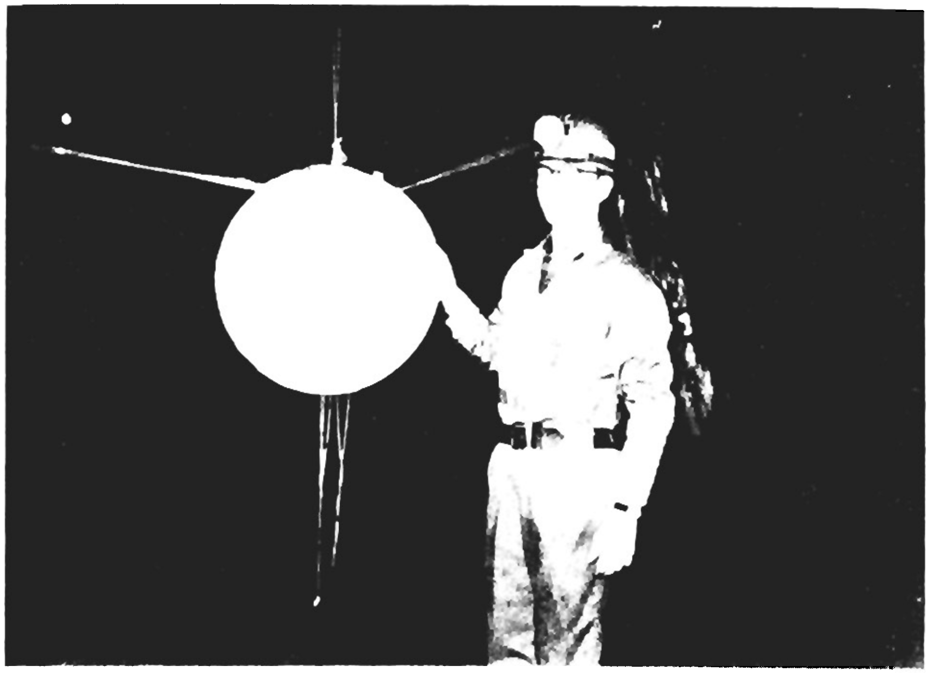


Figure 2. Low-Frequency Transmitting Antenna

Figure 3. Measurements of 10-MHz RF Current

2.4 MEASUREMENT PROCEDURE AT EACH MINE LOCATION

A circular loop antenna was hung in the center of the tunnel, at eye level, with its axis pointing along the tunnel. Current in the loop was driven by the transmitter set to that antenna's tuned frequency. Loop current was measured by the current probe. The strength of the magnetic field was first measured at points along the axis of the loop, and then at points in the plane of the loop. Approximately twenty-four measurements were made, at distances up to three meters from the center of the loop. This was a practical limit because at greater distances the signal level was generally too low to measure. All recorded data are the maximum values observed when orienting the pickup loop for maximum signal.

Then the loop was rotated so its axis pointed across the tunnel. This was important because we expected the tunnel-loop coupling to be dependent upon the relative orientation of the loop and the tunnel. Another twenty-four measurements were then made like those described above.

Having thus finished with the first frequency, the loop antenna was exchanged for another one, tuned to another frequency, and the whole procedure described above was followed again. In all, data was taken at five frequencies (approximately 0.175, 0.5, 1, 5, 10 MHz) in each mine location.

After the loop measurement the long-wire antenna was set up. The long-wire antenna has the form of a long narrow rectangle, 1 by 10 meters. The wire is suspended on wooden forms so that one of the long sides was 1 meter above the floor for its 10 meters of length. The opposite long side of the rectangle was on the floor. The rectangular loop was driven by the same transmitters used for the circular loops and current in the source loop measured with the current probe. The magnetic field was measured at a point 5 meters (half way down) from the driven end at heights of 0.5 and 1.0 meters at various distances from the plane of the rectangular loop. Measurements were carried out at approximately 0.175, 0.5 and 1.0 MHz.

Note that all data were recorded for B field measurements as millivolts -- (peak-to-peak) displayed on the oscilloscope. All source antenna currents were also recorded as total amps (number of turns times current, peak-to-peak) so that no conversion from RMS to peak-to-peak was needed for our calculations. Thus, all references to transmitting loop currents can be assumed to be in ampere turns.

3.0 MINE MEASUREMENT RESULTS

3.1 LOOP MEASUREMENT RESULTS

The raw loop data is given in Appendix B. The loop is always assumed to be in the X,Y plane with the axis of the loop perpendicular to this plane. Further, the loop is assumed to be suspended along the Y axis. Thus if the axis of the loop is pointed along the drift, Z is measured along the drift from the center of the loop. X is then measured to the drift wall from the center of the loop. This orientation, with the axis of the loop in the direction of the drift axis is referred to in Appendix B as direction 1.

Direction 2 is associated with the axis of the loop pointing to the drift wall. In this case also X and Z are defined as above. Thus, the X,Y,Z coordinate system is associated with the loop, not its orientation in respect to the tunnel.

In particular, if X=0 for a data point, then the measurement is at a point along the axis of loop and if Z=0, the measurement point is in the plane of the loop. Note that both X and Z values can be greater than or less than zero. Measurements were made in both directions along the axes.

In Appendix B the column headed "Current" gives the total (number of turns times single turn peak to peak current) current in the source loop, the column headed "Pickup" is the peak-to-peak voltage recorded from the oscilloscope connected to the 10 cm search coil.

The order of measurements in Appendix B is the Actual order in which the measurments were taken.

3.2 TRANSMISSION LINE RESULTS

Appendix C gives all the raw data for the transmission line (long line simulator) measurements. Notation is the same as in Section 3.1; note that here, however, we have no direction notation since the long line always runs down the drift. With the transmission line, measurement data were always taken at the midpoint of the line. The Z dimension was taken as vertical height from the floor. The Y direction was measured toward the mine wall from the middle of the drift (the location of the transmission line). A sketch of the coordinate system is given as the first page of Appendix H.

4.0 ANALYSIS OF MEASUREMENT RESULTS

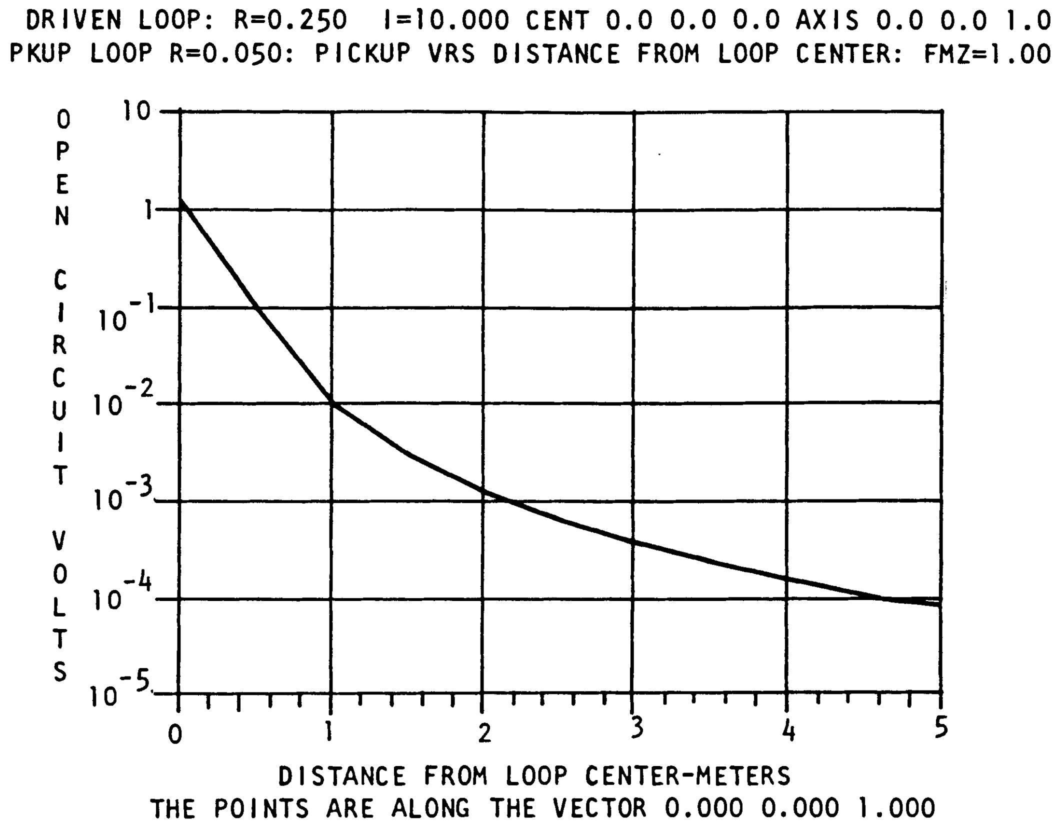
4.1 LOOP DATA ANALYSIS

The raw data listing of Appendix B is difficult to interpret even if exactly the same frequencies were used at each location and exactly the same loop source currents were obtained. In order to compare the results at differing locations we have lumped all frequencies that are close together, e.g. all 0.173, 0.174 and 0.175 frequencies are lumped together for clarity. Specifically we have lumped all data for frequencies 1.71 to 1.75 MHz into 1.73 MHz data; all 0.52 MHz data into 0.53 MHz data; all 5.7 to 5.8 MHz data into 5.0 MHz data, and all 9.0 to 9.8 MHz data into 10 MHz data. In every case we have scaled the pickup for the frequency change assuming that the pickup is proportional to frequency. Also, we expect all results of these experiments to be linear in relation to source current. Therefore, all source currents can be normalized to a single value if the "pickups" are changed by the same factor. Applying these rules and normalizing all the data to a 10 ampere source current, we have plotted the results for all frequencies (1.73, 0.5, 1.0, 5.0 and 10.0 MHz) for both possible directions of the loop axis and for both X=0 and Z=0 data. These plots are given in Appendix D. Note that some individual curves show a sawtooth pattern. This is the result of our plotting both the result at a negative coordinate and a positive coodinate at the same positive value of the coordinate. Each individual curve on a given graph thus presents all data for a single location and direction along the indicated coordinate.

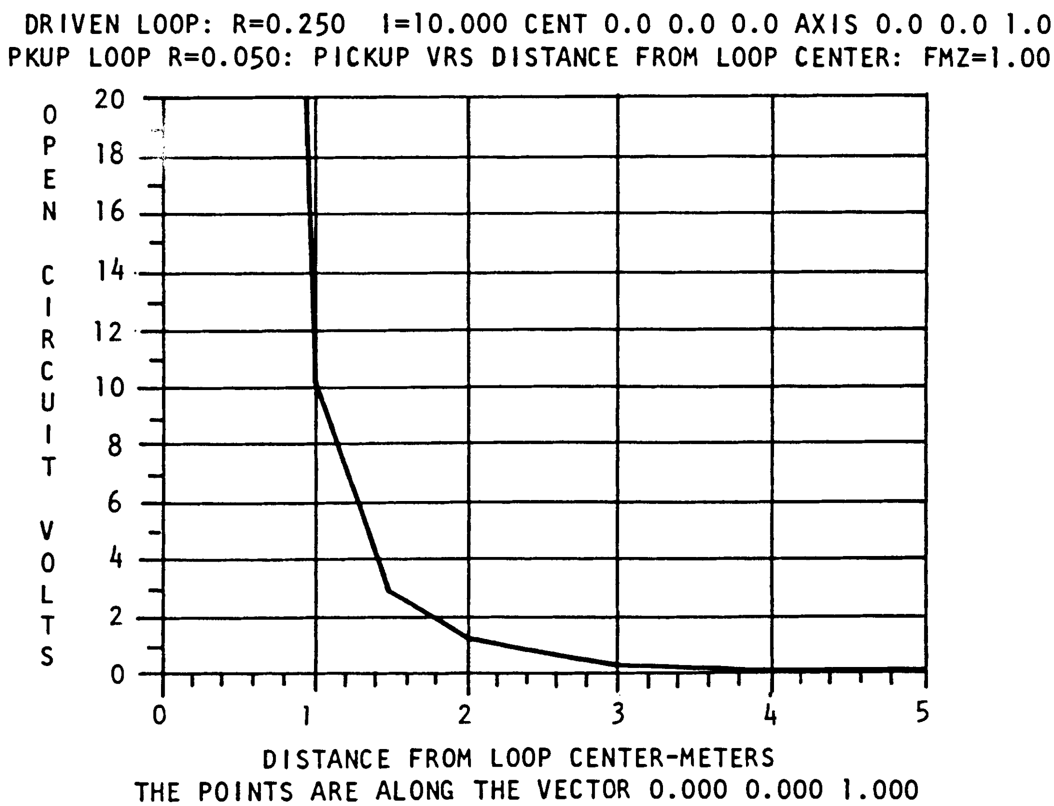
The curves of Appendix D, then, present a good visual picture of the variation from location to location for the same conditions. Our overall interest is in determining how far our measurement data deviates from a computed free space value. The free space values of induced voltage in a 10 cm diameter loop at various distances from a 0.5 meter diameter receiving loop along both the X and Z axes can easily be computed for a frequency of 1 MHz. These data are shown in Figures 4 and 5. Note that Figure 4-B expands Figure 4-A at the 1 meter point where our first data point in the Z direction was taken. Figure 5 provides the same data for the X direction. Tables 1 and 2 present the same data in tabular form. Thus, we know the calculated data for all the data points at 1 MHz.

The pickup values at all frequencies are assumed to be proportional to $\frac{\partial B}{\partial t}$, thus all pickups can be scaled to any other frequency. For the 10 MHz data we can simply divide the measured pickup by 10 to scale it to 1 MHz. Appendix E presents all the loop data scaled to 1 MHz and 10 amperes source loop current. It also presents the free space calculated value for data and the ratio of measured over calculated values. This ratio of measured to calculated values is precisely the "correction factor" mentioned in the Introduction.

(text continued on page 31)

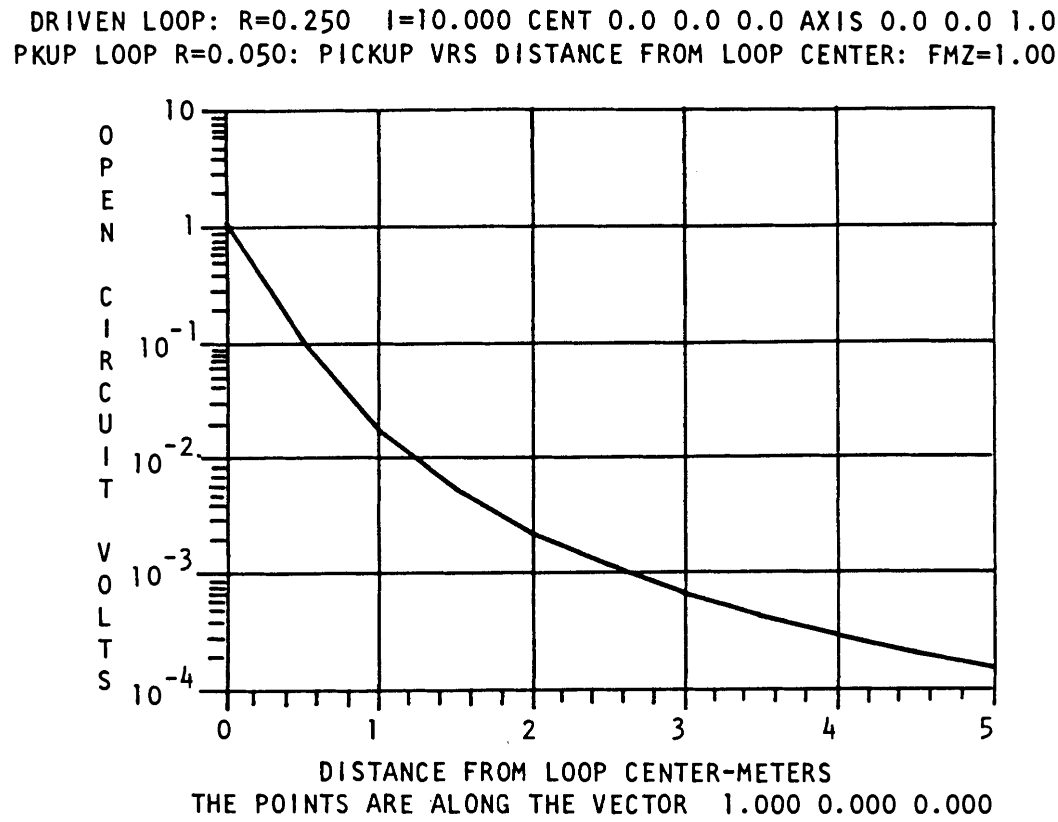


(A)

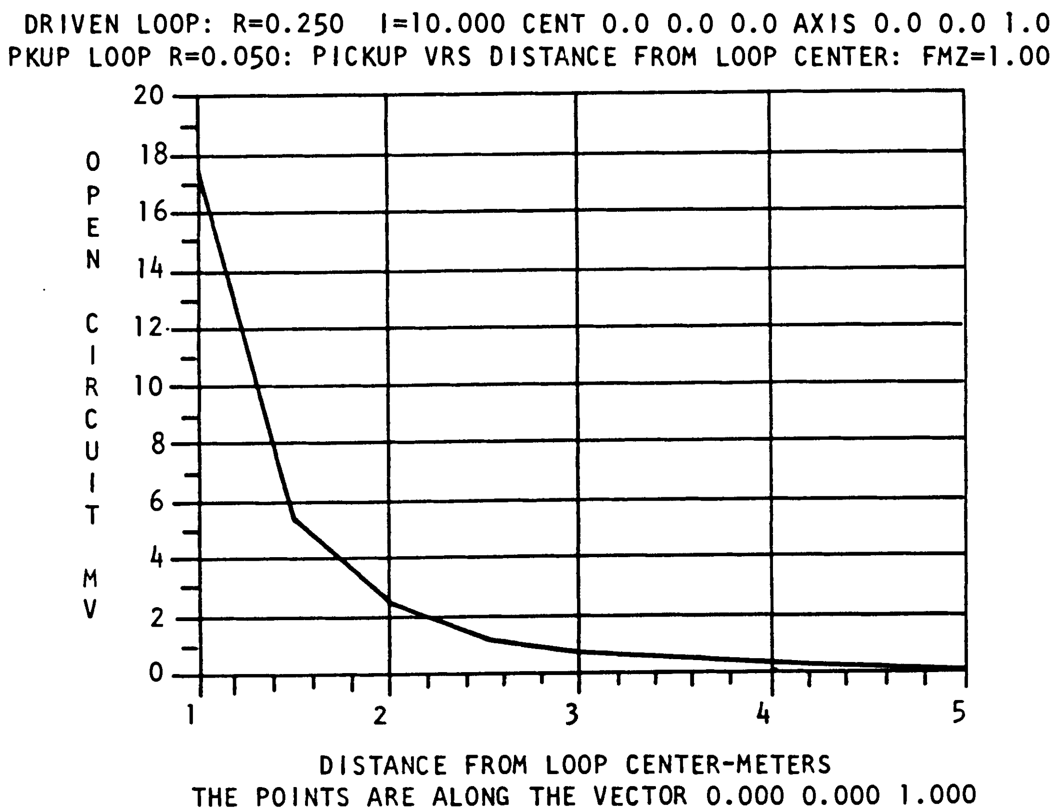


(B)

Figure 4. Calculated Z Pickup



(A)



(B)

Figure 5. Calculated X Pickup

TABLE 1. - Computed Pickup for a 0.5 CM Radius Loop Source Current is a 10 Ampere Loop of 0.25 M Radius

Distance Z (Meters)	Pickup (Volts)
0.000000	1.240850
0.500000	0.110916
1.000000	0.017693
1.500000	0.005512
2.000000	0.002368
2.500000	0.001223
3.000000	0.000711
3.500000	0.000450
4.000000	0.000302
5.000000	0.000155

TABLE 2. - Computed Pickup for a 0.5 CM Radius Loop Source Current is a 10 Ampere Loop of 0.25 M Radius

Distance X (Meters)	Pickup (Volts)
0.000000	1.240850
0.500000	0.106922
1.000000	0.010413
1.500000	0.002961
2.000000	0.001231
2.500000	0.000361
3.000000	0.000227
3.500000	0.000227
4.000000	0.000151
4.500000	0.000106
5.000000	0.000077

(text continued from page 27)

Comparison of data from location to location or direction to direction is difficult in Appendix E. Table 3 gives a breakdown of the ways the ratio of measured to calculated pickup varies with direction. Here, all measurements along a given axis, at a given frequency, are lumped together. Note the table suggests that changing the direction of the loop axis has only a small effect on the data obtained. As explained earlier, direction refers to the loop axis direction.

Table 4 gives much the same data as Table 3 but here direction of the axis is ignored.

Table 5 breaks down the variation in the ratio for each measurement distance and direction. Note that high values of the ratio seems to be associated most frequently with high values of X or Z.

Appendix F investigates this association in detail. Here, each ratio larger than 2, 3, 4, 5 ... is listed so that distance, location, direction can all be evaluated. There were approximately 193 data points taken at each location. Study of Appendix F shows that these were 294 points greater than 2. Of these, 103 occurred at Location 5 -- our most conductor rich location. Study of the locations and conditions for values of the ratio greater than 5 shows that there were 29 such values and, of these, only 3 occur at distances less than 2.5 or 3 meters. At these distances (2.5 and 3 meters) we are close to our noise level and small changes in field can make large changes in our ratio. Also, note that 16 of the 29 values are from location 5 and location 1 -- our high conductor density locations.

For ratios equal or greater than 7 all 10 occur close to the wall of the drift -- except one occurring in location 5. The values of the ratio greater than 8 all show the same pattern. We checked these against the data notebook and some show marginal notations showing that they were taken close to conductors.

Figures 6 and 7 are bar graphs of the occurrence of various values of the ratio on differing scales. We see that we had only 29 of 1744 occurrences of the ratio larger than 5 -- approximately 1.7% -- and it seems that most of these are associated with measurements close to conductors and relatively far (2 to 3 meters) from the source loops.

Table 6 is the output of a commonly available statistics program (STP) that evaluated the basic statistics for the 1744 values of the measured to collected ratios. Table 7 is an evaluation of the same data by the program that prepared the previously presented breakdowns. We present it here to show the agreement.

(text continued to page 42)

TABLE 3. - Ratio of Normalized Data to Computed Value for the Data Normalized in Frequency and Drive Current to 1 MHz and 10.0 Amps

Direction is Loop Axis Direction

WITH X=0.0 AND DIRECTION= ALONG THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	2.4	.7	1.4	99	.3
.530	5.4	.1	1.6	107	.9
1.000	2.7	.5	1.3	108	.3
5.000	2.7	.6	1.3	81	.4
10.000	3.7	.4	1.4	104	.6

NOTE THAT SIGMA (S) IS COMPUTED FROM:
S**2=(1/(N-1))*(SUM((X-MEAN)**2)
WHERE: N=# OFITEMS; X IS PICKUP; AND MEAN IS THE MEAN OF THE PICKUPS

WITH X=0.0 AND DIRECTION= ACROSS THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	2.0	.5	1.2	85	.3
.530	4.8	.9	1.7	88	.8
1.000	4.1	.4	1.6	87	.7
5.000	4.2	.6	1.4	67	.5
10.000	3.5	.6	1.4	66	.5

WITH Z=0.0 AND DIRECTION= ALONG THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	3.2	.8	1.7	71	.4
.530	7.1	.7	2.0	87	1.3
1.000	2.8	1.0	1.6	85	.4
5.000	8.0	.4	1.9	63	1.2
10.000	13.0	.4	2.9	92	2.4

WITH Z=0.0 AND DIRECTION= ACROSS THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	3.3	.9	1.6	89	.4
.530	5.8	.8	1.8	100	.9
1.000	5.3	.9	1.8	104	.8
5.000	6.1	.5	2.0	79	1.1
10.000	7.5	.5	2.4	82	1.5

TABLE 4. - Ratio of Normalized Data to Computed Value For the Data Normalized in Frequency and Drive Current to 1 MHz and 10.0 Amps

Direction is Loop Axis Direction

FREQ(MHZ)	PICKUP RATIO MAX	MIN	AVG.	# OF ITEMS	SIGMA
WITH X=0.0					
.173	2.4	.5	1.3	184	.3
.530	5.4	.1	1.6	195	.9
1.000	4.1	.4	1.4	195	.5
5.000	4.2	.6	1.4	148	.4
10.000	3.7	.4	1.4	170	.5
WITH Z=0.0					
.173	3.3	.8	1.7	160	.4
.530	7.1	.7	1.9	187	1.1
1.000	5.3	.9	1.7	189	.7
5.000	8.0	.4	2.0	142	1.1
10.000	13.0	.4	2.7	174	2.0
FOR ALL DATA					
.173	3.3	.5	1.5	344	.4
.530	7.1	.1	1.8	382	1.0
1.000	5.3	.4	1.6	384	.6
5.000	8.0	.4	1.6	290	.9
10.000	13.0	.4	2.0	344	1.6

NOTE THAT SIGMA (S) IS COMPUTED FROM:
S**2=(1/(N-1))*(SUM((X-MEAN)**2)
WHERE: N=# OF ITEMS; X is PICKUP; AND MEAN IS THE MEAN OF THE PICKUPS

Table 4 (Cont.)

WITH X=0.0 ; Z=1.5 AND DIRECTION= ALONG THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	1.6	.7	1.2	19	.2
.530	3.8	.1	1.5	18	.8
1.000	2.7	.9	1.4	18	.4
5.000	1.8	.8	1.2	13	.3
10.000	2.0	.7	1.2	20	.4

WITH X=0.0 ; Z=1.5 AND DIRECTION= ACROSS THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	1.5	.7	1.2	18	.2
.530	4.7	1.1	1.7	18	1.0
1.000	3.1	1.1	1.6	18	.6
5.000	2.3	.7	1.3	16	.4
10.000	1.7	.6	1.2	15	.3

WITH X=0.0 ; Z=2.0 AND DIRECTION= ALONG THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	1.7	1.0	1.4	19	.2
.530	3.9	.9	1.6	18	.8
1.000	1.5	.9	1.3	18	.2
5.000	1.6	1.0	1.2	12	.2
10.000	2.7	.6	1.4	17	.6

WITH X=0.0 ; Z=2.0 AND DIRECTION= ACROSS THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	1.9	.5	1.3	14	.4
.530	3.6	1.1	1.6	15	.8
1.000	3.6	.8	1.6	15	.7
5.000	1.6	.6	1.3	8	.4
10.000	2.4	.9	1.4	10	.5

WITH X=0.0 ; Z=2.5 AND DIRECTION= ALONG THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	1.9	1.1	1.7	15	.2
.530	4.8	.7	1.7	16	1.1
1.000	1.6	1.0	1.3	18	.2
5.000	1.8	.7	1.3	12	.4
10.000	2.5	.4	1.5	15	.6

Table 4 (Cont.)

WITH X=0.0 ; Z=2.5 AND DIRECTION= ACROSS THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	1.9	.7	1.3	11	.4
.530	3.4	.9	1.7	13	.8
1.000	4.1	1.0	1.8	11	.9
5.000	2.2	.9	1.5	7	.5
10.000	2.3	.6	1.5	6	.7

WITH X=0.0 ; Z=3.0 AND DIRECTION= ALONG THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	2.4	1.4	1.8	8	.4
.530	5.4	1.1	1.8	17	1.2
1.000	1.7	1.0	1.3	18	.2
5.000	2.7	.6	1.6	12	.7
10.000	3.7	.7	2.2	12	.9

WITH X=0.0 ; Z=3.0 AND DIRECTION= ACROSS THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	2.0	1.1	1.3	6	.4
.530	3.0	1.1	1.7	6	.7
1.000	2.5	.4	1.6	7	.8
5.000	4.2	.7	2.1	4	1.5
10.000	3.5	1.1	2.1	3	1.2

WITH X= .5 ; Z=0.0 AND DIRECTION= ALONG THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	3.2	.8	1.8	17	.6
.530	7.1	1.0	2.1	18	1.5
1.000	2.5	1.0	1.6	16	.4
5.000	2.7	.9	1.7	16	.4
10.000	3.4	.8	2.0	20	.8

WITH X= .5 ; Z=0.0 AND DIRECTION= ACROSS THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	2.4	.9	1.4	18	.4
.530	3.6	.8	1.6	18	.8
1.000	5.3	1.2	2.2	18	1.1
5.000	2.5	1.1	1.7	16	.4
10.000	4.0	.8	1.7	16	.9

Table 4 (Cont.)

WITH X=1.0 ; Z=0.0 AND DIRECTION= ALONG THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	2.0	1.0	1.5	17	.3
.530	4.6	1.1	1.8	18	1.0
1.000	2.2	1.0	1.4	18	.3
5.000	1.8	.9	1.4	16	.3
10.000	2.2	.4	1.4	20	.5

WITH X=1.0 ; Z=0.0 AND DIRECTION= ACROSS THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	2.4	1.1	1.5	18	.3
.530	4.1	1.1	1.6	18	.8
1.000	4.3	1.2	1.8	18	.8
5.000	1.9	.5	1.3	15	.4
10.000	2.1	.5	1.5	16	.4

WITH X=1.5 ; Z=0.0 AND DIRECTION= ALONG THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	1.9	1.1	1.6	17	.2
.530	5.0	.7	1.8	18	1.1
1.000	2.8	1.1	1.5	18	.4
5.000	4.0	.4	1.7	13	.9
10.000	3.6	.8	2.0	19	.7

WITH X=1.5 ; Z=0.0 AND DIRECTION= ACROSS THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	2.7	.9	1.5	18	.4
.530	4.1	1.1	1.6	18	.8
1.000	3.8	.9	1.6	18	.7
5.000	3.5	.7	1.8	14	.7
10.000	2.9	1.1	1.9	15	.6

WITH X=2.0 ; Z=0.0 AND DIRECTION= ALONG THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	2.1	1.0	1.7	12	.3
.530	4.8	1.1	1.9	15	1.1
1.000	2.3	1.1	1.5	15	.3
5.000	3.5	1.1	2.2	8	.9
10.000	6.7	1.2	3.3	15	1.6

Table 4 (Cont.)

WITH X=2.0 ; Z=0.0 AND DIRECTION= ACROSS THE DRIFT

FREQ(MHZ)	PICKUP RATIO MAX	MIN	AVG.	# OF ITEMS	SIGMA
.173	2.8	1.4	1.8	16	.5
.530	3.8	1.1	1.6	18	.8
1.000	4.1	.9	1.6	18	.7
5.000	2.8	.9	1.9	12	.7
10.000	4.3	1.3	2.6	14	.9

WITH X=2.5 ; Z=0.0 AND DIRECTION= ALONG THE DRIFT

FREQ(MHZ)	PICKUP RATIO MAX	MIN	AVG.	# OF ITEMS	SIGMA
.173	2.7	1.8	2.0	6	.4
.530	6.1	1.1	2.3	13	1.6
1.000	2.4	1.3	1.8	13	.3
5.000	6.1	1.4	2.9	6	1.7
10.000	8.3	2.4	5.2	11	1.9

WITH X=2.5 ; Z=0.0 AND DIRECTION= ACROSS THE DRIFT

FREQ(MHZ)	PICKUP RATIO MAX	MIN	AVG.	# OF ITEMS	SIGMA
.173	2.6	1.3	1.9	13	.4
.530	4.8	1.3	1.9	18	1.1
1.000	4.3	1.0	1.8	17	.7
5.000	3.5	1.0	2.2	11	.9
10.000	6.2	1.6	3.5	11	1.6

WITH X=3.0 ; Z=0.0 AND DIRECTION= ALONG THE DRIFT

FREQ(MHZ)	PICKUP RATIO MAX	MIN	AVG.	# OF ITEMS	SIGMA
.173	1.9	1.9	1.9	2	
.530	6.9	1.4	2.7	5	2.4
1.000	2.5	1.4	1.8	3	.6
5.000	8.0	1.4	4.0	4	3.1
10.000	13.0	3.3	8.1	7	3.7

WITH X=3.0 ; Z=0.0 AND DIRECTION= ACROSS THE DRIFT

FREQ(MHZ)	PICKUP RATIO MAX	MIN	AVG.	# OF ITEMS	SIGMA
.173	3.3	1.9	2.2	6	.6
.530	5.8	1.4	2.4	10	1.5
1.000	4.4	1.1	2.0	15	.8
5.000	6.1	.8	3.3	11	1.9
10.000	7.5	2.8	4.6	10	1.9

TABLE 5. - Ratio of Normalized Data to Computed Value For the Data Normalized in Frequency and Drive Current to 1 MHz and 10.0 Amps

Direction is Loop Axis Direction

WITH X=0.0 ; Z= .5 AND DIRECTION= ALONG THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	1.7	.9	1.2	19	.2
.530	4.2	1.1	1.6	18	.8
1.000	1.7	.8	1.3	18	.3
5.000	1.9	1.2	1.4	16	.2
10.000	1.7	.6	1.3	20	.3

NOTE THAT SIGMA (S) IS COMPUTED FROM:
S**2=(1/(N-1))*(SUM((X-MEAN)**2)
WHERE: N=# OFITEMS; X IS PICKUP; AND MEAN IS THE MEAN OF THE PICKUPS

WITH X=0.0 ; Z= .5 AND DIRECTION= ACROSS THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	1.8	.7	1.2	18	.3
.530	4.4	1.0	1.7	18	.9
1.000	4.1	1.0	1.6	18	.7
5.000	1.7	1.3	1.5	16	.1
10.000	2.1	1.1	1.5	16	.3

WITH X=0.0 ; Z=1.0 AND DIRECTION= ALONG THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	1.6	.9	1.2	19	.2
.530	3.6	1.0	1.6	18	.7
1.000	2.3	.5	1.3	18	.4
5.000	1.5	.6	1.2	16	.2
10.000	1.8	.6	1.2	20	.3

WITH X=0.0 ; Z=1.0 AND DIRECTION= ACROSS THE DRIFT

FREQ(MHZ)	PICKUP RATIO			# OF ITEMS	SIGMA
	MAX	MIN	AVG.		
.173	1.6	.7	1.2	18	.2
.530	4.8	1.1	1.7	18	.9
1.000	3.2	.7	1.5	18	.7
5.000	2.1	.9	1.3	16	.3
10.000	1.6	.9	1.2	16	.2

PKUP = Measured Value/Expected Free Space Measured Value

```
***** BAR GRAPH FOR VARIABLE: PKUP  *****

 RANGE OF VALUES         FREQ  PCENT +----+----+----+----+
.0000     -  1.000        184   10.6 IXXX
1.000     -  2.000       1282   73.5 IXXXXXXXXXXXXXXXXXX
2.000     -  3.000        157    9.0 IXX
3.000     -  4.000         52    3.0 IX
4.000     -  5.000         40    2.3 IX
5.000     -  6.000         10    0.6 I
6.000     -  7.000         10    0.6 I
7.000     -  8.000          4    0.2 I
8.000     -  16.00          5    0.3 I
                         ----        +----+----+----+----+
                         1744             ^    ^    ^    ^
                                       20.0 40.0 60.0 80.0
                                                 PERCENTAGE
```

Figure 6. Bar Graph for Variable: PKUP

PKUP = Measured Value/Expected Free Space Measured Value

***** BAR GRAPH FOR VARIABLE: PKUP *****

RANGE OF VALUES			FREQ	PCENT	+----+----+----+----+
.1000E+00	-	.3580	1	0.1	I
.3580	-	.6160	20	1.1	IX
.6160	-	.8740	42	2.4	IX
.8740	-	1.132	272	15.6	IXXXXXXXX
1.132	-	1.390	347	19.9	IXXXXXXXXXX
1.390	-	1.648	518	29.7	IXXXXXXXXXXXXXXX
1.648	-	1.906	233	13.4	IXXXXXXX
1.906	-	2.164	61	3.5	IXX
2.164	-	2.422	52	3.0	IX
2.422	-	2.680	35	2.0	IX
2.680	-	2.938	32	1.8	IX
2.938	-	3.196	17	1.0	I
3.196	-	3.454	18	1.0	IX
3.454	-	3.712	16	0.9	I
3.712	-	3.970	8	0.5	I
3.970	-	4.228	14	0.8	I
4.228	-	4.486	8	0.5	I
4.486	-	4.744	8	0.5	I
4.744	-	5.002	13	0.7	I
5.002	-	5.260	0	0.0	I
5.260	-	5.518	6	0.3	I
5.518	-	5.776	1	0.1	I
5.776	-	6.034	3	0.2	I
6.034	-	6.292	5	0.3	I
6.292	-	6.550	0	0.0	I
6.550	-	6.808	1	0.1	I
6.808	-	7.066	4	0.2	I
7.066	-	7.324	1	0.1	I
7.324	-	7.582	2	0.1	I
7.582	-	7.840	0	0.0	I
7.840	-	8.098	1	0.1	I
8.098	-	8.356	1	0.1	I
8.356	-	8.614	0	0.0	I
8.614	-	8.872	0	0.0	I
8.872	-	9.130	1	0.1	I
9.130	-	9.388	0	0.0	I
9.388	-	9.646	0	0.0	I
9.646	-	9.904	0	0.0	I
9.904	-	10.16	0	0.0	I
10.16	-	10.42	0	0.0	I
10.42	-	10.68	2	0.1	I
10.68	-	10.94	0	0.0	I
10.94	-	11.19	0	0.0	I
11.19	-	11.45	0	0.0	I
11.45	-	11.71	0	0.0	I
11.71	-	11.97	0	0.0	I
11.97	-	12.23	0	0.0	I
12.23	-	12.48	0	0.0	I
12.48	-	12.74	0	0.0	I
12.74	-	13.00	1	0.1	I
			----		+----+----+----+----+
			1744		10.0 20.0 30.0 40.0
					PERCENTAGE

Figure 7. Bar Graph for Variable: PKUP

TABLE 6. - Normalized Pickup for All Mines

There are 1 variable and 1744 observations.

Var.	Means	Std. Dev.	Variance	
Pkup	1.696101	1.010665	1.021444	
Var.	Median	Mode	Maximum	Minimum
Pkup	1.400000	1.400000	13.00000	0.1000000E+00
Var.	Std Err of Mean	Skewness	Coef. of Var.	
Pkup	0.2420204E-01	3.968134	59.58756	

TABLE 7. - Ratio of Normalized Loop Data to Computed Value for the Data Normalized in Frequency and Drive Current to 1 MHz and 10.0 Amps

For All Loop Data

Pickup Ratio			No. of Items	Sigma
Max	Min	Avg.		
13.0	.1	1.7	1744	1.0107

(text continued from page 31)

4.2 TRANSMISSION LINE RESULTS

We have processed the transmission line (long line simulator) data in much the same manner as the loop data. In order to compare data at different mines the nearby frequencies are first grouped, e.g. 0.175, 0.74, 0.72 MHz, all go to 0.170 MHz, then all pickup data is normalized to a line current of 10 amperes. The data are all also normalized to a pickup for 1.0 MHz. The resulting data is plotted in Appendix G. Note that plots are presented for both Z = 0.5 and Z = 1.0 meters. This allows a comparison of the spread in the data for both mine location and Z distance.

We next computed the free space pickup from a 10 amp., 1 MHz current. This computation was performed by a specialized computer program. The results are given in Table 8. The computer program only computes the magnitude and direction of the H field. Pick up for the 10 cm diameter search loop was computed from:

$$\text{Pickup (volts)} = A\ \omega\mu\ |H|$$

where A = area of the pickup coil (radius 0.05 m)
$\omega = 2\pi \cdot \text{frequency} = 2\pi \times 10^6$ for $f = 10^6$
$\mu = 4\pi \times 10^{-7}$ h/m
$|H|$ = magnitude of the H field linking the search coil

Appendix H gives the computer program output.

Using the calculated pickup and the current normalized data we can compare the measured results to the calculated free space values. The comparison is given for each measurement in Appendix I. Table 9 breaks down the data by location and measurement point. Table 10 gives the basic statistics for all the transmission line measured/calculated ratios and Figures 8 and 9 are bar graphs of the distribution.

Note that there are only 4 of the 128 ratios more than 3 (about 3.2%) and of these, 2 occur at location 7 and 2 at location 8. Study of the notebook entries -- and Appendix C -- shows that all three values greater than 4 are associated with a measurement at 170 or 500 KHz at a point 0.5 meters from the plane of the rectangular loop and 1 meter from the floor. This measurement point is the one nearest to the driven wires of the loop. The field varies more rapidly at this point than at any other mesurement point. Errors in pickup measurement due to pickup loop location uncertainty would be expected to be maximum at this point.

(text continued on page 48)

TABLE 8. - Free Space H Field and Pickup From Transmission Line Wire Configuration -- 10 Amps at 1 MHz

Z Meters	Y Meters	H Amps/Meters	Pickup (mV)
0.5	0.5	3.21	199
0.5	1.0	1.3	80.6
0.5	1.5	0.664	41.176
1.0	0.5	1.3	80.6
1.0	1.0	0.826	51.22
1.0	1.5	0.52	32.2

TABLE 9. - For Transmission Line Data
All Data Normalized to 10 Amps and 1 MHz

RATIO OF MEASURED/CALCULATED FOR DATA

LOCATION	MIN	MAX	AVG	# ITEMS
1	.591	2.481	1.302	14
2	.764	2.256	1.218	16
3	.914	2.377	1.333	18
4	.680	1.997	1.093	16
5	.731	1.997	1.084	16
6	.607	1.861	.991	16
7	.827	4.726	2.354	8
8	.993	5.104	2.123	10
9	.837	2.995	1.549	14

RATIO OF MEASURED/CALCULATED FOR ALL DATA

MIN	MAX	AVG	# ITEMS
.591	5.104	1.361	128

RATIO OF MEASURED/CALCULATED FOR DATA
FOR ALL Y=.5 DATA

MIN	MAX	AVG	# ITEMS
.591	5.104	1.725	52

RATIO OF MEASURED/CALCULATED FOR DATA
FOR ALL Y=1.0 DATA

MIN	MAX	AVG	# ITEMS
.620	2.231	1.167	46

RATIO OF MEASURED/CALCULATED FOR DATA
FOR ALL Y=1.5 DATA

MIN	MAX	AVG	# ITEMS
.607	1.581	1.026	30

RATIO OF MEASURED/CALCULATED FOR DATA
FOR ALL Z=0.5 DATA

MIN	MAX	AVG	# ITEMS
.591	1.914	.980	64

RATIO OF MEASURED/CALCULATED FOR DATA
FOR ALL Z=1.0 DATA

MIN	MAX	AVG	# ITEMS
.731	5.104	1.741	64

TABLE 10. - Transmission Line Data Basic Statistics

Transmission Line - Measured/Calculated

There are 1 variable and 128 observations.

Var.	Means	Std. Dev.	Variance
Pkup	1.360641	0.7601704	0.5778590

Var.	Median	Mode	Maximum	Minimum
Pkup	1.116000	0.6200000	5.104000	0.591000

More than 1 mode exists - only the first is shown.

Var.	Std Err of Mean	Skewness	Coef. of Var.
pkup	0.6719020E-01	2.552539	55.86856

PKUP = Measured Value/Expected Free Space Measured Value

```
           ***** BAR GRAPH FOR VARIABLE: PKUP   *****

 RANGE OF VALUES          FREQ   PCENT  +----+----+----+----+
.0000     -    .5000        0      0.0  I
.5001     -   1.000        48     37.5  IXXXXXXXXXXXXXXXXXXX
1.000     -   1.500        46     35.9  IXXXXXXXXXXXXXXXXXX
1.500     -   2.000        18     14.1  IXXXXXXX
2.000     -   2.500         8      6.3  IXXX
2.500     -   3.000         4      3.1  IXX
3.000     -   3.500         1      0.8  I
3.500     -   4.000         0      0.0  I
4.000     -   4.500         0      0.0  I
4.500     -   5.000         2      1.6  IX
5.000     -   5.500         1      0.8  I
                          ----          +----+----+----+----+
                          128                ^    ^    ^    ^
                                          10.0 20.0 30.0 40.0
                                                    PERCENTAGE
```

Figure 8. Bar Graph of Measured/Calculated Ratio Distribution-Coarse Division

PKUP = Measured Value/Expected Free Space Measured Value

```
XMISSION LINE - MEASURED/CALCULATED

        ***** BAR GRAPH FOR VARIABLE: PKUP  *****

 RANGE OF VALUES        FREQ  PCENT +----+----+----+----+
.5910    -  .6813         5    3.9 IXXXX
.6813    -  .7715         6    4.7 IXXXXX
.7715    -  .8618        19   14.8 IXXXXXXXXXXXXXXX
.8618    -  .9520        11    8.6 IXXXXXXXXX
.9520    -  1.042        14   10.9 IXXXXXXXXXXX
1.042    -  1.133        12    9.4 IXXXXXXXXX
1.133    -  1.223         8    6.3 IXXXXXX
1.223    -  1.313         7    5.5 IXXXXX
1.313    -  1.403         7    5.5 IXXXXX
1.403    -  1.494         5    3.9 IXXXX
1.494    -  1.584         3    2.3 IXX
1.584    -  1.674         0    0.0 I
1.674    -  1.764         5    3.9 IXXXX
1.764    -  1.855         4    3.1 IXXX
1.855    -  1.945         2    1.6 IXX
1.945    -  2.035         5    3.9 IXXXX
2.035    -  2.125         2    1.6 IXX
2.125    -  2.216         0    0.0 I
2.216    -  2.306         3    2.3 IXX
2.306    -  2.396         1    0.8 IX
2.396    -  2.486         1    0.8 IX
2.486    -  2.577         0    0.0 I
2.577    -  2.667         1    0.8 IX
2.667    -  2.757         1    0.8 IX
2.757    -  2.847         0    0.0 I
2.847    -  2.938         1    0.8 IX
2.938    -  3.028         1    0.8 IX
3.028    -  3.118         0    0.0 I
3.118    -  3.209         0    0.0 I
3.209    -  3.299         0    0.0 I
3.299    -  3.389         1    0.8 IX
3.389    -  3.479         0    0.0 I
3.479    -  3.570         0    0.0 I
3.570    -  3.660         0    0.0 I
3.660    -  3.750         0    0.0 I
3.750    -  3.840         0    0.0 I
3.840    -  3.931         0    0.0 I
3.931    -  4.021         0    0.0 I
4.021    -  4.111         0    0.0 I
4.111    -  4.201         0    0.0 I
4.201    -  4.292         0    0.0 I
4.292    -  4.382         0    0.0 I
4.382    -  4.472         0    0.0 I
4.472    -  4.562         1    0.8 IX
4.562    -  4.653         0    0.0 I
4.653    -  4.743         1    0.8 IX
4.743    -  4.833         0    0.0 I
4.833    -  4.923         0    0.0 I
4.923    -  5.014         0    0.0 I
5.014    -  5.104         1    0.8 IX
                       ----        +----+----+----+----+
                        128             .    .    .    .
                                      5.0 10.0 15.0 20.0
                                                PERCENTAGE
```

Figure 9. Bar Graph of Measured/Calculated
Ratio Distribution - Fine Division

(text continued from page 42)

5. CONCLUSIONS FROM MEASUREMENTS

Study of our data indicates that, for frequencies of 10 MHz and below, an adequate approximation for the magnitude of the magnetic field, for use in blasting safe distances, can be computed from the free space predictions of the magnetic field if we use a multiplying factor of 5.

Only one of our transmission line measurements showed ratios as high as 5 and of the 1.7% of our loop measurements that were greater than 5, most seem to be associated with measurements taken very close to conductors or in -- or close to -- our noise level for the measurement. Further, those ratios greater than 5 that were not associated with measurement near conductors or close to the noise level are isolated, i.e. the neighboring values are not greater than five. This indicates a "hot spot" of small extent or errors in the measurements. For use in the calculation of blasting safe distances, we speculate that "hot spots" of very localized extent will not contribute unduly to the overall pickup and they can be safely ignored.

This is, quite clearly, <u>not</u> a worst case assumption. We believe that existence and extent of "hot spots" should be investigated experimentally with equipment having greater sensitivity and lower noise levels than that used in the work described in this report. A battery powered, well shielded, wide band (up to 15 MHz) amplifier used before the scope would probably solve the problem. We feel that such a program would show that any "hot spots" are of very localized nature and thus a factor of 5 can be safely used in prediction of hazard. If not, a higher multiplier can be used to modify the safe distances derived in this report.

6.0 SAFE DISTANCES FROM SOURCES

6.1 CRITICAL VALUES OF THE FIELD

In order to evaluate safe distances for blasting wire from transmission line and loop sources we assume -- as a worst case estimate -- that the shorted loop of blasting wiring is arranged normal to the B field produced by the source and that it is formed as a circle of area A square meters. This assures maximum area for a given lead length. Further, we assume that the B linking the loop is the maximum B anywhere in the loop. Thus, if the edge of the loop is at a given maximum of the source field and the field is less at other portions of the loop, we will use the maximum value of B everywhere in the loop. This is a worst case assumption. We further assume that the blasting wiring loop is loaded with only one cap and that its resistance is R_{dc} and R_{dc} equals 1 ohm. This, too, is a worst case assumption in that more resistance lessens power pickup and the nominal resistance of American made caps is 1.2 ohms or greater (Reference 7, p. 4-3). This is, of course, true only for low frequencies where the radiation resistance of the pickup antenna is much less than one ohm. That is the case here considered.

The maximum open circuit voltage included in the blasting wiring is then

$$V_b = A \frac{\partial}{\partial t} |B_m| \cos \omega t \quad \text{volts} \tag{2}$$

where $\omega = 2\pi \cdot f_{MHz} \times 10^6$

f_{MHz} = frequency in megahertz

$|B_m|$ = the maximum B field magnitude linking the loop (maxwells). Note that we will use this notation throughout this report, i.e. $|A|$ is read as "magnitude of the vector (or phasor) A."

A = area of the blasting cap (m^2)

V_b = open circuit voltage (volts)

In terms of the H field ($B = \mu H$)

$$|V_b| = A\omega\mu |H| \tag{3}$$

where $\mu = 4\pi \times 10^{-7}$ henrys/meter, and

$|H|$ = maximum $|H|$ linking the loop - amps/meter.

The total current I_B that will flow in the blasting wiring loop is

$$|I_B| = \frac{|V_B|}{|Z_b|} = \frac{A\mu\omega|H}{|Z_b|} \quad \text{amps} \tag{4}$$

where Z_b is the total impedance of the blasting wiring loop. This impedance includes R_{dc} -- the blasting cap resistance -- any reactance of the cap, any internal drop of the wire forming the loop and the external inductance for the loop. The external inductance term is of considerable importance for our application. It represents the reduction in current flow due to the reduction of the linking B field by the field produced by the current in the loop. Reference 8, Chapter 5, gives an excellent outline of these points. We recommend that the interested reader review this chapter if difficulty is encountered in the following exposition.

Thus, $Z_b = R_{dc} + Z_i + j\ \omega\ L_o + j\ X_{cap}$ (5)

where Z_i is the internal impedance of the blasting wire forming the loop,
L_o is the external inductance of the loop (henrys) and,
X_{cap} is the reactance of the cap (ohms).

We will assume that the blasting wire that forms the pickup loop is 20 gauge (B & W) copper wire. Caps are usually supplied in 22 gauge for short leads (30 feet or less) and 20 gauge for longer wires. The assumption of 20 gauge wire results in a tiny bit more pickup than the 22 gauge wire assumption. Thus, using the 20 gauge wire in the calculations is conservative. 20 gauge wire has a diameter of 31.96 mils (0.8118 millimeters) and a dc resistance of 10.15 ohms/1000 feet. Figure 10 is from reference 8, p. 297. It shows the variation of the internal impedance terms for round wires in terms of R_o (the dc resistance), r_o (the radius of the wire) and δ (the skin depth). Figure 11 gives the same data in a more accessible way for the internal resistance term. In this figure ρ_R is resistivity in relation to copper and μ_R is permeability in relation to free space.

Using these figures, we compute that

$$Z_i = \left\{0.008 + 0.102\ (1+j)\ \sqrt{f_{MHz}}\right\} \text{ ohms/meter} , \tag{6}$$

where f_{MHz} is frequency in megahertz.

For a circle of this wire of area A square meters,

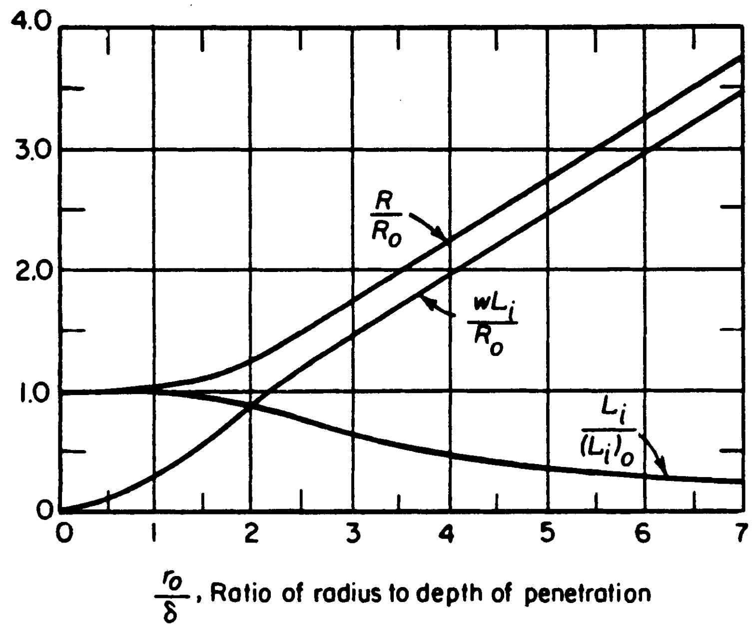


Figure 10. Solid Wire Skin Effect Quantities Compared with d-c Values

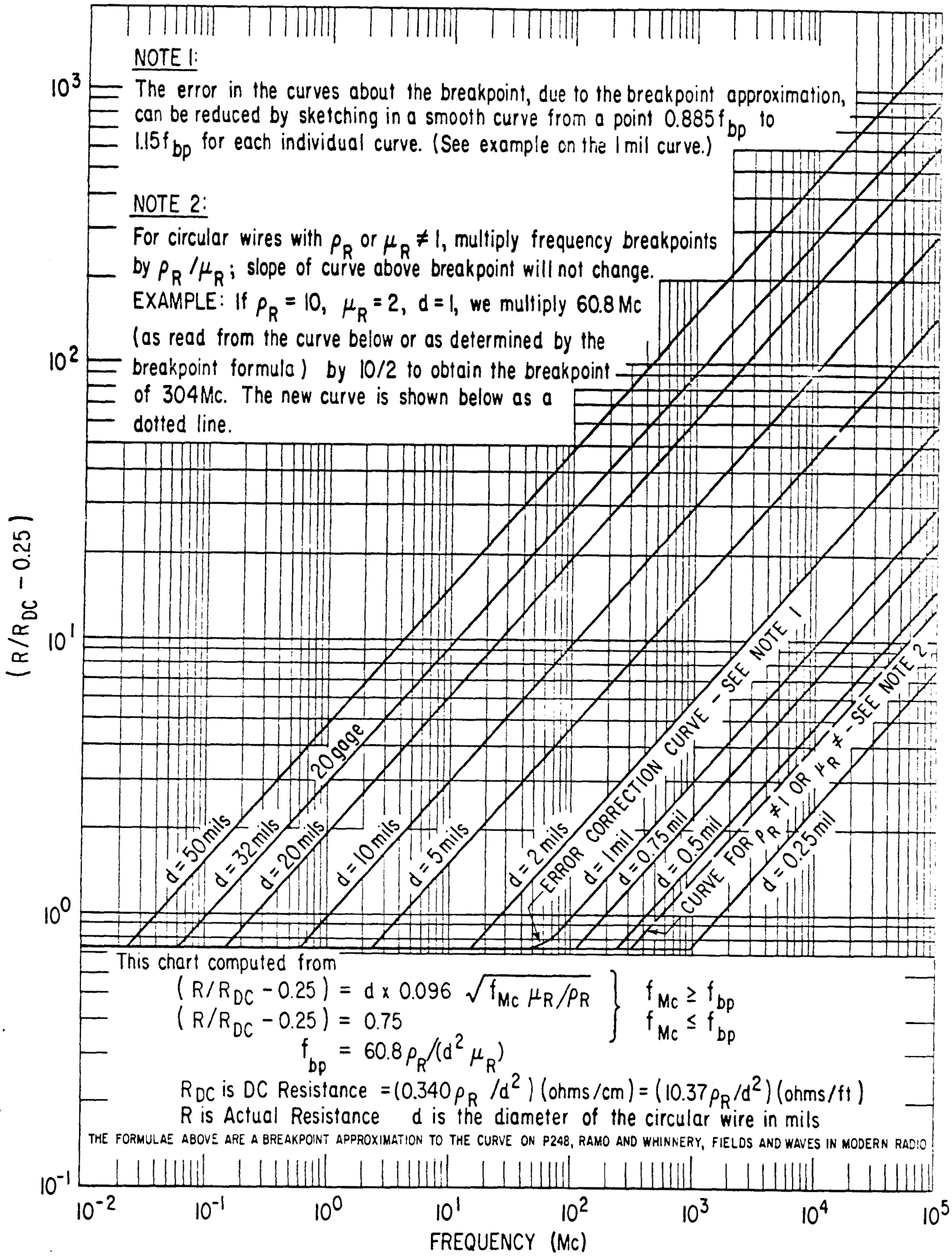


Figure 11. $(R/R_{DC} - 0.25)$ vs. Frequency for A Circular Wire $\rho_R = \mu_R = 1$

$$Z_i = \sqrt{A\pi}\left\{0.016 + 0.204\ (1+j)\ \sqrt{f_{MHz}}\right\}\ \text{ohms}, \tag{7}$$

since the circumference equals 2π times the radius and the radius is equal to the square root of the area divided by π.

The X_{cap} term is of the form ωL_c, where L_c is the external inductance of the small rectangular loop (approximately 1mm x 1 cm) formed where the cap leads enter the base of the cap through the cap plug. The external inductance for a circular loop of the same area can be evaluated using (see reference 8, page 311).

$$L = r_o\ \mu\left[\ell n\left(\frac{8\ r_o}{a_c}\right) - 2\right]\qquad \text{henrys}, \tag{8}$$

where r_o is the radius of the loop (m), $\mu = 4\pi \times 10^{-7}$ (h/m) and a_c is the radius of the wire (m). Since the area of our loop is $(10^{-3} \times 10^{-2}) = 10^{-5}\ m^2$, $a_c = 8.1 \times 10^{-4}$m and $r = \sqrt{A/\pi}$ for a circle, we compute

$$L_c = 0.00196\ \text{microhenrys}$$

The L_o term of (6-4) is evaluated in the same way from equation 8; we obtain

$$L_o = \sqrt{\frac{A}{\pi}} \cdot 4 \cdot 10^{-1}\left[\ell n\left(\frac{8\sqrt{\frac{A}{\pi}}}{0.8118 \cdot 10^{-3}}\right) - 2\right]\ \text{microhenrys} \tag{9}$$

We can now write equation (5) as

$$Z_o = R_{dc} + \sqrt{A\pi}\left\{0.016 + 0.204\ (1+j)\ \sqrt{f_{MHz}}\right\}$$
$$+ j\omega\sqrt{\frac{A}{\pi}} \cdot 4\pi \cdot 10^{-7}\left[\ell n\left(\frac{8\sqrt{\frac{A}{\pi}}}{0.8118\ 10^{-3}}\right) - 2\right] + j\omega \cdot 1.96 \cdot 10^{-9}\ \text{ohms} \tag{10}$$

At frequencies as high as 10 MHz and areas as large as 10 square meters, all of the terms can have magnitudes comparable to $R_{dc} = 1$ so we will retain them all in our calculations.

The no-fire power level (0.1% probability with 95% confidence) for American made caps is 0.04 watts (see Ref. 6). For a 1 ohm cap this gives a no-fire current level of 0.2 amperes. If we substitute this value for current in equation (4) we form an expression for $|H|$ that will just produce the no-fire current in the cap. Thus

$$0.2 = \frac{A\mu\omega |H|}{|Z_b|} \quad \text{amps,} \tag{11}$$

or

$$|H_c| = \frac{0.2\ |Z_b|}{A\mu\omega} \quad \text{a/m,} \tag{12}$$

where here we have written $|H_c|$ to call attention to the face that this is the critical value of $|H|$ and we have indicated that the magnitude of the impedance Z_b is to be used. Note that Z_b is given completely in terms of frequency and area (A) of the blasting cap wiring. We have used a computer program to evaluate equation (12). Table 11 lists the values of $|H_c|$ for frequencies up to 10 MHz and areas up to 10 square meters. Table 12 shows $|H_c|$ for a finer gradation of frequencies for the 0.1 to 1 MHz range.

Note that Tables 11 and 12 also give values for the L_o term of equation (9) (the column labeled microhenrys) and the ratio of the external reactance (ωL_o) to the dc resistance term (the column labeled X/RDC). RDC was assumed equal to 1 ohm.

If we can now calculate the free space values of $|H|$ due to various sources, we can determine safe distances for the blasting wiring configurations.

6.2 FREE SPACE VALUES OF THE FIELD FROM VARIOUS SOURCES

Our main concern is with small loop antennas such as those used in "back pack" applications and bandolier configurations. Also we are interested in the typical "trolley wire" communication systems.

(text continued on page 63)

TABLE 11. - Frequencies from 0.01 to 10 MHz

VALUES OF HAZARD CRITICAL H FIELD FOR VARIOUS CONDITIONS
RDC=1 OHM, CRITICAL HAZARD CURRENT = 0.2 AMPS

FOR PICKUP AREA= 0.000100 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.010000	25346.717000	0.001693	0.026937
0.031623	8017.672500	0.004852	0.024419
0.100000	2536.912600	0.014453	0.023002
0.316228	803.648980	0.044122	0.022206
1.000000	256.638170	0.136710	0.021758
3.162278	87.602976	0.427312	0.021506
10.000000	42.578767	1.342380	0.021365

FOR PICKUP AREA= 0.000316 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.010000	8019.391600	0.003370	0.053634
0.031623	2537.328200	0.009767	0.049156
0.100000	803.391260	0.029303	0.046637
0.316228	255.363250	0.089850	0.045221
1.000000	83.698559	0.279125	0.044424
3.162278	33.865993	0.873773	0.043976
10.000000	23.476313	2.747287	0.043724

FOR PICKUP AREA= 0.001000 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.010000	2538.258600	0.006708	0.106757
0.031623	803.516550	0.019629	0.098793
0.100000	254.888810	0.059259	0.094314
0.316228	82.000418	0.182390	0.091796
1.000000	29.401626	0.567869	0.090379
3.162278	16.437565	1.779934	0.089583
10.000000	14.427429	5.600504	0.089135

TABLE 11. - Frequencies from 0.01 to 10 MHz (Cont.)

VALUES OF HAZARD CRITICAL H FIELD FOR VARIOUS CONDITIONS
RDC=1 OHM, CRITICAL HAZARD CURRENT = 0.2 AMPS

FOR PICKUP AREA= 0.003162 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.010000	803.992080	0.013274	0.211270
0.031623	254.816410	0.039163	0.197106
0.100000	81.303556	0.118841	0.189142
0.316228	27.291609	0.366910	0.184663
1.000000	12.290029	1.144446	0.182144
3.162278	9.468130	3.590916	0.180728
10.000000	9.095986	11.305431	0.179932

FOR PICKUP AREA= 0.010000 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.010000	255.023160	0.026074	0.414983
0.031623	81.081456	0.077449	0.389797
0.100000	26.378213	0.236018	0.375634
0.316228	10.070351	0.730528	0.367669
1.000000	6.351298	2.281992	0.363191
3.162278	5.803572	7.166248	0.360672
10.000000	5.724734	22.572677	0.359256

FOR PICKUP AREA= 0.031623 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.010000	81.122809	0.050831	0.809006
0.031623	26.033408	0.151844	0.764218
0.100000	9.016372	0.464347	0.739032
0.316228	4.501701	1.440254	0.724869
1.000000	3.708405	4.504440	0.716904
3.162278	3.596779	14.155299	0.712426
10.000000	3.574220	44.604736	0.709907

FOR PICKUP AREA= 0.100000 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.010000	25.967046	0.098405	1.566173
0.031623	8.577597	0.295361	1.486526
0.100000	3.503371	0.905871	1.441740
0.316228	2.412869	2.814573	1.416554
1.000000	2.250039	8.811472	1.402391
3.162278	2.221423	27.706073	1.394426
10.000000	2.212444	87.332887	1.389947

TABLE 11. - Frequencies from 0.01 to 10 MHz (Cont.)

VALUES OF HAZARD CRITICAL H FIELD FOR VARIOUS CONDITIONS
RDC=1 OHM, CRITICAL HAZARD CURRENT = 0.2 AMPS

FOR PICKUP AREA= 0.316228 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.010000	8.438153	0.189317	3.013072
0.031623	3.031642	0.570531	2.871440
0.100000	1.650155	1.754135	2.791795
0.316228	1.411882	5.458072	2.747007
1.000000	1.373349	17.101691	2.721821
3.162278	1.363191	53.798885	2.707658
10.000000	1.358800	169.626590	2.699693

FOR PICKUP AREA= 1.000000 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.010000	2.848272	0.362205	5.764681
0.031623	1.239297	1.095351	5.512820
0.100000	0.902526	3.374814	5.371188
0.316228	0.847935	10.513852	5.291543
1.000000	0.835790	32.966307	5.246755
3.162278	0.831147	103.748190	5.221569
10.000000	0.828803	327.190690	5.207406

FOR PICKUP AREA= 3.162278 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.010000	1.049966	0.689607	10.975444
0.031623	0.606452	2.091739	10.527565
0.100000	0.526829	6.456410	10.275704
0.316228	0.511293	20.135550	10.134072
1.000000	0.506214	63.173774	10.054427
3.162278	0.503808	198.883120	10.009639
10.000000	0.502516	627.341150	9.984453

FOR PICKUP AREA= 10.000000 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.010000	0.450191	1.307308	20.806476
0.031623	0.334888	3.975824	20.010023
0.100000	0.313504	12.291247	19.562144
0.316228	0.307646	38.367910	19.310283
1.000000	0.305131	120.440090	19.168651
3.162278	0.303822	379.282510	19.089005
10.000000	0.303101	1196.582500	19.044217

TABLE 12. - Frequencies from 0.1 to 1 MHz

VALUES OF HAZARD CRITICAL H FIELD FOR VARIOUS CONDITIONS
RDC=1 OHM, CRITICAL HAZARD CURRENT = 0.2 AMPS

FOR PICKUP AREA= 0.000100 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.100000	2536.912700	0.014453	0.023002
0.200000	1269.427900	0.028236	0.022469
0.300000	846.995750	0.041909	0.022233
0.400000	635.859130	0.055525	0.022093
0.500000	509.250480	0.069104	0.021997
0.600000	424.909770	0.082658	0.021926
0.700000	364.724080	0.096191	0.021871
0.800000	319.636220	0.109710	0.021826
0.900000	284.614070	0.123215	0.021789
1.000000	256.638180	0.136710	0.021758

FOR PICKUP AREA= 0.000316 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.100000	803.391270	0.029303	0.046637
0.200000	402.518840	0.057415	0.045689
0.300000	269.046640	0.085330	0.045269
0.400000	202.441200	0.113145	0.045019
0.500000	162.586730	0.140894	0.044848
0.600000	136.108840	0.168598	0.044722
0.700000	117.274720	0.196266	0.044624
0.800000	103.217460	0.223907	0.044545
0.900000	92.344069	0.251526	0.044480
1.000000	83.698562	0.279125	0.044424

FOR PICKUP AREA= 0.001000 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.100000	254.688820	0.059259	0.094314
0.200000	128.262950	0.116400	0.092629
0.300000	86.287155	0.173193	0.091882
0.400000	65.478232	0.229805	0.091437
0.500000	53.133698	0.286302	0.091133
0.600000	45.017464	0.342718	0.090909
0.700000	39.313161	0.399071	0.090734
0.800000	35.112133	0.455375	0.090594
0.900000	31.909330	0.511639	0.090478
1.000000	29.401627	0.567869	0.090379

TABLE 12. - Frequencies from 0.1 to 1 MHz (Cont.)

VALUES OF HAZARD CRITICAL H FIELD FOR VARIOUS CONDITIONS
RDC=1 OHM, CRITICAL HAZARD CURRENT = 0.2 AMPS

FOR PICKUP AREA= 0.003162 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.100000	81.303558	0.118841	0.189142
0.200000	41.548839	0.233916	0.186145
0.300000	28.595594	0.348371	0.184817
0.400000	22.326551	0.462505	0.184025
0.500000	18.713458	0.576434	0.183485
0.600000	16.412630	0.690218	0.183086
0.700000	14.848695	0.803891	0.182776
0.800000	13.734988	0.917477	0.182526
0.900000	12.913379	1.030992	0.182319
1.000000	12.290029	1.144446	0.182144

FOR PICKUP AREA= 0.010000 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.100000	26.378213	0.236018	0.375634
0.200000	14.187886	0.465337	0.370304
0.300000	10.433078	0.693555	0.367942
0.400000	8.730432	0.921202	0.366535
0.500000	7.810013	1.148484	0.365574
0.600000	7.256774	1.375508	0.364865
0.700000	6.898905	1.602335	0.364314
0.800000	6.654383	1.829008	0.363870
0.900000	6.480007	2.055553	0.363502
1.000000	6.351298	2.281992	0.363191

TABLE 12. - Frequencies from 0.1 to 1 MHz (Cont.)

VALUES OF HAZARD CRITICAL H FIELD FOR VARIOUS CONDITIONS
RDC=1 OHM, CRITICAL HAZARD CURRENT = 0.2 AMPS

FOR PICKUP AREA= 0.031623 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.100000	9.016372	0.464347	0.739032
0.200000	5.534014	0.916783	0.729554
0.300000	4.587165	1.367260	0.725355
0.400000	4.197691	1.816722	0.722851
0.500000	4.000662	2.265536	0.721143
0.600000	3.887174	2.713890	0.719882
0.700000	3.815666	3.161895	0.718902
0.800000	3.767542	3.609623	0.718112
0.900000	3.733484	4.057126	0.717456
1.000000	3.708405	4.504439	0.716904

FOR PICKUP AREA= 0.100000 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.100000	3.503371	0.905871	1.441740
0.200000	2.635429	1.790561	1.424885
0.300000	2.430577	2.671767	1.417417
0.400000	2.350743	3.551168	1.412966
0.500000	2.310896	4.429417	1.409928
0.600000	2.287816	5.306847	1.407686
0.700000	2.273053	6.183656	1.405943
0.800000	2.262915	7.059975	1.404539
0.900000	2.255576	7.935892	1.403375
1.000000	2.250039	8.811472	1.402391

TABLE 12. - Frequencies from 0.1 to 1 MHz (Cont.)

VALUES OF HAZARD CRITICAL H FIELD FOR VARIOUS CONDITIONS
RDC=1 OHM, CRITICAL HAZARD CURRENT = 0.2 AMPS

FOR PICKUP AREA= 0.316228 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.100000	1.650155	1.754135	2.791795
0.200000	1.458986	3.470604	2.761822
0.300000	1.415690	5.180877	2.748543
0.400000	1.398250	6.887942	2.740627
0.500000	1.389099	8.592957	2.735225
0.600000	1.383510	10.296515	2.731238
0.700000	1.379743	11.998971	2.728139
0.800000	1.377027	13.700553	2.725641
0.900000	1.374969	15.401421	2.723571
1.000000	1.373349	17.101691	2.721821

FOR PICKUP AREA= 1.000000 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.100000	0.902526	3.374814	5.371188
0.200000	0.859685	6.682649	5.317887
0.300000	0.848950	9.979463	5.294274
0.400000	0.844132	13.270574	5.280198
0.500000	0.841360	16.558039	5.270592
0.600000	0.839532	19.842915	5.263501
0.700000	0.838220	23.125828	5.257990
0.800000	0.837224	26.407188	5.253548
0.900000	0.836434	29.687279	5.249868
1.000000	0.835790	32.966306	5.246755

TABLE 12. - Frequencies from 0.1 to 1 MHz (Cont.)

VALUES OF HAZARD CRITICAL H FIELD FOR VARIOUS CONDITIONS
RDC=1 OHM, CRITICAL HAZARD CURRENT = 0.2 AMPS

FOR PICKUP AREA= 3.162278 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.100000	0.526829	6.456410	10.275704
0.200000	0.515193	12.793711	10.180920
0.300000	0.511657	19.111415	10.138929
0.400000	0.509861	25.418976	10.113898
0.500000	0.508737	31.720054	10.096815
0.600000	0.507951	38.016528	10.084206
0.700000	0.507363	44.309512	10.074405
0.800000	0.506901	50.599733	10.066506
0.900000	0.506526	56.887699	10.059962
1.000000	0.506214	63.173772	10.054427

FOR PICKUP AREA= 10.000000 SQ. METERS

FREQUENCY(MHZ)	HC(AMPS/METER)	X/RDC	MICROHENRYS
0.100000	0.313504	12.291247	19.562141
0.200000	0.309324	24.370685	19.393591
0.300000	0.307812	36.415276	19.318920
0.400000	0.306977	48.441827	19.274407
0.500000	0.306429	60.456851	19.244030
0.600000	0.306035	72.463687	19.221606
0.700000	0.305734	84.464318	19.204179
0.800000	0.305494	96.460037	19.190131
0.900000	0.305297	108.451740	19.178494
1.000000	0.305131	120.440080	19.168651

(text continued from page 54)

For the trolley wire configuration, we consider the geometry of Figure 12. Figures 13 through 17 give, for a current of 1 ampere, the magnitude of the H field along various lines indicated in Figure 12. Figures 18 through 20 give the same sort of data for the lines indicated in Figure 21. Study of these plots shows that the magnitude of the H field ($|H|$ in a/m) around the 2 meter separation transmission line varies from about 0.318,half way between the driven lines, to about 0.15 at 1 meter away along the y axis. Figure 22 shows some of the values. For the 0.5 meter radius loop $|H|$ varies as shown by the points in Figure 23. For the moment we can note that $|H|$ = 0.32 a/m for a 1 meter separation from the transmission line current carriers and $|H|$ = 0.1 a/m for a 1 meter separation from the loop source. We will use these values later.

6.3 SAFE DISTANCES FROM CARRIER PHONE LINE CONDUCTORS

A. D. Little's Mr. Robert LaGace has supplied us with data on mine trolley carrier phones -- see Appendix J -- that indicates that the carrier frequencies are no more than 0.190 MHz and the maximum short circuit current for the transmitters -- and therefore the maximum current on the trolley line -- is approximately 2.6 amperes RMS.

For a carrier phone operating at the worst-highest-frequency, say 200 KHz, and running into a shorted line with the short located precisely right -- about a half wavelength away (a distance somewhat smaller than 3000 meters or about 2 miles) with no loss in the lines, then the maximum current close to the end of the line near the short will be 2.6 amperes. The values of H given in Figure 22 multiplied by 2.6 and again multiplied by our correction factor of 5 (to account for the difference between free space and the mine environment) indicate that the maximum H field one meter from either transmission conductor line would be 4.16 or less. Indeed, since the return would be split through the tracks, the 4.16 a/m figure would be high for a 1 meter separation from either rail. Note, however, that even if one of the rails carried none of the return current, the 4.16 a/m value would still apply.

If we consult Table 12, we see that a blasting wiring loop of area 0.0316 square about 17.8 cms (about 8 inches) on a side or a circular loop formed of 63 cm (about 2 feet) of wire.

