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Agency

Office of Radiation Program
P.O. Box 98517
Las Vegas NV 89193-8517

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Radiofrequency Electromagnetic Fields and Induced Currents in the Spokane, Washington Area

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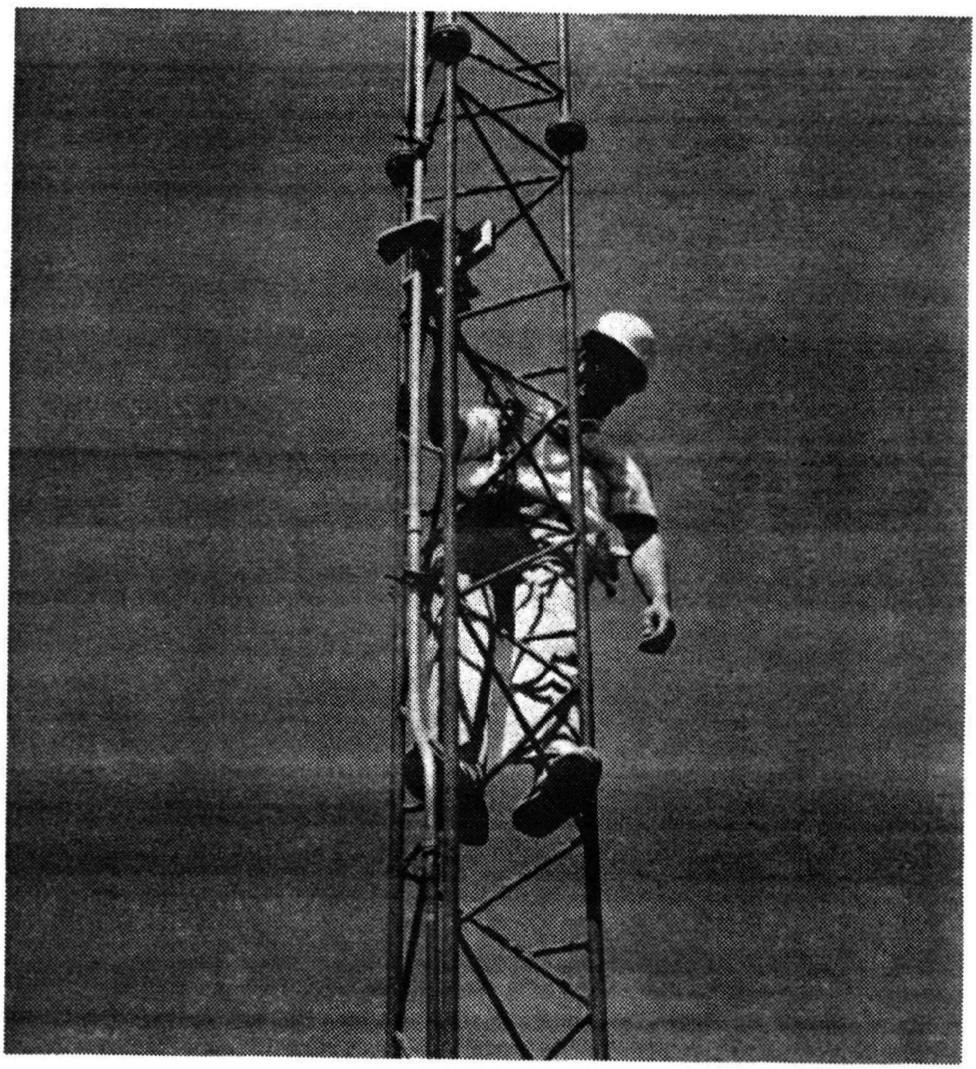

RADIOFREQUENCY ELECTROMAGNETIC FIELDS AND INDUCED CURRENTS IN THE SPOKANE, WASHINGTON AREA JUNE 29 - JULY 3, 1987

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Electromagnetics Branch
Office of Radiation Programs
U.S. Environmental Protection Agency
P.O. Box 98517
Las Vegas, Nevada 89193-8517

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STUDY PARTICIPANTS

Environmental Protection Agency
Office of Radiation Programs
Las Vegas Facility

*Richard A. Tell
Edwin D. Mantiply
**Paul Wagner

Federal Communications Commission
Office of Engineering and Technology

Robert F. Cleveland, Jr.

*Richard A. Tell Associates, Inc.
Las Vegas, Nevada

**U.S. Environmental Protection Agency
Region 4
Atlanta, GA

EXECUTIVE SUMMARY

The Environmental Protection Agency and the Federal Communications Commission conducted a joint study of radiofrequency (RF) electromagnetic field levels and induced RF currents in the Spokane area in June, 1987. The location of several AM towers in residential areas of southern Spokane made this an advantageous location for the study and allowed the collection of data on many different sources at every measurement site. One high power station, KGA-AM, is located within a few hundred feet of an elementary school. Induced currents due to the KGA-AM antenna have caused concerns among the workers at Mullan Road School and have lead to corrective actions. Measurements were made at the school to assess the present situation. A first endeavor was also made to collect data to predict induced currents in workers climbing active AM radio towers.

Another goal of the study was to investigate RF levels near TV and FM antennas in the Spokane area. At the base of FM radio towers on Mica Peak, calculations indicated power densities would exceed 1000 microwatts per square centimeter ($\mu W/cm^2$). The maximum measured power density was 2000 $\mu W/cm^2$. Measurements were also made close to TV and FM antennas on Mt. Spokane and on Krell Hill. Power densities that approach or exceed the American National Standards Institute radiofrequency radiation protection guide (Reference 5) were found on Mt. Spokane, but only low power densities were found on Krell Hill.

The final purpose of the study was to refine broadband measurement procedures. Field perturbation by an individual making a measurement and by conductive objects were investigated, and two problems associated with broadband measurement equipment, RF potential sensitivity and nonsinusoidal response were demonstrated.

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INTRODUCTION

In an effort to obtain data on levels of radiofrequency radiation near broadcast facilities, the Federal Communications Commission (FCC) and U.S. Environmental Protection Agency (EPA) have been conducting measurement surveys at selected sites around the country over the past few years. These surveys have been performed under the terms of an interagency agreement between the FCC and the EPA and have involved staff from both agencies. One area of interest has been the determination of electric and magnetic fields near AM broadcast towers. Data on such fields have been limited and are needed in order to better understand the potential for exposure of the public and workers to RF radiation from these stations. Spokane, Washington is a good area for acquiring such data due to the relatively large number of AM broadcast stations in the vicinity, many of which are located in relatively close proximity to residential and commercial areas. In addition, there are several potential measurement sites with FM and television broadcast stations. Therefore, it was decided that the Spokane area would offer the FCC and EPA an excellent opportunity to acquire data on electromagnetic fields from broadcast transmitters. The study was carried out between June 29 and July 3, 1987, and measurements were obtained of fields near AM, FM, and television transmitters. In addition, measurements of induced body current were made on a human subject while climbing an active AM tower.

MEASUREMENT EQUIPMENT

The equipment used in the Spokane study can be divided into two classes, devices used to measure radiofrequency (RF) currents induced in objects by AM broadcast fields and equipment used to measure RF electric (E) or magnetic (H) field strengths at AM, FM, and TV broadcast frequencies.

Electric and Magnetic Field Measuring Equipment

RF field strength was measured using either broadband electric or magnetic field strength meters or, alternatively, narrowband tunable meters connected to antennas sensitive to electric or magnetic fields (E or H).

Broadband Field Strength Meters

Several different broadband meters were used during the Spokane study. Appendix A contains EPA calibration data for the equipment used in the study. The broadband meters have complementary characteristics which allow most environments to be surveyed accurately by at least one meter. Important limiting characteristics include: RF potential sensitivity, non-sinusoidal response, zero stability, electrostatic sensitivity, out-of-band response, isotropy, and absolute calibration as a function of frequency. While this list is not exhaustive, it does include topics that EPA has found to be significant practical problems in the field and which can completely invalidate measurements. A description of these characteristics is presented below; examples of their effects are included in later sections of the report. Other characteristics such as linearity, thermal stability, and cable flexure response are not usually practical concerns for well designed instruments.

RF potential sensitivity--Potential sensitivity affects electric field meters which use high resistance leads to isolate the probe from the meter readout. This sensitivity appears to be a practical problem only at frequencies below about 10 MHz. The problem can be demonstrated by electrically isolating the system near an AM radio station and changing the vertical separation between the meter readout and probe; the meter response will increase with separation. This increase occurs in an essentially uniform vertical electric field which has equally spaced horizontal potential surfaces. This is because the high resistance leads offer inadequate isolation between the probe and the meter at low frequenies, and perturb the electric field at the probe. This perturbation can be demonstrated by bringing the high-resistance-lead probe near a well isolated meter and noting the change in measured field displayed on the isolated unit. This effect is not a problem for instruments without high resistance leads, such as those in which the antenna and meter are a single well isolated unit.

Non-sinusoidal response--Ideally, field strength meters should respond to the true RMS field strength even in non-sinusoidal fields. However, diode-based meters operating above the square law region of the diode will generally respond high in non-sinusoidal fields, if calibrated in sinusoidal fields. Non-sinusoidal fields in the broadcast environment include video- or amplitude-modulated signals and multiple frequency environments. Typically, a meter will read 1 to 2 dB high in these environments. The amount of error can vary with time and spatial position.

Zero stability--While thermocouple based meters are true RMS detectors, they can have problems with zero drift especially on the most sensitive range. The zero may drift only while the field is applied but be relatively stable when the probe is shielded or in the absence of a field. This property limits the usable sensitivity of these meters and requires careful re-zeroing during measurement and calibration.

Electrostatic sensitivity--Some meters are sensitive to electrostatic fields. Preliminary laboratory work has demonstrated this sensitivity. In the field, it has been observed that meter readings can stabilize when the surveyor is grounded. Stability may also depend on weather conditions and on the type of shoes and clothing worn by the operator.

Out-of-band response--Many field meters have resonant responses at certain frequencies well above their specified frequency range. These resonances can lead to significant meter responses at frequencies where the meter should not respond at all. The responses of some meters at frequencies below their specified frequency range can also be unpredictable because of potential sensitivity. For example, some RF meters inappropriately respond to 60 Hz electric fields.

Isotropy--The IFI unit used in this study detects only one polarization at a time and must be reoriented if isotropic measurements are necessary. The other meters used are designed to be isotropic and are successful to a good approximation. One exception, however, is magnetic field probes which contain three orthogonal loops in a "petal" arrangement on three faces of a cube. These probes typically read 3 dB low when the magnetic field is perpendicular to the probe axis. The probe is usually calibrated with the field parallel to the probe axis and reads a maximum in this orientation. So, if the probe is oriented to read a maximum during field measurements the reading should be accurate.

Absolute calibration--Finally, all measurements are dependent on the absolute value of the field used to calibrate the field strength meter. The accuracy of the EPA laboratory calibration fields at these frequencies is believed to be better than 0.5 dB based on cross checks with the National Bureau of Standards. Propagation of worst case errors for factors leading to the theoretical calculation of the field gives a probable error of about 1 dB (Reference 1). Generally, the EPA laboratory calibration of a meter will agree with the manufacturer's calibration within 0.5 dB.

Narrowband Field Strength Measuring Equipment

While broadband meters are portable, respond quickly, and are easy to operate, they do not provide information on the RF field intensity at any particular frequency. When several RF sources are present, it is often necessary to know the contribution from each source. Narrowband methods allow this determination. Most of the broadband meter limitations described above do not apply to narrowband measurement systems, however, narrowband equipment is not a panacea. Potential sensitivity can be a problem for narrowband electric field antennas which use coaxial cable at low frequencies. Isotropy can only be achieved by making three orthogonal measurements with antennas having a short-dipole pattern. The large physical size of some narrowband antennas does not allow the fine spatial resolution of a field that is possible with smaller broadband equipment. Each narrowband measurement requires an individual set up, and the complexity, weight, power requirement, and expense is greater with narrowband systems than with broadband systems.

A narrowband system generally consists of an antenna, a cable, and a calibrated receiver. Two receivers and two antennas were used in this study. Either antenna could be used with either receiver. An Eaton loop antenna with coaxial cable was used to measure magnetic fields at AM broadcast frequencies. A Nanofast fiber optically isolated spherical dipole (FOISD) was used for electric field measurement at AM to UHF-TV broadcast frequencies. The primary receiver was a Hewlett-Packard (HP) Model 8566A spectrum analyzer used in an automated system. A Potomac Model FIM-41, as described in the next section on current probe measurements, was also used as a receiver at AM frequencies.

The automated system diagramed in Figure 1 consists of the FOISD antenna, spectrum analyzer, antenna rotator system, and the controlling HP 9845B computer with peripherals. This small antenna (11.5 cm in diameter) is sensitive to electric fields, is linearly polarized, and has a short-dipole pattern. The axis of the antenna was oriented at about 55° from the axis of its support mast. With this orientation, the antenna is placed in three orthogonal positions by rotating the mast to three azimuths, 120° apart. A computer program called ZOOM is used to control the system and is listed in Appendix B. The program is edited to contain a list of broadcast stations to be measured. When executed, the program sets the spectrum analyzer to measure power at each frequency in the list and the measurement is repeated at each of the three orthogonal antenna positions. Antenna factors are applied to give field strengths. Finally the three power values are added to give an "isotropic received power," i. e., the power received by a hypothetical isotropic antenna, and the results are printed and stored on disk.

The accurate measurement of average power by the spectrum analyzer requires special analyzer settings for each broadcast band. These settings (Table 1) have been determined empirically in the laboratory using a power splitter, thermocouple power sensors, and real broadcast signals. For video measurements, the peak power during the synchronization pulse is multiplied by 0.4 to give an average power for normal programming.

The absolute calibration of the field system is tested in the EPA laboratory. The accuracy of the field system is similar to that for the broadband probes because the same calibration source is used. A corrollary is that small differences between FOISD and probe measurements do not necessarily imply high absolute accuracy - only consistency. Also, large differences in results from broadband and narrowband systems must be due to factors other than calibration.

Current Measuring Equipment

Two devices were used to measure RF current, an RF "clamp-on" current prŏbe used with a tunable voltmeter and a direct reading RF current panel meter.

Current Probe

The current probe used was an Eaton Model 91550-1 having a window diameter of 1.25 inch and a frequency range of 30 Hz to 100 MHz. The maximum impedance added to the conductor under test is 0.75 ohm. The net RF current through the window (I_P) is determined from the RF voltage (E_S) across 50 ohms at the current probe output, divided by the current probe transfer impedance (Z_T). During this field work, RF current was measured in several situations at either 630 kHz or 1510 kHz, the broadcast frequencies of stations KKPL-AM and KGA-AM. The transfer impedance can be read from the manufacturer-supplied graph to be 3.6 ohms at 630 kHz and 4.5 ohms at 1510 kHz. These values were corroborated with laboratory measurements of 3.58 ohms at 630 kHz and 4.49 ohms at 1510 kHz, with an accuracy of about 1%.

The error in measuring E_S dominates the error in I_P measurement. E_S was measured using a Potomac Model FIM-41 as a tunable voltmeter. The Potomac external input was calibrated in the field at 100 mV_{RMS} using a Hewlett-Packard 3314A function generator as a known RF voltage source into 50 ohms. The accuracy of the function generator voltage is ±2%. Potomac specifies that non-linearity contributes up to 5% error. Two complicating factors have to be considered. First, some measurements were made without a 50 ohm feed-through resistor on the Potomac input. An experimental correction factor for not using the resistor was found to be 0.641 at 630 kHz and 0.392 at 1510 kHz and that factor has been incorporated in the data presented here. Second, the non-linearity of the Potomac was determined to be out of specification for levels below 10 mV. These lower voltages were only measured at 630 kHz where the readings could be 10% high due to the nonlinearity. It is unknown whether this nonlinearity existed in the field so no corrections are made based upon it. The only measurements that could be affected by this nonlinearity are the current probe measurements at the KKPL-AM site.

Current Meter

The current induced through the arms of an individual climbing an AM broadcast tower was measured using a Simpson RF current meter (150 mA full scale). The current meter was mounted in a jig which allowed the meter to be inserted in series between the tower and the climber's hands. The jig also included a 150 mA fuse in series to protect the meter. The total impedance of the jig, fuse, and meter is equivalent to 15.0 ohms resistance in series with about 0.5 microhenry inductance. After returning from the field the meter zero was about 15 mA negative. However, at higher currents, the error was insignificant due to the nonlinear meter scale. Measured values were corrected to compensate for this error. See Appendix A for calibration data.