With the "worst case" presently existing carrier phone and a loop of this size at a point one meter from the carrier phone conductor wire we would still need to orient the loop correctly to receive maximum power. At that orientation we assume

(text continued on page 76)

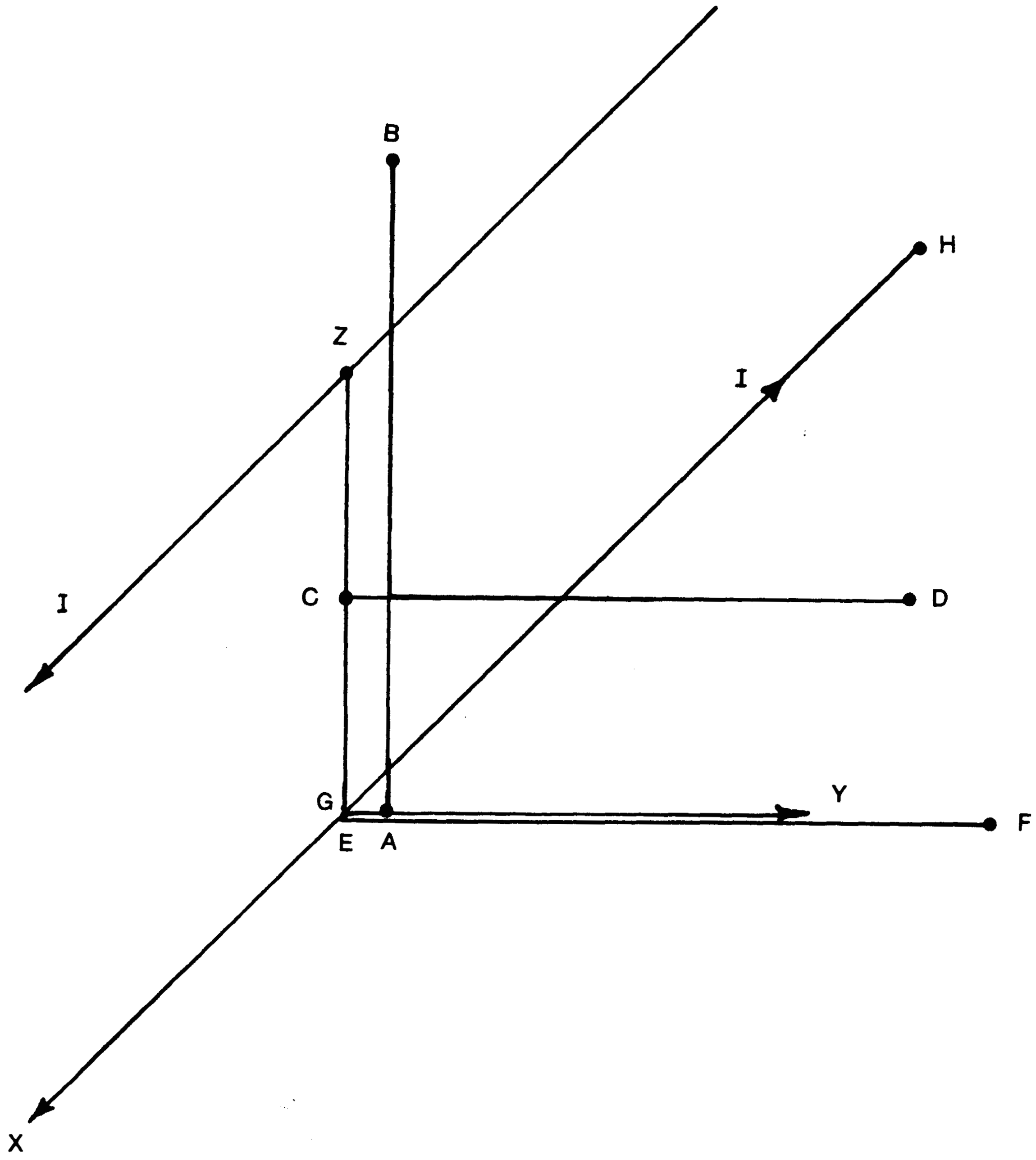


Figure 12. Trolley Wire Coordinate System for H Field Sampling

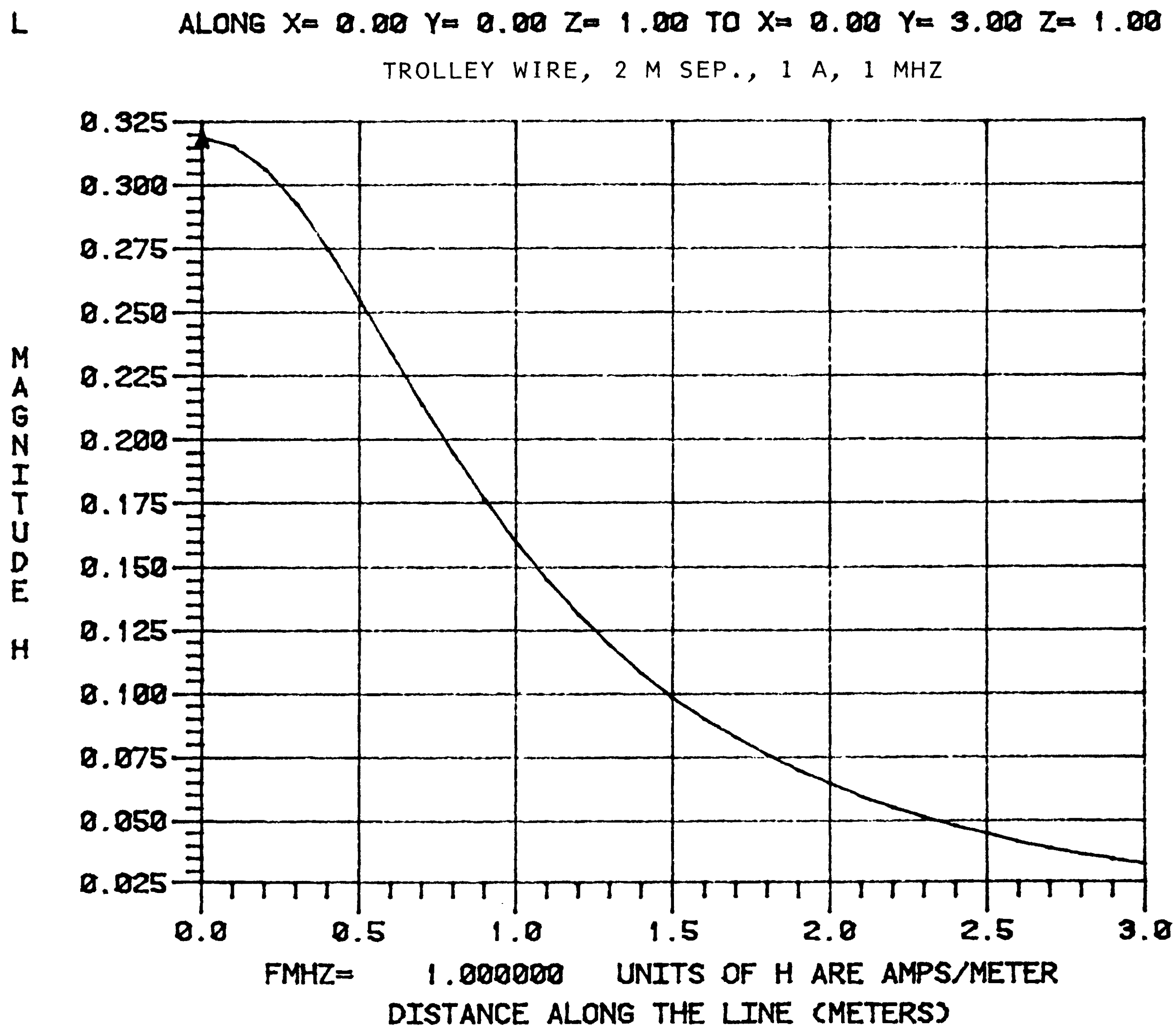

L
ALONG X= 0.00 Y= 0.00 Z= 1.00 TO X= 0.00 Y= 3.00 Z= 1.00
TROLLEY WIRE, 2 M SEP., 1 A, 1 MHZ
MAGNITUDE H
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.0
0.5
1.0
1.5
2.0
2.5
3.0
FMHZ= 1.000000 UNITS OF H ARE AMPS/METER
DISTANCE ALONG THE LINE (METERS)

Figure 13

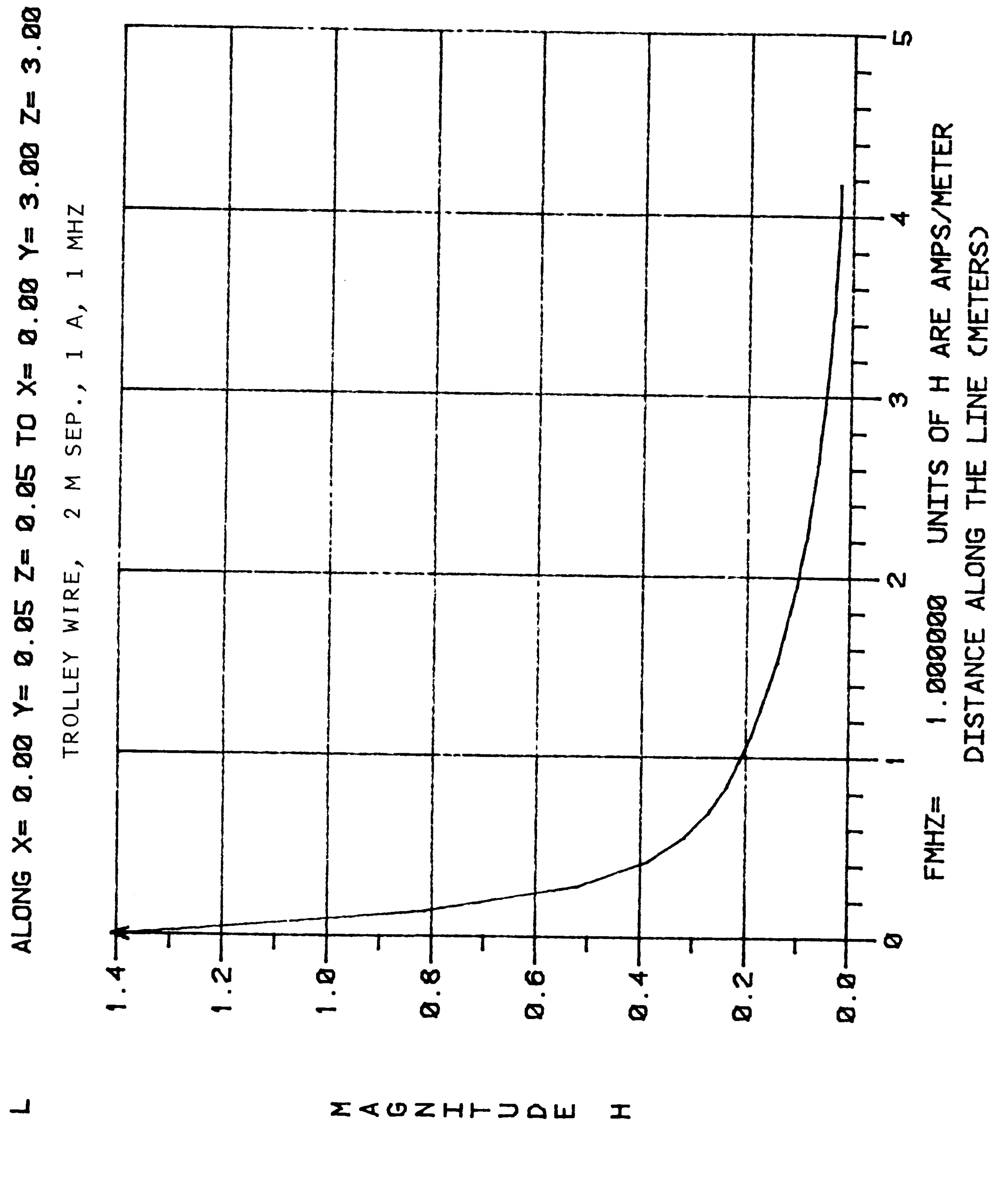

ALONG X= 0.00 Y= 0.05 Z= 0.05 TO X= 0.00 Y= 3.00 Z= 3.00
TROLLEY WIRE, 2 M SEP., 1 A, 1 MHZ
L
MAGNITUDE H
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
FMHZ= 1.000000 UNITS OF H ARE AMPS/METER
DISTANCE ALONG THE LINE (METERS)

Figure 14

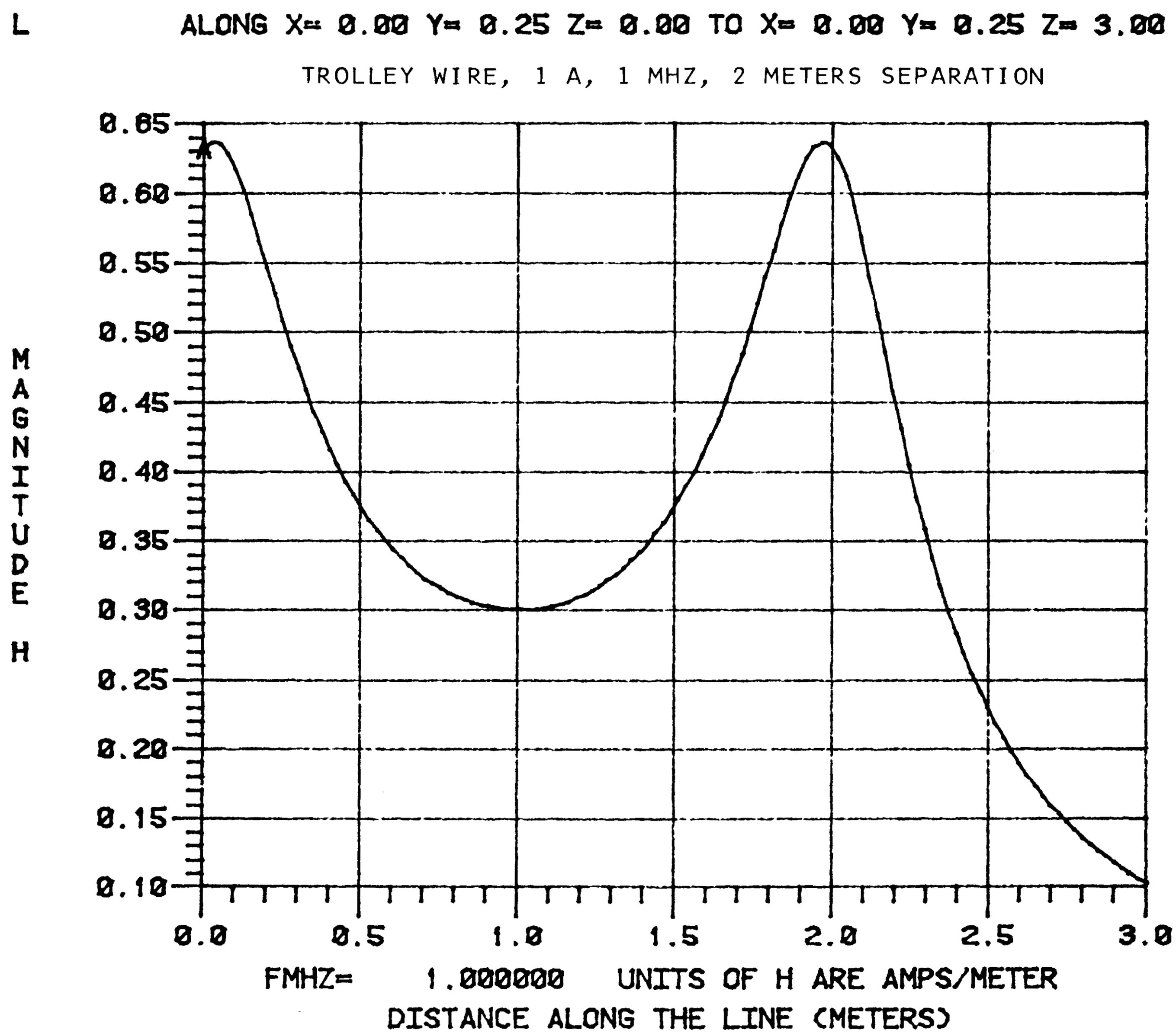

L
ALONG X= 0.00 Y= 0.25 Z= 0.00 TO X= 0.00 Y= 0.25 Z= 3.00
TROLLEY WIRE, 1 A, 1 MHZ, 2 METERS SEPARATION
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
MAGNITUDE H
0.0
0.5
1.0
1.5
2.0
2.5
3.0
FMHZ= 1.000000 UNITS OF H ARE AMPS/METER
DISTANCE ALONG THE LINE (METERS)

Figure 15

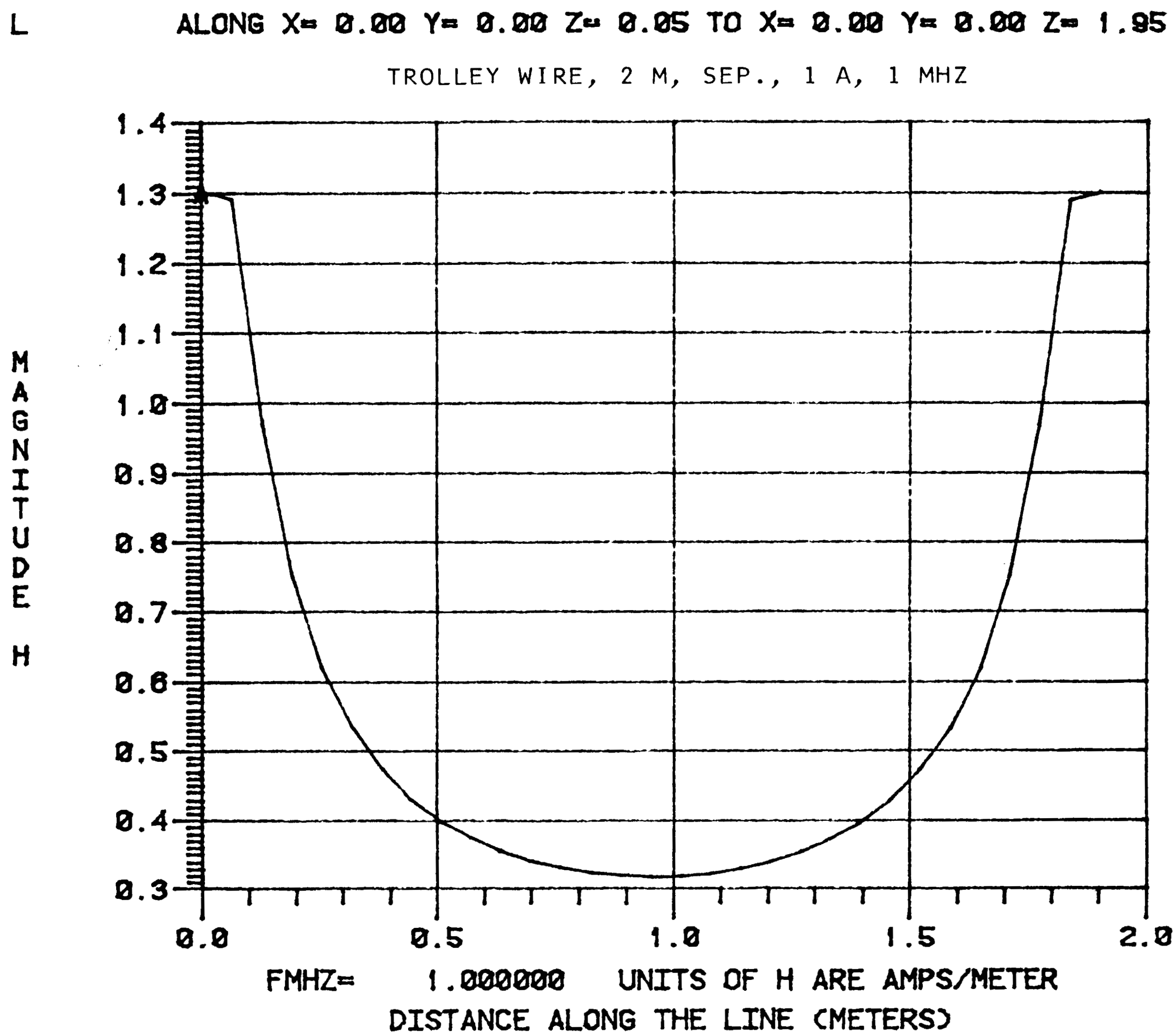

L
ALONG X= 0.00 Y= 0.00 Z= 0.05 TO X= 0.00 Y= 0.00 Z= 1.95
TROLLEY WIRE, 2 M, SEP., 1 A, 1 MHZ
MAGNITUDE H
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.0
0.5
1.0
1.5
2.0
FMHZ= 1.000000 UNITS OF H ARE AMPS/METER
DISTANCE ALONG THE LINE (METERS)

Figure 16

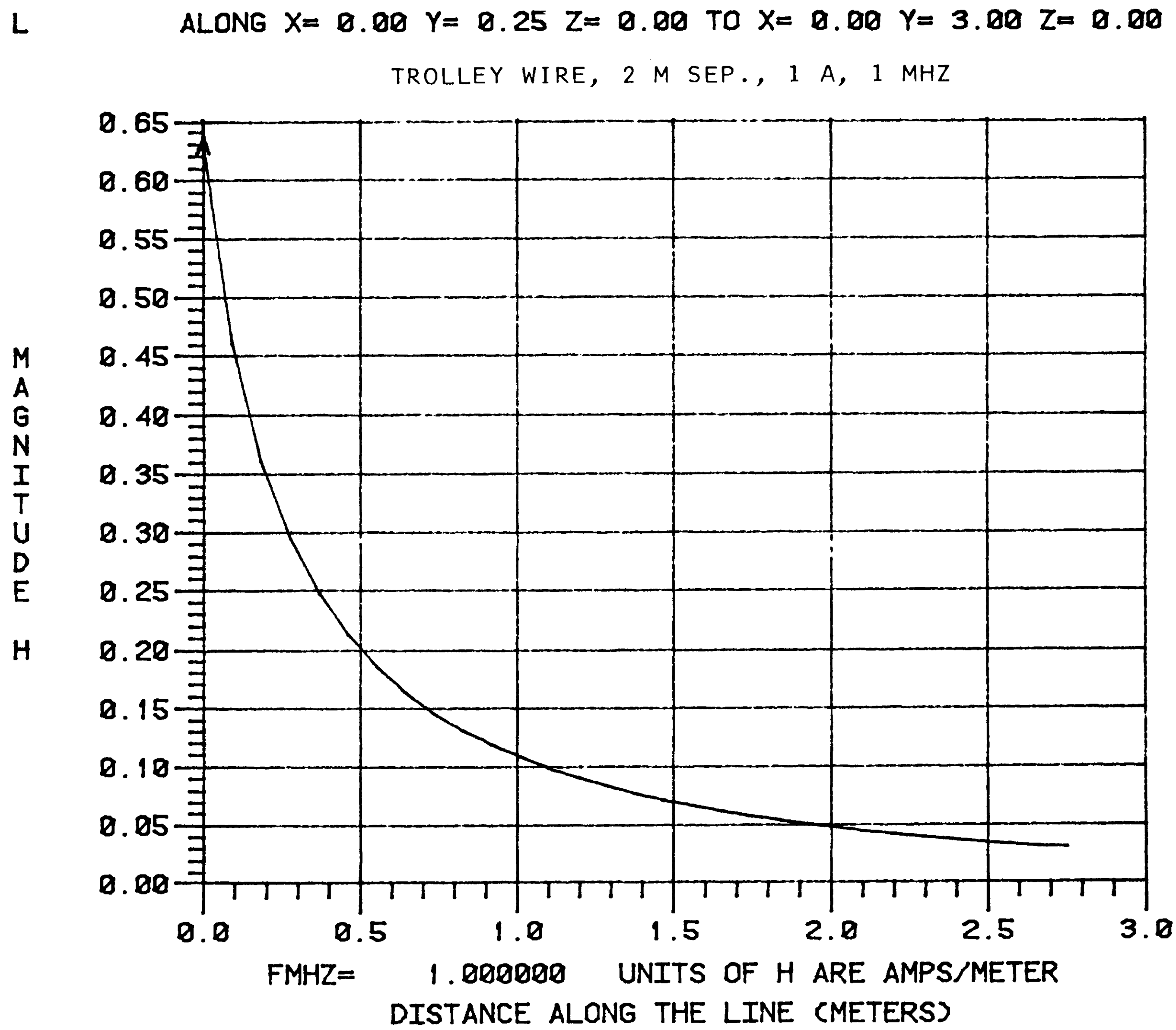

L
ALONG X= 0.00 Y= 0.25 Z= 0.00 TO X= 0.00 Y= 3.00 Z= 0.00
TROLLEY WIRE, 2 M SEP., 1 A, 1 MHZ
MAGNITUDE H
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0.0
0.5
1.0
1.5
2.0
2.5
3.0
FMHZ= 1.000000 UNITS OF H ARE AMPS/METER
DISTANCE ALONG THE LINE (METERS)

Figure 17

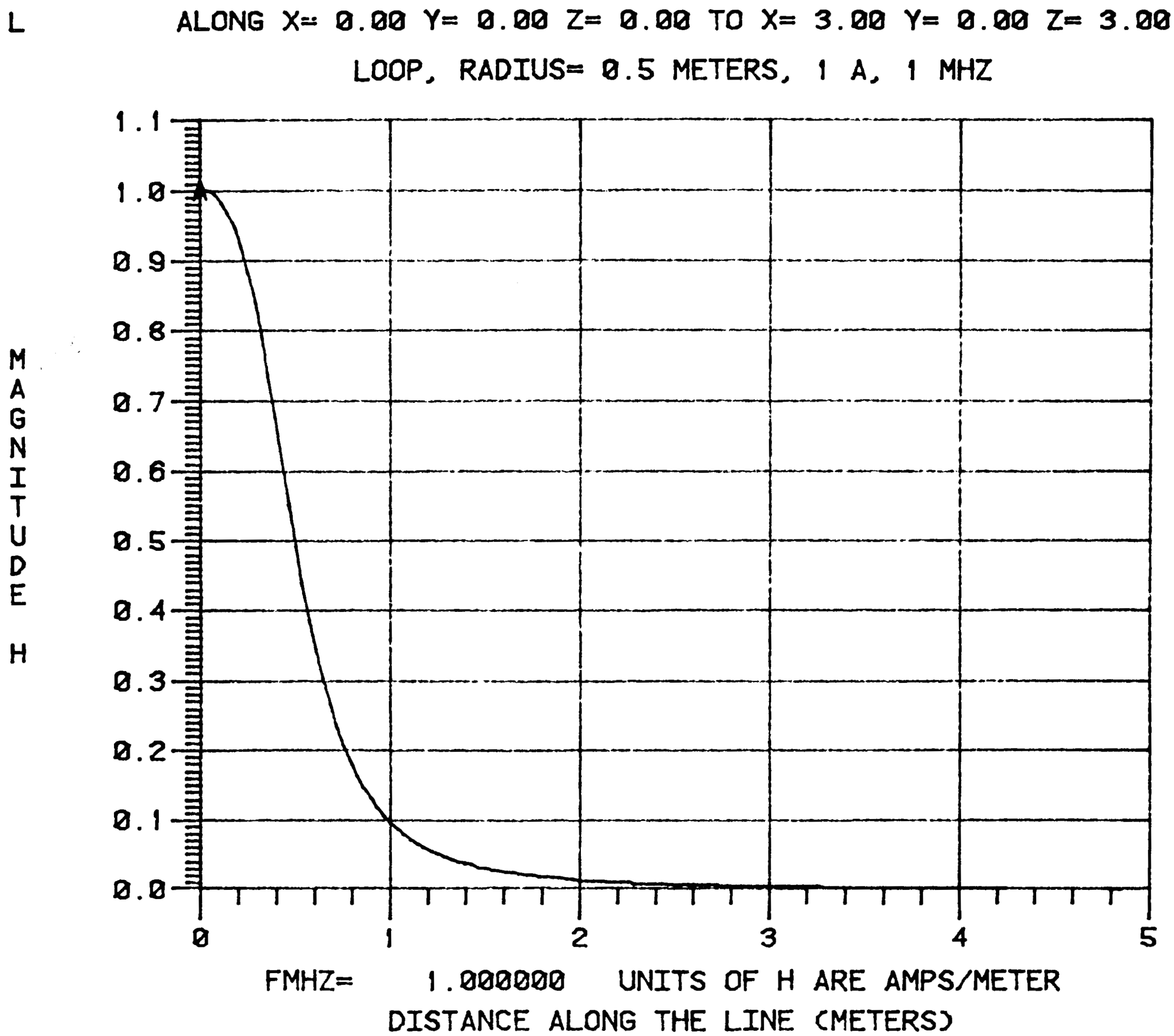

L
ALONG X= 0.00 Y= 0.00 Z= 0.00 TO X= 3.00 Y= 0.00 Z= 3.00
LOOP, RADIUS= 0.5 METERS, 1 A, 1 MHZ
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
MAGNITUDE H
0
1
2
3
4
5
FMHZ= 1.000000 UNITS OF H ARE AMPS/METER
DISTANCE ALONG THE LINE (METERS)

Figure 18

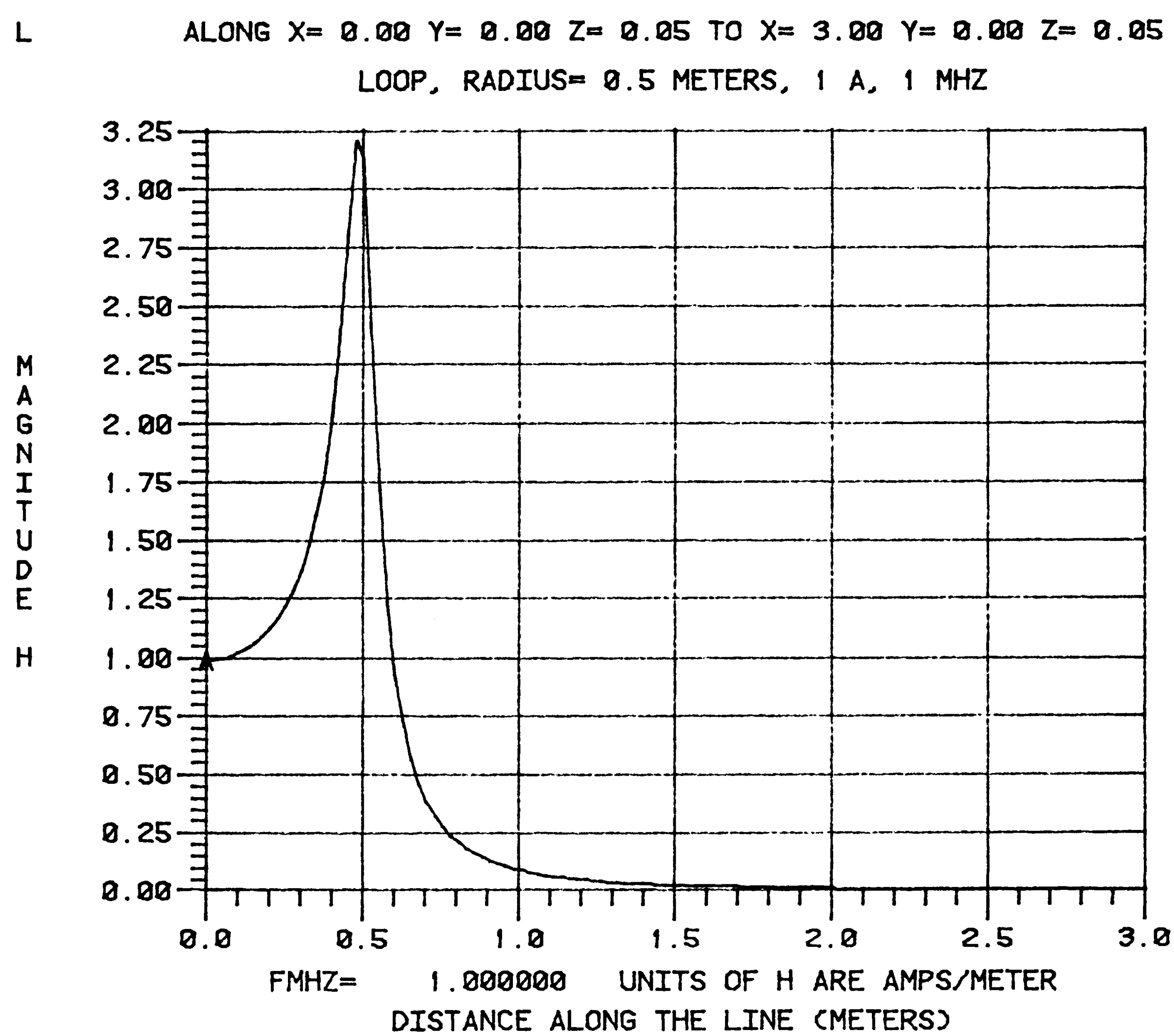

L
ALONG X= 0.00 Y= 0.00 Z= 0.05 TO X= 3.00 Y= 0.00 Z= 0.05
LOOP, RADIUS= 0.5 METERS, 1 A, 1 MHZ
MAGNITUDE H
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0.0
0.5
1.0
1.5
2.0
2.5
3.0
FMHZ= 1.000000 UNITS OF H ARE AMPS/METER
DISTANCE ALONG THE LINE (METERS)

Figure 19

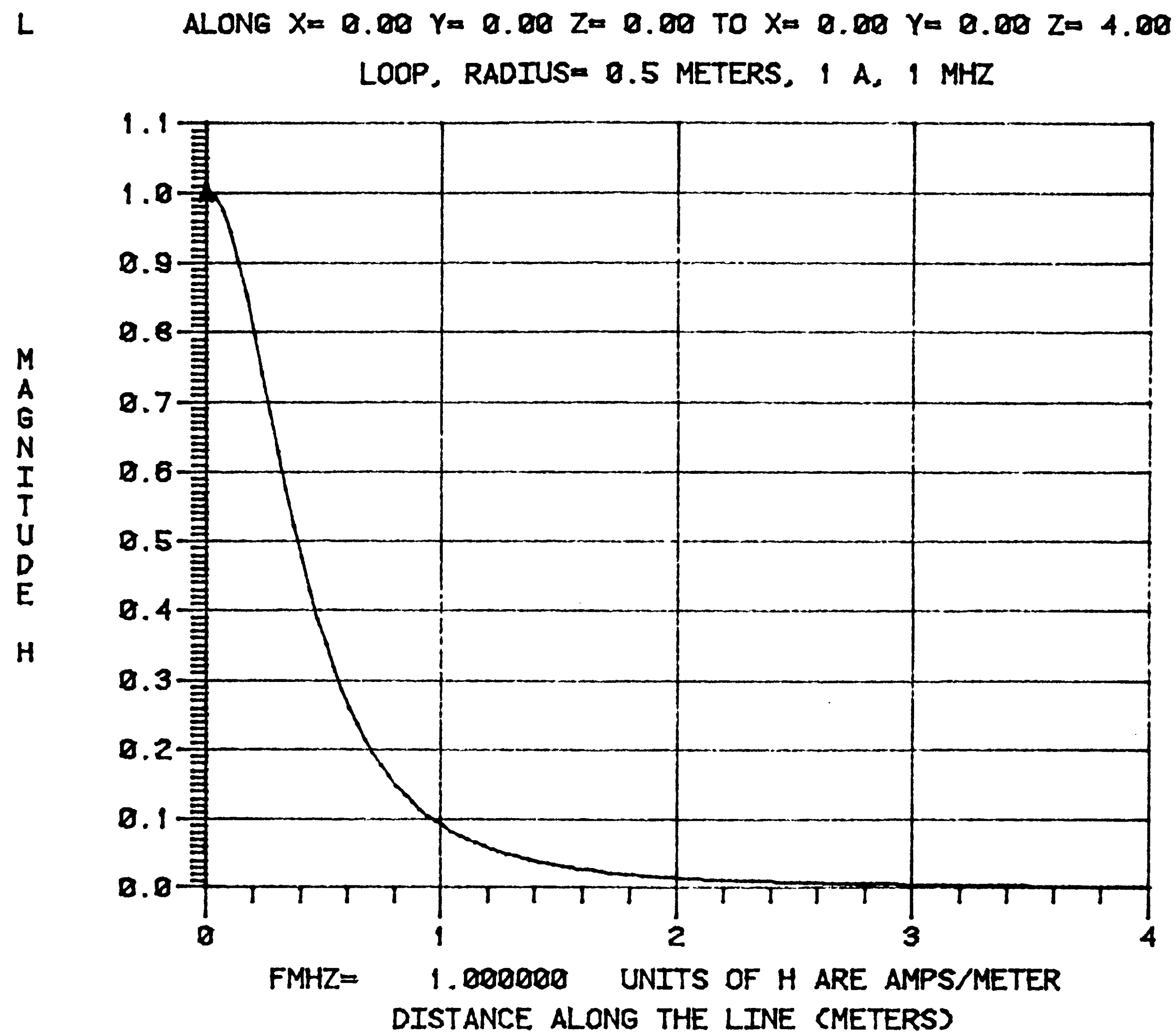

L
ALONG X= 0.00 Y= 0.00 Z= 0.00 TO X= 0.00 Y= 0.00 Z= 4.00
LOOP, RADIUS= 0.5 METERS, 1 A, 1 MHZ
MAGNITUDE H
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
1
2
3
4
FMHZ= 1.000000 UNITS OF H ARE AMPS/METER
DISTANCE ALONG THE LINE (METERS)

Figure 20

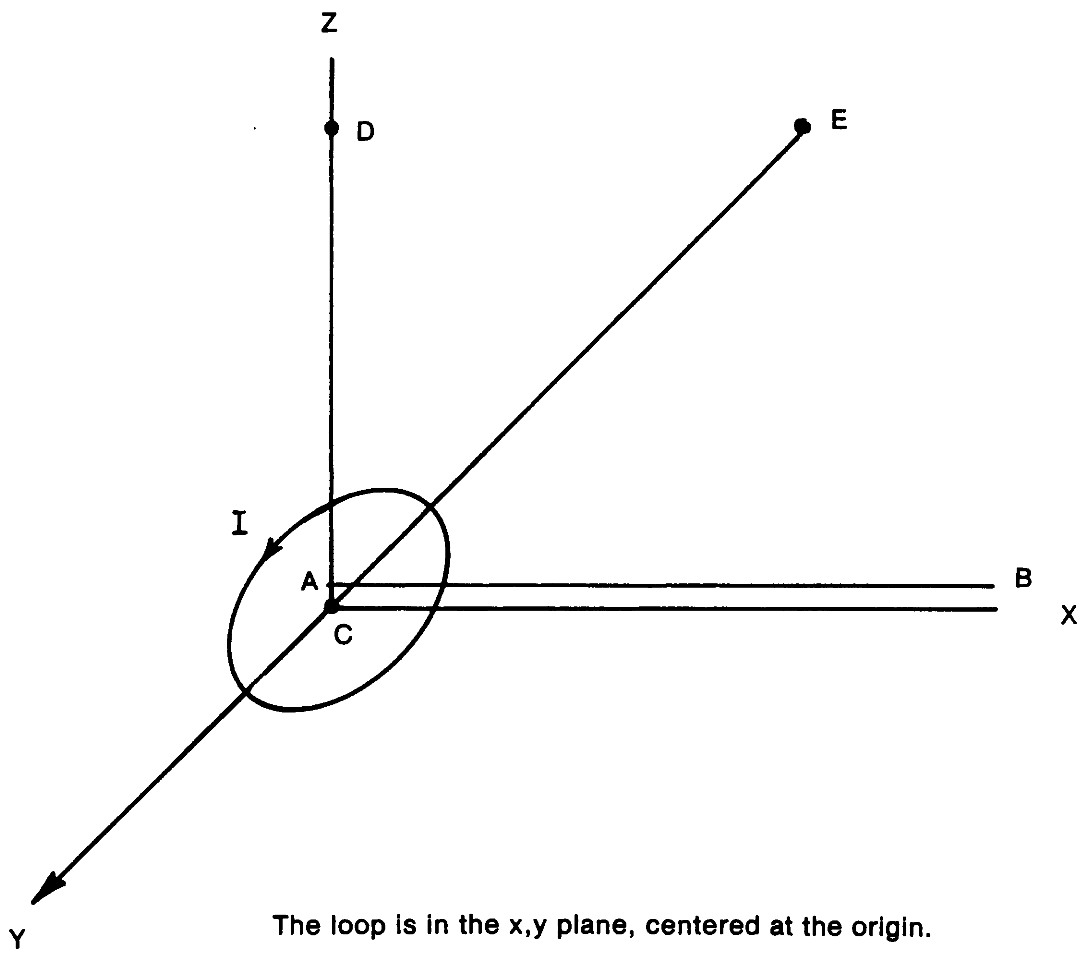


Figure 21. Loop Coordinate System for H Field Sampling

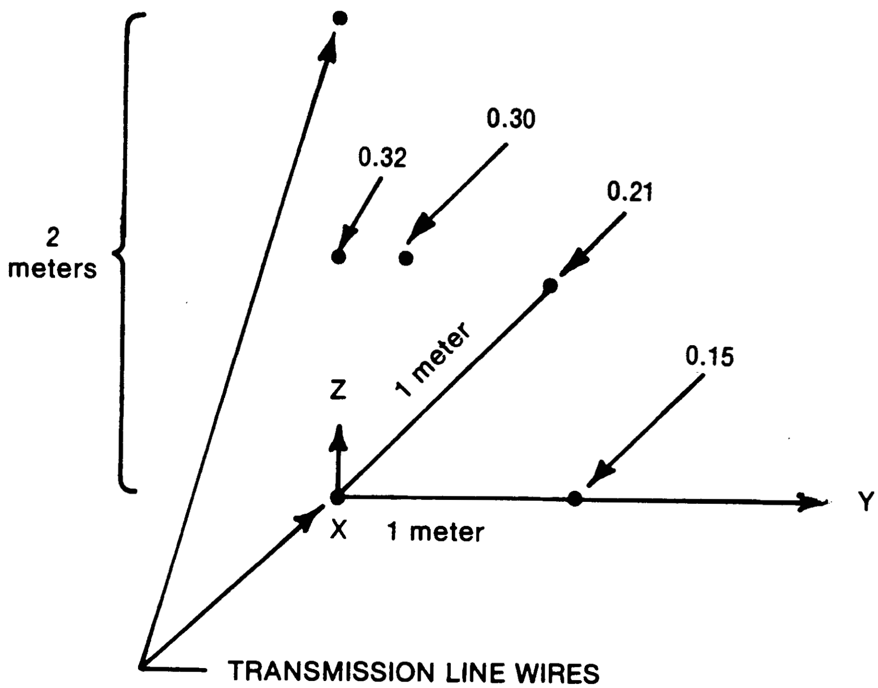


Figure 22. H Values at Various Points Around the Transmission Line

H Values at various points
from the 0.5 M Radius Loop

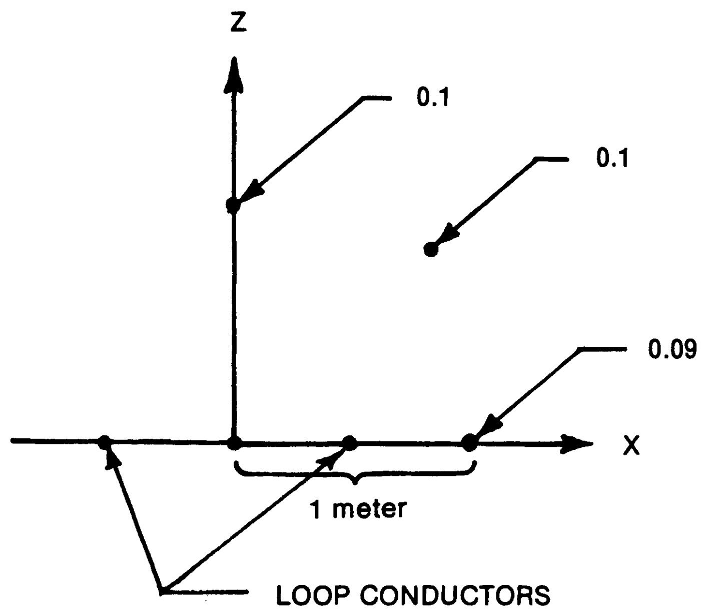


Figure 23. H Values at Various Points from the 0.5 M Radius Loop

(text continued from page 63)

that the "no fire" current -- the current that will function the cap with 0.1% probability at 95% confidence, i.e. 1 in 1000, 95% of the time, -- will flow in the cap. Our analysis has "worst cased" several other factors however; we assume that the maximum B field can be normal to our loop over its total area of the blasting wiring; we assume that the cap lead wires are only as long as the loop periphery -- they are in general longer and will tend to reduce the current due to inductance and resistance -- in addition and most important, we assume that our correction factor of 5 applies at all times and all places in the mines.

Each of these factors, however, cannot be shown to be improbable. At some time they may all occur naturally together. So our overall result is that blasting cap wiring with areas of greater than 0.0316 sq. meters -- a square about 8 inches on a side -- should not be brought closer than 1 meter to any trolley phone wire or track return. Also note that this figure is dependent on a study of presently existing equipment. If differing equipments that produce more current are developed in the future, corrections in this predicted figure must be made.

Lest we convey the idea that our assumptions are so "worst case" as to be restrictive of cap use, consider a cap with six foot leg wires and the short still on the wires. If the leg wires were pulled apart in the middle forming an approximate 1 sq. meter loop and this loop were placed coplaner (plane of the loop in the plane of the carrier phone conductors) with the conductors of a normally operating carrier phone at 200 KHz with about 1.32 amps in the conductors, we can see from Figure 15 that the H field would be more than 0.3 x 1.32 = 0.4 amp/meter over the loop assuming no correction factor of 5. Table 12 shows the H_c for this area to be about 0.85 a/m. So we would be about a factor or two from the "no fire" level even if we were in free space. It is also wise to consider that the spread in currents for blasting caps from the "no fire" level to the "all fire" level -- 99.9% probability with 95% confidence -- is about 1.2 to 1.4, e.g. 1.25 times the "no fire" current level for at least one American-made cap gives the "all fire." So the total safety factor separating us from a "sure fire" would be about 2 x 1.2 = 2.4. Study of the data taken in our mine measurements shows that, under some conditions, "correction factors" of much greater than 2.4 have been measured. This would convince me to leave the area quickly.

6.4 SAFE DISTANCES FROM LOOP SOURCES

Study of Figures 18 and 20 shows that the magnetic field of the loop along the loop's axis is larger -- at a given distance from the center of the loop -- than the magnetic field in any other direction unless we get very close to the current carrying conductors. The field variation along the axis has a particularly simple form.

$$H_a = \frac{I\ R_\ell^2}{2\ (R_\ell^2 + Z^2)^{3/2}} \qquad (13)$$

where H_a is the H field on the axis (amps/meter),
Z is distance (meters) from the center of the loop,
R_ℓ is the loop radius in meters, and
I is the loop current in ampere-turns.

For $Z \gg R$

$$H_a \cong \frac{I\ R_\ell^2}{2\ Z^3} = \frac{I\ \pi R^2}{2\pi\ Z^3} = \frac{I\ A_\ell}{2\pi Z^3} \quad , \tag{14}$$

where A is the area of the loop in square meters.

If we define the magnetic moment of the loop as

$$M_m = IA_\ell$$

where M_m is the magnetic moment in amps-meters^2,

then for $Z \gg R$

$$H_a \cong \frac{M_m}{2\pi Z^3} \quad a/m \tag{15}$$

This definition allows us to treat small loop antenna sources without regard to the geometrical differences and actual number of turns. Note that equation (15) is valid only for $Z \gg R$. How much bigger is "much, much" bigger. Figure 24 plots H field variation for a $R_\ell = 0.5$ meter loop along the Z axis. On this "log log" plot the slope of -3 at distances such that $Z > 2R$ is readily apparent. Now, for equations of the form

$$y = cx^q \ ,$$

$$\log y = \log c + q \log x \text{ and}$$

$$\frac{d\ (\log y)}{d\ (\log x)} = q \ .$$

Thus the slope on "log log" paper gives the value of the exponent in the equation. Since the slope of Figure 24 is -3 for $Z > 2R$ we know that the form

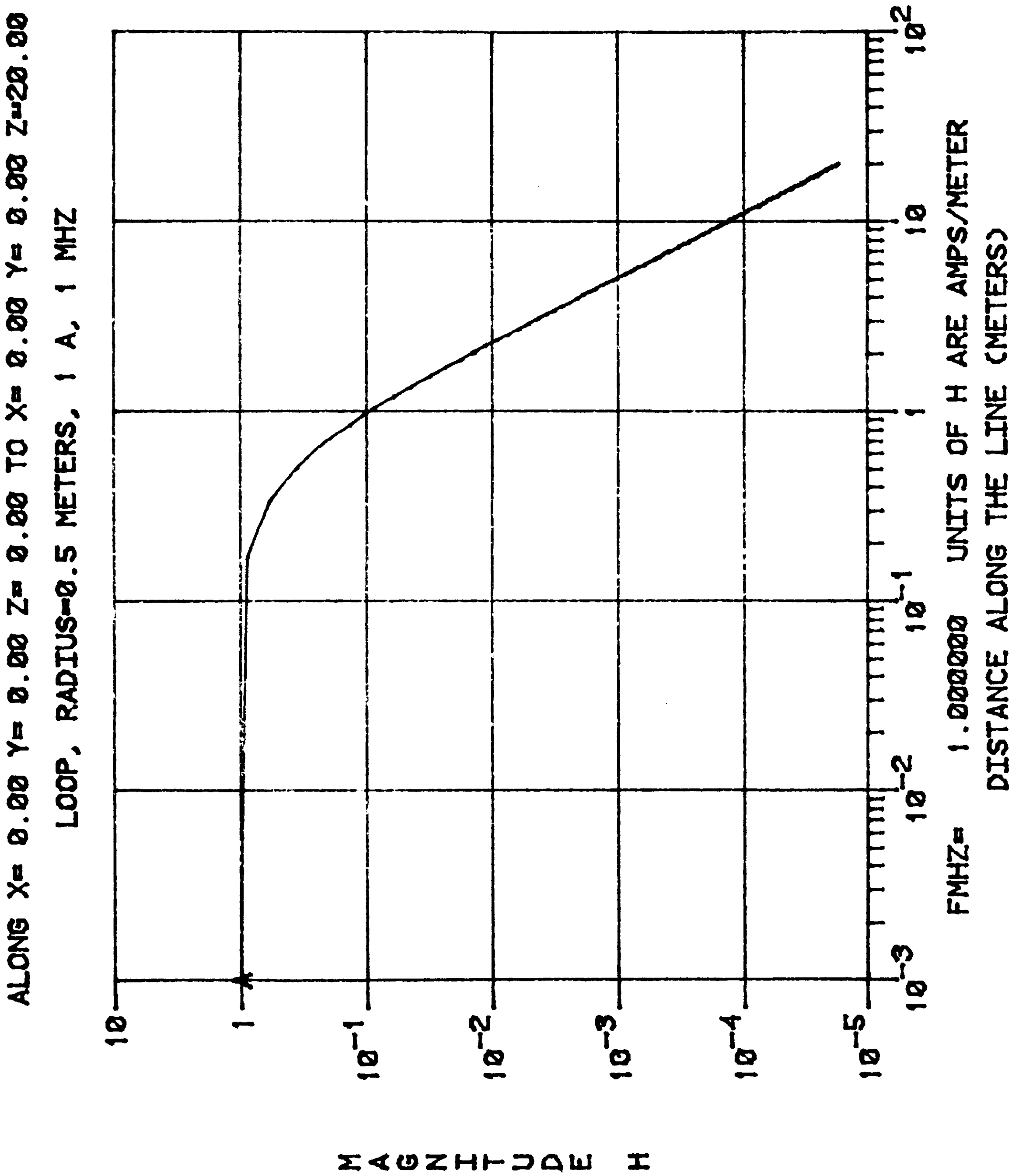

ALONG X= 0.00 Y= 0.00 Z= 0.00 TO X= 0.00 Y= 0.00 Z=20.00
LOOP, RADIUS=0.5 METERS, 1 A, 1 MHZ
FMHZ= 1.000000 UNITS OF H ARE AMPS/METER
DISTANCE ALONG THE LINE (METERS)
MAGNITUDE H
10
1
10^-1
10^-2
10^-3
10^-4
10^-5
10^-3
10^-2
10^-1
1
10
10^2

Figure 24

of the equation in that range conforms to the approximation equation (15). We therefore write, with only a very small error

$$H_a \cong \frac{M_m}{2\pi Z^3} \quad a/m \quad \text{for} \quad Z > 2R \tag{16}$$

To determine safe distances from loops we need only compare 5.0 times H_z in (6-15) to the $|H_c|$ values of Figures 11 and 12 for various values of blasting wiring loops.

Mr. Larry Stolarczyk of the ARF Company of Raton, New Mexico, has informed us, by private communication, that the "back pack" and vehicular communication systems, that they manufacture for underground use, operate at frequencies of less than 400 KHz and that the magnetic moments of the antennas are 1.5 ampere turns meter^2 for the "back pack" system and 11.09 (6.3 x 11 x 0.16) for the vehicular system. Table 13 shows the results of substituting these values for M_m in

$$H_c\ (A)\Big|_{f=400\ KHz} = \frac{M_m \cdot (5.0)}{2\pi\ Z^3} \quad a/m \tag{17}$$

and solving for Z. Note that use of this equation overestimates H_a for values of $Z < 2R$ - unless we approach a current carrying conductors very closely. Thus, the equation gives a conservative estimate of safe distance for distances less than 2R for all cases of concern. The values of $H_c\ (A)\Big|_{f=400\ KHz}$ are taken from Table 12. Note that we have included the "correction factor" of 5 in Eq. (17).

Transmitting systems of this type are usually tuned for peak current and any malfunction of the system results in <u>less</u> current flowing in the antenna than the design value. We therefore feel that the above distances are valid even for presently existing equipment malfunction conditions.

TABLE 13. - Values for Safe Distance (Z) for ARF Transmitter Antennas

Blasting Wire Area (Sq. m)	Safe Distance (Z) (meters): Vehicular System M_m=11.088	Safe Distance (Z) (meters): "Back Pack" System M_m=1.5	$\|H_c\|$ amp/meter
0.0316	1.28	0.65	4.19
0.10	1.54	0.79	2.35
0.316	1.84	0.96	1.39
1.00	2.19	1.13	0.84
3.16	2.58	1.33	0.51
10.00	3.06	1.55	0.31

Note that a blasting wiring configuration having a 10 square meter area is large indeed. This is the area of a typical blasting face layout -- the maximum we would expect to see underground. Table 13 shows that we would be safe -- even for 10 sq. meters of blasting wiring loop area -- if such portable transmitter equipment is always kept about 3 meters from any blasting wiring. This is a convenient number in that any electronic or electrical equipment should always be kept five (about 1.55 meters) or ten feet (about 3.06 meters) from any portion of a blasting wiring layout to eliminate potential premature firings due to dropping the equipment on the wiring or due to a man carrying (body mounted) equipment falling on or into the wiring and having the equipment come in contact with the blasting wiring.

Safe distances from other underground loop sources such as "bandolier" antennas can be calculated by the same methods as used above if the frequency exceeds 400 KC and/or the magnetic mount exceeds 11.09 amp-turns-meters squared.

6.5 SUMMARY OF SAFE DISTANCES AND COMMENT

Our derivations of safe distance have been of a worst case nature with the following exceptions:

- We have used data for resently existing trolley phone equipments.
- We have used a correction factor of five for free space to underground magnetic fields. This factor needs investigation by further measurement.

Section 6.3 recommends that blasting wiring with areas of greater than 0.0316 square meters -- a square about 8 inches on a side or a circle formed from 2 feet of wire -- not be brought closer than 1 meter to any carrier phone wire or track return. Certainly no blasting wiring should approach even this close to a "hot" dc trolley wire.

This recommendation can be implemented most easily by prohibiting any blasting operation in a haulage way containing an operating carrier phone. The recommendation could allow, however, a shot line from a remote blasting wiring configuration to be run into (or along) a haulage way that contains an operating carrier phone. Thus firing could be done from the haulage way if care is taken to keep the shot line conductors close together so that any shorted loop is less than 64 sq. inches in area.

Section 6.4 recommends that the "back pack" and vehicular antennas (operating at less than 400 KHz) made by ARF be kept respectively 5 feet and 10 feet from blasting wiring of 10 square meters area to preclude RF hazard. In essence this recommendation says that as long as these antennas are restrained from being within 10 feet of any blasting wiring configuration we eliminate the possibility of RF hazard. Since the hazard separation distance would be smaller for smaller areas, one might conclude that smaller separations are desirable for smaller blasting wiring areas. We do not believe so. Some minimum distance should be provided to eliminate accidental contact between the blasting wires and the transmitting equipment.

Note that we have considered here only the shorted blasting wire configuration. For frequencies and sources below 10 MHz at the distances considered, the entire possibility of RF hazards to blasting caps is eliminated by keeping the blasting circuit open. We do not recommend this procedure however. Caps are shipped shorted with the leg wires configured so as to form a minimum coupling area. Good blasting practice -- dictated by consideration of electrostatic hazards and stray currents -- requires that blasting circuits be kept shorted. We agree.

Also note that we have considered only the pin-to-pin firing mode of the caps. American-made caps require very high voltages to function in the pin-to-case case mode for the frequency range up to 10 MHz. The open circuit voltages produced by the sources considered in the blasting wiring pin-to-case loops is extremely small for the separations recommended and thus safety for the pin-to-pin mode insures -- for the conditions considered here -- safety for the pin-to-case mode. To eliminate confusion we note that other references, even ours, use differing notations for pin-to-case mode firing. It is sometimes written pins to case, pins-to-case or pin to case; they all refer to the same phenomena although a real difference can be involved in devices that "arc over" from one pin (or lead) to case when the other pine (or lead) is raised to a high potential in relation to the case. In this rare instance a device can be "safe" for a given potential in the <u>pins</u>-to-case mode and "unsafe" in the <u>pin</u>-to-case made for the same potential. The actual mode of firing in this rare, although possible, case is pin-to-pin.

7.0 CONCLUSIONS

Our overall recommendations for blasting wiring safe distances from loop or long straight wire current sources are given in detail in Section 6 of this report. They are assumed valid for frequencies up to 10 MHz.

It should be carefully noted that the recommended distances are based on measurements performed in three locations in each of three coal mines. Although the locations and mines were selected to give a wide diversity of electrical characteristics, it is quite obvious that they can not be expected to give a statistically valid sample of <u>all</u> coal mines.

Further, if the safe blasting distances derived herein are to be applied to "hard rock" or metal mines we are even further from a valid statistical sample. We remark in passing, that we would expect the derived safe distances to increase somewhat in metal rich surroundings and decrease a bit in conductor poor mines.

A further limitation on the safe distances presented is that they are based on presently used mine equipment. If newly designed equipment is introduced it may change required safe distances.

Another important point in the validity of the safe distances is our use of a multiplying factor of 5 for the mine to "free space" magnetic field. As discussed in Section 5.0, this is <u>not</u> a worst case assumption. We had 29 of our 1744 (approximately 1.7%) measured values exceed 5. We attribute most of these to measurements near our noise level, measurements very close to conductors [and very limited in extent] or errors in measurement. There are, however, some measurements we feel were valid that did exceed a factor of 5 over the calculated free space value. We <u>think</u> that these "hot spots" are of very limited spacial extent and they would thus not make significant differences in our safe distance calculations. We do not <u>know</u>.

We recommend that further measurements of the type made here be performed in several more coal mines and, if non-coal mines are to be considered, several metal/non-metal mines. The measurement apparatus should incorporate more gain to alleviate our small signal problem and the measurement procedure should be changed somewhat. Tables of values of the calculated free space pickup multiplied by 5 for each frequency/source can easily be prepared using the procedures given in Sections 6.2 and 6.3. We recommend that tables of this type be used during the measurements and any measured pickup in excess of 5 be closely investigated for its area of extent.

The measurement equipment is already in existence, the measurement procedures are documented, the software for reduction of the data has already been developed and checked out. Thus, the additional measurements and data reduction can be carried out quickly with relatively small expense.

The results of such additional measurements will result in a higher multiplying factor or confirm our recommended value of 5. The safe distance calculating procedure is structured so that a change of the multiplying factor is easy to incorporate.

8.0 REFERENCES

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2. "RF Pickup of Antenna Simulating Blasting Wiring Configurations, Measurement Results," FIRL Technical Report F-B2256-1, R. H. Thompson, prepared for the Institute of Makers of Explosives, 1966.

3. "Measurements of the RF Coupling Between an Antenna Simulating a Blasting Wiring Configuration and Nearly Mobile Transmitting Antenna," FIRL Technical Report F-C1951, R. H. Thompson and K. Fertner, prepared for the Institute of Makers of Explosives, 1967.

4. "The Possible RF Hazard to Blasting Caps Caused by a Lossy Communication System," FIRL Technical Report F-C2399, R. H. Thompson and P. F. Mohrbach, prepared for Motorola, Inc., 1969.

5. "RF Pickup of Blasting Face Wiring," FIRL Technical Report F-C2942, R. H. Thompson, prepared for Motorola, Inc., 1970.

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7. "RF Hazards to Blasting Caps in Coal Mines," FIRL Technical Report F-C4075, R. H. Thompson, prepared for U.S. Bureau of Mines under Contract H0252015, October, 1976.

8. "Fields and Waves in Communication Electronics," Ramo, Whinnery & Van Duzer, John Wiley & Sons, 1965.

APPENDICES

APPENDIX A

MONOGRAPH ON

COMPUTATION OF RF HAZARDS

Monograph M-C2210-1
"Computation of RF Hazards"
Paul F. Mohrbach, Ramie H. Thompson,
Robert F. Wood, Daniel J. Mullen
The Franklin Institute Research Laboratories
July, 1968
for National Aeronautics and Space
Administration/Goddard Space Flight Center

W. B. Ligett, Vice President
Director of Laboratories

ABSTRACT

This monograph presents a method for analyzing the potential RF susceptibility to the electrical components and systems used in typical space vehciles. It presents the philosophy, applicability and limitattions of this approach. While not exhaustive, enough mathematics is presented to permit analysis of a very large percentage of the types of problems which normally occur. Where the actual development of equations is not given in detail, suitable references are provided. Familiarization with the test and the cited references should provide the reader with the necessary information to analyze most systems and the general procedures to handle those situations which are beyond the scope of this monograph.

ACKNOWLEDGEMENTS

This monograph is based on work performed and techniques and ideas developed by the Applied Physics Laboratory, P. F. Mohrbach, Principal Scientist. Inquiries concerning this work should be referred to him at Area Code 215-448-1236 or to the sponsoring agency.

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a	= Radius of Connector Shell Opening - Meters
A	= Area - Square Meters
A_c	= Circular Aperture - Square Meters
A_e	= Effective Aperture - Square Meters
A_{ec}	= Effective Composite Aperture - Square Meters
A_{em}	= Maximum Effective Aperture - Square Meters
A_{em_q}	= Maximum Effective Aperture of qth gap - Square Meters
A_m	= Area of mth loop - Square Meters
b	= Length of Lead Wire or Largest Length of Opening in Shield Braid - Meters
$\bar{B}$	= Magnetic Flux Density -Webers per Square Meter (Vector Notation)
c	= Velocity of Light, 3×10^8 Meters per Second
d	= Lead Wire Spacing or Pin Spacing - Meters
dB	= Decibels
D	= Directivity of Antenna
$\bar{E}$	= Electric Field Intensity - Volts per Meter (Vector Notation)
$\lvert\bar{E}\rvert$	= Magnitude of Electric Field Intensity - Volts per Meter
$\lvert E_{r_1}\rvert^2$	= Square of Magnitude of Electric Field Intensity at radius r_1
EED	= Electroexplosive Device
f_{Hz}	= Frequency - Hertz
f_{MHz}	= Frequency - Megahertz
G	= Gain of Antenna
$\bar{H}$	= Magnetic Field Intensity - Amperes per Meter (Vector Notation)
$\lvert\bar{H}\rvert$	= Magnitude of Magnetic Field Intensity - Amperes per Meter
I_o	= Current on Antenna - Amperes
$Im\{Z_c\}$	= Imaginary Part of Surface Impedance - Ohms
K	$= \frac{2\pi}{\lambda}$ - Meter^{-1}

LIST OF SYMBOLS (cont)

ℓ	=	Length - Meters
ℓ_D	=	Length of Dipole - Meters
max	=	Maximum
n	=	Total Number of Loops or Gaps
P	=	Poynting Vector
$\bar{P}$	=	Power Density - Watts per Square Meter (Vector Notation)
$\lvert\bar{P}\rvert$	=	Magnitude of Power Density - Watts per Square Meter
P_i	=	Incident TEM Field Power Density - Watts per Square Meter
P_o	=	Average Power Density at Inner Surface of Shield - Watts per Square Meter
P_T	=	Power Density at Outer Surface of Shield - Watts per Square Meter
Q	=	Ratio of Solid Area to Hole Area in the Shield
r	=	Radius of Poynting Vector - Meters
$Re\{Z_c\}$	=	Real Part of Surface Impedance - Ohms
RF	=	Radio Frequency
R_L	=	Loss Resistance of Antenna - Ohms
R_R	=	Radiation Resistance of Antenna - Ohms
R_T	=	Termination Resistance - Ohms
t	=	Thickness of Braid - Inches
TEM	=	Transverse Electromagnetic Wave
T_{wc}	=	Transmission Coefficient
U_m	=	Maximum Radiation Intensity - Watts per Square Radian
U_o	=	Average Radiation Intensity - Watts per Square Radian
V	=	Total Voltage Reduced in Antenna - Volts
W	=	Power Dissipated in Load - Watts
X_T	=	Termination Reactance - Ohms
X_R	=	Antenna Reactance - Ohms
Z_c	=	Surface Impedance - Ohms
Z_o	=	Impedance of Free Space, 377 Ohms
Z_{pc}	=	Pins-to-Case Impedance of EED - Ohms

LIST OF SYMBOLS (cont)

Z_{pct}	= Pins-to-Case Firing Mode Impedance of EED (Z_{pc}) Transformed Along Connecting Lines - Ohms
Z_{pp}	= Pin-to-Pin Impedance of EED - Ohms
Z_{ppt}	= Pin-to-Pin Firing Mode Impedance of EED (Z_{pp}) Transformed Along Connecting Lines - Ohms
Z_{u_1}	= Unknown Pin-to-Pin Impedance Looking Toward Arming Circuits - Ohms
Z_{u_2}	= Unknown Pins-to-Case Impedance Looking Toward Arming Circuits - Ohms
α	= Attenuation - Nepers per Unit Length
β	= $\frac{2\pi}{\lambda}$ - Meter^{-1}
$\frac{\partial \bar{B}}{\partial t}$	= Partial Derivative of $\bar{B}$ with Respect to Time
ε_o	= Permittivity of Free Space, 8.85 x 10^{-12} Farad per Meter
μ_o	= Permeability of Free Space, 12.5 x 10^{-7} Henry per Meter
θ, ϕ, ψ	= Angles - Radians
ω	= $2\pi f_{Hz}$
δ	= Skin Depth - Inches
ρ	= Reflection Coefficient
λ	= Wave Length - Meters
λ_c	= Cutoff Wavelength - Meters

1. INTRODUCTION

The determination of the potential radio frequency (RF) hazard to any system exposed to an incident RF field is a very complex problem. Consider, for example, a typical electroexplosive device (EED) and its associated firing circuit mounted in a missile. To begin with, the missile may be transported to the launch site with some or all of its circuits installed and could conceivably be exposed to a wide variety of RF signals along the way. At the launch site it may be necessary to install some of the EEDs or electronic components while in an RF environment. This would permit the possibility of the individual components being irradiated during handling and, subsequently, after installation in its circuit. In addition check out procedures often result in altering the circuits, connecting temporary new circuits to the potentially vulnerable component and such actions as the opening and closing of vents and ports in the missile skin. Furthermore, there would probably be constant movement of vehicles and personnel in the area and this movement would cause continual fluctuation in local RF field intensities. All of these factors would contribute to a constantly changing and very difficult to define set of conditions with respect to RF hazards. It should be noted that localized field intensity conditions can exceed the overall field intensity that would be determined by measuring the field produced at a given point by a radiating transmitter. Unless one can measure the field at the exact point of interest, under the actual conditions and with all equipment that will be in the area and without serious perturbation of the field by the measuring equipment one can be certain only of an approximation of the actual field conditions.

Even if one could accomplish a testing program which would cover all of the conditions, the inherent variation from missile to missile would introduce another large variable. Slight changes in the arrangement of the wiring or in the orientation of the missile with respect to the RF field might well produce large variations in the amount of RF energy delivered to the device under investigation, identical electrical impedance conditions cannot be maintained from missile to missile and on board transmitters may directly interact with the vulnerable circuits.

Of course, if the circuit designer were free to design his circuits with nothing else in mind but to make them insensitive to RF, the RF problem could be essentially eliminated. Complete continuous shielding of the entire systems would in general reduce RF levels at the components to safe values. However, this is often almost impossible, for in our modern complex electric circuits it is usually necessary to break branch circuits out of the shield, to terminate on circuit boards open to RF signals or to follow other procedures which compromise RF safety. In addition, other design groups may argue for and obtain different concepts for wiring to accomplish their ends, and in so doing may also seriously compromise the RF protection.

On the other hand it is often suggested that even with circuits poorly designed from the RF viewpoint, there have been relatively few accidents directly attributed to RF and therefore the problem must be negligible. This could be a very dangerous viewpoint. First of all, information on accidents of any nature is usually very poorly disseminated so that it is difficult to know what accidents have occurred and what situations surrounded such accidents. This is particularly true of accidents which do not result in severe injury to personnel or very large property damage. Second, the determination of the cause of an accident after it has happened is a very difficult business. This is particularly true when trying to evaluate the after-the-fact influence of anything as variable as the potential RF hazard. Furthermore if the investigators do not fully understand how RF energy can be transferred they will easily miss many possibilities. Third, at the present time most RF fields in proximity of vulnerable systems are of reasonably low intensity or are turned off during possibly critical periods. Every year, however, the RF environmental levels are increasing, and RF silence may not always be possible. Systems which are now marginal may eventually become quite vulnerable.

With all of these complicating and generally uncontrollable factors, how can one even evaluate the potential RF hazard to any critical system? Unfortunately, the answer at the present state-of-the-art is that it cannot be done with great precision for anything but a very specifically defined case; however, the hazard can sometimes be evaluated in such a manner that it can be conclusively stated that no hazard exists if this should be the case.

Two methods are now in general use. Both of these require that the RF sensitivity of the device in question be known. There are laboratory techniques for determining this with reasonable precision; unfortunately, the RF sensitivity is of the device is not always so determined and this in general will negate the effectiveness of either method unless suitable precautions are taken.

The first method, stated briefly, is to directly radiate the system in question with a variety of high powered transmitters and to observe the RF levels that arrive at the device under test. The method is appealing, if expensive, since it is a direct approach which superficially appears to simulate the actual conditions that will occur. But, while such tests are much used, and have a definite place in the scheme of things, there are many pitfalls that generally make them unsatisfactory for a really valid hazard determination. The chief weaknesses of the method include inadequacy of present RF detectors, inability to determine field strengths accurately, the very large expense of suitably powerful transmitters, the risk of assuming that tests on one or two systems can be extended to all such systems and the lack of complete understanding by most field testers of the mechanisms of RF damage on the vulnerable devices.

To minimize the effect of these various problems, irradiation tests are often conducted with an arbitrary safety factor added to the acceptable RF pick up at the detector. Many times this factor is not large enough for all conditions. In addition it should be recognized that the only positive result of a field irradiation is to demonstrate that a hazard exists for certain frequencies, irradiation angles, polarizations and orientations of the irradiating antenna and the system being irradiated. Specifically a field irradiation test can never assure complete RF safety since only a finite number of frequencies, polarizations, etc., can be tested from the literally infinite number of situations that can develop in the actual use of the system. However, properly conducted, field tests can give considerable reassurance regarding RF safety.

The second method is the application of analytical techniques to the systems to determine the extent of RF hazard. This approach in its present form has two distinct advantages: first, properly conducted the results are always on the safe side, and should it be demonstrated by this approach that a system is safe in a given field and at a specific frequency, its safety can practically be guaranteed; second, the actual analysis is reasonably inexpensive. The main expense comes from the fact that to perform the analysis properly the RF sensitivity of the device in question must be determined, but as was pointed out earlier, this should also be done in the case of the direct radiation method. The one exception to this occurs when the circuits are so well designed from an RF standpoint that it can be demonstrated analytically that protection levels are so large that the sensitivity of the device is not a factor after installation in these circuits. The main objection to the analytic method in its present form is that it can put unusually stringent restrictions on the circuits so that only the very well designed systems can be shown to be safe; in other words, the safety factor afforded thereby can be unreasonably large. In contrast to the irradiation method, it should be noted that the only positive result of the analytical approach is to show that a given system is safe. Specifically, the analysis can not show that a system is hazardous since the worst case assumptions implicit in the analysis can never be guaranteed to exist.

1.1 General Approach

The procedure for establishing the extent of the RF hazard to any system by means of the analytic method is as follows:

a. The RF sensitivity of the particular device or devices in each of the circuits in the system is determined over the entire frequency range of interest, for both continuous wave (CW) and pulsed RF signals and for all possible modes of damage such as through the regular leads or between the leads and the case or any other potential damage mode which exists.

b. Using circuit diagrams, wiring diagrams, observation of the actual systems, observations and discussions of the handling, installation and checkout procedures and discussions with the engineers directly concerned the details of the actual physical systems are established. These details include such things as length of cables, locations of wiring breakouts, and separation of distance between firing leads and between the firing leads and the ground plane.

c. Mathematical models are constructed which closely resemble the actual wiring systems, and which can be handled with analytic techniques. These models are constructed for all phases of the problem; i.e., handling, installation, check out and installed; and treat circuits, in the case of EED's for example, for pin-to-pin, pins-to-case and bridgewire-to-bridgewire effects, as applicable. All known parameters of the circuits are used such as the length of unshielded portions, and the physical shape; but wherever a parameter cannot be properly defined a worst case assumption is made. For example it is normally assumed that a given circuit is oriented with respect to the

RF field for maximum pick-up of energy, that the entire circuit is in a single plane and that all impedances in the circuit are matched for optimum pick-up and transfer of energy.

d. The mathematical model is analyzed to establish the amount of RF energy that can be extracted from any incident RF field and subsequently transferred to the device under consideration, for example, the EED terminating the circuit. The analysis gives, for a particular circuit, a quantity known as "aperture" a measure of ability to pick up energy. The aperture as a function of frequency plot can be applied to any assumed field intensity.

e. For any assumed field intensity and frequency the amount of RF energy that could be delivered to the test item is obtained by the product of the incident power density and the aperture and this value compared with its RF sensitivity. The degree of potential hazard is thereby established. Under the assumptions which are made, an indicated safe condition should be quite safe; an indicated hazardous condition may or may not be hazardous.

These data are usually presented graphically and in such a manner that as long as the same circuits and test items are employed, the analysis can be immediately applied to any change, present or future, in the incident field desnities. Only those circuits which are completely different need be analyzed; for example, in the case of redundant circuits only one analysis need be conducted if the two circuits are very similar. In a few rare cases the evaluation of the RF sensitivity of the device under test can be eliminated. The usual case occurs when preliminary investigations of the circuits indicates that they are so well designed from an RF standpoint that only a small amount of energy can be extracted from even a very strong incident field; then the sensitivity of the test device may be of secondary importance. However, RF sensitive EEDs should always be avoided if possible.

This approach is often designated a "worst case" analysis, however, it should be noted that this is a mild misnomer. In actual fact, all of the known or reasonably obtained data bearing upon any circuit is used. For example, such details as actual sizes of loops, length of unshielded wire runs, separation distance of cable from frame, pin configuration of test device, RF sensitivity of test device, impedance of test device, quality of shielding material used and attenuation provided by switches and arming devices used in the circuit are carefully determined and actual values are used in the calculations wherever possible. On the other hand, those characteristics which could be variable from test vehicle to test vehicle or very expensive to determine are assumed to be at their worst. For example; orientation of all circuits is assumed to be optimized in the incident field, impedances throughtout the circuit are generally assumed to be matched in such a manner as to give maximum transfer of RF energy to the test device, RF pickup from all loops is assumed to be in phase and missile skins, except under unusual circumstances, are assumed to offer no attenuation. Experience has shown this last assumption to be quite valid.

As a result, the analysis produces values of RF power delivered to the test device which are always on the conservative side, occasionally by rather large amounts. This leads to the statement made earlier that if under the worst case approach a system is found to be safe, it is most likely quite safe; if on the other hand a hazard is indicated, the system may still be safe.

Three additional points should be noted, however. First, experience has shown that if the missile system is considered across a wide frequency band there is a good probability that at some point in the frequency spectrum the worst case assumptions will come close to being satisfied and the analysis and the real conditions will come close to coinciding. Second, attempts to assign probability values to the worst case assumptions so as to modify the worst case analysis is extremely difficult to do in any meaningful manner. Even if sufficient data was obtained in one or two systems to permit assignment of such probabilities, the next system may be so different that practically all of the former data is not applicable. Third, systems carefully designed with the RF hazard problem in mind, will generally be shown to be safe by even this worst case analysis. Only those circuits which have serious deficiencies in this respect tend to fail and these circuits should in general be corrected anyway.

2. DETAILED ANALYSIS PROCEDURES

It is the purpose of this section to describe in detail most of the mathematical procedures necessary to conduct an RF analysis on a component. From the start it should be carefully noted that when analyzing the potential hazard to a component such as an EED every pertinent aspect of its history must be carefully considered in its own specific situation. For example, the circuit attached to an EED when it is installed in a space vehicle may have very different RF pickup characteristics than the circuit which might be temporarily attached to check the resistance or some other parameter of the EED. If the EED is installed in a vehicle with the shorting cap attached and the shorting cap is removed to attach the functioning circuit while an RF field is present, possible RF hazard must be considered for the EED with shorting cap, without shorting cap and installed in circuit. Should a monitoring circuit be included in the EED, the RF pickup associated with this circuit must be considered along with its possible coupling to the EED functioning circuit. In short, the engineer performing the analysis must become intimately familar with all aspects of the device, its associated circuits usually back to the power source and its history insofar as handling, installation, checkout and final installed condition are concerned.

In addition the engineer must consider all of the possible functioning modes of a device. For a wire bridge EED this would include the following: through the bridgewire, between the bridgewire and the case and between the bridgewires, if applicable.

For each condition, the engineer must characterize the system as to its most likely manner of acting as a receiving antenna. In its simplest form one might consider a wire lead EED with its leads twisted together at the end. This system could probably be most directly characterized as a small loop antenna terminated in the bridgewire impedance. The same EED installed in a complex missile circuit may be much more elusive to characterize, however. A typical configuration would result in shielding of the cables leading to the EED but no attachment of the shield to the case of the EED. If single point grounding of the shield philosophy is also followed, the engineer may find that a large loop is formed and attached to the pins-to-case mode of the EED.

In summary, and it cannot be said too strongly, when applying the analytical techniques discussed here, it is most important to consider all possible configurations and hazard modes and to characterize the systems being considered into their proper patterns. This step is the single most important and time consuming element of the analysis.

Before proceeding to specific cases a few of the general considerations under which we will operate should be stated. The object of all of the analyses to be presented here is to determine the maximum amount of power which can be delivered to any particular failure mode of the EED or device under consideration. It is assumed that the incident RF field is essentially TEM; i.e., far field. Under these conditions the power density P can be expressed as

$$P = |\bar{P}| = |\bar{E}||\bar{H}| = \frac{|\bar{E}|^2}{Z_o} = |\bar{H}|^2 Z_o \tag{2-1}$$

where

$\bar{P}$ is the power density,

$\bar{E}$ is the electric field,

$\bar{H}$ is the magnetic field,

Z_o is the impedance of free space, 377 ohms.

The lines above the letters indicate vector notation.

With an incident TEM field the basic antenna formulas can be applied and the hazard expressed in terms of the effective aperture (A_e) which is defined by

$$A_e = \frac{W}{P} \text{ meter}^2 \qquad (2\text{-}2)$$

where

A_e = effective aperture (square meters),

P = power density, (watts/square meter),

W = power dissipated in the antenna load, the EED, (watts).

This concept of aperture is used in all of our analyses.

A general equation[1] for expressing the effective aperture is

$$A_e = \frac{V^2 R_T}{P\,[(R_R + R_L + R_T)^2 + (X_R + X_T)^2]} \qquad (2\text{-}3)$$

where

V = the total voltage induced in the antenna,

R_R = radiation resistance,

R_L = loss resistance of the antenna,

R_T = termination resistance,

X_T = termination reactance,

X_R = antenna reactance.

This basic equation is used to formulate many of the analyses.

In an actual computation the effective aperture must be calculated for each frequency of interest using the applicable equations. If the product of the effective aperture and incident power density at any given frequency is now formed, the result is the actual RF power delivered to the EED under the assumed conditions. This value can then be compared with the sensitivity of the EED at that frequency to establish the possibility of RF susceptibility.

With respect to specific cases we are concerned with only two conditions for the EED: <u>disconnected</u>; i.e., not attached to any firing or testing circuit; and connected. In the former, we are concerned with the physical and electrical structure of the EED alone including any shorting or shielding caps. This would be the normal condition for the various analyses designated as hand held, transportation (when the EEDs are not installed) and installation (before the circuits are attached). In the latter or connected condition we are concerned with the EED as a component in an electrical system. This would be the normal condition whenever the device is installed or during check out or other electrical testing procedures. It is these two conditions that we will now examine in more detail.

2.1 EED Disconnected

In order to determine the potential hazard to an EED resulting from exposure to an incident RF field during handling and installation (hand-held mode) it is necessary to analyze the physical body of the initiator in terms of its ability to pick up and deliver energy to its explosive components. The method of analysis depends heavily upon the connector type: twin-lead, coaxial or others. Various analytical methods are available which include similitude to a small loop, a coaxial aperture, or a circular aperture. In all of these methods, we assume that the field is essentially TEM or far field. With an incident TEM field, the basic antenna formulas can be applied considering the initiator or initiator assembly positioned for maximum power pick up. The various firing modes (pin-to-pin, pins-to-case and bridgewire-to-bridgewire) must also be considered both for continuous wave (CW) and for pulsed power.

2.1.1 Multipin Connector Type

In this section we are concerned with EEDs in which the input uses some form of the standard type metal shelled, multipin connector. The analysis applies even if there is only a single pin such as in the coaxial type. Over the years we have developed numerous analysis procedures for models in which it was assumed that the model was a coaxial line; i.e., the pins in the connector are assumed to be the inner conductor of a coaxial line and the connector body the outer connector, a two wire end driven line (the connector body if assumed to be removed and the exposed pins end driven) and a small loop formed by the connector pins (connector body removed). However, it was determined that the worst case aperture exists when the axis of the connector on the EED lies along the direction of propagation of the incident radiation. In this case we assume that the power delivered to the initiator is not more than that which would be transmitted through a circular aperture (of the same diameter as the inside diameter of the pin shield) in an infinite conducting screen normal to the direction of propagation. This approach is now used for all connector type EEDs whether shorted or unshorted and for all excitation modes (pin-to-pin, pins-to-case or bridge-to-bridge), and while this approach produces a "worst-worst case" value of aperture, the values are in general so low that no hazard exists in reasonable incident RF fields and the overall calculation is simplified. The circular aperture is given by

$$A_c = T_{wc} A \tag{2-4}$$

where

A = area of the opening of the pin shield in square meters,

T_{wc} = transmission coefficient as given in Figure 2-1.

Figure 2-1 is a straight line approximation we developed from the relationship of transmission coefficient to the radius of the circular aperture which is given in reference (2), page 126.

In practice, for any given frequency we can compute a value of Ka where $K = \frac{2\pi}{\lambda}$ and a = the radius of the aperture; a and λ should be in the same units. T_{wc} can then be obtained from Figure 2-1 for the calculated value of Ka and the circular aperture can be calculated from Equation 2-4. This calculation must be repeated for each frequency of interest.

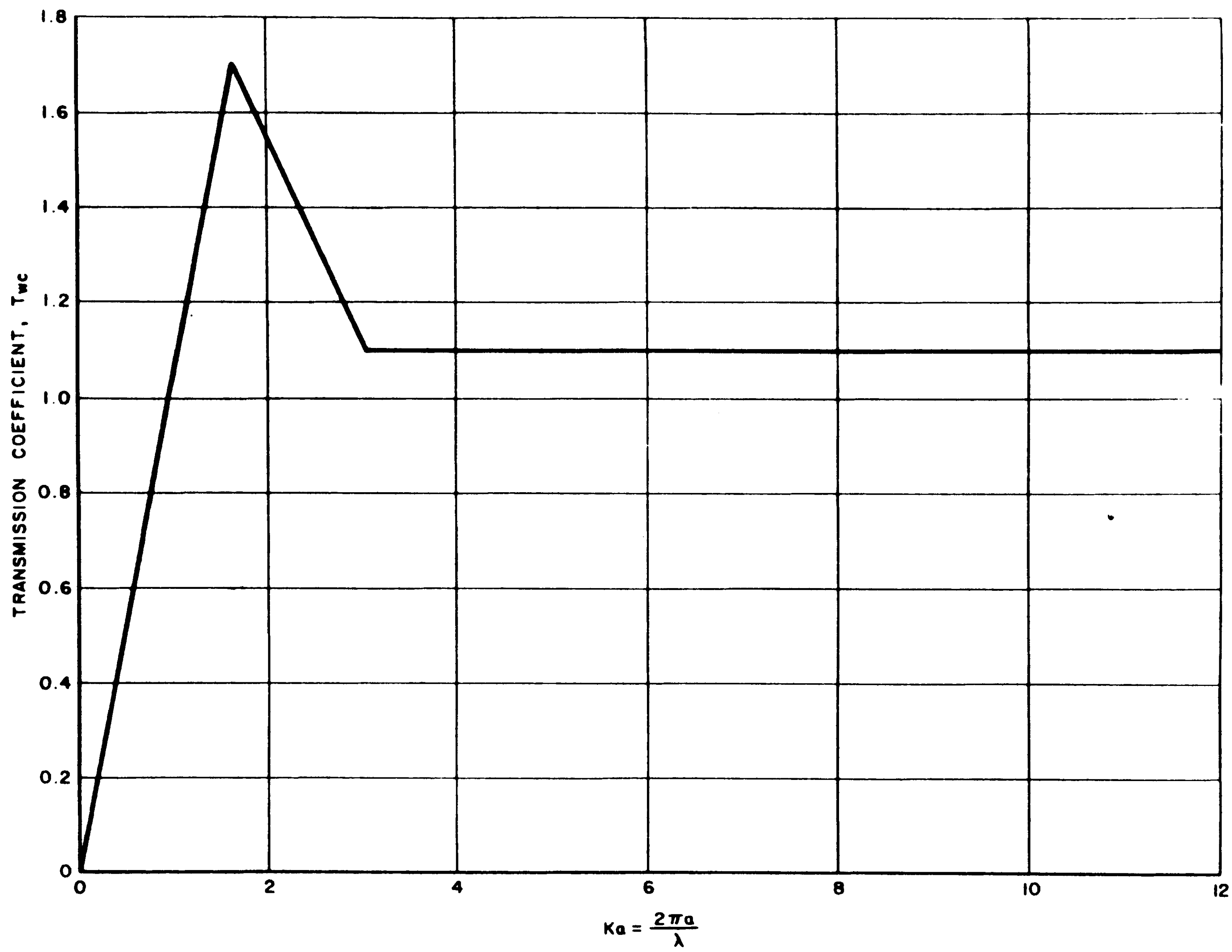


Fig. 2-1 - Transmission Coefficient of Circular Apertures of Radius a (Meters), Straight Line Approximation

2.1.2 Wire Lead Type

The other most common type of EED which is in usage is the wire lead type in which the pins to which the bridgewire is applied are wires which extend through the base plug and are used to make connections to the EED. These wires may be very short or as long as several feet although the most common length is 6 to 8 inches. For the EED disconnected we are interested in both the shorted and unshorted case.

2.1.2.1 Unshorted Wire Lead Type (Pin-to-Pin)

Figure 2-2 sketches this type configuration and its antenna model. This configuration is also often formed by firing system wiring. We can evaluate the maximum possible aperture of this configuration by using (from reference (1))

$$A_{em} = \frac{G\lambda^2}{4\pi} \qquad (2\text{-}5)$$

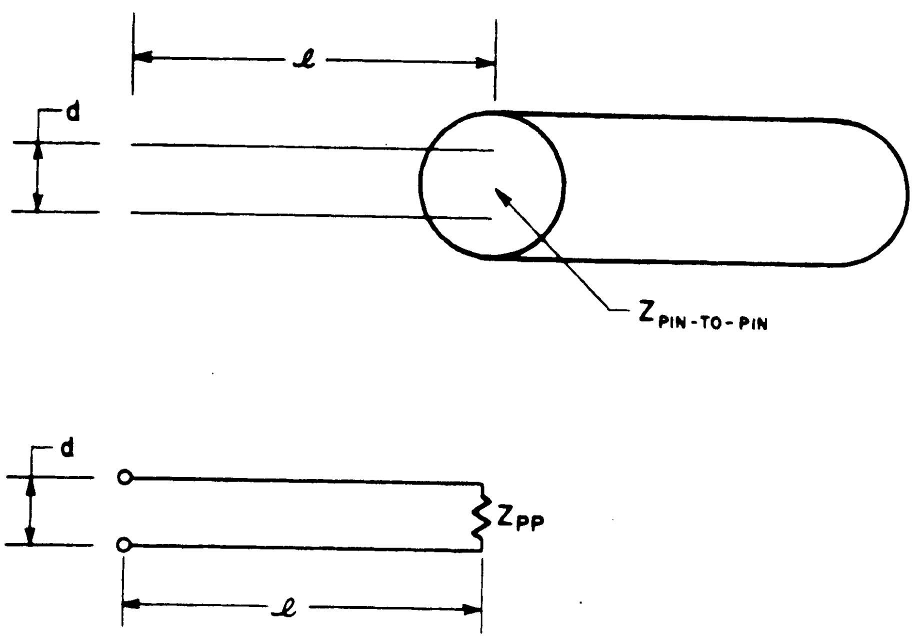


Fig. 2-2 - Unshorted EED and Its Antenna Model

Here we must compute the gain G of the antenna, where G is defined for a lossless antenna, (which is clearly necessary for prediction for maximum aperture) as equal to the directivity D. D in turn is defined by

$$D = \frac{\text{maximum radiation intensity}}{\text{average radiation intensity}} = \frac{U_m}{U_o} \qquad (2\text{-}6)$$

The units of U are watts per square radian and since a sphere contains 4π square radians,

$$D = \frac{4\pi\ U_m}{\text{total power radiated}} \qquad (2\text{-}7)$$

At large values of r we will have TEM propagation and therefore the Poynting vector will be real and perpencidular to the surface of a sphere centered at the antenna. Using P_{r_1} as the magnitude of the Poynting vector at a large radius r_1 and the definition of U_m at radius r_1 as

$$U_{m_{r_1}} = r_1^2\ P_{r_1 max} \qquad (2\text{-}8)$$

then

$$D = \frac{4\pi\ r_1^2\ P_{r_1 max}}{\oiint_{r_1} P_{r_1}\ ds} \qquad (2\text{-}9)$$

Combining Equations (2-5) and (2-6) gives, for a lossless antenna,

$$A_{em} = \frac{\lambda^2\ r_1^2\ P_{r_1 max}}{\oiint_{r_1} P_{r_1}\ ds} \qquad (2\text{-}10)$$

where r_1 is a very large radius. The Poynting vector at a large radius may be computed from Equation (2-1), and we obtain

$$A_{em} = \frac{\lambda^2 r_1^2 \dfrac{|\bar{E}_{r_1}|^2_{max}}{Z_o}}{I_o^2 R_R} \qquad (2\text{-}11)$$

where I_o is the current on the antenna and R_R is the radiation resistance. I_o must be the current actually passing thru R_R in the equivalent circuit. The denominator of Equation (2-10) is the total power radiated and $I_o^2 R_R$ is also equal to the total power.

If in Equation (2-3), an impedance match is assumed; i.e.,

$$(R_R = R_T, R_L = 0, X_T = -X_R)$$

we obtain

$$A_e = A_{em} = \frac{V^2}{4\ PR_R} \qquad (2\text{-}12)$$

since this must be the maximum aperture. This may be equated to Equation (2-11), yielding

$$V^2 = \frac{4\ P\ \lambda^2\ r_1^2\ |\bar{E}_{r_1}|^2_{max}}{Z_o\ I_o^2} \qquad (2\text{-}13)$$

If we now can find $|\bar{E}_{r_1}|_{max}$ for our configuration we will have found V^2, the induced voltage squared. Substitution of this in Equation (2-3) will then yield

$$A_e = \frac{4\ \lambda^2\ r_1^2\ R_T |\bar{E}_{r_1}|^2_{max}}{Z_o\ I_o^2\ [(R_R + R_L + R_T)^2 + (X_R + X_T)^2]} \qquad (2\text{-}14)$$

If we now maximize Equation (2-13) in relation to the unknowns we obtain, for $X_R = -X_T$, $R_L = 0$, $R_R = 0$,

$$A_e = \frac{4 \lambda^2 r_1^2 \left|\bar{E}_{r_1}\right|^2_{max}}{Z_o I_o^2 R_T} \tag{2-15}$$

and our only unknown is $\left|\bar{E}_{r_1}\right|_{max}$. Figure 2-3 shows the configuration to be evaluated for the $\bar{E}$ field at a large r. A similar case with a different phase relationship between the currents has already been analyzed[3]. Substitution of our value of phase difference (i.e., 180°) in this analysis yields

$$\left|\bar{E}_{r_1}\right|^2 = \frac{Z_o^2 I_o^2 \ell^2}{\lambda^2 r_1^2} (1 - \sin^2 \phi \sin^2 \theta) \sin^2 (\frac{\beta d}{2} \cos \theta) \tag{2-16}$$

where

$$\beta = \frac{2\Pi}{\lambda}$$

This expression has a maximum value, at $\theta = 0$, of

$$\left|\bar{E}_{r_1}\right|^2_{max} = \frac{Z_o^2 I_o^2 \ell^2}{\lambda^2 r_1^2} \sin^2 (\frac{\beta d}{2}) \tag{2-17}$$

Substituting this result in Equation (2-5), yields

$$A_e = \frac{4 Z_o \ell^2}{R_T} \cdot \sin^2 (\frac{\beta d}{2}) \tag{2-18}$$

The above derivation is subject to the restriction that $\ell << \lambda$ since we have considered the currents as linear, whereas they are actually, to a first approximation at least, distributed sinusoidally along the wires.

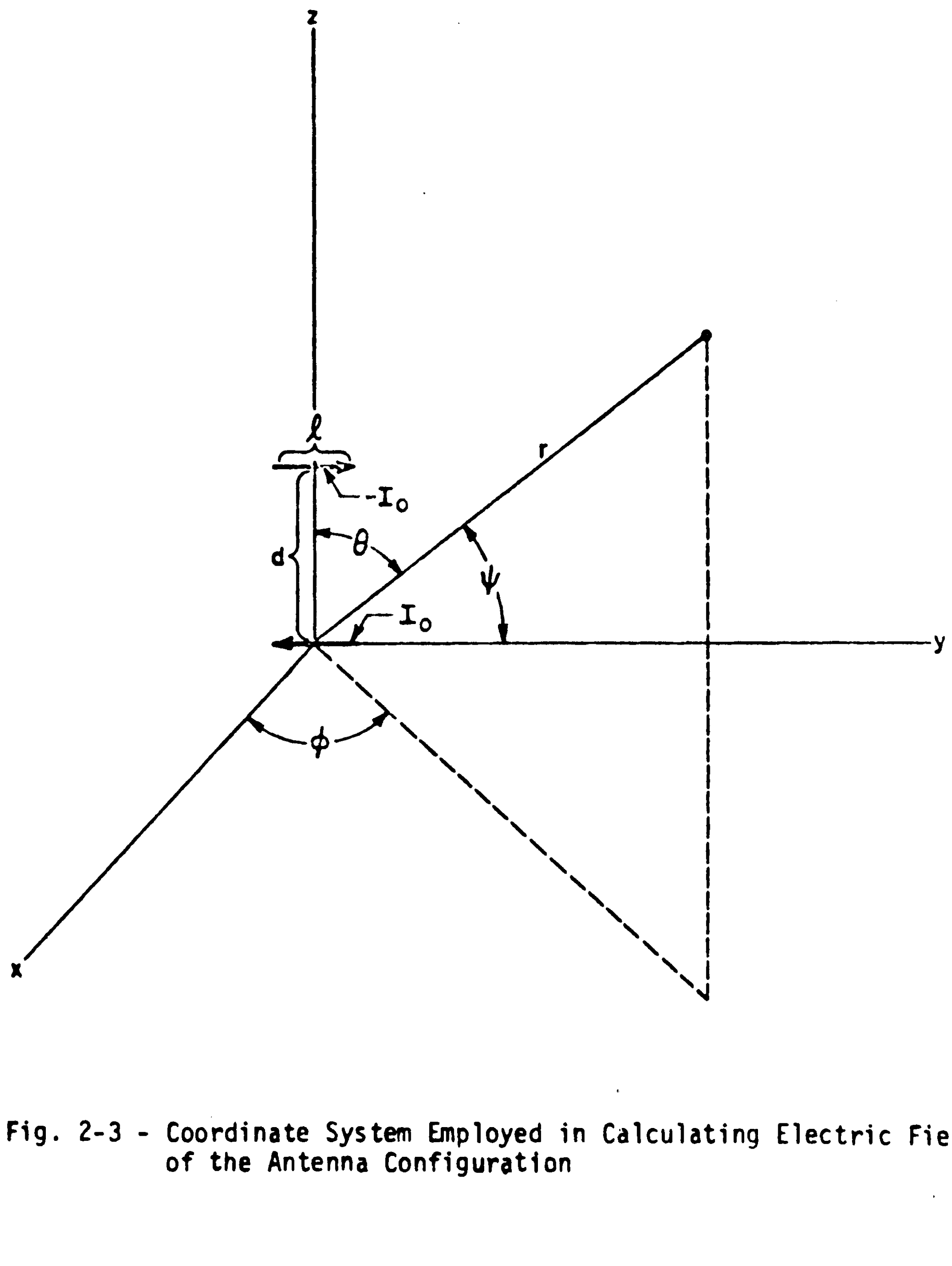


Fig. 2-3 - Coordinate System Employed in Calculating Electric Field of the Antenna Configuration

For $\ell << \lambda$, $d < \ell$,

$$\sin\left(\frac{\beta d}{2}\right) \rightarrow \frac{\pi d}{\lambda}$$

and

$$A_e = \frac{4\pi^2 Z_o \ell^2 d^2}{R_T \lambda^2} = \frac{4\pi^2 Z_o A^2}{R_T \lambda^2} \qquad (2\text{-}19)$$

A can be considered the area of the antenna given by the product of d and ℓ.

2.1.2.2 Shorted Wire Lead Type (Pin-to-Pin)

The standard method of shorting a wire lead type EED is to twist the ends of the wires together. This forms the leads into a loop antenna.

On page 171 of Reference (1) it is shown that for a small loop whose area, A, is less than $r^2/100$ the radiation resistance is given by:

$$R_R = \frac{320\ \pi^4 A^2}{\lambda^4} = \frac{3.12 \times 10^4 A^2}{\lambda^4} \qquad (2\text{-}20)$$

and that the directivity, D, of the small loop is 3/2. Using the formula for maximum effective aperture of a lossless antenna[(1)],

$$A_{em} = \frac{D\lambda^2}{4\pi} = \frac{W_{max}}{P} \qquad (2\text{-}21)$$

which is evaluated when the terminating resistance equals the radiation resistance and the reactances cancel, we can obtain for the induced voltage

$$\left(\frac{V}{2}\right)^2 \frac{1}{R_R} = W_{max} = \frac{PD\lambda^2}{4\pi} \qquad (2\text{-}22)$$

Substituting for R_R, we get

$$V^2 = \frac{P \times 4.67 \times 10^4 A^2}{\pi \lambda^2} \quad (2\text{-}23)$$

Substituting this expression and $R_L = 0$, $X_R = -X_T$ in Equation (2-3) we obtain

$$A_e = \frac{4.67 \times 10^4 A^2}{\pi \lambda^2} \frac{R_T}{(R_T + R_R)^2} \quad (2\text{-}24)$$

At large λ, the λ^4 term in the expression for the radiation resistance (Equation 2-20) dominates and the radiation resistance becomes very small (for reasonable areas, <0.01 m^2) in relation to the other resistance in the circuits; we therefore may assume $R_R = 0$. Using this approximation, Equation (2-24) becomes

$$A_e = \frac{4.67 \times 10^4 A^2}{\pi \lambda^2 R_T} \quad (2\text{-}25)$$

This equation represents the aperture of a small loop assuming a reactive match between antenna and load, no dissipation of power in the radiation resistance (which we have seen is very low for small loops), and orientation of the loop for maximum pickup.

An alternate method of deriving the maximum aperture of a small loop is to obtain an expression for the voltage induced in the loop. Consider that the magnetic flux density is uniform over the loop. The total voltage around the loop is then given by

$$|V| = \left| -\oint \frac{\partial \bar{B}}{\partial t} \cdot ds \right| = A \mu_o \omega |\bar{H}| \quad (2\text{-}26)$$

where

A = area of the loop,
$\omega = 2\pi f = 6\pi \times 10^8/\lambda$,
f = frequency,
λ = wavelength,

μ_o = permeability of free space, 12.5 x 10^{-7} h/m,
$\bar{B}$ = magnetic flux density.

If we express $|\bar{H}|^2$ in terms of P and Z_o from Equation (2-1) and frequency in terms of wavelength and substitute these into the square of Equation (2-26) we obtain

$$|V|^2 = \frac{A^2\, 4\, \pi^2\, P\, \mu_o\, c^2}{Z_o\, \lambda^2} \qquad (2\text{-}27)$$

where $c = f\lambda = 3 \times 10^8$ m/sec.

If we now make use of

$$c = \frac{1}{\sqrt{\mu_o\, \varepsilon_o}} = 300 \times 10^6 \text{ and } z_o = \sqrt{\frac{\mu_o}{\varepsilon_o}} = 377$$

where ε_o is the permittivity of free space, we can write Equation 2-27 as

$$|V|^2 = \frac{A^2\, 4\, \pi^2\, P\, Z_o}{\lambda^2} = \frac{1.48 \times 10^4\, A^2 P}{\lambda^2} \qquad (2\text{-}28)$$

Substitution of Equation(2-28) in (2-3) with $R_L = 0$, $X_R = -X_T$ gives

$$A_e = \frac{1.48 \times 10^4\, A^2}{\lambda^2} \cdot \frac{R_T}{(R_T + R_R)^2} \qquad (2\text{-}29)$$

Using the assumption that $R_R = 0$ as before, Equation (2-29) can be rewritten as

$$A_e = \frac{4.67 \times 10^4\, A^2}{\pi\, \lambda^2\, R_T} \qquad (2\text{-}30)$$

which is identical to Equation (2-25).

Furthermore, if we now compare this result with Equation (2-19), the expression for unshorted wire lead configuration, we find that the two expressions are also identical. Therefore, the effective aperture for a wire lead EED in the pin-to-pin mode is the same whether the leads are shorted together or not,if the physical dimensions are the same.

2.1.2.3 Wire Lead Type (Pins-to-Case)

The two preceeding sections discuss the case for pin-to-pin or "through-the-bridgewire" conditions; however, a pins-to-case functioning mode is also possible. Figure 2-4 shows a typical EED and the corresponding antenna equivalent. As shown, the approximation of this configuration as an antenna is an end driven short dipole where the impedance that must be used is the real part of the pins-to-case impedance. This must be obtained by measurement at the frequencies of interest. The formula for calculating the maximum power pickup in this impedance from an end driven dipole is as follows:

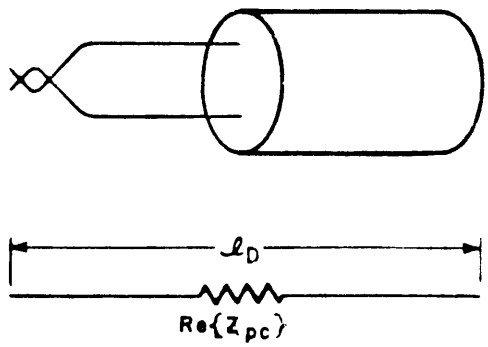


Fig. 2-4 - Antenna Equivalent Circuit for Wire Lead EED in Pins-to-Case Mode

$$W = \frac{|\bar{E}|^2 \ell_D^2}{Re\{Z_{pc}\}} \qquad (2\text{-}31)$$

where

W = maximum power in watts,

$|\bar{E}|$ = magnitude of field density in volts/meter,

ℓ_D = length of dipole in meters,

$Re\{Z_{pc}\}$ = real part of pins-to-case impedance in ohms.

This formula utilizes the fact that the effective height of a short dipole is its physical length and therefore the total open circuit voltage in the antenna equivalent circuit will be equal to the magnitude of the electric field times the dipole length. The worst case assumption for series impedances of this model is that the radiation and terminating impedances have equal and opposite reactances and that the radiation resistance is zero. From Equation (2-2) it can be seen that Equation (2-31) can be expressed as an aperture by dividing both sides by the incident power density (P_i).

$$A_e = \frac{W}{P_i} = \frac{\ell_D^2 Z_o}{Re\{Z_{pc}\}} \text{ Meter}^2 \qquad (2\text{-}32)$$

where Z_o = impedance of free space in ohms.

2.1.2.4 Wire Lead Type (High Frequency Calculations)

In the preceding three sections we have discussed the methods of analyzing the RF pickup of a wire lead device in all of its various configurations and hazard modes. However, each of these approaches has the limitation that the wavelength must be long with respect to the physical dimensions of the receiving antennas. When the wave length becomes too short the assumptions which lead to the various calculations are no longer valid due to non uniform current distribution in the antennas. For the unshorted loop the shortest applicable wavelength occurs at $\lambda = 20\ell$ where ℓ is the length of one of the leads. For the shorted loop the shortest applicable wavelength is $\lambda = 2\ell$ where ℓ is the perimeter of the loop. For the end driven dipole, the shortest applicable wavelength is $\lambda = 10\ell_D$ where ℓ_D is the length of the dipole. In each case the equations are valid for any wavelength longer than these conditions.

At the shorter wave lengths; i.e., the higher frequencies, the maximum effective aperture (A_{em}) can be calculated from

$$A_{em} = \frac{D\lambda^2}{4\pi} \qquad (2-33)$$

which holds for a lossless antenna. In this formula A_{em} is the maximum possible aperture, assuming a complete impedance match, and D is the directivity of the antenna. Generally, at these higher frequencies the directivity of the actual configuration under consideration as a function of frequency is not known; but if we assume that it can be no more than that of an antenna of known directivity we can calculate A_{em}, the maximum effective aperture.

Another reference(4), shows curves of directivity for three types of antennas: the unterminated rhombic, the long wire and the circular loop. It is reasonable to assume that our configuration will be no more directive than these, since these are among the most directional linear antennas known.

Figure 2-5 is a composite plot of the greatest directivity of these antennas types as a function of overall lead length. The plot was made directly from the above reference. Using Figure 2-5 and Equation (2-33) the maximum effective aperture of our antenna configurations can be calculated. The maximum effective aperture (A_{em}) is calculated under the assumption that the lead configuration will be no more directive than an unterminated rhombic, a long wire or a circular loop antenna of equal linear dimension. The calculation is straightforward.

It is interesting to note at this point the previous determinations for effective aperture (A_e) at the lower frequencies were calculated with the following assumptions: the terminating bridgewire resistance is no less than the dc resistance, the antenna is reactively matched, loss resistance is zero, and the radiation resistance is zero.

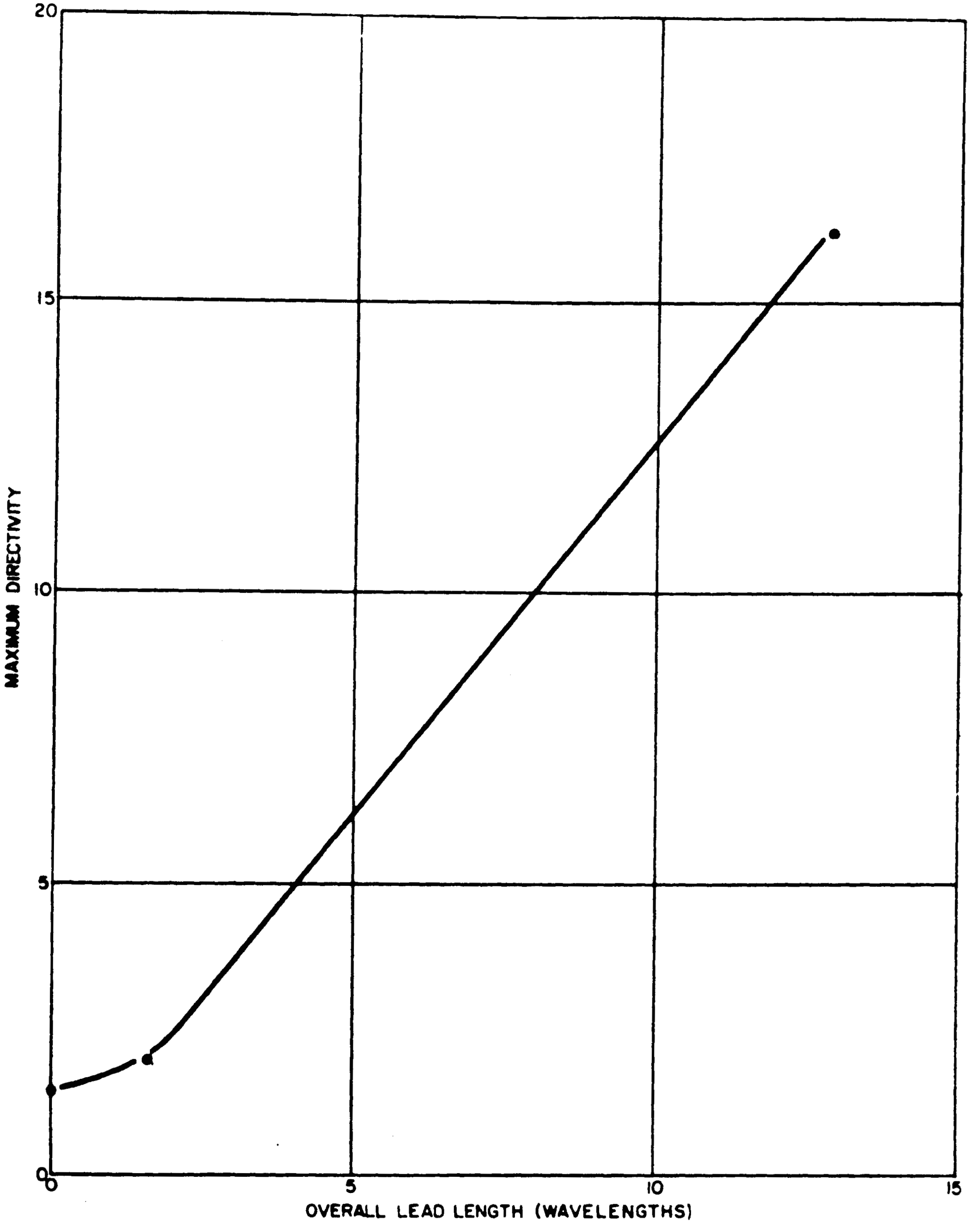


Fig. 2-5 - Maximum Directivity of Three Known Antenna Configurations

Note that these last assumptions effectively maximize the A_e expression (see Equation (2-3) where V^2 is considered constant). These calculations contain a seeming anomaly since the effective aperture curve, if continued, would rise above the maximum effective aperture curve. This is a result of considering the radiation resistance to be equal to zero in our maximizing procedure of the effective aperture. If the radiation resistance were taken into consideration the curves would not intersect so abruptly but the effective aperture curve would roll over at the higher frequencies to meet the maximum effective aperture curve.

2.2 EED Connected

The preceding discussions provided the necessary formulas to determine the worst case RF pick up of the majority of EED disconnected situations that one is likely to come upon and which would be applicable for hand-held, installation and transportation considerations. In turning our attention to the EED connected in its various circuits, for example installed and checkout, it is important to restate that the most important and necessary part of the analysis is to properly characterize the antennas represented and that this procedure is considerably more complicated when the EED is connected. However, experience has shown that the majority of present missile circuits fall into one of two categories. The first of these is the circuit which contains breakout of the shields to go to circuit boards, through bulkhead connectors, to other circuits or at the EED itself. A common occurrence is for the shielding to terminate just prior to the EED, for example. Most of these breakouts can be characterized as loops of varying dimensions. One must pay particular attention to possible pins-to-case loops in these systems. The second type is the circuit which is completely shielded from end to end and through 360°. In this section we will treat these two possibilities.

2.2.1 Circuits with Shielding Caps

Many EED firing systems use shielded cables between the safe/arm device and the EED, or if no safe/arm unit is used, between the timers or firing switches and the EED. For such circuits the first assumption used in arriving at the antenna models to be used is that the power coupled to the EED firing mode impedances through the braided shield of the cables is negligible in relation to that coupled to these impedances by the non-shielded portions of the wiring. In consequence the models chosen represent the physical characteristics of the gaps or breaks in the shielding. Figure 2-6 diagrams a typical break or gap in a shielded firing lead and Figure 2-7 diagrams the equivalent antenna model used for this gap. The dimensions given are representative of commonly used separation switches.

The impedances Z_{u_1} and Z_{u_2} are considered to be completely unknown while Z_{ppt} and Z_{pct} represent the firing mode impedances (Z_{pp} and Z_{pc}) of the EED transformed along the connecting lines to the separation switch. The models for pin-to-pin and pins-to-case pickup are thus seen to be, for the lower frequencies at least, small loops loaded with the indicated impedance. We further assume that the transmission lines formed by the shielded cables that connect the gaps and the EED are lossless. This is to be expected since these cables are constructed of good conductors and good insulators. In addition we have made measurements on many typical types of two wire twisted shielded cable in the low frequency ranges and although attenuation is not zero it is usually small for the lengths of cable considered in these ranges. The only worst case assumption that can be made, without extensive and expensive measurements, is that the loss is zero.

Once the loop has been reduced to its diagrammatic representation as shown in Figure 2-7, the aperture for this loop can be calculated from the same equations as developed before. For wavelengths up to twice the perimeter of the loop, Equation (2-25) applies. For shorter wavelengths Equation (2-33) applies.

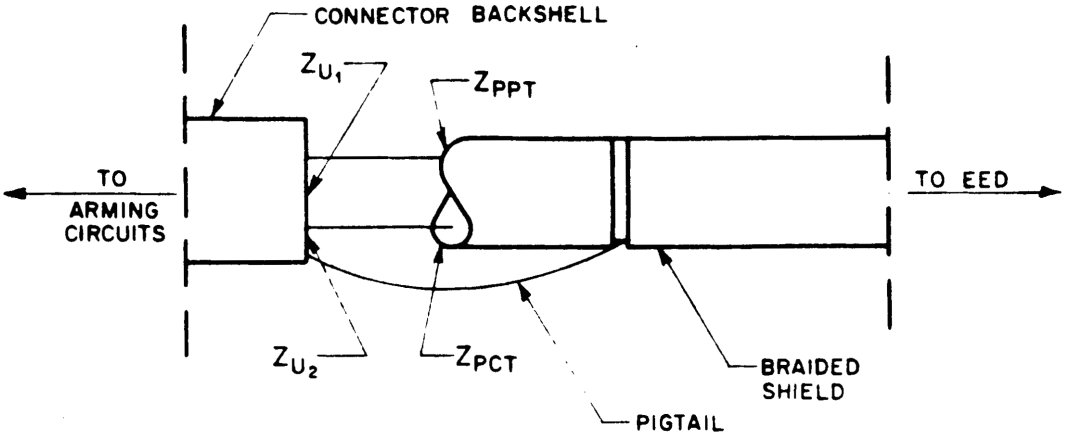


Fig. 2-6 - A Typical Shielding Gap Configuration

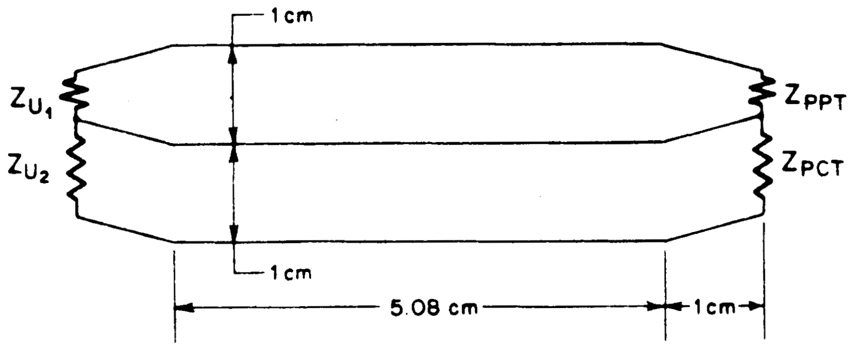


Fig. 2-7 - Basic Antenna Model for a Shielding Gap

$$A_e = \frac{4.67 \times 10^4 A^2}{\pi \lambda^2 R_T} \tag{2-25}$$

$$A_{em} = \frac{D\lambda^2}{4\pi} \tag{2-33}$$

The above methods allow us to predict the maximum possible aperture of a single loop across the frequency range of interest. If more than one loop exists in the same firing circuit the composite aperture of the combined loops is obtained, at all frequencies such that $2\ell < \lambda$, from

$$A_{ec} = \frac{4.67 \times 10^4}{\pi \lambda^2 R_T} (A_1 + A_2 + A_3 + \ldots + A_m + \ldots + A_n)^2 \tag{2-34}$$

where A_{ec} is the composite effective aperture of n loops and A_m is the area of the mth loop. This result reflects the fact that the methods employed in this frequency range are based on a maximum voltage and since the voltage contributions of the individual loops could add in phase, we must consider this worst case possibility. In fact, at the lower frequencies where the wavelengths could be considerably longer than the circuit considered, this is a distinct possibility.

At the higher frequencies such that $2\ell \geq \lambda$ a similar procedure must be used, here the composite aperture is calculated from

$$A_{ec} = \left(\sqrt{A_{em_1}} + \sqrt{A_{em_2}} + \ldots + \sqrt{A_{em_q}} + \ldots + \sqrt{A_{em_n}}\right)^2 \tag{2-35}$$

where A_{em_q} is the maximum aperture of the qth gap and A_{ec} is the composite aperture.

Figure 2-8 shows the pin-to-pin aperture computed by the above methods for a small shielding gap in a 6.4 ohm (dc resistance) EED firing circuit. The geometry of the gap is shown on the figure.

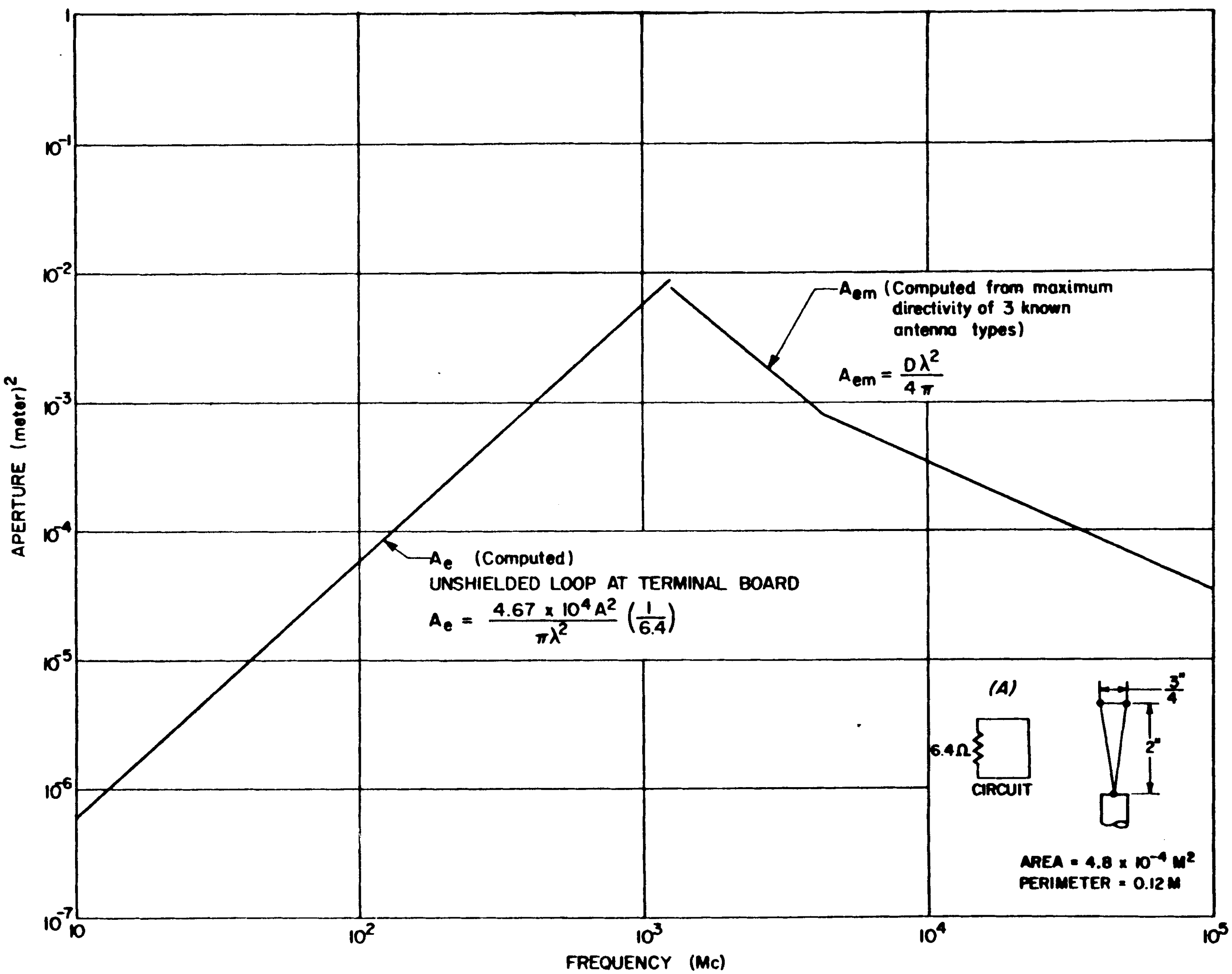


FIG. 2-8 APERTURE OF LOOP AS SHOWN IN FIGURE (A) AT TYPICAL TERMINAL BOARD

2.2.2 Completely Shielded Circuits

The case where circuits are completely shielded with no gaps is comparatively rare and it should be noted immediately that when this is done there is rarely any RF hazard problem involved with such circuits. However, it is sometimes necessary to demonstrate by analysis that such is the case.

Since in such a system the shields completely enclose the EED, shorting switch, power supply and interconnecting wires, the analysis can be broken into the following parts:

1. Determining the total power into the outer surface of the shield as a function of frequency and of the incident field assuming matched conditions inside the shield.

2. Determining the total power loss of the shield assuming matched conditions inside the shield.

3. Using the results of steps one and two to calculate the maximum possible power that can be delivered to the EED as a function of frequency and incident field, assuming the EED to be installed in the longest firing circuit.

4. Comparing the results of step three to a composite 0.1% firing level that is the minimum 0.1% level for all the EEDs under consideration for any firing mode.

Dividing the analysis into the parts given above implies the assumption that the field that is reradiated by any structure within the shield or by the boundary between the inner surface of the shield and the region internal to the shield will, at the outer surface of the shield, be very small in relation to the field induced on the outer surface by the incident radiation. A worst case approach which insures the above is to assume that all power that penetrates the shield is perfectly matched to the EED. If this were the case, there would be no reflection from either the shield/internal region boundary or any internal structure. We may further assume that the power that penetrates the shield can be matched to any of the firing modes' impedances.

2.2.2.1 Calculation of the Maximum Power Density at the Outer Surface of the Braided Shield

As a start toward determining the maximum power density at the surface of the braid, we assume that the entire surface of the cable is illuminated by a TEM field at normal incidence and the field has a power density P_i. We realize that generation of such a field (normal to an irregular convex surface) is well nigh impossible, but it is surely the worst case TEM field assumption. The maximum power density (P_T) at the surface of the shield is given by

$$P_T = P_i \left(1 - |\rho|^2\right) \tag{2-36}$$

where

P_T is the power density at the surface of the braid,

P_i is the incident TEM field power density,

$\rho = \dfrac{Z_c - Z_o}{Z_c + Z_o}$,

Z_o = 377 ohms,

$Z_c = (1 + j) \times 2.59 \times 10^{-4} \sqrt{f_{MHz}}$ = the surface impedance of a copper sheet in ohms,

f_{MHz} = frequency in megahertz.

If we note that $\text{Re}\{Z_c\} = \text{Im}\{Z_c\} \ll Z_o$ we can write Equation (2-36) as

$$P_T = P_i \frac{4\,\text{Re}\{Z_c\}}{Z_o} = P_i \times 2.75 \times 10^{-6} \sqrt{f_{MHz}} \tag{2-37}$$

with negligible error. It can be shown that this equation provides a worst case estimate of surface power density.

2.2.2.2 Calculation of the Power Density at the Inner Surface of the Braided Shield

Power passes through the shield by two separate paths: propagation through the copper ribbon of the braid and propagation through the interstices. The loss in the metallic path is a dissipative attenuation, and that produced by the small holes is due to reflection. The copper loss can be evaluated by the planar attenuation which is

$$dB = 8.68 \frac{t}{\delta} \tag{2-38}$$

where t is the thickness of the braid and δ is the skin depth. The justification of the use of planar attenuation instead of the attenuation of the curved surface of the shield can be found on page 248 of reference (5) where it is shown that as long as the radius of the cable divided by the skin depth is more than 7.55, the planar approximation leads to very small errors. If we use the minimum thickness of the ribbon that makes up the braid as t and calculate δ for copper we obtain

$$dB_{copper} = 5 \sqrt{f_{MHz}} \tag{2-39}$$

where f_{MHz} is frequency in megahertz.

The attenuation of the small holes can be computed from that of a waveguide operating below cutoff frequency. From page 346 of reference (5), we obtain, for a cutoff rectangular guide

$$\alpha = \frac{2\pi}{\lambda_c} \sqrt{1 - \left(\frac{\lambda_c}{\lambda}\right)^2} \tag{2-40}$$

where α is the attenuation in nepers per unit length,
λ_c is the cutoff wavelength of the guide,
λ is the free space wavelength of the propagating energy.

The applicable cutoff wavelength is given by

$$\lambda_c = 2b \qquad (2\text{-}41)$$

where b is the largest dimension of a rectangular guide. Converting to nepers gives

$$dB = 8.68\alpha t \qquad (2\text{-}42)$$

where t is the thickness of the shield.

Since the power density at the surface of the shield has been assumed constant and since the ratio of open to solid area of the shield can be determined, a symbolic equation can be written for the average power density out of the inner surface of the shield. If P_o is the average power density at the inner surface of the cable, P_T is the outer surface power density and Q is the ratio of solid area to hole area in the shield.

$$P_o = (1-Q)\ P_T\ [\text{down } 8.68\alpha t \text{ dB}] + QP_T\ [\text{down } 8.68\tfrac{t}{\delta} \text{ dB}] \qquad (2\text{-}43)$$

It should be noted that shielded cable varies greatly in construction and quality and to apply the above system it is necessary to carefully investigate the shield in question to determine thickness, material and ratio of hole area to solid area. General construction should also be noted.

It is now possible at any one frequency to use Equation (2-36) and Equation (2-43) to establish the maximum amount of RF power arriving at the inside of the shield in terms of the RF field incident upon the cable. If this is now adjusted for the total area of cable exposed, the total maximum RF power inside the shield will have been determined. By our original assumptions all of this power is assumed to be delivered to the EED. For consistency we could construct a symbolic aperture equation as follows:

$$A_{em} = \frac{P_o A}{P_i} = \frac{A}{P_i}\left[(1-Q)P_T[\text{down } 8.68\alpha t \text{ dB}] + QP_T[\text{down } 8.68\frac{t}{\delta} \text{ dB}]\right] \qquad (2\text{-}44)$$

where

A is the total surface area of the cable.

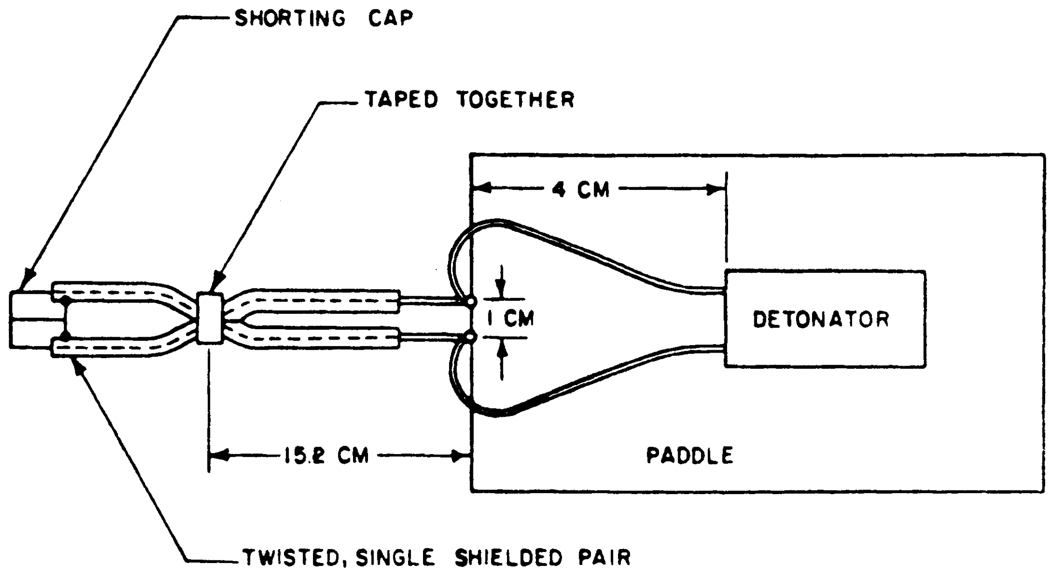


Fig. 3-1 - Schematic Drawing of System to be Analysed

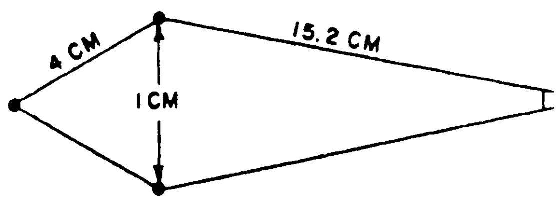


Fig. 3-2 - Loop Approximation of System Shown in Fig. 3-1

3. EXAMPLE OF AN EVALUATION

Figure 3-1 is a schematic drawing of a simple system configuration actually used on a space vehicle. Figure 3-2 is an approximation of this configuration shown as a simple loop and finally Figure 3-3 shows the antenna configuration for analysis derived from the actual circuit. R_{dc} is the dc resistance of the initiator.

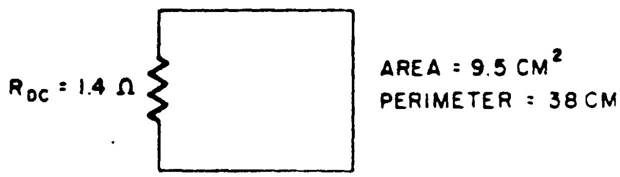


Fig. 3-3 - Antenna Configuration for Evaluation Derived from Fig. 3-2

While this is an installed mode, the final antenna configuration is a single loop. Therefore Equation (2-25) can be used to compute the aperture for all wave lengths up to $\lambda = 2$ times the perimeter of the loop, i.e., for all wave lengths up to 76 cm or a frequency of 395 MHz. Above this frequency Equation (2-33) is used. For each frequency of interest, and sufficient frequencies should be chosen to define the curve, one must calculate an aperture using the appropriate equation. Figure 3-4 is a plot of such calculations made for the circuit under consideration here.

The final step consists of using this aperture versus frequency data to produce a plot of RF power received at the EED as a function of the RF field incident on the system and to compare this RF pick-up with the RF sensitivity of the EED established by testing. Figure 3-5 shows such a plot where the incident RF power density was assumed to be 2 watts/meter^2 up to 50 MHz and 100 watts/meter^2 above 50 MHz. The data for this plot was obtained by multiplying chosen points on the aperture curve of Figure 3-4 by the assumed incident power density at the same point. Superimposed on the power pick-up

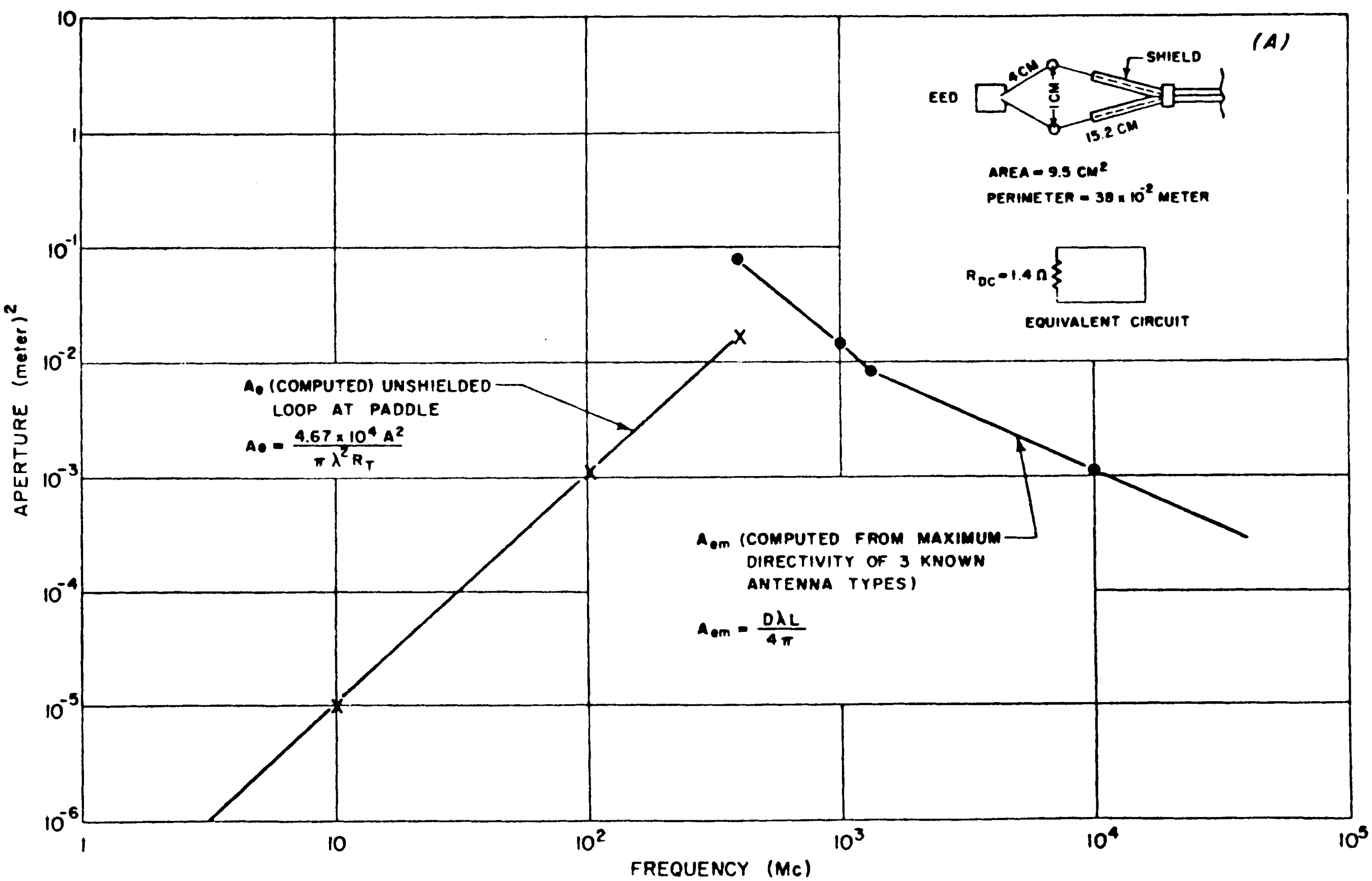


FIG. 3-4. APERTURE OF LOOP CONFIGURATION AT PADDLE

(Pin-to-Pin Mode)

curve of Figure 3-5 is the RF sensitivity curve of the EED used in the installation. The conclusion one would draw from this plot is that should this system be exposed to 100 watts/meter^2 fields across the frequency spectrum from 10 MHz to 10^5 MHz safety could be guaranteed on the basis of the analysis only from 10 MHz to 80 MHz and from approximately 1600 MHz to 8500 MHz.

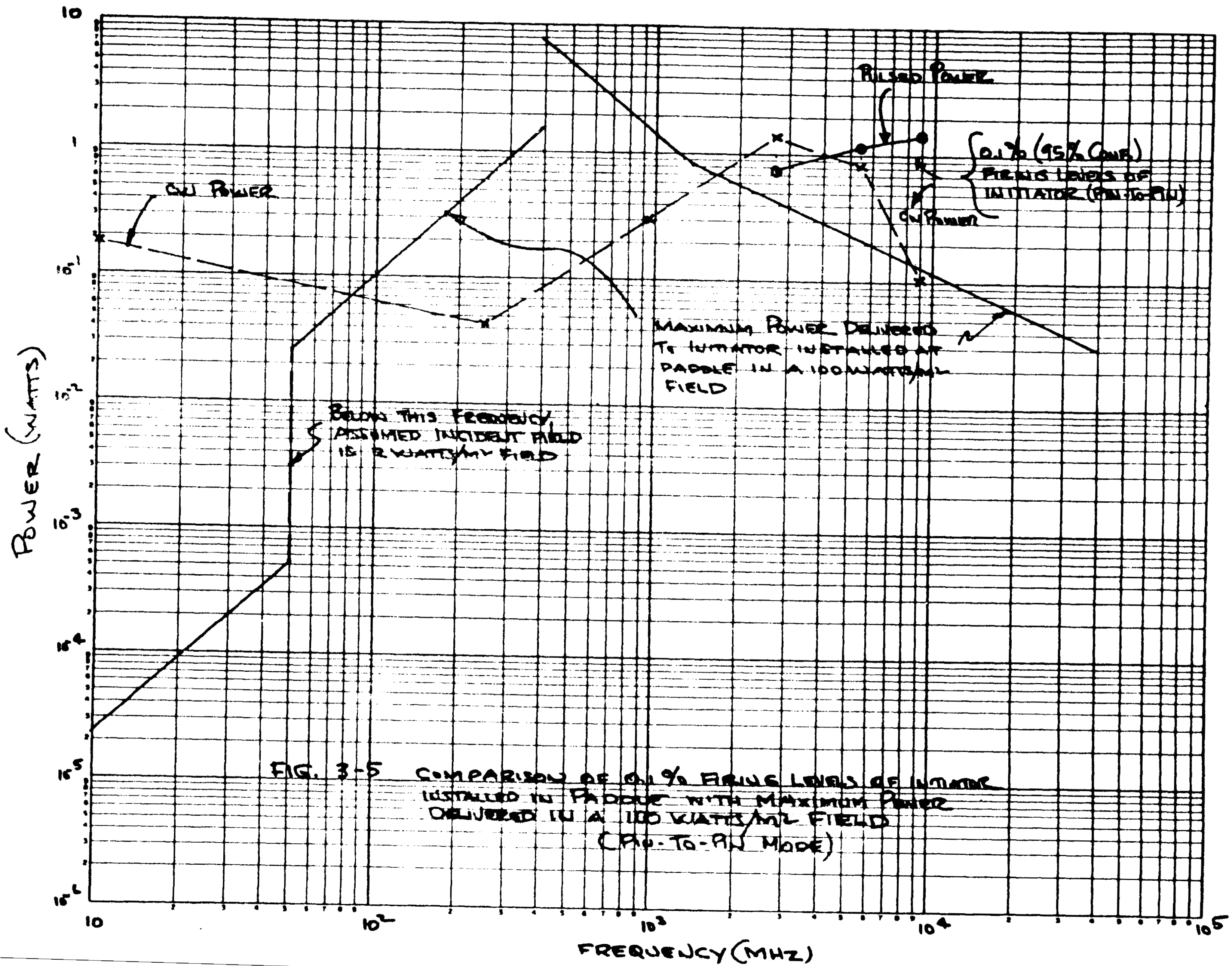


FIG. 3-5 COMPARISON OF 0.1% FIRING LEVELS OF INITIATOR INSTALLED IN PADDLE WITH MAXIMUM POWER DELIVERED IN A 100 WATTS/M2 FIELD (PIN-TO-PIN MODE)

4. SUMMARY

As indicated in the beginning of this monograph there has been no attempt to be exhaustive in coverage since it is almost impossible to predict all of the possible circuit characteristics that one may be faced with in any given analysis. However, our experience has shown that most problems fall into the general categories discussed here. We have not touched on the special case of near field, for example, nor have we considered devices other than wire bridge type EEDs. It should be apparent, however, that the general philosophy and methods of approach can be used for any type of field, any type of circuit and component. In general, to apply the technique three conditions must be met:

a) Knowledge of all of the failure modes for the component being considered and the RF levels that will cause failure or degradation of these components.

b) Proper construction of a mathematical model which accurately simulates the actual circuits involved so that the system connected to the device in question can be characterized in terms of a workable RF receiving antenna. Once again it is essential to consider all possible failure modes.

c) Proper application of electromagnetic theory principles to this model.

No one part of this sequence can be taken lightly since a failure to properly conduct any one part could cause a failure of the entire approach. To be successful the engineer must be painstaking and methodical in his approach and must accept no unsupported heresay regarding any elements of the device or circuits.

It should be remembered that, properly applied, the analysis approach is only semi worst case and every attempt should be made in constructing the model to use actual conditions wherever possible. Note that in a very general way the analytical approach can prove that a circuit is safe, but cannot always prove that a system indicated to be in trouble is really unsafe. In contrast the field test approach can only show that a system is in trouble and cannot prove that a system is absolutely safe.

In conclusion Table 4-1 summarizes the conditions and equations we have presented in this monograph.

Table 4-1 - Summary of Analytical Methods for RF Hazard Evaluation

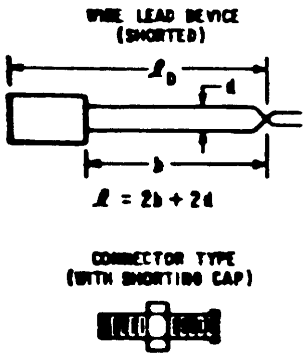
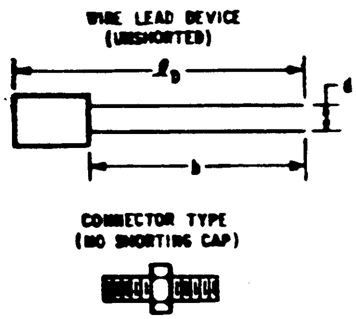
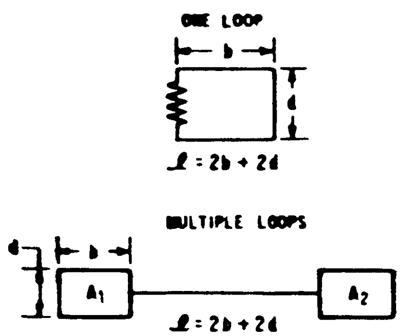
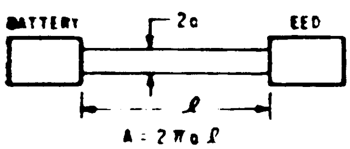
Configuration	Configuration Designation
	A
	B
	C
	D

Table 4-1 (Cont.)

Configuration Designation	LOW FREQUENCY APERTURE Equation (Pin-to-Pin)	Limit of Validity	Equation (Pins-to-Case)	HANDLING, TRANSPORT, AND STORAGE Limit of Validity
A	$A_e = \frac{4.67 \times 10^4 A^2}{\pi A^2 R_T}$	$\lambda \geq 2\ell$	$A_e = \frac{\ell_D^2 Z_0}{Re(Z_{po})}$	$\lambda \geq 10\ \ell_D$
	$A_o = T_{wo} A$	$f_{MHz} \leq 10^5$ MHz	$A_o = T_{wo} A$	$f_{MHz} \leq 10^5$ MHz
B	$A_e = \frac{4Z_0 \ell^2}{R_T} \left(\frac{\beta_d}{2}\right)^2$	$\lambda \geq 20\ \ell$	$A_e = \frac{\ell_D^2 Z_0}{Re(Z_{po})}$	INSTALLATION $\lambda \geq 10\ \ell_D$
	$A_o = T_{wo} A$	$f_{MHz} \leq 10^5$ MHz	$A_o = T_{wo} A$	$f_{MHz} \leq 10^5$ MHz
C	$A_e = \frac{4.67 \times 10^4 A^2}{\pi \lambda^2 R_T}$	$\lambda \geq 2\ell$	$A_e = \frac{4.67 \times 10^4 A^2}{\pi\lambda^2 Re(Z_{pc})}$	INSTALLED (Shield Breakouts) $\lambda \geq 2\ell$
	$A_e = \frac{4.67 \times 10^4}{\pi \lambda^2 R_T} (n_1 A_1 + n_2 A_2 ---)^2$	$\lambda \geq 2\ell$ (Equal Loops)	$A_e = \frac{4.67 \times 10^4 A^2}{\pi\lambda^2 Re(Z_{pc})}$	$\lambda \geq 2\ell$ (Equal Loops)
	" "	$\lambda \geq 2\ \ell$ = perimeter of smallest loop (Unequal Loops)	"	$\lambda \geq 2\ \ell$ = perimeter of smallest loop (Unequal Loops)

D

TOTAL APERTURE

INSTALLED (360° Completely Shielded)

$$A_{en} = \frac{P_o A}{P_1} - \frac{A}{P_1} \{ (1-Q)\ P_T [\text{down } 8.68\alpha\ t \text{ dB}] + Q\ P_T\ [\text{down } 8.68 \frac{t}{\delta} \text{ dB}] \}$$

Table 4-1 (Concl.)

Configuration Designation	Equation (Pin-to-Pin)	Overall Lead Length	Limit of Validity	Equation (Pins-to-Case)	Overall Lead Length	Limit of Validity
	HIGH FREQUENCY APERTURE					
	HANDLING, TRANSPORT, AND STORAGE					
A	$A_{em} = \frac{D\lambda^2}{4\pi}$	ℓ	$\lambda \le 2\ell$	$A_{em} = \frac{D\lambda^2}{4\pi}$	ℓ_D	$\lambda \le 10\,\ell_D$
	--	--	--	--	--	--
	INSTALLATION					
B	$A_{em} = \frac{D\lambda^2}{4\pi}$	2ℓ	$\lambda \le 20\ell$	$A_{em} = \frac{D\lambda^2}{4\pi}$	ℓ_D	$\lambda \le 10\ell_D$
	--	--	--	--	--	--
	INSTALLED (Shield Breakouts)					
C	$A_{em} = \frac{D\lambda^2}{4\pi}$	ℓ	$\lambda \le 2\ell$	$A_{em} = \frac{D\lambda^2}{4\pi}$	ℓ	$\lambda \le 2\ell$
	$A_{em} = \frac{D\lambda^2}{4\pi}$	ℓ	$\lambda \le 2\ell$	$A_{em} = \frac{D\lambda^2}{4\pi}$	ℓ	$\lambda \le 2\ell$
	"	ℓ	$\lambda \le 2\ell$	"	ℓ	$\lambda \le 2\ell$
D	INSTALLED (360° Completely Shielded)		LIMIT OF VALIDITY: $f_{MHz} \le 10^5$ MHz typical, but depends on shield characteristics			

5. REFERENCES

1. Kraus, J. D., Antennas, McGraw-Hill, New York 1950.

2. King and Wu, The Scattering and Diffraction of Waves, Harvard University Press, Cambridge, Mass. 1959.

3. Plonsey and Collin, Principles and Application of Electromagnetic Fields, New York, 1961 p. 404.

4. Rawls, Stilwell, McDonald, RF Radiation Hazards, Air Force Missile Test Center Report AFMTC-TM-59-4; July 1959, p.16.

5. Ramo and Whinnery, Fields and Waves in Modern Radio, John Wiley & Sons, New York, 1953.

Appendix A

Notes on RF Sensitivity of EEDs and the Need for Testing

Throughout this monograph reference is made to various functioning modes of EEDs. While it is not the purpose of this document to present a comprehensive picture of EED's behavior under RF irradiation a brief discussion should help clarify the situation.

A standard EED normally contains a transducer to which electrical energy can be applied. Some of this energy is usually converted to heat which in turn initiates the explosive mix next to the transducer. It is in this manner that EEDs are normally designed to operate and this is what we have designated as the pin-to-pin mode. However, there are other modes in which an EED can be caused to fire which were not planned in the original design. The most common such mode is designated pins-to-case.

In this mode an electrical signal impressed between the pins leading to the normal transducer and the case of the EED can cause a voltage breakdown or some other disruptive phenomena directly through the explosives between the bridgewire posts and the case. This mode is frequently overlooked but is of vital interest in the case of irradiation by RF and spurious electrostatic potentials.

In addition some EEDs contain an additional circuit either to permit monitoring of proper connection or to support a redundant transducer. In this case, in a manner similar to the pins-to-case phenomena, signals can appear between the two circuits and once again directly across the explosive mix. This is the bridge-to-bridge mode.

Frequently, when a group is considering the possibility of RF hazard in connection with an EED the assumption is made that the RF sensitivity of the EED can be characterized as no greater than the dc no fire level, or, in some more conservative cases, to be no greater than an arbitrarily chosen 6 db below the no fire level. The reasoning behind this seems to stem from the concept that the RF probably heats up the transducer in the same manner as dc. Were it not for the other modes this assumption would be reasonably valid at least over part of the frequency spectrum. Experience gained in performing RF sensitivity tests on over 75 different EEDs has indicated that up to approximately 1000 MHz and for RF applied directly to the normal transducer, i.e., pin-to-pin, the functioning sensitivity of hot wire type EEDs is no greater than the dc constant current sensitivity for long pulses of 10 seconds or more duration. However, RF signals applied between the pins and the case or between dual bridgewires may frequently produce sensitivities much greater than the dc sensitivity over the frequency range. Above 1000 MHz, and particularly when pulsed RF signals are applied, the sensitivity may be greater than dc in all modes including through the bridgewire. In many cases this sensitivity is increased by considerabely more than the 6 dB safety factor sometimes used, and since the pins-to-case and bridge-to-bridge mode have very little to do with the normal functioning mode, insensitivity to dc signals in the normal firing mode (pin-to-pin) is no protection. Many 1 ampere -1 watt devices are more sensitive in the pins-to-case mode than EEDs designed to be considerably more sensitive in the normal functioning mode.

On the other side of the ledger many EEDs are far less sensitive to RF than they are to dc particularly in the pin-to-pin mode. In these cases assumption of the dc level as the sensitivity could so severely penalize the evaluation of the EED circuits as to make acceptable circuits appear quite hazardous.

All of these pitfalls can be avoided by adequate RF testing of the EEDs. Procedures and equipment are available which permit accurate determination of the amount of RF power required to be delivered to an EED in any functioning mode to produce functioning or degrading. The expense of the hardware required for such tests is frequently a deterrent, but more often than not it is false economy to avoid this step.

Appendix B

Notes on Multiple Sources

While the analysis procedures discussed in this monograph assume that the magnitude of the incident RF field is already known it is frequently necessary for the engineer to make some judgments of this field himself. A classical case of this occurs when several RF sources exist at or near the same frequency and while an incident field can be calculated for each source, the question arises as to the effect of all of the sources combined.

It can be shown that the worst case average power absorbed (P_A) by a given load from n sources at the same frequency is given by

$$\bar{P}_A = \{\sqrt{P_1} + \sqrt{P_2} + \sqrt{P_q} + \ldots + \sqrt{P_n}\}^2 \qquad \text{(B-1)}$$

where P_q is the power supplied by the qth source with other sources quiescent and when the phase angles of the individual sources are chosen to maximize the simultaneous absorbed power. The use of the above equation as a worst case condition should be limited, however, to continuous wave sources of precisely the same frequencies. If the frequencies differ by even a small amount and average power (P_A) is defined as

$$P_A = \lim_{q \to \infty} \frac{1}{q} \int_0^q P_I \, dt \qquad \text{(B-2)}$$

where P_I is the instantaneous simultaneous power, then the worst case average power is given by

$$P_A = P_1 + P_2 + P_q + \ldots + P_n \qquad \text{(B-3)}$$

where P_q is defined as before.

This equation is a worst case condition for either continuous wave or pulsed sources of differing frequency and in addition is independent of the starting times of individual pulses of the pulsed sources.

The technique of combining power densitities for closely spaced frequencies and then predicting worst case possible hazard at the widely spaced frequency groups so obtained is founded on the assumption that the worst case conditions assumed in the pickup analysis will not occur more than once in the entire frequency band of interest. Due to the complicated frequency dependence of many of the parameters that are worst case approximated we believe this assumption to be conservative. The alternative to this technique is to combine power densities at all frequencies and use this result throughout the frequency range of interest. In our judgement this technique is overly conservative.

Appendix C
Notes on Field Tests

One approach to determining the extent of RF vulnerability of a system is to place the system in question in the fields of various RF transmitters and to observe the effects produced on the system components. This technique has been extensively applied to missile systems containing firing circuits terminated in electroexplosive devices (EEDs) but the basic technique is applicable to circuits containing components other than EEDs. If the data obtained are to be anything more than go/no-go information for the particular RF field intensity used it is necessary to put detectors in place of the components being evaluated; these detectors must give an indication of the amount of RF energy delivered to the component. In general this approach to hazard determination is particularly appealing because it is direct and appears to be a test which closely approximates the actual conditions which would exist in a operational situation. However, in most cases the technique falls somewhat short of the ideal.

Among the major problems in using this technique is the extension of information received on one system to other systems of the same type. The number of more or less uncontrollable variables makes any generalized correlation very difficult. For example, determination of the actual RF field incident on a given circuit at the time of test can be very difficult since environmental factors can greatly influence localized field strengths and variation of circuit orientation and circuit design from test vehicle to test vehicle can present a problem. Frequently, this situation is handled by using an arbitrary safety factor in connection with the results; in a sense, "worst casing" the field tests.

A more definitive problem grows out of the same problem that was discussed in the notes on EED sensitivity; i.e., the detectors used in the field tests consider only the pin-to-pin mode and are calibrated on the basis of dc sensitivity and with dc signals only.

Appendix D

Notes on Protection of EED Systems Against RF

Basically, there are three general methods commonly used to minimize the RF hazard to EED systems: Use of components less sensitive to RF; proper design of circuits; and use of RF filters. The first of these is somewhat out of control of the circuit designer. While it is possible to lower the RF susceptibility of an EED circuit by using less sensitive EEDs most manufacturers have as yet done comparatively little work on this phase particularly with respect to hazard modes other than pin-to-pin. Furthermore, most approaches to lowering the RF sensitivity in the pin-to-pin mode also make the EED considerably less sensitive to normal functioning signals thereby requiring larger power sources with increased weight. However, to the extent that he can, a designer should select EEDs that have no marked RF sensitivity.

The most straightforeward and certain protection can be gained by properly designing the circuits to minimize the RF hazard. In general this means that firing circuits should be separate from other circuits, wires should be twisted pairs, all circuits should be shielded end to end and through 360° and the shields should be grounded at as many places as possible. There are many specification documents that go into considerable detail on the proper design of EED circuits. However, in actual practice the designer often finds it difficult to comply with all of the requirements. The physical layout and the complexity of the system often force him to break the shields. Furthermore the wiring philosophy is often in conflict with other philosophies. The primary example of this is the multiple point grounds versus the single point ground philosophy. And yet the single point ground combined with discontinuous shields frequently leads to large pins-to-case RF pickup problems.

The third solution is the use of RF filters. Ideally these filters should be broadband, very light and small and should not affect the EED's dc firing characteristics. In addition, the filter should in no way compromise system reliability. The optimum solution would have the filter as an integral part of the EED; however this is not very common. It is more common to mount the filter separately but close to the EED. When this is done the wiring between the filter and the EED must be completely shielded.

While RF filters are a valid solution to the problem, the designer must be certain that the filter is capable of accomplishing the task he desires. To do this he must be certain of the information on the filters. The parameter of major interest is attenuation as a function of frequency. Frequently filter values are quoted in terms of insertion loss which has meaning only in the specific measuring system used. What is worse, occasionally attenuation, or true loss, is used interchangeably with the term insertion loss. If the designer is uncertain of how published data was obtained and is unable to find out, he should make certain the proper tests are performed.