PROCEDURES AND RESULTS

Community Measurements Near the AM Radio Towers

Among the objectives of the Spokane project was a study of ambient fields in the vicinity of several AM radio antennas. Near Spokane's southern city limits, there are eight AM stations in an area about 1.5 miles square. This collection of AM stations provided a good laboratory for determining typical electric fields near the towers. Figure 2 is a map of this area, identifying the community measurement locations with numbers and the AM radio broadcast stations (some of which included more than one tower) with letters.

Narrowband Measurements

To obtain the narrowband AM data, the FOISD was placed on a fiberglass mast five feet above the roof of the measurement vehicle. Measurements were made at each of 19 locations. These data are presented in Table 2. The site numbers in Table 2 correspond to those plotted in Figure 2. The second column in Table 2, "FOISD File" is the name given the narrowband data stored in the computer for each measurement. The third column lists the AM band electric field found at the site using the FOISD antenna system. The detailed frequency-specific data for each site are contained in Appendix C.

A check to evaluate the spectrum analyzer system was conducted at the Mullan Road School parking lot. This check involved two measurements using the FOISD antenna system. For one of the measurements the signal was processed with the spectrum analyzer. For the second measurement the signal was input to the Potomac field strength meter. For one orientation of the antenna, the spectrum analyzer reported a power of -7.75 dBm for the dominant frequency at the Site (file ZOGB07). For the same antenna orientation and frequency, the Potomac reported 93 mV or -7.63 dBm for a difference of 0.12 dB.

In order to resolve questions about how the vehicle orientation might affect the electric field measurements, data were collected at Site 1 with the vehicle facing each of the four major compass directions, but with the antenna positioned at the same location (within inches) for each measurement. These four data files are listed in Table 2, showing a maximum deviation of less than 0.6 dB between the lowest and highest value.

The data collected above the vehicle are also influenced by the height of the measurement and the presence of the large conductive vehicle. To obtain an indication of the importance of this effect, measurements were made at another location in the Mullan Road School parking lot, using the broadband IFI EFS-1 (SN 1059). Above the vehicle, at the approximate height of the FOISD, the IFI reported a 12 V/m vertical field and no horizontal field. In the same area, but at shoulder-height, the IFI reported about a 9.2 V/m vertical field. This shows that the values collected with the FOISD positioned above the measurement vehicle probably overestimate the ground level field intensities. Because these intensities are far below any standard for AM-radio frequencies in the U.S., the more accurate but also far more time consuming process of obtaining shoulder-height FOISD measurements was not pursued. Instead, shoulder-height measurements were made with the IFI meters at several locations.

Broadband Measurements

The IFI meters were used to make rapid measurements along the streets that surround the KGA towers. Two sets of data were collected and are presented in Table 2. The first set was taken during daylight hours, when the KGA pattern is omnidirectional. The second set of data was collected after KGA shifted to its night-time, directional pattern. The data collected before and after KGA shifted to a directional pattern indicate that KGA's directional pattern increases its westward gain and protects areas to the east. The data for Sites 2 and 3 support the hypothesis that values measured above the vehicle roof are generally higher than those measured in the same area but at shoulder height and with the vehicle removed.

Residential Measurements

In an effort to obtain an indication of the relationship between indoor and outdoor fields, both electric and magnetic field measurements were made at a home near Mount Vernon and 61st Street, the closest residence to the KGA daytime tower. None of the values obtained exceeded either the ANSI or NCRP guides for safe exposure (see References 5 and 6). Vertical E-field measurements were made with an IFI EFS-1 (SN 1059). Electric field values of 9 to 19 V/m were found outside the house in locations where the fields did not appear to be perturbed, i.e., were not affected by any nearby metallic objects. Measurements were taken between waist and head height. Higher and lower values could be found in areas affected by metallic objects. For example, near a barbed wire fence, 37 V/m was found, but under the patio cover, the field fell to about 2 V/m.

Inside the home, measurements made away from obvious metallic objects ranged from about 1 to 9 V/m but were generally below 5 V/m. As with the outside measurements, higher perturbed field values could be found inside. Near a living room chandelier fields up to 55 V/m were measured, 28 V/m near TV cables, and 46 V/m near the kitchen stove. The values found inside a grounded metal workshop in the yard were around 1 V/m. These indoor and outdoor data suggest that the electric field is attenuated somewhat by normal residential construction, but as one would expect, grounded metal structures are far better shields against electric fields.

. Magnetic fields were also measured inside and outside the residence. For these measurements the Eaton loop antenna was connected to the Potomac meter through a 50 ohm load. The Potomac was calibrated at the KGA 1510 kHz broadcast frequency for absolute voltage prior to these measurements. The KGA signal dominates the AM band in this area (see file ZOGBTw for site 14), so at this home, only the 1510 kHz fields were determined with this narrowband magnetic field system. The loop antenna was oriented for a maximum value and the reading on the Potomac recorded. This voltage was multiplied by the loop antenna factor to obtain the magnetic field value.

Magnetic field values at four locations outside the house ranged from 30 to 40 mA/m. Inside the house, the value found in the center of the living room was 31 mA/m, and in the kitchen was 49 mA/m. These limited data suggest that AM-radio magnetic fields are not attenuated significantly by typical residential construction.

AM Measurements at the Mullan Road School

The Mullan Road School property is just across 63rd Street from the KGA antenna (Figure 2). Approximately one year after the school was built, a metal roof was installed and connected to ground with several ground straps in order to limit the electric fields inside the classrooms. These actions were prompted by complaints of electric shocks or RF burns in the school. The EPA and FCC were aware before coming to Spokane that there was still some concern about the fields at the Mullan Road Elementary School. So, several measurements were made both inside and outside the school.

First, electric field measurements were made at several locations along the north side of 63rd Street, across from the Mullan Road School property. These data are listed in Table 3. The data were collected with an IFI EFS-1 electric field strength meter (SN 1059). All these values were measured at a height of about four feet.

Since the IFI measures only one polarization of the field at any given time, three measurements would be necessary for a complete evaluation of the E-field at any point. It was assumed that at these distances from the active KGA tower, the dominant field orientation would be vertical. To show this, all three orthogonal components were measured near the KGA east tower. There was no measured field tangent to the tower, 10 V/m radial to the tower, and 37 V/m vertical. The total field of 38 V/m is not significantly different from the vertical component, as expected.

One additional measurement was made at the gazebo near the northeast corner of the old half of the Mullan Road School building. There a vertical electric field of about 15 V/m was found.

Inside the Mullan Road Elementary School, both electric and magnetic field measurements were made. The magnetic field measurements were taken with the Eaton loop antenna connected to the Potomac meter via a 50 ohm "feed-through" resistor. The loop antenna factor was taken from manufacturer-supplied data.

A comparison between E and H field values was made at a location in front of the school near 63rd Street. At this point the 1510 kHz H field was found to be 39.7 mA/m. At the same point the electric field, as measured with the IFI meter, was 13.9 V/m. The ratio of E/H was 350 ohms, which is within measurement error of the 377 ohms impedance of free space indicating far-field conditions.

Inside the school, measurements were made in 9 rooms. The electric and magnetic field data collected in the school are presented in Table 4. The first room investigated was E120, which is the room closest to the KGA active tower (see Figure 3). An initial east/west transverse of the room with the IFI survey instrument showed a nearly constant 3.2 V/m vertical electric field. A survey from the north side of the room (the window side) to the south side of the room (the interior side) showed the vertical electric field falling from about 9.2 V/m to about 2.8 V/m, but with changes of this magnitude occurring over a distance as small as 2 feet. The electric field was also found to be dependent on proximity to the fluorescent ceiling lights but not affected by whether those lights were turned on or off. Table 4 shows that the highest electric fields were found in rooms E120, E118A, and E101. None of these values exceeds the current ANSI RF radiation protection guide.

Generally the magnetic fields were less than 50 mA/m. The exceptions to this rule occurred near ground wires and conduit electrical panels, or metal fixtures that could carry an RF current. These currents create localized elevated magnetic fields, however, none of the magnetic fields listed in Table 4 even approaches the 1600 mA/m ANSI guide.

Induced Currents at the Mullan Road School

After the Mullan Road School was constructed, complaints about RF burns and shocks in the school led to the installation of a metal roof. This roof covers the single-story east wing of the Mullan Road School and is connected to driven ground rods at eight points around its perimeter. The grounded roof was intended to lower the electric fields and thereby the RF-related problems inside the school.

EPA measured the current at each of the ground connections using the Potomac and current probe. The results are presented in Figure 3. The ground current is a maximum at the northeast corner of the school, the corner closest to the KGA-AM tower, and is typically four times greater on the north side of the building facing the tower than on the other side of the building. If all the currents are assumed to be in phase they sum to a total of 1.67 amp. At the northeast corner, the localized magnetic field close to the ground conductor was measured using the Eaton loop antenna. The value was 1.0 A/m (1000 mA/m).

Two simple models can be used to estimate the current to ground due to the electric and magnetic fields in this situation. The unperturbed electric field is assumed to be 15 V/m as measured at the gazebo and the magnetic field is set at 0.04 A/m (E/H = 377 ohms). If the roof and ground are modeled as two shorted parallel plates in the electric field, the current between them is given by $I=2\pi f \varepsilon_0 EA$ where f is the frequency in Hz, $\varepsilon_0 = 8.854\times10^{-12}$ and A is the area in m^2. The roof area is approximately 1480 m^2 so the estimated current due to the electric field is 1.8 A. To model the magnetic field interaction, the roof, ground wires, and ground are viewed as forming a shorted rectangular loop 3 m high and 18 m across with the loop plane perpendicular to the magnetic field. A shorted circular loop having the same area will have a current due to the magnetic field of approximately 90 mA, i.e., only 5 percent of the current is due to the magnetic field. One would expect this current to be even less because of the limited conductivity of ground. So, the primary coupling is probably with the electric field.

Body Current on an AM Tower

An objective of this study was to obtain information useful for predicting induced body currents which might be experienced by workers climbing active AM radio towers. EPA sought a simple AM tower configuration for this experiment. KKPL, an AM station in the Spokane area broadcasts from a 1/4 wavelength guy-supported single tower having a height of 119 meters. KKPL offered unlimited access to its AM tower and transmitter and provided assistance to EPA during the study. KKPL normally operates at 1 kW power at 630 kHz.

The RF current meter/test jig as described in the equipment section was used to measured RF current through the hands of the climber at 7 heights on the tower while the station operated at normal power. The climber held the metal jig contacts with both bare hands, leaned away from the tower, and adjusted the jig to give a stable maximum reading, indicating good contact. The climber wore work boots during the measurements. The results are given in Table 5 and have been corrected for meter zero error. At the 98 m height, the current increased from 75 to 84 mA when one arm was extended away from the tower. No change was observed in meter response when the modulation was turned off. No induced current was observed near the tower base even when the climber was barefoot. This indicates that the magnetic field which is a maximum at the tower base did not contribute significantly to the body current.

The body current increased nearly linearly with height (see Figure 4). The only near-field component which behaves similarly is the radial electric field. The vertical electric field is relatively small except near the ends of the tower and the magnetic field is a maximum near the base and decreases with height. Modeling the tower as a thin monopole allows an exact theoretical solution for the near fields, but predicts radial electric fields which decrease near the top of the tower, resulting in a poor fit. A linear combination of radial and vertical electric field also failed to fit the body current data when using the thin monopole solution. This solution assumes a sinusoidal antenna current distribution which is only a good approximation "if the monopole element is sufficiently thin electrically and not too long" (Reference 2 Weiner et. al. p. 20). The ratio of tower radius (r) to wavelength (λ) must be less than about 0.0001 for a 1/4 wavelength monopole to use this approach. At 630 kHz, the ratio r/λ is 0.00044, too large for a sinusoidal current distribution to apply. However, an alternative approach using numerical methods can be used to solve for the current.

The triangular cross-section KKPL tower can be modeled as a circular cylinder by using a same-perimeter rule-of-thumb, $3L=2\pi r$ where L is the length of a tower cross-section side and r is the equivalent radius. Since L equals 17.25 inches, r equals 0.209 meter.

A numerical electromagnetic code (NEC) operating on a personal computer was used to solve for the current distribution and calculate the radial electric field at a distance of 0.5 meter from the modeled tower surface (0.709 meter from the axis). The base drive current was set at 4.47 A RMS. Figure 4 displays a schematic tower, the calculated radial electric field, and the measured body current. All values are RMS. Figure 5 is a plot of the measured body current as a function of calculated radial electric field at the 7 measurement heights; a linear fit assuming zero body current for zero radial electric field was generated, having a slope of 0.23 mA/V/m and a correlation coefficient of 0.98. In this situation the radial electric field is decreasing rapidly with distance from the tower and is not uniform across the body. So, the slope in Figure 5 depends on the choice of distance between the tower and climber.

Given similar tower cross sections these results should be useful in predicting body currents on other towers. The current per radial electric field should increase with frequency, however, further measurements should be made to confirm these results and extend the model.

Measured Electric Fields near an AM Tower Surface

The idealized model used above will not accurately predict fields very close to the real KKPL tower surface. Detailed modeling of all the structural components of the triangular tower would be required to obtain accurate field estimates very close to the tower. The difference between the model and reality is demonstrated by comparing the measured electric fields with the NEC-calculated fields for the cylindrical model, as presented in Table 6. The electric field measurements were made using an IFI EFS-1 (SN 1059). For the 2 meter-height measurement, the instrument was held by an operator standing on the ground. At 6 meters above the ground, the operator held on to the tower and leaned away from the instrument. The base current in the tower was reduced to 1.06 A from the normal 4.47 A during these measurements. Consequently, the measured fields have been multiplied by a scaling factor of 4.23. The distance from the tower is the radial distance from the tower outer surface for measurements and is the distance from the modeled circular cylindrical surface for the calculations. Only the radial electric field was measured or calculated.

Table 6 shows that the real fields close to the tower are very different from the idealized fields calculated using NEC. Despite this fact, if the cross sectional geometry of the tower does not change significantly with height, the relationship shown in Figure 5 can be used to predict induced body current in tower climbers. However, it should be emphasized that for towers having different electric heights the radial electric field will not necessarily increase with height; in fact radial electric fields can reach a maximum value at the tower base. This is because the modeled field variation with height should be similar to the real field variation with height at any fixed horizontal coordinate. At higher locations on the tower, the radial electrical field would be greater that at the tower base and would certainly exceed the ANSI guideline of 632 V/m at points close to the tower.

It should be noted that measurements at the 2 meter height above ground were made near the lower tapered section of the tower only .3 meter above the insulator. Thus, the criteria of small changes in cross sectional geometry is not met for comparisons of measurements at 2 and 6 meters.

Body Current due to AM Magnetic Fields

Body currents induced by magnetic fields are also of interest. A special concern arises when the body can complete a large loop. At low frequencies Faraday's Law may be used to calculate the voltage across the body's impedance. The measured impedance across the hands or feet at AM frequencies is approximately 500 ohms (mainly resistive). From this impedance (Z), the loop area (S), and the magnetic field (H), the current (I) can be determined. Assuming a uniform sinusoidal magnetic field and the loop oriented for maximum current, the formula is: $I=S2\pi f\mu_0 H/Z$. For a frequency (f) of 630 kHz, Z magnitude of 500 ohms and $\mu_0=4\pi x10^{-7}$ henry/m, the expression reduces to $I(mA)=9.95\cdot S(m^2)\cdot H(A/m)$.

On the ground near the KKPL tower, measurements were made using an individual standing near the tower to test this formula. The magnetic field was measured using the Eaton loop antenna; the result was 0.032 A/m. In the first measurement of body current, an approximately hexagonal loop was formed by the arms, upper torso, and an aluminum rod. The current through the rod was measured using the Eaton current probe and Potomac meter. When the individual rotated, the response nulled as would be expected for magnetic field detection. The area of this loop was about 0.35 m^2 (hexagon 0.37 m on a side). So, the calculated current is 0.11 mA. The measured current was 0.090 mA. A second measurement involved using two individuals and two rods forming an octagonal loop, and gave similar results. Here, the impedance is increased to 1000 ohms and the area is 1.29 m^2, the calculated current is 0.205 mA, and the measured current was 0.150 mA. The differences between calculated and measured currents are consistent with the approximations used for area and impedance.