APPENDIX B

RAW DATA FOR THE LOOP MEASUREMENTS

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
1	10.000	1	400.0	.0	.5	6.00
1	10.000	1	100.0	.0	1.0	6.00
1	10.000	1	22.0	.0	1.5	6.00
1	10.000	1	12.5	.0	2.0	6.00
1	10.000	1	6.0	.0	2.5	6.00
1	10.000	1	6.5	.0	3.0	6.00
1	10.000	1	1000.0	.0	-.5	6.00
1	10.000	1	125.0	.0	-1.0	6.00
1	10.000	1	43.0	.0	-1.5	6.00
1	10.000	1	20.0	.0	-2.0	6.00
1	10.000	1	15.0	.0	-2.5	6.00
1	10.000	1	12.5	.0	-3.0	6.00
1	10.000	1	1150.0	.5	.0	6.00
1	10.000	1	100.0	1.0	.0	6.00
1	10.000	1	64.0	1.5	.0	6.00
1	10.000	1	40.0	2.0	.0	6.00
1	10.000	1	30.5	2.5	.0	6.00
1	10.000	1	1300.0	-.5	.0	6.00
1	10.000	1	100.0	-1.0	.0	6.00
1	10.000	1	30.0	-1.5	.0	6.00
1	10.000	1	22.0	-2.0	.0	6.00
1	10.000	1	15.0	-2.5	.0	6.00
1	10.000	1	15.0	-3.0	.0	6.00
1	10.000	2	500.0	.5	.0	6.00
1	10.000	2	60.5	1.0	.0	6.00
1	10.000	2	20.0	1.5	.0	6.00
1	10.000	2	14.0	2.0	.0	6.00
1	10.000	2	11.0	2.5	.0	6.00
1	10.000	2	11.0	3.0	.0	6.00
1	10.000	2	700.0	-.5	.0	6.00
1	10.000	2	100.0	-1.0	.0	6.00
1	10.000	2	45.0	-1.5	.0	6.00
1	10.000	2	32.0	-2.0	.0	6.00
1	10.000	2	20.0	-2.5	.0	6.00
1	10.000	2	16.0	-3.0	.0	6.00
1	10.000	2	750.0	.0	.5	6.00
1	10.000	2	115.0	.0	1.0	6.00
1	10.000	2	32.0	.0	1.5	6.00
1	10.000	2	12.5	.0	2.0	6.00
1	10.000	2	14.0	.0	2.5	6.00
1	10.000	2	800.0	.0	-.5	6.00
1	10.000	2	120.0	.0	-1.0	6.00
1	10.000	2	56.0	.0	-1.5	6.00
1	10.000	2	25.0	.0	-2.0	6.00
1	10.000	2	16.5	.0	-2.5	6.00
1	10.000	2	15.0	.0	-3.0	6.00

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
1	1.000	2	280.0	.0	.5	11.25
1	1.000	2	44.0	.0	1.0	11.25
1	1.000	2	13.0	.0	1.5	11.25
1	1.000	2	5.0	.0	2.0	11.25
1	1.000	2	2.4	.0	2.5	11.25
1	1.000	2	160.0	.0	-.5	11.25
1	1.000	2	32.0	.0	-1.0	11.25
1	1.000	2	13.0	.0	-1.5	11.25
1	1.000	2	6.0	.0	-2.0	11.25
1	1.000	2	3.0	.0	-2.5	11.25
1	1.000	2	2.0	.0	-3.0	11.25
1	1.000	2	200.0	.5	.0	11.25
1	1.000	2	20.0	1.0	.0	11.25
1	1.000	2	6.0	1.5	.0	11.25
1	1.000	2	2.4	2.0	.0	11.25
1	1.000	2	1.6	2.5	.0	11.25
1	1.000	2	1.0	3.0	.0	11.25
1	1.000	2	240.0	-.5	.0	11.25
1	1.000	2	23.0	-1.0	.0	11.25
1	1.000	2	5.0	-1.5	.0	11.25
1	1.000	2	2.4	-2.0	.0	11.25
1	1.000	2	1.2	-2.5	.0	11.25
1	1.000	2	.6	-3.0	.0	11.25
1	1.000	1	150.0	.0	.5	12.45
1	1.000	1	30.0	.0	1.0	12.45
1	1.000	1	10.0	.0	1.5	12.45
1	1.000	1	3.6	.0	2.0	12.45
1	1.000	1	2.0	.0	2.5	12.45
1	1.000	1	1.0	.0	3.0	12.45
1	1.000	1	175.0	.0	-.5	12.45
1	1.000	1	26.0	.0	-1.0	12.45
1	1.000	1	8.0	.0	-1.5	12.45
1	1.000	1	4.0	.0	-2.0	12.45
1	1.000	1	2.0	.0	-2.5	12.45
1	1.000	1	1.0	.0	-3.0	12.45
1	1.000	1	180.0	.5	.0	12.45
1	1.000	1	20.0	1.0	.0	12.45
1	1.000	1	5.0	1.5	.0	12.45
1	1.000	1	2.4	2.0	.0	12.45
1	1.000	1	1.6	2.5	.0	12.45
1	1.000	1	200.0	-.5	.0	12.45
1	1.000	1	18.0	-1.0	.0	12.45
1	1.000	1	4.6	-1.5	.0	12.45
1	1.000	1	2.0	-2.0	.0	12.45
1	1.000	1	1.0	-2.5	.0	12.45
1	1.000	1	.6	-3.0	.0	12.45

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
1	.530	1	150.0	.0	.5	21.38
1	.530	1	24.0	.0	1.0	21.38
1	.530	1	8.0	.0	1.5	21.38
1	.530	1	3.2	.0	2.0	21.38
1	.530	1	1.0	.0	2.5	21.38
1	.530	1	180.0	.0	-.5	21.38
1	.530	1	24.0	.0	-1.0	21.38
1	.530	1	8.0	.0	-1.5	21.38
1	.530	1	3.6	.0	-2.0	21.38
1	.530	1	2.0	.0	-2.5	21.38
1	.530	1	1.0	.0	-3.0	21.38
1	.530	1	150.0	.5	.0	21.38
1	.530	1	15.0	1.0	.0	21.38
1	.530	1	4.0	1.5	.0	21.38
1	.530	1	1.6	2.0	.0	21.38
1	.530	1	1.0	2.5	.0	21.38
1	.530	1	.8	3.0	.0	21.38
1	.530	1	120.0	-.5	.0	21.38
1	.530	1	16.0	-1.0	.0	21.38
1	.530	1	4.0	-1.5	.0	21.38
1	.530	1	2.0	-2.0	.0	21.38
1	.530	1	1.0	-2.5	.0	21.38
1	.530	2	160.0	.0	.5	21.80
1	.530	2	26.0	.0	1.0	21.80
1	.530	2	7.5	.0	1.5	21.80
1	.530	2	3.2	.0	2.0	21.80
1	.530	2	1.6	.0	2.5	21.80
1	.530	2	1.0	.0	3.0	21.80
1	.530	2	140.0	.0	-.5	21.80
1	.530	2	28.0	.0	-1.0	21.80
1	.530	2	8.0	.0	-1.5	21.80
1	.530	2	3.2	.0	-2.0	21.80
1	.530	2	1.8	.0	-2.5	21.80
1	.530	2	240.0	.5	.0	21.80
1	.530	2	20.0	1.0	.0	21.80
1	.530	2	5.4	1.5	.0	21.80
1	.530	2	2.0	2.0	.0	21.80
1	.530	2	1.2	2.5	.0	21.80
1	.530	2	.8	3.0	.0	21.80
1	.530	2	360.0	-.5	.0	21.80
1	.530	2	20.0	-1.0	.0	21.80
1	.530	2	5.2	-1.5	.0	21.80
1	.530	2	2.0	-2.0	.0	21.80
1	.530	2	1.0	-2.5	.0	21.80
1	.530	2	.8	-3.0	.0	21.80

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
1	.171	2	50.0	.0	.5	29.25
1	.171	2	6.5	.0	1.0	29.25
1	.171	2	2.4	.0	1.5	29.25
1	.171	2	.6	.0	2.0	29.25
1	.171	2	.4	.0	2.5	29.25
1	.171	2	.4	.0	3.0	29.25
1	.171	2	100.0	.0	-.5	29.25
1	.171	2	8.0	.0	-1.0	29.25
1	.171	2	2.0	.0	-1.5	29.25
1	.171	2	.8	.0	-2.0	29.25
1	.171	2	.6	.0	-2.5	29.25
1	.171	2	.4	.0	-3.0	29.25
1	.171	2	50.0	.5	.0	29.25
1	.171	2	10.0	1.0	.0	29.25
1	.171	2	3.0	1.5	.0	29.25
1	.171	2	1.6	2.0	.0	29.25
1	.171	2	.8	2.5	.0	29.25
1	.171	2	64.0	-.5	.0	29.25
1	.171	2	12.5	-1.0	.0	29.25
1	.171	2	4.0	-1.5	.0	29.25
1	.171	2	1.6	-2.0	.0	29.25
1	.171	2	.8	-2.5	.0	29.25
1	.171	2	.6	-3.0	.0	29.25
1	.171	2	85.0	.5	.0	27.75
1	.171	2	7.5	1.0	.0	27.75
1	.171	2	2.0	1.5	.0	27.75
1	.171	2	1.0	2.0	.0	27.75
1	.171	2	.6	2.5	.0	27.75
1	.171	2	.4	3.0	.0	27.75
1	.171	2	100.0	-.5	.0	27.75
1	.171	2	7.5	-1.0	.0	27.75
1	.171	2	2.0	-1.5	.0	27.75
1	.171	2	.8	-2.0	.0	27.75
1	.171	2	.4	-2.5	.0	27.75
1	.171	2	70.0	.0	.5	27.75
1	.171	2	10.0	.0	1.0	27.75
1	.171	2	4.0	.0	1.5	27.75
1	.171	2	1.6	.0	2.0	27.75
1	.171	2	.8	.0	2.5	27.75
1	.171	2	.4	.0	3.0	27.75
1	.171	2	52.0	.0	-.5	27.75
1	.171	2	8.0	.0	-1.0	27.75
1	.171	2	3.0	.0	-1.5	27.75
1	.171	2	1.2	.0	-2.0	27.75
1	.171	2	.8	.0	-2.5	27.75
1	.171	2	.4	.0	-3.0	27.75

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
2	.174	1	23.0	.0	.5	9.90
2	.174	1	3.8	.0	1.0	9.90
2	.174	1	1.2	.0	1.5	9.90
2	.174	1	.6	.0	2.0	9.90
2	.174	1	.4	.0	2.5	9.90
2	.174	1	18.0	.0	-.5	9.90
2	.174	1	3.0	.0	-1.0	9.90
2	.174	1	1.0	.0	-1.5	9.90
2	.174	1	.6	.0	-2.0	9.90
2	.174	1	.4	.0	-2.5	9.90
2	.174	1	40.0	.5	.0	9.90
2	.174	1	2.4	1.0	.0	9.90
2	.174	1	.6	1.5	.0	9.90
2	.174	1	.4	2.0	.0	9.90
2	.174	1	30.0	.0	-.5	9.90
2	.174	1	2.6	.0	-1.0	9.90
2	.174	1	.8	.0	-1.5	9.90
2	.174	1	.6	.0	-2.0	9.90
2	.174	1	.4	.0	-2.5	9.90
2	.174	2	20.0	.0	.5	9.90
2	.174	2	4.0	.0	1.0	9.90
2	.174	2	1.2	.0	1.5	9.90
2	.174	2	.8	.0	2.0	9.90
2	.174	2	.4	.0	2.5	9.90
2	.174	2	25.0	.0	-.5	9.90
2	.174	2	4.4	.0	-1.0	9.90
2	.174	2	1.2	.0	-1.5	9.90
2	.174	2	.8	.0	-2.0	9.90
2	.174	2	.4	.0	-2.5	9.90
2	.174	2	20.0	.5	.0	9.90
2	.174	2	2.4	1.0	.0	9.90
2	.174	2	.8	1.5	.0	9.90
2	.174	2	.4	2.0	.0	9.90
2	.174	2	20.0	-.5	.0	9.90
2	.174	2	2.0	-1.0	.0	9.90
2	.174	2	.8	-1.5	.0	9.90
2	.174	2	.6	-2.0	.0	9.90
2	.174	2	.2	-2.5	.0	9.90

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
2	.530	2	60.0	.0	.5	5.70
2	.530	2	9.0	.0	1.0	5.70
2	.530	2	2.6	.0	1.5	5.70
2	.530	2	1.2	.0	2.0	5.70
2	.530	2	.8	.0	2.5	5.70
2	.530	2	.4	.0	3.0	5.70
2	.530	2	36.0	.0	-.5	5.70
2	.530	2	9.0	.0	-1.0	5.70
2	.530	2	2.8	.0	-1.5	5.70
2	.530	2	1.2	.0	-2.0	5.70
2	.530	2	.6	.0	-2.5	5.70
2	.530	2	50.0	.5	.0	5.70
2	.530	2	6.0	1.0	.0	5.70
2	.530	2	1.6	1.5	.0	5.70
2	.530	2	.6	2.0	.0	5.70
2	.530	2	.4	2.5	.0	5.70
2	.530	2	26.0	-.5	.0	5.70
2	.530	2	4.4	-1.0	.0	5.70
2	.530	2	1.4	-1.5	.0	5.70
2	.530	2	.6	-2.0	.0	5.70
2	.530	2	.4	-2.5	.0	5.70
2	.530	1	40.0	.0	.5	6.00
2	.530	1	9.0	.0	1.0	6.00
2	.530	1	2.0	.0	1.5	6.00
2	.530	1	1.2	.0	2.0	6.00
2	.530	1	.8	.0	2.5	6.00
2	.530	1	.4	.0	3.0	6.00
2	.530	1	50.0	.0	-.5	6.00
2	.530	1	9.0	.0	-1.0	6.00
2	.530	1	2.4	.0	-1.5	6.00
2	.530	1	1.4	.0	-2.0	6.00
2	.530	1	.8	.0	-2.5	6.00
2	.530	1	.4	.0	-3.0	6.00
2	.530	1	60.0	.5	.0	6.00
2	.530	1	5.0	1.0	.0	6.00
2	.530	1	1.4	1.5	.0	6.00
2	.530	1	.6	2.0	.0	6.00
2	.530	1	.4	2.5	.0	6.00
2	.530	1	60.0	-.5	.0	6.00
2	.530	1	4.4	-1.0	.0	6.00
2	.530	1	1.6	-1.5	.0	6.00
2	.530	1	.8	-2.0	.0	6.00
2	.530	1	.4	-2.5	.0	6.00

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
2	1.000	1	150.0	.0	.5	10.50
2	1.000	1	23.0	.0	1.0	10.50
2	1.000	1	9.0	.0	1.5	10.50
2	1.000	1	3.4	.0	2.0	10.50
2	1.000	1	1.8	.0	2.5	10.50
2	1.000	1	1.0	.0	3.0	10.50
2	1.000	1	145.0	.0	-.5	10.50
2	1.000	1	20.0	.0	-1.0	10.50
2	1.000	1	7.5	.0	-1.5	10.50
2	1.000	1	3.6	.0	-2.0	10.50
2	1.000	1	1.6	.0	-2.5	10.50
2	1.000	1	.8	.0	-3.0	10.50
2	1.000	1	115.0	.5	.0	10.50
2	1.000	1	15.0	1.0	.0	10.50
2	1.000	1	5.0	1.5	.0	10.50
2	1.000	1	2.0	2.0	.0	10.50
2	1.000	1	1.4	2.5	.0	10.50
2	1.000	1	165.0	-.5	.0	10.50
2	1.000	1	14.0	-1.0	.0	10.50
2	1.000	1	4.0	-1.5	.0	10.50
2	1.000	1	1.6	-2.0	.0	10.50
2	1.000	1	1.0	-2.5	.0	10.50
2	1.000	2	115.0	.0	.5	9.90
2	1.000	2	20.0	.0	1.0	9.90
2	1.000	2	6.0	.0	1.5	9.90
2	1.000	2	2.0	.0	2.0	9.90
2	1.000	2	1.2	.0	2.5	9.90
2	1.000	2	.8	.0	3.0	9.90
2	1.000	2	150.0	.0	-.5	9.90
2	1.000	2	20.0	.0	-1.0	9.90
2	1.000	2	7.0	.0	-1.5	9.90
2	1.000	2	3.2	.0	-2.0	9.90
2	1.000	2	1.6	.0	-2.5	9.90
2	1.000	2	1.2	.0	-3.0	9.90
2	1.000	2	210.0	.5	.0	9.90
2	1.000	2	14.0	1.0	.0	9.90
2	1.000	2	4.0	1.5	.0	9.90
2	1.000	2	1.6	2.0	.0	9.90
2	1.000	2	1.0	2.5	.0	9.90
2	1.000	2	.6	3.0	.0	9.90
2	1.000	2	180.0	-.5	.0	9.90
2	1.000	2	16.0	-1.0	.0	9.90
2	1.000	2	4.4	-1.5	.0	9.90
2	1.000	2	2.0	-2.0	.0	9.90
2	1.000	2	1.2	-2.5	.0	9.90
2	1.000	2	.8	-3.0	.0	9.90

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
2	5.000	1	32.0	.0	.5	.48
2	5.000	1	6.0	.0	1.0	.48
2	5.000	1	35.0	.0	-.5	.48
2	5.000	1	6.0	.0	-1.0	.48
2	5.000	1	2.0	.0	-1.5	.48
2	5.000	1	36.0	.5	.0	.48
2	5.000	1	4.0	1.0	.0	.48
2	5.000	1	40.0	-.5	.0	.48
2	5.000	1	4.0	-1.0	.0	.48
2	5.000	1	1.2	-1.5	.0	.48
2	5.000	2	36.0	.0	.5	.48
2	5.000	2	9.0	.0	1.0	.48
2	5.000	2	3.2	.0	1.5	.48
2	5.000	2	34.0	.0	-.5	.48
2	5.000	2	6.5	.0	-1.0	.48
2	5.000	2	2.0	.0	-1.5	.48
2	5.000	2	30.0	.5	.0	.48
2	5.000	2	2.4	1.5	.0	.48
2	5.000	2	40.0	-.5	.0	.48
2	5.000	2	4.0	-1.0	.0	.48
2	5.000	2	2.0	-1.5	.0	.48

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
2	10.000	2	1750.0	.0	.5	13.25
2	10.000	2	300.0	.0	1.0	13.25
2	10.000	2	2500.0	.0	-.5	13.25
2	10.000	2	300.0	.0	-1.0	13.25
2	10.000	2	110.0	.0	-1.5	13.25
2	10.000	2	40.0	.0	-2.0	13.25
2	10.000	2	3600.0	.5	.0	13.25
2	10.000	2	240.0	1.0	.0	13.25
2	10.000	2	60.0	1.5	.0	13.25
2	10.000	2	3000.0	-.5	.0	13.25
2	10.000	2	200.0	-1.0	.0	13.25
2	10.000	2	100.0	-1.5	.0	13.25
2	10.000	2	64.0	-2.0	.0	13.25
2	10.000	1	2300.0	.0	.5	12.75
2	10.000	1	240.0	.0	1.0	12.75
2	10.000	1	100.0	.0	1.5	12.75
2	10.000	1	20.0	.0	2.5	12.75
2	10.000	1	1750.0	.0	-.5	12.75
2	10.000	1	280.0	.0	-1.0	12.75
2	10.000	1	60.0	.0	-1.5	12.75
2	10.000	1	1100.0	.5	.0	12.75
2	10.000	1	50.0	1.0	.0	12.75
2	10.000	1	1500.0	-.5	.0	12.75
2	10.000	1	200.0	-1.0	.0	12.75
2	10.000	1	90.0	-1.5	.0	12.75
2	10.000	1	70.0	-2.0	.0	12.75
2	10.000	1	56.0	-2.5	.0	12.75
2	10.000	1	60.0	-3.0	.0	12.75

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
3	9.600	1	500.0	.0	.5	4.00
3	9.600	1	90.0	.0	1.0	4.00
3	9.600	1	20.0	.0	1.5	4.00
3	9.600	1	9.0	.0	2.0	4.00
3	9.600	1	3.6	.0	2.5	4.00
3	9.600	1	3.6	.0	3.0	4.00
3	9.600	1	600.0	.0	-.5	4.00
3	9.600	1	60.0	.0	-1.0	4.00
3	9.600	1	24.0	.0	-1.5	4.00
3	9.600	1	14.0	.0	-2.0	4.00
3	9.600	1	8.0	.0	-2.5	4.00
3	9.600	1	7.5	.0	-3.0	4.00
3	9.600	1	1000.0	.5	.0	4.00
3	9.600	1	56.0	1.0	.0	4.00
3	9.600	1	17.0	1.5	.0	4.00
3	9.600	1	8.5	2.0	.0	4.00
3	9.600	1	6.4	2.5	.0	4.00
3	9.600	1	900.0	-.5	.0	4.00
3	9.600	1	54.0	-1.0	.0	4.00
3	9.600	1	28.0	-1.5	.0	4.00
3	9.600	1	21.0	-2.0	.0	4.00
3	9.600	1	16.0	-2.5	.0	4.00
3	9.600	2	620.0	.0	.5	3.80
3	9.600	2	75.0	.0	1.0	3.80
3	9.600	2	25.0	.0	1.5	3.80
3	9.600	2	13.0	.0	2.0	3.80
3	9.600	2	8.5	.0	2.5	3.80
3	9.600	2	440.0	.0	-.5	3.80
3	9.600	2	80.0	.0	-1.0	3.80
3	9.600	2	18.0	.0	-1.5	3.80
3	9.600	2	8.0	.0	-2.0	3.80
3	9.600	2	4.4	.0	-2.5	3.80
3	9.600	2	500.0	.5	.0	3.80
3	9.600	2	56.0	1.0	.0	3.80
3	9.600	2	18.0	1.5	.0	3.80
3	9.600	2	9.0	2.0	.0	3.80
3	9.600	2	5.4	2.5	.0	3.80
3	9.600	2	4.0	3.0	.0	3.80
3	9.600	2	480.0	-.5	.0	3.80
3	9.600	2	50.0	-1.0	.0	3.80
3	9.600	2	14.0	-1.5	.0	3.80
3	9.600	2	6.0	-2.0	.0	3.80
3	9.600	2	4.0	-2.5	.0	3.80
3	9.600	2	3.8	-3.0	.0	3.80

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
3	5.000	2	40.0	.0	.5	.53
3	5.000	2	5.0	.0	1.0	.53
3	5.000	2	1.2	.0	1.5	.53
3	5.000	2	40.0	.0	-.5	.53
3	5.000	2	5.0	.0	-1.0	.53
3	5.000	2	1.5	.0	-1.5	.53
3	5.000	2	50.0	.5	.0	.53
3	5.000	2	2.5	1.0	.0	.53
3	5.000	2	50.0	-.5	.0	.53
3	5.000	2	2.0	-1.0	.0	.53
3	5.000	1	40.0	.0	.5	.52
3	5.000	1	5.0	.0	1.0	.52
3	5.000	1	40.0	.0	-.5	.52
3	5.000	1	3.0	.0	-1.0	.52
3	5.000	1	50.0	.5	.0	.52
3	5.000	1	3.0	1.0	.0	.52
3	5.000	1	30.0	-.5	.0	.52
3	5.000	1	5.0	-1.0	.0	.52

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
3	1.000	2	200.0	.0	.5	15.00
3	1.000	2	36.0	.0	1.0	15.00
3	1.000	2	10.0	.0	1.5	15.00
3	1.000	2	4.4	.0	2.0	15.00
3	1.000	2	2.0	.0	2.5	15.00
3	1.000	2	200.0	.0	-.5	15.00
3	1.000	2	34.0	.0	-1.0	15.00
3	1.000	2	9.5	.0	-1.5	15.00
3	1.000	2	4.0	.0	-2.0	15.00
3	1.000	2	2.0	.0	-2.5	15.00
3	1.000	2	330.0	.5	.0	15.00
3	1.000	2	22.0	1.0	.0	15.00
3	1.000	2	6.5	1.5	.0	15.00
3	1.000	2	2.4	2.0	.0	15.00
3	1.000	2	1.2	2.5	.0	15.00
3	1.000	2	1.0	3.0	.0	15.00
3	1.000	2	200.0	-.5	.0	15.00
3	1.000	2	20.0	-1.0	.0	15.00
3	1.000	2	5.0	-1.5	.0	15.00
3	1.000	2	2.4	-2.0	.0	15.00
3	1.000	2	1.0	-2.5	.0	15.00
3	1.000	2	.8	-3.0	.0	15.00
3	1.000	1	180.0	.0	.5	14.63
3	1.000	1	30.0	.0	1.0	14.63
3	1.000	1	7.5	.0	1.5	14.63
3	1.000	1	4.0	.0	2.0	14.63
3	1.000	1	2.0	.0	2.5	14.63
3	1.000	1	1.0	.0	3.0	14.63
3	1.000	1	200.0	.0	-.5	14.63
3	1.000	1	34.0	.0	-1.0	14.63
3	1.000	1	10.0	.0	-1.5	14.63
3	1.000	1	4.6	.0	-2.0	14.63
3	1.000	1	2.4	.0	-2.5	14.63
3	1.000	1	1.6	.0	-3.0	14.63
3	1.000	1	300.0	.5	.0	14.63
3	1.000	1	20.0	1.0	.0	14.63
3	1.000	1	6.0	1.5	.0	14.63
3	1.000	1	2.4	2.0	.0	14.63
3	1.000	1	1.2	2.5	.0	14.63
3	1.000	1	350.0	-.5	.0	14.63
3	1.000	1	24.0	-1.0	.0	14.63
3	1.000	1	7.0	-1.5	.0	14.63
3	1.000	1	2.8	-2.0	.0	14.63
3	1.000	1	1.6	-2.5	.0	14.63

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
3	.530	1	240.0	.0	.5	24.00
3	.530	1	34.0	.0	1.0	24.00
3	.530	1	10.0	.0	1.5	24.00
3	.530	1	4.0	.0	2.0	24.00
3	.530	1	2.0	.0	2.5	24.00
3	.530	1	1.2	.0	3.0	24.00
3	.530	1	160.0	.0	-.5	24.00
3	.530	1	28.0	.0	-1.0	24.00
3	.530	1	8.5	.0	-1.5	24.00
3	.530	1	4.2	.0	-2.0	24.00
3	.530	1	2.0	.0	-2.5	24.00
3	.530	1	1.0	.0	-3.0	24.00
3	.530	1	200.0	.5	.0	24.00
3	.530	1	19.0	1.0	.0	24.00
3	.530	1	5.0	1.5	.0	24.00
3	.530	1	2.4	2.0	.0	24.00
3	.530	1	1.2	2.5	.0	24.00
3	.530	1	130.0	-.5	.0	24.00
3	.530	1	17.0	-1.0	.0	24.00
3	.530	1	4.6	-1.5	.0	24.00
3	.530	1	2.0	-2.0	.0	24.00
3	.530	1	1.2	-2.5	.0	24.00
3	.530	2	150.0	.0	.5	26.25
3	.530	2	26.0	.0	1.0	26.25
3	.530	2	9.0	.0	1.5	26.25
3	.530	2	3.6	.0	2.0	26.25
3	.530	2	1.8	.0	2.5	26.25
3	.530	2	150.0	.0	-.5	26.25
3	.530	2	28.0	.0	-1.0	26.25
3	.530	2	9.0	.0	-1.5	26.25
3	.530	2	4.0	.0	-2.0	26.25
3	.530	2	1.6	.0	-2.5	26.25
3	.530	2	240.0	.5	.0	26.25
3	.530	2	16.0	1.0	.0	26.25
3	.530	2	5.0	1.5	.0	26.25
3	.530	2	2.0	2.0	.0	26.25
3	.530	2	1.2	2.5	.0	26.25
3	.530	2	.8	3.0	.0	26.25
3	.530	2	250.0	-.5	.0	26.25
3	.530	2	20.0	-1.0	.0	26.25
3	.530	2	5.5	-1.5	.0	26.25
3	.530	2	2.4	-2.0	.0	26.25
3	.530	2	1.2	-2.5	.0	26.25
3	.530	2	.8	-3.0	.0	26.25

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
3	.174	2	85.0	.0	.5	31.88
3	.174	2	12.0	.0	1.0	31.88
3	.174	2	4.6	.0	1.5	31.88
3	.174	2	1.6	.0	2.0	31.88
3	.174	2	.8	.0	2.5	31.88
3	.174	2	65.0	.0	-.5	31.88
3	.174	2	12.0	.0	-1.0	31.88
3	.174	2	3.6	.0	-1.5	31.88
3	.174	2	1.6	.0	-2.0	31.88
3	.174	2	.8	.0	-2.5	31.88
3	.174	2	140.0	.5	.0	31.88
3	.174	2	8.5	1.0	.0	31.88
3	.174	2	2.6	1.5	.0	31.88
3	.174	2	1.0	2.0	.0	31.88
3	.174	2	.6	2.5	.0	31.88
3	.174	2	.4	3.0	.0	31.88
3	.174	2	100.0	-.5	.0	31.88
3	.174	2	9.0	-1.0	.0	31.88
3	.174	2	2.0	-1.5	.0	31.88
3	.174	2	1.2	-2.0	.0	31.88
3	.174	2	.6	-2.5	.0	31.88
3	.174	2	.4	-3.0	.0	31.88
3	.174	1	54.0	.0	.5	32.25
3	.174	1	12.0	.0	1.0	32.25
3	.174	1	3.2	.0	1.5	32.25
3	.174	1	1.6	.0	2.0	32.25
3	.174	1	1.0	.0	2.5	32.25
3	.174	1	.6	.0	3.0	32.25
3	.174	1	80.0	.0	-.5	32.25
3	.174	1	12.0	.0	-1.0	32.25
3	.174	1	3.6	.0	-1.5	32.25
3	.174	1	1.6	.0	-2.0	32.25
3	.174	1	.8	.0	-2.5	32.25
3	.174	1	.6	.0	-3.0	32.25
3	.174	1	130.0	.5	.0	32.25
3	.174	1	7.6	1.0	.0	32.25
3	.174	1	2.2	1.5	.0	32.25
3	.174	1	1.0	2.0	.0	32.25
3	.174	1	.6	2.5	.0	32.25
3	.174	1	105.0	-.5	.0	32.25
3	.174	1	9.5	-1.0	.0	32.25
3	.174	1	2.4	-1.5	.0	32.25
3	.174	1	1.2	-2.0	.0	32.25
3	.174	1	.6	-2.5	.0	32.25

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
4	.174	2	90.0	.0	.5	32.63
4	.174	2	15.0	.0	1.0	32.63
4	.174	2	4.4	.0	1.5	32.63
4	.174	2	1.8	.0	2.0	32.63
4	.174	2	1.0	.0	2.5	32.63
4	.174	2	.8	.0	3.0	32.63
4	.174	2	46.0	.0	-.5	32.63
4	.174	2	10.6	.0	-1.0	32.63
4	.174	2	3.8	.0	-1.5	32.63
4	.174	2	1.6	.0	-2.0	32.63
4	.174	2	.8	.0	-2.5	32.63
4	.174	2	.6	.0	-3.0	32.63
4	.174	2	80.0	.5	.0	32.63
4	.174	2	9.5	1.0	.0	32.63
4	.174	2	2.4	1.5	.0	32.63
4	.174	2	1.0	2.0	.0	32.63
4	.174	2	.6	2.5	.0	32.63
4	.174	2	.4	3.0	.0	32.63
4	.174	2	85.0	-.5	.0	32.63
4	.174	2	8.0	-1.0	.0	32.63
4	.174	2	2.4	-1.5	.0	32.63
4	.174	2	1.0	-2.0	.0	32.63
4	.174	2	.6	-2.5	.0	32.63
4	.174	2	.4	-3.0	.0	32.63
4	.174	1	72.0	.0	.5	32.25
4	.174	1	12.5	.0	1.0	32.25
4	.174	1	3.8	.0	1.5	32.25
4	.174	1	1.8	.0	2.0	32.25
4	.174	1	1.0	.0	2.5	32.25
4	.174	1	.6	.0	3.0	32.25
4	.174	1	92.0	.0	-.5	32.25
4	.174	1	14.0	.0	-1.0	32.25
4	.174	1	4.4	.0	-1.5	32.25
4	.174	1	2.0	.0	-2.0	32.25
4	.174	1	1.0	.0	-2.5	32.25
4	.174	1	.6	.0	-3.0	32.25
4	.174	1	120.0	.5	.0	32.25
4	.174	1	10.0	1.0	.0	32.25
4	.174	1	2.8	1.5	.0	32.25
4	.174	1	1.0	2.0	.0	32.25
4	.174	1	.6	2.5	.0	32.25
4	.174	1	.4	3.0	.0	32.25
4	.174	1	110.0	-.5	.0	32.25
4	.174	1	10.0	-1.0	.0	32.25
4	.174	1	2.6	-1.5	.0	32.25
4	.174	1	1.2	-2.0	.0	32.25
4	.174	1	.6	-2.5	.0	32.25
4	.174	1	.4	-3.0	.0	32.25

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
4	.520	2	180.0	.0	.5	23.25
4	.520	2	30.0	.0	1.0	23.25
4	.520	2	9.0	.0	1.5	23.25
4	.520	2	3.8	.0	2.0	23.25
4	.520	2	2.0	.0	2.5	23.25
4	.520	2	1.0	.0	3.0	23.25
4	.520	2	135.0	.0	-.5	23.25
4	.520	2	25.0	.0	-1.0	23.25
4	.520	2	7.5	.0	-1.5	23.25
4	.520	2	3.0	.0	-2.0	23.25
4	.520	2	2.0	.0	-2.5	23.25
4	.520	2	1.2	.0	-3.0	23.25
4	.520	2	185.0	.5	.0	23.25
4	.520	2	18.0	1.0	.0	23.25
4	.520	2	5.0	1.5	.0	23.25
4	.520	2	2.0	2.0	.0	23.25
4	.520	2	1.0	2.5	.0	23.25
4	.520	2	.6	3.0	.0	23.25
4	.520	2	130.0	-.5	.0	23.25
4	.520	2	16.0	-1.0	.0	23.25
4	.520	2	5.0	-1.5	.0	23.25
4	.520	2	2.0	-2.0	.0	23.25
4	.520	2	1.2	-2.5	.0	23.25
4	.520	2	.8	-3.0	.0	23.25
4	.520	1	200.0	.0	.5	22.50
4	.520	1	30.0	.0	1.0	22.50
4	.520	1	10.0	.0	1.5	22.50
4	.520	1	4.0	.0	2.0	22.50
4	.520	1	2.0	.0	2.5	22.50
4	.520	1	1.2	.0	3.0	22.50
4	.520	1	145.0	.0	-.5	22.50
4	.520	1	21.0	.0	-1.0	22.50
4	.520	1	6.8	.0	-1.5	22.50
4	.520	1	3.4	.0	-2.0	22.50
4	.520	1	1.6	.0	-2.5	22.50
4	.520	1	1.2	.0	-3.0	22.50
4	.520	1	230.0	.5	.0	22.50
4	.520	1	18.0	1.0	.0	22.50
4	.520	1	5.0	1.5	.0	22.50
4	.520	1	2.4	2.0	.0	22.50
4	.520	1	1.2	2.5	.0	22.50
4	.520	1	.8	3.0	.0	22.50
4	.520	1	250.0	-.5	.0	22.50
4	.520	1	24.0	-1.0	.0	22.50
4	.520	1	5.6	-1.5	.0	22.50
4	.520	1	2.0	-2.0	.0	22.50
4	.520	1	1.2	-2.5	.0	22.50
4	.520	1	.6	-3.0	.0	22.50

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
4	1.000	1	210.0	.0	.5	11.55
4	1.000	1	10.0	.0	1.0	11.55
4	1.000	1	9.5	.0	1.5	11.55
4	1.000	1	3.6	.0	2.0	11.55
4	1.000	1	2.0	.0	2.5	11.55
4	1.000	1	1.0	.0	3.0	11.55
4	1.000	1	145.0	.0	-.5	11.55
4	1.000	1	28.0	.0	-1.0	11.55
4	1.000	1	8.0	.0	-1.5	11.55
4	1.000	1	4.0	.0	-2.0	11.55
4	1.000	1	2.0	.0	-2.5	11.55
4	1.000	1	1.0	.0	-3.0	11.55
4	1.000	1	205.0	.5	.0	11.55
4	1.000	1	18.0	1.0	.0	11.55
4	1.000	1	5.0	1.5	.0	11.55
4	1.000	1	2.2	2.0	.0	11.55
4	1.000	1	1.0	2.5	.0	11.55
4	1.000	1	1.0	3.0	.0	11.55
4	1.000	1	130.0	-.5	.0	11.55
4	1.000	1	18.0	-1.0	.0	11.55
4	1.000	1	4.6	-1.5	.0	11.55
4	1.000	1	2.2	-2.0	.0	11.55
4	1.000	1	1.4	-2.5	.0	11.55
4	1.000	2	170.0	.0	.5	11.70
4	1.000	2	25.0	.0	1.0	11.70
4	1.000	2	8.0	.0	1.5	11.70
4	1.000	2	3.2	.0	2.0	11.70
4	1.000	2	1.6	.0	2.5	11.70
4	1.000	2	1.4	.0	3.0	11.70
4	1.000	2	195.0	.0	-.5	11.70
4	1.000	2	31.0	.0	-1.0	11.70
4	1.000	2	10.0	.0	-1.5	11.70
4	1.000	2	4.0	.0	-2.0	11.70
4	1.000	2	2.0	.0	-2.5	11.70
4	1.000	2	.4	.0	-3.0	11.70
4	1.000	2	195.0	.5	.0	11.70
4	1.000	2	17.0	1.0	.0	11.70
4	1.000	2	5.2	1.5	.0	11.70
4	1.000	2	2.0	2.0	.0	11.70
4	1.000	2	1.2	2.5	.0	11.70
4	1.000	2	.8	3.0	.0	11.70
4	1.000	2	225.0	-.5	.0	11.70
4	1.000	2	18.0	-1.0	.0	11.70
4	1.000	2	4.6	-1.5	.0	11.70
4	1.000	2	2.2	-2.0	.0	11.70
4	1.000	2	1.2	-2.5	.0	11.70
4	1.000	2	.8	-3.0	.0	11.70

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
4	9.600	1	660.0	.0	.5	6.00
4	9.600	1	125.0	.0	1.0	6.00
4	9.600	1	35.0	.0	1.5	6.00
4	9.600	1	13.0	.0	2.0	6.00
4	9.600	1	3.2	.0	2.5	6.00
4	9.600	1	2.8	.0	3.0	6.00
4	9.600	1	1000.0	.0	-.5	6.00
4	9.600	1	65.0	.0	-1.0	6.00
4	9.600	1	36.0	.0	-1.5	6.00
4	9.600	1	16.0	.0	-2.0	6.00
4	9.600	1	10.0	.0	-2.5	6.00
4	9.600	1	8.4	.0	-3.0	6.00
4	9.600	1	1650.0	.5	.0	6.00
4	9.600	1	80.0	1.0	.0	6.00
4	9.600	1	36.0	1.5	.0	6.00
4	9.600	1	24.0	2.0	.0	6.00
4	9.600	1	20.0	2.5	.0	6.00
4	9.600	1	22.0	3.0	.0	6.00
4	9.600	1	1300.0	-.5	.0	6.00
4	9.600	1	28.0	-1.0	.0	6.00
4	9.600	1	13.0	-1.5	.0	6.00
4	9.600	1	15.0	-2.0	.0	6.00
4	9.600	1	16.0	-2.5	.0	6.00
4	9.600	1	22.5	-3.0	.0	6.00
4	9.600	2	1000.0	.0	.5	6.00
4	9.600	2	110.0	.0	1.0	6.00
4	9.600	2	32.0	.0	1.5	6.00
4	9.600	2	17.5	.0	2.0	6.00
4	9.600	2	8.0	.0	2.5	6.00
4	9.600	2	5.2	.0	3.0	6.00
4	9.600	2	800.0	.0	-.5	6.00
4	9.600	2	120.0	.0	-1.0	6.00
4	9.600	2	34.0	.0	-1.5	6.00
4	9.600	2	12.5	.0	-2.0	6.00
4	9.600	2	4.0	.0	-2.5	6.00
4	9.600	2	6.4	.0	-3.0	6.00
4	9.600	2	500.0	.5	.0	6.00
4	9.600	2	75.0	1.0	.0	6.00
4	9.600	2	28.0	1.5	.0	6.00
4	9.600	2	20.0	2.0	.0	6.00
4	9.600	2	13.5	2.5	.0	6.00
4	9.600	2	11.0	3.0	.0	6.00
4	9.600	2	800.0	-.5	.0	6.00
4	9.600	2	90.0	-1.0	.0	6.00
4	9.600	2	25.0	-1.5	.0	6.00
4	9.600	2	12.0	-2.0	.0	6.00
4	9.600	2	6.0	-2.5	.0	6.00
4	9.600	2	5.4	-3.0	.0	6.00

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
4	5.800	1	200.0	.0	.5	1.68
4	5.800	1	19.0	.0	1.0	1.68
4	5.800	1	5.4	.0	1.5	1.68
4	5.800	1	2.4	.0	2.0	1.68
4	5.800	1	1.2	.0	2.5	1.68
4	5.800	1	1.0	.0	3.0	1.68
4	5.800	1	140.0	.0	-.5	1.68
4	5.800	1	20.0	.0	-1.0	1.68
4	5.800	1	6.4	.0	-1.5	1.68
4	5.800	1	2.6	.0	-2.0	1.68
4	5.800	1	1.4	.0	-2.5	1.68
4	5.800	1	.8	.0	-3.0	1.68
4	5.800	1	180.0	.5	.0	1.68
4	5.800	1	14.0	1.0	.0	1.68
4	5.800	1	4.2	1.5	.0	1.68
4	5.800	1	1.6	2.0	.0	1.68
4	5.800	1	1.0	2.5	.0	1.68
4	5.800	1	.8	3.0	.0	1.68
4	5.800	1	190.0	-.5	.0	1.68
4	5.800	1	17.0	-1.0	.0	1.68
4	5.800	1	5.6	-1.5	.0	1.68
4	5.800	1	2.8	-2.0	.0	1.68
4	5.800	1	1.6	-2.5	.0	1.68
4	5.800	1	1.8	-3.0	.0	1.68
4	5.800	2	160.0	.0	.5	1.64
4	5.800	2	23.0	.0	1.0	1.64
4	5.800	2	8.0	.0	1.5	1.64
4	5.800	2	3.4	.0	2.0	1.64
4	5.800	2	2.6	.0	2.5	1.64
4	5.800	2	2.8	.0	3.0	1.64
4	5.800	2	150.0	.0	-.5	1.64
4	5.800	2	17.0	.0	-1.0	1.64
4	5.800	2	5.0	.0	-1.5	1.64
4	5.800	2	2.6	.0	-2.0	1.64
4	5.800	2	1.6	.0	-2.5	1.64
4	5.800	2	1.4	.0	-3.0	1.64
4	5.800	2	160.0	.5	.0	1.64
4	5.800	2	11.5	1.0	.0	1.64
4	5.800	2	4.2	1.5	.0	1.64
4	5.800	2	2.2	2.0	.0	1.64
4	5.800	2	1.6	2.5	.0	1.64
4	5.800	2	1.6	3.0	.0	1.64
4	5.800	2	125.0	-.5	.0	1.64
4	5.800	2	12.5	-1.0	.0	1.64
4	5.800	2	3.4	-1.5	.0	1.64
4	5.800	2	1.2	-2.0	.0	1.64
4	5.800	2	.6	-2.5	.0	1.64
4	5.800	2	.4	-3.0	.0	1.64

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
5	5.800	2	190.0	.0	.5	1.84
5	5.800	2	22.0	.0	1.0	1.84
5	5.800	2	7.0	.0	1.5	1.84
5	5.800	2	4.0	.0	2.0	1.84
5	5.800	2	2.8	.0	2.5	1.84
5	5.800	2	170.0	.0	-.5	1.84
5	5.800	2	23.0	.0	-1.0	1.84
5	5.800	2	7.4	.0	-1.5	1.84
5	5.800	2	3.8	.0	-2.0	1.84
5	5.800	2	1.2	.0	-2.5	1.84
5	5.800	2	.8	.0	-3.0	1.84
5	5.800	2	180.0	.5	.0	1.84
5	5.800	2	15.0	1.0	.0	1.84
5	5.800	2	5.6	1.5	.0	1.84
5	5.800	2	3.2	2.0	.0	1.84
5	5.800	2	2.4	2.5	.0	1.84
5	5.800	2	2.2	3.0	.0	1.84
5	5.800	2	130.0	-.5	.0	1.84
5	5.800	2	6.0	-1.0	.0	1.84
5	5.800	2	2.6	-1.5	.0	1.84
5	5.800	2	1.4	-2.0	.0	1.84
5	5.800	2	1.0	-2.5	.0	1.84
5	5.800	2	.8	-3.0	.0	1.84
5	5.800	1	160.0	.0	.5	1.82
5	5.800	1	22.0	.0	1.0	1.82
5	5.800	1	7.0	.0	1.5	1.82
5	5.800	1	2.8	.0	2.0	1.82
5	5.800	1	1.4	.0	2.5	1.82
5	5.800	1	1.2	.0	3.0	1.82
5	5.800	1	165.0	.0	-.5	1.82
5	5.800	1	22.0	.0	-1.0	1.82
5	5.800	1	7.4	.0	-1.5	1.82
5	5.800	1	3.6	.0	-2.0	1.82
5	5.800	1	2.4	.0	-2.5	1.82
5	5.800	1	2.0	.0	-3.0	1.82
5	5.800	1	210.0	.5	.0	1.82
5	5.800	1	17.0	1.0	.0	1.82
5	5.800	1	7.0	1.5	.0	1.82
5	5.800	1	3.6	2.0	.0	1.82
5	5.800	1	2.4	2.5	.0	1.82
5	5.800	1	225.0	-.5	.0	1.82
5	5.800	1	15.0	-1.0	.0	1.82
5	5.800	1	4.0	-1.5	.0	1.82
5	5.800	1	2.4	-2.0	.0	1.82
5	5.800	1	1.4	-2.5	.0	1.82
5	5.800	1	.8	-3.0	.0	1.82

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
5	9.600	1	850.0	.0	.5	6.20
5	9.600	1	125.0	.0	1.0	6.20
5	9.600	1	34.0	.0	1.5	6.20
5	9.600	1	15.0	.0	2.0	6.20
5	9.600	1	6.4	.0	2.5	6.20
5	9.600	1	4.0	.0	3.0	6.20
5	9.600	1	1100.0	.0	-.5	6.20
5	9.600	1	125.0	.0	-1.0	6.20
5	9.600	1	44.0	.0	-1.5	6.20
5	9.600	1	22.0	.0	-2.0	6.20
5	9.600	1	15.0	.0	-2.5	6.20
5	9.600	1	12.0	.0	-3.0	6.20
5	9.600	1	1600.0	.5	.0	6.20
5	9.600	1	125.0	1.0	.0	6.20
5	9.600	1	46.0	1.5	.0	6.20
5	9.600	1	32.0	2.0	.0	6.20
5	9.600	1	23.0	2.5	.0	6.20
5	9.600	1	1700.0	-.5	.0	6.20
5	9.600	1	100.0	-1.0	.0	6.20
5	9.600	1	30.0	-1.5	.0	6.20
5	9.600	1	14.0	-2.0	.0	6.20
5	9.600	1	12.0	-2.5	.0	6.20
5	9.600	1	8.0	-3.0	.0	6.20

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
5	9.000	1	840.0	.0	.5	5.85
5	9.000	1	125.0	.0	1.0	5.85
5	9.000	1	27.0	.0	1.5	5.85
5	9.000	1	12.5	.0	2.0	5.85
5	9.000	1	7.0	.0	2.5	5.85
5	9.000	1	10.0	.0	3.0	5.85
5	9.000	1	900.0	.0	-.5	5.85
5	9.000	1	115.0	.0	-1.0	5.85
5	9.000	1	43.0	.0	-1.5	5.85
5	9.000	1	23.0	.0	-2.0	5.85
5	9.000	1	16.0	.0	-2.5	5.85
5	9.000	1	1500.0	.5	.0	5.85
5	9.000	1	85.0	1.0	.0	5.85
5	9.000	1	40.0	1.5	.0	5.85
5	9.000	1	25.0	2.0	.0	5.85
5	9.000	1	19.0	2.5	.0	5.85
5	9.000	1	17.0	3.0	.0	5.85
5	9.000	1	1000.0	-.5	.0	5.85
5	9.000	1	36.0	-1.0	.0	5.85
5	9.000	1	23.5	-1.5	.0	5.85
5	9.000	1	11.5	-2.0	.0	5.85
5	9.000	1	8.5	-2.5	.0	5.85
5	9.000	1	6.4	-3.0	.0	5.85

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
5	1.000	1	225.0	.0	.5	13.50
5	1.000	1	56.0	.0	1.0	13.50
5	1.000	1	20.0	.0	1.5	13.50
5	1.000	1	4.6	.0	2.0	13.50
5	1.000	1	2.4	.0	2.5	13.50
5	1.000	1	1.4	.0	3.0	13.50
5	1.000	1	140.0	.0	-.5	13.50
5	1.000	1	32.0	.0	-1.0	13.50
5	1.000	1	9.0	.0	-1.5	13.50
5	1.000	1	4.4	.0	-2.0	13.50
5	1.000	1	2.6	.0	-2.5	13.50
5	1.000	1	1.6	.0	-3.0	13.50
5	1.000	1	200.0	.5	.0	13.50
5	1.000	1	20.0	1.0	.0	13.50
5	1.000	1	6.0	1.5	.0	13.50
5	1.000	1	2.4	2.0	.0	13.50
5	1.000	1	1.6	2.5	.0	13.50
5	1.000	1	300.0	-.5	.0	13.50
5	1.000	1	24.0	-1.0	.0	13.50
5	1.000	1	7.4	-1.5	.0	13.50
5	1.000	1	3.8	-2.0	.0	13.50
5	1.000	1	2.0	-2.5	.0	13.50
5	1.000	2	250.0	.0	.5	8.85
5	1.000	2	48.0	.0	1.0	8.85
5	1.000	2	14.0	.0	1.5	8.85
5	1.000	2	5.2	.0	2.0	8.85
5	1.000	2	4.4	.0	2.5	8.85
5	1.000	2	1.6	.0	3.0	8.85
5	1.000	2	400.0	.0	-.5	8.85
5	1.000	2	50.0	.0	-1.0	8.85
5	1.000	2	15.0	.0	-1.5	8.85
5	1.000	2	7.5	.0	-2.0	8.85
5	1.000	2	2.8	.0	-2.5	8.85
5	1.000	2	.8	.0	-3.0	8.85
5	1.000	2	440.0	.5	.0	8.85
5	1.000	2	30.0	1.0	.0	8.85
5	1.000	2	7.5	1.5	.0	8.85
5	1.000	2	3.0	2.0	.0	8.85
5	1.000	2	1.2	2.5	.0	8.85
5	1.000	2	500.0	-.5	.0	8.85
5	1.000	2	40.0	-1.0	.0	8.85
5	1.000	2	10.0	-1.5	.0	8.85
5	1.000	2	4.4	-2.0	.0	8.85
5	1.000	2	2.4	-2.5	.0	8.85
5	1.000	2	1.4	-3.0	.0	8.85

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
5	.520	2	230.0	.0	.5	9.00
5	.520	2	40.0	.0	1.0	9.00
5	.520	2	12.0	.0	1.5	9.00
5	.520	2	4.0	.0	2.0	9.00
5	.520	2	2.0	.0	2.5	9.00
5	.520	2	160.0	.0	-.5	9.00
5	.520	2	22.0	.0	-1.0	9.00
5	.520	2	10.0	.0	-1.5	9.00
5	.520	2	3.6	.0	-2.0	9.00
5	.520	2	2.0	.0	-2.5	9.00
5	.520	2	1.0	.0	-3.0	9.00
5	.520	2	180.0	.5	.0	9.00
5	.520	2	20.0	1.0	.0	9.00
5	.520	2	5.6	1.5	.0	9.00
5	.520	2	2.2	2.0	.0	9.00
5	.520	2	1.4	2.5	.0	9.00
5	.520	2	1.0	3.0	.0	9.00
5	.520	2	150.0	-.5	.0	9.00
5	.520	2	15.0	-1.0	.0	9.00
5	.520	2	4.6	-1.5	.0	9.00
5	.520	2	2.2	-2.0	.0	9.00
5	.520	2	1.4	-2.5	.0	9.00
5	.520	2	.8	-3.0	.0	9.00
5	.520	1	180.0	.0	.5	9.15
5	.520	1	27.0	.0	1.0	9.15
5	.520	1	9.0	.0	1.5	9.15
5	.520	1	4.0	.0	2.0	9.15
5	.520	1	2.8	.0	2.5	9.15
5	.520	1	1.8	.0	3.0	9.15
5	.520	1	220.0	.0	-.5	9.15
5	.520	1	30.0	.0	-1.0	9.15
5	.520	1	10.0	.0	-1.5	9.15
5	.520	1	4.4	.0	-2.0	9.15
5	.520	1	2.4	.0	-2.5	9.15
5	.520	1	1.4	.0	-3.0	9.15
5	.520	1	360.0	.5	.0	9.15
5	.520	1	23.0	1.0	.0	9.15
5	.520	1	7.0	1.5	.0	9.15
5	.520	1	2.8	2.0	.0	9.15
5	.520	1	1.6	2.5	.0	9.15
5	.520	1	230.0	-.5	.0	9.15
5	.520	1	22.0	-1.0	.0	9.15
5	.520	1	6.0	-1.5	.0	9.15
5	.520	1	2.4	-2.0	.0	9.15
5	.520	1	1.8	-2.5	.0	9.15
5	.520	1	1.2	-3.0	.0	9.15

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
5	.173	1	56.0	.0	.5	20.63
5	.173	1	7.5	.0	1.0	20.63
5	.173	1	2.8	.0	1.5	20.63
5	.173	1	1.2	.0	2.0	20.63
5	.173	1	.8	.0	2.5	20.63
5	.173	1	.6	.0	3.0	20.63
5	.173	1	40.0	.0	-.5	20.63
5	.173	1	6.8	.0	-1.0	20.63
5	.173	1	2.4	.0	-1.5	20.63
5	.173	1	1.2	.0	-2.0	20.63
5	.173	1	.8	.0	-2.5	20.63
5	.173	1	.6	.0	-3.0	20.63
5	.173	1	60.0	.5	.0	20.63
5	.173	1	4.6	1.0	.0	20.63
5	.173	1	1.6	1.5	.0	20.63
5	.173	1	.8	2.0	.0	20.63
5	.173	1	.4	2.5	.0	20.63
5	.173	1	60.0	-.5	.0	20.63
5	.173	1	5.0	-1.0	.0	20.63
5	.173	1	1.6	-1.5	.0	20.63
5	.173	1	.8	-2.0	.0	20.63
5	.173	1	.6	-2.5	.0	20.63
5	.173	1	54.0	.0	.5	19.88
5	.173	1	6.0	.0	1.0	19.88
5	.173	1	3.0	.0	1.5	19.88
5	.173	1	1.0	.0	2.0	19.88
5	.173	1	.6	.0	2.5	19.88
5	.173	1	36.0	.0	-.5	19.88
5	.173	1	6.4	.0	-1.0	19.88
5	.173	1	1.4	.0	-1.5	19.88
5	.173	1	.8	.0	-2.0	19.88
5	.173	1	.6	.0	-2.5	19.88
5	.173	1	65.0	.5	.0	19.88
5	.173	1	5.2	1.0	.0	19.88
5	.173	1	1.6	1.5	.0	19.88
5	.173	1	.4	2.0	.0	19.88
5	.173	1	28.0	-.5	.0	19.88
5	.173	1	3.6	-1.0	.0	19.88
5	.173	1	1.2	-1.5	.0	19.88
5	.173	1	.6	-2.0	.0	19.88

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
6	.174	2	13.0	.0	.5	8.85
6	.174	2	2.4	.0	1.0	8.85
6	.174	2	.8	.0	1.5	8.85
6	.174	2	22.0	.0	-.5	8.85
6	.174	2	3.6	.0	-1.0	8.85
6	.174	2	.8	.0	-1.5	8.85
6	.174	2	.4	.0	-2.0	8.85
6	.174	2	26.0	.5	.0	8.85
6	.174	2	2.4	1.0	.0	8.85
6	.174	2	.4	1.5	.0	8.85
6	.174	2	25.0	-.5	.0	8.85
6	.174	2	2.2	-1.0	.0	8.85
6	.174	2	.6	-1.5	.0	8.85
6	.174	1	22.0	.0	.5	8.85
6	.174	1	3.0	.0	1.0	8.85
6	.174	1	1.2	.0	1.5	8.85
6	.174	1	.6	.0	2.0	8.85
6	.174	1	20.0	.0	-.5	8.85
6	.174	1	3.2	.0	-1.0	8.85
6	.174	1	1.0	.0	-1.5	8.85
6	.174	1	.6	.0	-2.0	8.85
6	.174	1	20.0	.5	.0	8.85
6	.174	1	2.6	1.0	.0	8.85
6	.174	1	.8	1.5	.0	8.85
6	.174	1	.4	2.0	.0	8.85
6	.174	1	20.0	-.5	.0	8.85
6	.174	1	2.4	-1.0	.0	8.85
6	.174	1	.8	-1.5	.0	8.85
6	.174	1	.4	-2.0	.0	8.85

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
6	.520	1	220.0	.0	.5	26.25
6	.520	1	32.0	.0	1.0	26.25
6	.520	1	1.0	.0	1.5	26.25
6	.520	1	4.4	.0	2.0	26.25
6	.520	1	2.0	.0	2.5	26.25
6	.520	1	1.2	.0	3.0	26.25
6	.520	1	200.0	.0	-.5	26.25
6	.520	1	36.0	.0	-1.0	26.25
6	.520	1	7.0	.0	-1.5	26.25
6	.520	1	3.0	.0	-2.0	26.25
6	.520	1	1.6	.0	-2.5	26.25
6	.520	1	1.4	.0	-3.0	26.25
6	.520	1	260.0	.5	.0	26.25
6	.520	1	15.0	1.0	.0	26.25
6	.520	1	4.6	1.5	.0	26.25
6	.520	1	2.2	2.0	.0	26.25
6	.520	1	1.0	2.5	.0	26.25
6	.520	1	170.0	-.5	.0	26.25
6	.520	1	15.0	-1.0	.0	26.25
6	.520	1	4.4	-1.5	.0	26.25
6	.520	1	2.0	-2.0	.0	26.25
6	.520	1	1.2	-2.5	.0	26.25
6	.520	1	.6	-3.0	.0	26.25
6	.520	2	280.0	.0	.5	27.00
6	.520	2	36.0	.0	1.0	27.00
6	.520	2	10.0	.0	1.5	27.00
6	.520	2	3.8	.0	2.0	27.00
6	.520	2	2.6	.0	2.5	27.00
6	.520	2	200.0	.0	-.5	27.00
6	.520	2	34.0	.0	-1.0	27.00
6	.520	2	10.0	.0	-1.5	27.00
6	.520	2	4.4	.0	-2.0	27.00
6	.520	2	2.6	.0	-2.5	27.00
6	.520	2	1.6	.0	-3.0	27.00
6	.520	2	200.0	.5	.0	27.00
6	.520	2	20.0	1.0	.0	27.00
6	.520	2	6.0	1.5	.0	27.00
6	.520	2	2.6	2.0	.0	27.00
6	.520	2	1.4	2.5	.0	27.00
6	.520	2	.8	3.0	.0	27.00
6	.520	2	150.0	-.5	.0	27.00
6	.520	2	19.0	-1.0	.0	27.00
6	.520	2	4.8	-1.5	.0	27.00
6	.520	2	2.0	-2.0	.0	27.00
6	.520	2	1.2	-2.5	.0	27.00
6	.520	2	.8	-3.0	.0	27.00

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
6	1.000	2	380.0	.0	.5	23.63
6	1.000	2	60.0	.0	1.0	23.63
6	1.000	2	20.0	.0	1.5	23.63
6	1.000	2	6.5	.0	2.0	23.63
6	1.000	2	400.0	.0	-.5	23.63
6	1.000	2	58.0	.0	-1.0	23.63
6	1.000	2	16.0	.0	-1.5	23.63
6	1.000	2	7.5	.0	-2.0	23.63
6	1.000	2	5.0	.0	-2.5	23.63
6	1.000	2	540.0	.5	.0	23.63
6	1.000	2	44.0	1.0	.0	23.63
6	1.000	2	10.0	1.5	.0	23.63
6	1.000	2	3.2	2.0	.0	23.63
6	1.000	2	3.2	2.5	.0	23.63
6	1.000	2	2.2	3.0	.0	23.63
6	1.000	2	360.0	-.5	.0	23.63
6	1.000	2	36.0	-1.0	.0	23.63
6	1.000	2	9.5	-1.5	.0	23.63
6	1.000	2	4.0	-2.0	.0	23.63
6	1.000	2	2.0	-2.5	.0	23.63
6	1.000	2	1.2	-3.0	.0	23.63
6	1.000	1	360.0	.0	.5	20.63
6	1.000	1	50.0	.0	1.0	20.63
6	1.000	1	15.0	.0	1.5	20.63
6	1.000	1	6.2	.0	2.0	20.63
6	1.000	1	3.0	.0	2.5	20.63
6	1.000	1	2.0	.0	3.0	20.63
6	1.000	1	230.0	.0	-.5	20.63
6	1.000	1	43.0	.0	-1.0	20.63
6	1.000	1	12.0	.0	-1.5	20.63
6	1.000	1	5.0	.0	-2.0	20.63
6	1.000	1	2.4	.0	-2.5	20.63
6	1.000	1	1.6	.0	-3.0	20.63
6	1.000	1	230.0	.5	.0	20.63
6	1.000	1	21.0	1.0	.0	20.63
6	1.000	1	7.5	1.5	.0	20.63
6	1.000	1	3.0	2.0	.0	20.63
6	1.000	1	2.0	2.5	.0	20.63
6	1.000	1	250.0	-.5	.0	20.63
6	1.000	1	25.0	-1.0	.0	20.63
6	1.000	1	8.4	-1.5	.0	20.63
6	1.000	1	4.4	-2.0	.0	20.63
6	1.000	1	2.0	-2.5	.0	20.63
6	1.000	1	1.0	-3.0	.0	20.63

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
6	5.800	1	600.0	.0	.5	5.60
6	5.800	1	50.0	.0	1.0	5.60
6	5.800	1	14.0	.0	1.5	5.60
6	5.800	1	8.0	.0	2.0	5.60
6	5.800	1	6.2	.0	2.5	5.60
6	5.800	1	5.2	.0	3.0	5.60
6	5.800	1	500.0	.0	-.5	5.60
6	5.800	1	75.0	.0	-1.0	5.60
6	5.800	1	23.0	.0	-1.5	5.60
6	5.800	1	10.0	.0	-2.0	5.60
6	5.800	1	4.6	.0	-2.5	5.60
6	5.800	1	2.8	.0	-3.0	5.60
6	5.800	1	300.0	.5	.0	5.60
6	5.800	1	30.0	1.0	.0	5.60
6	5.800	1	9.0	1.5	.0	5.60
6	5.800	1	5.0	2.0	.0	5.60
6	5.800	1	3.0	2.5	.0	5.60
6	5.800	1	600.0	-.5	.0	5.60
6	5.800	1	50.0	-1.0	.0	5.60
6	5.800	1	22.0	-1.5	.0	5.60
6	5.800	1	14.0	-2.0	.0	5.60
6	5.800	1	12.0	-2.5	.0	5.60
6	5.800	1	9.5	-3.0	.0	5.60
6	5.800	2	500.0	.0	.5	5.30
6	5.800	2	80.0	.0	1.0	5.30
6	5.800	2	14.0	.0	1.5	5.30
6	5.800	2	4.8	.0	2.0	5.30
6	5.800	2	4.0	.0	2.5	5.30
6	5.800	2	540.0	.0	-.5	5.30
6	5.800	2	50.0	.0	-1.0	5.30
6	5.800	2	14.5	.0	-1.5	5.30
6	5.800	2	7.0	.0	-2.0	5.30
6	5.800	2	4.5	.0	-2.5	5.30
6	5.800	2	4.0	.0	-3.0	5.30
6	5.800	2	560.0	.5	.0	5.30
6	5.800	2	40.0	1.0	.0	5.30
6	5.800	2	9.5	1.5	.0	5.30
6	5.800	2	4.0	2.0	.0	5.30
6	5.800	2	2.8	2.5	.0	5.30
6	5.800	2	2.2	3.0	.0	5.30
6	5.800	2	400.0	-.5	.0	5.30
6	5.800	2	22.0	-1.0	.0	5.30
6	5.800	2	13.0	-1.5	.0	5.30
6	5.800	2	8.0	-2.0	.0	5.30
6	5.800	2	6.0	-2.5	.0	5.30
6	5.800	2	4.8	-3.0	.0	5.30

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
6	9.500	1	1800.0	.0	.5	14.00
6	9.500	1	280.0	.0	1.0	14.00
6	9.500	1	50.0	.0	1.5	14.00
6	9.500	1	20.0	.0	2.0	14.00
6	9.500	1	1350.0	.0	-.5	14.00
6	9.500	1	280.0	.0	-1.0	14.00
6	9.500	1	65.0	.0	-1.5	14.00
6	9.500	1	30.0	.0	-2.0	14.00
6	9.500	1	3600.0	.5	.0	14.00
6	9.500	1	200.0	1.0	.0	14.00
6	9.500	1	50.0	1.5	.0	14.00
6	9.500	1	20.0	2.0	.0	14.00
6	9.500	1	4800.0	-.5	.0	14.00
6	9.500	1	300.0	-1.0	.0	14.00
6	9.500	1	100.0	-1.5	.0	14.00
6	9.500	1	50.0	-2.0	.0	14.00
6	9.500	2	2200.0	.0	.5	13.50
6	9.500	2	200.0	.0	1.0	13.50
6	9.500	2	100.0	.0	1.5	13.50
6	9.500	2	50.0	.0	2.0	13.50
6	9.500	2	3000.0	.0	-.5	13.50
6	9.500	2	250.0	.0	-1.0	13.50
6	9.500	2	40.0	.0	-1.5	13.50
6	9.500	2	1400.0	.5	.0	13.50
6	9.500	2	200.0	1.0	.0	13.50
6	9.500	2	100.0	1.5	.0	13.50
6	9.500	2	50.0	2.0	.0	13.50
6	9.500	2	50.0	2.5	.0	13.50
6	9.500	2	2300.0	-.5	.0	13.50
6	9.500	2	65.0	-1.0	.0	13.50

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
7	9.800	1	1500.0	.0	.5	12.50
7	9.800	1	250.0	.0	1.0	12.50
7	9.800	1	56.0	.0	1.5	12.50
7	9.800	1	2000.0	.0	-.5	12.50
7	9.800	1	180.0	.0	-1.0	12.50
7	9.800	1	64.0	.0	-1.5	12.50
7	9.800	1	25.0	.0	-2.0	12.50
7	9.800	1	1400.0	.5	.0	12.50
7	9.800	1	65.0	1.0	.0	12.50
7	9.800	1	40.0	1.5	.0	12.50
7	9.800	1	1200.0	-.5	.0	12.50
7	9.800	1	160.0	-1.0	.0	12.50
7	9.800	1	96.0	-1.5	.0	12.50
7	9.800	1	100.0	-2.0	.0	12.50

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
7	10.000	2	1800.0	.0	.5	12.25
7	10.000	2	300.0	.0	1.0	12.25
7	10.000	2	80.0	.0	1.5	12.25
7	10.000	2	1600.0	.0	-.5	12.25
7	10.000	2	220.0	.0	-1.0	12.25
7	10.000	2	94.0	.0	-1.5	12.25
7	10.000	2	68.0	.0	-2.0	12.25
7	10.000	2	3200.0	.5	.0	12.25
7	10.000	2	200.0	1.0	.0	12.25
7	10.000	2	66.0	1.5	.0	12.25
7	10.000	2	30.0	2.0	.0	12.25
7	10.000	2	5200.0	-.5	.0	12.25
7	10.000	2	220.0	-1.0	.0	12.25
7	10.000	2	90.0	-1.5	.0	12.25
7	10.000	2	36.0	-2.0	.0	12.25

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
7	.520	1	200.0	.0	.5	26.25
7	.520	1	30.0	.0	1.0	26.25
7	.520	1	9.0	.0	1.5	26.25
7	.520	1	3.8	.0	2.0	26.25
7	.520	1	2.0	.0	2.5	26.25
7	.520	1	1.4	.0	3.0	26.25
7	.520	1	180.0	.0	-.5	26.25
7	.520	1	30.0	.0	-1.0	26.25
7	.520	1	10.0	.0	-1.5	26.25
7	.520	1	4.2	.0	-2.0	26.25
7	.520	1	2.0	.0	-2.5	26.25
7	.520	1	1.4	.0	-3.0	26.25
7	.520	1	220.0	.5	.0	26.25
7	.520	1	24.0	1.0	.0	26.25
7	.520	1	3.0	1.5	.0	26.25
7	.520	1	2.6	2.0	.0	26.25
7	.520	1	220.0	-.5	.0	26.25
7	.520	1	20.0	-1.0	.0	26.25
7	.520	1	5.2	-1.5	.0	26.25
7	.520	1	2.6	-2.0	.0	26.25
7	.520	1	1.6	-2.5	.0	26.25
7	.520	2	170.0	.0	.5	19.50
7	.520	2	26.0	.0	1.0	19.50
7	.520	2	8.0	.0	1.5	19.50
7	.520	2	3.6	.0	2.0	19.50
7	.520	2	125.0	.0	-.5	19.50
7	.520	2	22.0	.0	-1.0	19.50
7	.520	2	7.0	.0	-1.5	19.50
7	.520	2	3.0	.0	-2.0	19.50
7	.520	2	1.2	.0	-2.5	19.50
7	.520	2	125.0	.5	.0	19.50
7	.520	2	13.0	1.0	.0	19.50
7	.520	2	3.4	1.5	.0	19.50
7	.520	2	1.6	2.0	.0	19.50
7	.520	2	1.0	2.5	.0	19.50
7	.520	2	135.0	-.5	.0	19.50
7	.520	2	14.0	-1.0	.0	19.50
7	.520	2	3.4	-1.5	.0	19.50
7	.520	2	1.6	-2.0	.0	19.50
7	.520	2	1.0	-2.5	.0	19.50

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
7	1.000	2	240.0	.0	.5	18.00
7	1.000	2	34.0	.0	1.0	18.00
7	1.000	2	12.0	.0	1.5	18.00
7	1.000	2	5.6	.0	2.0	18.00
7	1.000	2	230.0	.0	-.5	18.00
7	1.000	2	40.0	.0	-1.0	18.00
7	1.000	2	13.0	.0	-1.5	18.00
7	1.000	2	7.0	.0	-2.0	18.00
7	1.000	2	400.0	.5	.0	18.00
7	1.000	2	27.0	1.0	.0	18.00
7	1.000	2	7.0	1.5	.0	18.00
7	1.000	2	3.0	2.0	.0	18.00
7	1.000	2	1.6	2.5	.0	18.00
7	1.000	2	1.0	3.0	.0	18.00
7	1.000	2	400.0	-.5	.0	18.00
7	1.000	2	23.0	-1.0	.0	18.00
7	1.000	2	5.0	-1.5	.0	18.00
7	1.000	2	2.0	-2.0	.0	18.00
7	1.000	1	300.0	.0	.5	16.90
7	1.000	1	44.0	.0	1.0	16.90
7	1.000	1	12.5	.0	1.5	16.90
7	1.000	1	5.2	.0	2.0	16.90
7	1.000	1	2.4	.0	2.5	16.90
7	1.000	1	1.4	.0	3.0	16.90
7	1.000	1	150.0	.0	-.5	16.90
7	1.000	1	23.0	.0	-1.0	16.90
7	1.000	1	8.0	.0	-1.5	16.90
7	1.000	1	3.6	.0	-2.0	16.90
7	1.000	1	2.0	.0	-2.5	16.90
7	1.000	1	1.2	.0	-3.0	16.90
7	1.000	1	300.0	.5	.0	16.90
7	1.000	1	20.0	1.0	.0	16.90
7	1.000	1	7.0	1.5	.0	16.90
7	1.000	1	2.4	2.0	.0	16.90
7	1.000	1	340.0	-.5	.0	16.90
7	1.000	1	18.0	-1.0	.0	16.90
7	1.000	1	5.6	-1.5	.0	16.90
7	1.000	1	2.4	-2.0	.0	16.90
7	1.000	1	2.0	-2.5	.0	16.90

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
7	.175	1	20.0	.0	.5	8.25
7	.175	1	3.0	.0	1.0	8.25
7	.175	1	1.0	.0	1.5	8.25
7	.175	1	.6	.0	2.0	8.25
7	.175	1	15.0	.0	-.5	8.25
7	.175	1	2.4	.0	-1.0	8.25
7	.175	1	.8	.0	-1.5	8.25
7	.175	1	.6	.0	-2.0	8.25
7	.175	1	28.0	.5	.0	8.25
7	.175	1	2.8	1.0	.0	8.25
7	.175	1	.8	1.5	.0	8.25
7	.175	1	25.0	-.5	.0	8.25
7	.175	1	2.0	-1.0	.0	8.25
7	.175	1	.6	-1.5	.0	8.25
7	.175	2	55.0	.0	.5	25.50
7	.175	2	9.0	.0	1.0	25.50
7	.175	2	2.6	.0	1.5	25.50
7	.175	2	1.4	.0	2.0	25.50
7	.175	2	.8	.0	2.5	25.50
7	.175	2	70.0	.0	-.5	25.50
7	.175	2	10.0	.0	-1.0	25.50
7	.175	2	3.2	.0	-1.5	25.50
7	.175	2	1.6	.0	-2.0	25.50
7	.175	2	50.0	.5	.0	25.50
7	.175	2	5.6	1.0	.0	25.50
7	.175	2	1.6	1.5	.0	25.50
7	.175	2	.8	2.0	.0	25.50
7	.175	2	60.0	-.5	.0	25.50
7	.175	2	6.0	-1.0	.0	25.50
7	.175	2	1.6	-1.5	.0	25.50
7	.175	2	.8	-2.0	.0	25.50

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
7	5.800	1	450.0	.0	.5	4.50
7	5.800	1	70.0	.0	1.0	4.50
7	5.800	1	19.0	.0	1.5	4.50
7	5.800	1	8.6	.0	2.0	4.50
7	5.800	1	2.6	.0	2.5	4.50
7	5.800	1	1.4	.0	3.0	4.50
7	5.800	1	340.0	.0	-.5	4.50
7	5.800	1	48.0	.0	-1.0	4.50
7	5.800	1	14.0	.0	-1.5	4.50
7	5.800	1	7.0	.0	-2.0	4.50
7	5.800	1	4.0	.0	-2.5	4.50
7	5.800	1	2.2	.0	-3.0	4.50
7	5.800	1	260.0	.5	.0	4.50
7	5.800	1	30.0	1.0	.0	4.50
7	5.800	1	12.5	1.5	.0	4.50
7	5.800	1	10.0	2.0	.0	4.50
7	5.800	1	440.0	-.5	.0	4.50
7	5.800	1	26.0	-1.0	.0	4.50
7	5.800	1	4.2	-1.5	.0	4.50
7	5.800	2	380.0	.0	.5	4.45
7	5.800	2	44.0	.0	1.0	4.45
7	5.800	2	16.0	.0	1.5	4.45
7	5.800	2	9.5	.0	2.0	4.45
7	5.800	2	440.0	.0	-.5	4.45
7	5.800	2	48.0	.0	-1.0	4.45
7	5.800	2	17.0	.0	-1.5	4.45
7	5.800	2	8.0	.0	-2.0	4.45
7	5.800	2	5.2	.0	-2.5	4.45
7	5.800	2	680.0	.5	.0	4.45
7	5.800	2	40.0	1.0	.0	4.45
7	5.800	2	15.0	1.5	.0	4.45
7	5.800	2	8.5	2.0	.0	4.45
7	5.800	2	3.0	2.5	.0	4.45
7	5.800	2	5.0	3.0	.0	4.45
7	5.800	2	560.0	-.5	.0	4.45
7	5.800	2	40.0	-1.0	.0	4.45
7	5.800	2	14.0	-1.5	.0	4.45
7	5.800	2	6.0	-2.0	.0	4.45
7	5.800	2	3.0	-2.5	.0	4.45
7	5.800	2	2.0	-3.0	.0	4.45

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LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
8	5.800	1	320.0	.0	.5	3.65
8	5.800	1	56.0	.0	1.0	3.65
8	5.800	1	21.5	.0	1.5	3.65
8	5.800	1	8.0	.0	2.0	3.65
8	5.800	1	4.4	.0	2.5	3.65
8	5.800	1	4.0	.0	3.0	3.65
8	5.800	1	320.0	.0	-.5	3.65
8	5.800	1	48.0	.0	-1.0	3.65
8	5.800	1	13.5	.0	-1.5	3.65
8	5.800	1	8.0	.0	-2.0	3.65
8	5.800	1	4.6	.0	-2.5	3.65
8	5.800	1	3.4	.0	-3.0	3.65
8	5.800	1	380.0	.5	.0	3.65
8	5.800	1	38.0	1.0	.0	3.65
8	5.800	1	25.0	1.5	.0	3.65
8	5.800	1	440.0	-.5	.0	3.65
8	5.800	1	38.0	-1.0	.0	3.65
8	5.800	1	8.5	-1.5	.0	3.65
8	5.800	1	3.0	-2.0	.0	3.65

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
8	5.700	2	360.0	.0	.5	3.50
8	5.700	2	36.0	.0	1.0	3.50
8	5.700	2	12.0	.0	1.5	3.50
8	5.700	2	370.0	.0	-.5	3.50
8	5.700	2	56.0	.0	-1.0	3.50
8	5.700	2	18.5	.0	-1.5	3.50
8	5.700	2	320.0	.5	.0	3.50
8	5.700	2	36.0	1.0	.0	3.50
8	5.700	2	10.0	1.5	.0	3.50
8	5.700	2	3.4	2.0	.0	3.50
8	5.700	2	1.0	2.5	.0	3.50
8	5.700	2	.6	3.0	.0	3.50
8	5.700	2	480.0	-.5	.0	3.50
8	5.700	2	40.0	-1.0	.0	3.50
8	5.700	2	14.0	-1.5	.0	3.50
8	5.700	2	6.4	-2.0	.0	3.50
8	5.700	2	3.4	-2.5	.0	3.50
8	5.700	2	2.4	-3.0	.0	3.50

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
8	9.800	1	1800.0	.0	.5	9.75
8	9.800	1	150.0	.0	1.0	9.75
8	9.800	1	60.0	.0	1.5	9.75
8	9.800	1	27.0	.0	2.0	9.75
8	9.800	1	20.0	.0	2.5	9.75
8	9.800	1	11.5	.0	3.0	9.75
8	9.800	1	1500.0	.0	-.5	9.75
8	9.800	1	300.0	.0	-1.0	9.75
8	9.800	1	100.0	.0	-1.5	9.75
8	9.800	1	60.0	.0	-2.0	9.75
8	9.800	1	25.0	.0	-2.5	9.75
8	9.800	1	2300.0	.5	.0	9.75
8	9.800	1	150.0	1.0	.0	9.75
8	9.800	1	50.0	1.5	.0	9.75
8	9.800	1	3000.0	-.5	.0	9.75
8	9.800	1	190.0	-1.0	.0	9.75
8	9.800	1	48.0	-1.5	.0	9.75
8	9.800	1	22.0	-2.0	.0	9.75
8	9.800	2	1600.0	.0	.5	9.50
8	9.800	2	260.0	.0	1.0	9.50
8	9.800	2	32.0	.0	1.5	9.50
8	9.800	2	1800.0	.0	-.5	9.50
8	9.800	2	190.0	.0	-1.0	9.50
8	9.800	2	56.0	.0	-1.5	9.50
8	9.800	2	22.0	.0	-2.0	9.50
8	9.800	2	2500.0	.5	.0	9.50
8	9.800	2	180.0	1.0	.0	9.50
8	9.800	2	40.0	1.5	.0	9.50
8	9.800	2	19.0	2.0	.0	9.50
8	9.800	2	12.0	2.5	.0	9.50
8	9.800	2	10.0	3.0	.0	9.50
8	9.800	2	3000.0	-.5	.0	9.50
8	9.800	2	200.0	-1.0	.0	9.50
8	9.800	2	80.0	-1.5	.0	9.50
8	9.800	2	40.0	-2.0	.0	9.50
8	9.800	2	28.0	-2.5	.0	9.50
8	9.800	2	20.0	-3.0	.0	9.50

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
8	.175	2	66.0	.0	.5	22.50
8	.175	2	11.5	.0	1.0	22.50
8	.175	2	2.2	.0	1.5	22.50
8	.175	2	65.0	.0	-.5	22.50
8	.175	2	10.0	.0	-1.0	22.50
8	.175	2	3.0	.0	-1.5	22.50
8	.175	2	1.0	.0	-2.0	22.50
8	.175	2	65.0	.5	.0	22.50
8	.175	2	6.5	1.0	.0	22.50
8	.175	2	2.0	1.5	.0	22.50
8	.175	2	.8	2.0	.0	22.50
8	.175	2	.4	2.5	.0	22.50
8	.175	2	60.0	-.5	.0	22.50
8	.175	2	6.5	-1.0	.0	22.50
8	.175	2	1.6	-1.5	.0	22.50
8	.175	2	.8	-2.0	.0	22.50
8	.175	2	.6	-2.5	.0	22.50
8	.175	1	50.0	.0	.5	20.25
8	.175	1	8.0	.0	1.0	20.25
8	.175	1	2.8	.0	1.5	20.25
8	.175	1	1.2	.0	2.0	20.25
8	.175	1	.8	.0	2.5	20.25
8	.175	1	52.0	.0	-.5	20.25
8	.175	1	10.0	.0	-1.0	20.25
8	.175	1	2.8	.0	-1.5	20.25
8	.175	1	1.2	.0	-2.0	20.25
8	.175	1	.8	.0	-2.5	20.25
8	.175	1	60.0	.5	.0	20.25
8	.175	1	5.0	1.0	.0	20.25
8	.175	1	2.0	1.5	.0	20.25
8	.175	1	100.0	-.5	.0	20.25
8	.175	1	7.0	-1.0	.0	20.25
8	.175	1	1.8	-1.5	.0	20.25
8	.175	1	.8	-2.0	.0	20.25