While this situation is contrived, conductive loops that include humans do exist in the environment. For example, a child using a swingset completes a loop formed with the support bar and the chains of the swing. The area of this loop could be several square meters increasing the induced current, but the apparatus would probably be far enough from an AM tower that the fields, and therefore the induced currents, would be small.

At the location near KKPL where the magnetic fields were measured, the electric field measured with an IFI EFS-1 (SN 1060) was 1.9 V/m. Thus, the wave impedance (E/H) was 59 ohms. This relatively low wave impedance (strong magnetic field relative to electric field) close to the tower contributed to the successful measurement of body currents due to magnetic fields.

<u>Body Current due to AM Electric Fields</u>

The body current due to uniform vertical electric fields has been examined previously (Reference 3 and 4). However, the following measurement technique employs a current probe instead of a shunt resistor or direct reading current meter. A 30.5 cm square horizontal aluminum plate supported 14 cm above ground was connected directly to a 50 cm ground rod driven into the earth beneath the plate. The Eaton current probe was clamped around the ground rod. The probe output voltage was measured with the Potomac meter.

This technique was used to measure body current near the KKPL AM tower for a number of body configurations with and without shoes. The body current through the feet of an adult standing barefoot on the plate with a vertical field of 1.9 V/m at 630 kHz is expected to be about 0.4 mA (Reference 4). The results of measurements nears KKPL are presented in Table 7, and agree with this value. The current is reduced by a factor of two when wearing boots and is relatively insensitive to whether one or two feet are on the ground plate, but can be affected by body configuration. So, the body currents which were measured may be similar to those experienced during normal activity.

Mt. Spokane

On Mt. Spokane, a Forest Service fire lookout tower is located approximately 100 feet from the transmitting antennas for KXLY-FM and TV. The State of Washington and the KXLY management were concerned that a newly installed main FM antenna might cause higher power densities in the cab of the fire tower than the auxiliary antenna would. For this reason, KXLY-FM was broadcasting from its auxiliary antenna as the study began. However, the measurements documented here demonstrate that the highest fields in the cab occur when KXLY is operating from its auxiliary FM and not the main FM antenna.

On the fire tower catwalk facing the antennas a test was made to determine the maximum contribution to the field from the KXLY-TV main antenna. A Holaday Model HI-3001, (SN 26038) was used. The survey probe was moved to find a maximum reading with only the TV transmitter operating. That reading increased from 28 to 850 $\mu W/cm^2$ when the FM auxiliary antenna was activated indicating that the field due to the FM auxiliary antenna was dominant.

With the main TV and auxiliary FM antennas operating, the typical reading on the catwalk was 710 $\mu W/cm^2$ with a maximum of 1100 $\mu W/cm^2$ using the Holaday. The maximum seen on the catwalk using a Narda 8662 electric field probe (SN 01008) was 1100 $\mu W/cm^2$, in good agreement with the Holaday measurement. Although the Narda 8631 magnetic field probe (SN 17136) was apparently sensitive to static charge, grounding the operator stabilized the meter allowing successful measurement of a typical value of 360 $\mu W/cm^2$ and a maximum of 1400 $\mu W/cm^2$ on the catwalk.

With the main FM antenna operating, the maximum value on the catwalk was 340 $\mu W/cm^2$, well below the value found when the auxiliary FM antenna was operating.

Thirty-six measurements were made on a six by six horizontal grid inside the fire tower cab when the FM auxiliary antenna was operating and again when the FM main antenna was operating. At each horizontal location, the vertical column between the floor and ceiling was probed for a maximum reading. Table 8 shows the results for a view looking down on the cab. The perimeter values were measured just inside the walls or windows. The Holaday HI-3001 (SN 26038) was used to measure the electric field. Auxiliary antenna values are shown in parenthesis.

The data in Table 8 show the exposure due to the auxiliary antenna is greater than that due to the main FM antenna. While all of the values due to the main antenna are below the ANSI guide of 1000 $\mu W/cm^2$, some do exceed the National Council on Radiation Protection and Measurements (NCRP) recommendation of 200 $\mu W/cm^2$, (Reference 6) and two of the EPA guidance options (Reference 7).

Survey of Areas Near the Transmitter Building

Radiofrequency fields were surveyed on the roof of and around the KXLY transmitter building with auxiliary or main FM or TV antennas operating. The auxiliary antennas are closer to the roof and generate higher field strengths on the roof than the main antennas.

With the main TV and auxiliary FM antenna operating, the following results were obtained. On the wooden platform near the ground the maximum value seen using the Holaday HI-3001 (SN 26038) was 990 $\mu W/cm^2$. On the roof beneath the auxiliary FM antenna, the maximum value observed was 2700 $\mu W/cm^2$ with typical values in the range of 990 to 2100 $\mu W/cm^2$.

With the auxiliary TV and main FM antenna operating, measurements of electric and magnetic fields were made beneath the auxiliary TV antenna on the roof. The average power transmitted by the TV video signal varies with programming, so generally a spatial maximum was found and a range of readings in time reported. Using the Narda 8631 magnetic field probe (SN 17136), the maximum value was 4000 $\mu W/cm^2$. The 8631 is a thermocouple based probe and will give accurate RMS magnetic field readings. The Holaday HI-3002, (SN 33182) with STE-02 electric field probe and Narda 8662 (SN 01008) electric field probe found maximum values from 3900 to 6100 $\mu W/cm^2$ and from 4500 to 6000 $\mu W/cm^2$, respectively. These data suggest that the local electric fields exceed the local magnetic fields at this location.

Finally, a survey was made on the ground with both the FM and TV main antennas operating in normal mode. For this survey, the Holaday HI-3001 (SN 26038) meter was used. The maximum value observed beneath the antenna tower was 740 $\mu W/cm^2$; generally the range was 280 to 570 $\mu W/cm^2$.

The fields on top of the transmitter building can exceed ANSI while either auxiliary antenna is used. Although the roof area is posted for RF hazards it remains accessible.

Krell Hill

At Krell Hill the TV and FM transmitting antennas are located high enough on their towers that ground level power densities are low and are not of concern. The maximum value measured was 8.5 $\mu W/cm^2$ below the channel 6 KHQ tower; the values were generally less than 4.3 $\mu W/cm^2$. The maximum seen in the area between Channel 28 and Channel 7 towers was 4.3 $\mu W/cm^2$. These measurements were made using the Holaday HI-3001 meter (SN 26038).

Mica Peak

Four high power FM broadcast transmitters are located on Mica Peak. The transmitting antennas are close to the ground and radiate power downward. This results in ground level power densities which are twice the ANSI guide. Mica Peak is a remote area, however it is not fenced.

Figure 6 shows the relative location of the FM antennas on Mica Peak and the approximate locations and values of the peak magnetic fields measured. At FM frequencies the peak magnetic field is typically found near the ground or 1/2 wavelength (about 1.5 m) above ground. These measurements were made using a Narda 8631 (SN 17136) probe.

The maximum calculated ground level power density for each FM station on Mica Peak is shown in parenthesis on Figure 6. For the Mica Peak stations, this maximum occurs on the ground at 3 to 6 m from the tower base. The value is predicted using an EPA model which incorporates theoretical methods and empirical information about FM antenna patterns, ground reflection, etc. (Reference 8). The model is designed to avoid underpredicting the highest ground-level power density one would find near an antenna, so it tends to predict power density values that are higher than those one would measure. Based on the model results, the contribution to the peak measured value between KKPL and KPBX (2000 $\mu W/cm^2$) may be greater from KKPL than from KPBX even though the point is closer to KPBX.

Measurement Issues

RF Potential Sensitivity

The responses of several instruments were compared on the grass at the northeast area of the Mullan Road School property close to the KGA-AM antenna (1510 kHz). Using the FOISD antenna and spectrum analyzer the total electric field was found to be 24.8 V/m at an arbitrarily chosen location and a height of approximately 5 feet. Using the Eaton loop antenna with the spectrum analyzer or with the Potomac, the magnetic field at the same location was found to be 90 mA/m. Table 9 presents the values obtained with several broadband instruments. The probe of these instruments was always placed at the same position as the FOISD.

The IFI data compare well with the value obtained using the FOISD; the greatest difference between the IFI value and the FOISD value is 1.4 dB. Much of this difference is probably due to short term drift in the absolute calibration of the IFI EFS-1 (SN 1060). The Holaday and Narda systems reported electric fields that vary widely from the reference value obtained with the FOISD. In the worst case the difference was over 21 dB, in the best comparison the difference was over 7 dB. These comparisons illustrate the large errors that can result from RF potential sensitivity of some measurement systems at low (AM band) frequencies.

Non-Sinusoidal Response

During the study the performance of broadband survey meters was also checked at one location for the higher FM-band frequencies. The intent was to evaluate the multiple-frequency response of broadband meters at a location where the field strengths from more than one FM station were approximately equal. Figure 6 shows the relative locations of the four FM antennas on Mica Peak and the location of the comparison point. FOISD file ZOGCN6 reports a power density of 856 $\mu W/cm^2$ at that location. Three of the four stations on the mountain account for over 99% of this value, and those three are comparable in magnitude. For the comparison, each broadband probe tested was placed at the same location as the FOISD and read from a distance of at least 3 m in order to avoid perturbation of the field by the experimenter. These data are presented in Figure 6. All three of the broadband meters in the comparison are based on diode detectors which may be subject to non-sinusoidal response problems as discussed in the equipment section. A multiple-frequency field is one type of non-sinusoidal field that may cause diode-based broadband meters to report higher field values than actually exist. This effect is the most likely explanation for the response of the Holaday and IFI equipment which reported values that were 1.5 and 1.1 dB high respectively. The value measured with the Narda 8662 Probe (SN 01008) is in good agreement with the FOISD measurement. This is probably because the Narda diodes are operated in their square law region. However, the Narda's sensitivity to static charge made this measurement difficult.

Field Perturbation by Operator

The value that an observer reports can depend not only on the response of the meter, but also on the interaction of the observer with the field. To check the magnitude of this interaction with magnetic fields, a Narda probe (8631 SN 17136) was placed at an arbitrarily chosen, fixed position about 0.4 m above the KXLY transmitter building roof and below the auxiliary FM broadcast antenna. A reference measurement value was taken with no one near the probe. Then an investigator stood and squatted .6 to .9 m to the north, south, east, and west of the probe while reaching toward the probe as if making a measurement. Magnetic field values were read for each of these configurations by a person who remained stationary at least 6 m away. The same approach was used for evaluating the effect of the observer on measured electric field values. In this case, however, the Holaday electric field probe (HI-3001, SN 26038) was placed about 1 m above the roof at a location that was chosen because the electric field there was elevated. The results of these measurements are presented in Table 10.

Table 10 shows that the electric field was not strongly affected by the observer, with the maximum deviation from reference value being about 0.5 dB. The magnetic field values, however, were affected by the location of the observer by as much as 1 to 2 dB.

A part of this exercise was repeated with the observer holding the Holaday meter and probe as he stood at 8 major compass points around a fixed location. The sensitive volume of the probe was positioned at the same point, atop an inverted plastic bucket, for each measurement. The results of this exercise are presented in Table 11. The difference between the lowest and highest electric field values is less than 1 dB. Hence the operator does interact with the electric field in a normal field survey, but the magnitude of the effect is not great.

At Mica Peak, a narrowband (FOISD) test of the field perturbation by a person in a measurement stance was made (see files ZOGCLU and ZOGCLf). The results showed that the magnitude of the electric fields due to each of four FM stations decreased by 0.4 dB or less due to the presence of the observer. This result is similar to that found using the broadband instruments (Tables 10 and 11).

The information presented here suggests that the perturbation of the field by the observer was more significant for the magnetic field than for the electric field. The generality of this result is unknown, but indicates that attention should be paid to observer interaction with the field when critical measurements such as instrument comparison measurements are made.

Field Enhancement by Conductive Objects

A troublesome question for those who conduct RF compliance studies is the effect of conductive objects on the ambient field. Metal objects can perturb an electric field, concentrating that field in very localized areas. To illustrate this effect, an area of fairly uniform 10 V/m electric field strength was found near the base of the fire tower on Mount Spokane. Then a 1.46 m electrical conduit pipe was held horizontally in that field by one investigator while another person measured the electric fields near the rod using a Holaday HI-3001. At one end of the rod 62 V/m was measured; at the other end over 80 V/m was found. Had that rod been a permanent fixture, the nearby stations would have been faced with the question of how to handle very localized areas that exceed the ANSI guide. This question is the subject of a petition recently brought before the FCC by a communications consulting firm. (Reference 9).

CONCLUSIONS

1. KGA-AM is among the stations in the United States that have been granted a license by the FCC to operate at the maximum allowable power of 50 kW. Despite the high power at which KGA operates, the electric fields along 63rd Street, only 100 to 200 feet away, are well below the ANSI guideline of 632 V/m. Electric field values throughout the southern Spokane AM antenna cluster are rarely over 5% of the ANSI guideline. This holds true for measurements made inside the Mullan Road School and inside a residence near the KGA antennas. Similarly, the magnetic fields measured in the school and residence were almost always less than 5% of the ANSI guideline of 1581 mA/m. EPA found no electric or magnetic field values, even in localized areas, that exceeded the ANSI guideline at AM radio frequencies in publicly accessible areas. However, levels far below the ANSI guide can cause annoying RF shocks/burns and can interfere with the operation of electronic equipment.

   The metal roof at the Mullan Road School is grounded to lower the electric field inside. The highest current flowing through one of the ground straps is 0.8 ampere. As long as the ground strap remains continuous, this current poses no danger. However, should the ground straps weather and break, a serious risk of being burned would exist for anyone who would contact it.

2. Body currents of over 100 mA were measured in an AM tower climber. These currents have been related to calculated radial electric fields near the surface of that tower with a correlation coefficient of 0.98 (Figure 5). Further studies should be conducted to extend the relationship to situations beyond a simple quarter-wave guyed tower.

3. Body currents of 0.4 mA were measured using a current-probe technique in a person standing in a 2 V/m, 630 kHz vertical electric field. The current is reduced by about a factor of 2 when one puts on boots. Although magnetic fields can induce currents in conductive loops that include body parts (such as a person swinging on a park swing), it is unlikely that strong enough AM magnetic fields will be found in the environment to induce significant currents.

4. Measurements in the fire lookout tower on Mount Spokane found no location where the power density exceeds the ANSI guideline of 1000 $\mu W/cm^2$ at VHF frequencies when KXLY-FM was broadcasting from its main antenna. When the auxiliary antenna was used, however, localized power densities over the ANSI guide were found in the cab, so use of the main antenna is recommended. The KXLY-FM and KXLY-TV auxiliary antennas can each cause power densities on the roof of the transmitter building that exceed the ANSI guideline. The roof area is posted for RF hazards. When KXLY FM and TV operate from the main antennas, the maximum power density found on the ground beneath the antenna tower was 740 $\mu W/cm^2$.

5. Power densities as high as 2000 $\mu W/cm^2$ were found on Mica Peak, the site of four FM broadcast antennas. Although this is a remote area, it is not fenced.

6. Krell Hill is the site of several television and FM radio antennas. Because those antennas are mounted on high towers, the ground level power densities are low and not of concern.

7. Broadband RF measuring equipment should be used cautiously to avoid problems of RF potential sensitivity and nonsinusoidal response. Field perturbation by the instrument operator can be significant. Local field perturbation by conductive objects was demonstrated and remains an open issue.

REFERENCES

1. Mantiply, Edwin D., An Automated TEM Cell Calibration System. EPA 520/1-84-024, U.S. Environmental Protection Agency, Las Vegas, Nevada, 1984, 112 pp.

2. Weiner, M. M., S. P. Cruze, C. Li, and W. J. Wilson. Monopole Elements on Circular Ground Planes. Artech House, Inc., Norwood, MA 02062. 306 pp.

3. Guy, A. W. Letter to the Environmental Protection Agency concerning the Federal Radiation Protection Guidance. November 20, 1986, Docket No. A-81-43-IV-D-61, University of Washington, Seattle, Washington 98195. 42 pp.

4. Gandhi, O. P., I. Chatterjee, D. Wu, and Y. Gu. Likelihood of High Rates of Energy Deposition in the Human Legs at the ANSI Recommended 3-30 MHz RF Safety Levels. Proceedings of the IEEE, Vol. 73, No. 6, June 1985, pp. 1145-1147.

5. ANSI C95.1-1982. Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz to 100 GHz, American National Standards Institute. Available from the Institute of Electrical and Electronics Engineers, Inc., New York, NY 10017.

6. Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields, National Council on Radiation Protection and Measurements, Report No. 86, Bethesda, MD 1986.

7. Federal Radiation Protection Guidance; Proposed Alternatives for Controlling Public Exposure to Radiofrequency Radiation, Notice of Proposed Recommendations; Environmental Protection Agency; Federal Register, Vol. 51, No. 146, Wednesday, July 30, 1986; p. 27318.

8. Gailey, P., and R. Tell. An Engineering Assessment of the Potential Impact of Federal Radiation Protection Guidance on the AM, FM, and TV Broadcast Services. EPA 520/6-85-011, U.S. Environmental Protection Agency, Las Vegas, NV, 1985, PB 85-245868.

9. Public Notice, Federal Communications Commission, Petition for Rule Making, Radiofrequency Radiation Compliance, RM-6081, September 10, 1987.

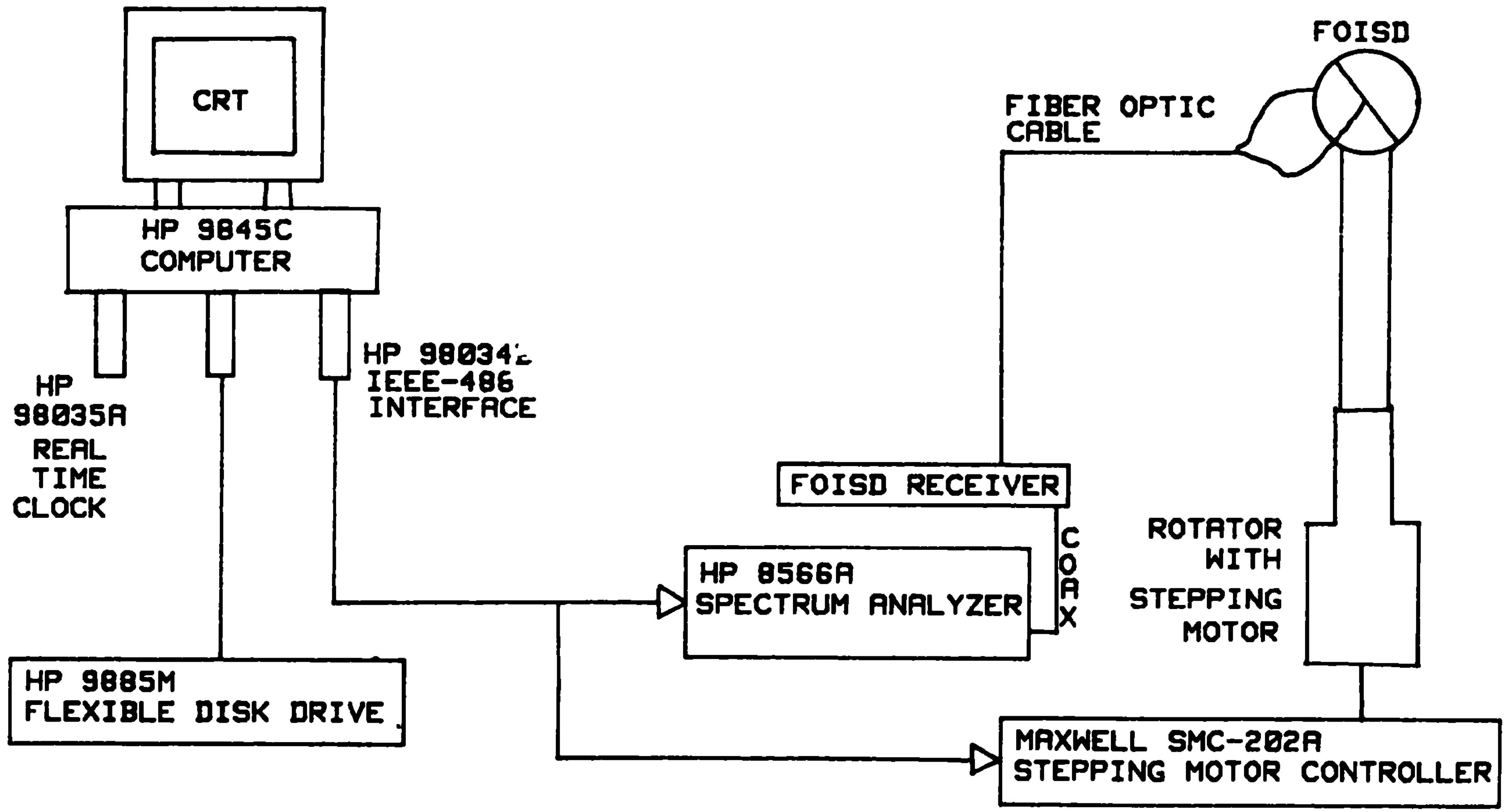
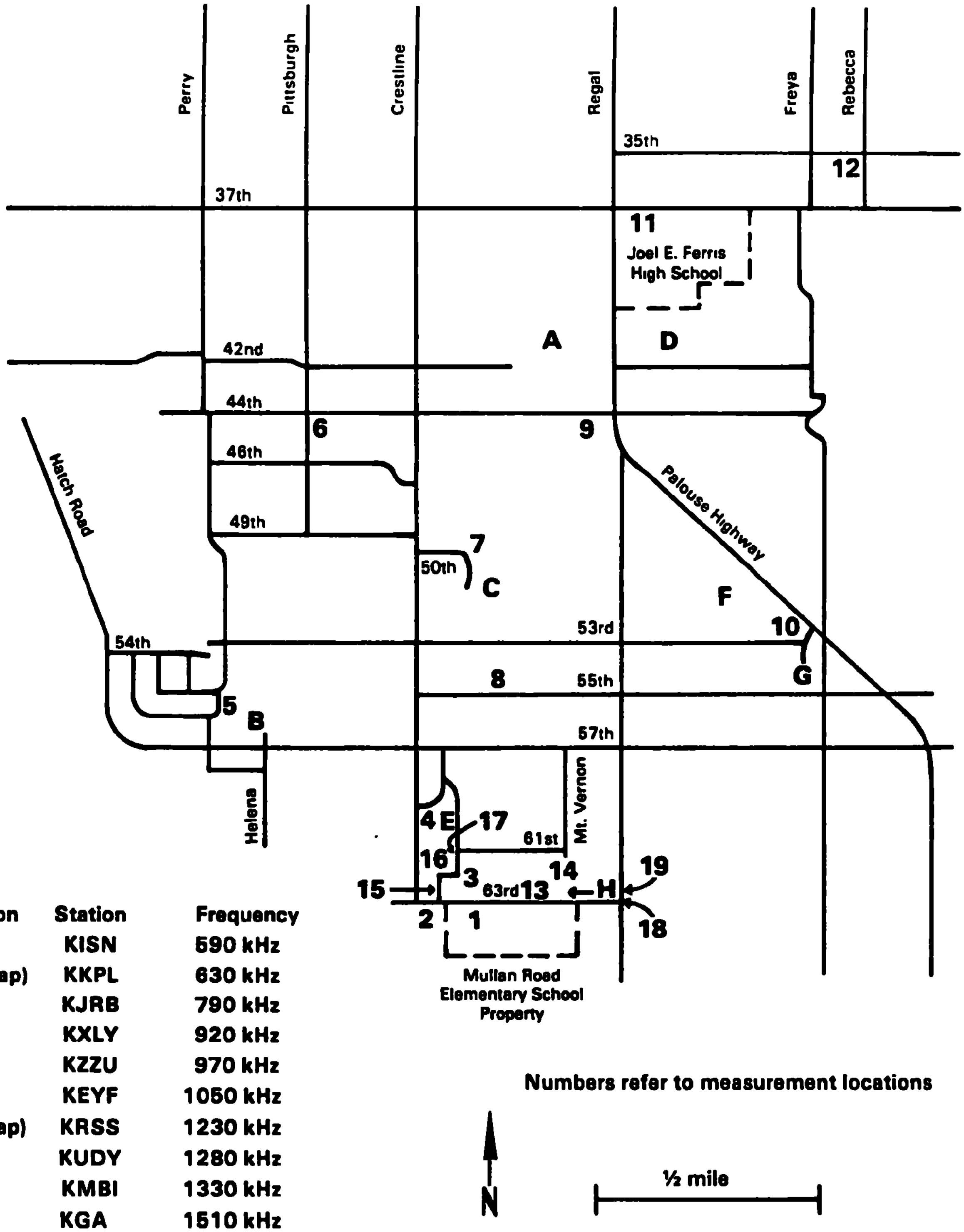


Figure 1. Automated Measurement System



Location	Station	Frequency
A	KISN	590 kHz
(Off map)	KKPL	630 kHz
B	KJRB	790 kHz
C	KXLY	920 kHz
D	KZZU	970 kHz
E	KEYF	1050 kHz
(Off map)	KRSS	1230 kHz
F	KUDY	1280 kHz
G	KMBI	1330 kHz
H	KGA	1510 kHz