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
8	.530	2	200.0	.0	.5	17.00
8	.530	2	28.0	.0	1.0	17.00
8	.530	2	6.0	.0	1.5	17.00
8	.530	2	125.0	.0	-.5	17.00
8	.530	2	20.0	.0	-1.0	17.00
8	.530	2	6.4	.0	-1.5	17.00
8	.530	2	2.8	.0	-2.0	17.00
8	.530	2	140.0	.5	.0	17.00
8	.530	2	12.0	1.0	.0	17.00
8	.530	2	3.6	1.5	.0	17.00
8	.530	2	1.6	2.0	.0	17.00
8	.530	2	.8	2.5	.0	17.00
8	.530	2	140.0	-.5	.0	17.00
8	.530	2	12.5	-1.0	.0	17.00
8	.530	2	3.6	-1.5	.0	17.00
8	.530	2	1.4	-2.0	.0	17.00
8	.530	2	.8	-2.5	.0	17.00
8	.530	1	140.0	.0	.5	15.40
8	.530	1	23.0	.0	1.0	15.40
8	.530	1	7.6	.0	1.5	15.40
8	.530	1	3.0	.0	2.0	15.40
8	.530	1	1.6	.0	2.5	15.40
8	.530	1	1.0	.0	3.0	15.40
8	.530	1	125.0	.0	-.5	15.40
8	.530	1	21.0	.0	-1.0	15.40
8	.530	1	6.0	.0	-1.5	15.40
8	.530	1	2.8	.0	-2.0	15.40
8	.530	1	1.6	.0	-2.5	15.40
8	.530	1	.8	.0	-3.0	15.40
8	.530	1	160.0	.5	.0	15.40
8	.530	1	14.0	1.0	.0	15.40
8	.530	1	5.4	1.5	.0	15.40
8	.530	1	150.0	-.5	.0	15.40
8	.530	1	15.0	-1.0	.0	15.40
8	.530	1	4.0	-1.5	.0	15.40
8	.530	1	1.8	-2.0	.0	15.40

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
8	1.000	1	340.0	.0	.5	20.60
8	1.000	1	50.0	.0	1.0	20.60
8	1.000	1	16.0	.0	1.5	20.60
8	1.000	1	6.4	.0	2.0	20.60
8	1.000	1	3.6	.0	2.5	20.60
8	1.000	1	2.0	.0	3.0	20.60
8	1.000	1	280.0	.0	-.5	20.60
8	1.000	1	48.0	.0	-1.0	20.60
8	1.000	1	13.5	.0	-1.5	20.60
8	1.000	1	7.0	.0	-2.0	20.60
8	1.000	1	3.2	.0	-2.5	20.60
8	1.000	1	1.6	.0	-3.0	20.60
8	1.000	1	440.0	.5	.0	20.60
8	1.000	1	40.0	1.0	.0	20.60
8	1.000	1	17.0	1.5	.0	20.60
8	1.000	1	540.0	-.5	.0	20.60
8	1.000	1	48.0	-1.0	.0	20.60
8	1.000	1	12.5	-1.5	.0	20.60
8	1.000	1	4.4	-2.0	.0	20.60
8	1.000	2	340.0	.0	.5	19.90
8	1.000	2	26.0	.0	1.0	19.90
8	1.000	2	16.0	.0	1.5	19.90
8	1.000	2	7.2	.0	2.0	19.90
8	1.000	2	360.0	.0	-.5	19.90
8	1.000	2	24.0	.0	-1.0	19.90
8	1.000	2	17.0	.0	-1.5	19.90
8	1.000	2	500.0	.5	.0	19.90
8	1.000	2	28.0	1.0	.0	19.90
8	1.000	2	7.5	1.5	.0	19.90
8	1.000	2	2.6	2.0	.0	19.90
8	1.000	2	1.2	2.5	.0	19.90
8	1.000	2	400.0	-.5	.0	19.90
8	1.000	2	34.0	-1.0	.0	19.90
8	1.000	2	7.5	-1.5	.0	19.90
8	1.000	2	3.6	-2.0	.0	19.90
8	1.000	2	2.0	-2.5	.0	19.90
8	1.000	2	1.2	-3.0	.0	19.90

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
9	1.000	1	400.0	.0	.5	21.00
9	1.000	1	56.0	.0	1.0	21.00
9	1.000	1	17.0	.0	1.5	21.00
9	1.000	1	7.0	.0	2.0	21.00
9	1.000	1	4.0	.0	2.5	21.00
9	1.000	1	2.2	.0	3.0	21.00
9	1.000	1	320.0	.0	-.5	21.00
9	1.000	1	50.0	.0	-1.0	21.00
9	1.000	1	15.0	.0	-1.5	21.00
9	1.000	1	6.2	.0	-2.0	21.00
9	1.000	1	3.4	.0	-2.5	21.00
9	1.000	1	1.8	.0	-3.0	21.00
9	1.000	1	400.0	.5	.0	21.00
9	1.000	1	30.0	1.0	.0	21.00
9	1.000	1	10.0	1.5	.0	21.00
9	1.000	1	300.0	-.5	.0	21.00
9	1.000	1	30.0	-1.0	.0	21.00
9	1.000	1	7.0	-1.5	.0	21.00
9	1.000	2	300.0	.0	.5	20.60
9	1.000	2	52.0	.0	1.0	20.60
9	1.000	2	17.0	.0	1.5	20.60
9	1.000	2	430.0	.0	-.5	20.60
9	1.000	2	56.0	.0	-1.0	20.60
9	1.000	2	19.0	.0	-1.5	20.60
9	1.000	2	360.0	.5	.0	20.60
9	1.000	2	34.0	1.0	.0	20.60
9	1.000	2	10.0	1.5	.0	20.60
9	1.000	2	4.0	2.0	.0	20.60
9	1.000	2	2.0	2.5	.0	20.60
9	1.000	2	1.4	3.0	.0	20.60
9	1.000	2	340.0	-.5	.0	20.60
9	1.000	2	26.0	-1.0	.0	20.60
9	1.000	2	7.0	-1.5	.0	20.60
9	1.000	2	3.0	-2.0	.0	20.60
9	1.000	2	1.6	-2.5	.0	20.60
9	1.000	2	.8	-3.0	.0	20.60

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
9	.530	2	200.0	.0	.5	15.80
9	.530	2	25.0	.0	1.0	15.80
9	.530	2	8.0	.0	1.5	15.80
9	.530	2	135.0	.0	-.5	15.80
9	.530	2	20.0	.0	-1.0	15.80
9	.530	2	6.4	.0	-1.5	15.80
9	.530	2	115.0	.5	.0	15.80
9	.530	2	10.5	1.0	.0	15.80
9	.530	2	3.6	1.5	.0	15.80
9	.530	2	1.4	2.0	.0	15.80
9	.530	2	.8	2.5	.0	15.80
9	.530	2	106.0	-.5	.0	15.80
9	.530	2	12.0	-1.0	.0	15.80
9	.530	2	3.0	-1.5	.0	15.80
9	.530	2	1.4	-2.0	.0	15.80
9	.530	2	.8	-2.5	.0	15.80
9	.530	1	150.0	.0	.5	16.90
9	.530	1	23.0	.0	1.0	16.90
9	.530	1	6.8	.0	1.5	16.90
9	.530	1	2.8	.0	2.0	16.90
9	.530	1	1.6	.0	2.5	16.90
9	.530	1	.8	.0	3.0	16.90
9	.530	1	120.0	.0	-.5	16.90
9	.530	1	18.0	.0	-1.0	16.90
9	.530	1	6.0	.0	-1.5	16.90
9	.530	1	2.8	.0	-2.0	16.90
9	.530	1	1.4	.0	-2.5	16.90
9	.530	1	.8	.0	-3.0	16.90
9	.530	1	180.0	.5	.0	16.90
9	.530	1	14.0	1.0	.0	16.90
9	.530	1	4.8	1.5	.0	16.90
9	.530	1	240.0	-.5	.0	16.90
9	.530	1	17.0	-1.0	.0	16.90
9	.530	1	3.5	-1.5	.0	16.90

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
9	.175	2	100.0	.0	.5	34.50
9	.175	2	14.0	.0	1.0	34.50
9	.175	2	4.6	.0	1.5	34.50
9	.175	2	75.0	.0	-.5	34.50
9	.175	2	14.5	.0	-1.0	34.50
9	.175	2	3.8	.0	-1.5	34.50
9	.175	2	115.0	.5	.0	34.50
9	.175	2	10.5	1.0	.0	34.50
9	.175	2	2.8	1.5	.0	34.50
9	.175	2	1.0	2.0	.0	34.50
9	.175	2	.6	2.5	.0	34.50
9	.175	2	70.0	-.5	.0	34.50
9	.175	2	9.0	-1.0	.0	34.50
9	.175	2	2.8	-1.5	.0	34.50
9	.175	2	1.0	-2.0	.0	34.50
9	.175	2	.6	-2.5	.0	34.50
9	.175	1	75.0	.0	.5	33.00
9	.175	1	13.0	.0	1.0	33.00
9	.175	1	4.0	.0	1.5	33.00
9	.175	1	1.6	.0	2.0	33.00
9	.175	1	1.0	.0	2.5	33.00
9	.175	1	.6	.0	3.0	33.00
9	.175	1	106.0	.0	-.5	33.00
9	.175	1	12.0	.0	-1.0	33.00
9	.175	1	4.8	.0	-1.5	33.00
9	.175	1	2.0	.0	-2.0	33.00
9	.175	1	1.2	.0	-2.5	33.00
9	.175	1	.8	.0	-3.0	33.00
9	.175	1	135.0	.5	.0	33.00
9	.175	1	9.5	1.0	.0	33.00
9	.175	1	3.0	1.5	.0	33.00
9	.175	1	200.0	-.5	.0	33.00
9	.175	1	12.0	-1.0	.0	33.00
9	.175	1	3.0	-1.5	.0	33.00

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
9	5.700	1	900.0	.0	.5	9.90
9	5.700	1	135.0	.0	1.0	9.90
9	5.700	1	49.0	.0	1.5	9.90
9	5.700	1	14.0	.0	2.0	9.90
9	5.700	1	5.0	.0	2.5	9.90
9	5.700	1	2.6	.0	3.0	9.90
9	5.700	1	950.0	.0	-.5	9.90
9	5.700	1	130.0	.0	-1.0	9.90
9	5.700	1	33.0	.0	-1.5	9.90
9	5.700	1	16.0	.0	-2.0	9.90
9	5.700	1	9.0	.0	-2.5	9.90
9	5.700	1	6.0	.0	-3.0	9.90
9	5.700	1	1600.0	.5	.0	9.90
9	5.700	1	70.0	1.0	.0	9.90
9	5.700	1	7.5	1.5	.0	9.90
9	5.700	1	1100.0	-.5	.0	9.90
9	5.700	1	95.0	-1.0	.0	9.90
9	5.700	1	36.0	-1.5	.0	9.90
9	5.700	2	1000.0	.0	.5	9.80
9	5.700	2	130.0	.0	1.0	9.80
9	5.700	2	46.0	.0	1.5	9.80
9	5.700	2	1000.0	.0	-.5	9.80
9	5.700	2	170.0	.0	-1.0	9.80
9	5.700	2	36.0	.0	-1.5	9.80
9	5.700	2	1000.0	.5	.0	9.80
9	5.700	2	85.0	1.0	.0	9.80
9	5.700	2	34.0	1.5	.0	9.80
9	5.700	2	19.0	2.0	.0	9.80
9	5.700	2	12.5	2.5	.0	9.80
9	5.700	2	10.0	3.0	.0	9.80
9	5.700	2	1300.0	-.5	.0	9.80
9	5.700	2	100.0	-1.0	.0	9.80
9	5.700	2	25.0	-1.5	.0	9.80
9	5.700	2	7.8	-2.0	.0	9.80

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	X	Z	CURRENT AMPS
9	10.000	2	1750.0	.0	.5	9.80
9	10.000	2	200.0	.0	1.0	9.80
9	10.000	2	70.0	.0	1.5	9.80
9	10.000	2	1800.0	.0	-.5	9.80
9	10.000	2	280.0	.0	-1.0	9.80
9	10.000	2	86.0	.0	-1.5	9.80
9	10.000	2	1150.0	.5	.0	9.80
9	10.000	2	145.0	1.0	.0	9.80
9	10.000	2	58.0	1.5	.0	9.80
9	10.000	2	40.0	2.0	.0	9.80
9	10.000	2	30.0	2.5	.0	9.80
9	10.000	2	26.0	3.0	.0	9.80
9	10.000	2	1150.0	-.5	.0	9.80
9	10.000	2	175.0	-1.0	.0	9.80
9	10.000	2	39.0	-1.5	.0	9.80
9	10.000	2	21.0	-2.0	.0	9.80
9	10.000	2	13.0	-2.5	.0	9.80
9	10.000	2	12.0	-3.0	.0	9.80
9	10.000	1	1600.0	.0	.5	9.40
9	10.000	1	200.0	.0	1.0	9.40
9	10.000	1	76.0	.0	1.5	9.40
9	10.000	1	40.0	.0	2.0	9.40
9	10.000	1	28.0	.0	2.5	9.40
9	10.000	1	24.0	.0	3.0	9.40
9	10.000	1	1400.0	.0	-.5	9.40
9	10.000	1	270.0	.0	-1.0	9.40
9	10.000	1	105.0	.0	-1.5	9.40
9	10.000	1	58.0	.0	-2.0	9.40
9	10.000	1	18.0	.0	-2.5	9.40
9	10.000	1	17.0	.0	-3.0	9.40
9	10.000	1	950.0	.5	.0	9.40
9	10.000	1	125.0	1.0	.0	9.40
9	10.000	1	56.0	1.5	.0	9.40
9	10.000	1	1250.0	-.5	.0	9.40
9	10.000	1	140.0	-1.0	.0	9.40
9	10.000	1	52.0	-1.5	.0	9.40

APPENDIX C

RAW DATA FOR THE TRANSMISSION LINE MEASUREMENTS

LISTING FOR ALL TRANSMISSION LINE RAW DATA PAGE 1

LOCATION	FREQUENCY (FMHZ)	PICKUP(MV)	Y	Z	CURRENT AMPS
1	.170	1.2	.5	.5	.60
1	.170	1.2	.5	1.0	.60
1	.500	4.0	.5	.5	.48
1	.500	4.0	.5	1.0	.48
1	.500	1.6	1.0	.5	.48
1	.500	2.0	1.0	1.0	.48
1	.500	1.0	1.5	.5	.48
1	.500	1.0	1.5	1.0	.48
1	1.000	20.0	.5	.5	1.00
1	1.000	18.0	.5	1.0	1.00
1	1.000	9.0	1.0	.5	1.00
1	1.000	8.5	1.0	1.0	1.00
1	1.000	4.4	1.5	.5	1.00
1	1.000	4.4	1.5	1.0	1.00
2	1.000	10.0	.5	.5	1.10
2	1.000	7.5	1.0	.5	1.10
2	1.000	3.0	1.5	.5	1.10
2	1.000	20.0	.5	1.0	1.10
2	1.000	7.5	1.0	1.0	1.10
2	1.000	4.0	1.5	1.0	1.10
2	.500	10.0	.5	.5	1.10
2	.500	4.4	1.0	.5	1.10
2	.500	2.4	1.5	.5	1.10
2	.500	12.5	.5	1.0	1.10
2	.500	5.0	1.0	1.0	1.10
2	.500	2.4	1.5	1.0	1.10
2	.174	1.6	.5	.5	.56
2	.174	.6	1.0	.5	.56
2	.174	2.0	.5	1.0	.56
2	.174	.6	1.0	1.0	.56

LOCATION	FREQUENCY (FMHZ)	PICKUP(MV)	Y	Z	CURRENT AMPS
3	.174	2.0	.5	.5	.60
3	.174	.6	1.0	.5	.60
3	.174	.4	1.5	.5	.60
3	.174	2.0	.5	1.0	.60
3	.174	.8	1.0	1.0	.60
3	.174	.4	1.5	1.0	.60
3	.500	10.0	.5	.5	1.10
3	.500	4.8	1.0	.5	1.10
3	.500	2.8	1.5	.5	1.10
3	.500	13.0	.5	1.0	1.10
3	.500	4.8	1.0	1.0	1.10
3	.500	2.8	1.5	1.0	1.10
3	1.000	15.0	.5	.5	.95
3	1.000	5.4	1.0	.5	.95
3	1.000	4.0	1.5	.5	.95
3	1.000	18.0	.5	1.0	.95
3	1.000	7.0	1.0	1.0	.95
3	1.000	4.6	1.5	1.0	.95
4	1.000	7.0	.5	.5	.50
4	1.000	2.6	1.0	.5	.50
4	1.000	1.4	1.5	.5	.50
4	1.000	8.0	.5	1.0	.50
4	1.000	3.2	1.0	1.0	.50
4	1.000	1.4	1.5	1.0	.50
4	.500	3.4	.5	.5	.65
4	.500	1.8	1.0	.5	.65
4	.500	1.0	1.5	.5	.65
4	.500	5.0	.5	1.0	.65
4	.500	2.0	1.0	1.0	.65
4	.500	1.0	1.5	1.0	.65
4	.174	1.4	.5	.5	.50
4	.174	.8	1.0	.5	.50
4	.174	1.8	.5	1.0	.50
4	.174	.8	1.0	1.0	.50

LISTING FOR ALL TRANSMISSION LINE RAW DATA PAGE 3

LOCATION	FREQUENCY (FMHZ)	PICKUP(MV)	Y	Z	CURRENT AMPS
5	.174	1.4	.5	.5	.50
5	.174	.4	1.0	.5	.50
5	.174	1.8	.5	1.0	.50
5	.174	.6	1.0	1.0	.50
5	.520	6.6	.5	.5	.85
5	.520	2.6	1.0	.5	.85
5	.520	1.2	1.5	.5	.85
5	.520	7.0	.5	1.0	.85
5	.520	2.8	1.0	1.0	.85
5	.520	1.4	1.5	1.0	.85
5	1.000	8.0	.5	.5	.68
5	1.000	5.0	1.0	.5	.68
5	1.000	1.6	1.5	.5	.68
5	1.000	13.0	.5	1.0	.68
5	1.000	5.0	1.0	1.0	.68
5	1.000	2.4	1.5	1.0	.68
6	1.000	8.0	.5	.5	.64
6	1.000	2.8	1.0	.5	.64
6	1.000	1.6	1.5	.5	.64
6	1.000	10.0	.5	1.0	.64
6	1.000	3.2	1.0	1.0	.64
6	1.000	1.6	1.5	1.0	.64
6	.500	6.0	.5	.5	.80
6	.500	2.0	1.0	.5	.80
6	.500	1.2	1.5	.5	.80
6	.500	6.4	.5	1.0	.80
6	.500	2.0	1.0	1.0	.80
6	.500	1.2	1.5	1.0	.80
6	.174	1.4	.5	.5	.54
6	.174	.6	1.0	.5	.54
6	.174	1.6	.5	1.0	.54
6	.174	.6	1.0	1.0	.54

LISTING FOR ALL TRANSMISSION LINE RAW DATA PAGE 4

LOCATION	FREQUENCY (FMHZ)	PICKUP(MV)	Y	Z	CURRENT AMPS
7	.175	1.0	.5	.5	.15
7	.175	1.0	.5	1.0	.15
7	.500	1.6	.5	.5	.12
7	.500	.6	1.0	.5	.12
7	.500	2.0	.5	1.0	.12
7	.500	.4	1.0	1.0	.12
7	1.000	20.0	.5	.5	.90
7	1.000	30.0	.5	1.0	.90
8	.500	6.4	.5	.5	.35
8	.500	1.6	1.0	.5	.35
8	.500	4.6	.5	1.0	.35
8	.500	1.4	1.0	1.0	.35
8	.500	.8	1.5	.5	.35
8	.500	1.0	1.5	1.0	.35
8	.175	3.6	.5	.5	.50
8	.175	1.0	1.0	.5	.50
8	.175	1.8	.5	1.0	.50
8	.175	1.0	1.0	1.0	.50

LISTING FOR ALL TRANSMISSION LINE RAW DATA PAGE 5

LOCATION	FREQUENCY (FMHZ)	PICKUP(MV)	Y	Z	CURRENT AMPS
9	1.000	20.0	.5	.5	.96
9	1.000	10.0	1.0	.5	.96
9	1.000	20.0	.5	1.0	.96
9	1.000	10.0	1.0	1.0	.96
9	.500	14.0	.5	.5	1.16
9	.500	4.0	1.0	.5	1.16
9	.500	2.5	1.5	.5	1.16
9	.500	12.5	.5	1.0	1.16
9	.500	5.0	1.0	1.0	1.16
9	.500	2.0	1.5	1.0	1.16
9	.175	2.4	.5	.5	.58
9	.175	.6	1.0	.5	.58
9	.175	2.0	.5	1.0	.58
9	.175	.8	1.0	1.0	.58

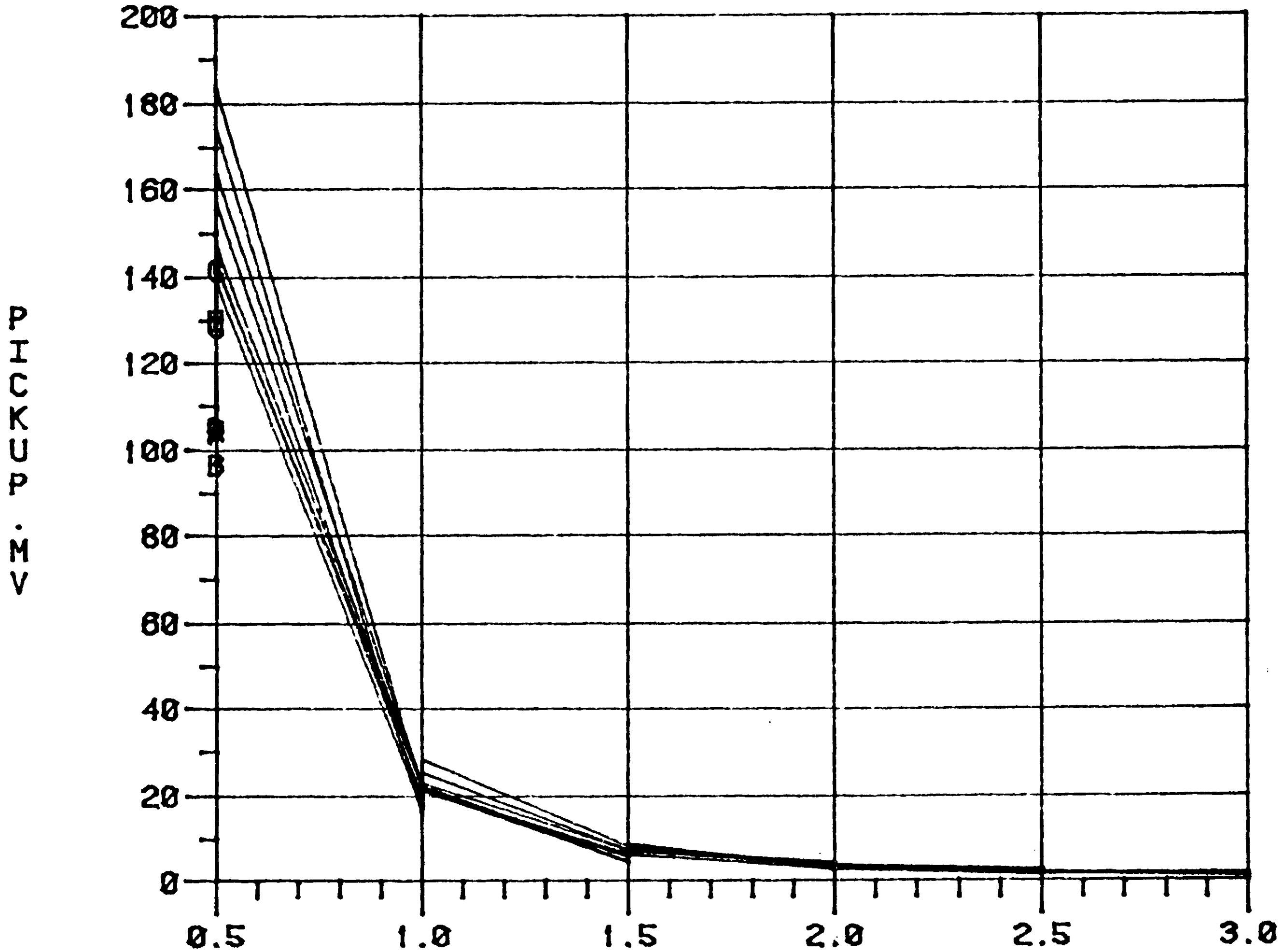
APPENDIX D

PLOTS OF THE NORMALIZED DATA FOR THE LOOP MEASUREMENTS

L

MINE DATA FROM PROJECT C5490---FREQUENCY= .173 MHZ

FOR X=0.0 AXIS OF COIL ALONG THE DRIFT

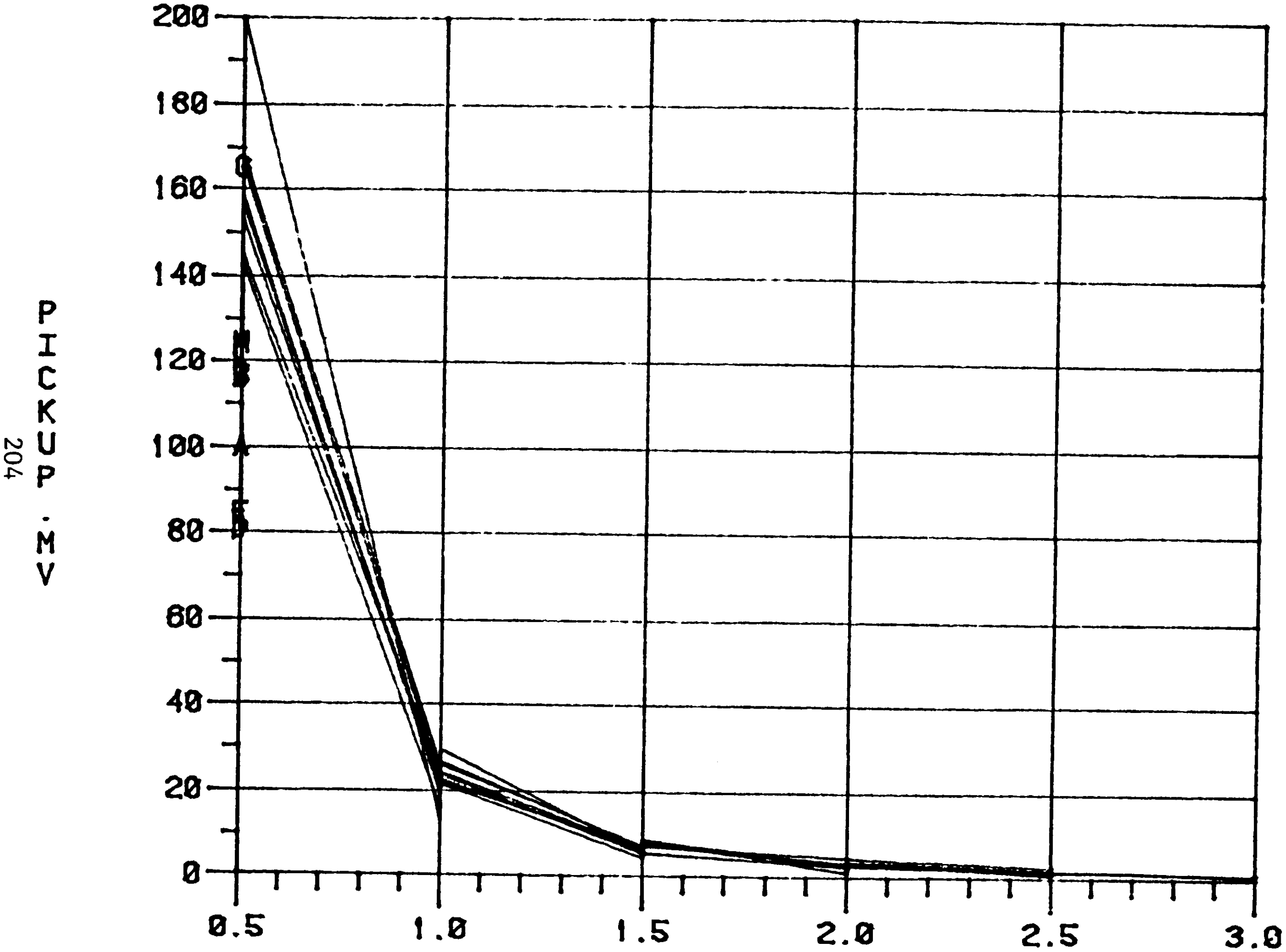


DISTANCE (Z) FROM CENTER OF THE COIL IN METERS
FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

L

MINE DATA FROM PROJECT C5490--FREQUENCY=   .173 MHZ

FOR X=0.0   AXIS OF COIL ACROSS THE DRIFT

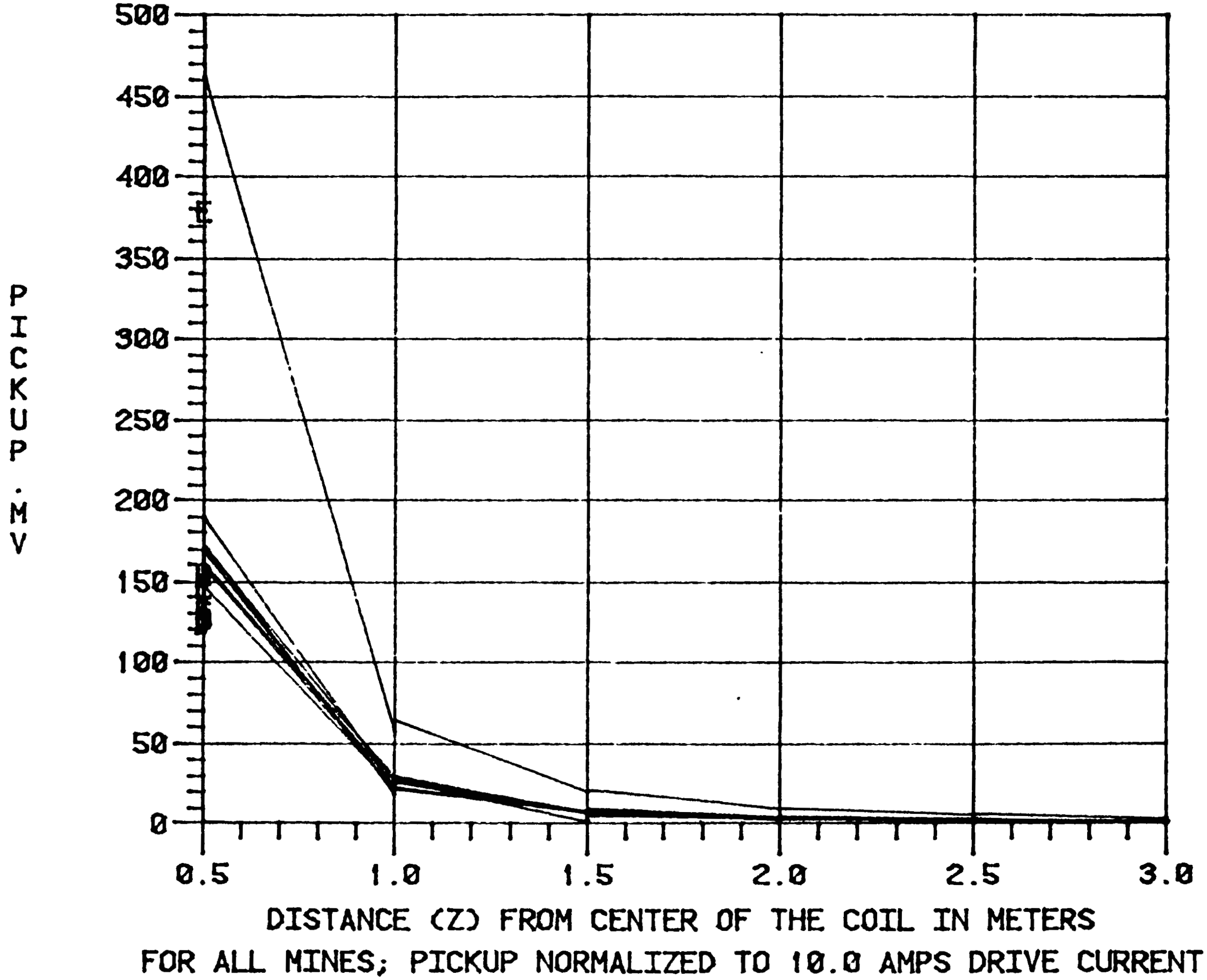


DISTANCE (Z) FROM CENTER OF THE COIL IN METERS
FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

L

MINE DATA FROM PROJECT C5490--FREQUENCY= .530 MHZ

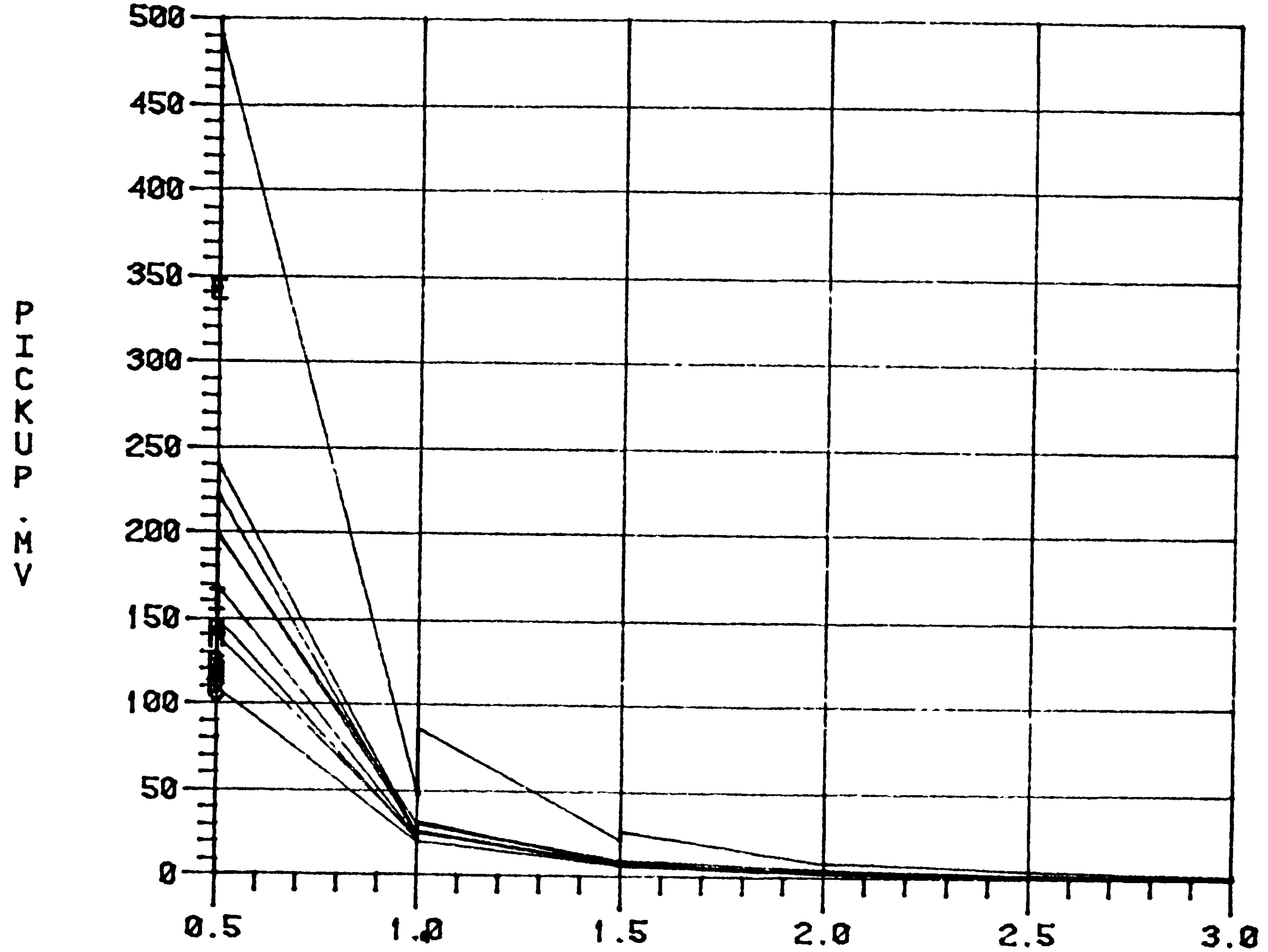
FOR X=0.0 AXIS OF COIL ALONG THE DRIFT



L

MINE DATA FROM PROJECT C5490—FREQUENCY= .530 MHZ

FOR X=0.0 · AXIS OF COIL ACROSS THE DRIFT



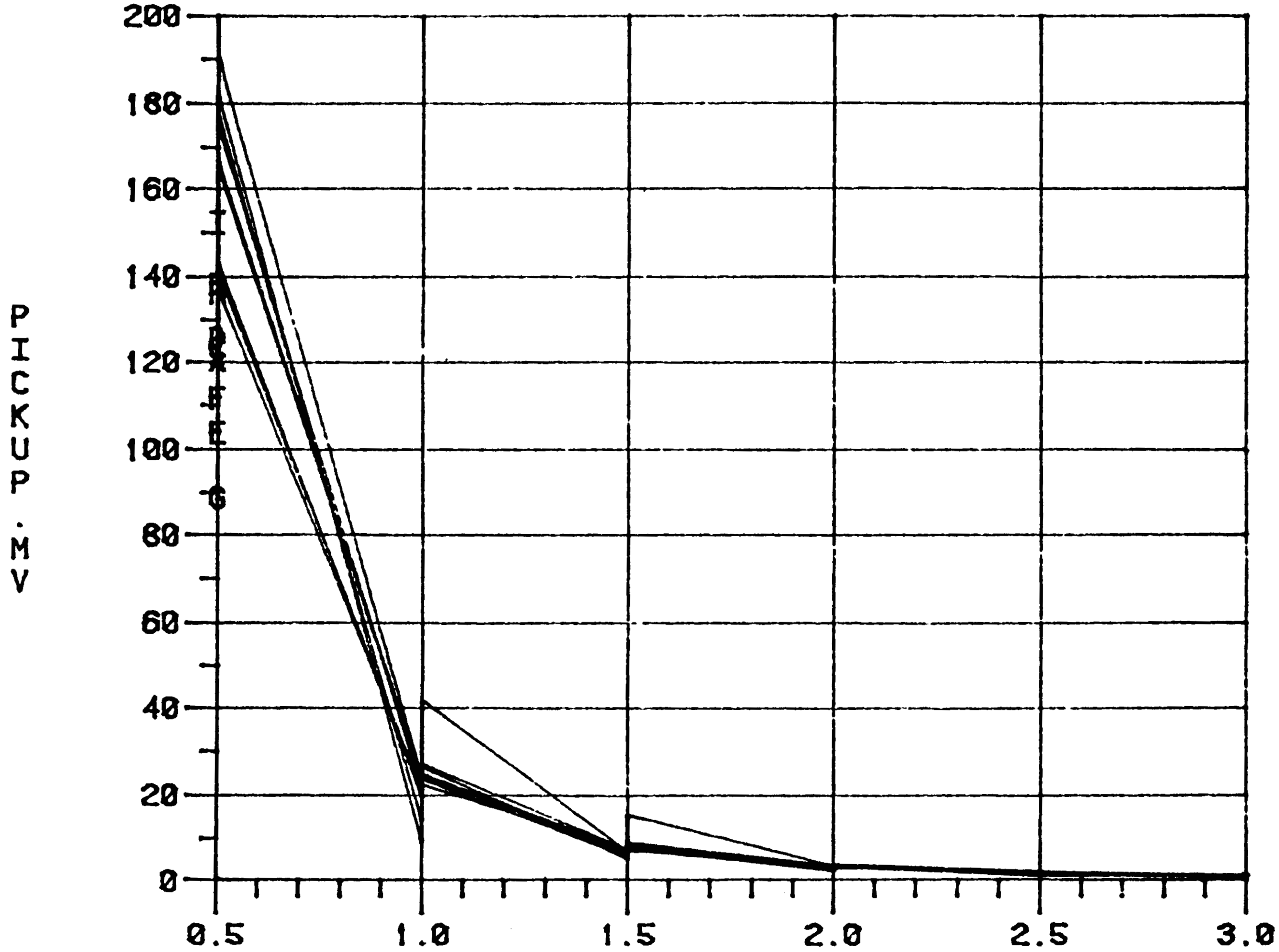
DISTANCE (Z) FROM CENTER OF THE COIL IN METERS

FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

L

MINE DATA FROM PROJECT C5490---FREQUENCY= 1.000 MHZ

FOR X=0.0 AXIS OF COIL ALONG THE DRIFT



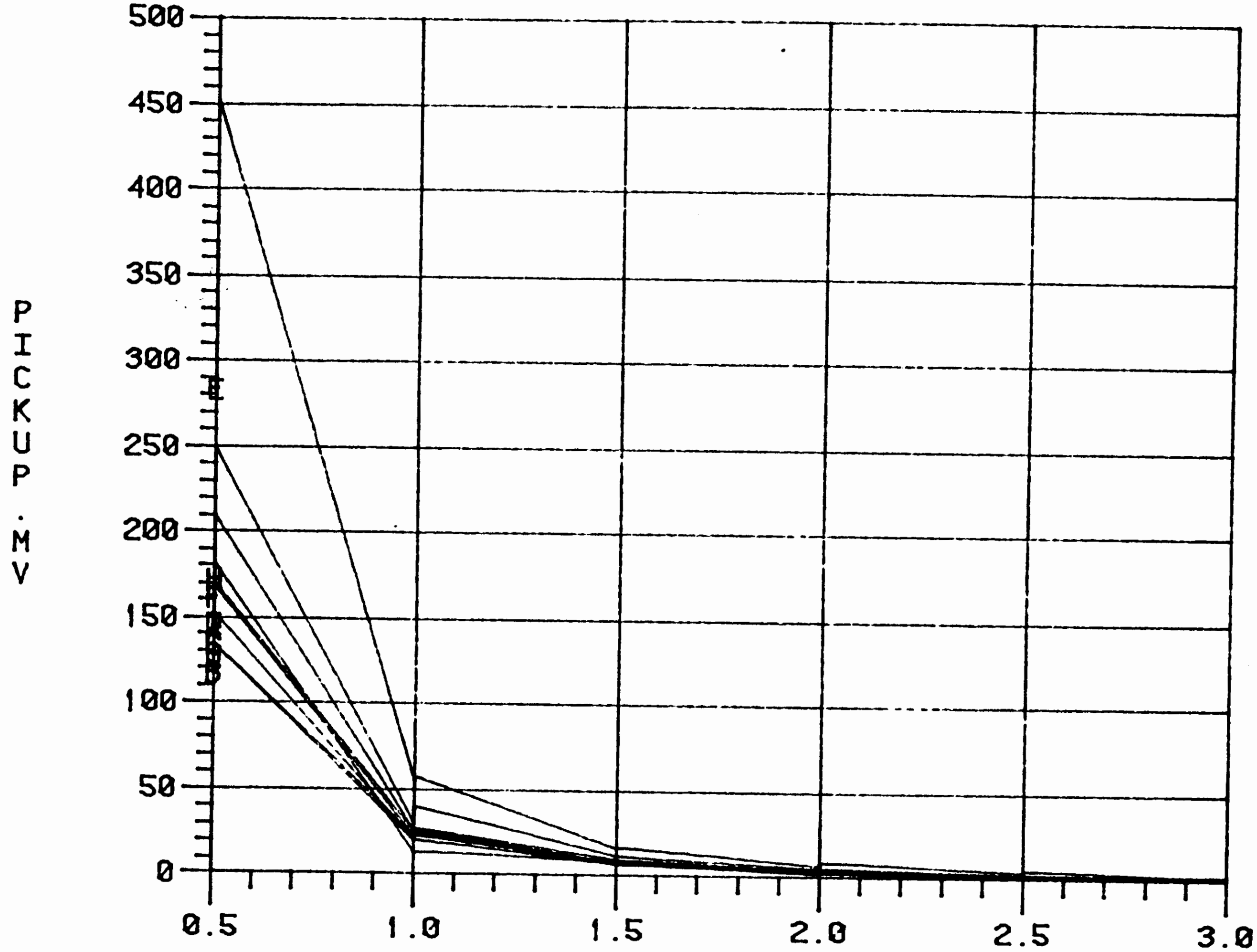
DISTANCE (Z) FROM CENTER OF THE COIL IN METERS

FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

L

MINE DATA FROM PROJECT C5490--FREQUENCY= 1.000 MHZ

FOR X=0.0 AXIS OF COIL ACROSS THE DRIFT



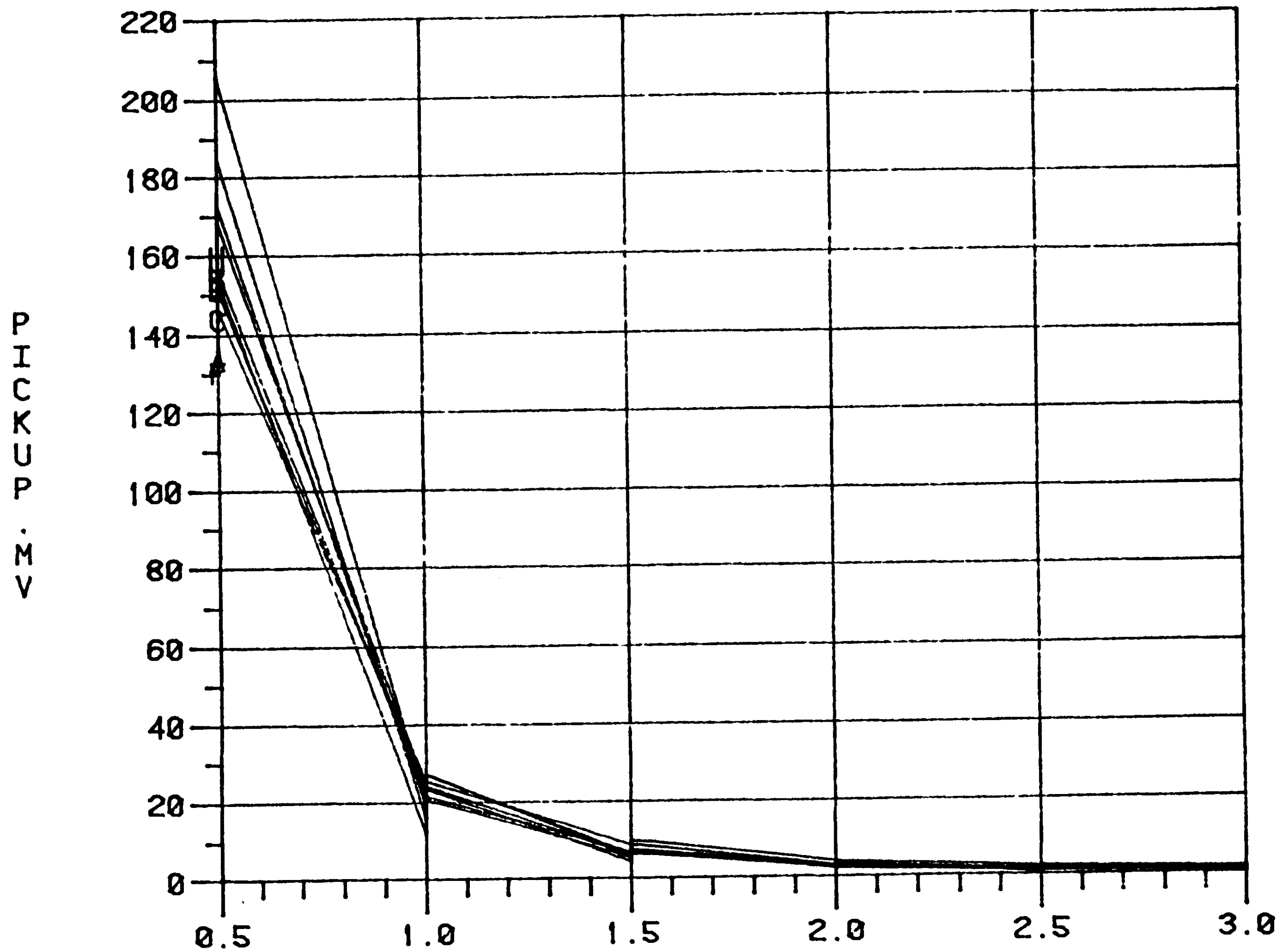
DISTANCE (Z) FROM CENTER OF THE COIL IN METERS

FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

L

MINE DATA FROM PROJECT C5490--FREQUENCY= 5.000 MHZ

FOR X=0.0 AXIS OF COIL ALONG THE DRIFT



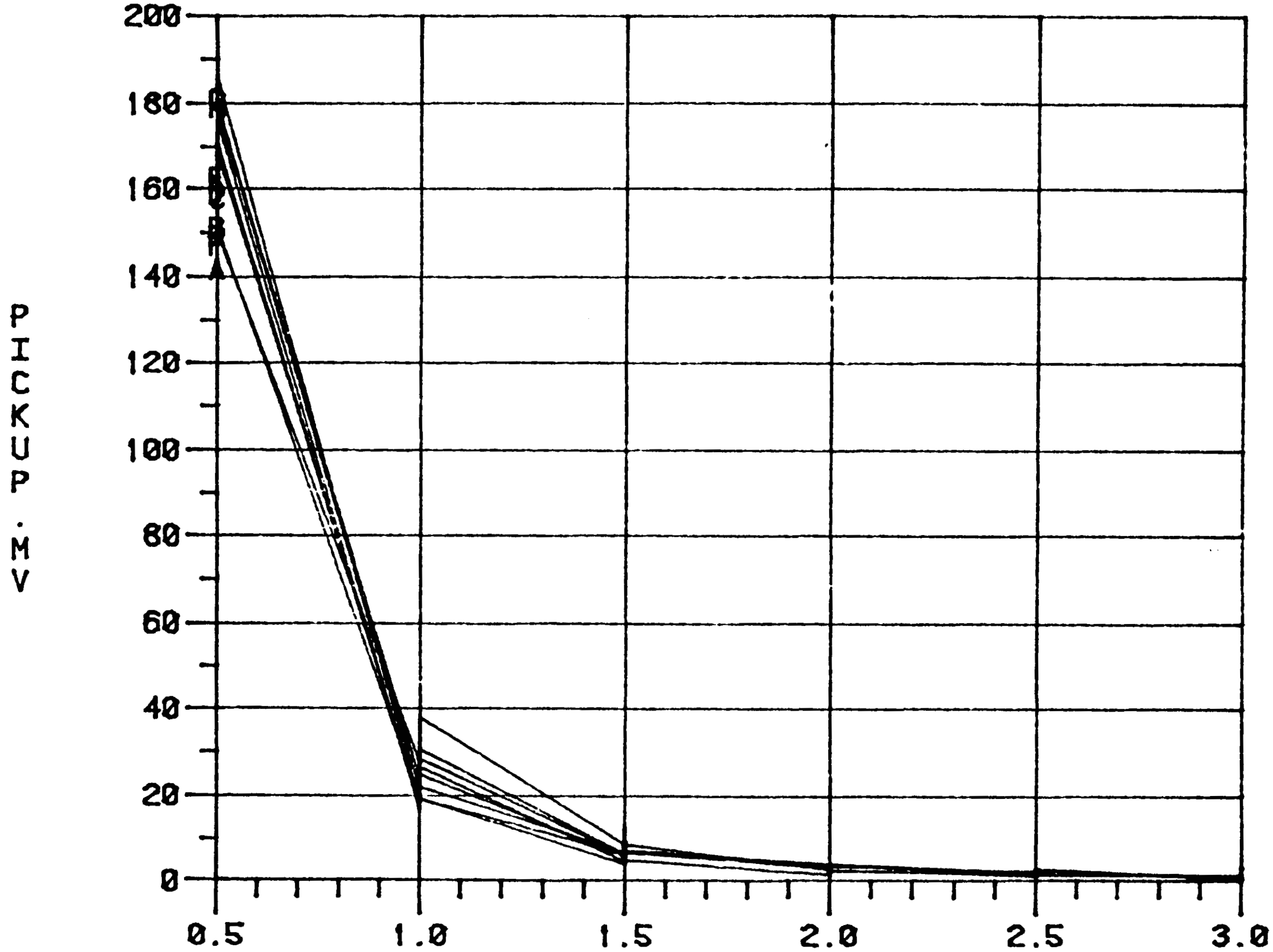
DISTANCE (Z) FROM CENTER OF THE COIL IN METERS

FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

L

MINE DATA FROM PROJECT C5490--FREQUENCY= 5.000 MHZ

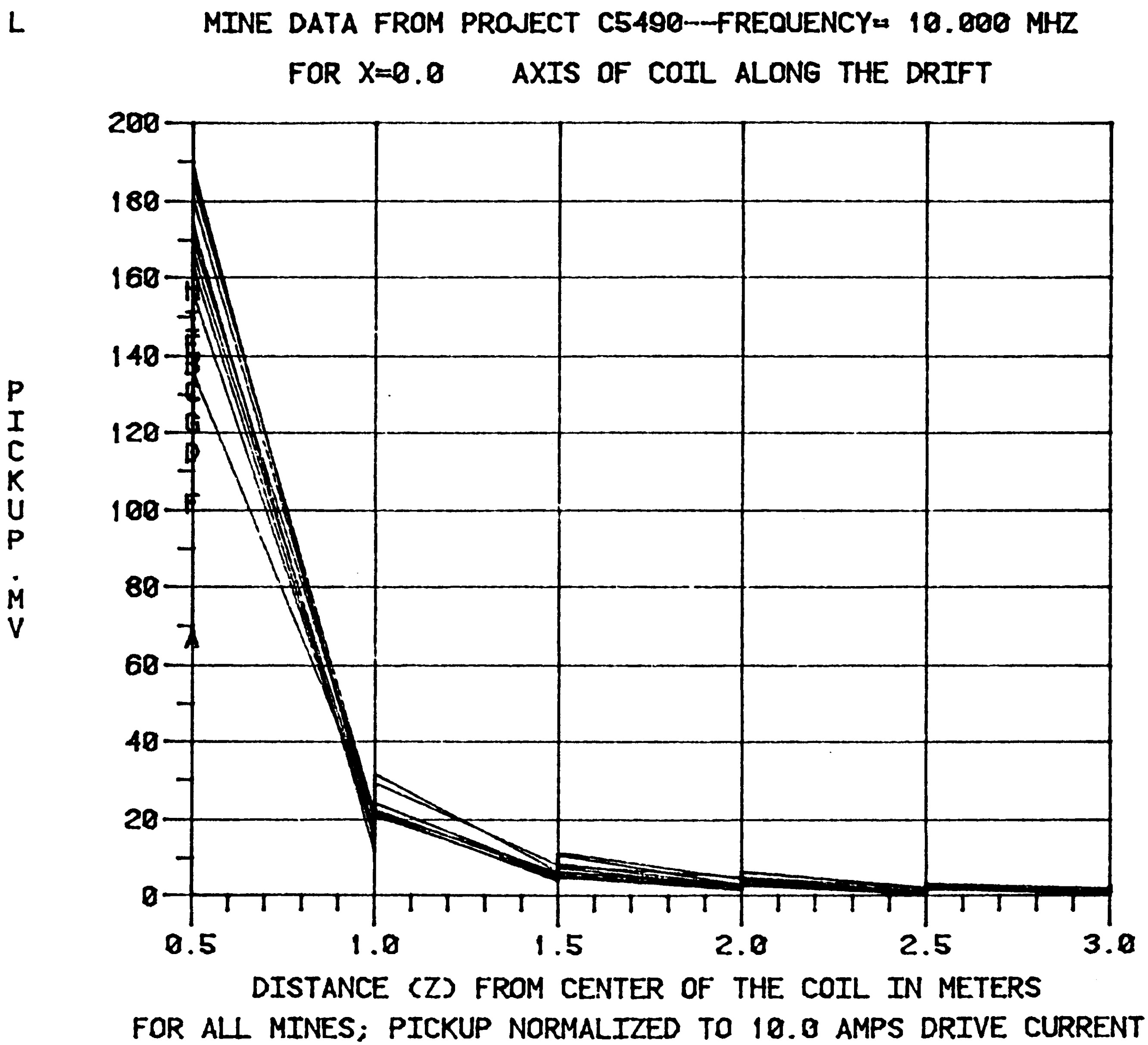
FOR X=0.0 AXIS OF COIL ACROSS THE DRIFT



DISTANCE (Z) FROM CENTER OF THE COIL IN METERS

FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

L

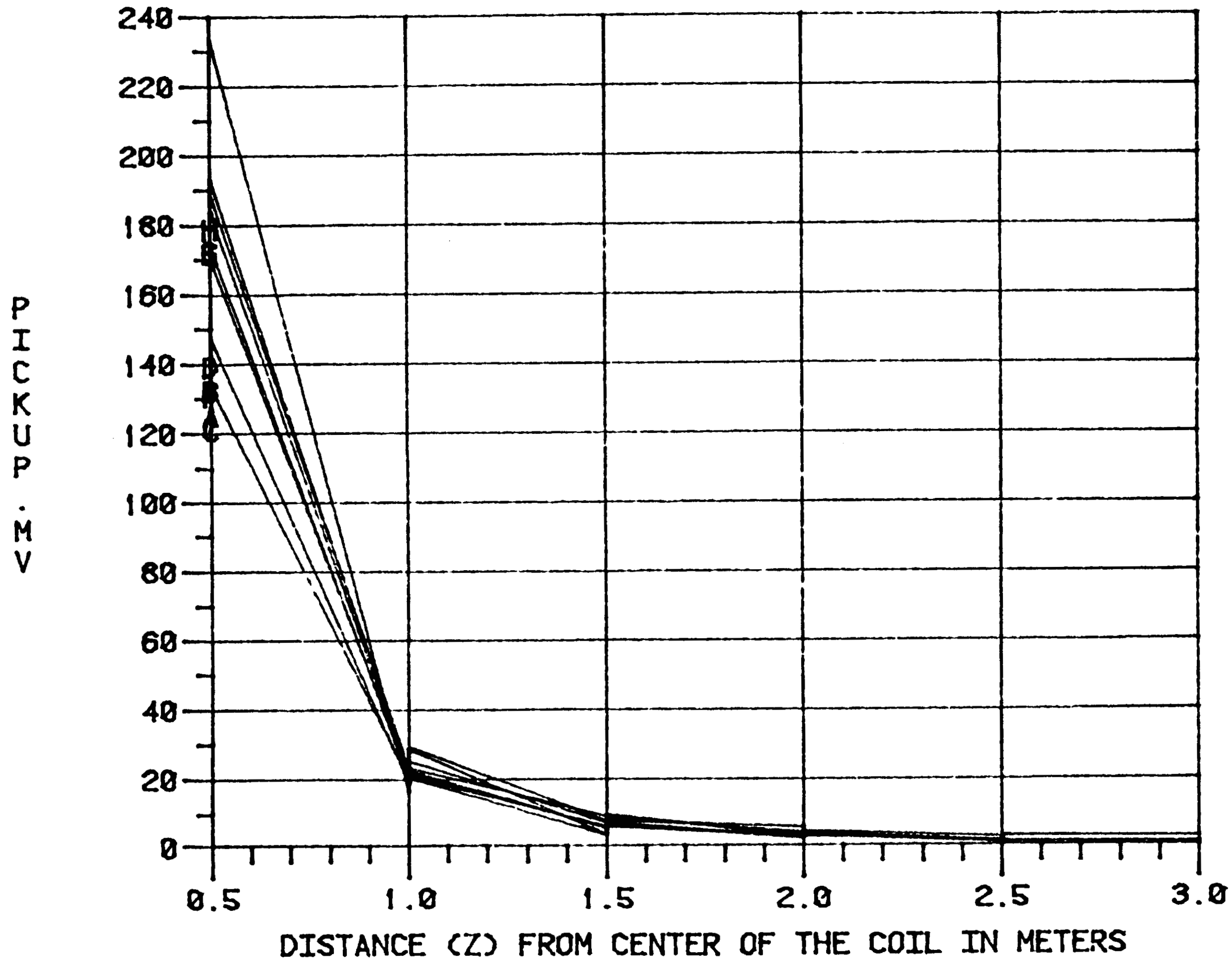


MINE DATA FROM PROJECT C5490--FREQUENCY= 10.000 MHZ
FOR X=0.0   AXIS OF COIL ALONG THE DRIFT
PICKUP .MV
200
180
160
140
120
100
80
60
40
20
0
H
E
B
C
G
D
F
A
0.5
1.0
1.5
2.0
2.5
3.0
DISTANCE (Z) FROM CENTER OF THE COIL IN METERS
FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

L

MINE DATA FROM PROJECT C5490---FREQUENCY= 10.000 MHZ

FOR X=0.0 AXIS OF COIL ACROSS THE DRIFT

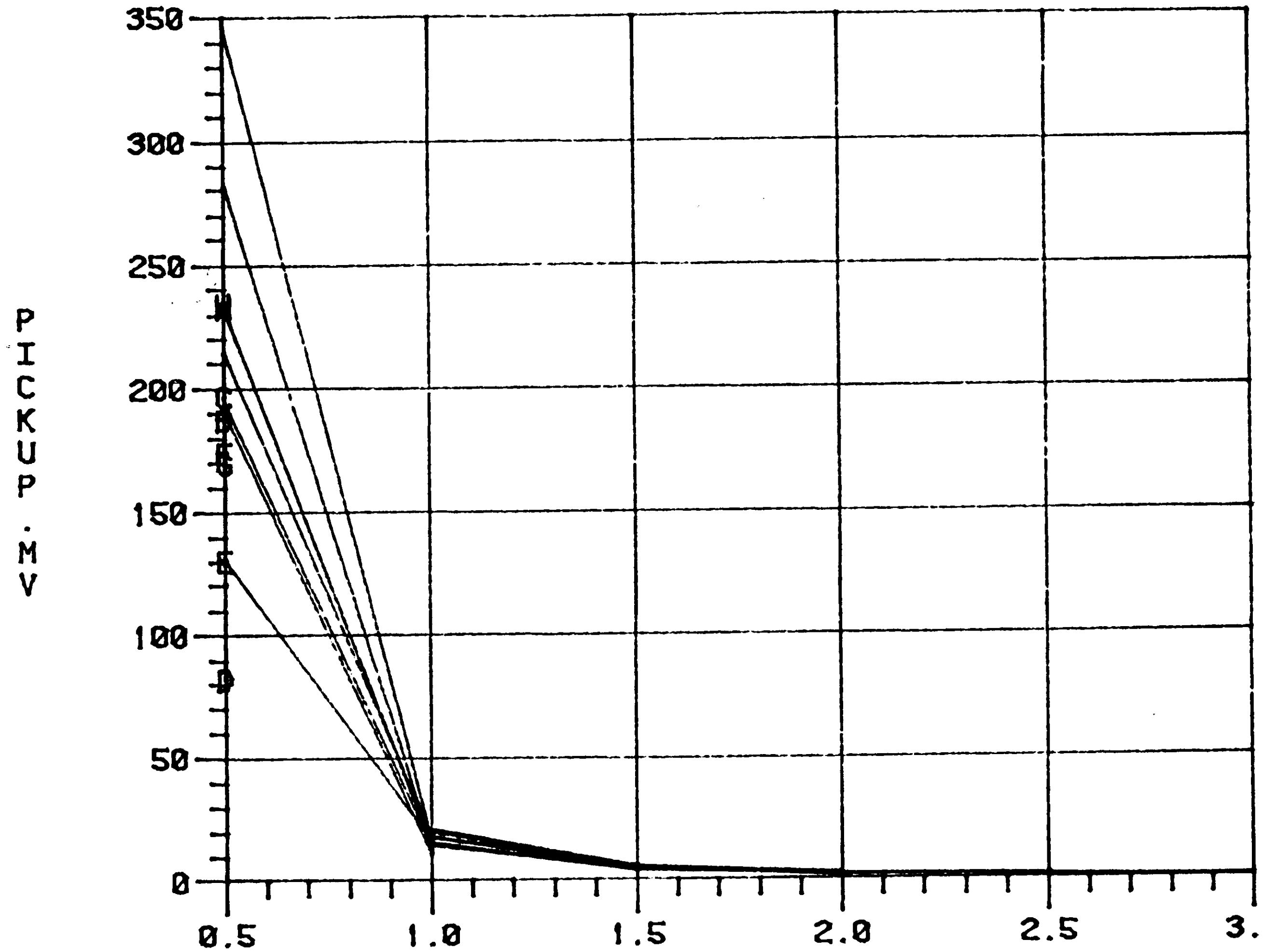


FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

L

MINE DATA FROM PROJECT C5490---FREQUENCY= .173 MHZ

FOR Z=0.0 COIL AXIS ALONG THE DRIFT



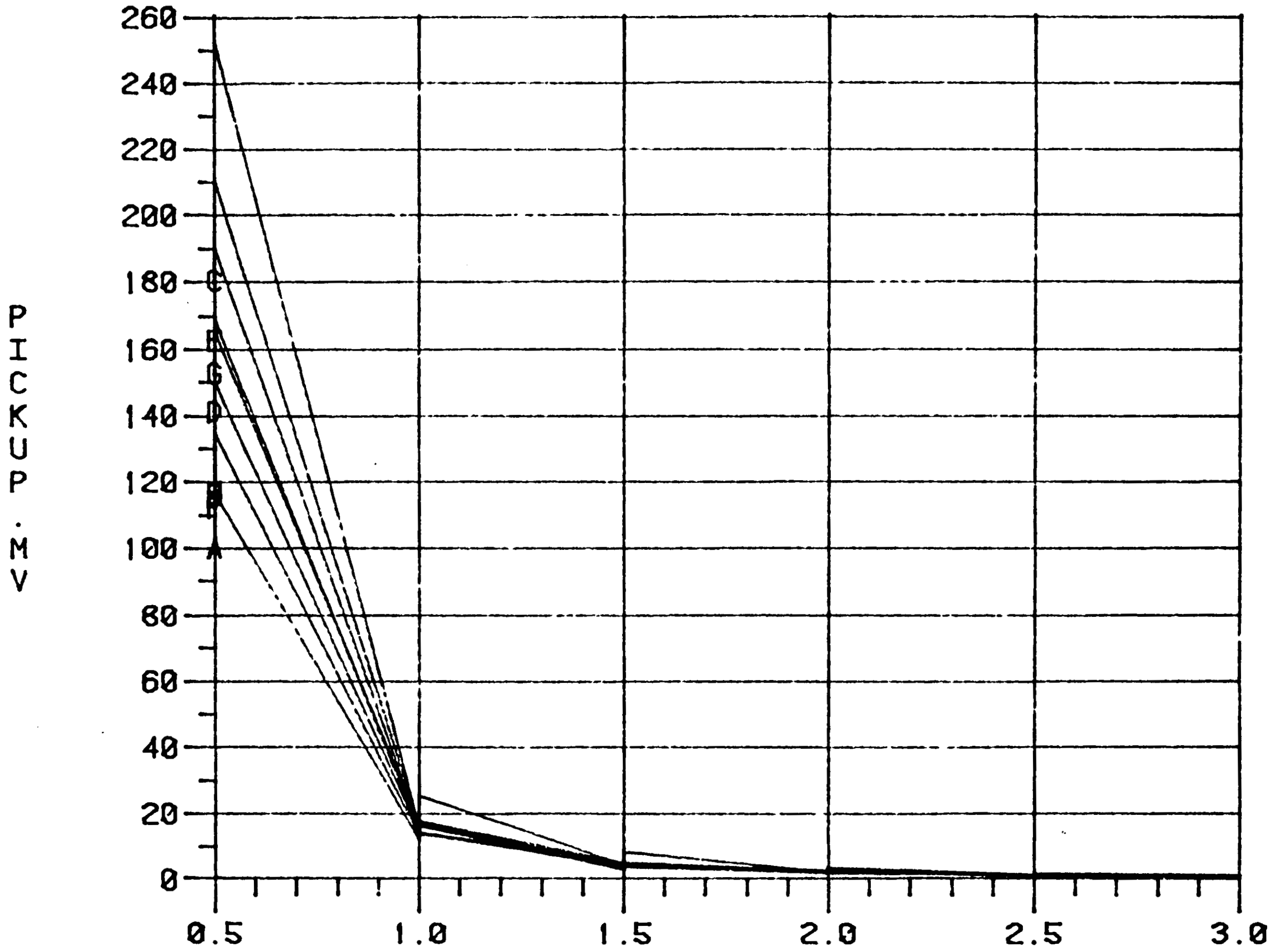
DISTANCE (X) FROM CENTER OF THE COIL IN METERS

FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

L

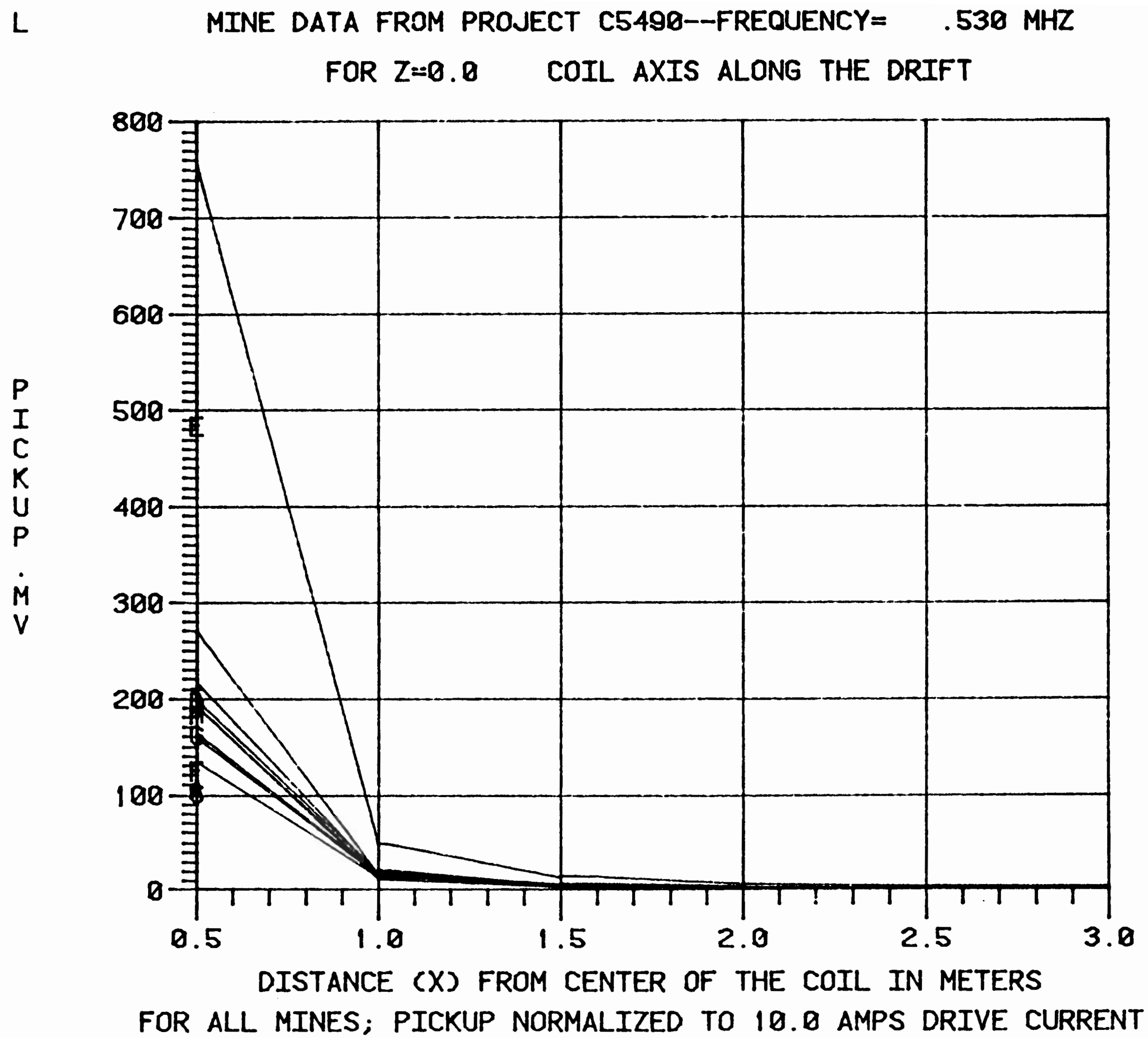
MINE DATA FROM PROJECT C5490--FREQUENCY= .173 MHZ

FOR Z=0.0 COIL AXIS ACROSS THE DRIFT



DISTANCE (X) FROM CENTER OF THE COIL IN METERS

FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

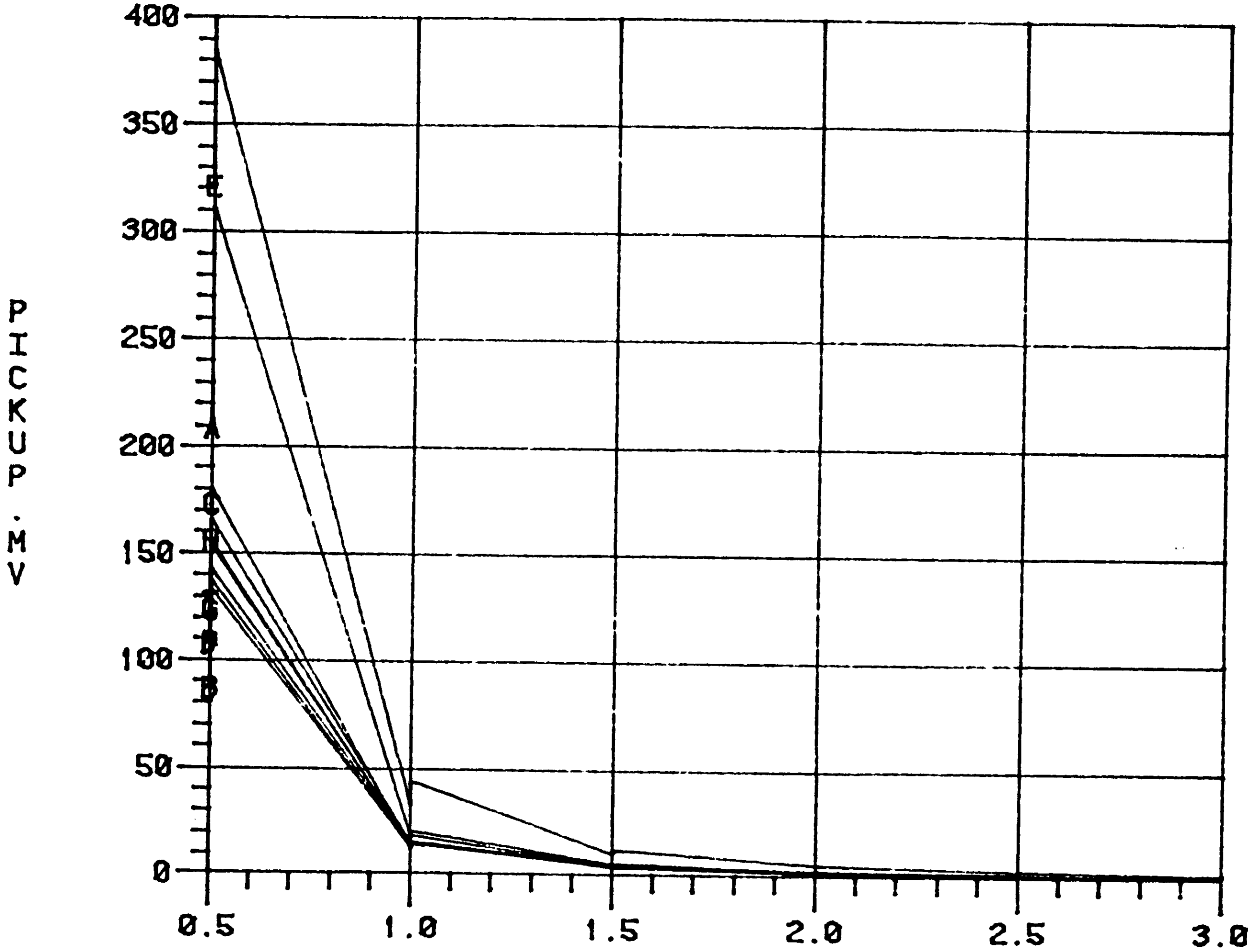

L
MINE DATA FROM PROJECT C5490--FREQUENCY= .530 MHZ
FOR Z=0.0 COIL AXIS ALONG THE DRIFT
800
700
600
500
400
300
200
100
0
PICKUP ·MV
0.5
1.0
1.5
2.0
2.5
3.0
DISTANCE (X) FROM CENTER OF THE COIL IN METERS
FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

215

L

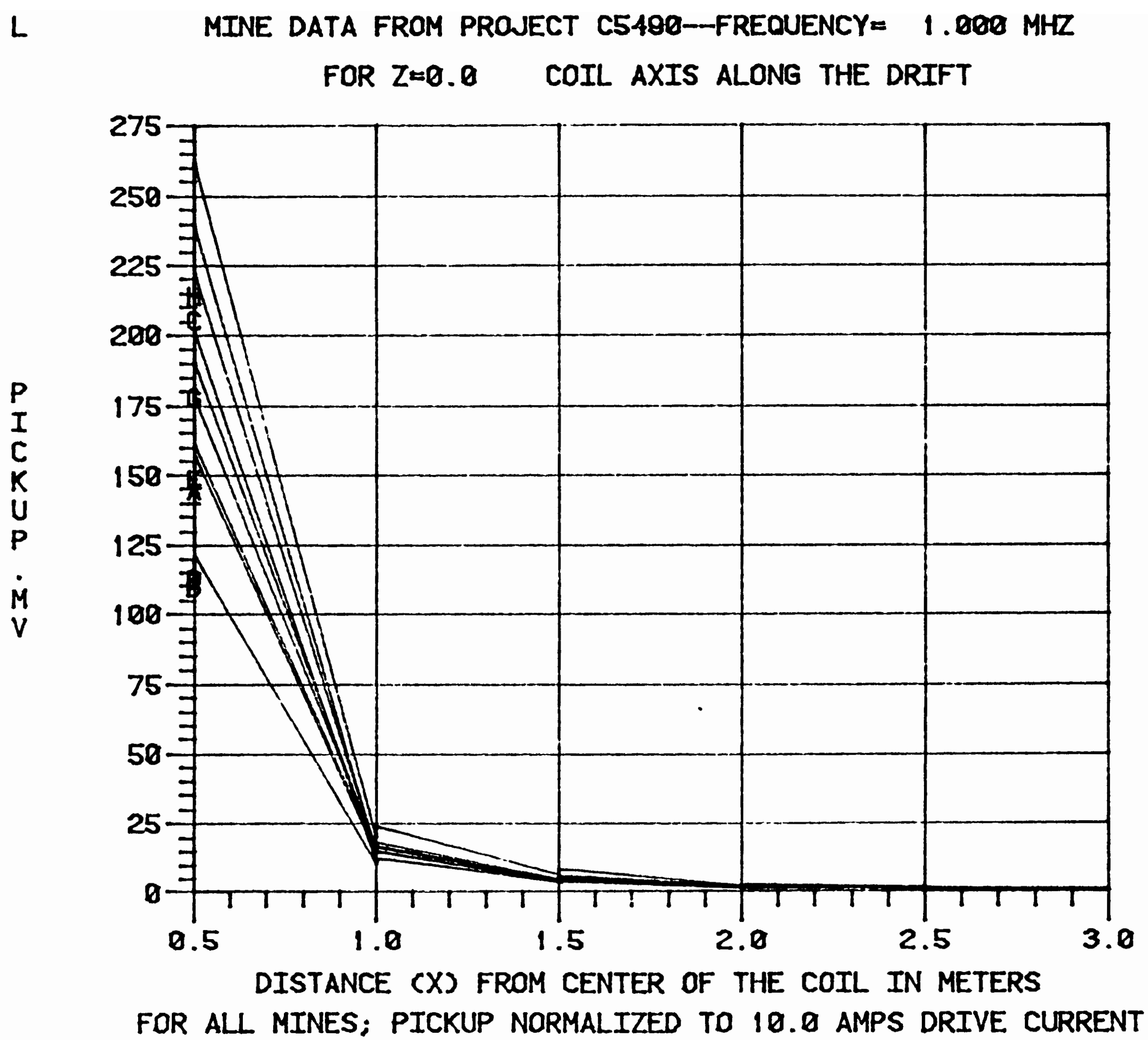
MINE DATA FROM PROJECT C5490--FREQUENCY= .530 MHZ