Figure 2. Southern Spokane Area

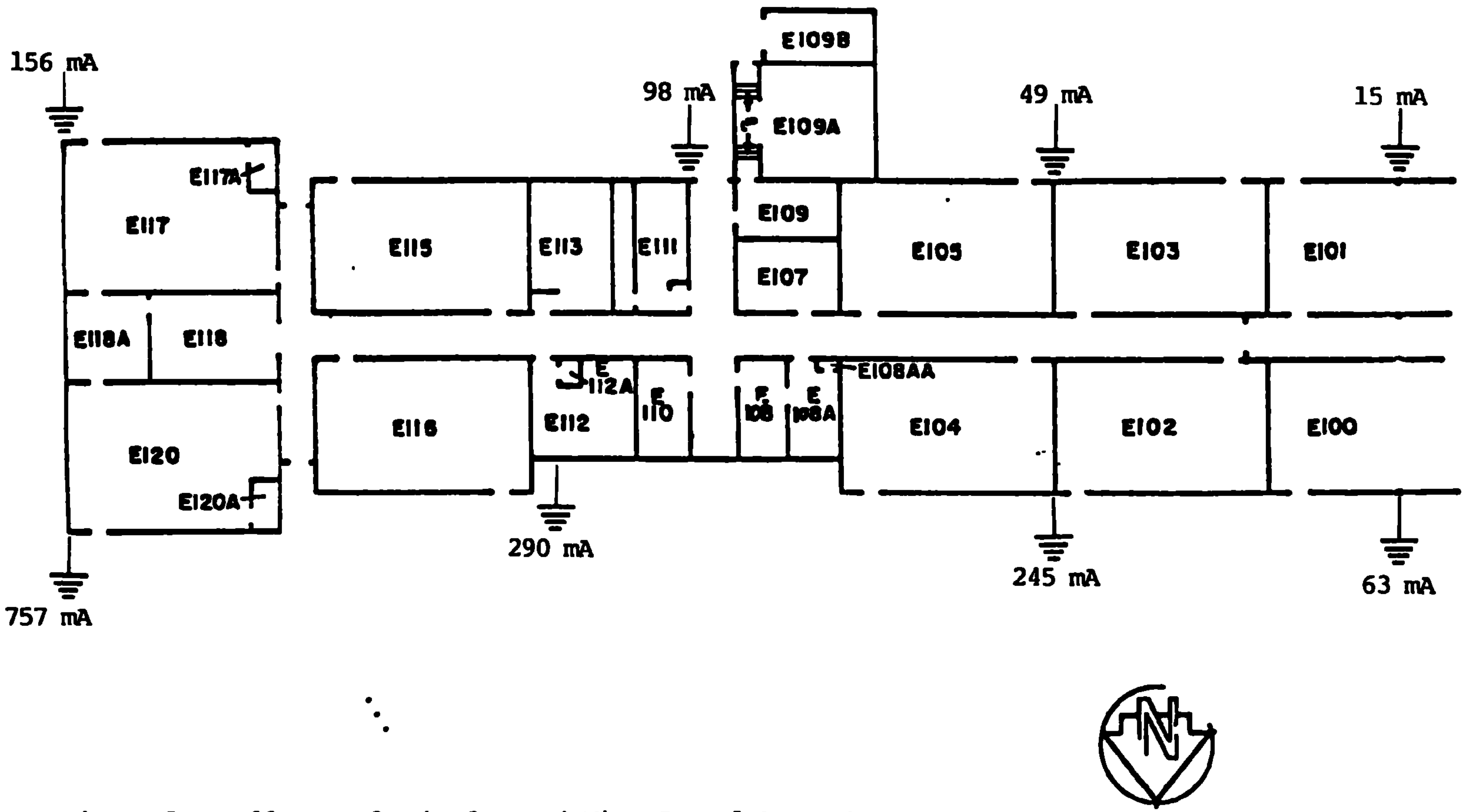


Figure 3. Mullan Road School, East Wing Ground Currents

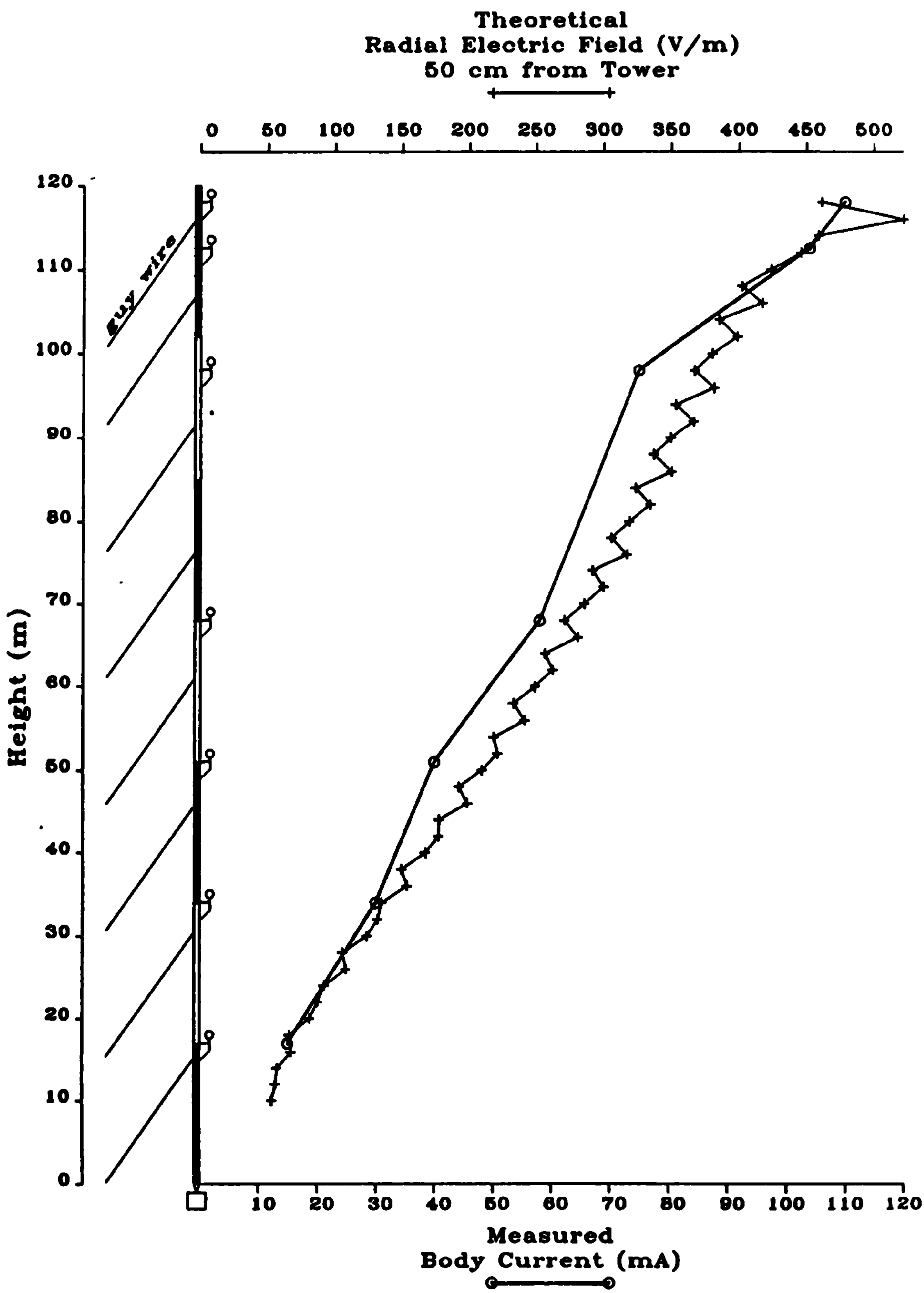


Figure 4. Tower Climb and Numerical Electromagnetic Code Modeling Results

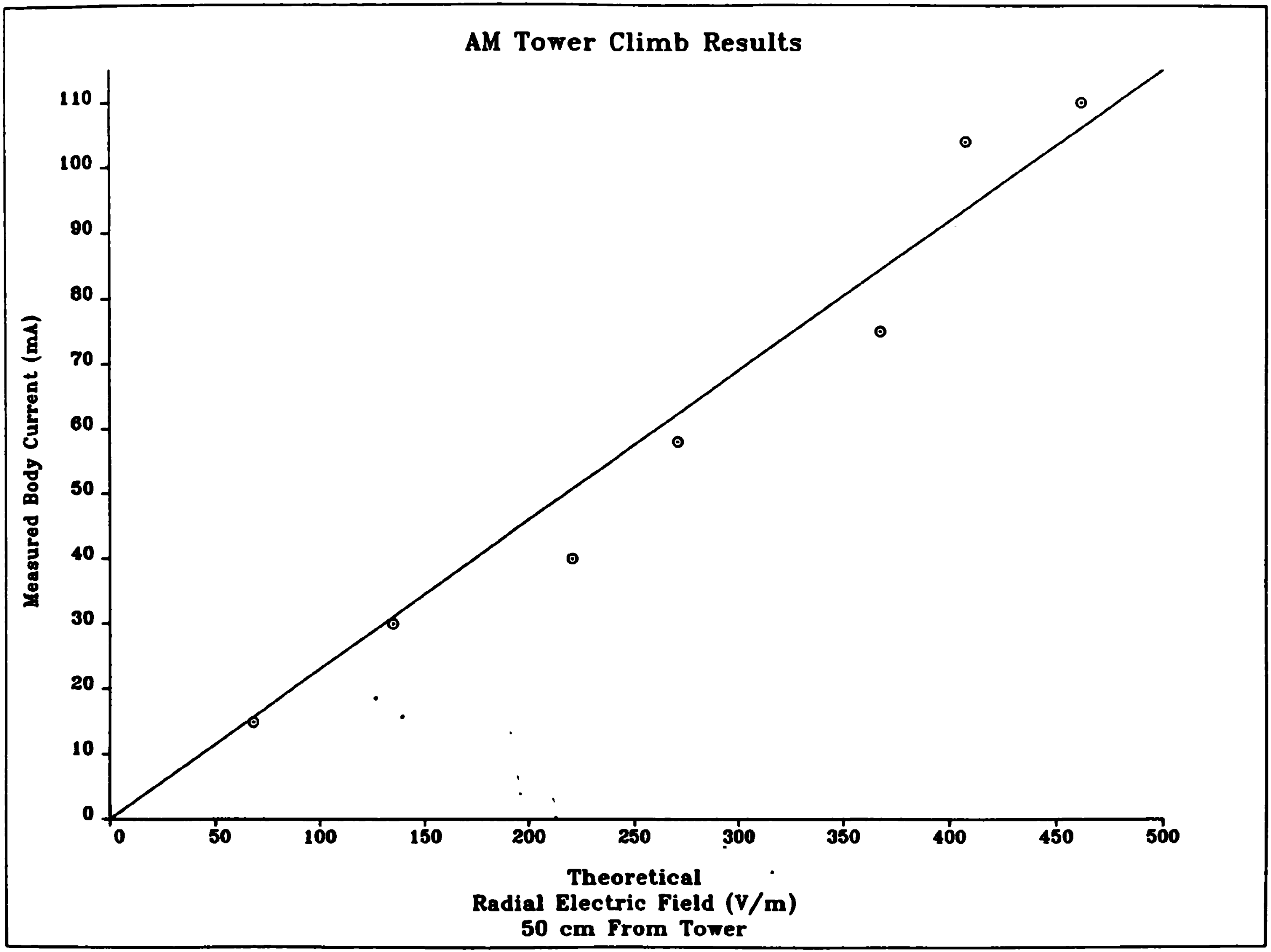
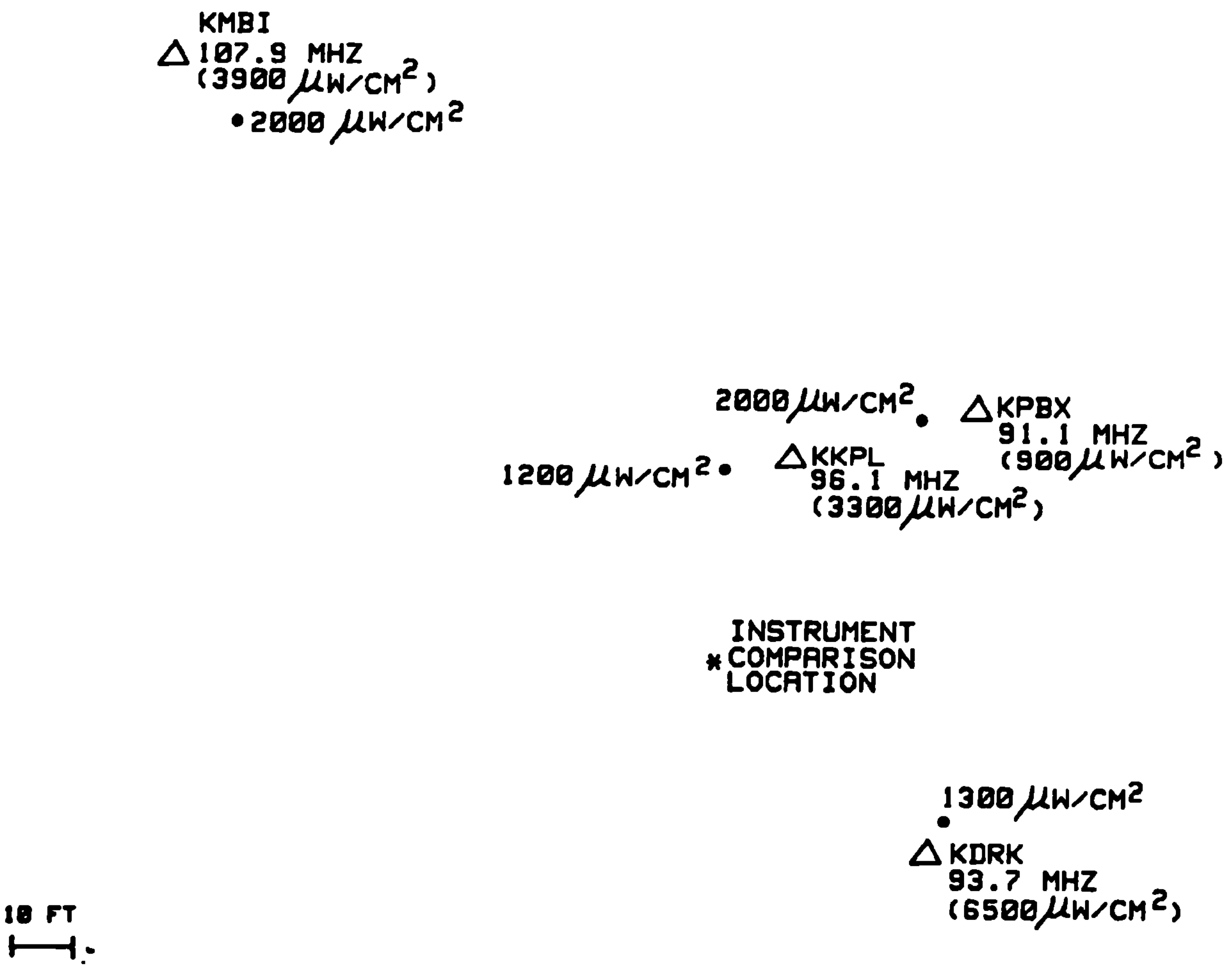


Figure 5. Tower Climber Body Current vs. Radial Electric Field



△ TOWER LOCATION AND FM CALL SIGN
FREQUENCY
(CALCULATED MAXIMUM GROUND LEVEL POWER DENSITY)

• MEASURED POWER DENSITY

INSTRUMENT	POWER DENSITY ($\mu W/CM^2$)
FOISD	856
NARDA 8662 PROBE(SN 01008)	820
HOLADAY 3001(SN 26038)	1200
IFI EFS-1(SN 1059)	1100

Figure 6. Mica Peak Towers and Results

Table 1. Spectrum Analyzer Setting for ZOOM Measurements.
Center Frequency is Station Frequency, Scale always 1 dB per division
Sweep Time always 20 msec

Band	Span	Resolution Bandwidth	Video Bandwidth	Measurement Method
FM	1 MHz	100 kHz	300 kHz	Maximum Hold for 2 sec Read Marker at Center Frequency
TV Audio	500 MHz	100 kHz	300 kHz	Maximum Hold for 2 sec Read Marker at Center Frequency
TV Video	0	1 MHz	3 MHz	Single Scan, Peak Search Read Marker at Peak
AM	0	1 kHz	1 Hz	Maximum Hold for 2 sec Peak Search Read Marker at Peak

TABLE 2. Community Measurement Data Near Spokane AM Radio Towers

			Electric Field (V/m)		
			KGA Omnidirectional		KGA Directional
Site # (See Figure 2)	FOISD File	Description	FOISD above vehicle	EFS-1(1059) shoulder height	EFS-1(1059) shoulder height
1	ZOGBRn	Mullan Road School Parking Lot	10.3		
	ZOGBRv		10.8		
	ZOGBR2		11.0		
	ZOGBR6		10.6		
2	ZOGBSF	63rd and Cook	6.70	5.5	11.
3	ZOGBSK	62and and Stone	7.51	6.5	13.
4	ZOGBSP	Crestline near Lee (in front of KEY)	7.47		
5	ZOGBSV	5517 Perry	4.57		
6	ZOGBSc	46th and Pittsburgh	1.67		
7	ZOGBSk	50th and Stone	4.68		
8	ZOGBSs	2116 55th	4.09		
9	ZOGBSz	On 44th near Regal	2.70		
10	ZOGBTA	Palouse and Ferrall	5.42		
11	ZOGBTV	Ferris High School Parking Lot	2.28		
12	ZOGBTZ	35th and Rebecca	1.05		
13	ZOGBTp	63rd Directly South of KGA East Tower	43.7		
14	ZOGBTw	61st at End of Mt. Vernon	13.9		
15		On Cook, aligned with KGA Towers		6.0	13.
16		62and and Cook		6.5	13.
17		61st and Stone		6.5	12.
18		63rd and Regal		17.	3.2
19		Just North of 63rd and Regal			2.3

TABLE 3. Electric Field Values Along the North Side of 63rd Street Across from the Mullan Road Elementary School

Electric Field* V/m	Location is Opposite:
9.2	West end of school property
14.	A point about 40 feet west of main school door
17.	Where old and new portions of school join
23.	Center of old school building
28.	KGA west tower
37.	Eastern edge of old school building
37.	KGA east tower
9.2	Radial to KGA east tower
0.	Tangent to KGH east tower
30.	East end of school property

*Unless stated otherwise, all values refer to the vertical component of the electric field.

TABLE 4. Electric and Magnetic Fields Inside the Mullan Road Elementary School*

Room	Location	Electric Field (V/m)	Magnetic Field (mA/m)
E101	Outside on Playground	12.	
	Everywhere in Room	≤9.2	
	Center of Room		22.
	East End of Room		31.
E103	Typical Value in Room	0.92 to 2.3	
	Center of Room		30.
	Near Ground Wire/Light Switch		58.
E105			31.
E109		≤0.92	
	Near Electrical Panel		72.
	Along Conduit		150.
E109A	Typical Value in Room	2.8	
E117	Throughout Room	2.8 to 3.7	
	Few Feet From Window		38.
	Center of Room		43.
	Near Sink where Person would stand		87.
	Near Ground Wire at Door		250.
E118A	Center of Room	17.	29.
	Point of Highest E	23.	
E120	East End of Room		22.
	West End of Room		35.
	Center of Room 6 Feet High		31.
	End of Counter Near Ground Wire		470.
	Near Electric Socket on Window Wall at Floor		72.
	Exterior Door, Top		140.
	Exterior Door, Center		120
	Along Window		22., 27.
	Atop a Table	5.5 to 6.9	
	Center of Room 6-1/2 feet high	28.	
	8 inches above Fluorescent Light	92.	
	6 inches above Fluorescents, on Window Side of Room	140.-190.	
Hall where Old and New Buildings Join		.92	7.2

*See Figure 3 for locations of rooms.

TABLE 5. Measured Body Current on KKPL Tower

Height (meters)	Current (mA)
17	15
34	30
51	40
68	58
98	75
112.5	104
118	110

Table 6. Measured and Modeled Radial Electric Fields

Distance from Tower (cm)	Height (meters)	Measured Field (V/m)	Modeled Field (V/m)
2.5	2	1170	124
5.1	2	1170	130
15.2	2	645	134
30.5	2	390	115
45.7	2	254	93
61.0	2	214	77
91.4	2	117	54
2.5	6	390	85
15.2	6	215	90
30.5	6	106	76

Table 7. Ground Level Body Current near KKPL

Current (mA)	Body Configuration
0.42	standing, 2 bare feet on plate, arms down
0.56	standing, 2 bare feet on plate, arms up
0.56	standing, 2 bare feet on plate, arms out
0.59	standing, 2 bare feet on plate, arms up at 45 degrees
0.40	standing, 2 stocking feet on plate, arms down
0.40	standing, 1 stocking foot on plate, arms down
0.22	standing, 2 booted feet on plate, arms down
0.16	standing, 1 booted foot on plate, arms down
0.28	push-up, 2 bare hands on plate, boots on feet
0.28	push-up, 1 bare hand on plate, boots on feet
0.09	squat, 2 booted feet on plate, arms at sides

Table 8. Maximum Power Densities in the Mt. Spokane Fire Tower. Values in parentheses are with the KXLY-FM auxiliary antenna operating. Other values are with the main KXLY-FM antenna operating. Units (μW/cm²)

North

160 (510)	430 (340)	140 (230)	280 (430)	51 (240)	28 (400)
140 (340)	160 (71)	170 (71)	71 (200)	28 (220)	91 (110)
430 (1300)	220 (340)	140 (140)	48 (255)	45 (170)	430 (650)
280 (430)	28 (370)	43 (280)	160 (140)	16 (77)	430 (230)
140 (120)	85 (280)	110 (180)	48 (120)	48 (57)	430 (1600)
170 (110)	110 (650)	210 (850)	100 (770)	140 (110)	77 (71)

South

Table 9. Measurements Made for Instrument Evaluation. Electric Field as Determined with Several Instruments at a Single Location Near the Mullan Road School

Instrument	V/m
FOISD	24.8
IFI (SN 1060)	29
IFI (SN 1059)	25
Holaday (SN 26038 - no calibration at AM frequencies)	
Operator Kneeling	95*
Operator Standing	60*
Narda 8616 (SN 20049) with 8662 E probe (SN 01008)	
Operator Kneeling	290*
Operator Standing	160*

*These readings were excessively high because of RF potential sensitivity (see text for discussion).

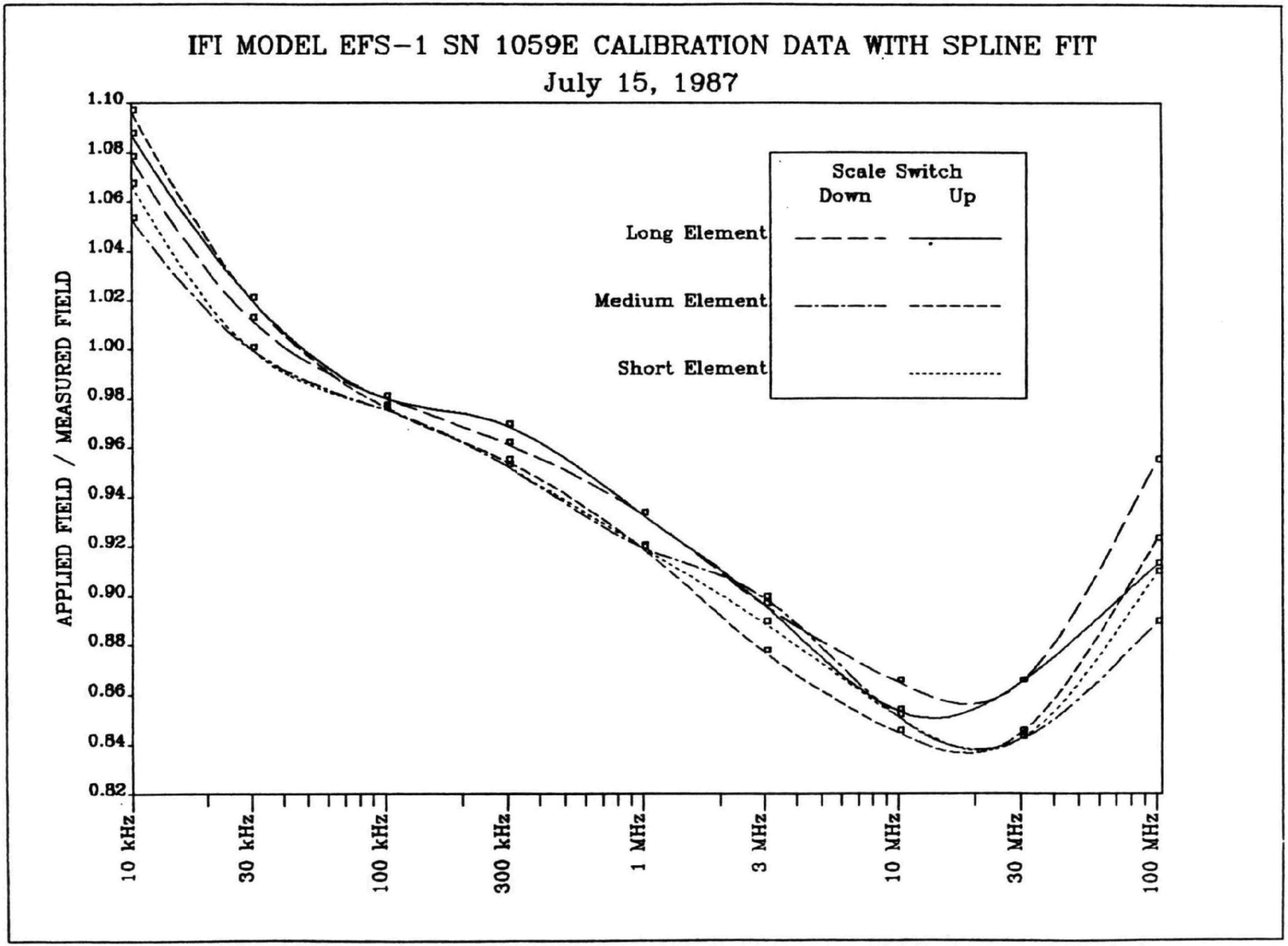
Table 10. Operator Perturbation of Field Values with Probe Remaining Stationary on Top of Dielectric Support.

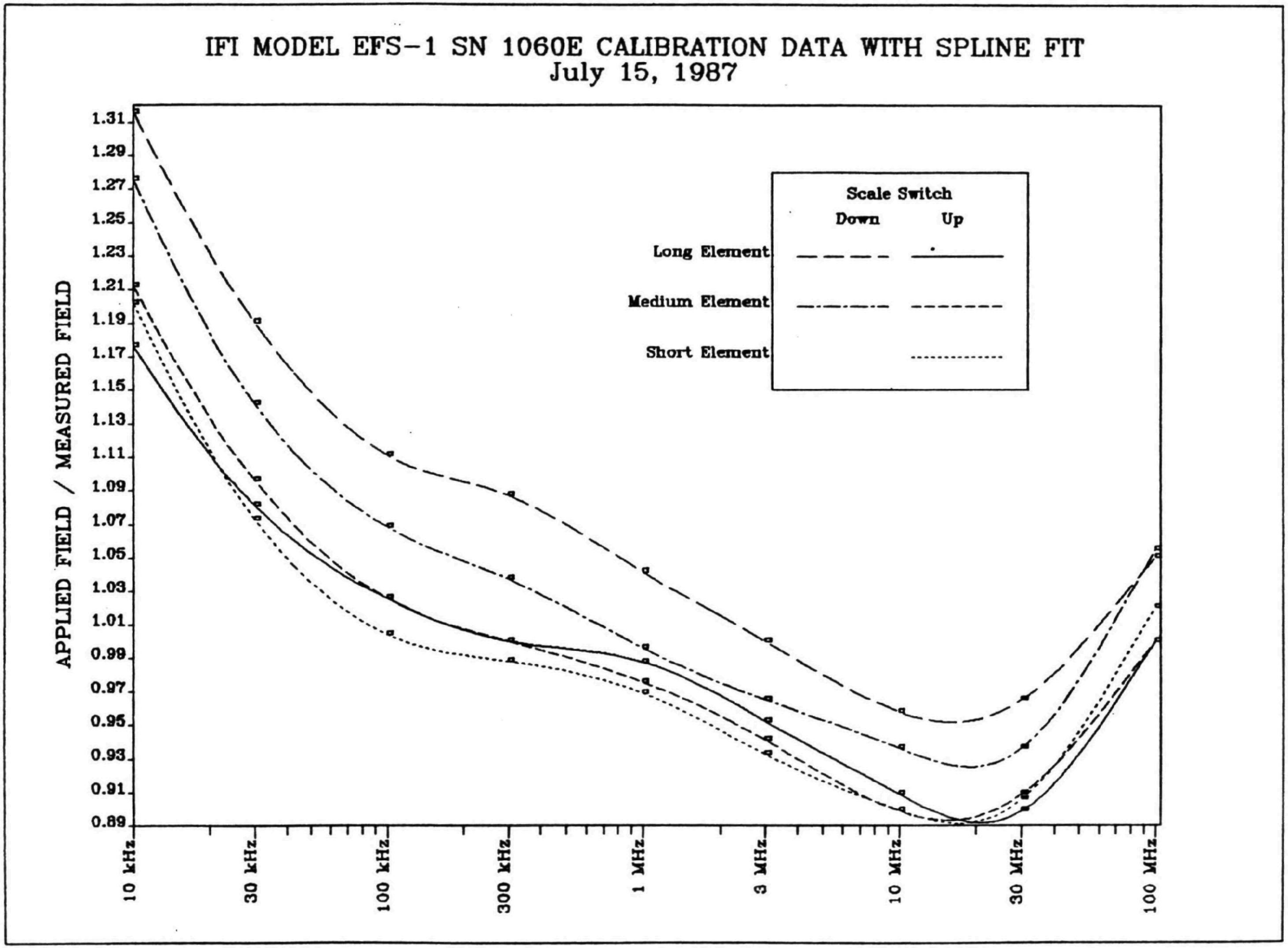
	Magnetic Field A/m	Electric Field V/m
Observer Standing		
to the N	.098	95
S	.126	96
E	.132	100
W	.115	96
Reference Value	.121	96
Observe Squatting		
to the N	.104	95
S	.147	99
E	.132	96
W	.121	92
Reference Value	.121	97

Table 11. Operator Perturbation of Field Values Under Normal Field Conditions - i.e. Operator Holding Probe and Meter. Probe Placed at Same Location for Each Measurement.

	Electric Field V/m
Observer Standing to the S	88
SW	88
W	87
NW	83
N	82
NE	80
E	86
SE	86
S	85

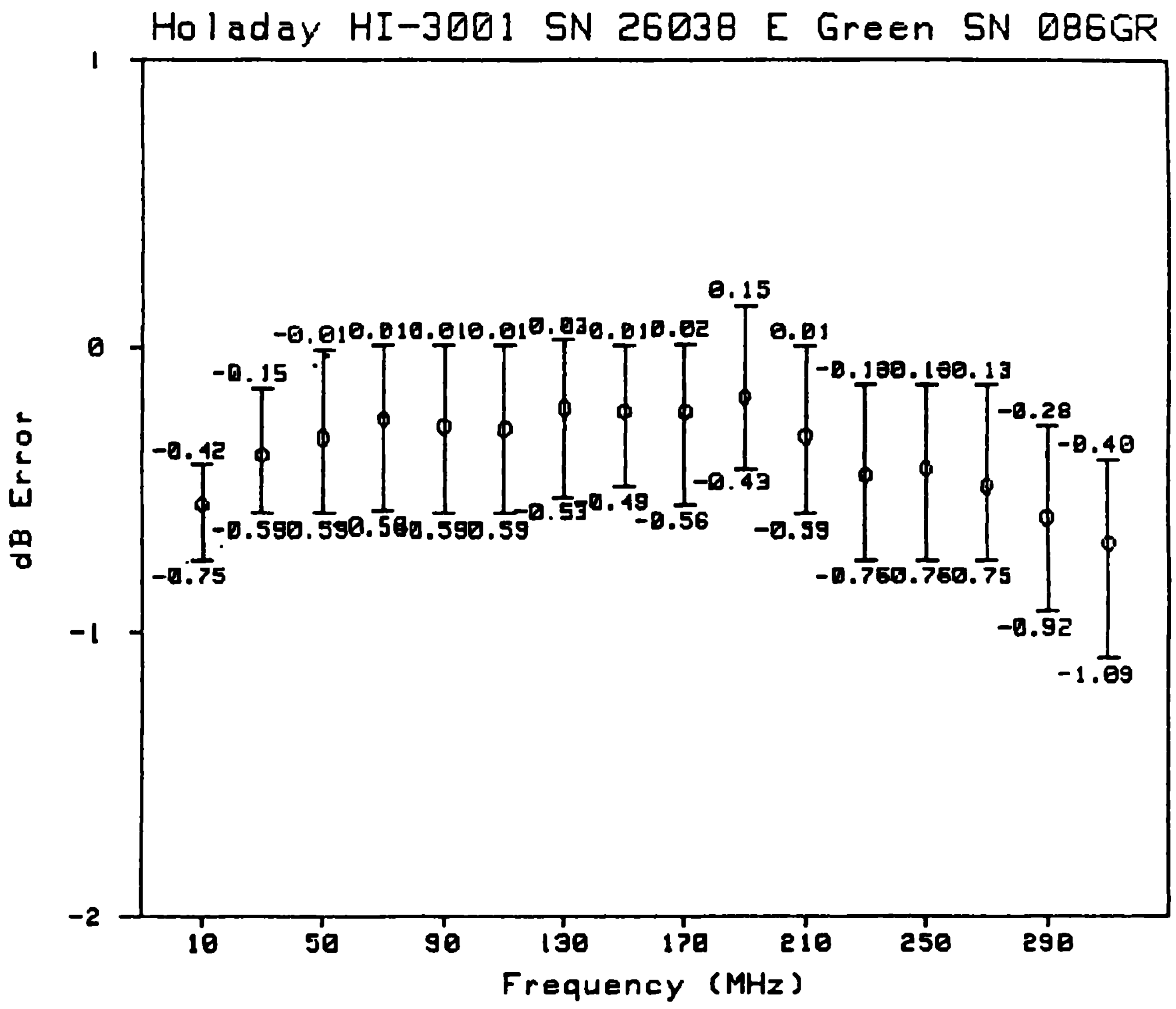
APPENDIX A
Instrument Calibration Data


IFI MODEL EFS-1 SN 1059E CALIBRATION DATA WITH SPLINE FIT
July 15, 1987
APPLIED FIELD / MEASURED FIELD
1.10
1.08
1.06
1.04
1.02
1.00
0.98
0.96
0.94
0.92
0.90
0.88
0.86
0.84
0.82
Scale Switch
Down
Up
Long Element
Medium Element
Short Element
10 kHz
30 kHz
100 kHz
300 kHz
1 MHz
3 MHz
10 MHz
30 MHz
100 MHz

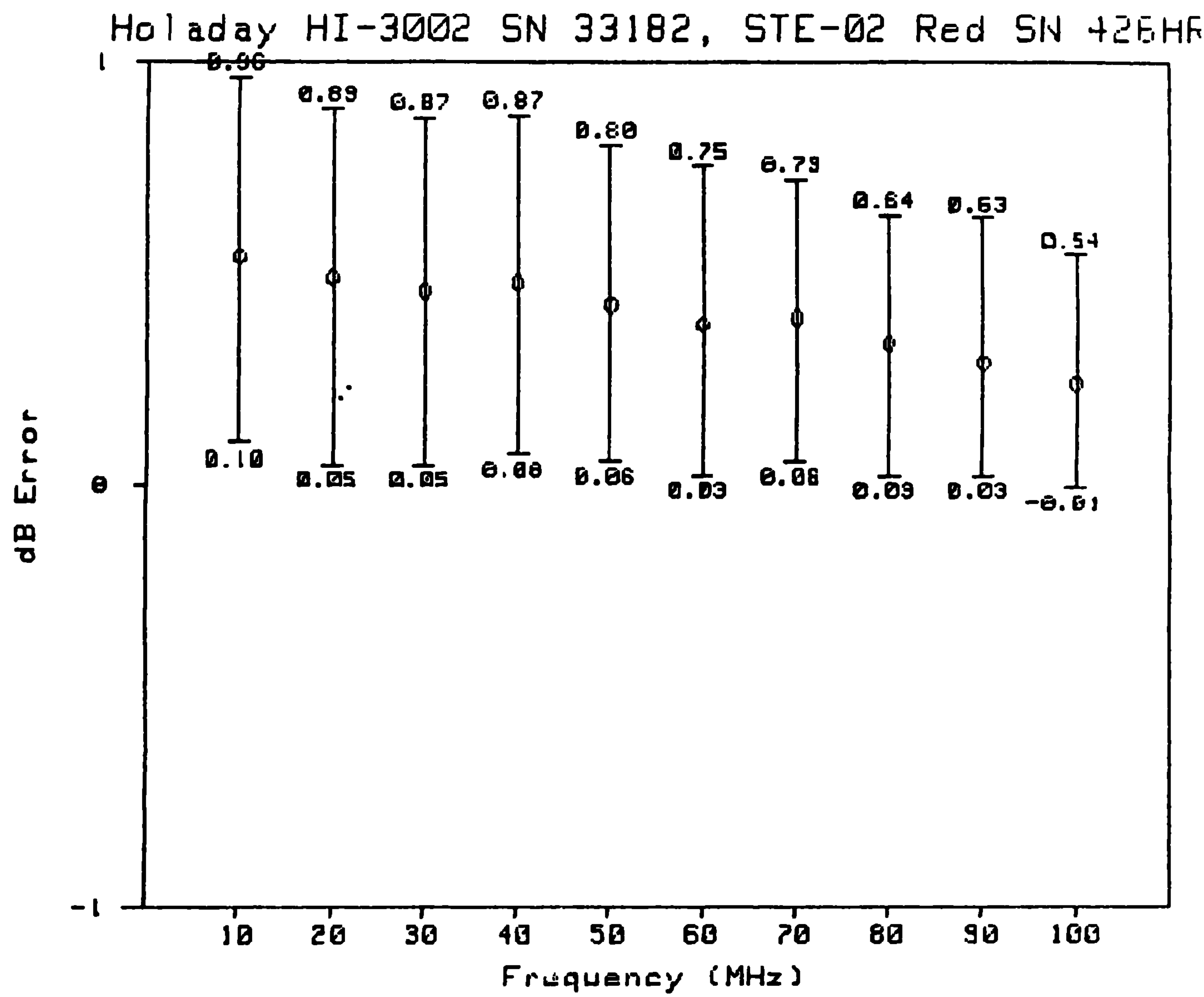


IFI MODEL EFS-1 SN 1060E CALIBRATION DATA WITH SPLINE FIT
July 15, 1987
Scale Switch
Down
Up
Long Element
Medium Element
Short Element
APPLIED FIELD / MEASURED FIELD
1.31
1.29
1.27
1.25
1.23
1.21
1.19
1.17
1.15
1.13
1.11
1.09
1.07
1.05
1.03
1.01
0.99
0.97
0.95
0.93
0.91
0.89
10 kHz
30 kHz
100 kHz
300 kHz
1 MHz
3 MHz
10 MHz
30 MHz
100 MHz