FOR Z=0.0 COIL AXIS ACROSS THE DRIFT



DISTANCE (X) FROM CENTER OF THE COIL IN METERS

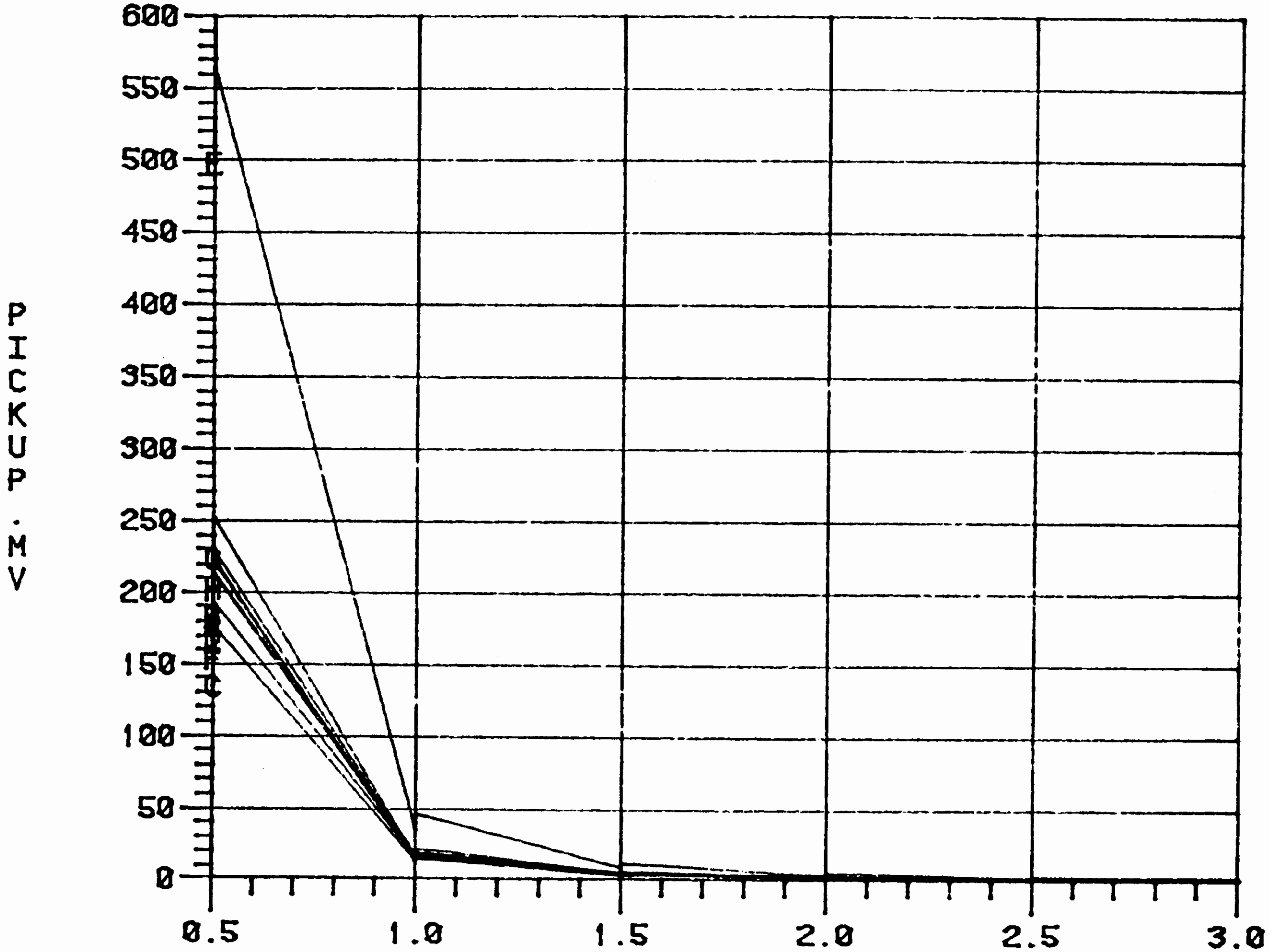
FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT


L
MINE DATA FROM PROJECT C5490---FREQUENCY= 1.000 MHZ
FOR Z=0.0 COIL AXIS ALONG THE DRIFT
PICKUP .MV
275
250
225
200
175
150
125
100
75
50
25
0
0.5
1.0
1.5
2.0
2.5
3.0
DISTANCE (X) FROM CENTER OF THE COIL IN METERS
FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

L

MINE DATA FROM PROJECT C5490--FREQUENCY= 1.000 MHZ

FOR Z=0.0 COIL AXIS ACROSS THE DRIFT



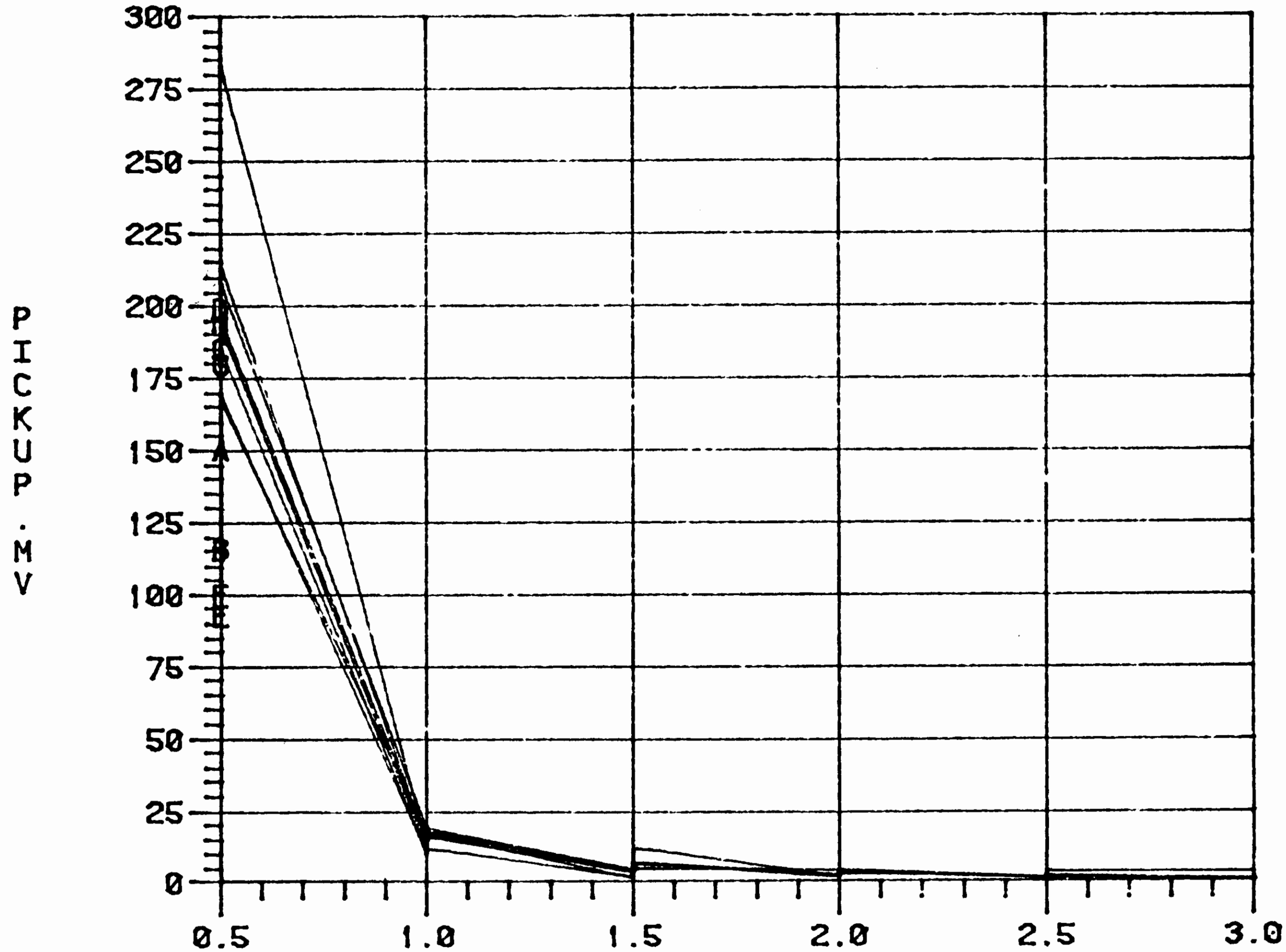
DISTANCE (X) FROM CENTER OF THE COIL IN METERS

FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

L

MINE DATA FROM PROJECT C5490—FREQUENCY= 5.000 MHZ

FOR Z=0.0 COIL AXIS ALONG THE DRIFT



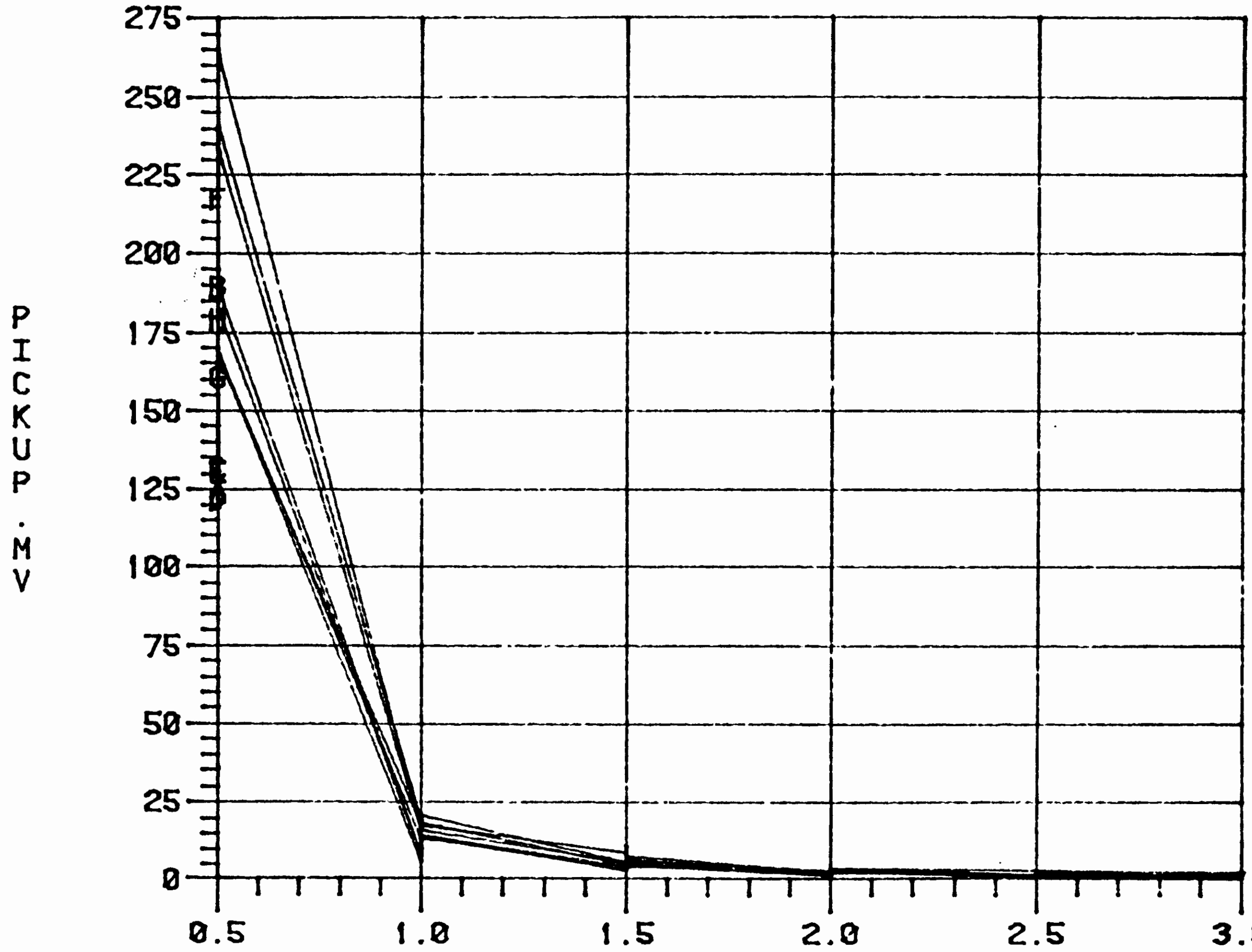
DISTANCE (X) FROM CENTER OF THE COIL IN METERS

FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

L

MINE DATA FROM PROJECT C5490--FREQUENCY= 5.000 MHZ

FOR Z=0.0 COIL AXIS ACROSS THE DRIFT



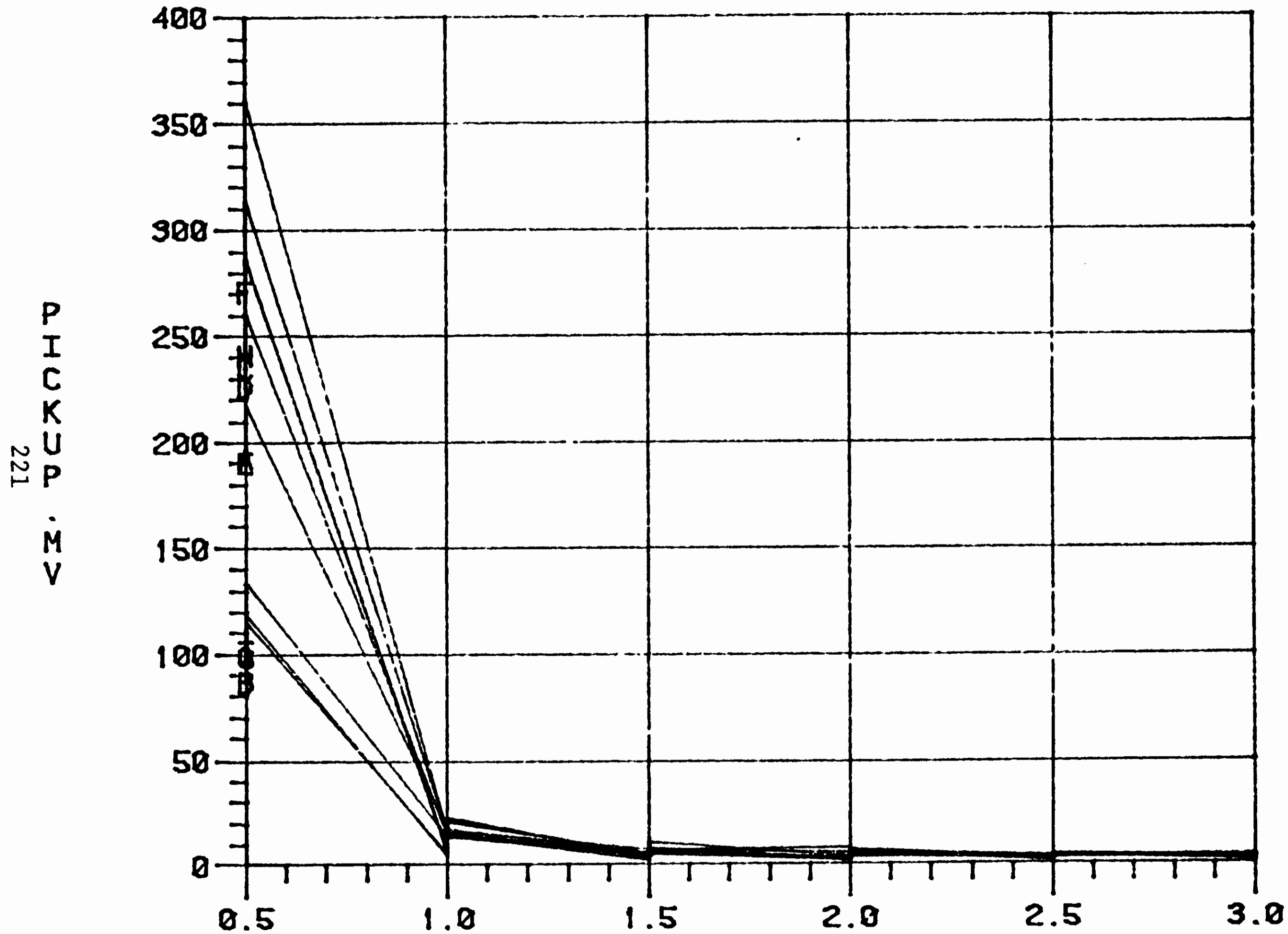
DISTANCE (X) FROM CENTER OF THE COIL IN METERS

FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

L

MINE DATA FROM PROJECT C5490--FREQUENCY= 10.000 MHZ

FOR Z=0.0 COIL AXIS ALONG THE DRIFT



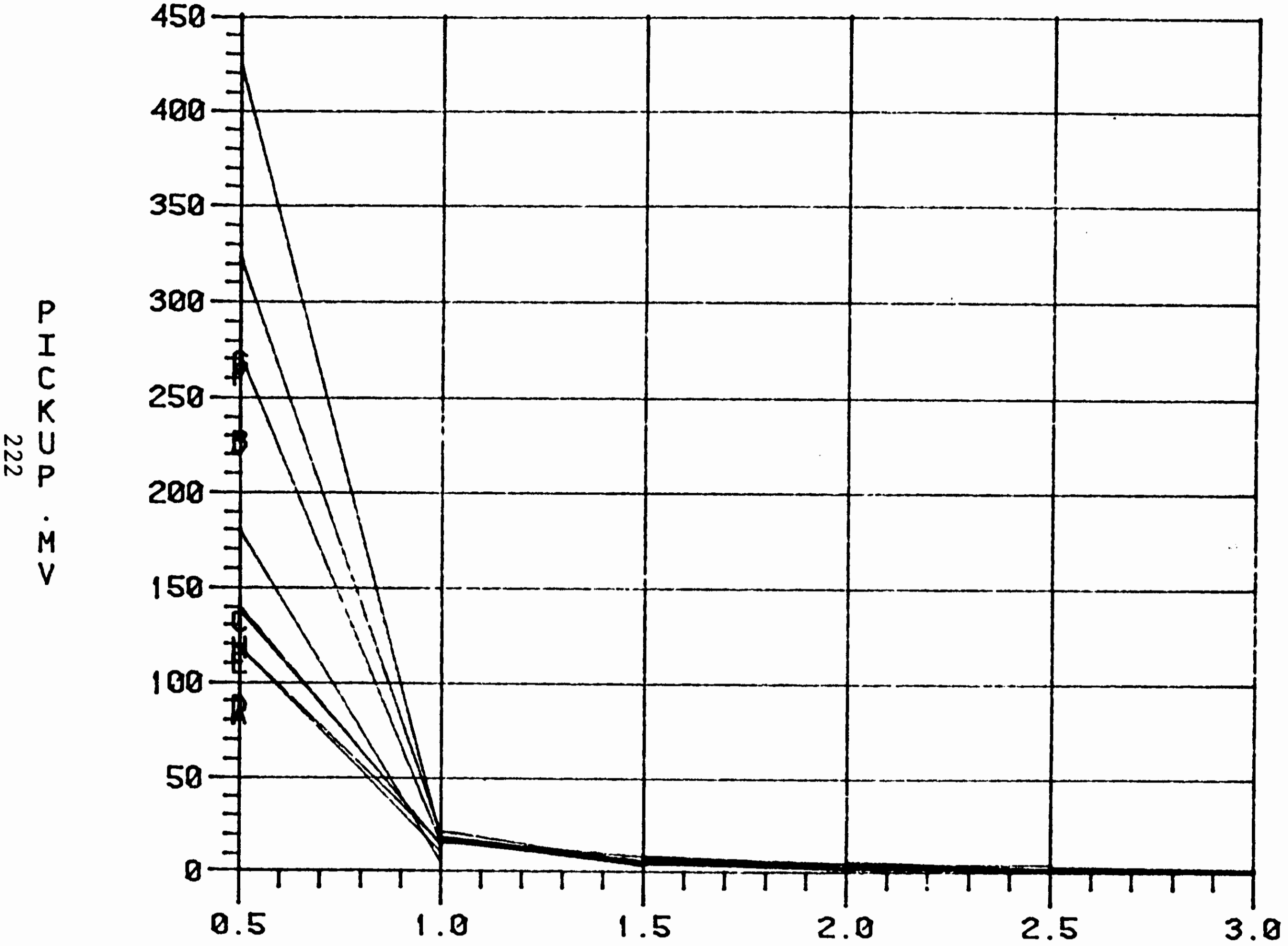
DISTANCE (X) FROM CENTER OF THE COIL IN METERS

FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

L

MINE DATA FROM PROJECT C5490--FREQUENCY= 10.000 MHZ

FOR Z=0.0   COIL AXIS ACROSS THE DRIFT



DISTANCE (X) FROM CENTER OF THE COIL IN METERS

FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS DRIVE CURRENT

APPENDIX E

NORMALIZED DATA

FOR THE LOOP MEASUREMENTS

COMPLETE LISTING FOR ALL MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
1	10.000	1	66.7	100.90	.66	.0	.5
1	10.000	1	16.7	17.70	.94	.0	1.
1	10.000	1	3.7	5.50	.67	.0	1.5
1	10.000	1	2.2	2.37	.93	.0	2.0
1	10.000	1	1.0	1.22	.82	.0	2.
1	10.000	1	1.2	.71	1.69	.0	3.
1	10.000	1	166.7	100.90	1.65	.0	.5
1	10.000	1	20.8	17.70	1.18	.0	1.
1	10.000	1	7.2	5.50	1.31	.0	1.
1	10.000	1	3.3	2.37	1.39	.0	2.0
1	10.000	1	2.5	1.22	2.05	.0	2.5
1	10.000	1	2.2	.71	3.10	.0	3.
1	10.000	1	191.7	106.90	1.79	.5	.0
1	10.000	1	16.7	10.40	1.61	1.0	.0
1	10.000	1	10.7	2.96	3.61	1.5	.
1	10.000	1	6.7	1.23	5.45	2.0	.
1	10.000	1	5.2	.63	8.31	2.5	.0
1	10.000	1	216.7	106.90	2.03	.5	.
1	10.000	1	16.7	10.40	1.61	1.0	.
1	10.000	1	5.0	2.96	1.69	1.5	.0
1	10.000	1	3.7	1.23	3.01	2.0	.0
1	10.000	1	2.5	.63	3.99	2.5	.
1	10.000	1	2.5	.36	6.93	3.0	.0
1	10.000	2	83.3	106.90	.78	.5	.0
1	10.000	2	10.2	10.40	.98	1.0	.
1	10.000	2	3.3	2.96	1.11	1.5	.
1	10.000	2	2.3	1.23	1.87	2.0	.0
1	10.000	2	1.8	.63	2.88	2.5	.
1	10.000	2	1.8	.36	4.99	3.0	.
1	10.000	2	116.7	106.90	1.09	.5	.0
1	10.000	2	16.7	10.40	1.61	1.0	.0
1	10.000	2	7.5	2.96	2.53	1.5	.
1	10.000	2	5.3	1.23	4.31	2.0	.0
1	10.000	2	3.3	.63	5.27	2.5	.0
1	10.000	2	2.7	.36	7.48	3.0	.
1	10.000	2	125.0	100.90	1.24	.0	.
1	10.000	2	19.2	17.70	1.08	.0	1.0
1	10.000	2	5.3	5.50	.96	.0	1.
1	10.000	2	2.2	2.37	.93	.0	2.
1	10.000	2	2.3	1.22	1.89	.0	2.5
1	10.000	2	133.3	100.90	1.32	.0	.5
1	10.000	2	20.0	17.70	1.13	.0	1.
1	10.000	2	9.3	5.50	1.69	.0	1.
1	10.000	2	4.2	2.37	1.77	.0	2.0
1	10.000	2	2.8	1.22	2.30	.0	2.
1	10.000	2	2.5	.71	3.52	.0	3.

COMPLETE LISTING FOR ALL MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
1	1.000	2	248.9	100.90	2.47	.0	.5
1	1.000	2	39.1	17.70	2.21	.0	1.0
1	1.000	2	11.6	5.50	2.11	.0	1.5
1	1.000	2	4.4	2.37	1.86	.0	2.0
1	1.000	2	2.1	1.22	1.72	.0	2.5
1	1.000	2	142.2	100.90	1.41	.0	.5
1	1.000	2	28.4	17.70	1.60	.0	1.0
1	1.000	2	11.6	5.50	2.11	.0	1.5
1	1.000	2	5.3	2.37	2.24	.0	2.0
1	1.000	2	2.7	1.22	2.21	.0	2.5
1	1.000	2	1.8	.71	2.54	.0	3.0
1	1.000	2	177.8	106.90	1.66	.5	.0
1	1.000	2	17.8	10.40	1.71	1.0	.0
1	1.000	2	5.3	2.96	1.79	1.5	.0
1	1.000	2	2.1	1.23	1.71	2.0	.0
1	1.000	2	1.4	.63	2.24	2.5	.0
1	1.000	2	.9	.36	2.49	3.0	.0
1	1.000	2	213.3	106.90	2.00	.5	.0
1	1.000	2	20.4	10.40	1.96	1.0	.0
1	1.000	2	4.4	2.96	1.49	1.5	.0
1	1.000	2	2.1	1.23	1.71	2.0	.0
1	1.000	2	1.1	.63	1.76	2.5	.0
1	1.000	2	.5	.36	1.39	3.0	.0
1	1.000	1	120.5	100.90	1.19	.0	.5
1	1.000	1	24.1	17.70	1.36	.0	1.0
1	1.000	1	8.0	5.50	1.45	.0	1.5
1	1.000	1	2.9	2.37	1.22	.0	2.0
1	1.000	1	1.6	1.22	1.31	.0	2.5
1	1.000	1	.8	.71	1.13	.0	3.0
1	1.000	1	140.6	100.90	1.39	.0	.5
1	1.000	1	20.9	17.70	1.18	.0	1.0
1	1.000	1	6.4	5.50	1.16	.0	1.5
1	1.000	1	3.2	2.37	1.35	.0	2.0
1	1.000	1	1.6	1.22	1.31	.0	2.5
1	1.000	1	.8	.71	1.13	.0	3.0
1	1.000	1	144.6	106.90	1.35	.5	.0
1	1.000	1	16.1	10.40	1.55	1.0	.0
1	1.000	1	4.0	2.96	1.35	1.5	.0
1	1.000	1	1.9	1.23	1.54	2.0	.0
1	1.000	1	1.3	.63	2.08	2.5	.0
1	1.000	1	160.6	106.90	1.50	.5	.0
1	1.000	1	14.5	10.40	1.39	1.0	.0
1	1.000	1	3.7	2.96	1.25	1.5	.0
1	1.000	1	1.6	1.23	1.30	2.0	.0
1	1.000	1	.8	.63	1.28	2.5	.0
1	1.000	1	.5	.36	1.39	3.0	.0

COMPLETE LISTING FOR ALL MINE DATA

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
1	.530	1	132.4	100.90	1.31	.0	.5
1	.530	1	21.2	17.70	1.20	.0	1.[illegible]
1	.530	1	7.1	5.50	1.29	.0	1.5
1	.530	1	2.8	2.37	1.18	.0	2.0
1	.530	1	.9	1.22	.74	.0	2.5
1	.530	1	158.8	100.90	1.57	.0	.5
1	.530	1	21.2	17.70	1.20	.0	1.0
1	.530	1	7.1	5.50	1.29	.0	1.5
1	.530	1	3.2	2.37	1.35	.0	2.0
1	.530	1	1.8	1.22	1.48	.0	2.5
1	.530	1	.9	.71	1.27	.0	3.[illegible]
1	.530	1	132.4	106.90	1.24	.5	.[illegible]
1	.530	1	13.2	10.40	1.27	1.0	.0
1	.530	1	3.5	2.96	1.18	1.5	.[illegible]
1	.530	1	1.4	1.23	1.14	2.0	.[illegible]
1	.530	1	.9	.63	1.44	2.5	.0
1	.530	1	.7	.36	1.94	3.0	.0
1	.530	1	105.9	106.90	.99	.5	.[illegible]
1	.530	1	14.1	10.40	1.36	1.0	.0
1	.530	1	3.5	2.96	1.18	1.5	.0
1	.530	1	1.8	1.23	1.46	2.0	.[illegible]
1	.530	1	.9	.63	1.44	2.5	.[illegible]
1	.530	2	138.5	100.90	1.37	.0	.5
1	.530	2	22.5	17.70	1.27	.0	1.0
1	.530	2	6.5	5.50	1.18	.0	1.[illegible]
1	.530	2	2.8	2.37	1.18	.0	2.0
1	.530	2	1.4	1.22	1.15	.0	2.5
1	.530	2	.9	.71	1.27	.0	3.[illegible]
1	.530	2	121.2	100.90	1.20	.0	.[illegible]
1	.530	2	24.2	17.70	1.37	.0	1.0
1	.530	2	6.9	5.50	1.25	.0	1.[illegible]
1	.530	2	2.8	2.37	1.18	.0	2.[illegible]
1	.530	2	1.6	1.22	1.31	.0	2.5
1	.530	2	207.7	106.90	1.94	.5	.0
1	.530	2	17.3	10.40	1.66	1.0	.[illegible]
1	.530	2	4.7	2.96	1.59	1.5	.0
1	.530	2	1.7	1.23	1.38	2.0	.0
1	.530	2	1.1	.63	1.76	2.5	.[illegible]
1	.530	2	.7	.36	1.94	3.0	.0
1	.530	2	311.6	106.90	2.91	.5	.0
1	.530	2	17.3	10.40	1.66	1.0	.[illegible]
1	.530	2	4.5	2.96	1.52	1.5	.[illegible]
1	.530	2	1.7	1.23	1.38	2.0	.0
1	.530	2	.9	.63	1.44	2.5	.0
1	.530	2	.7	.36	1.94	3.0	.[illegible]

COMPLETE LISTING FOR ALL MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
1	.173	2	100.0	100.90	.99	.0	.5
1	.173	2	13.0	17.70	.73	.0	1.0
1	.173	2	4.8	5.50	.87	.0	1.5
1	.173	2	1.2	2.37	.51	.0	2.0
1	.173	2	.8	1.22	.66	.0	2.5
1	.173	2	.8	.71	1.13	.0	3.0
1	.173	2	199.9	100.90	1.98	.0	.5
1	.173	2	16.0	17.70	.90	.0	1.0
1	.173	2	4.0	5.50	.73	.0	1.5
1	.173	2	1.6	2.37	.68	.0	2.0
1	.173	2	1.2	1.22	.98	.0	2.5
1	.173	2	.8	.71	1.13	.0	3.0
1	.173	2	100.0	106.90	.94	.5	.0
1	.173	2	20.0	10.40	1.92	1.0	.0
1	.173	2	6.0	2.96	2.03	1.5	.0
1	.173	2	3.2	1.23	2.60	2.0	.0
1	.173	2	1.6	.63	2.56	2.5	.0
1	.173	2	128.0	106.90	1.20	.5	.0
1	.173	2	25.0	10.40	2.40	1.0	.0
1	.173	2	8.0	2.96	2.70	1.5	.0
1	.173	2	3.2	1.23	2.60	2.0	.0
1	.173	2	1.6	.63	2.56	2.5	.0
1	.173	2	1.2	.36	3.32	3.0	.0
1	.173	2	179.1	106.90	1.68	.5	.0
1	.173	2	15.8	10.40	1.52	1.0	.0
1	.173	2	4.2	2.96	1.42	1.5	.0
1	.173	2	2.1	1.23	1.71	2.0	.0
1	.173	2	1.3	.63	2.08	2.5	.0
1	.173	2	.8	.36	2.22	3.0	.0
1	.173	2	210.7	106.90	1.97	.5	.0
1	.173	2	15.8	10.40	1.52	1.0	.0
1	.173	2	4.2	2.96	1.42	1.5	.0
1	.173	2	1.7	1.23	1.38	2.0	.0
1	.173	2	.8	.63	1.28	2.5	.0
1	.173	2	147.5	100.90	1.46	.0	.5
1	.173	2	21.1	17.70	1.19	.0	1.0
1	.173	2	8.4	5.50	1.53	.0	1.5
1	.173	2	3.4	2.37	1.43	.0	2.0
1	.173	2	1.7	1.22	1.39	.0	2.5
1	.173	2	.8	.71	1.13	.0	3.0
1	.173	2	109.6	100.90	1.09	.0	.5
1	.173	2	16.9	17.70	.95	.0	1.0
1	.173	2	6.3	5.50	1.15	.0	1.5
1	.173	2	2.5	2.37	1.05	.0	2.0
1	.173	2	1.7	1.22	1.39	.0	2.5
1	.173	2	.8	.71	1.13	.0	3.0

COMPLETE LISTING FOR ALL MINE DATA

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
2	.173	1	133.5	100.90	1.32	.0	.5
2	.173	1	22.0	17.70	1.24	.0	1.0
2	.173	1	7.0	5.50	1.27	.0	1.5
2	.173	1	3.4	2.37	1.43	.0	2.0
2	.173	1	2.3	1.22	1.89	.0	2.5
2	.173	1	104.4	100.90	1.03	.0	.5
2	.173	1	17.4	17.70	.98	.0	1.0
2	.173	1	5.8	5.50	1.05	.0	1.5
2	.173	1	3.4	2.37	1.43	.0	2.0
2	.173	1	2.3	1.22	1.89	.0	2.5
2	.173	1	232.2	106.90	2.17	.5	.0
2	.173	1	13.9	10.40	1.34	1.0	.0
2	.173	1	3.4	2.96	1.15	1.5	.0
2	.173	1	2.3	1.23	1.87	2.0	.0
2	.173	1	174.1	100.90	1.73	.0	.5
2	.173	1	15.1	17.70	.85	.0	1.0
2	.173	1	4.6	5.50	.84	.0	1.5
2	.173	1	3.4	2.37	1.43	.0	2.0
2	.173	1	2.3	1.22	1.89	.0	2.5
2	.173	2	116.1	100.90	1.15	.0	.5
2	.173	2	23.2	17.70	1.31	.0	1.0
2	.173	2	7.0	5.50	1.27	.0	1.5
2	.173	2	4.6	2.37	1.94	.0	2.0
2	.173	2	2.3	1.22	1.89	.0	2.5
2	.173	2	145.2	100.90	1.44	.0	.5
2	.173	2	25.6	17.70	1.45	.0	1.0
2	.173	2	7.0	5.50	1.27	.0	1.5
2	.173	2	4.6	2.37	1.94	.0	2.0
2	.173	2	2.3	1.22	1.89	.0	2.5
2	.173	2	116.1	106.90	1.09	.5	.0
2	.173	2	13.9	10.40	1.34	1.0	.0
2	.173	2	4.6	2.96	1.55	1.5	.0
2	.173	2	2.3	1.23	1.87	2.0	.0
2	.173	2	116.1	106.90	1.09	.5	.0
2	.173	2	11.6	10.40	1.12	1.0	.0
2	.173	2	4.6	2.96	1.55	1.5	.0
2	.173	2	3.4	1.23	2.76	2.0	.0
2	.173	2	1.1	.63	1.76	2.5	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
2	.530	2	198.6	100.90	1.97	.0	.5
2	.530	2	29.8	17.70	1.68	.0	1.0
2	.530	2	8.6	5.50	1.56	.0	1.5
2	.530	2	4.0	2.37	1.69	.0	2.0
2	.530	2	2.6	1.22	2.13	.0	2.5
2	.530	2	1.4	.71	1.97	.0	3.0
2	.530	2	119.1	100.90	1.18	.0	.5
2	.530	2	29.8	17.70	1.68	.0	1.0
2	.530	2	9.3	5.50	1.69	.0	1.5
2	.530	2	4.0	2.37	1.69	.0	2.0
2	.530	2	1.9	1.22	1.56	.0	2.5
2	.530	2	165.4	106.90	1.55	.5	.0
2	.530	2	19.8	10.40	1.90	1.0	.0
2	.530	2	5.3	2.96	1.79	1.5	.0
2	.530	2	1.9	1.23	1.54	2.0	.0
2	.530	2	1.4	.63	2.24	2.5	.0
2	.530	2	86.1	106.90	.81	.5	.0
2	.530	2	14.6	10.40	1.40	1.0	.0
2	.530	2	4.6	2.96	1.55	1.5	.0
2	.530	2	1.9	1.23	1.54	2.0	.0
2	.530	2	1.4	.63	2.24	2.5	.0
2	.530	1	125.8	100.90	1.25	.0	.5
2	.530	1	28.3	17.70	1.60	.0	1.0
2	.530	1	6.3	5.50	1.15	.0	1.5
2	.530	1	3.8	2.37	1.60	.0	2.0
2	.530	1	2.5	1.22	2.05	.0	2.5
2	.530	1	1.3	.71	1.83	.0	3.0
2	.530	1	157.2	100.90	1.56	.0	.5
2	.530	1	28.3	17.70	1.60	.0	1.0
2	.530	1	7.5	5.50	1.36	.0	1.5
2	.530	1	4.3	2.37	1.81	.0	2.0
2	.530	1	2.5	1.22	2.05	.0	2.5
2	.530	1	1.3	.71	1.83	.0	3.0
2	.530	1	188.7	106.90	1.77	.5	.0
2	.530	1	15.7	10.40	1.51	1.0	.0
2	.530	1	4.3	2.96	1.45	1.5	.0
2	.530	1	1.8	1.23	1.46	2.0	.0
2	.530	1	1.3	.63	2.08	2.5	.0
2	.530	1	188.7	106.90	1.77	.5	.0
2	.530	1	13.8	10.40	1.33	1.0	.0
2	.530	1	5.0	2.96	1.69	1.5	.0
2	.530	1	2.5	1.23	2.03	2.0	.0
2	.530	1	1.3	.63	2.08	2.5	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
2	1.000	1	142.9	100.90	1.42	.0	.5
2	1.000	1	21.9	17.70	1.24	.0	1.
2	1.000	1	8.6	5.50	1.56	.0	1.5
2	1.000	1	3.2	2.37	1.35	.0	2.0
2	1.000	1	1.7	1.22	1.39	.0	2.
2	1.000	1	1.0	.71	1.41	.0	3.
2	1.000	1	138.1	100.90	1.37	.0	.5
2	1.000	1	19.0	17.70	1.07	.0	1.
2	1.000	1	7.1	5.50	1.29	.0	1.
2	1.000	1	3.4	2.37	1.43	.0	2.0
2	1.000	1	1.5	1.22	1.23	.0	2.5
2	1.000	1	.8	.71	1.13	.0	3.
2	1.000	1	109.5	106.90	1.02	.5	.0
2	1.000	1	14.3	10.40	1.38	1.0	.0
2	1.000	1	4.8	2.96	1.62	1.5	.
2	1.000	1	1.9	1.23	1.54	2.0	.
2	1.000	1	1.3	.63	2.08	2.5	.0
2	1.000	1	157.1	106.90	1.47	.5	.
2	1.000	1	13.3	10.40	1.28	1.0	.
2	1.000	1	3.8	2.96	1.28	1.5	.0
2	1.000	1	1.5	1.23	1.22	2.0	.
2	1.000	1	1.0	.63	1.60	2.5	.
2	1.000	2	116.2	100.90	1.15	.0	.5
2	1.000	2	20.2	17.70	1.14	.0	1.0
2	1.000	2	6.1	5.50	1.11	.0	1.
2	1.000	2	2.0	2.37	.84	.0	2.
2	1.000	2	1.2	1.22	.98	.0	2.5
2	1.000	2	.8	.71	1.13	.0	3.
2	1.000	2	151.5	100.90	1.50	.0	.
2	1.000	2	20.2	17.70	1.14	.0	1.0
2	1.000	2	7.1	5.50	1.29	.0	1.5
2	1.000	2	3.2	2.37	1.35	.0	2.
2	1.000	2	1.6	1.22	1.31	.0	2.5
2	1.000	2	1.2	.71	1.69	.0	3.0
2	1.000	2	212.1	106.90	1.98	.5	.
2	1.000	2	14.1	10.40	1.36	1.0	.
2	1.000	2	4.0	2.96	1.35	1.5	.0
2	1.000	2	1.6	1.23	1.30	2.0	.
2	1.000	2	1.0	.63	1.60	2.5	.
2	1.000	2	.6	.36	1.66	3.0	.0
2	1.000	2	181.8	106.90	1.70	.5	.0
2	1.000	2	16.2	10.40	1.56	1.0	.
2	1.000	2	4.4	2.96	1.49	1.5	.0
2	1.000	2	2.0	1.23	1.63	2.0	.0
2	1.000	2	1.2	.63	1.92	2.5	.
2	1.000	2	.8	.36	2.22	3.0	.

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
2	5.000	1	133.3	100.90	1.32	.0	.5
2	5.000	1	25.0	17.70	1.41	.0	1.0
2	5.000	1	145.8	100.90	1.44	.0	.5
2	5.000	1	25.0	17.70	1.41	.0	1.0
2	5.000	1	8.3	5.50	1.51	.0	1.5
2	5.000	1	150.0	106.90	1.40	.5	.0
2	5.000	1	16.7	10.40	1.61	1.0	.0
2	5.000	1	166.7	106.90	1.56	.5	.0
2	5.000	1	16.7	10.40	1.61	1.0	.0
2	5.000	1	4.2	2.96	1.42	1.5	.0
2	5.000	2	150.0	100.90	1.49	.0	.5
2	5.000	2	37.5	17.70	2.12	.0	1.0
2	5.000	2	12.5	5.50	2.27	.0	1.5
2	5.000	2	141.7	100.90	1.40	.0	.5
2	5.000	2	27.1	17.70	1.53	.0	1.0
2	5.000	2	8.3	5.50	1.51	.0	1.5
2	5.000	2	125.0	106.90	1.17	.5	.0
2	5.000	2	10.4	2.96	3.51	1.5	.0
2	5.000	2	166.7	106.90	1.56	.5	.0
2	5.000	2	16.7	10.40	1.61	1.0	.0
2	5.000	2	8.3	2.96	2.80	1.5	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
2	10.000	2	132.1	100.90	1.31	.0	.5
2	10.000	2	22.6	17.70	1.28	.0	1.
2	10.000	2	188.7	100.90	1.87	.0	.5
2	10.000	2	22.6	17.70	1.28	.0	1.0
2	10.000	2	8.3	5.50	1.51	.0	1.
2	10.000	2	3.0	2.37	1.27	.0	2.
2	10.000	2	271.7	106.90	2.54	.5	.0
2	10.000	2	18.1	10.40	1.74	1.0	.
2	10.000	2	4.5	2.96	1.52	1.5	.
2	10.000	2	226.4	106.90	2.12	.5	.0
2	10.000	2	15.1	10.40	1.45	1.0	.0
2	10.000	2	7.5	2.96	2.53	1.5	.
2	10.000	2	4.8	1.23	3.90	2.0	.0
2	10.000	1	180.4	100.90	1.79	.0	.5
2	10.000	1	18.8	17.70	1.06	.0	1.
2	10.000	1	7.8	5.50	1.42	.0	1.
2	10.000	1	1.6	1.22	1.31	.0	2.5
2	10.000	1	137.3	100.90	1.36	.0	.
2	10.000	1	22.0	17.70	1.24	.0	1.
2	10.000	1	4.7	5.50	.85	.0	1.5
2	10.000	1	86.3	106.90	.81	.5	.0
2	10.000	1	3.9	10.40	.38	1.0	.
2	10.000	1	117.6	106.90	1.10	.5	.0
2	10.000	1	15.7	10.40	1.51	1.0	.0
2	10.000	1	7.1	2.96	2.40	1.5	.
2	10.000	1	5.5	1.23	4.47	2.0	.
2	10.000	1	4.4	.63	7.03	2.5	.0
2	10.000	1	4.7	.36	13.02	3.0	.

COMPLETE LISTING FOR ALL MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
3	10.000	1	130.3	100.90	1.29	.0	.5
3	10.000	1	23.5	17.70	1.33	.0	1.0
3	10.000	1	5.3	5.50	.96	.0	1.5
3	10.000	1	2.3	2.37	.97	.0	2.0
3	10.000	1	1.0	1.22	.82	.0	2.5
3	10.000	1	1.0	.71	1.41	.0	3.0
3	10.000	1	156.3	100.90	1.55	.0	.5
3	10.000	1	15.8	17.70	.89	.0	1.0
3	10.000	1	6.3	5.50	1.15	.0	1.5
3	10.000	1	3.8	2.37	1.60	.0	2.0
3	10.000	1	2.0	1.22	1.64	.0	2.5
3	10.000	1	2.0	.71	2.82	.0	3.0
3	10.000	1	260.5	106.90	2.44	.5	.0
3	10.000	1	14.5	10.40	1.39	1.0	.0
3	10.000	1	4.5	2.96	1.52	1.5	.0
3	10.000	1	2.3	1.23	1.87	2.0	.0
3	10.000	1	1.8	.63	2.88	2.5	.0
3	10.000	1	234.5	106.90	2.19	.5	.0
3	10.000	1	14.0	10.40	1.35	1.0	.0
3	10.000	1	7.3	2.96	2.47	1.5	.0
3	10.000	1	5.5	1.23	4.47	2.0	.0
3	10.000	1	4.3	.63	6.87	2.5	.0
3	10.000	2	170.0	100.90	1.68	.0	.5
3	10.000	2	20.5	17.70	1.16	.0	1.0
3	10.000	2	6.8	5.50	1.24	.0	1.5
3	10.000	2	3.7	2.37	1.56	.0	2.0
3	10.000	2	2.4	1.22	1.97	.0	2.5
3	10.000	2	120.5	100.90	1.19	.0	.5
3	10.000	2	21.8	17.70	1.23	.0	1.0
3	10.000	2	5.0	5.50	.91	.0	1.5
3	10.000	2	2.1	2.37	.89	.0	2.0
3	10.000	2	1.3	1.22	1.07	.0	2.5
3	10.000	2	137.1	106.90	1.28	.5	.0
3	10.000	2	15.3	10.40	1.47	1.0	.0
3	10.000	2	5.0	2.96	1.69	1.5	.0
3	10.000	2	2.4	1.23	1.95	2.0	.0
3	10.000	2	1.6	.63	2.56	2.5	.0
3	10.000	2	1.1	.36	3.05	3.0	.0
3	10.000	2	131.6	106.90	1.23	.5	.0
3	10.000	2	13.7	10.40	1.32	1.0	.0
3	10.000	2	3.9	2.96	1.32	1.5	.0
3	10.000	2	1.6	1.23	1.30	2.0	.0
3	10.000	2	1.1	.63	1.76	2.5	.0
3	10.000	2	1.1	.36	3.05	3.0	.0

COMPLETE LISTING FOR ALL MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
3	5.000	2	150.9	100.90	1.50	.0	.[illegible]
3	5.000	2	18.9	17.70	1.07	.0	1.[illegible]
3	5.000	2	3.8	5.50	.69	.0	1.5
3	5.000	2	150.9	100.90	1.50	.0	.[illegible]
3	5.000	2	18.9	17.70	1.07	.0	1.[illegible]
3	5.000	2	5.7	5.50	1.04	.0	1.5
3	5.000	2	188.7	106.90	1.77	.5	.[illegible]
3	5.000	2	9.4	10.40	.90	1.0	.[illegible]
3	5.000	2	188.7	106.90	1.77	.5	.0
3	5.000	2	7.5	10.40	.72	1.0	.0
3	5.000	1	153.8	100.90	1.52	.0	.[illegible]
3	5.000	1	19.2	17.70	1.08	.0	1.[illegible]
3	5.000	1	153.8	100.90	1.52	.0	.5
3	5.000	1	11.5	17.70	.65	.0	1.[illegible]
3	5.000	1	192.3	106.90	1.80	.5	.[illegible]
3	5.000	1	11.5	10.40	1.11	1.0	.0
3	5.000	1	115.4	106.90	1.08	.5	.[illegible]
3	5.000	1	19.2	10.40	1.85	1.0	.[illegible]

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
3	1.000	2	133.3	100.90	1.32	.0	.5
3	1.000	2	24.0	17.70	1.36	.0	1.0
3	1.000	2	6.7	5.50	1.22	.0	1.5
3	1.000	2	2.9	2.37	1.22	.0	2.0
3	1.000	2	1.3	1.22	1.07	.0	2.5
3	1.000	2	133.3	100.90	1.32	.0	.5
3	1.000	2	22.7	17.70	1.28	.0	1.0
3	1.000	2	6.3	5.50	1.15	.0	1.5
3	1.000	2	2.7	2.37	1.14	.0	2.0
3	1.000	2	1.3	1.22	1.07	.0	2.5
3	1.000	2	220.0	106.90	2.06	.5	.0
3	1.000	2	14.7	10.40	1.41	1.0	.0
3	1.000	2	4.3	2.96	1.45	1.5	.0
3	1.000	2	1.6	1.23	1.30	2.0	.0
3	1.000	2	.8	.63	1.28	2.5	.0
3	1.000	2	.7	.36	1.94	3.0	.0
3	1.000	2	133.3	106.90	1.25	.5	.0
3	1.000	2	13.3	10.40	1.28	1.0	.0
3	1.000	2	3.3	2.96	1.11	1.5	.0
3	1.000	2	1.6	1.23	1.30	2.0	.0
3	1.000	2	.7	.63	1.12	2.5	.0
3	1.000	2	.5	.36	1.39	3.0	.0
3	1.000	1	123.0	100.90	1.22	.0	.5
3	1.000	1	20.5	17.70	1.16	.0	1.0
3	1.000	1	5.1	5.50	.93	.0	1.5
3	1.000	1	2.7	2.37	1.14	.0	2.0
3	1.000	1	1.4	1.22	1.15	.0	2.5
3	1.000	1	.7	.71	.99	.0	3.0
3	1.000	1	136.7	100.90	1.35	.0	.5
3	1.000	1	23.2	17.70	1.31	.0	1.0
3	1.000	1	6.8	5.50	1.24	.0	1.5
3	1.000	1	3.1	2.37	1.31	.0	2.0
3	1.000	1	1.6	1.22	1.31	.0	2.5
3	1.000	1	1.1	.71	1.55	.0	3.0
3	1.000	1	205.1	106.90	1.92	.5	.0
3	1.000	1	13.7	10.40	1.32	1.0	.0
3	1.000	1	4.1	2.96	1.38	1.5	.0
3	1.000	1	1.6	1.23	1.30	2.0	.0
3	1.000	1	.8	.63	1.28	2.5	.0
3	1.000	1	239.2	106.90	2.24	.5	.0
3	1.000	1	16.4	10.40	1.58	1.0	.0
3	1.000	1	4.8	2.96	1.62	1.5	.0
3	1.000	1	1.9	1.23	1.54	2.0	.0
3	1.000	1	1.1	.63	1.76	2.5	.0

COMPLETE LISTING FOR ALL MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
3	.530	1	188.7	100.90	1.87	.0	.
3	.530	1	26.8	17.70	1.51	.0	1.
3	.530	1	7.9	5.50	1.44	.0	1.5
3	.530	1	3.1	2.37	1.31	.0	2.
3	.530	1	1.6	1.22	1.31	.0	2.
3	.530	1	1.0	.71	1.41	.0	3.0
3	.530	1	125.8	100.90	1.25	.0	.5
3	.530	1	22.0	17.70	1.24	.0	1.
3	.530	1	6.7	5.50	1.22	.0	1.
3	.530	1	3.3	2.37	1.39	.0	2.0
3	.530	1	1.6	1.22	1.31	.0	2.
3	.530	1	.8	.71	1.13	.0	3.
3	.530	1	157.3	106.90	1.47	.5	.0
3	.530	1	14.9	10.40	1.43	1.0	.
3	.530	1	3.9	2.96	1.32	1.5	.
3	.530	1	1.9	1.23	1.54	2.0	.0
3	.530	1	1.0	.63	1.60	2.5	.0
3	.530	1	102.2	106.90	.96	.5	.
3	.530	1	13.4	10.40	1.29	1.0	.
3	.530	1	3.6	2.96	1.22	1.5	.0
3	.530	1	1.6	1.23	1.30	2.0	.
3	.530	1	1.0	.63	1.60	2.5	.
3	.530	2	107.8	100.90	1.07	.0	.5
3	.530	2	18.7	17.70	1.06	.0	1.
3	.530	2	6.5	5.50	1.18	.0	1.
3	.530	2	2.6	2.37	1.10	.0	2.0
3	.530	2	1.3	1.22	1.07	.0	2.5
3	.530	2	107.8	100.90	1.07	.0	.
3	.530	2	20.1	17.70	1.14	.0	1.
3	.530	2	6.5	5.50	1.18	.0	1.5
3	.530	2	2.9	2.37	1.22	.0	2.
3	.530	2	1.1	1.22	.90	.0	2.
3	.530	2	172.5	106.90	1.61	.5	.0
3	.530	2	11.5	10.40	1.11	1.0	.
3	.530	2	3.6	2.96	1.22	1.5	.
3	.530	2	1.4	1.23	1.14	2.0	.0
3	.530	2	.9	.63	1.44	2.5	.0
3	.530	2	.6	.36	1.66	3.0	.
3	.530	2	179.7	106.90	1.68	.5	.
3	.530	2	14.4	10.40	1.38	1.0	.0
3	.530	2	4.0	2.96	1.35	1.5	.
3	.530	2	1.7	1.23	1.38	2.0	.
3	.530	2	.9	.63	1.44	2.5	.0
3	.530	2	.6	.36	1.66	3.0	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
3	.173	2	153.2	100.90	1.52	.0	.5
3	.173	2	21.6	17.70	1.22	.0	1.0
3	.173	2	8.3	5.50	1.51	.0	1.5
3	.173	2	2.9	2.37	1.22	.0	2.0
3	.173	2	1.4	1.22	1.15	.0	2.5
3	.173	2	117.2	100.90	1.16	.0	.5
3	.173	2	21.6	17.70	1.22	.0	1.0
3	.173	2	6.5	5.50	1.18	.0	1.5
3	.173	2	2.9	2.37	1.22	.0	2.0
3	.173	2	1.4	1.22	1.15	.0	2.5
3	.173	2	252.4	106.90	2.36	.5	.0
3	.173	2	15.3	10.40	1.47	1.0	.0
3	.173	2	4.7	2.96	1.59	1.5	.0
3	.173	2	1.8	1.23	1.46	2.0	.0
3	.173	2	1.1	.63	1.76	2.5	.0
3	.173	2	.7	.36	1.94	3.0	.0
3	.173	2	180.3	106.90	1.69	.5	.0
3	.173	2	16.2	10.40	1.56	1.0	.0
3	.173	2	3.6	2.96	1.22	1.5	.0
3	.173	2	2.2	1.23	1.79	2.0	.0
3	.173	2	1.1	.63	1.76	2.5	.0
3	.173	2	.7	.36	1.94	3.0	.0
3	.173	1	96.2	100.90	.95	.0	.5
3	.173	1	21.4	17.70	1.21	.0	1.0
3	.173	1	5.7	5.50	1.04	.0	1.5
3	.173	1	2.9	2.37	1.22	.0	2.0
3	.173	1	1.8	1.22	1.48	.0	2.5
3	.173	1	1.1	.71	1.55	.0	3.0
3	.173	1	142.6	100.90	1.41	.0	.5
3	.173	1	21.4	17.70	1.21	.0	1.0
3	.173	1	6.4	5.50	1.16	.0	1.5
3	.173	1	2.9	2.37	1.22	.0	2.0
3	.173	1	1.4	1.22	1.15	.0	2.5
3	.173	1	1.1	.71	1.55	.0	3.0
3	.173	1	231.7	106.90	2.17	.5	.0
3	.173	1	13.6	10.40	1.31	1.0	.0
3	.173	1	3.9	2.96	1.32	1.5	.0
3	.173	1	1.8	1.23	1.46	2.0	.0
3	.173	1	1.1	.63	1.76	2.5	.0
3	.173	1	187.1	106.90	1.75	.5	.0
3	.173	1	16.9	10.40	1.63	1.0	.0
3	.173	1	4.3	2.96	1.45	1.5	.0
3	.173	1	2.1	1.23	1.71	2.0	.0
3	.173	1	1.1	.63	1.76	2.5	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
4	.173	2	158.5	100.90	1.57	.0	.5
4	.173	2	26.4	17.70	1.49	.0	1.
4	.173	2	7.8	5.50	1.42	.0	1.5
4	.173	2	3.2	2.37	1.35	.0	2.0
4	.173	2	1.7	1.22	1.39	.0	2.
4	.173	2	1.4	.71	1.97	.0	3.
4	.173	2	81.0	100.90	.80	.0	.5
4	.173	2	18.7	17.70	1.06	.0	1.
4	.173	2	6.7	5.50	1.22	.0	1.
4	.173	2	2.8	2.37	1.18	.0	2.0
4	.173	2	1.4	1.22	1.15	.0	2.5
4	.173	2	1.0	.71	1.41	.0	3.
4	.173	2	140.9	106.90	1.32	.5	.0
4	.173	2	16.7	10.40	1.61	1.0	.0
4	.173	2	4.2	2.96	1.42	1.5	.
4	.173	2	1.7	1.23	1.38	2.0	.
4	.173	2	1.0	.63	1.60	2.5	.0
4	.173	2	.7	.36	1.94	3.0	.
4	.173	2	149.7	106.90	1.40	.5	.
4	.173	2	14.1	10.40	1.36	1.0	.0
4	.173	2	4.2	2.96	1.42	1.5	.0
4	.173	2	1.7	1.23	1.38	2.0	.
4	.173	2	1.0	.63	1.60	2.5	.0
4	.173	2	.7	.36	1.94	3.0	.0
4	.173	1	128.3	100.90	1.27	.0	.
4	.173	1	22.3	17.70	1.26	.0	1.
4	.173	1	6.8	5.50	1.24	.0	1.5
4	.173	1	3.2	2.37	1.35	.0	2.
4	.173	1	1.8	1.22	1.48	.0	2.
4	.173	1	1.1	.71	1.55	.0	3.0
4	.173	1	163.9	100.90	1.62	.0	.5
4	.173	1	25.0	17.70	1.41	.0	1.
4	.173	1	7.8	5.50	1.42	.0	1.5
4	.173	1	3.6	2.37	1.52	.0	2.0
4	.173	1	1.8	1.22	1.48	.0	2.
4	.173	1	1.1	.71	1.55	.0	3.
4	.173	1	213.9	106.90	2.00	.5	.0
4	.173	1	17.8	10.40	1.71	1.0	.
4	.173	1	5.0	2.96	1.69	1.5	.
4	.173	1	1.8	1.23	1.46	2.0	.0
4	.173	1	1.1	.63	1.76	2.5	.0
4	.173	1	.7	.36	1.94	3.0	.
4	.173	1	196.0	106.90	1.83	.5	.0
4	.173	1	17.8	10.40	1.71	1.0	.0
4	.173	1	4.6	2.96	1.55	1.5	.
4	.173	1	2.1	1.23	1.71	2.0	.
4	.173	1	1.1	.63	1.76	2.5	.0
4	.173	1	.7	.36	1.94	3.0	.

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
4	.530	2	148.9	100.90	1.48	.0	.5
4	.530	2	24.8	17.70	1.40	.0	1.0
4	.530	2	7.4	5.50	1.35	.0	1.5
4	.530	2	3.1	2.37	1.31	.0	2.0
4	.530	2	1.6	1.22	1.31	.0	2.5
4	.530	2	.8	.71	1.13	.0	3.0
4	.530	2	111.7	100.90	1.11	.0	.5
4	.530	2	20.7	17.70	1.17	.0	1.0
4	.530	2	6.2	5.50	1.13	.0	1.5
4	.530	2	2.5	2.37	1.05	.0	2.0
4	.530	2	1.6	1.22	1.31	.0	2.5
4	.530	2	1.0	.71	1.41	.0	3.0
4	.530	2	153.0	106.90	1.43	.5	.0
4	.530	2	14.9	10.40	1.43	1.0	.0
4	.530	2	4.1	2.96	1.38	1.5	.0
4	.530	2	1.6	1.23	1.30	2.0	.0
4	.530	2	.8	.63	1.28	2.5	.0
4	.530	2	.5	.36	1.39	3.0	.0
4	.530	2	107.5	106.90	1.01	.5	.0
4	.530	2	13.2	10.40	1.27	1.0	.0
4	.530	2	4.1	2.96	1.38	1.5	.0
4	.530	2	1.6	1.23	1.30	2.0	.0
4	.530	2	1.0	.63	1.60	2.5	.0
4	.530	2	.6	.36	1.66	3.0	.0
4	.530	1	170.9	100.90	1.69	.0	.5
4	.530	1	25.6	17.70	1.45	.0	1.0
4	.530	1	8.5	5.50	1.55	.0	1.5
4	.530	1	3.4	2.37	1.43	.0	2.0
4	.530	1	1.7	1.22	1.39	.0	2.5
4	.530	1	1.0	.71	1.41	.0	3.0
4	.530	1	123.9	100.90	1.23	.0	.5
4	.530	1	18.0	17.70	1.02	.0	1.0
4	.530	1	5.8	5.50	1.05	.0	1.5
4	.530	1	2.9	2.37	1.22	.0	2.0
4	.530	1	1.4	1.22	1.15	.0	2.5
4	.530	1	1.0	.71	1.41	.0	3.0
4	.530	1	196.6	106.90	1.84	.5	.0
4	.530	1	15.4	10.40	1.48	1.0	.0
4	.530	1	4.3	2.96	1.45	1.5	.0
4	.530	1	2.0	1.23	1.63	2.0	.0
4	.530	1	1.0	.63	1.60	2.5	.0
4	.530	1	.7	.36	1.94	3.0	.0
4	.530	1	213.7	106.90	2.00	.5	.0
4	.530	1	20.5	10.40	1.97	1.0	.0
4	.530	1	4.8	2.96	1.62	1.5	.0
4	.530	1	1.7	1.23	1.38	2.0	.0
4	.530	1	1.0	.63	1.60	2.5	.0
4	.530	1	.5	.36	1.39	3.0	.0

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
4	1.000	1	181.8	100.90	1.80	.0	.
4	1.000	1	8.7	17.70	.49	.0	1.
4	1.000	1	8.2	5.50	1.49	.0	1.5
4	1.000	1	3.1	2.37	1.31	.0	2.0
4	1.000	1	1.7	1.22	1.39	.0	2.
4	1.000	1	.9	.71	1.27	.0	3.0
4	1.000	1	125.5	100.90	1.24	.0	.5
4	1.000	1	24.2	17.70	1.37	.0	1.0
4	1.000	1	6.9	5.50	1.25	.0	1.5
4	1.000	1	3.5	2.37	1.48	.0	2.0
4	1.000	1	1.7	1.22	1.39	.0	2.5
4	1.000	1	.9	.71	1.27	.0	3.
4	1.000	1	177.5	106.90	1.66	.5	.0
4	1.000	1	15.6	10.40	1.50	1.0	.0
4	1.000	1	4.3	2.96	1.45	1.5	.
4	1.000	1	1.9	1.23	1.54	2.0	.0
4	1.000	1	.9	.63	1.44	2.5	.0
4	1.000	1	.9	.36	2.49	3.0	.
4	1.000	1	112.6	106.90	1.05	.5	.0
4	1.000	1	15.6	10.40	1.50	1.0	.0
4	1.000	1	4.0	2.96	1.35	1.5	.0
4	1.000	1	1.9	1.23	1.54	2.0	.0
4	1.000	1	1.2	.63	1.92	2.5	.0
4	1.000	2	145.3	100.90	1.44	.0	.5
4	1.000	2	21.4	17.70	1.21	.0	1.0
4	1.000	2	6.8	5.50	1.24	.0	1.5
4	1.000	2	2.7	2.37	1.14	.0	2.0
4	1.000	2	1.4	1.22	1.15	.0	2.5
4	1.000	2	1.2	.71	1.69	.0	3.0
4	1.000	2	166.7	100.90	1.65	.0	.5
4	1.000	2	26.5	17.70	1.50	.0	1.0
4	1.000	2	8.5	5.50	1.55	.0	1.5
4	1.000	2	3.4	2.37	1.43	.0	2.0
4	1.000	2	1.7	1.22	1.39	.0	2.5
4	1.000	2	.3	.71	.42	.0	3.0
4	1.000	2	166.7	106.90	1.56	.5	.0
4	1.000	2	14.5	10.40	1.39	1.0	.0
4	1.000	2	4.4	2.96	1.49	1.5	.0
4	1.000	2	1.7	1.23	1.38	2.0	.0
4	1.000	2	1.0	.63	1.60	2.5	.0
4	1.000	2	.7	.36	1.94	3.0	.0
4	1.000	2	192.3	106.90	1.80	.5	.0
4	1.000	2	15.4	10.40	1.48	1.0	.0
4	1.000	2	3.9	2.96	1.32	1.5	.0
4	1.000	2	1.9	1.23	1.54	2.0	.0
4	1.000	2	1.0	.63	1.60	2.5	.0
4	1.000	2	.7	.36	1.94	3.0	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
4	10.000	1	114.7	100.90	1.14	.0	.5
4	10.000	1	21.7	17.70	1.23	.0	1.0
4	10.000	1	6.0	5.50	1.09	.0	1.5
4	10.000	1	2.3	2.37	.97	.0	2.0
4	10.000	1	.5	1.22	.41	.0	2.5
4	10.000	1	.5	.71	.70	.0	3.0
4	10.000	1	173.7	100.90	1.72	.0	.5
4	10.000	1	11.3	17.70	.64	.0	1.0
4	10.000	1	6.3	5.50	1.15	.0	1.5
4	10.000	1	2.8	2.37	1.18	.0	2.0
4	10.000	1	1.7	1.22	1.39	.0	2.5
4	10.000	1	1.5	.71	2.11	.0	3.0
4	10.000	1	286.5	106.90	2.68	.5	.0
4	10.000	1	13.8	10.40	1.33	1.0	.0
4	10.000	1	6.3	2.96	2.13	1.5	.0
4	10.000	1	4.2	1.23	3.41	2.0	.0
4	10.000	1	3.5	.63	5.59	2.5	.0
4	10.000	1	3.8	.36	10.53	3.0	.0
4	10.000	1	225.7	106.90	2.11	.5	.0
4	10.000	1	4.8	10.40	.46	1.0	.0
4	10.000	1	2.3	2.96	.78	1.5	.0
4	10.000	1	2.7	1.23	2.20	2.0	.0
4	10.000	1	2.8	.63	4.47	2.5	.0
4	10.000	1	3.8	.36	10.53	3.0	.0
4	10.000	2	173.7	100.90	1.72	.0	.5
4	10.000	2	19.2	17.70	1.08	.0	1.0
4	10.000	2	5.5	5.50	1.00	.0	1.5
4	10.000	2	3.0	2.37	1.27	.0	2.0
4	10.000	2	1.3	1.22	1.07	.0	2.5
4	10.000	2	.8	.71	1.13	.0	3.0
4	10.000	2	138.8	100.90	1.38	.0	.5
4	10.000	2	20.8	17.70	1.18	.0	1.0
4	10.000	2	5.8	5.50	1.05	.0	1.5
4	10.000	2	2.2	2.37	.93	.0	2.0
4	10.000	2	.7	1.22	.57	.0	2.5
4	10.000	2	1.2	.71	1.69	.0	3.0
4	10.000	2	86.8	106.90	.81	.5	.0
4	10.000	2	13.0	10.40	1.25	1.0	.0
4	10.000	2	4.8	2.96	1.62	1.5	.0
4	10.000	2	3.5	1.23	2.85	2.0	.0
4	10.000	2	2.3	.63	3.67	2.5	.0
4	10.000	2	1.8	.36	4.99	3.0	.0
4	10.000	2	138.8	106.90	1.30	.5	.0
4	10.000	2	15.7	10.40	1.51	1.0	.0
4	10.000	2	4.3	2.96	1.45	1.5	.0
4	10.000	2	2.2	1.23	1.79	2.0	.0
4	10.000	2	1.0	.63	1.60	2.5	.0
4	10.000	2	1.0	.36	2.77	3.0	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
4	5.000	1	205.4	100.90	2.04	.0	.
4	5.000	1	19.6	17.70	1.11	.0	1.
4	5.000	1	5.4	5.50	.98	.0	1.5
4	5.000	1	2.4	2.37	1.01	.0	2.
4	5.000	1	1.2	1.22	.98	.0	2.
4	5.000	1	1.2	.71	1.69	.0	3.0
4	5.000	1	143.5	100.90	1.42	.0	.5
4	5.000	1	20.2	17.70	1.14	.0	1.
4	5.000	1	6.5	5.50	1.18	.0	1.5
4	5.000	1	2.4	2.37	1.01	.0	2.0
4	5.000	1	1.2	1.22	.98	.0	2.
4	5.000	1	.6	.71	.85	.0	3.
4	5.000	1	184.5	106.90	1.73	.5	.0
4	5.000	1	14.3	10.40	1.38	1.0	.
4	5.000	1	4.2	2.96	1.42	1.5	.
4	5.000	1	1.8	1.23	1.46	2.0	.0
4	5.000	1	1.2	.63	1.92	2.5	.0
4	5.000	1	.6	.36	1.66	3.0	.
4	5.000	1	195.2	106.90	1.83	.5	.0
4	5.000	1	17.3	10.40	1.66	1.0	.0
4	5.000	1	6.0	2.96	2.03	1.5	.
4	5.000	1	3.0	1.23	2.44	2.0	.
4	5.000	1	1.8	.63	2.88	2.5	.0
4	5.000	1	1.8	.36	4.99	3.0	.
4	5.000	2	168.3	100.90	1.67	.0	.
4	5.000	2	24.4	17.70	1.38	.0	1.0
4	5.000	2	8.5	5.50	1.55	.0	1.5
4	5.000	2	3.7	2.37	1.56	.0	2.
4	5.000	2	2.4	1.22	1.97	.0	2.5
4	5.000	2	3.0	.71	4.23	.0	3.0
4	5.000	2	157.9	100.90	1.56	.0	.
4	5.000	2	17.7	17.70	1.00	.0	1.
4	5.000	2	5.5	5.50	1.00	.0	1.5
4	5.000	2	2.4	2.37	1.01	.0	2.
4	5.000	2	1.8	1.22	1.48	.0	2.
4	5.000	2	1.2	.71	1.69	.0	3.0
4	5.000	2	168.3	106.90	1.57	.5	.0
4	5.000	2	12.2	10.40	1.17	1.0	.
4	5.000	2	4.3	2.96	1.45	1.5	.0
4	5.000	2	2.4	1.23	1.95	2.0	.0
4	5.000	2	1.8	.63	2.88	2.5	.
4	5.000	2	1.8	.36	4.99	3.0	.
4	5.000	2	131.7	106.90	1.23	.5	.0
4	5.000	2	13.4	10.40	1.29	1.0	.
4	5.000	2	3.7	2.96	1.25	1.5	.
4	5.000	2	1.2	1.23	.98	2.0	.0
4	5.000	2	.6	.63	.96	2.5	.0
4	5.000	2	.6	.36	1.66	3.0	.

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
5	5.000	2	178.3	100.90	1.77	.0	.5
5	5.000	2	20.7	17.70	1.17	.0	1.0
5	5.000	2	6.5	5.50	1.18	.0	1.5
5	5.000	2	3.8	2.37	1.60	.0	2.0
5	5.000	2	2.7	1.22	2.21	.0	2.5
5	5.000	2	159.2	100.90	1.58	.0	.5
5	5.000	2	21.7	17.70	1.23	.0	1.0
5	5.000	2	7.1	5.50	1.29	.0	1.5
5	5.000	2	3.8	2.37	1.60	.0	2.0
5	5.000	2	1.1	1.22	.90	.0	2.5
5	5.000	2	.5	.71	.70	.0	3.0
5	5.000	2	168.5	106.90	1.58	.5	.0
5	5.000	2	14.1	10.40	1.36	1.0	.0
5	5.000	2	5.4	2.96	1.82	1.5	.0
5	5.000	2	3.3	1.23	2.68	2.0	.0
5	5.000	2	2.2	.63	3.51	2.5	.0
5	5.000	2	2.2	.36	6.09	3.0	.0
5	5.000	2	121.7	106.90	1.14	.5	.0
5	5.000	2	5.4	10.40	.52	1.0	.0
5	5.000	2	2.2	2.96	.74	1.5	.0
5	5.000	2	1.1	1.23	.89	2.0	.0
5	5.000	2	1.1	.63	1.76	2.5	.0
5	5.000	2	.5	.36	1.39	3.0	.0
5	5.000	1	151.6	100.90	1.50	.0	.5
5	5.000	1	20.9	17.70	1.18	.0	1.0
5	5.000	1	6.6	5.50	1.20	.0	1.5
5	5.000	1	2.7	2.37	1.14	.0	2.0
5	5.000	1	1.1	1.22	.90	.0	2.5
5	5.000	1	1.1	.71	1.55	.0	3.0
5	5.000	1	156.0	100.90	1.55	.0	.5
5	5.000	1	20.9	17.70	1.18	.0	1.0
5	5.000	1	7.1	5.50	1.29	.0	1.5
5	5.000	1	3.3	2.37	1.39	.0	2.0
5	5.000	1	2.2	1.22	1.80	.0	2.5
5	5.000	1	1.6	.71	2.25	.0	3.0
5	5.000	1	198.9	106.90	1.86	.5	.0
5	5.000	1	15.9	10.40	1.53	1.0	.0
5	5.000	1	6.6	2.96	2.23	1.5	.0
5	5.000	1	3.3	1.23	2.68	2.0	.0
5	5.000	1	2.2	.63	3.51	2.5	.0
5	5.000	1	213.2	106.90	1.99	.5	.0
5	5.000	1	14.3	10.40	1.38	1.0	.0
5	5.000	1	3.8	2.96	1.28	1.5	.0
5	5.000	1	2.2	1.23	1.79	2.0	.0
5	5.000	1	1.1	.63	1.76	2.5	.0
5	5.000	1	.5	.36	1.39	3.0	.0

COMPLETE LISTING FOR ALL MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
5	10.000	1	142.7	100.90	1.41	.0	.
5	10.000	1	21.0	17.70	1.19	.0	1.0
5	10.000	1	5.6	5.50	1.02	.0	1.5
5	10.000	1	2.6	2.37	1.10	.0	2.
5	10.000	1	1.1	1.22	.90	.0	2.
5	10.000	1	.6	.71	.85	.0	3.0
5	10.000	1	184.8	100.90	1.83	.0	.
5	10.000	1	21.0	17.70	1.19	.0	1.
5	10.000	1	7.4	5.50	1.35	.0	1.5
5	10.000	1	3.7	2.37	1.56	.0	2.
5	10.000	1	2.6	1.22	2.13	.0	2.
5	10.000	1	2.1	.71	2.96	.0	3.0
5	10.000	1	268.9	106.90	2.52	.5	.0
5	10.000	1	21.0	10.40	2.02	1.0	.
5	10.000	1	7.7	2.96	2.60	1.5	.
5	10.000	1	5.3	1.23	4.31	2.0	.0
5	10.000	1	3.9	.63	6.23	2.5	.
5	10.000	1	285.6	106.90	2.67	.5	.
5	10.000	1	16.8	10.40	1.62	1.0	.0
5	10.000	1	5.0	2.96	1.69	1.5	.
5	10.000	1	2.4	1.23	1.95	2.0	.
5	10.000	1	2.1	.63	3.35	2.5	.0
5	10.000	1	1.3	.36	3.60	3.0	.0
5	10.000	1	159.5	100.90	1.58	.0	.
5	10.000	1	23.8	17.70	1.34	.0	1.
5	10.000	1	5.1	5.50	.93	.0	1.5
5	10.000	1	2.4	2.37	1.01	.0	2.
5	10.000	1	1.4	1.22	1.15	.0	2.
5	10.000	1	1.9	.71	2.68	.0	3.0
5	10.000	1	170.9	100.90	1.69	.0	.5
5	10.000	1	21.9	17.70	1.24	.0	1.
5	10.000	1	8.2	5.50	1.49	.0	1.5
5	10.000	1	4.4	2.37	1.86	.0	2.0
5	10.000	1	3.1	1.22	2.54	.0	2.
5	10.000	1	285.0	106.90	2.67	.5	.
5	10.000	1	16.1	10.40	1.55	1.0	.0
5	10.000	1	7.5	2.96	2.53	1.5	.
5	10.000	1	4.8	1.23	3.90	2.0	.
5	10.000	1	3.6	.63	5.75	2.5	.0
5	10.000	1	3.2	.36	8.86	3.0	.0
5	10.000	1	189.9	106.90	1.78	.5	.
5	10.000	1	6.8	10.40	.65	1.0	.0
5	10.000	1	4.4	2.96	1.49	1.5	.0
5	10.000	1	2.2	1.23	1.79	2.0	.
5	10.000	1	1.5	.63	2.40	2.5	.
5	10.000	1	1.2	.36	3.32	3.0	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
5	1.000	1	166.7	100.90	1.65	.0	.5
5	1.000	1	41.5	17.70	2.34	.0	1.0
5	1.000	1	14.8	5.50	2.69	.0	1.5
5	1.000	1	3.4	2.37	1.43	.0	2.0
5	1.000	1	1.8	1.22	1.48	.0	2.5
5	1.000	1	1.0	.71	1.41	.0	3.0
5	1.000	1	103.7	100.90	1.03	.0	.5
5	1.000	1	23.7	17.70	1.34	.0	1.0
5	1.000	1	6.7	5.50	1.22	.0	1.5
5	1.000	1	3.3	2.37	1.39	.0	2.0
5	1.000	1	1.9	1.22	1.56	.0	2.5
5	1.000	1	1.2	.71	1.69	.0	3.0
5	1.000	1	148.1	106.90	1.39	.5	.0
5	1.000	1	14.8	10.40	1.42	1.0	.0
5	1.000	1	4.4	2.96	1.49	1.5	.0
5	1.000	1	1.8	1.23	1.46	2.0	.0
5	1.000	1	1.2	.63	1.92	2.5	.0
5	1.000	1	222.2	106.90	2.08	.5	.0
5	1.000	1	17.8	10.40	1.71	1.0	.0
5	1.000	1	5.5	2.96	1.86	1.5	.0
5	1.000	1	2.8	1.23	2.28	2.0	.0
5	1.000	1	1.5	.63	2.40	2.5	.0
5	1.000	2	282.5	100.90	2.80	.0	.5
5	1.000	2	54.2	17.70	3.06	.0	1.0
5	1.000	2	15.8	5.50	2.87	.0	1.5
5	1.000	2	5.9	2.37	2.49	.0	2.0
5	1.000	2	5.0	1.22	4.10	.0	2.5
5	1.000	2	1.8	.71	2.54	.0	3.0
5	1.000	2	452.0	100.90	4.48	.0	.5
5	1.000	2	56.5	17.70	3.19	.0	1.0
5	1.000	2	16.9	5.50	3.07	.0	1.5
5	1.000	2	8.5	2.37	3.59	.0	2.0
5	1.000	2	3.2	1.22	2.62	.0	2.5
5	1.000	2	.9	.71	1.27	.0	3.0
5	1.000	2	497.2	106.90	4.65	.5	.0
5	1.000	2	33.9	10.40	3.26	1.0	.0
5	1.000	2	8.5	2.96	2.87	1.5	.0
5	1.000	2	3.4	1.23	2.76	2.0	.0
5	1.000	2	1.4	.63	2.24	2.5	.0
5	1.000	2	565.0	106.90	5.29	.5	.0
5	1.000	2	45.2	10.40	4.35	1.0	.0
5	1.000	2	11.3	2.96	3.82	1.5	.0
5	1.000	2	5.0	1.23	4.07	2.0	.0
5	1.000	2	2.7	.63	4.31	2.5	.0
5	1.000	2	1.6	.36	4.43	3.0	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
5	.530	2	491.4	100.90	4.87	.0	.
5	.530	2	85.4	17.70	4.82	.0	1.0
5	.530	2	25.7	5.50	4.67	.0	1.5
5	.530	2	8.6	2.37	3.63	.0	2.
5	.530	2	4.2	1.22	3.44	.0	2.
5	.530	2	341.9	100.90	3.39	.0	.5
5	.530	2	47.0	17.70	2.66	.0	1.
5	.530	2	21.3	5.50	3.87	.0	1.
5	.530	2	7.7	2.37	3.25	.0	2.0
5	.530	2	4.2	1.22	3.44	.0	2.
5	.530	2	2.1	.71	2.96	.0	3.
5	.530	2	384.7	106.90	3.60	.5	.0
5	.530	2	42.8	10.40	4.12	1.0	.0
5	.530	2	12.0	2.96	4.05	1.5	.
5	.530	2	4.7	1.23	3.82	2.0	.
5	.530	2	3.0	.63	4.79	2.5	.0
5	.530	2	2.1	.36	5.82	3.0	.
5	.530	2	320.6	106.90	3.00	.5	.
5	.530	2	32.0	10.40	3.08	1.0	.0
5	.530	2	9.8	2.96	3.31	1.5	.
5	.530	2	4.7	1.23	3.82	2.0	.
5	.530	2	3.0	.63	4.79	2.5	.0
5	.530	2	1.7	.36	4.71	3.0	.0
5	.530	1	378.4	100.90	3.75	.0	.
5	.530	1	56.7	17.70	3.20	.0	1.
5	.530	1	18.9	5.50	3.44	.0	1.5
5	.530	1	8.4	2.37	3.54	.0	2.
5	.530	1	5.9	1.22	4.84	.0	2.
5	.530	1	3.8	.71	5.35	.0	3.0
5	.530	1	462.4	100.90	4.58	.0	.
5	.530	1	63.1	17.70	3.56	.0	1.
5	.530	1	21.0	5.50	3.82	.0	1.5
5	.530	1	9.3	2.37	3.92	.0	2.0
5	.530	1	5.0	1.22	4.10	.0	2.
5	.530	1	3.0	.71	4.23	.0	3.
5	.530	1	756.6	106.90	7.08	.5	.0
5	.530	1	48.3	10.40	4.64	1.0	.
5	.530	1	14.8	2.96	5.00	1.5	.
5	.530	1	5.9	1.23	4.80	2.0	.0
5	.530	1	3.4	.63	5.43	2.5	.
5	.530	1	483.4	106.90	4.52	.5	.
5	.530	1	46.2	10.40	4.44	1.0	.0
5	.530	1	12.6	2.96	4.26	1.5	.0
5	.530	1	5.0	1.23	4.07	2.0	.
5	.530	1	3.8	.63	6.07	2.5	.
5	.530	1	2.5	.36	6.93	3.0	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
5	.173	1	156.9	100.90	1.56	.0	.5
5	.173	1	21.0	17.70	1.19	.0	1.0
5	.173	1	7.9	5.50	1.44	.0	1.5
5	.173	1	3.3	2.37	1.39	.0	2.0
5	.173	1	2.2	1.22	1.80	.0	2.5
5	.173	1	1.7	.71	2.39	.0	3.0
5	.173	1	112.1	100.90	1.11	.0	.5
5	.173	1	19.0	17.70	1.07	.0	1.0
5	.173	1	6.7	5.50	1.22	.0	1.5
5	.173	1	3.3	2.37	1.39	.0	2.0
5	.173	1	2.2	1.22	1.80	.0	2.5
5	.173	1	1.7	.71	2.39	.0	3.0
5	.173	1	168.1	106.90	1.57	.5	.0
5	.173	1	12.9	10.40	1.24	1.0	.0
5	.173	1	4.5	2.96	1.52	1.5	.0
5	.173	1	2.2	1.23	1.79	2.0	.0
5	.173	1	1.1	.63	1.76	2.5	.0
5	.173	1	168.1	106.90	1.57	.5	.0
5	.173	1	14.0	10.40	1.35	1.0	.0
5	.173	1	4.5	2.96	1.52	1.5	.0
5	.173	1	2.2	1.23	1.79	2.0	.0
5	.173	1	1.7	.63	2.72	2.5	.0
5	.173	1	157.0	100.90	1.56	.0	.5
5	.173	1	17.5	17.70	.99	.0	1.0
5	.173	1	8.7	5.50	1.58	.0	1.5
5	.173	1	2.9	2.37	1.22	.0	2.0
5	.173	1	1.8	1.22	1.48	.0	2.5
5	.173	1	104.7	100.90	1.04	.0	.5
5	.173	1	18.6	17.70	1.05	.0	1.0
5	.173	1	4.1	5.50	.75	.0	1.5
5	.173	1	2.3	2.37	.97	.0	2.0
5	.173	1	1.8	1.22	1.48	.0	2.5
5	.173	1	189.0	106.90	1.77	.5	.0
5	.173	1	15.1	10.40	1.45	1.0	.0
5	.173	1	4.6	2.96	1.55	1.5	.0
5	.173	1	1.2	1.23	.98	2.0	.0
5	.173	1	81.4	106.90	.76	.5	.0
5	.173	1	10.5	10.40	1.01	1.0	.0
5	.173	1	3.5	2.96	1.18	1.5	.0
5	.173	1	1.8	1.23	1.46	2.0	.0

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
6	.173	2	84.4	100.90	.84	.0	.
6	.173	2	15.6	17.70	.88	.0	1.
6	.173	2	5.2	5.50	.95	.0	1.5
6	.173	2	142.8	100.90	1.42	.0	.
6	.173	2	23.4	17.70	1.32	.0	1.
6	.173	2	5.2	5.50	.95	.0	1.5
6	.173	2	2.6	2.37	1.10	.0	2.0
6	.173	2	168.8	106.90	1.58	.5	.
6	.173	2	15.6	10.40	1.50	1.0	.0
6	.173	2	2.6	2.96	.88	1.5	.0
6	.173	2	162.4	106.90	1.52	.5	.
6	.173	2	14.2	10.40	1.37	1.0	.
6	.173	2	3.8	2.96	1.28	1.5	.0
6	.173	1	142.8	100.90	1.42	.0	.
6	.173	1	19.4	17.70	1.10	.0	1.
6	.173	1	7.8	5.50	1.42	.0	1.5
6	.173	1	3.8	2.37	1.60	.0	2.0
6	.173	1	129.8	100.90	1.29	.0	.
6	.173	1	20.8	17.70	1.18	.0	1.0
6	.173	1	6.4	5.50	1.16	.0	1.5
6	.173	1	3.8	2.37	1.60	.0	2.
6	.173	1	129.8	106.90	1.21	.5	.
6	.173	1	16.8	10.40	1.62	1.0	.0
6	.173	1	5.2	2.96	1.76	1.5	.
6	.173	1	2.6	1.23	2.11	2.0	.
6	.173	1	129.8	106.90	1.21	.5	.0
6	.173	1	15.6	10.40	1.50	1.0	.0
6	.173	1	5.2	2.96	1.76	1.5	.
6	.173	1	2.6	1.23	2.11	2.0	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
6	.530	1	161.2	100.90	1.60	.0	.5
6	.530	1	23.4	17.70	1.32	.0	1.0
6	.530	1	.7	5.50	.13	.0	1.5
6	.530	1	3.2	2.37	1.35	.0	2.0
6	.530	1	1.4	1.22	1.15	.0	2.5
6	.530	1	.9	.71	1.27	.0	3.0
6	.530	1	146.5	100.90	1.45	.0	.5
6	.530	1	26.4	17.70	1.49	.0	1.0
6	.530	1	5.1	5.50	.93	.0	1.5
6	.530	1	2.2	2.37	.93	.0	2.0
6	.530	1	1.2	1.22	.98	.0	2.5
6	.530	1	1.0	.71	1.41	.0	3.0
6	.530	1	190.5	106.90	1.78	.5	.0
6	.530	1	11.0	10.40	1.06	1.0	.0
6	.530	1	3.4	2.96	1.15	1.5	.0
6	.530	1	1.6	1.23	1.30	2.0	.0
6	.530	1	.7	.63	1.12	2.5	.0
6	.530	1	124.5	106.90	1.16	.5	.0
6	.530	1	11.0	10.40	1.06	1.0	.0
6	.530	1	3.2	2.96	1.08	1.5	.0
6	.530	1	1.4	1.23	1.14	2.0	.0
6	.530	1	.9	.63	1.44	2.5	.0
6	.530	1	.5	.36	1.39	3.0	.0
6	.530	2	199.4	100.90	1.98	.0	.5
6	.530	2	25.6	17.70	1.45	.0	1.0
6	.530	2	7.1	5.50	1.29	.0	1.5
6	.530	2	2.7	2.37	1.14	.0	2.0
6	.530	2	1.9	1.22	1.56	.0	2.5
6	.530	2	142.4	100.90	1.41	.0	.5
6	.530	2	24.2	17.70	1.37	.0	1.0
6	.530	2	7.1	5.50	1.29	.0	1.5
6	.530	2	3.1	2.37	1.31	.0	2.0
6	.530	2	1.9	1.22	1.56	.0	2.5
6	.530	2	1.1	.71	1.55	.0	3.0
6	.530	2	142.4	106.90	1.33	.5	.0
6	.530	2	14.3	10.40	1.38	1.0	.0
6	.530	2	4.3	2.96	1.45	1.5	.0
6	.530	2	1.9	1.23	1.54	2.0	.0
6	.530	2	1.0	.63	1.60	2.5	.0
6	.530	2	.6	.36	1.66	3.0	.0
6	.530	2	106.9	106.90	1.00	.5	.0
6	.530	2	13.5	10.40	1.30	1.0	.0
6	.530	2	3.4	2.96	1.15	1.5	.0
6	.530	2	1.4	1.23	1.14	2.0	.0
6	.530	2	.9	.63	1.44	2.5	.0
6	.530	2	.6	.36	1.66	3.0	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
6	1.000	2	160.8	100.90	1.59	.0	.
6	1.000	2	25.4	17.70	1.44	.0	1.
6	1.000	2	8.5	5.50	1.55	.0	1.5
6	1.000	2	2.8	2.37	1.18	.0	2.
6	1.000	2	169.3	100.90	1.68	.0	.
6	1.000	2	24.5	17.70	1.38	.0	1.0
6	1.000	2	6.8	5.50	1.24	.0	1.5
6	1.000	2	3.2	2.37	1.35	.0	2.
6	1.000	2	2.1	1.22	1.72	.0	2.5
6	1.000	2	228.5	106.90	2.14	.5	.0
6	1.000	2	18.6	10.40	1.79	1.0	.
6	1.000	2	4.2	2.96	1.42	1.5	.
6	1.000	2	1.4	1.23	1.14	2.0	.0
6	1.000	2	1.4	.63	2.24	2.5	.
6	1.000	2	.9	.36	2.49	3.0	.
6	1.000	2	152.3	106.90	1.42	.5	.0
6	1.000	2	15.2	10.40	1.46	1.0	.0
6	1.000	2	4.0	2.96	1.35	1.5	.
6	1.000	2	1.7	1.23	1.38	2.0	.0
6	1.000	2	.8	.63	1.28	2.5	.0
6	1.000	2	.5	.36	1.39	3.0	.
6	1.000	1	174.5	100.90	1.73	.0	.
6	1.000	1	24.2	17.70	1.37	.0	1.0
6	1.000	1	7.3	5.50	1.33	.0	1.
6	1.000	1	3.0	2.37	1.27	.0	2.
6	1.000	1	1.5	1.22	1.23	.0	2.5
6	1.000	1	1.0	.71	1.41	.0	3.0
6	1.000	1	111.5	100.90	1.11	.0	.
6	1.000	1	20.8	17.70	1.18	.0	1.0
6	1.000	1	5.8	5.50	1.05	.0	1.5
6	1.000	1	2.4	2.37	1.01	.0	2.
6	1.000	1	1.2	1.22	.98	.0	2.
6	1.000	1	.8	.71	1.13	.0	3.0
6	1.000	1	111.5	106.90	1.04	.5	.
6	1.000	1	10.2	10.40	.98	1.0	.
6	1.000	1	3.6	2.96	1.22	1.5	.0
6	1.000	1	1.5	1.23	1.22	2.0	.0
6	1.000	1	1.0	.63	1.60	2.5	.
6	1.000	1	121.2	106.90	1.13	.5	.0
6	1.000	1	12.1	10.40	1.16	1.0	.0
6	1.000	1	4.1	2.96	1.38	1.5	.
6	1.000	1	2.1	1.23	1.71	2.0	.
6	1.000	1	1.0	.63	1.60	2.5	.0
6	1.000	1	.5	.36	1.39	3.0	.0

COMPLETE LISTING FOR ALL MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
6	5.000	1	184.6	100.90	1.83	.0	.5
6	5.000	1	15.4	17.70	.87	.0	1.0
6	5.000	1	4.3	5.50	.78	.0	1.5
6	5.000	1	2.5	2.37	1.05	.0	2.0
6	5.000	1	2.0	1.22	1.64	.0	2.5
6	5.000	1	1.6	.71	2.25	.0	3.0
6	5.000	1	153.9	100.90	1.53	.0	.5
6	5.000	1	23.0	17.70	1.30	.0	1.0
6	5.000	1	7.1	5.50	1.29	.0	1.5
6	5.000	1	3.0	2.37	1.27	.0	2.0
6	5.000	1	1.4	1.22	1.15	.0	2.5
6	5.000	1	.9	.71	1.27	.0	3.0
6	5.000	1	92.3	106.90	.86	.5	.0
6	5.000	1	9.3	10.40	.89	1.0	.0
6	5.000	1	2.9	2.96	.98	1.5	.0
6	5.000	1	1.6	1.23	1.30	2.0	.0
6	5.000	1	.9	.63	1.44	2.5	.0
6	5.000	1	184.6	106.90	1.73	.5	.0
6	5.000	1	15.4	10.40	1.48	1.0	.0
6	5.000	1	6.8	2.96	2.30	1.5	.0
6	5.000	1	4.3	1.23	3.50	2.0	.0
6	5.000	1	3.8	.63	6.07	2.5	.0
6	5.000	1	2.9	.36	8.03	3.0	.0
6	5.000	2	162.6	100.90	1.61	.0	.5
6	5.000	2	26.0	17.70	1.47	.0	1.0
6	5.000	2	4.5	5.50	.82	.0	1.5
6	5.000	2	1.5	2.37	.63	.0	2.0
6	5.000	2	1.3	1.22	1.07	.0	2.5
6	5.000	2	175.7	100.90	1.74	.0	.5
6	5.000	2	16.2	17.70	.92	.0	1.0
6	5.000	2	4.7	5.50	.85	.0	1.5
6	5.000	2	2.3	2.37	.97	.0	2.0
6	5.000	2	1.5	1.22	1.23	.0	2.5
6	5.000	2	1.3	.71	1.83	.0	3.0
6	5.000	2	182.3	106.90	1.71	.5	.0
6	5.000	2	13.0	10.40	1.25	1.0	.0
6	5.000	2	3.0	2.96	1.01	1.5	.0
6	5.000	2	1.3	1.23	1.06	2.0	.0
6	5.000	2	.9	.63	1.44	2.5	.0
6	5.000	2	.8	.36	2.22	3.0	.0
6	5.000	2	130.2	106.90	1.22	.5	.0
6	5.000	2	7.2	10.40	.69	1.0	.0
6	5.000	2	4.2	2.96	1.42	1.5	.0
6	5.000	2	2.6	1.23	2.11	2.0	.0
6	5.000	2	1.9	.63	3.04	2.5	.0
6	5.000	2	1.5	.36	4.16	3.0	.0

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
6	10.000	1	135.4	100.90	1.34	.0	.
6	10.000	1	21.1	17.70	1.19	.0	1.0
6	10.000	1	3.8	5.50	.69	.0	1.5
6	10.000	1	1.5	2.37	.63	.0	2.
6	10.000	1	101.5	100.90	1.01	.0	.
6	10.000	1	21.1	17.70	1.19	.0	1.0
6	10.000	1	4.9	5.50	.89	.0	1.
6	10.000	1	2.3	2.37	.97	.0	2.
6	10.000	1	270.6	106.90	2.53	.5	.0
6	10.000	1	15.1	10.40	1.45	1.0	.0
6	10.000	1	3.8	2.96	1.28	1.5	.
6	10.000	1	1.5	1.23	1.22	2.0	.0
6	10.000	1	360.9	106.90	3.38	.5	.0
6	10.000	1	22.6	10.40	2.17	1.0	.
6	10.000	1	7.5	2.96	2.53	1.5	.
6	10.000	1	3.8	1.23	3.09	2.0	.0
6	10.000	2	171.6	100.90	1.70	.0	.
6	10.000	2	15.6	17.70	.88	.0	1.
6	10.000	2	7.8	5.50	1.42	.0	1.5
6	10.000	2	3.9	2.37	1.65	.0	2.0
6	10.000	2	233.9	100.90	2.32	.0	.
6	10.000	2	19.5	17.70	1.10	.0	1.0
6	10.000	2	3.1	5.50	.56	.0	1.5
6	10.000	2	109.2	106.90	1.02	.5	.
6	10.000	2	15.6	10.40	1.50	1.0	.
6	10.000	2	7.8	2.96	2.63	1.5	.0
6	10.000	2	3.9	1.23	3.17	2.0	.
6	10.000	2	3.9	.63	6.23	2.5	.
6	10.000	2	179.3	106.90	1.68	.5	.0
6	10.000	2	5.0	10.40	.48	1.0	.0

COMPLETE LISTING FOR ALL MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
7	10.000	1	122.5	100.90	1.21	.0	.5
7	10.000	1	20.4	17.70	1.15	.0	1.0
7	10.000	1	4.6	5.50	.84	.0	1.5
7	10.000	1	163.3	100.90	1.62	.0	.5
7	10.000	1	14.7	17.70	.83	.0	1.0
7	10.000	1	5.2	5.50	.95	.0	1.5
7	10.000	1	2.1	2.37	.89	.0	2.0
7	10.000	1	114.3	106.90	1.07	.5	.0
7	10.000	1	5.3	10.40	.51	1.0	.0
7	10.000	1	3.3	2.96	1.11	1.5	.0
7	10.000	1	97.9	106.90	.92	.5	.0
7	10.000	1	13.0	10.40	1.25	1.0	.0
7	10.000	1	7.8	2.96	2.63	1.5	.0
7	10.000	1	8.2	1.23	6.67	2.0	.0
7	10.000	2	146.9	100.90	1.46	.0	.5
7	10.000	2	24.5	17.70	1.38	.0	1.0
7	10.000	2	6.5	5.50	1.18	.0	1.5
7	10.000	2	130.6	100.90	1.29	.0	.5
7	10.000	2	18.0	17.70	1.02	.0	1.0
7	10.000	2	7.7	5.50	1.40	.0	1.5
7	10.000	2	5.6	2.37	2.36	.0	2.0
7	10.000	2	261.2	106.90	2.44	.5	.0
7	10.000	2	16.3	10.40	1.57	1.0	.0
7	10.000	2	5.4	2.96	1.82	1.5	.0
7	10.000	2	2.4	1.23	1.95	2.0	.0
7	10.000	2	424.5	106.90	3.97	.5	.0
7	10.000	2	18.0	10.40	1.73	1.0	.0
7	10.000	2	7.3	2.96	2.47	1.5	.0
7	10.000	2	2.9	1.23	2.36	2.0	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
7	.530	1	146.5	100.90	1.45	.0	.
7	.530	1	22.0	17.70	1.24	.0	1.0
7	.530	1	6.6	5.50	1.20	.0	1.5
7	.530	1	2.8	2.37	1.18	.0	2.
7	.530	1	1.4	1.22	1.15	.0	2.
7	.530	1	1.0	.71	1.41	.0	3.0
7	.530	1	131.9	100.90	1.31	.0	.
7	.530	1	22.0	17.70	1.24	.0	1.
7	.530	1	7.3	5.50	1.33	.0	1.5
7	.530	1	3.1	2.37	1.31	.0	2.
7	.530	1	1.4	1.22	1.15	.0	2.
7	.530	1	1.0	.71	1.41	.0	3.0
7	.530	1	161.2	106.90	1.51	.5	.0
7	.530	1	17.6	10.40	1.69	1.0	.
7	.530	1	2.2	2.96	.74	1.5	.
7	.530	1	1.9	1.23	1.54	2.0	.0
7	.530	1	161.2	106.90	1.51	.5	.
7	.530	1	14.7	10.40	1.41	1.0	.
7	.530	1	3.8	2.96	1.28	1.5	.0
7	.530	1	1.9	1.23	1.54	2.0	.
7	.530	1	1.2	.63	1.92	2.5	.
7	.530	2	167.6	100.90	1.66	.0	.5
7	.530	2	25.6	17.70	1.45	.0	1.0
7	.530	2	7.9	5.50	1.44	.0	1.
7	.530	2	3.5	2.37	1.48	.0	2.
7	.530	2	123.3	100.90	1.22	.0	.5
7	.530	2	21.7	17.70	1.23	.0	1.
7	.530	2	6.9	5.50	1.25	.0	1.
7	.530	2	3.0	2.37	1.27	.0	2.0
7	.530	2	1.2	1.22	.98	.0	2.5
7	.530	2	123.3	106.90	1.15	.5	.
7	.530	2	12.8	10.40	1.23	1.0	.0
7	.530	2	3.3	2.96	1.11	1.5	.0
7	.530	2	1.6	1.23	1.30	2.0	.
7	.530	2	1.0	.63	1.60	2.5	.
7	.530	2	133.1	106.90	1.25	.5	.0
7	.530	2	13.8	10.40	1.33	1.0	.
7	.530	2	3.3	2.96	1.11	1.5	.
7	.530	2	1.6	1.23	1.30	2.0	.0
7	.530	2	1.0	.63	1.60	2.5	.

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
7	1.000	2	133.3	100.90	1.32	.0	.5
7	1.000	2	18.9	17.70	1.07	.0	1.0
7	1.000	2	6.7	5.50	1.22	.0	1.5
7	1.000	2	3.1	2.37	1.31	.0	2.0
7	1.000	2	127.8	100.90	1.27	.0	.5
7	1.000	2	22.2	17.70	1.25	.0	1.0
7	1.000	2	7.2	5.50	1.31	.0	1.5
7	1.000	2	3.9	2.37	1.65	.0	2.0
7	1.000	2	222.2	106.90	2.08	.5	.0
7	1.000	2	15.0	10.40	1.44	1.0	.0
7	1.000	2	3.9	2.96	1.32	1.5	.0
7	1.000	2	1.7	1.23	1.38	2.0	.0
7	1.000	2	.9	.63	1.44	2.5	.0
7	1.000	2	.6	.36	1.66	3.0	.0
7	1.000	2	222.2	106.90	2.08	.5	.0
7	1.000	2	12.8	10.40	1.23	1.0	.0
7	1.000	2	2.8	2.96	.95	1.5	.0
7	1.000	2	1.1	1.23	.89	2.0	.0
7	1.000	1	177.5	100.90	1.76	.0	.5
7	1.000	1	26.0	17.70	1.47	.0	1.0
7	1.000	1	7.4	5.50	1.35	.0	1.5
7	1.000	1	3.1	2.37	1.31	.0	2.0
7	1.000	1	1.4	1.22	1.15	.0	2.5
7	1.000	1	.8	.71	1.13	.0	3.0
7	1.000	1	88.8	100.90	.88	.0	.5
7	1.000	1	13.6	17.70	.77	.0	1.0
7	1.000	1	4.7	5.50	.85	.0	1.5
7	1.000	1	2.1	2.37	.89	.0	2.0
7	1.000	1	1.2	1.22	.98	.0	2.5
7	1.000	1	.7	.71	.99	.0	3.0
7	1.000	1	177.5	106.90	1.66	.5	.0
7	1.000	1	11.8	10.40	1.13	1.0	.0
7	1.000	1	4.1	2.96	1.38	1.5	.0
7	1.000	1	1.4	1.23	1.14	2.0	.0
7	1.000	1	201.2	106.90	1.88	.5	.0
7	1.000	1	10.7	10.40	1.03	1.0	.0
7	1.000	1	3.3	2.96	1.11	1.5	.0
7	1.000	1	1.4	1.23	1.14	2.0	.0
7	1.000	1	1.2	.63	1.92	2.5	.0

COMPLETE LISTING FOR ALL MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
7	.173	1	138.5	100.90	1.37	.0	.
7	.173	1	20.7	17.70	1.17	.0	1.[illegible]
7	.173	1	6.9	5.50	1.25	.0	1.5
7	.173	1	4.1	2.37	1.73	.0	2.
7	.173	1	103.9	100.90	1.03	.0	.
7	.173	1	16.6	17.70	.94	.0	1.0
7	.173	1	5.6	5.50	1.02	.0	1.[illegible]
7	.173	1	4.1	2.37	1.73	.0	2.
7	.173	1	193.9	106.90	1.81	.5	.0
7	.173	1	19.4	10.40	1.87	1.0	.0
7	.173	1	5.6	2.96	1.89	1.5	.
7	.173	1	173.2	106.90	1.62	.5	.[illegible]
7	.173	1	13.8	10.40	1.33	1.0	.0
7	.173	1	4.1	2.96	1.38	1.5	.
7	.173	2	123.3	100.90	1.22	.0	.
7	.173	2	20.2	17.70	1.14	.0	1.0
7	.173	2	5.8	5.50	1.05	.0	1.[illegible]
7	.173	2	3.1	2.37	1.31	.0	2.
7	.173	2	1.8	1.22	1.48	.0	2.5
7	.173	2	156.9	100.90	1.56	.0	.5
7	.173	2	22.4	17.70	1.27	.0	1.
7	.173	2	7.2	5.50	1.31	.0	1.[illegible]
7	.173	2	3.6	2.37	1.52	.0	2.0
7	.173	2	112.0	106.90	1.05	.5	.
7	.173	2	12.5	10.40	1.20	1.0	.
7	.173	2	3.6	2.96	1.22	1.5	.0
7	.173	2	1.8	1.23	1.46	2.0	.[illegible]
7	.173	2	134.5	106.90	1.26	.5	.
7	.173	2	13.5	10.40	1.30	1.0	.0
7	.173	2	3.6	2.96	1.22	1.5	.0
7	.173	2	1.8	1.23	1.46	2.0	.

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
7	5.000	1	172.4	100.90	1.71	.0	.5
7	5.000	1	26.9	17.70	1.52	.0	1.0
7	5.000	1	7.3	5.50	1.33	.0	1.5
7	5.000	1	3.3	2.37	1.39	.0	2.0
7	5.000	1	.9	1.22	.74	.0	2.5
7	5.000	1	.4	.71	.56	.0	3.0
7	5.000	1	130.2	100.90	1.29	.0	.5
7	5.000	1	18.4	17.70	1.04	.0	1.0
7	5.000	1	5.3	5.50	.96	.0	1.5
7	5.000	1	2.7	2.37	1.14	.0	2.0
7	5.000	1	1.6	1.22	1.31	.0	2.5
7	5.000	1	.9	.71	1.27	.0	3.0
7	5.000	1	99.6	106.90	.93	.5	.0
7	5.000	1	11.6	10.40	1.12	1.0	.0
7	5.000	1	4.9	2.96	1.65	1.5	.0
7	5.000	1	3.8	1.23	3.09	2.0	.0
7	5.000	1	168.7	106.90	1.58	.5	.0
7	5.000	1	10.0	10.40	.96	1.0	.0
7	5.000	1	1.6	2.96	.54	1.5	.0
7	5.000	2	147.2	100.90	1.46	.0	.5
7	5.000	2	17.1	17.70	.97	.0	1.0
7	5.000	2	6.3	5.50	1.15	.0	1.5
7	5.000	2	3.6	2.37	1.52	.0	2.0
7	5.000	2	170.6	100.90	1.69	.0	.5
7	5.000	2	18.7	17.70	1.06	.0	1.0
7	5.000	2	6.5	5.50	1.18	.0	1.5
7	5.000	2	3.1	2.37	1.31	.0	2.0
7	5.000	2	2.0	1.22	1.64	.0	2.5
7	5.000	2	263.4	106.90	2.46	.5	.0
7	5.000	2	15.5	10.40	1.49	1.0	.0
7	5.000	2	5.8	2.96	1.96	1.5	.0
7	5.000	2	3.4	1.23	2.76	2.0	.0
7	5.000	2	1.1	.63	1.76	2.5	.0
7	5.000	2	2.0	.36	5.54	3.0	.0
7	5.000	2	217.1	106.90	2.03	.5	.0
7	5.000	2	15.5	10.40	1.49	1.0	.0
7	5.000	2	5.4	2.96	1.82	1.5	.0
7	5.000	2	2.2	1.23	1.79	2.0	.0
7	5.000	2	1.1	.63	1.76	2.5	.0
7	5.000	2	.7	.36	1.94	3.0	.0

COMPLETE LISTING FOR ALL MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
8	5.000	1	151.2	100.90	1.50	.0	.
8	5.000	1	26.6	17.70	1.50	.0	1.
8	5.000	1	10.1	5.50	1.84	.0	1.5
8	5.000	1	3.8	2.37	1.60	.0	2.
8	5.000	1	2.2	1.22	1.80	.0	2.
8	5.000	1	1.9	.71	2.68	.0	3.0
8	5.000	1	151.2	100.90	1.50	.0	.
8	5.000	1	22.7	17.70	1.28	.0	1.
8	5.000	1	6.3	5.50	1.15	.0	1.5
8	5.000	1	3.8	2.37	1.60	.0	2.0
8	5.000	1	2.2	1.22	1.80	.0	2.
8	5.000	1	1.6	.71	2.25	.0	3.
8	5.000	1	179.5	106.90	1.68	.5	.0
8	5.000	1	18.1	10.40	1.74	1.0	.
8	5.000	1	11.8	2.96	3.99	1.5	.
8	5.000	1	207.9	106.90	1.94	.5	.0
8	5.000	1	18.1	10.40	1.74	1.0	.
8	5.000	1	4.1	2.96	1.38	1.5	.
8	5.000	1	1.4	1.23	1.14	2.0	.0
8	5.000	2	180.6	100.90	1.79	.0	.5
8	5.000	2	18.0	17.70	1.02	.0	1.
8	5.000	2	6.0	5.50	1.09	.0	1.5
8	5.000	2	185.4	100.90	1.84	.0	.5
8	5.000	2	28.0	17.70	1.58	.0	1.
8	5.000	2	9.1	5.50	1.65	.0	1.
8	5.000	2	160.3	106.90	1.50	.5	.0
8	5.000	2	18.0	10.40	1.73	1.0	.
8	5.000	2	5.1	2.96	1.72	1.5	.
8	5.000	2	1.7	1.23	1.38	2.0	.0
8	5.000	2	.6	.63	.96	2.5	.0
8	5.000	2	.3	.36	.83	3.0	.
8	5.000	2	240.6	106.90	2.25	.5	.0
8	5.000	2	20.0	10.40	1.92	1.0	.0
8	5.000	2	7.1	2.96	2.40	1.5	.
8	5.000	2	3.1	1.23	2.52	2.0	.
8	5.000	2	1.7	.63	2.72	2.5	.0
8	5.000	2	1.1	.36	3.05	3.0	.

COMPLETE LISTING FOR ALL MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
8	10.000	1	188.4	100.90	1.87	.0	.5
8	10.000	1	15.7	17.70	.89	.0	1.0
8	10.000	1	6.3	5.50	1.15	.0	1.5
8	10.000	1	2.9	2.37	1.22	.0	2.0
8	10.000	1	2.1	1.22	1.72	.0	2.5
8	10.000	1	1.2	.71	1.69	.0	3.0
8	10.000	1	157.0	100.90	1.56	.0	.5
8	10.000	1	31.4	17.70	1.77	.0	1.0
8	10.000	1	10.5	5.50	1.91	.0	1.5
8	10.000	1	6.3	2.37	2.66	.0	2.0
8	10.000	1	2.7	1.22	2.21	.0	2.5
8	10.000	1	240.7	106.90	2.25	.5	.0
8	10.000	1	15.7	10.40	1.51	1.0	.0
8	10.000	1	5.2	2.96	1.76	1.5	.0
8	10.000	1	313.9	106.90	2.94	.5	.0
8	10.000	1	19.9	10.40	1.91	1.0	.0
8	10.000	1	5.0	2.96	1.69	1.5	.0
8	10.000	1	2.3	1.23	1.87	2.0	.0
8	10.000	2	171.9	100.90	1.70	.0	.5
8	10.000	2	27.9	17.70	1.58	.0	1.0
8	10.000	2	3.5	5.50	.64	.0	1.5
8	10.000	2	193.4	100.90	1.92	.0	.5
8	10.000	2	20.4	17.70	1.15	.0	1.0
8	10.000	2	6.0	5.50	1.09	.0	1.5
8	10.000	2	2.3	2.37	.97	.0	2.0
8	10.000	2	268.5	106.90	2.51	.5	.0
8	10.000	2	19.4	10.40	1.87	1.0	.0
8	10.000	2	4.3	2.96	1.45	1.5	.0
8	10.000	2	2.0	1.23	1.63	2.0	.0
8	10.000	2	1.3	.63	2.08	2.5	.0
8	10.000	2	1.1	.36	3.05	3.0	.0
8	10.000	2	322.2	106.90	3.01	.5	.0
8	10.000	2	21.5	10.40	2.07	1.0	.0
8	10.000	2	8.6	2.96	2.90	1.5	.0
8	10.000	2	4.3	1.23	3.50	2.0	.0
8	10.000	2	3.1	.63	4.95	2.5	.0
8	10.000	2	2.1	.36	5.82	3.0	.0

COMPLETE LISTING FOR ALL MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
8	.173	2	167.6	100.90	1.66	.0	.[illegible]
8	.173	2	29.2	17.70	1.65	.0	1.0
8	.173	2	5.6	5.50	1.02	.0	1.5
8	.173	2	165.1	100.90	1.64	.0	.[illegible]
8	.173	2	25.4	17.70	1.44	.0	1.0
8	.173	2	7.6	5.50	1.38	.0	1.5
8	.173	2	2.5	2.37	1.05	.0	2.0
8	.173	2	165.1	106.90	1.54	.5	.0
8	.173	2	16.5	10.40	1.59	1.0	.0
8	.173	2	5.1	2.96	1.72	1.5	.0
8	.173	2	2.0	1.23	1.63	2.0	.0
8	.173	2	1.0	.63	1.60	2.5	.0
8	.173	2	152.4	106.90	1.43	.5	.0
8	.173	2	16.5	10.40	1.59	1.0	.0
8	.173	2	4.0	2.96	1.35	1.5	.[illegible]
8	.173	2	2.0	1.23	1.63	2.0	.0
8	.173	2	1.5	.63	2.40	2.5	.0
8	.173	1	141.1	100.90	1.40	.0	.[illegible]
8	.173	1	22.6	17.70	1.28	.0	1.0
8	.173	1	7.9	5.50	1.44	.0	1.5
8	.173	1	3.4	2.37	1.43	.0	2.[illegible]
8	.173	1	2.3	1.22	1.89	.0	2.[illegible]
8	.173	1	146.7	100.90	1.45	.0	.5
8	.173	1	28.2	17.70	1.59	.0	1.[illegible]
8	.173	1	7.9	5.50	1.44	.0	1.[illegible]
8	.173	1	3.4	2.37	1.43	.0	2.0
8	.173	1	2.3	1.22	1.89	.0	2.5
8	.173	1	169.3	106.90	1.58	.5	.[illegible]
8	.173	1	14.1	10.40	1.36	1.0	.0
8	.173	1	5.6	2.96	1.89	1.5	.0
8	.173	1	282.2	106.90	2.64	.5	.[illegible]
8	.173	1	19.8	10.40	1.90	1.0	.[illegible]
8	.173	1	5.1	2.96	1.72	1.5	.0
8	.173	1	2.3	1.23	1.87	2.0	.[illegible]

COMPLETE LISTING FOR ALL MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
8	.530	2	222.0	100.90	2.20	.0	.5
8	.530	2	31.1	17.70	1.76	.0	1.0
8	.530	2	6.6	5.50	1.20	.0	1.5
8	.530	2	138.7	100.90	1.37	.0	.5
8	.530	2	22.2	17.70	1.25	.0	1.0
8	.530	2	7.1	5.50	1.29	.0	1.5
8	.530	2	3.1	2.37	1.31	.0	2.0
8	.530	2	155.4	106.90	1.45	.5	.0
8	.530	2	13.3	10.40	1.28	1.0	.0
8	.530	2	4.0	2.96	1.35	1.5	.0
8	.530	2	1.8	1.23	1.46	2.0	.0
8	.530	2	.9	.63	1.44	2.5	.0
8	.530	2	155.4	106.90	1.45	.5	.0
8	.530	2	13.9	10.40	1.34	1.0	.0
8	.530	2	4.0	2.96	1.35	1.5	.0
8	.530	2	1.5	1.23	1.22	2.0	.0
8	.530	2	.9	.63	1.44	2.5	.0
8	.530	1	171.6	100.90	1.70	.0	.5
8	.530	1	28.2	17.70	1.59	.0	1.0
8	.530	1	9.3	5.50	1.69	.0	1.5
8	.530	1	3.7	2.37	1.56	.0	2.0
8	.530	1	1.9	1.22	1.56	.0	2.5
8	.530	1	1.2	.71	1.69	.0	3.0
8	.530	1	153.1	100.90	1.52	.0	.5
8	.530	1	25.7	17.70	1.45	.0	1.0
8	.530	1	7.3	5.50	1.33	.0	1.5
8	.530	1	3.4	2.37	1.43	.0	2.0
8	.530	1	1.9	1.22	1.56	.0	2.5
8	.530	1	1.0	.71	1.41	.0	3.0
8	.530	1	196.0	106.90	1.83	.5	.0
8	.530	1	17.1	10.40	1.64	1.0	.0
8	.530	1	6.6	2.96	2.23	1.5	.0
8	.530	1	183.8	106.90	1.72	.5	.0
8	.530	1	18.4	10.40	1.77	1.0	.0
8	.530	1	4.9	2.96	1.65	1.5	.0
8	.530	1	2.2	1.23	1.79	2.0	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
8	1.000	1	165.0	100.90	1.64	.0	.[illegible]
8	1.000	1	24.3	17.70	1.37	.0	1.0
8	1.000	1	7.8	5.50	1.42	.0	1.5
8	1.000	1	3.1	2.37	1.31	.0	2.[illegible]
8	1.000	1	1.7	1.22	1.39	.0	2.[illegible]
8	1.000	1	1.0	.71	1.41	.0	3.0
8	1.000	1	135.9	100.90	1.35	.0	.[illegible]
8	1.000	1	23.3	17.70	1.32	.0	1.[illegible]
8	1.000	1	6.6	5.50	1.20	.0	1.5
8	1.000	1	3.4	2.37	1.43	.0	2.0
8	1.000	1	1.6	1.22	1.31	.0	2.[illegible]
8	1.000	1	.8	.71	1.13	.0	3.0
8	1.000	1	213.6	106.90	2.00	.5	.0
8	1.000	1	19.4	10.40	1.87	1.0	.[illegible]
8	1.000	1	8.3	2.96	2.80	1.5	.[illegible]
8	1.000	1	262.1	106.90	2.45	.5	.0
8	1.000	1	23.3	10.40	2.24	1.0	.[illegible]
8	1.000	1	6.1	2.96	2.06	1.5	.[illegible]
8	1.000	1	2.1	1.23	1.71	2.0	.0
8	1.000	2	170.9	100.90	1.69	.0	.5
8	1.000	2	13.1	17.70	.74	.0	1.[illegible]
8	1.000	2	8.0	5.50	1.45	.0	1.[illegible]
8	1.000	2	3.6	2.37	1.52	.0	2.0
8	1.000	2	180.9	100.90	1.79	.0	.[illegible]
8	1.000	2	12.1	17.70	.68	.0	1.[illegible]
8	1.000	2	8.5	5.50	1.55	.0	1.5
8	1.000	2	251.3	106.90	2.35	.5	.[illegible]
8	1.000	2	14.1	10.40	1.36	1.0	.[illegible]
8	1.000	2	3.8	2.96	1.28	1.5	.0
8	1.000	2	1.3	1.23	1.06	2.0	.0
8	1.000	2	.6	.63	.96	2.5	.[illegible]
8	1.000	2	201.0	106.90	1.88	.5	.0
8	1.000	2	17.1	10.40	1.64	1.0	.0
8	1.000	2	3.8	2.96	1.28	1.5	.[illegible]
8	1.000	2	1.8	1.23	1.46	2.0	.[illegible]
8	1.000	2	1.0	.63	1.60	2.5	.0
8	1.000	2	.6	.36	1.66	3.0	.[illegible]

COMPLETE LISTING FOR ALL MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
9	1.000	1	190.5	100.90	1.89	.0	.5
9	1.000	1	26.7	17.70	1.51	.0	1.0
9	1.000	1	8.1	5.50	1.47	.0	1.5
9	1.000	1	3.3	2.37	1.39	.0	2.0
9	1.000	1	1.9	1.22	1.56	.0	2.5
9	1.000	1	1.0	.71	1.41	.0	3.0
9	1.000	1	152.4	100.90	1.51	.0	.5
9	1.000	1	23.8	17.70	1.34	.0	1.0
9	1.000	1	7.1	5.50	1.29	.0	1.5
9	1.000	1	3.0	2.37	1.27	.0	2.0
9	1.000	1	1.6	1.22	1.31	.0	2.5
9	1.000	1	.9	.71	1.27	.0	3.0
9	1.000	1	190.5	106.90	1.78	.5	.0
9	1.000	1	14.3	10.40	1.38	1.0	.0
9	1.000	1	4.8	2.96	1.62	1.5	.0
9	1.000	1	142.9	106.90	1.34	.5	.0
9	1.000	1	14.3	10.40	1.38	1.0	.0
9	1.000	1	3.3	2.96	1.11	1.5	.0
9	1.000	2	145.6	100.90	1.44	.0	.5
9	1.000	2	25.2	17.70	1.42	.0	1.0
9	1.000	2	8.3	5.50	1.51	.0	1.5
9	1.000	2	208.7	100.90	2.07	.0	.5
9	1.000	2	27.2	17.70	1.54	.0	1.0
9	1.000	2	9.2	5.50	1.67	.0	1.5
9	1.000	2	174.8	106.90	1.64	.5	.0
9	1.000	2	16.5	10.40	1.59	1.0	.0
9	1.000	2	4.9	2.96	1.65	1.5	.0
9	1.000	2	1.9	1.23	1.54	2.0	.0
9	1.000	2	1.0	.63	1.60	2.5	.0
9	1.000	2	.7	.36	1.94	3.0	.0
9	1.000	2	165.0	106.90	1.54	.5	.0
9	1.000	2	12.6	10.40	1.21	1.0	.0
9	1.000	2	3.4	2.96	1.15	1.5	.0
9	1.000	2	1.5	1.23	1.22	2.0	.0
9	1.000	2	.8	.63	1.28	2.5	.0
9	1.000	2	.4	.36	1.11	3.0	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
9	.530	2	238.9	100.90	2.37	.0	.
9	.530	2	29.9	17.70	1.69	.0	1.0
9	.530	2	9.6	5.50	1.75	.0	1.5
9	.530	2	161.2	100.90	1.60	.0	.
9	.530	2	23.9	17.70	1.35	.0	1.
9	.530	2	7.7	5.50	1.40	.0	1.5
9	.530	2	137.3	106.90	1.28	.5	.
9	.530	2	12.5	10.40	1.20	1.0	.
9	.530	2	4.3	2.96	1.45	1.5	.0
9	.530	2	1.6	1.23	1.30	2.0	.0
9	.530	2	.9	.63	1.44	2.5	.
9	.530	2	126.6	106.90	1.18	.5	.0
9	.530	2	14.3	10.40	1.38	1.0	.0
9	.530	2	3.6	2.96	1.22	1.5	.
9	.530	2	1.6	1.23	1.30	2.0	.
9	.530	2	.9	.63	1.44	2.5	.0
9	.530	1	167.5	100.90	1.66	.0	.
9	.530	1	25.7	17.70	1.45	.0	1.
9	.530	1	7.6	5.50	1.38	.0	1.5
9	.530	1	3.1	2.37	1.31	.0	2.0
9	.530	1	1.8	1.22	1.48	.0	2.
9	.530	1	.9	.71	1.27	.0	3.0
9	.530	1	134.0	100.90	1.33	.0	.5
9	.530	1	20.1	17.70	1.14	.0	1.
9	.530	1	6.7	5.50	1.22	.0	1.
9	.530	1	3.1	2.37	1.31	.0	2.0
9	.530	1	1.5	1.22	1.23	.0	2.5
9	.530	1	.9	.71	1.27	.0	3.0
9	.530	1	200.9	106.90	1.88	.5	.0
9	.530	1	15.6	10.40	1.50	1.0	.0
9	.530	1	5.4	2.96	1.82	1.5	.0
9	.530	1	267.9	106.90	2.51	.5	.0
9	.530	1	19.0	10.40	1.83	1.0	.0
9	.530	1	3.9	2.96	1.32	1.5	.

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
9	.173	2	165.6	100.90	1.64	.0	.5
9	.173	2	23.2	17.70	1.31	.0	1.0
9	.173	2	7.6	5.50	1.38	.0	1.5
9	.173	2	124.2	100.90	1.23	.0	.5
9	.173	2	24.0	17.70	1.36	.0	1.0
9	.173	2	6.3	5.50	1.15	.0	1.5
9	.173	2	190.5	106.90	1.78	.5	.0
9	.173	2	17.4	10.40	1.67	1.0	.0
9	.173	2	4.6	2.96	1.55	1.5	.0
9	.173	2	1.7	1.23	1.38	2.0	.0
9	.173	2	1.0	.63	1.60	2.5	.0
9	.173	2	115.9	106.90	1.08	.5	.0
9	.173	2	14.9	10.40	1.43	1.0	.0
9	.173	2	4.6	2.96	1.55	1.5	.0
9	.173	2	1.7	1.23	1.38	2.0	.0
9	.173	2	1.0	.63	1.60	2.5	.0
9	.173	1	129.9	100.90	1.29	.0	.5
9	.173	1	22.5	17.70	1.27	.0	1.0
9	.173	1	6.9	5.50	1.25	.0	1.5
9	.173	1	2.8	2.37	1.18	.0	2.0
9	.173	1	1.7	1.22	1.39	.0	2.5
9	.173	1	1.0	.71	1.41	.0	3.0
9	.173	1	183.5	100.90	1.82	.0	.5
9	.173	1	20.8	17.70	1.18	.0	1.0
9	.173	1	8.3	5.50	1.51	.0	1.5
9	.173	1	3.5	2.37	1.48	.0	2.0
9	.173	1	2.1	1.22	1.72	.0	2.5
9	.173	1	1.4	.71	1.97	.0	3.0
9	.173	1	233.8	106.90	2.19	.5	.0
9	.173	1	16.5	10.40	1.59	1.0	.0
9	.173	1	5.2	2.96	1.76	1.5	.0
9	.173	1	346.3	106.90	3.24	.5	.0
9	.173	1	20.8	10.40	2.00	1.0	.0
9	.173	1	5.2	2.96	1.76	1.5	.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
9	5.000	1	159.5	100.90	1.58	.0	.
9	5.000	1	23.9	17.70	1.35	.0	1.
9	5.000	1	8.7	5.50	1.58	.0	1.5
9	5.000	1	2.5	2.37	1.05	.0	2.
9	5.000	1	.9	1.22	.74	.0	2.
9	5.000	1	.5	.71	.70	.0	3.0
9	5.000	1	168.4	100.90	1.67	.0	.5
9	5.000	1	23.0	17.70	1.30	.0	1.
9	5.000	1	5.9	5.50	1.07	.0	1.
9	5.000	1	2.8	2.37	1.18	.0	2.0
9	5.000	1	1.6	1.22	1.31	.0	2.
9	5.000	1	1.1	.71	1.55	.0	3.
9	5.000	1	283.5	106.90	2.65	.5	.0
9	5.000	1	12.4	10.40	1.19	1.0	.
9	5.000	1	1.3	2.96	.44	1.5	.
9	5.000	1	194.9	106.90	1.82	.5	.0
9	5.000	1	16.9	10.40	1.63	1.0	.0
9	5.000	1	6.4	2.96	2.16	1.5	.
9	5.000	2	179.0	100.90	1.77	.0	.
9	5.000	2	23.3	17.70	1.32	.0	1.0
9	5.000	2	8.3	5.50	1.51	.0	1.
9	5.000	2	179.0	100.90	1.77	.0	.
9	5.000	2	30.4	17.70	1.72	.0	1.0
9	5.000	2	6.4	5.50	1.16	.0	1.
9	5.000	2	179.0	106.90	1.67	.5	.
9	5.000	2	15.2	10.40	1.46	1.0	.0
9	5.000	2	6.1	2.96	2.06	1.5	.0
9	5.000	2	3.4	1.23	2.76	2.0	.
9	5.000	2	2.2	.63	3.51	2.5	.
9	5.000	2	1.8	.36	4.99	3.0	.0
9	5.000	2	232.8	106.90	2.18	.5	.
9	5.000	2	17.9	10.40	1.72	1.0	.
9	5.000	2	4.5	2.96	1.52	1.5	.0
9	5.000	2	1.4	1.23	1.14	2.0	.

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
9	10.000	2	178.6	100.90	1.77	.0	.5
9	10.000	2	20.4	17.70	1.15	.0	1.0
9	10.000	2	7.1	5.50	1.29	.0	1.5
9	10.000	2	183.7	100.90	1.82	.0	.5
9	10.000	2	28.6	17.70	1.62	.0	1.0
9	10.000	2	8.8	5.50	1.60	.0	1.5
9	10.000	2	117.3	106.90	1.10	.5	.0
9	10.000	2	14.8	10.40	1.42	1.0	.0
9	10.000	2	5.9	2.96	1.99	1.5	.0
9	10.000	2	4.1	1.23	3.33	2.0	.0
9	10.000	2	3.1	.63	4.95	2.5	.0
9	10.000	2	2.7	.36	7.48	3.0	.0
9	10.000	2	117.3	106.90	1.10	.5	.0
9	10.000	2	17.9	10.40	1.72	1.0	.0
9	10.000	2	4.0	2.96	1.35	1.5	.0
9	10.000	2	2.1	1.23	1.71	2.0	.0
9	10.000	2	1.3	.63	2.08	2.5	.0
9	10.000	2	1.2	.36	3.32	3.0	.0
9	10.000	1	170.2	100.90	1.69	.0	.5
9	10.000	1	21.3	17.70	1.20	.0	1.0
9	10.000	1	8.1	5.50	1.47	.0	1.5
9	10.000	1	4.3	2.37	1.81	.0	2.0
9	10.000	1	3.0	1.22	2.46	.0	2.5
9	10.000	1	2.6	.71	3.66	.0	3.0
9	10.000	1	148.9	100.90	1.48	.0	.5
9	10.000	1	28.7	17.70	1.62	.0	1.0
9	10.000	1	11.2	5.50	2.04	.0	1.5
9	10.000	1	6.2	2.37	2.62	.0	2.0
9	10.000	1	1.9	1.22	1.56	.0	2.5
9	10.000	1	1.8	.71	2.54	.0	3.0
9	10.000	1	101.1	106.90	.95	.5	.0
9	10.000	1	13.3	10.40	1.28	1.0	.0
9	10.000	1	6.0	2.96	2.03	1.5	.0
9	10.000	1	133.0	106.90	1.24	.5	.0
9	10.000	1	14.9	10.40	1.43	1.0	.0
9	10.000	1	5.5	2.96	1.86	1.5	.0

APPENDIX F

BREAKDOWN OF HIGH VALUES
OF THE MEASURED/CALCULATED RATIO
BY OCCURRENCE

FOR MEASURED/CALCULATED RATIO >= 2.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

L CATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
1	10.000	1	2.5	1.22	2.05	.0	2.5
1	10.000	1	2.2	.71	3.10	.0	3.0
1	10.000	1	10.7	2.96	3.61	1.5	.0
1	10.000	1	6.7	1.23	5.45	2.0	.0
1	10.000	1	5.2	.63	8.31	2.5	.0
1	10.000	1	216.7	106.90	2.03	.5	.0
1	10.000	1	3.7	1.23	3.01	2.0	.0
1	10.000	1	2.5	.63	3.99	2.5	.0
1	10.000	1	2.5	.36	6.93	3.0	.0
1	10.000	2	1.8	.63	2.88	2.5	.0
1	10.000	2	1.8	.36	4.99	3.0	.0
1	10.000	2	7.5	2.96	2.53	1.5	.0
1	10.000	2	5.3	1.23	4.31	2.0	.0
1	10.000	2	3.3	.63	5.27	2.5	.0
1	10.000	2	2.7	.36	7.48	3.0	.0
1	10.000	2	2.8	1.22	2.30	.0	2.5
1	10.000	2	2.5	.71	3.52	.0	3.0
1	1.000	2	248.9	100.90	2.47	.0	.5
1	1.000	2	39.1	17.70	2.21	.0	1.0
1	1.000	2	11.6	5.50	2.11	.0	1.5
1	1.000	2	11.6	5.50	2.11	.0	1.5
1	1.000	2	5.3	2.37	2.24	.0	2.0
1	1.000	2	2.7	1.22	2.21	.0	2.5
1	1.000	2	1.8	.71	2.54	.0	3.0
1	1.000	2	1.4	.63	2.24	2.5	.0
1	1.000	2	.9	.36	2.49	3.0	.0
1	1.000	1	1.3	.63	2.08	2.5	.0
1	.530	2	311.6	106.90	2.91	.5	.0
1	.173	2	6.0	2.96	2.03	1.5	.0
1	.173	2	3.2	1.23	2.60	2.0	.0
1	.173	2	1.6	.63	2.56	2.5	.0
1	.173	2	25.0	10.40	2.40	1.0	.0
1	.173	2	8.0	2.96	2.70	1.5	.0
1	.173	2	3.2	1.23	2.60	2.0	.0
1	.173	2	1.6	.63	2.56	2.5	.0
1	.173	2	1.2	.36	3.32	3.0	.0
1	.173	2	1.3	.63	2.08	2.5	.0
1	.173	2	.8	.36	2.22	3.0	.0

OF MEAUSREMENTS >= 2.0 FOR LOCATION 1 IS 38

FOR MEASURED/CALCULATED RATIO >= 2.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	
2	.173	1	232.2	106.90	2.17	.5	0
2	.173	2	3.4	1.23	2.76	2.0	.0
2	.530	2	2.6	1.22	2.13	.0	2.5
2	.530	2	1.4	.63	2.24	2.5	0
2	.530	2	1.4	.63	2.24	2.5	.0
2	.530	1	2.5	1.22	2.05	.0	2.5
2	.530	1	2.5	1.22	2.05	.0	2 5
2	.530	1	1.3	.63	2.08	2.5	.0
2	.530	1	2.5	1.23	2.03	2.0	.0
2	.530	1	1.3	.63	2.08	2.5	0
2	1.000	1	1.3	.63	2.08	2.5	.0
2	1.000	2	.8	.36	2.22	3.0	0
2	5.000	2	37.5	17.70	2.12	.0	1 0
2	5.000	2	12.5	5.50	2.27	.0	1.5
2	5.000	2	10.4	2.96	3.51	1.5	.0
2	5.000	2	8.3	2.96	2.80	1.5	0
2	10.000	2	271.7	106.90	2.54	.5	.0
2	10.000	2	226.4	106.90	2.12	.5	.0
2	10.000	2	7.5	2.96	2.53	1.5	0
2	10.000	2	4.8	1.23	3.90	2.0	0
2	10.000	1	7.1	2.96	2.40	1.5	.0
2	10.000	1	5.5	1.23	4.47	2.0	0
2	10.000	1	4.4	.63	7.03	2.5	0
2	10.000	1	4.7	.36	13.02	3.0	.0

OF MEAUSREMENTS >= 2.0 FOR LOCATION 2 IS 24

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	
3	10.000	1	2.0	.71	2.82	.0	3.0
3	10.000	1	260.5	106.90	2.44	.5	0
3	10.000	1	1.8	.63	2.88	2.5	0
3	10.000	1	234.5	106.90	2.19	.5	.0
3	10.000	1	7.3	2.96	2.47	1.5	0
3	10.000	1	5.5	1.23	4.47	2.0	0
3	10.000	1	4.3	.63	6.87	2.5	.0
3	10.000	2	1.6	.63	2.56	2.5	0
3	10.000	2	1.1	.36	3.05	3.0	0
3	10.000	2	1.1	.36	3.05	3.0	.0
3	1.000	2	220.0	106.90	2.06	.5	.0
3	1.000	1	239.2	106.90	2.24	.5	0
3	.173	2	252.4	106.90	2.36	.5	0
3	.173	1	231.7	106.90	2.17	.5	.0

OF MEAUSREMENTS >= 2.0 FOR LOCATION 3 IS 14

FOR MEASURED/CALCULATED RATIO >= 2.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
4	.173	1	213.9	106.90	2.00	.5	.0
4	1.000	1	.9	.36	2.49	3.0	.0
4	10.000	1	1.5	.71	2.11	.0	3.0
4	10.000	1	286.5	106.90	2.68	.5	.0
4	10.000	1	6.3	2.96	2.13	1.5	.0
4	10.000	1	4.2	1.23	3.41	2.0	.0
4	10.000	1	3.5	.63	5.59	2.5	.0
4	10.000	1	3.8	.36	10.53	3.0	.0
4	10.000	1	225.7	106.90	2.11	.5	.0
4	10.000	1	2.7	1.23	2.20	2.0	.0
4	10.000	1	2.8	.63	4.47	2.5	.0
4	10.000	1	3.8	.36	10.53	3.0	.0
4	10.000	2	3.5	1.23	2.85	2.0	.0
4	10.000	2	2.3	.63	3.67	2.5	.0
4	10.000	2	1.8	.36	4.99	3.0	.0
4	10.000	2	1.0	.36	2.77	3.0	.0
4	5.000	1	205.4	100.90	2.04	.0	.5
4	5.000	1	6.0	2.96	2.03	1.5	.0
4	5.000	1	3.0	1.23	2.44	2.0	.0
4	5.000	1	1.8	.63	2.88	2.5	.0
4	5.000	1	1.8	.36	4.99	3.0	.0
4	5.000	2	3.0	.71	4.23	.0	3.0
4	5.000	2	1.8	.63	2.88	2.5	.0
4	5.000	2	1.8	.36	4.99	3.0	.0

OF MEAUSREMENTS >= 2.0 FOR LOCATION 4 IS 24

5	5.000	2	2.7	1.22	2.21	.0	2.5
5	5.000	2	3.3	1.23	2.68	2.0	.0
5	5.000	2	2.2	.63	3.51	2.5	.0
5	5.000	2	2.2	.36	6.09	3.0	.0
5	5.000	1	1.6	.71	2.25	.0	3.0
5	5.000	1	6.6	2.96	2.23	1.5	.0
5	5.000	1	3.3	1.23	2.68	2.0	.0
5	5.000	1	2.2	.63	3.51	2.5	.0
5	10.000	1	2.6	1.22	2.13	.0	2.5
5	10.000	1	2.1	.71	2.96	.0	3.0
5	10.000	1	268.9	106.90	2.52	.5	.0
5	10.000	1	21.0	10.40	2.02	1.0	.0
5	10.000	1	7.7	2.96	2.60	1.5	.0
5	10.000	1	5.3	1.23	4.31	2.0	.0
5	10.000	1	3.9	.63	6.23	2.5	.0
5	10.000	1	285.6	106.90	2.67	.5	.0
5	10.000	1	2.1	.63	3.35	2.5	.0
5	10.000	1	1.3	.36	3.60	3.0	.0
5	10.000	1	1.9	.71	2.68	.0	3.0
5	10.000	1	3.1	1.22	2.54	.0	2.5
5	10.000	1	285.0	106.90	2.67	.5	.0
5	10.000	1	7.5	2.96	2.53	1.5	.0
5	10.000	1	4.8	1.23	3.90	2.0	.0
5	10.000	1	3.6	.63	5.75	2.5	.0
5	10.000	1	3.2	.36	8.86	3.0	.0
5	10.000	1	1.5	.63	2.40	2.5	.0

FOR MEASURED/CALCULATED RATIO >= 2.00

SELECTED LISTING FOR HIGH MINE DATA

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	_
5	10.000	1	1.2	.36	3.32	3.0	.
5	1.000	1	41.5	17.70	2.34	.0	1.
5	1.000	1	14.8	5.50	2.69	.0	.
5	1.000	1	222.2	106.90	2.08	.5	.
5	1.000	1	2.8	1.23	2.28	2.0	.
5	1.000	1	1.5	.63	2.40	2.5	.
5	1.000	2	282.5	100.90	2.80	.0	.
5	1.000	2	54.2	17.70	3.06	.0	1.
5	1.000	2	15.8	5.50	2.87	.0	.
5	1.000	2	5.9	2.37	2.49	.0	.
5	1.000	2	5.0	1.22	4.10	.0	2.
5	1.000	2	1.8	.71	2.54	.0	3.
5	1.000	2	452.0	100.90	4.48	.0	.
5	1.000	2	56.5	17.70	3.19	.0	1.
5	1.000	2	16.9	5.50	3.07	.0	.
5	1.000	2	8.5	2.37	3.59	.0	.
5	1.000	2	3.2	1.22	2.62	.0	2.
5	1.000	2	497.2	106.90	4.65	.5	.
5	1.000	2	33.9	10.40	3.26	1.0	.
5	1.000	2	8.5	2.96	2.87	1.5	.
5	1.000	2	3.4	1.23	2.76	2.0	.
5	1.000	2	1.4	.63	2.24	2.5	.
5	1.000	2	565.0	106.90	5.29	.5	.
5	1.000	2	45.2	10.40	4.35	1.0	.
5	1.000	2	11.3	2.96	3.82	1.5	.
5	1.000	2	5.0	1.23	4.07	2.0	.
5	1.000	2	2.7	.63	4.31	2.5	.
5	1.000	2	1.6	.36	4.43	3.0	.
5	.530	2	491.4	100.90	4.87	.0	.
5	.530	2	85.4	17.70	4.82	.0	1.
5	.530	2	25.7	5.50	4.67	.0	1.
5	.530	2	8.6	2.37	3.63	.0	.
5	.530	2	4.2	1.22	3.44	.0	.
5	.530	2	341.9	100.90	3.39	.0	.
5	.530	2	47.0	17.70	2.66	.0	.
5	.530	2	21.3	5.50	3.87	.0	.
5	.530	2	7.7	2.37	3.25	.0	2.
5	.530	2	4.2	1.22	3.44	.0	[illegible]
5	.530	2	2.1	.71	2.96	.0	.
5	.530	2	384.7	106.90	3.60	.5	.
5	.530	2	42.8	10.40	4.12	1.0	.
5	.530	2	12.0	2.96	4.05	1.5	.
5	.530	2	4.7	1.23	3.82	2.0	.
5	.530	2	3.0	.63	4.79	2.5	.
5	.530	2	2.1	.36	5.82	3.0	.
5	.530	2	320.6	106.90	3.00	.5	.
5	.530	2	32.0	10.40	3.08	1.0	.
5	.530	2	9.8	2.96	3.31	1.5	.
5	.530	2	4.7	1.23	3.82	2.0	.
5	.530	2	3.0	.63	4.79	2.5	.

FOR MEASURED/CALCULATED RATIO >= 2.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
5	.530	2	1.7	.36	4.71	3.0	.0
5	.530	1	378.4	100.90	3.75	.0	.5
5	.530	1	56.7	17.70	3.20	.0	1.0
5	.530	1	18.9	5.50	3.44	.0	1.5
5	.530	1	8.4	2.37	3.54	.0	2.0
5	.530	1	5.9	1.22	4.84	.0	2.5
5	.530	1	3.8	.71	5.35	.0	3.0
5	.530	1	462.4	100.90	4.58	.0	.5
5	.530	1	63.1	17.70	3.56	.0	1.0
5	.530	1	21.0	5.50	3.82	.0	1.5
5	.530	1	9.3	2.37	3.92	.0	2.0
5	.530	1	5.0	1.22	4.10	.0	2.5
5	.530	1	3.0	.71	4.23	.0	3.0
5	.530	1	756.6	106.90	7.08	.5	.0
5	.530	1	48.3	10.40	4.64	1.0	.0
5	.530	1	14.8	2.96	5.00	1.5	.0
5	.530	1	5.9	1.23	4.80	2.0	.0
5	.530	1	3.4	.63	5.43	2.5	.0
5	.530	1	483.4	106.90	4.52	.5	.0
5	.530	1	46.2	10.40	4.44	1.0	.0
5	.530	1	12.6	2.96	4.26	1.5	.0
5	.530	1	5.0	1.23	4.07	2.0	.0
5	.530	1	3.8	.63	6.07	2.5	.0
5	.530	1	2.5	.36	6.93	3.0	.0
5	.173	1	1.7	.71	2.39	.0	3.0
5	.173	1	1.7	.71	2.39	.0	3.0
5	.173	1	1.7	.63	2.72	2.5	.0

OF MEAUSREMENTS >= 2.0 FOR LOCATION 5 IS 103

6	.173	1	2.6	1.23	2.11	2.0	.0
6	.173	1	2.6	1.23	2.11	2.0	.0
6	1.000	2	228.5	106.90	2.14	.5	.0
6	1.000	2	1.4	.63	2.24	2.5	.0
6	1.000	2	.9	.36	2.49	3.0	.0
6	5.000	1	1.6	.71	2.25	.0	3.0
6	5.000	1	6.8	2.96	2.30	1.5	.0
6	5.000	1	4.3	1.23	3.50	2.0	.0
6	5.000	1	3.8	.63	6.07	2.5	.0
6	5.000	1	2.9	.36	8.03	3.0	.0
6	5.000	2	.8	.36	2.22	3.0	.0
6	5.000	2	2.6	1.23	2.11	2.0	.0
6	5.000	2	1.9	.63	3.04	2.5	.0
6	5.000	2	1.5	.36	4.16	3.0	.0
6	10.000	1	270.6	106.90	2.53	.5	.0
6	10.000	1	360.9	106.90	3.38	.5	.0
6	10.000	1	22.6	10.40	2.17	1.0	.0
6	10.000	1	7.5	2.96	2.53	1.5	.0
6	10.000	1	3.8	1.23	3.09	2.0	.0
6	10.000	2	233.9	100.90	2.32	.0	.5
6	10.000	2	7.8	2.96	2.63	1.5	.0
6	10.000	2	3.9	1.23	3.17	2.0	.0
6	10.000	2	3.9	.63	6.23	2.5	.0

OF MEAUSREMENTS >= 2.0 FOR LOCATION 6 IS 23

FOR MEASURED/CALCULATED RATIO >= 2.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	-
7	10.000	1	7.8	2.96	2.63	1.5	.
7	10.000	1	8.2	1.23	6.67	2.0	.0
7	10.000	2	5.6	2.37	2.36	.0	2.
7	10.000	2	261.2	106.90	2.44	.5	.
7	10.000	2	424.5	106.90	3.97	.5	.0
7	10.000	2	7.3	2.96	2.47	1.5	.
7	10.000	2	2.9	1.23	2.36	2.0	.
7	1.000	2	222.2	106.90	2.08	.5	.0
7	1.000	2	222.2	106.90	2.08	.5	.
7	5.000	1	3.8	1.23	3.09	2.0	.
7	5.000	2	263.4	106.90	2.46	.5	.0
7	5.000	2	3.4	1.23	2.76	2.0	.
7	5.000	2	2.0	.36	5.54	3.0	.
7	5.000	2	217.1	106.90	2.03	.5	.

OF MEAUSREMENTS >= 2.0 FOR LOCATION 7 IS 14

8	5.000	1	1.9	.71	2.68	.0	3.0
8	5.000	1	1.6	.71	2.25	.0	3.
8	5.000	1	11.8	2.96	3.99	1.5	.
8	5.000	2	240.6	106.90	2.25	.5	.0
8	5.000	2	7.1	2.96	2.40	1.5	.
8	5.000	2	3.1	1.23	2.52	2.0	.
8	5.000	2	1.7	.63	2.72	2.5	.
8	5.000	2	1.1	.36	3.05	3.0	.0
8	10.000	1	6.3	2.37	2.66	.0	2.
8	10.000	1	2.7	1.22	2.21	.0	2.
8	10.000	1	240.7	106.90	2.25	.5	.0
8	10.000	1	313.9	106.90	2.94	.5	.
8	10.000	2	268.5	106.90	2.51	.5	.
8	10.000	2	1.3	.63	2.08	2.5	.0
8	10.000	2	1.1	.36	3.05	3.0	.
8	10.000	2	322.2	106.90	3.01	.5	.
8	10.000	2	21.5	10.40	2.07	1.0	.0
8	10.000	2	8.6	2.96	2.90	1.5	.0
8	10.000	2	4.3	1.23	3.50	2.0	.
8	10.000	2	3.1	.63	4.95	2.5	.
8	10.000	2	2.1	.36	5.82	3.0	.0
8	.173	2	1.5	.63	2.40	2.5	.
8	.173	1	282.2	106.90	2.64	.5	.
8	.530	2	222.0	100.90	2.20	.0	.5
8	.530	1	6.6	2.96	2.23	1.5	.
8	1.000	1	8.3	2.96	2.80	1.5	.
8	1.000	1	262.1	106.90	2.45	.5	.0
8	1.000	1	23.3	10.40	2.24	1.0	.0
8	1.000	1	6.1	2.96	2.06	1.5	.
8	1.000	2	251.3	106.90	2.35	.5	.