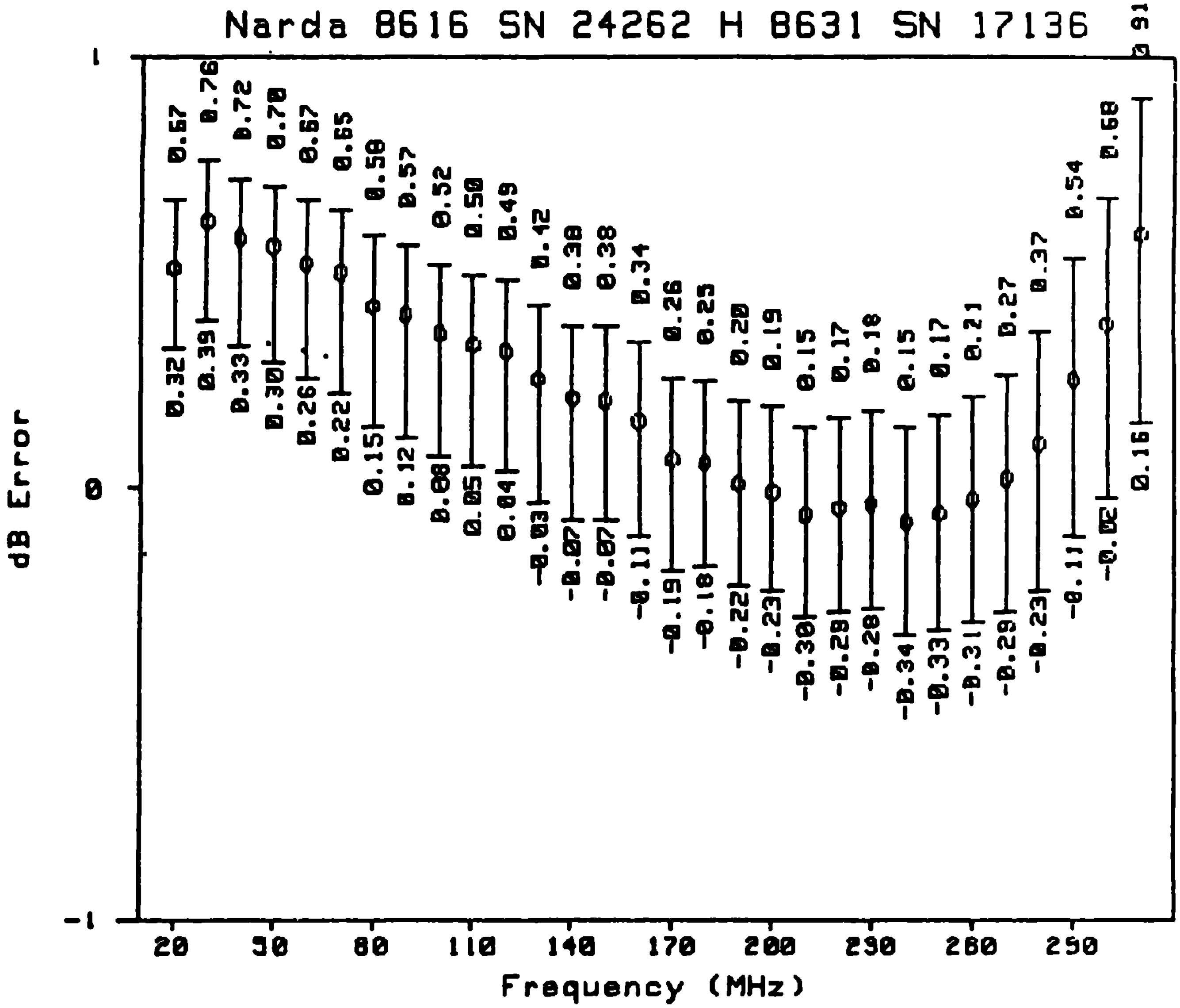
03/20/87 1:01 PM



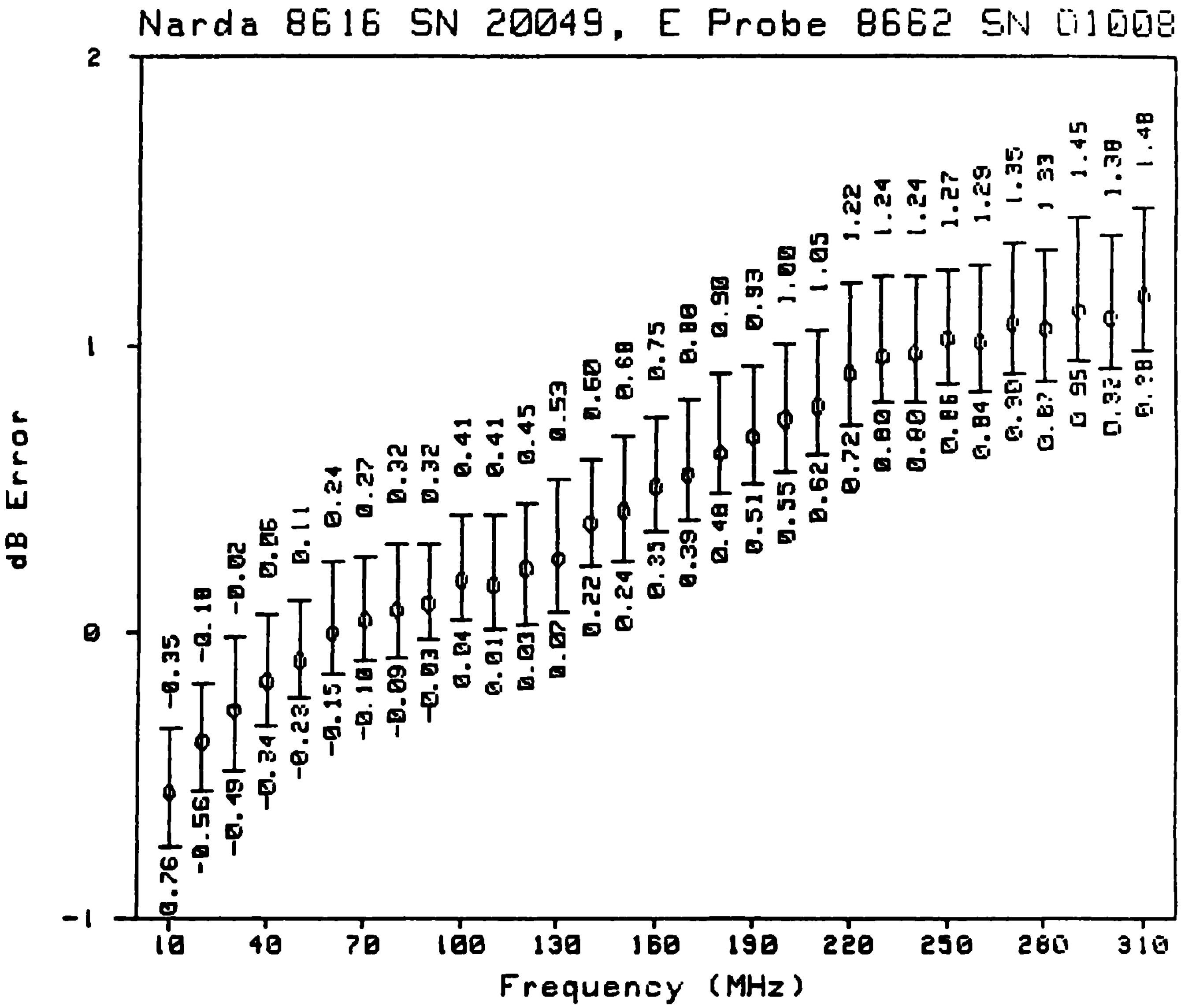
03/28/80 3:02 PM



09/17/87 1:19 PM



03/28/88 4:42 PM



Manufacturer's Calibration Data Reproduced here
but not used in the Report

Narda Microwave Corporation   Calibration Date: 10/86

Model Number 8631   Serial Number 17136

H Field Equivalent Power Density

(Multiply by Indicated Correction Factor to Obtain Actual mW/cm^2)

Frequency (MHz)	Correct Factor	Frequency (MHz)	Correct Factor
10.00	1.227	100.00	1.054
13.56	1.026	150.00	1.091
27.12	0.911	200.00	1.098
40.68	0.934	250.00	1.085
50.00	0.953	300.00	0.972
75.00	1.020		

Narda Microwave Corporation

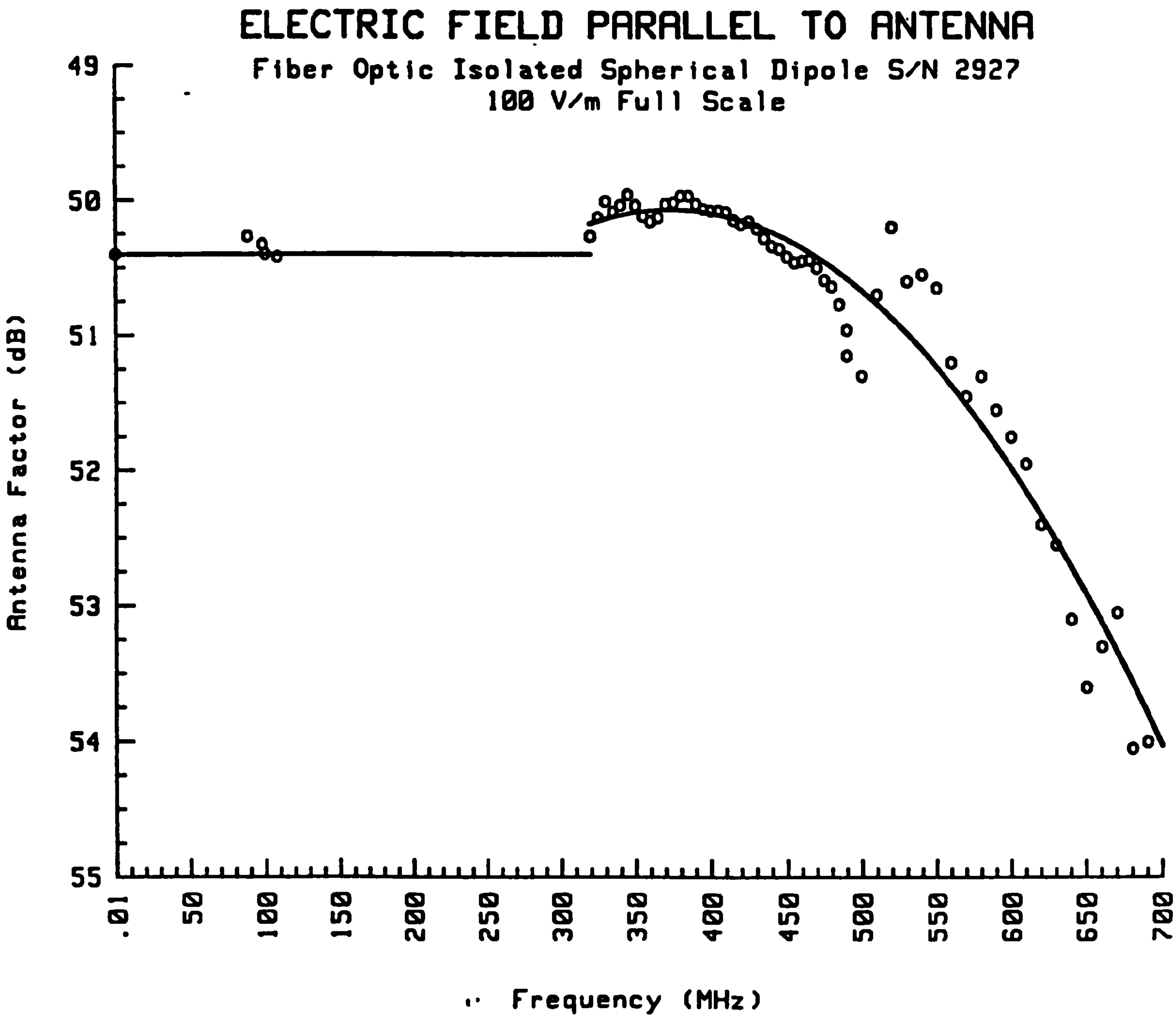
Model Number 8662   Serial Number 01008

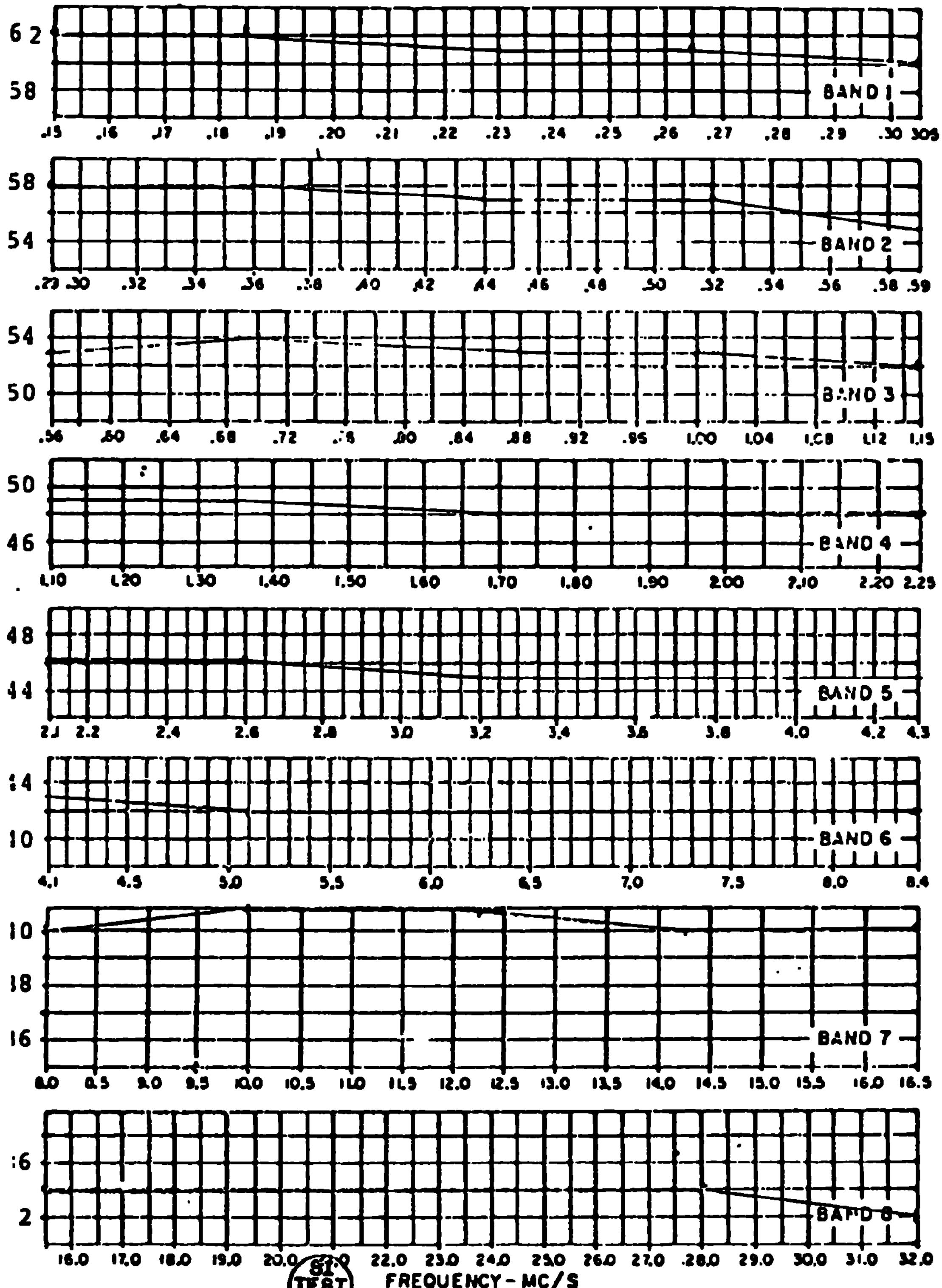
E Field Equivalent Power Density

(Multiply by Indicated Correction Factor to Obtain Actual mW/cm^2)

Frequency (MHz)	Correct Factor	Frequency (MHz)	Correct Factor
0.30	1.663	27.12	1.1??*
0.50	1.539	40.68	1.0??*
1.00	1.401	100.00	0.8??*
3.00	1.235	200.00	0.872
13.56	1.171	300.00	0.891

*? indicates calibration marking on probe unreadable.