OF MEAUSREMENTS >= 2.0 FOR LOCATION 8 IS 30

FOR MEASURED/CALCULATED RATIO >= 2.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
9	1.000	2	208.7	100.90	2.07	.0	.5
9	.530	2	238.9	100.90	2.37	.0	.5
9	.530	1	267.9	106.90	2.51	.5	.0
9	.173	1	233.8	106.90	2.19	.5	.0
9	.173	1	346.3	106.90	3.24	.5	.0
9	.173	1	20.8	10.40	2.00	1.0	.0
9	5.000	1	283.5	106.90	2.65	.5	.0
9	5.000	1	6.4	2.96	2.16	1.5	.0
9	5.000	2	6.1	2.96	2.06	1.5	.0
9	5.000	2	3.4	1.23	2.76	2.0	.0
9	5.000	2	2.2	.63	3.51	2.5	.0
9	5.000	2	1.8	.36	4.99	3.0	.0
9	5.000	2	232.8	106.90	2.18	.5	.0
9	10.000	2	4.1	1.23	3.33	2.0	.0
9	10.000	2	3.1	.63	4.95	2.5	.0
9	10.000	2	2.7	.36	7.48	3.0	.0
9	10.000	2	1.3	.63	2.06	2.5	.0
9	10.000	2	1.2	.36	3.32	3.0	.0
9	10.000	1	3.0	1.22	2.46	.0	2.5
9	10.000	1	2.6	.71	3.66	.0	3.0
9	10.000	1	11.2	5.50	2.04	.0	1.5
9	10.000	1	6.2	2.37	2.62	.0	2.0
9	10.000	1	1.8	.71	2.54	.0	3.0
9	10.000	1	6.0	2.96	2.03	1.5	.0

OF MEAUSREMENTS >= 2.0 FOR LOCATION 9 IS 24

TOTAL # OF MEAUSREMENTS >= 2.0 IS 294

FOR MEASURED/CALCULATED RATIO >= 3.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
1	10.000	1	2.2	.71	3.10	.0	3.0
1	10.000	1	10.7	2.96	3.61	1.5	[illegible]
1	10.000	1	6.7	1.23	5.45	2.0	[illegible]
1	10.000	1	5.2	.63	8.31	2.5	.0
1	10.000	1	3.7	1.23	3.01	2.0	.0
1	10.000	1	2.5	.63	3.99	2.5	[illegible]
1	10.000	1	2.5	.36	6.93	3.0	.0
1	10.000	2	1.8	.36	4.99	3.0	.0
1	10.000	2	5.3	1.23	4.31	2.0	[illegible]
1	10.000	2	3.3	.63	5.27	2.5	[illegible]
1	10.000	2	2.7	.36	7.48	3.0	.0
1	10.000	2	2.5	.71	3.52	.0	3.[illegible]
1	.173	2	1.2	.36	3.32	3.0	[illegible]

OF MEAUSREMENTS >= 3.0 FOR LOCATION 1 IS 13

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
2	5.000	2	10.4	2.96	3.51	1.5	.0
2	10.000	2	4.8	1.23	3.90	2.0	.0
2	10.000	1	5.5	1.23	4.47	2.0	[illegible]
2	10.000	1	4.4	.63	7.03	2.5	.0
2	10.000	1	4.7	.36	13.02	3.0	.0

OF MEAUSREMENTS >= 3.0 FOR LOCATION 2 IS 5

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
3	10.000	1	5.5	1.23	4.47	2.0	[illegible]
3	10.000	1	4.3	.63	6.87	2.5	[illegible]
3	10.000	2	1.1	.36	3.05	3.0	.0
3	10.000	2	1.1	.36	3.05	3.0	.0

OF MEAUSREMENTS >= 3.0 FOR LOCATION 3 IS 4

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
4	10.000	1	4.2	1.23	3.41	2.0	[illegible]
4	10.000	1	3.5	.63	5.59	2.5	[illegible]
4	10.000	1	3.8	.36	10.53	3.0	.0
4	10.000	1	2.8	.63	4.47	2.5	[illegible]
4	10.000	1	3.8	.36	10.53	3.0	[illegible]
4	10.000	2	2.3	.63	3.67	2.5	.0
4	10.000	2	1.8	.36	4.99	3.0	.0
4	5.000	1	1.8	.36	4.99	3.0	[illegible]
4	5.000	2	3.0	.71	4.23	.0	3.0
4	5.000	2	1.8	.36	4.99	3.0	.0

OF MEAUSREMENTS >= 3.0 FOR LOCATION 4 IS 10

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
5	5.000	2	2.2	.63	3.51	2.5	[illegible]
5	5.000	2	2.2	.36	6.09	3.0	[illegible]
5	5.000	1	2.2	.63	3.51	2.5	.0
5	10.000	1	5.3	1.23	4.31	2.0	[illegible]
5	10.000	1	3.9	.63	6.23	2.5	[illegible]
5	10.000	1	2.1	.63	3.35	2.5	.0

FOR MEASURED/CALCULATED RATIO >= 3.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
5	10.000	1	1.3	.36	3.60	3.0	.0
5	10.000	1	4.8	1.23	3.90	2.0	.0
5	10.000	1	3.6	.63	5.75	2.5	.0
5	10.000	1	3.2	.36	8.86	3.0	.0
5	10.000	1	1.2	.36	3.32	3.0	.0
5	1.000	2	54.2	17.70	3.06	.0	1.0
5	1.000	2	5.0	1.22	4.10	.0	2.5
5	1.000	2	452.0	100.90	4.48	.0	.5
5	1.000	2	56.5	17.70	3.19	.0	1.0
5	1.000	2	16.9	5.50	3.07	.0	1.5
5	1.000	2	8.5	2.37	3.59	.0	2.0
5	1.000	2	497.2	106.90	4.65	.5	.0
5	1.000	2	33.9	10.40	3.26	1.0	.0
5	1.000	2	565.0	106.90	5.29	.5	.0
5	1.000	2	45.2	10.40	4.35	1.0	.0
5	1.000	2	11.3	2.96	3.82	1.5	.0
5	1.000	2	5.0	1.23	4.07	2.0	.0
5	1.000	2	2.7	.63	4.31	2.5	.0
5	1.000	2	1.6	.36	4.43	3.0	.0
5	.530	2	491.4	100.90	4.87	.0	.5
5	.530	2	85.4	17.70	4.82	.0	1.0
5	.530	2	25.7	5.50	4.67	.0	1.5
5	.530	2	8.6	2.37	3.63	.0	2.0
5	.530	2	4.2	1.22	3.44	.0	2.5
5	.530	2	341.9	100.90	3.39	.0	.5
5	.530	2	21.3	5.50	3.87	.0	1.5
5	.530	2	7.7	2.37	3.25	.0	2.0
5	.530	2	4.2	1.22	3.44	.0	2.5
5	.530	2	384.7	106.90	3.60	.5	.0
5	.530	2	42.8	10.40	4.12	1.0	.0
5	.530	2	12.0	2.96	4.05	1.5	.0
5	.530	2	4.7	1.23	3.82	2.0	.0
5	.530	2	3.0	.63	4.79	2.5	.0
5	.530	2	2.1	.36	5.82	3.0	.0
5	.530	2	32.0	10.40	3.08	1.0	.0
5	.530	2	9.8	2.96	3.31	1.5	.0
5	.530	2	4.7	1.23	3.82	2.0	.0
5	.530	2	3.0	.63	4.79	2.5	.0
5	.530	2	1.7	.36	4.71	3.0	.0
5	.530	1	378.4	100.90	3.75	.0	.5
5	.530	1	56.7	17.70	3.20	.0	1.0
5	.530	1	18.9	5.50	3.44	.0	1.5
5	.530	1	8.4	2.37	3.54	.0	2.0
5	.530	1	5.9	1.22	4.84	.0	2.5
5	.530	1	3.8	.71	5.35	.0	3.0
5	.530	1	462.4	100.90	4.58	.0	.5
5	.530	1	63.1	17.70	3.56	.0	1.0
5	.530	1	21.0	5.50	3.82	.0	1.5
5	.530	1	9.3	2.37	3.92	.0	2.0
5	.530	1	5.0	1.22	4.10	.0	2.5

FOR MEASURED/CALCULATED RATIO >= 3.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
5	.530	1	3.0	.71	4.23	.0	3.0
5	.530	1	756.6	106.90	7.08	.5	.0
5	.530	1	48.3	10.40	4.64	1.0	.0
5	.530	1	14.8	2.96	5.00	1.5	.0
5	.530	1	5.9	1.23	4.80	2.0	.0
5	.530	1	3.4	.63	5.43	2.5	.0
5	.530	1	483.4	106.90	4.52	.5	.0
5	.530	1	46.2	10.40	4.44	1.0	.0
5	.530	1	12.6	2.96	4.26	1.5	.0
5	.530	1	5.0	1.23	4.07	2.0	.0
5	.530	1	3.8	.63	6.07	2.5	.0
5	.530	1	2.5	.36	6.93	3.0	.0

OF MEAUSREMENTS >= 3.0 FOR LOCATION 5 IS 68

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
6	5.000	1	4.3	1.23	3.50	2.0	.0
6	5.000	1	3.8	.63	6.07	2.5	.0
6	5.000	1	2.9	.36	8.03	3.0	.0
6	5.000	2	1.9	.63	3.04	2.5	.0
6	5.000	2	1.5	.36	4.16	3.0	.0
6	10.000	1	360.9	106.90	3.38	.5	.0
6	10.000	1	3.8	1.23	3.09	2.0	.0
6	10.000	2	3.9	1.23	3.17	2.0	.0
6	10.000	2	3.9	.63	6.23	2.5	.0

OF MEAUSREMENTS >= 3.0 FOR LOCATION 6 IS 9

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
7	10.000	1	8.2	1.23	6.67	2.0	.0
7	10.000	2	424.5	106.90	3.97	.5	.0
7	5.000	1	3.8	1.23	3.09	2.0	.0
7	5.000	2	2.0	.36	5.54	3.0	.0

OF MEAUSREMENTS >= 3.0 FOR LOCATION 7 IS 4

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
8	5.000	1	11.8	2.96	3.99	1.5	.0
8	5.000	2	1.1	.36	3.05	3.0	.0
8	10.000	2	1.1	.36	3.05	3.0	.0
8	10.000	2	322.2	106.90	3.01	.5	.0
8	10.000	2	4.3	1.23	3.50	2.0	.0
8	10.000	2	3.1	.63	4.95	2.5	.0
8	10.000	2	2.1	.36	5.82	3.0	.0

OF MEAUSREMENTS >= 3.0 FOR LOCATION 8 IS 7

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
9	.173	1	346.3	106.90	3.24	.5	.0
9	5.000	2	2.2	.63	3.51	2.5	.0
9	5.000	2	1.8	.36	4.99	3.0	.0
9	10.000	2	4.1	1.23	3.33	2.0	.0
9	10.000	2	3.1	.63	4.95	2.5	.0
9	10.000	2	2.7	.36	7.48	3.0	.0

FOR MEASURED/CALCULATED RATIO >= 3.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

OCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
9	10.000	2	1.2	.36	3.32	3.0	.0
9	10.000	1	2.6	.71	3.66	.0	3.0

OF MEAUSREMENTS >= 3.0 FOR LOCATION 9 IS 8

TOTAL # OF MEAUSREMENTS >= 3.0 IS 128

FOR MEASURED/CALCULATED RATIO >= 4.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
1	10.000	1	6.7	1.23	5.45	2.0	.0
1	10.000	1	5.2	.63	8.31	2.5	.0
1	10.000	1	2.5	.36	6.93	3.0	.0
1	10.000	2	1.8	.36	4.99	3.0	.0
1	10.000	2	5.3	1.23	4.31	2.0	.0
1	10.000	2	3.3	.63	5.27	2.5	.0
1	10.000	2	2.7	.36	7.48	3.0	.0
# OF MEAUSREMENTS >= 4.0 FOR LOCATION 1 IS 7							
2	10.000	1	5.5	1.23	4.47	2.0	.0
2	10.000	1	4.4	.63	7.03	2.5	.0
2	10.000	1	4.7	.36	13.02	3.0	.0
# OF MEAUSREMENTS >= 4.0 FOR LOCATION 2 IS 3							
3	10.000	1	5.5	1.23	4.47	2.0	.0
3	10.000	1	4.3	.63	6.87	2.5	.0
# OF MEAUSREMENTS >= 4.0 FOR LOCATION 3 IS 2							
4	10.000	1	3.5	.63	5.59	2.5	.0
4	10.000	1	3.8	.36	10.53	3.0	.0
4	10.000	1	2.8	.63	4.47	2.5	.0
4	10.000	1	3.8	.36	10.53	3.0	.0
4	10.000	2	1.8	.36	4.99	3.0	.0
4	5.000	1	1.8	.36	4.99	3.0	.0
4	5.000	2	3.0	.71	4.23	.0	3.0
4	5.000	2	1.8	.36	4.99	3.0	.0
# OF MEAUSREMENTS >= 4.0 FOR LOCATION 4 IS 8							
5	5.000	2	2.2	.36	6.09	3.0	.0
5	10.000	1	5.3	1.23	4.31	2.0	.0
5	10.000	1	3.9	.63	6.23	2.5	.0
5	10.000	1	3.6	.63	5.75	2.5	.0
5	10.000	1	3.2	.36	8.86	3.0	.0
5	1.000	2	5.0	1.22	4.10	.0	2.5
5	1.000	2	452.0	100.90	4.48	.0	[illegible]
5	1.000	2	497.2	106.90	4.65	.5	.0
5	1.000	2	565.0	106.90	5.29	.5	.0
5	1.000	2	45.2	10.40	4.35	1.0	.0
5	1.000	2	5.0	1.23	4.07	2.0	.0
5	1.000	2	2.7	.63	4.31	2.5	.0
5	1.000	2	1.6	.36	4.43	3.0	.0
5	.530	2	491.4	100.90	4.87	.0	[illegible]
5	.530	2	85.4	17.70	4.82	.0	1.0
5	.530	2	25.7	5.50	4.67	.0	1.5
5	.530	2	42.8	10.40	4.12	1.0	[illegible]
5	.530	2	12.0	2.96	4.05	1.5	[illegible]

FOR MEASURED/CALCULATED RATIO >= 4.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
5	.530	2	3.0	.63	4.79	2.5	.0
5	.530	2	2.1	.36	5.82	3.0	.0
5	.530	2	3.0	.63	4.79	2.5	.0
5	.530	2	1.7	.36	4.71	3.0	.0
5	.530	1	5.9	1.22	4.84	.0	2.5
5	.530	1	3.8	.71	5.35	.0	3.0
5	.530	1	462.4	100.90	4.58	.0	.5
5	.530	1	5.0	1.22	4.10	.0	2.5
5	.530	1	3.0	.71	4.23	.0	3.0
5	.530	1	756.6	106.90	7.08	.5	.0
5	.530	1	48.3	10.40	4.64	1.0	.0
5	.530	1	14.8	2.96	5.00	1.5	.0
5	.530	1	5.9	1.23	4.80	2.0	.0
5	.530	1	3.4	.63	5.43	2.5	.0
5	.530	1	483.4	106.90	4.52	.5	.0
5	.530	1	46.2	10.40	4.44	1.0	.0
5	.530	1	12.6	2.96	4.26	1.5	.0
5	.530	1	5.0	1.23	4.07	2.0	.0
5	.530	1	3.8	.63	6.07	2.5	.0
5	.530	1	2.5	.36	6.93	3.0	.0

OF MEAUSREMENTS >= 4.0 FOR LOCATION 5 IS 38

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
6	5.000	1	3.8	.63	6.07	2.5	.0
6	5.000	1	2.9	.36	8.03	3.0	.0
6	5.000	2	1.5	.36	4.16	3.0	.0
6	10.000	2	3.9	.63	6.23	2.5	.0

OF MEAUSREMENTS >= 4.0 FOR LOCATION 6 IS 4

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
7	10.000	1	8.2	1.23	6.67	2.0	.0
7	5.000	2	2.0	.36	5.54	3.0	.0

OF MEAUSREMENTS >= 4.0 FOR LOCATION 7 IS 2

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
8	10.000	2	3.1	.63	4.95	2.5	.0
8	10.000	2	2.1	.36	5.82	3.0	.0

OF MEAUSREMENTS >= 4.0 FOR LOCATION 8 IS 2

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
9	5.000	2	1.8	.36	4.99	3.0	.0
9	10.000	2	3.1	.63	4.95	2.5	.0
9	10.000	2	2.7	.36	7.48	3.0	.0

OF MEAUSREMENTS >= 4.0 FOR LOCATION 9 IS 3

TOTAL # OF MEAUSREMENTS >= 4.0 IS 69

FOR MEASURED/CALCULATED RATIO >= 5.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	-
1	10.000	1	6.7	1.23	5.45	2.0	.0
1	10.000	1	5.2	.63	8.31	2.5	0
1	10.000	1	2.5	.36	6.93	3.0	.0
1	10.000	2	3.3	.63	5.27	2.5	.0
1	10.000	2	2.7	.36	7.48	3.0	0

OF MEAUSREMENTS >= 5.0 FOR LOCATION 1 IS 5

2	10.000	1	4.4	.63	7.03	2.5	0
2	10.000	1	4.7	.36	13.02	3.0	.0

OF MEAUSREMENTS >= 5.0 FOR LOCATION 2 IS 2

3	10.000	1	4.3	.63	6.87	2.5	.0

OF MEAUSREMENTS >= 5.0 FOR LOCATION 3 IS 1

4	10.000	1	3.5	.63	5.59	2.5	0
4	10.000	1	3.8	.36	10.53	3.0	0
4	10.000	1	3.8	.36	10.53	3.0	.0

OF MEAUSREMENTS >= 5.0 FOR LOCATION 4 IS 3

5	5.000	2	2.2	.36	6.09	3.0	.0
5	10.000	1	3.9	.63	6.23	2.5	0
5	10.000	1	3.6	.63	5.75	2.5	.0
5	10.000	1	3.2	.36	8.86	3.0	.0
5	1.000	2	565.0	106.90	5.29	.5	0
5	.530	2	2.1	.36	5.82	3.0	0
5	.530	1	3.8	.71	5.35	.0	3.0
5	.530	1	756.6	106.90	7.08	.5	0
5	.530	1	3.4	.63	5.43	2.5	0
5	.530	1	3.8	.63	6.07	2.5	.0
5	.530	1	2.5	.36	6.93	3.0	.0

OF MEAUSREMENTS >= 5.0 FOR LOCATION 5 IS 11

6	5.000	1	3.8	.63	6.07	2.5	)
6	5.000	1	2.9	.36	8.03	3.0	)
6	10.000	2	3.9	.63	6.23	2.5	.0

OF MEAUSREMENTS >= 5.0 FOR LOCATION 6 IS 3

7	10.000	1	8.2	1.23	6.67	2.0	.0
7	5.000	2	2.0	.36	5.54	3.0	)

OF MEAUSREMENTS >= 5.0 FOR LOCATION 7 IS 2

8	10.000	2	2.1	.36	5.82	3.0	)

FOR MEASURED/CALCULATED RATIO >= 5.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

OCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
# OF MEAUSREMENTS >= 5.0 FOR LOCATION 8 IS 1							
9	10.000	2	2.7	.36	7.48	3.0	.0
# OF MEAUSREMENTS >= 5.0 FOR LOCATION 9 IS 1							

TOTAL # OF MEAUSREMENTS >= 5.0 IS 29

FOR MEASURED/CALCULATED RATIO >= 6.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
1	10.000	1	5.2	.63	8.31	2.5	.0
1	10.000	1	2.5	.36	6.93	3.0	0
1	10.000	2	2.7	.36	7.48	3.0	0

OF MEAUSREMENTS >= 6.0 FOR LOCATION 1 IS 3

2	10.000	1	4.4	.63	7.03	2.5	.0
2	10.000	1	4.7	.36	13.02	3.0	0

OF MEAUSREMENTS >= 6.0 FOR LOCATION 2 IS 2

3	10.000	1	4.3	.63	6.87	2.5	0

OF MEAUSREMENTS >= 6.0 FOR LOCATION 3 IS 1

4	10.000	1	3.8	.36	10.53	3.0	0
4	10.000	1	3.8	.36	10.53	3.0	.0

OF MEAUSREMENTS >= 6.0 FOR LOCATION 4 IS 2

5	5.000	2	2.2	.36	6.09	3.0	.0
5	10.000	1	3.9	.63	6.23	2.5	0
5	10.000	1	3.2	.36	8.86	3.0	.0
5	.530	1	756.6	106.90	7.08	.5	.0
5	.530	1	3.8	.63	6.07	2.5	0
5	.530	1	2.5	.36	6.93	3.0	0

OF MEAUSREMENTS >= 6.0 FOR LOCATION 5 IS 6

6	5.000	1	3.8	.63	6.07	2.5	.0
6	5.000	1	2.9	.36	8.03	3.0	.0
6	10.000	2	3.9	.63	6.23	2.5	0

OF MEAUSREMENTS >= 6.0 FOR LOCATION 6 IS 3

7	10.000	1	8.2	1.23	6.67	2.0	0

OF MEAUSREMENTS >= 6.0 FOR LOCATION 7 IS 1

OF MEAUSREMENTS >= 6.0 FOR LOCATION 8 IS

9	10.000	2	2.7	.36	7.48	3.0	.0

OF MEAUSREMENTS >= 6.0 FOR LOCATION 9 IS 1

TOTAL # OF MEAUSREMENTS >= 6.0 IS 19

FOR MEASURED/CALCULATED RATIO >= 7.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

L CATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
1	10.000	1	5.2	.63	8.31	2.5	.0
1	10.000	2	2.7	.36	7.48	3.0	.0

OF MEAUSREMENTS >= 7.0 FOR LOCATION 1 IS 2

2	10.000	1	4.4	.63	7.03	2.5	.0
2	10.000	1	4.7	.36	13.02	3.0	.0

OF MEAUSREMENTS >= 7.0 FOR LOCATION 2 IS 2

OF MEAUSREMENTS >= 7.0 FOR LOCATION 3 IS

4	10.000	1	3.8	.36	10.53	3.0	.0
4	10.000	1	3.8	.36	10.53	3.0	.0

OF MEAUSREMENTS >= 7.0 FOR LOCATION 4 IS 2

5	10.000	1	3.2	.36	8.86	3.0	.0
5	.530	1	756.6	106.90	7.08	.5	.0

OF MEAUSREMENTS >= 7.0 FOR LOCATION 5 IS 2

6	5.000	1	2.9	.36	8.03	3.0	.0

OF MEAUSREMENTS >= 7.0 FOR LOCATION 6 IS 1

OF MEAUSREMENTS >= 7.0 FOR LOCATION 7 IS

OF MEAUSREMENTS >= 7.0 FOR LOCATION 8 IS

9	10.000	2	2.7	.36	7.48	3.0	.0

OF MEAUSREMENTS >= 7.0 FOR LOCATION 9 IS 1

TOTAL # OF MEAUSREMENTS >= 7.0 IS 10

FOR MEASURED/CALCULATED RATIO >= 8.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
1	10.000	1	5.2	.63	8.31	2.5	.

OF MEAUSREMENTS >= 8.0 FOR LOCATION 1 IS 1

2	10.000	1	4.7	.36	13.02	3.0	.0

OF MEAUSREMENTS >= 8.0 FOR LOCATION 2 IS 1

OF MEAUSREMENTS >= 8.0 FOR LOCATION 3 IS

4	10.000	1	3.8	.36	10.53	3.0	.0
4	10.000	1	3.8	.36	10.53	3.0	.0

OF MEAUSREMENTS >= 8.0 FOR LOCATION 4 IS 2

5	10.000	1	3.2	.36	8.86	3.0	.

OF MEAUSREMENTS >= 8.0 FOR LOCATION 5 IS 1

6	5.000	1	2.9	.36	8.03	3.0	.

OF MEAUSREMENTS >= 8.0 FOR LOCATION 6 IS 1

OF MEAUSREMENTS >= 8.0 FOR LOCATION 7 IS

OF MEAUSREMENTS >= 8.0 FOR LOCATION 8 IS

OF MEAUSREMENTS >= 8.0 FOR LOCATION 9 IS

TOTAL # OF MEAUSREMENTS >= 8.0 IS 6

FOR MEASURED/CALCULATED RATIO >= 10.00
SELECTED LISTING FOR HIGH MINE DATA
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

L CATION	FREQUENCY (FMHZ)	DIRECTION	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	X	Z
# OF MEAUSREMENTS >= 10.0 FOR LOCATION 1 IS							
2	10.000	1	4.7	.36	13.02	3.0	.0
# OF MEAUSREMENTS >= 10.0 FOR LOCATION 2 IS 1							
# OF MEAUSREMENTS >= 10.0 FOR LOCATION 3 IS							
4	10.000	1	3.8	.36	10.53	3.0	.0
4	10.000	1	3.8	.36	10.53	3.0	.0
# OF MEAUSREMENTS >= 10.0 FOR LOCATION 4 IS 2							
# OF MEAUSREMENTS >= 10.0 FOR LOCATION 5 IS							
# OF MEAUSREMENTS >= 10.0 FOR LOCATION 6 IS							
# OF MEAUSREMENTS >= 10.0 FOR LOCATION 7 IS							
# OF MEAUSREMENTS >= 10.0 FOR LOCATION 8 IS							
# OF MEAUSREMENTS >= 10.0 FOR LOCATION 9 IS							

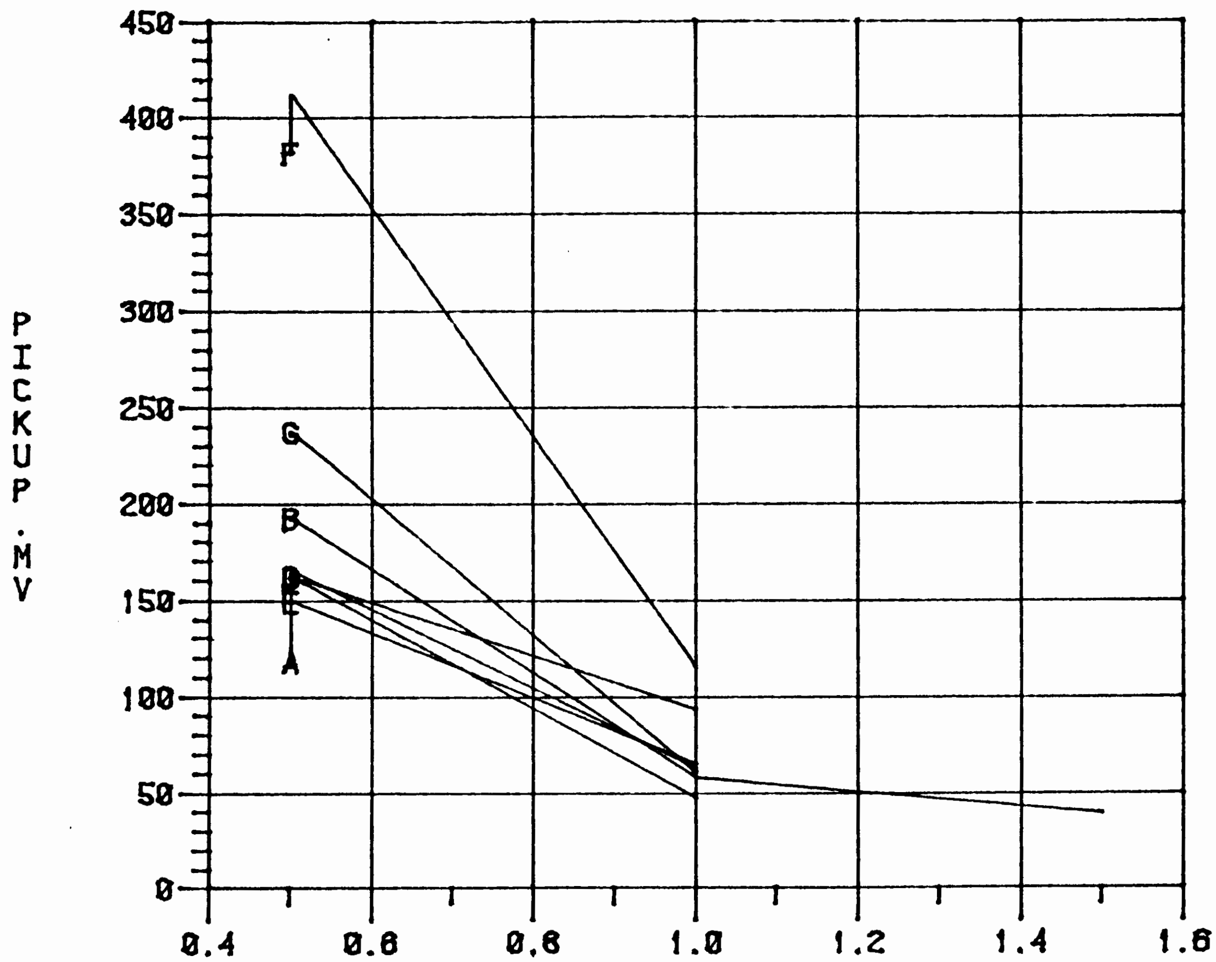
TOTAL # OF MEAUSREMENTS >= 10.0 IS 3

APPENDIX G

PLOTS OF CURRENT AND FREQUENCY NORMALIZED TRANSMISSION LINE DATA

L TRANSMISSION LINE DATA FROM PROJECT C5490—FREQUENCY= .170 MHZ

FOR Z=0.5 METERS

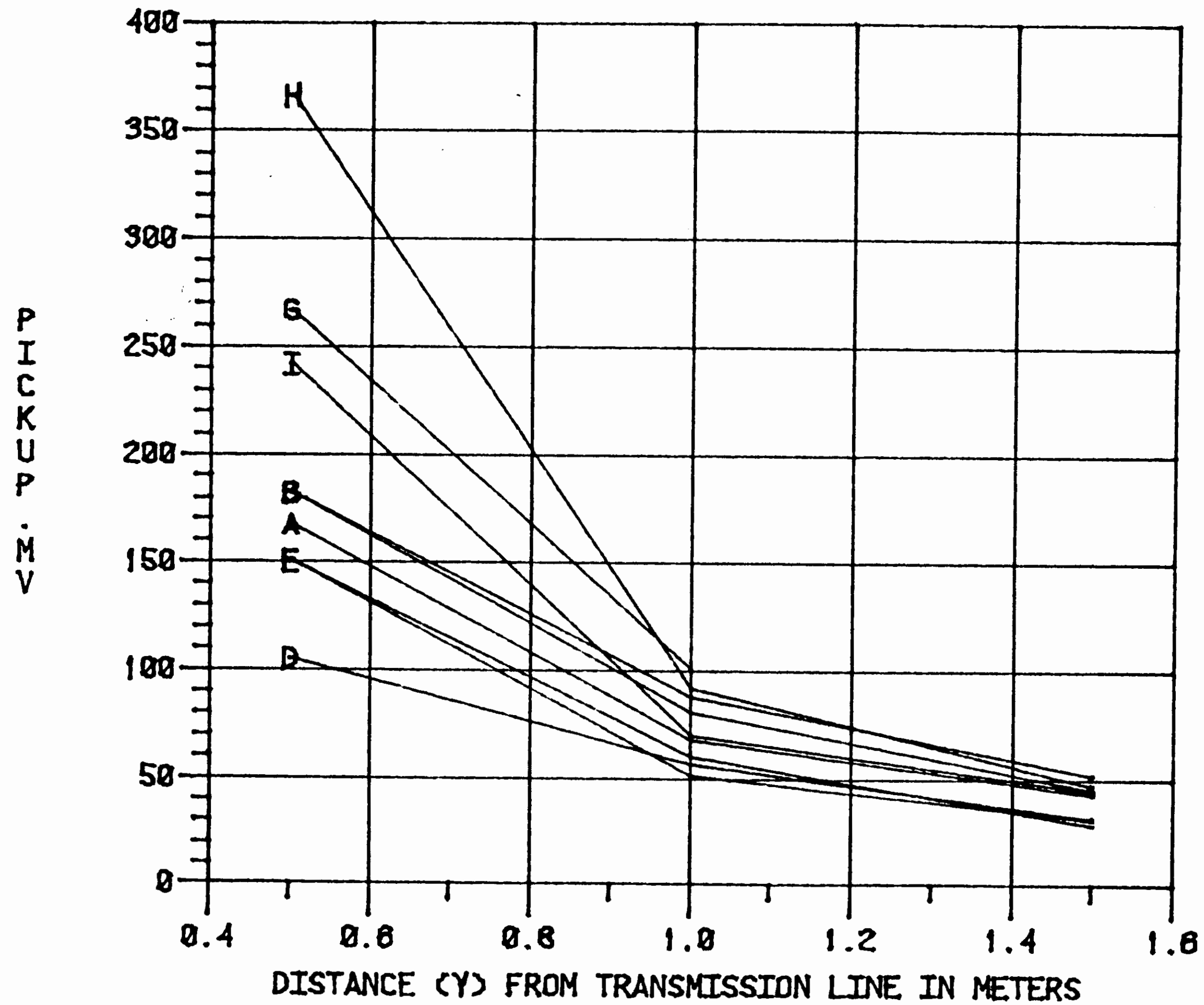


DISTANCE (Y) FROM TRANSMISSION LINE IN METERS

FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS LINE CURRENT

L TRANSMISSION LINE DATA FROM PROJECT C5490—FREQUENCY= .500 MHZ

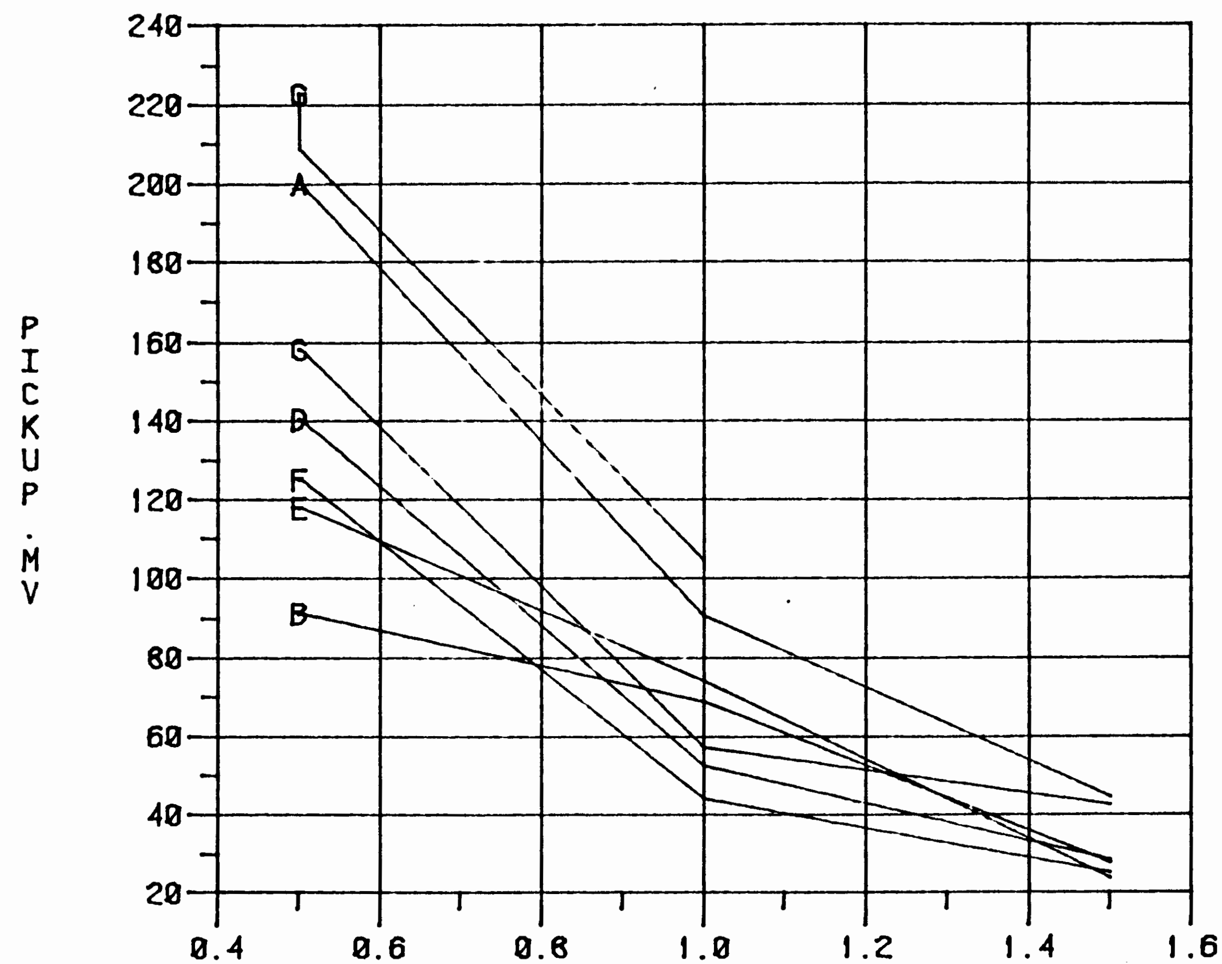
FOR Z=0.5 METERS



FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS LINE CURRENT

L TRANSMISSION LINE DATA FROM PROJECT C5490—FREQUENCY= 1.000 MHZ

FOR Z=0.5 METERS

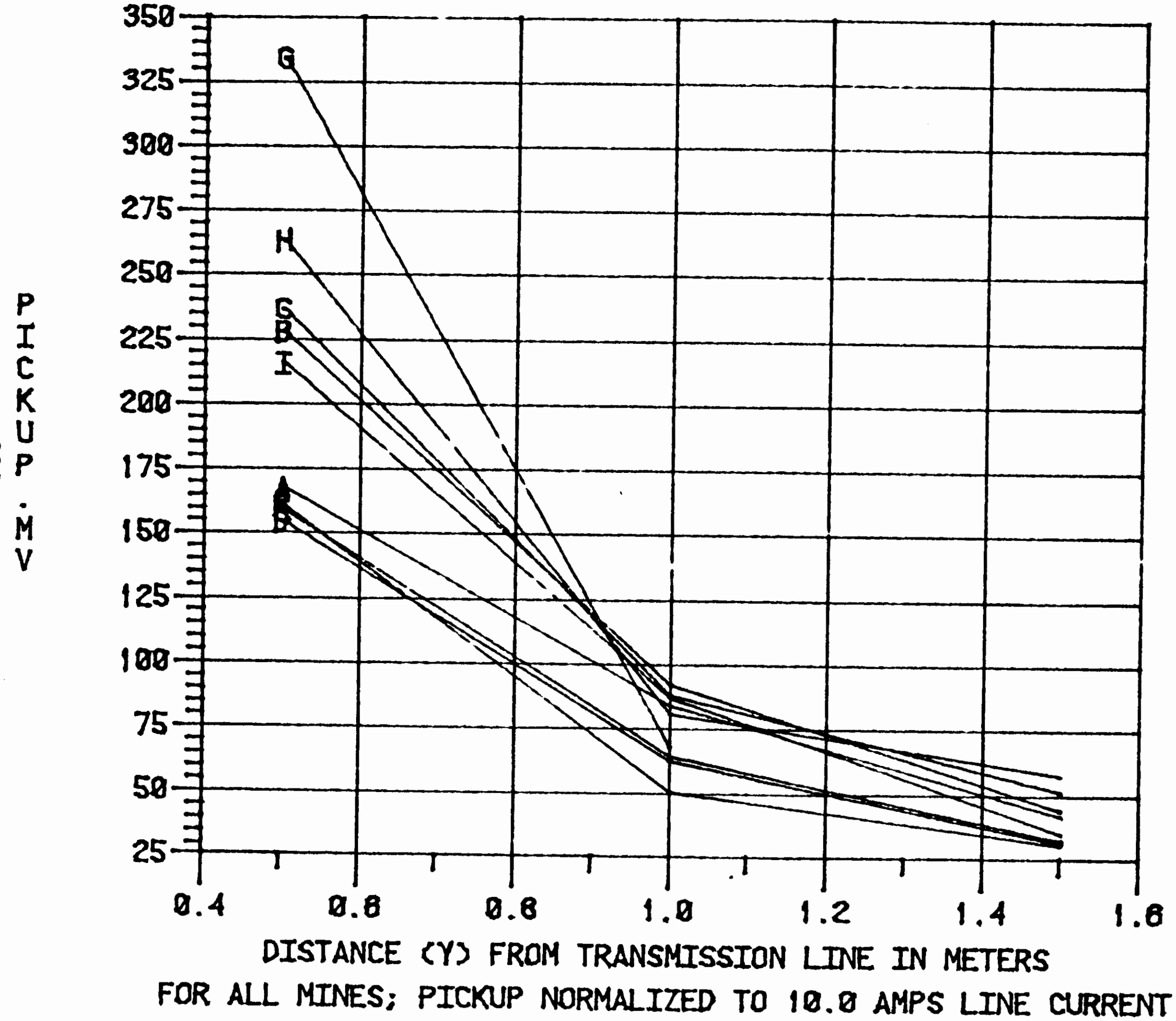


DISTANCE (Y) FROM TRANSMISSION LINE IN METERS

FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS LINE CURRENT

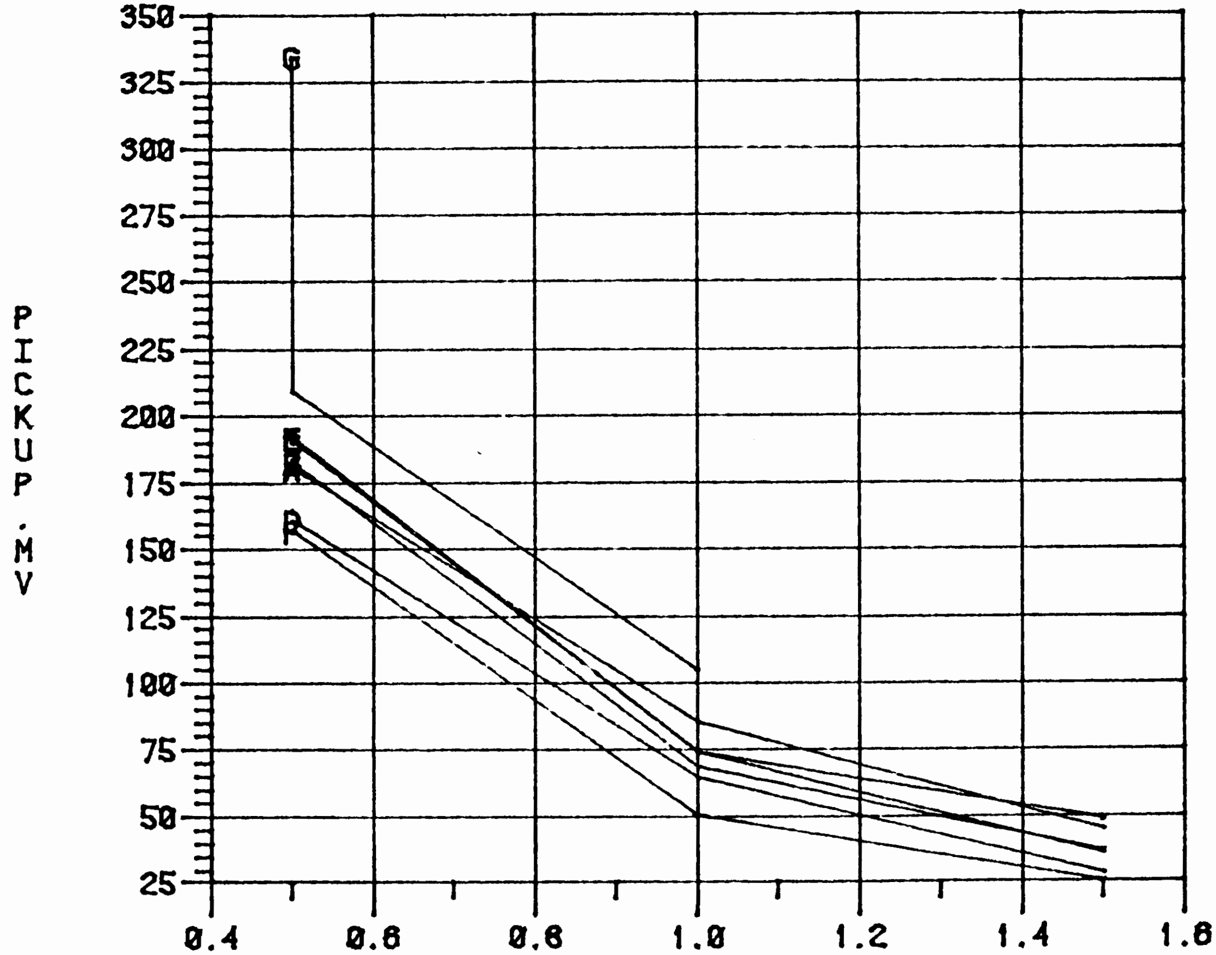
L TRANSMISSION LINE DATA FROM PROJECT C5490—FREQUENCY= .500 MHZ

FOR Z=1.0 METER



L TRANSMISSION LINE DATA FROM PROJECT C5490--FREQUENCY= 1.000 MHZ

FOR Z=1.0 METER



DISTANCE (Y) FROM TRANSMISSION LINE IN METERS

FOR ALL MINES; PICKUP NORMALIZED TO 10.0 AMPS LINE CURRENT

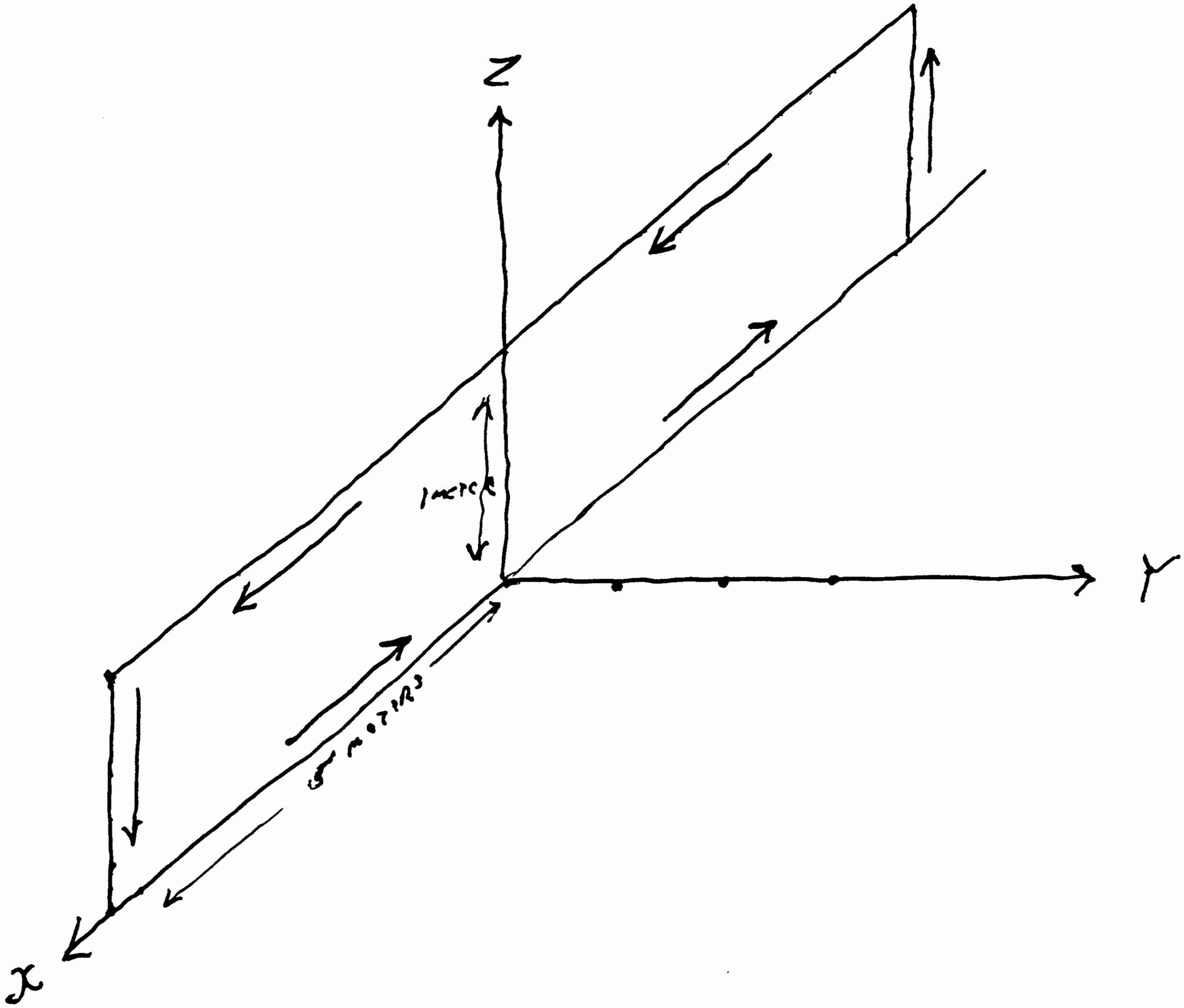
APPENDIX H

OUTPUT FROM

COMPUTER PROGRAM HECOMP

STRAIGHT LINE CURRENTS OF 10 AMPS

(RECTANGULAR--10 METERS BY 1 METER) FOR 1 MHZ



COORDINATE SYSTEM FOR THE COMPUTATION

THE FIELD COMPONENTS FOR X= 0.00000,Y= 0.00000,Z= 0.50000 ARE:

X	Y	Z	
0.000E+00	6.399E+00	0.000E+00	REAL PT--H FIELD (A/M)
0.000E+00	-4.870E-05	0.000E+00	IMAGINARY PT--H FIELD (A/M)
0.000E+00	6.399E+00	0.000E+00	MAG. H (A/M)
0.000E+00	-4.361E-04	0.000E+00	ANGLE H (DEG)
-3.300E-08	0.000E+00	0.000E+00	REAL PT--E FIELD (V/M)
-2.990E-07	0.000E+00	0.000E+00	IMAGINARY PT--E FIELD (V/M)
3.008E-07	0.000E+00	0.000E+00	MAG. E (V/M)
8.370E+01	0.000E+00	0.000E+00	ANGLE E (DEG)

NOTE THAT ONLY TERMS OF THE TYPE REAL{FIELD COMPONENT
*EXP(J*OMEGA*t) } HAVE PHYSICAL SIGNIFIGANCE.

POWER DENSITY IS 1.056E-07 (W/M**2)
IN A DIRECTION OF:
0.000E+00 0.000E+00 -1.000E+00

THE FIELD COMPONENTS FOR X= 0.00000,Y= 0.50000,Z= 0.50000 ARE:

X	Y	Z	
0.000E+00	3.215E+00	0.000E+00	REAL PT--H FIELD (A/M)
0.000E+00	-4.870E-05	0.000E+00	IMAGINARY PT--H FIELD (A/M)
0.000E+00	3.215E+00	0.000E+00	MAG. H (A/M)
0.000E+00	-8.678E-04	0.000E+00	ANGLE H (DEG)
-1.729E-08	1.143E-05	0.000E+00	REAL PT--E FIELD (V/M)
2.813E-07	-5.578E-04	0.000E+00	IMAGINARY PT--E FIELD (V/M)
2.818E-07	5.579E-04	0.000E+00	MAG. E (V/M)
-8.648E+01	-8.883E+01	0.000E+00	ANGLE E (DEG)

NOTE THAT ONLY TERMS OF THE TYPE REAL{FIELD COMPONENT
*EXP(J*OMEGA*t) } HAVE PHYSICAL SIGNIFIGANCE.

POWER DENSITY IS 2.780E-08 (W/M**2)
IN A DIRECTION OF:
0.000E+00 0.000E+00 -1.000E+00

THE FIELD COMPONENTS FOR X= 0.00000,Y= 1.00000,Z= 0.50000 ARE:

X	Y	Z	
0.000E+00	1.303E+00	0.000E+00	REAL PT--H FIELD (A/M)
0.000E+00	-4.870E-05	0.000E+00	IMAGINARY PT--H FIELD (A/M)
0.000E+00	1.303E+00	0.000E+00	MAG. H (A/M)
0.000E+00	-2.141E-03	0.000E+00	ANGLE H (DEG)
-3.545E-08	1.323E-05	0.000E+00	REAL PT--E FIELD (V/M)
3.073E-07	4.337E-04	0.000E+00	IMAGINARY PT--E FIELD (V/M)
3.094E-07	4.339E-04	0.000E+00	MAG. E (V/M)
-8.342E+01	8.825E+01	0.000E+00	ANGLE E (DEG)

NOTE THAT ONLY TERMS OF THE TYPE REAL{FIELD COMPONENT
*EXP(J*OMEGA*t) } HAVE PHYSICAL SIGNIFIGANCE.

POWER DENSITY IS 2.311E-08 (W/M**2)
IN A DIRECTION OF:
0.000E+00 0.000E+00 -1.000E+00

THE FIELD COMPONENTS FOR X= 0.00000,Y= 1.50000,Z= 0.50000 ARE:

X	Y	Z	
0.000E+00	6.637E-01	0.000E+00	REAL PT--H FIELD (A/M)
0.000E+00	-4.870E-05	0.000E+00	IMAGINARY PT--H FIELD (A/M)
0.000E+00	6.637E-01	0.000E+00	MAG. H (A/M)
0.000E+00	-4.204E-03	0.000E+00	ANGLE H (DEG)
1.380E-08	-4.429E-06	0.000E+00	REAL PT--E FIELD (V/M)
-9.313E-08	3.663E-05	0.000E+00	IMAGINARY PT--E FIELD (V/M)
9.415E-08	3.690E-05	0.000E+00	MAG. E (V/M)
-8.157E+01	-8.311E+01	0.000E+00	ANGLE E (DEG)

NOTE THAT ONLY TERMS OF THE TYPE REAL{FIELD COMPONENT
*EXP(J*OMEGA*t) } HAVE PHYSICAL SIGNIFIGANCE.

POWER DENSITY IS 4.580E-09 (W/M**2)
IN A DIRECTION OF:
0.000E+00 0.000E+00 1.000E+00

THE ABOVE DATA ARE FOR FREQUENCY(MHZ)= 1.00 AND :
STRAIGHT LINE CURRENTS:

AMPS	# PTS	XO	YO	ZO	XE	YE	ZE
10.0	400.	5.000	0.000	0.000	-5.000	0.000	0.000
10.0	400.	-5.000	0.000	0.000	-5.000	0.000	1.000
10.0	400.	-5.000	0.000	1.000	5.000	0.000	1.000
10.0	400.	5.000	0.000	1.000	5.000	0.000	0.000

THE FIELD COMPONENTS FOR X= 0.00000,Y= 0.00000,Z= 1.00000 ARE:

X	Y	Z	
0.000E+00	1.624E+00	0.000E+00	REAL PT--H FIELD (A/M)
0.000E+00	-4.870E-05	0.000E+00	IMAGINARY PT--H FIELD (A/M)
0.000E+00	1.624E+00	0.000E+00	MAG. H (A/M)
0.000E+00	-1.718E-03	0.000E+00	ANGLE H (DEG)
1.264E+03	0.000E+00	-6.676E-06	REAL PT--E FIELD (V/M)
-7.703E+08	0.000E+00	-2.041E-04	IMAGINARY PT--E FIELD (V/M)
7.703E+08	0.000E+00	2.042E-04	MAG. E (V/M)
-9.000E+01	0.000E+00	8.813E+01	ANGLE E (DEG)

NOTE THAT ONLY TERMS OF THE TYPE REAL{FIELD COMPONENT *EXP(J*OMEGA*t) } HAVE PHYSICAL SIGNIFIGANCE.

POWER DENSITY IS 1.978E+04 (W/M**2)
IN A DIRECTION OF:
2.738E-10 0.000E+00 1.000E+00

THE FIELD COMPONENTS FOR X= 0.00000,Y= 0.50000,Z= 1.00000 ARE:

X	Y	Z	
-5.821E-11	1.305E+00	2.546E+00	REAL PT--H FIELD (A/M)
-1.279E-13	-4.870E-05	-3.686E-10	IMAGINARY PT--H FIELD (A/M)
5.821E-11	1.305E+00	2.546E+00	MAG. H (A/M)
1.259E-01	-2.138E-03	-8.294E-09	ANGLE H (DEG)
-1.039E+03	1.119E-05	8.345E-06	REAL PT--E FIELD (V/M)
-1.001E+01	-1.438E-03	2.193E-04	IMAGINARY PT--E FIELD (V/M)
1.039E+03	1.438E-03	2.195E-04	MAG. E (V/M)
5.519E-01	-8.955E+01	8.782E+01	ANGLE E (DEG)

NOTE THAT ONLY TERMS OF THE TYPE REAL{FIELD COMPONENT *EXP(J*OMEGA*t) } HAVE PHYSICAL SIGNIFIGANCE.

POWER DENSITY IS 1.486E+03 (W/M**2)
IN A DIRECTION OF:
5.921E-09 8.899E-01 -4.562E-01

THE FIELD COMPONENTS FOR X= 0.00000,Y= 1.00000,Z= 1.00000 ARE:

X	Y	Z	
3.492E-10	8.257E-01	7.950E-01	REAL PT--H FIELD (A/M)
1.421E-13	-4.870E-05	-1.052E-09	IMAGINARY PT--H FIELD (A/M)
3.492E-10	8.257E-01	7.950E-01	MAG. H (A/M)
2.331E-02	-3.379E-03	-7.582E-08	ANGLE H (DEG)
-2.743E+02	-7.056E-06	0.000E+00	REAL PT--E FIELD (V/M)
-4.245E+00	-2.549E-04	-5.245E-05	IMAGINARY PT--E FIELD (V/M)
2.744E+02	2.550E-04	5.245E-05	MAG. E (V/M)
8.864E-01	8.841E+01	8.999E+01	ANGLE E (DEG)

NOTE THAT ONLY TERMS OF THE TYPE REAL{FIELD COMPONENT
*EXP(J*OMEGA*t) } HAVE PHYSICAL SIGNIFIGANCE.

POWER DENSITY IS 1.572E+02 (W/M**2)
IN A DIRECTION OF:
-1.783E-08 6.936E-01 -7.203E-01

THE FIELD COMPONENTS FOR X= 0.00000,Y= 1.50000,Z= 1.00000 ARE:

X	Y	Z	
-3.492E-10	5.166E-01	3.254E-01	REAL PT--H FIELD (A/M)
5.116E-13	-4.870E-05	-1.518E-09	IMAGINARY PT--H FIELD (A/M)
3.492E-10	5.166E-01	3.254E-01	MAG. H (A/M)
-8.393E-02	-5.401E-03	-2.674E-07	ANGLE H (DEG)
-1.041E+02	1.771E-05	-2.384E-07	REAL PT--E FIELD (V/M)
-2.201E+00	-3.821E-05	4.005E-05	IMAGINARY PT--E FIELD (V/M)
1.042E+02	4.211E-05	4.006E-05	MAG. E (V/M)
1.211E+00	-6.513E+01	-8.966E+01	ANGLE E (DEG)

NOTE THAT ONLY TERMS OF THE TYPE REAL{FIELD COMPONENT
*EXP(J*OMEGA*t) } HAVE PHYSICAL SIGNIFIGANCE.

POWER DENSITY IS 3.179E+01 (W/M**2)
IN A DIRECTION OF:
9.261E-08 5.330E-01 -8.461E-01

THE ABOVE DATA ARE FOR FREQUENCY(MHZ)= 1.00 AND :
STRAIGHT LINE CURRENTS:

AMPS	# PTS	XO	YO	ZO	XE	YE	ZE
10.0	400.	5.000	0.000	0.000	-5.000	0.000	0.000
10.0	400.	-5.000	0.000	0.000	-5.000	0.000	1.000
10.0	400.	-5.000	0.000	1.000	5.000	0.000	1.000
10.0	400.	5.000	0.000	1.000	5.000	0.000	0.000

APPENDIX I

LISTING FOR ALL TRANSMISSION LINE DATA NORMALIZED TO 10 AMPS AND 1 MHZ

LISTING FOR ALL TRANSMISSION LINE MINE DATA PAGE 1

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	Y	Z
1	.170	117.7	199.00	.59	.5	.5
1	.170	117.7	80.60	1.46	.5	1.0
1	.500	166.7	199.00	.84	.5	.5
1	.500	166.7	80.60	2.07	.5	1.0
1	.500	66.7	80.60	.83	1.0	.5
1	.500	83.3	51.22	1.63	1.0	1.0
1	.500	41.7	41.18	1.01	1.5	.5
1	.500	41.7	32.20	1.29	1.5	1.0
1	1.000	200.0	199.00	1.01	.5	.5
1	1.000	180.0	80.60	2.23	.5	1.0
1	1.000	90.0	80.60	1.12	1.0	.5
1	1.000	85.0	51.22	1.66	1.0	1.0
1	1.000	44.0	41.18	1.07	1.5	.5
1	1.000	44.0	32.20	1.37	1.5	1.0
2	1.000	90.9	199.00	.46	.5	.5
2	1.000	68.2	80.60	.85	1.0	.5
2	1.000	27.3	41.18	.66	1.5	.5
2	1.000	181.8	80.60	2.26	.5	1.0
2	1.000	68.2	51.22	1.33	1.0	1.0
2	1.000	36.4	32.20	1.13	1.5	1.0
2	.500	181.8	199.00	.91	.5	.5
2	.500	80.0	80.60	.99	1.0	.5
2	.500	43.6	41.18	1.06	1.5	.5
2	.500	227.3	80.60	2.82	.5	1.0
2	.500	90.9	51.22	1.77	1.0	1.0
2	.500	43.6	32.20	1.36	1.5	1.0
2	.174	164.2	199.00	.83	.5	.5
2	.174	61.6	80.60	.76	1.0	.5
2	.174	205.3	80.60	2.55	.5	1.0
2	.174	61.6	51.22	1.20	1.0	1.0

LISTING FOR ALL TRANSMISSION LINE MINE DATA PAGE 2
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	Y	Z
3	.174	191.6	199.00	.96	.5	.5
3	.174	57.5	80.60	.71	1.0	.5
3	.174	38.3	41.18	.93	1.5	.5
3	.174	191.6	80.60	2.38	.5	1.0
3	.174	76.6	51.22	1.50	1.0	1.0
3	.174	38.3	32.20	1.19	1.5	1.0
3	.500	181.8	199.00	.91	.5	.5
3	.500	87.3	80.60	1.08	1.0	.5
3	.500	50.9	41.18	1.24	1.5	.5
3	.500	236.4	80.60	2.93	.5	1.0
3	.500	87.3	51.22	1.70	1.0	1.0
3	.500	50.9	32.20	1.58	1.5	1.0
3	1.000	157.9	199.00	.79	.5	.5
3	1.000	56.8	80.60	.71	1.0	.5
3	1.000	42.1	41.18	1.02	1.5	.5
3	1.000	189.5	80.60	2.35	.5	1.0
3	1.000	73.7	51.22	1.44	1.0	1.0
3	1.000	48.4	32.20	1.50	1.5	1.0
4	1.000	140.0	199.00	.70	.5	.5
4	1.000	52.0	80.60	.65	1.0	.5
4	1.000	28.0	41.18	.68	1.5	.5
4	1.000	160.0	80.60	1.99	.5	1.0
4	1.000	64.0	51.22	1.25	1.0	1.0
4	1.000	28.0	32.20	.87	1.5	1.0
4	.500	104.6	199.00	.53	.5	.5
4	.500	55.4	80.60	.69	1.0	.5
4	.500	30.8	41.18	.75	1.5	.5
4	.500	153.8	80.60	1.91	.5	1.0
4	.500	61.5	51.22	1.20	1.0	1.0
4	.500	30.8	32.20	.96	1.5	1.0
4	.174	160.9	199.00	.81	.5	.5
4	.174	92.0	80.60	1.14	1.0	.5
4	.174	206.9	80.60	2.57	.5	1.0
4	.174	92.0	51.22	1.80	1.0	1.0

LISTING FOR ALL TRANSMISSION LINE MINE DATA PAGE 3
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	Y	Z
5	.174	160.9	199.00	.81	.5	.5
5	.174	46.0	80.60	.57	1.0	.5
5	.174	206.9	80.60	2.57	.5	1.0
5	.174	69.0	51.22	1.35	1.0	1.0
5	.520	149.3	199.00	.75	.5	.5
5	.520	58.8	80.60	.73	1.0	.5
5	.520	27.2	41.18	.66	1.5	.5
5	.520	158.4	80.60	1.96	.5	1.0
5	.520	63.4	51.22	1.24	1.0	1.0
5	.520	31.7	32.20	.98	1.5	1.0
5	1.000	117.6	199.00	.59	.5	.5
5	1.000	73.5	80.60	.91	1.0	.5
5	1.000	23.5	41.18	.57	1.5	.5
5	1.000	191.2	80.60	2.37	.5	1.0
5	1.000	73.5	51.22	1.44	1.0	1.0
5	1.000	35.3	32.20	1.10	1.5	1.0
6	1.000	125.0	199.00	.63	.5	.5
6	1.000	43.8	80.60	.54	1.0	.5
6	1.000	25.0	41.18	.61	1.5	.5
6	1.000	156.3	80.60	1.94	.5	1.0
6	1.000	50.0	51.22	.98	1.0	1.0
6	1.000	25.0	32.20	.78	1.5	1.0
6	.500	150.0	199.00	.75	.5	.5
6	.500	50.0	80.60	.62	1.0	.5
6	.500	30.0	41.18	.73	1.5	.5
6	.500	160.0	80.60	1.99	.5	1.0
6	.500	50.0	51.22	.98	1.0	1.0
6	.500	30.0	32.20	.93	1.5	1.0
6	.174	149.0	199.00	.75	.5	.5
6	.174	63.9	80.60	.79	1.0	.5
6	.174	170.3	80.60	2.11	.5	1.0
6	.174	63.9	51.22	1.25	1.0	1.0

LISTING FOR ALL TRANSMISSION LINE MINE DATA PAGE 4
PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	Y	Z
7	.175	380.9	199.00	1.91	.5	.5
7	.175	380.9	80.60	4.73	.5	1.0
7	.500	266.7	199.00	1.34	.5	.5
7	.500	100.0	80.60	1.24	1.0	.5
7	.500	333.3	80.60	4.14	.5	1.0
7	.500	66.7	51.22	1.30	1.0	1.0
7	1.000	222.2	199.00	1.12	.5	.5
7	1.000	333.3	80.60	4.14	.5	1.0
8	.500	365.7	199.00	1.84	.5	.5
8	.500	91.4	80.60	1.13	1.0	.5
8	.500	262.9	80.60	3.26	.5	1.0
8	.500	80.0	51.22	1.56	1.0	1.0
8	.500	45.7	41.18	1.11	1.5	.5
8	.500	57.1	32.20	1.77	1.5	1.0
8	.175	411.4	199.00	2.07	.5	.5
8	.175	114.3	80.60	1.42	1.0	.5
8	.175	205.7	80.60	2.55	.5	1.0
8	.175	114.3	51.22	2.23	1.0	1.0

PICKUP NORMALIZED TO 10 AMPS COIL CURRENT AND 1.0 MHZ

LOCATION	FREQUENCY (FMHZ)	PICKUP(MV)	CALCULATED PICKUP	MEASURED/ CALCULATED	Y	Z
9	1.000	208.3	199.00	1.05	.5	.5
9	1.000	104.2	80.60	1.29	1.0	.5
9	1.000	208.3	80.60	2.58	.5	1.0
9	1.000	104.2	51.22	2.03	1.0	1.0
9	.500	241.4	199.00	1.21	.5	.5
9	.500	69.0	80.60	.86	1.0	.5
9	.500	43.1	41.18	1.05	1.5	.5
9	.500	215.5	80.60	2.67	.5	1.0
9	.500	86.2	51.22	1.68	1.0	1.0
9	.500	34.5	32.20	1.07	1.5	1.0
9	.175	236.4	199.00	1.19	.5	.5
9	.175	59.1	80.60	.73	1.0	.5
9	.175	197.1	80.60	2.44	.5	1.0
9	.175	78.8	51.22	1.54	1.0	1.0

APPENDIX J

TROLLEY CARRIER PHONE DATA

WORKING MEMORANDUM

For your information and review of work in progress. The findings and methods may be modified or superseded as our work proceeds.

MEMORANDUM

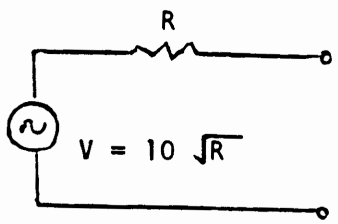
To: R. Lagace

Case: 86636 Date: March 1, 1982 Page: 1

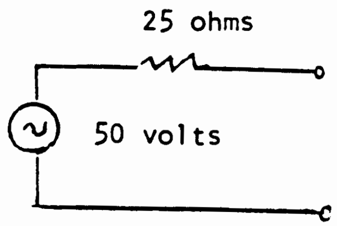
Subject: Power Output of Trolley Carrier Phones

Mine trolley carrier phones are of nominal 25 watt output rating. When these phones are used on mine vehicles, this rating typically applies to a 20 ohm resistive load. These phones are also used at fixed stations underground and often make use of transformer coupling which provides for delivering 25 watts of power to various other values of resistive loads up to 500 ohms. The frequency of operation ranges from 40 KHz to 190 KHz. Modulation is narrow band FM.

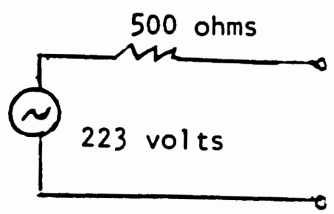
For the computation of output current under various load conditions and for various transformer coupling, it is convenient to use the generalized equivalent circuit show below. This circuit delivers 25 watts to a load of R ohms.



Generalized equivalent circuit



Equivalent circuit for R = 25 ohms



Equivalent circuit for R = 500 ohms

From: Richard H. Spencer

Bldg./Room.......... Ext..........

ADL-115-279-200M

Arthur D. Little Inc.

MEMORANDUM

To: R. Lagace

Case: 86636 Date: March 1, 1982 Page: 2

Subject: Power Output of Trolley Carrier Phones

The maximum current, the short circuit current, can readily be determined from these equivalent circuits and is determined by the equation:

$$I_{max} = \frac{10\sqrt{R}}{R} = \frac{10}{\sqrt{R}}$$

R can vary from 15 ohms to 500 ohms and thus the maximum currents range from 2.58 amperes to .447 amperes.

During our work for the Bureau of Mines on improving trolley carrier phone communications in operating coal mines, we did a considerable amount of experimental work underground. In one of the mines we installed a separate wire for aiding the propagation of carrier signals. This wire was matched and terminated to provide a transmission line of high integrity. Figure 1 shows the results of one set of experiments. An 88 KHz carrier phone was connected to the separate wire (using a rail return). Figure 1 shows the magnitude of the current in this wire over a distance of approximately 14,000 feet as it ran in a haulageway. The separate line was installed along the rib of the haulageway within 1-2 feet of an existing pager phone line. We measured the current in this pager phone line in common mode, that is the current carried by both conductors, as a function of distance along the haulageway. It can be seen that there is strong coupling between these two lines. The current fed into the separate wire had a maximum value of .15 amperes RMS into what we deduced to be approximately 250 ohms of characteristic impedance. The maximum current induced in the pager phone line in common mode was 56 milliamperes RMS. We estimate that the real power delivered to this line, assuming a 250 ohm characteristic impedance, was .78 watts. The maximum power on the dedicated line was 5.63 watts by comparison.

The Appendix contains copies of specification sheets and other general information regarding carrier phones.

RHS

From Richard H. Spencer ce Bldg./Room 15/273 Ext. 2122

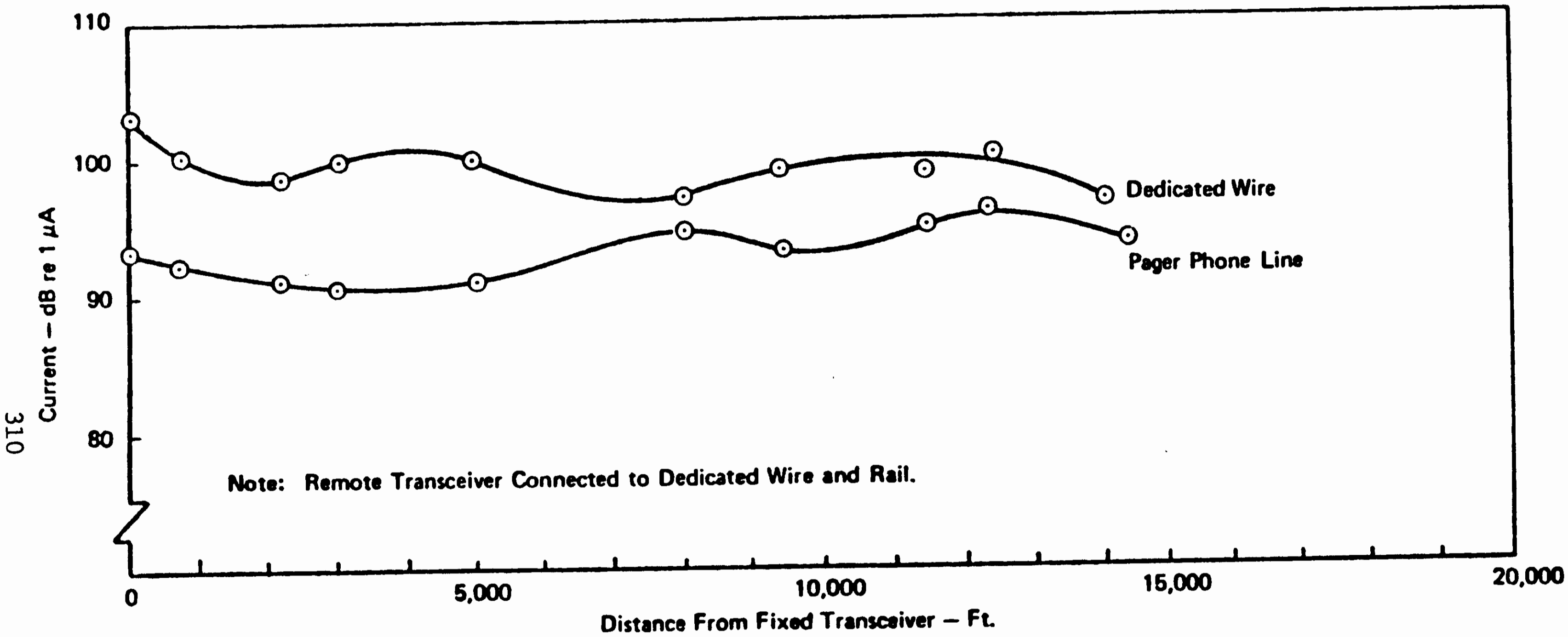


FIGURE 1 CURRENT COUPLING TO PAGER PHONE LINE *

*Lagace, R.L. et al "Trolley Carrier Phone Mine Communications - Adaptive Volume Control and Use of a Dedicated Wire or a Low Impedance Line for Improved Carrier Phone Communications in Mines," Final Report on Contract No. JO 377098, February 1979 Arthur D. Little, Inc.

TRANSISTORIZED TROLLEYPHONE *(641904 Cont.)*

It is a "carrier" system, in which the FM radio sig-
nal travels along a metallic conductor, which may be a power line, collector rail or almost any ungrounded conductor along the path of equipment operation.

The transmitter is activated when a button is pushed on the microphone; all Trolleyphones on the same frequency and signal path are open to receive the spoken message and answers are received when the button is released. Any number of two-way sets may be used, of course, with transmitters and receivers at all key points. Since all Femco communications systems are compatible, audio systems may also be used in combination.

A detailed instruction manual is available, containing full technical specifications, in addition to the descriptive information below. We also invite your inquiry as to special communications problems.

TECHNICAL SPECIFICATIONS

Mechanical

SIZE: . . . . 16" Wide x 11" High x 4" Deep

WEIGHT: . . . . 14 lb., 2 oz.

CONSTRUCTION: . . . . Shock Mounted, #14 gauge steel chassis.

FINISH: . . . . Gray Lacquer

Environmental

MOISTURE RESISTANCE: Operates when covered with condensation. For example, when cycling from below freezing to 70°F.

TEMPERATURE RANGE: −40°F. to +140°F. Can be continuously keyed in an ambient temperature of +140°F.

CONNECTIONS:

Power and Signal are brought out to a 3-terminal twist lock connector.

Microphone connections are made on a 4-terminal male Jones connector.

Speaker connections are made on a 4 terminal female Jones connector.

Electrical

FREQUENCY RANGE: . . . . 61KC to 190KC.

CHANNELS: . . . . 61KC, 72KC, 85KC, 100KC. 116KC, 133KC, 163KC, and 190KC.

POWER SOURCE:
Voltage — 190 to 300 volts dc Collector System.
Current — Transmit: . . . . .8 amperes
Standby: . . . . .4 amperes

INSULATION: The unit is insulated from ground and will withstand a 2500 volt dc high potential test.

RF INPUT IMPEDANCE: 100 ohms at channel frequency.

OPERATING RANGE: . . . . 70 db.

SENSITIVITY: 10 millivolts (Noise free, full open squelch)

SELECTIVITY:
3 db down @ ± 4KC above 100KC or ± 4% below 100KC.
20 db down @ ± 8KC above 100KC or ± 8% below 100KC.
40 db minimum rejection to adjacent channel.

SQUELCH: Balanced signal to noise type.

AUDIO OUTPUT IMPEDANCE: Will match a 16 ohm load.

RF LOAD IMPEDANCE: 0 to ∞, 25 ohms nominal.

RF OUTPUT POWER: 30 watts into a 25 ohm resistive load.

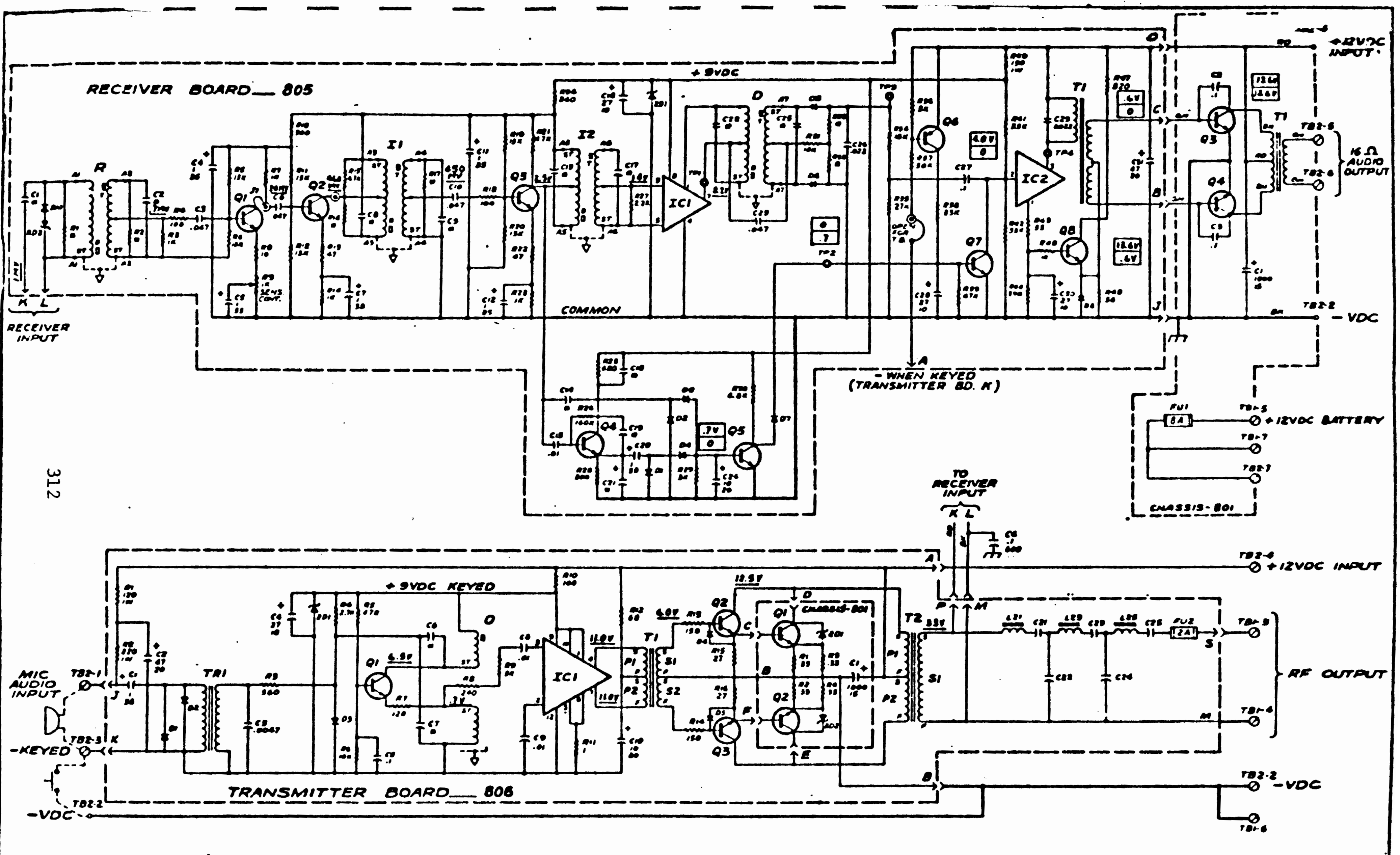
FREQUENCY STABILITY: Not more than ± 0.5KC throughout the specified voltage and temperature ranges.

HARMONIC CONTENT: 1%

FREQUENCY DEVIATION:
± 3% of channel frequency below 100KC.
± 3KC from channel frequency above 100KC.

For detailed information or application assistance, contact your local sales office, located in all major cities, or contact directly at Headquarters Office Irwin, Pennsylvania 15642
Phone 412-863-3200
TWX 510-468-8867

Femco DIVISION
Gulton Industries, Inc.



NOTES

1. A__INDICATES CHANGE WITH FREQUENCY
2. RECEIVER VOLTAGES WITH 1MV; AC VOLTAGES SHOWN ___, DC VOLTAGES SHOWN IN [box] SIGNAL / NO SIGNAL
3. TRANSMITTER VOLTAGES WITH UNIT KEYED, 25Ω LOAD.

LEGEND

RECEIVER BOARD-805
- Q1 THRU Q5, Q7, Q8__TU2N2222
- Q6__TU2N2907A
- IC1__TU2555
- IC2__TU2546
- D1 THRU D8, D10__TU1N659
- ZD1__TU1N757A
- ZD2__TU2567

TRANSMITTER BOARD-806
- Q1__TU2N2222
- Q2, Q3__TU2N1711
- D1 THRU D5__TU1N659
- ZD1__TU1N757A
- IC1__TUCA3020

CHASSIS-801
- Q1, Q2__TU2N5878
- Q3, Q4__TU2N3055
- ZD1, ZD2__TU2525

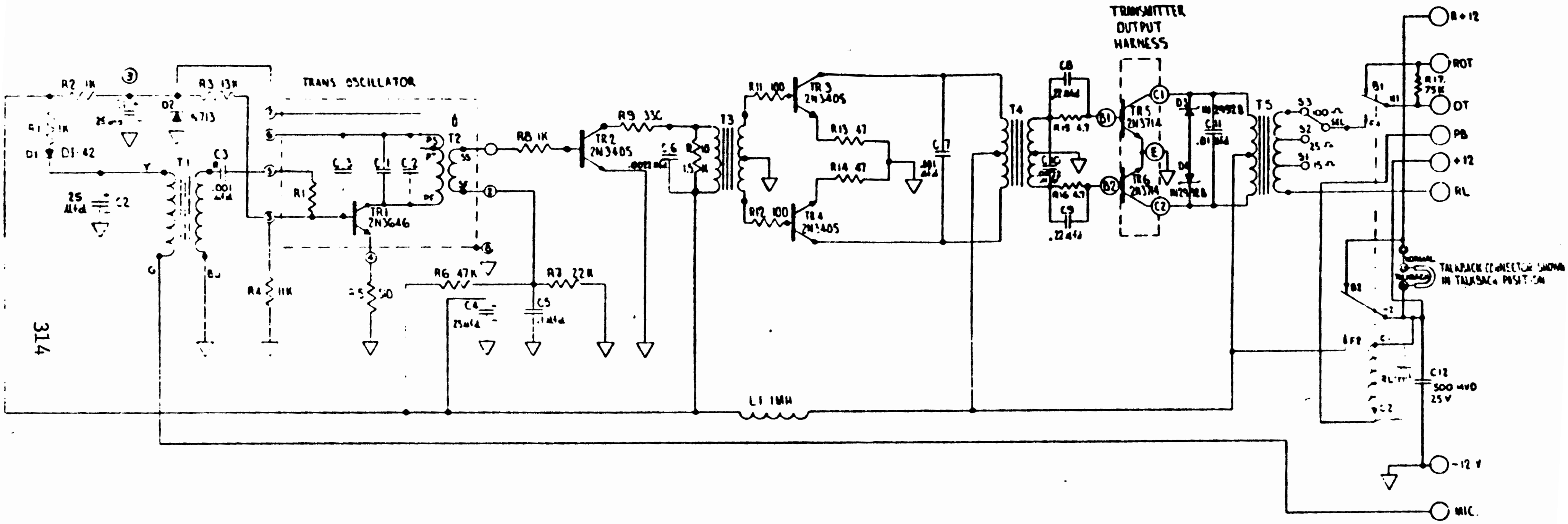
731901-401

CONDENSED TECHNICAL DATA

MinePhone System, MODEL 1601

MSA

1. Available Carrier Frequencies: 88 KC, 100 KC, 115 KC, 145 KC,—others available on special request.
2. System Operating Voltage—12.6 volts D.C.
3. Storage Battery—Lead Acid—12.6 volt D.C. 63 ampere hours @ 20 hour rate
4. Fully Charged Specific Gravity—1.275
5. Transmitter Carrier Output—Approximately 25 watts
6. Output Transformer Taps—15, 25 and 75 ohms
7. Receiver Audio Output—8 watts with normal modulation
8. Audio Output Transformer Taps—15 and 500 ohms
9. Maximum Operating Temperature—185° F. (Hottest Spot)
10. PLS Fuse Rating.. 3 amperes (57804)
11. Battery Charger Fuse.. 6 amperes (67343)
12. Transmitter Output Transistors—2N3714—2 Required
13. Transmitter 1st Driver Transistor—2N3405—1 Required
    Transmitter 2nd and 3rd Driver Transistors—2N3405—2 Required
14. Receiver Audio Output Transistors—2N3716—2 Required
15. Resistance of 250/300 Volt Charger— 288 ohms total
    Resistance of 550/600 Volt Charger—1152 ohms total
16. Weight of Complete Transmitter—Receiver Unit—15 lbs.
17. Weight of Chargers—250/300 Volts (with connecting cables)—21 lbs.
    Weights of Chargers—550/600 Volts (with connecting cables)—21 lbs.
18. Weight of Loud Speaker—(with connecting cables)—14 lbs.
19. Weight of Battery Case—18 lbs.
20. Battery—42 lbs.
21. Microphone with Hanger—1 lb. 10 oz.



MSA TRANSMITTER SCHEMATIC