ELECTRIC FIELD PARALLEL TO ANTENNA
Fiber Optic Isolated Spherical Dipole S/N 2927
100 V/m Full Scale
Antenna Factor (dB)
49
50
51
52
53
54
55
.01
50
100
150
200
250
300
350
400
450
500
550
600
650
700
Frequency (MHz)



ALIBRATED BY: ______________ FOR S E S 92200-3 LOOP ANTENNA

ATE: MAR 11 1978 SERIAL NO. 459

P/N 4009 CHART 4 — CORRECTION FACTORS, REMOTE LOOP ANTENNA

Eaton Loop Antenna

CURRENT PROBE 91550–1

CALIBRATING ENGINEER: ______________________

SERIAL NO.: ______________________

DATE: ______________

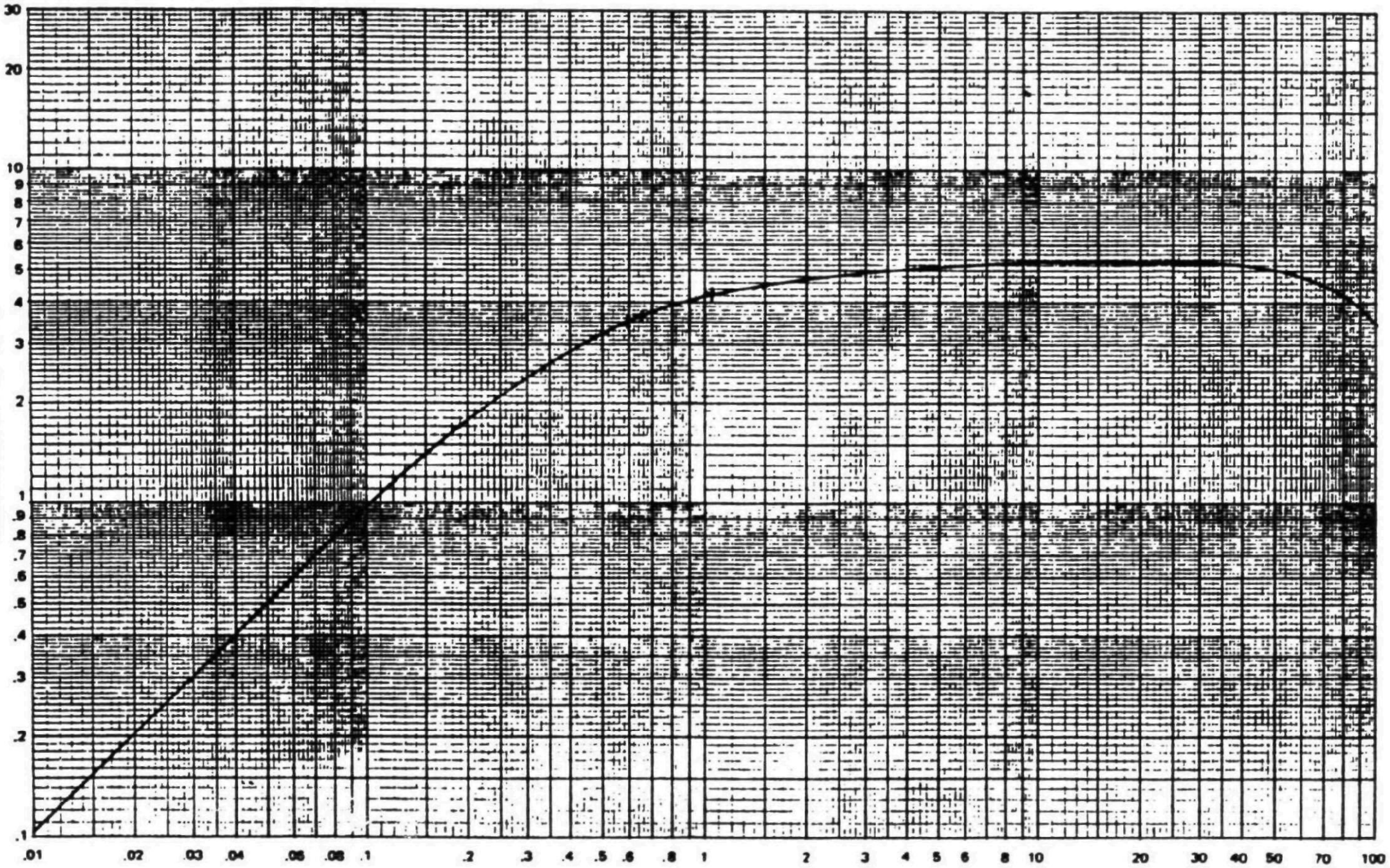


FIGURE 5. CURRENT PROBE TRANSFER IMPEDANCE – OHMS

CURRENT METER CALIBRATION*

Actual Current mA	Current Meter Reading mA
0	-15
15	0
29.8	15
40.2	36
57.9	55
77.0	75
101.4	100
119.4	120

*Meter zero is shifted negative.

APPENDIX B

Program ZOOM Listing

```
10     !  ZOOM -- 09/15/86 -- 07/10/86 est -- CSC jt
20     !
30     !  finds power densities using selected frequencies
40     !  of FM stations, TV stations, and AM stations
50     !  set up for FOISD measurements
60     !
70     !  Requires
80     !   sc=7,18   HP8566A Spectrum Analyzer
90     !   sc=7,23   Maxwell SMC-202A Stepping Motor Controller
100    !             Slo-Syn Stepping Rotater
110    !   Data_msus$  Defines MASS STORAGE DEVICE for DATA
120    !
130    OPTION BASE 1
140    Data_msus$=" F"
150    PRINTER IS 16
160    !
170    DEF FNPower(SHORT X)=10^(X/10)
180    !
190    DIM Mdesc$[80],Calls_fm$(50)[4],Calls_tv$(50)[4],Calls_am$(50)[4]
200    !
210    ! FM   _f     TV Video   _v     TV Audio   _a     AM   _s
220    !
230    SHORT Freqz_f(50),Afact_f(50),Table_f(3,50)
240    SHORT Freqz_v(50),Afact_v(50),Table_v(3,50)
250    SHORT Freqz_a(50),Afact_a(50),Table_a(3,50)
260    SHORT Freqz_s(50),Afact_s(50),Table_s(3,50)
270    !
280    DIM Year$[2],Date$[8],Time$[8],File$[6]
290    Year$="87"
300    CALL Get_date_time(Year$,Date$,Time$)
310    !
320    Squared$=CHR$(190)
330    !
340    ! FM DATA  Number of frequencies (MHz), Calls, Freqs
350    !             To ignore FM, the first DATA must be 0
360    !             and the calls & frequencies commented out
370    !
380    ! LAS VEGAS, NEVADA
390   ! DATA 16
400   ! DATA KCEP,KNPR,KNPR,K1LA,KUNV,KOMP,KXXX,KXTZ,KXXX,KYYX,KKLZ,KYRK,KIUC,KMZ
Q,KFMS,KRRI
410   ! DATA 88 1,88 7,89 5,90 5,91 5,92 3,93 1,94 1,94 7,95 5,96 3,97 1,98 5,100
 5,101 9,105 5
420    !
470    !
480    ! SPOKANE WASHINGTON
490   DATA 0
500 ! DATA KPBX,KZZU,KDRK,KPPL,KISC,KQSP,KXLY,KEYF,KEZE,KMBI
510 ! DATA 91 1,92.9,93 7,96 1,98 1,98.9,99 9,101 1,105 7,107 9
520    !
530    ! TV DATA  Number of frequencies (MHZ), Calls, Video Freqs, Audio Freqs
540    !             To ignore TV, the first DATA must be 0
550    !             and the calls & both sets of frequencies commented out
560    !
570    ! LAS VEGAS, NEVADA
580   ! DATA 6
590   ! DATA KVBC,KVVU,KLAS,KLVX,KTNV,KRLR
600   ! DATA 61 25,77 26,181 24,193 26,211 24,513 26     ! video
610   ! DATA 65 75,81 76,185 74,197 76,215 74,517 76     ! audio
```

```
620    !
630    ! SPOKANE WASHINGTON
640   DATA 0
650 ! DATA KREM,KXLY,KHG ,KSPS,KAYU
660 ! DATA 55 24,67 24,83 24,175 26,555 24
670 ! DATA 59 74,71 74,87 74,179 76,559 74
680    !
690    ! AM DATA  Number of frequencies (kHz), Calls, Freqs
700    !             To ignore AM, the first DATA must be 0
710    !             and the calls & frequencies commented out
720    !
730    ! LAS VEGAS, NEVADA
740   ! DATA 10
750   ! DATA KDWN,KXXX,KORK,KNUU,KMJJ,KEZD,KXXX,KRAM,KVEG,KENO
760   ! DATA 720,870,920,970,1140,1230,1280,1340,1410,1460
770    ! SPOKANE, WASHINGTON
780   DATA 10
790   DATA KLSN,KPPL,KJRB,KXLY,KZZU,KEYF,KRSS,KUDY,KMBI,KGA
800   DATA 590,630,790,920,970,1050,1230,1280,1330,1510
810    !
820    DATA 20    ! FOISD Full Scale (V/m)          var  Fss
830    DATA 0      ! Starting reference level (dBm)  var  R1
840    !
850    !  READ IN DATA
860    !
870    READ Nfmf
880    IF Nfmf=0 THEN Read_ntvf
890    MAT READ Calls_fm$(Nfmf),Freqz_f(Nfmf)
900    REDIM Afact_f(Nfmf),Table_f(3,Nfmf)
910 Read_ntvf     !
920    READ Ntvf
930    IF Ntvf=0 THEN Read_namf
940    MAT READ Calls_tv$(Ntvf),Freqz_v(Ntvf),Freqz_a(Ntvf)
950    REDIM Afact_v(Ntvf),Afact_a(Ntvf),Table_v(3,Ntvf),Table_a(3,Ntvf)
960 Read_namf     !
970    READ Namf
980    IF Namf=0 THEN Fssrl
990    MAT READ Calls_am$(Namf),Freqz_s(Namf)
1000   REDIM Afact_s(Namf),Table_s(3,Namf)
1010 Fssrl     !
1020   READ Fss,R1
1030   !
1040   !  END READING IN DATA
1050   !
1060   P$(1)="X"
1070   P$(2)="Y"
1080   P$(3)="Z"
1090   TYPEWRITER ON
1100   EDIT "Enter Measurement Description",Mdesc$
1110   TYPEWRITER OFF
1120   GOSUB Foisd
1130   !
1131   OUTPUT 723,"X=0 A=200 S=150 C=0"
1140   FOR I=1 TO 3
1150   !
1160   ! FM station measurements
1170   !
1180     IF Nfmf=0 THEN Dotv
1190     OUTPUT 718,"RC8 SP1MZ RB100KZ HD B1"     ! Initial State - FM
1200     FOR J=1 TO Nfmf
```

```
1210       !  Set MARKER to CENTER FREQUENCY
1220       !  Find approximate power in 10 dB/DIV
1230       OUTPUT 718,"A1 CF",Freqz_f(J),"MZ M2 RL",R1,"DM LG10DB A1 A2"
1240       WAIT 300      !    3 second MAX HOLD
1250       OUTPUT 718,"O3 MA"
1260       ENTER 718,Marker
1270       !  Set REFERENCE LEVEL so MKR is 5 dB below REF
1280       !  Change SCALE dB/DIV to 1 dB, Set MAX HOLD
1290       OUTPUT 718,"RL",INT(Marker)+5,"DM LG1DB HD A1 A2 "
1300       WAIT 2000      !   2 second MAX HOLD
1310       OUTPUT 718,"O3 MA"
1320       ENTER 718,Table_f(I,J)
1330       PRINT USING Shown,"FM  ->",P$(I),Freqz_f(J),INT(Marker)+5,Table_f(I,J)
1340     NEXT J
1350 Dotv       !
1360     !
1370     ! TV video measurements
1380     !
1390     IF Ntvf=0 THEN Doam
1400     OUTPUT 718,"RC8 SP0MZ HD B1"      ! Initial State - TV video
1410     FOR J=1 TO Ntvf
1420       !  Find approximate power in 10 dB/DIV
1430       OUTPUT 718,"A1 CF",Freqz_v(J),"MZ RL",R1,"DM LG10DB A1 A2"
1440       OUTPUT 718,"E1"
1450       OUTPUT 718,"O3 MA"
1460       ENTER 718,Marker
1470       !  Set REFERENCE LEVEL so MKR is 5 dB below REF
1480       !  Change SCALE dB/DIV to 1 dB, Set MAX HOLD
1490       OUTPUT 718,"RL",INT(Marker)+5,"DM LG1DB HD A1 A2 "
1500       OUTPUT 718,"E1"
1510       OUTPUT 718,"O3 MA"
1520       ENTER 718,Table_v(I,J)
1530       PRINT USING Shown,"TV Vid",P$(I),Freqz_v(J),INT(Marker)+5,Table_v(I,J)
1540     NEXT J
1550     !
1560     ! TV audio measurements
1570     !
1580     OUTPUT 718,"RC8 SP500KZ RB100KZ HD B1"      ! Initial State - TV audio
1590     FOR J=1 TO Ntvf
1600       !  Set MARKER to CENTER FREQUENCY
1610       !  Find approximate power in 10 dB/DIV
1620       OUTPUT 718,"A1 CF",Freqz_a(J),"MZ M2 RL",R1,"DM LG10DB A1 A2"
1630       WAIT 300      !    3 second MAX HOLD
1640       OUTPUT 718,"O3 MA"
1650       ENTER 718,Marker
1660       !  Set REFERENCE LEVEL so MKR is 5 dB below REF
1670       !  Change SCALE dB/DIV to 1 dB, Set MAX HOLD
1680       OUTPUT 718,"RL",INT(Marker)+5,"DM LG1DB HD A1 A2 "
1690       WAIT 2000      !   2 second MAX HOLD
1700       OUTPUT 718,"O3 MA"
1710       ENTER 718,Table_a(I,J)
1720       PRINT USING Shown,"TV Aud",P$(I),Freqz_a(J),INT(Marker)+5,Table_a(I,J)
1730     NEXT J
1740 Doam       !
1750     !
1760     ! AM station measurements
1770     !
1780     IF Namf=0 THEN Position
1790     OUTPUT 718,"RC8 SP0HZ RB1KZ HD B1"    ! Initial State - AM
1800     FOR J=1 TO Namf
```

```
1810       !  Find approximate power in 10 dB/DIV
1820       OUTPUT 718,"A1 CF",Freqz_s(J),"KZ RL",R1,"DM LG10DB VB10HZ A1"
1830       WAIT 300
1840       OUTPUT 718,"A2"
1850       WAIT 300
1860       OUTPUT 718,"E1"
1870       OUTPUT 718,"O3 MA"
1880       ENTER 718,Marker
1890       !  Set REFERENCE LEVEL so MKR is 5 dB below RFF
1900       !  Change SCALE dB/DIV to 1 dB, Set MAX HOLD
1910       OUTPUT 718,"RL",INT(Marker)+2,"DM LG1DB VB1HZ HD A1 A2 "
1920       WAIT 2000
1930       OUTPUT 718,"E1"
1940       OUTPUT 718,"O3 MA"
1950       ENTER 718,Table_s(I,J)
1960       PRINT USING Showk,"AM  ->",P$(I),Freqz_s(J),INT(Marker)+5,Table_s(I,J)
1970     NEXT J
1980     !
1990 Position       !  Rotates probe 120,-240,120 degrees
2000     IF I=1 THEN OUTPUT 723,"D=-667"
2010     IF I=2 THEN OUTPUT 723,"D=667"
2011     IF I=3 THEN OUTPUT 723,"D=0"
2020     DISP "ROTATING      "
2100     WAIT 10000
2110     DISP
2120   NEXT I
2130 Showm    IMAGE 6A,"  Axis  ",A,"  Freq  ",4D DD," (MHz)  Ref Lev  ",DDD DD,
" (dBm)  Power  ",DDD DD," (dBm)"
2140 Showk    IMAGE 6A,"  Axis  ",A,"  Freq  ",4D DD," (kHz)  Ref Lev  ",DDD DD,
" (dBm)  Power  ",DDD DD," (dBm)"
2150   !
2160   ! initialize and print table header
2170   !
2180   Sumpd=0
2190   Sumpd_f=Sumpd_v=Sumpd_a=0
2200   Sumpd_s=0
2210   PRINTER IS 0
2220   PRINT USING Id1,Mdesc$
2230   PRINT USING Id2,Fss,Date$,Time$
2240   !
2250   ! FM data
2260   !
2270   IF Nfmf=0 THEN Video
2280   PRINT USING Fmtitle
2290   PRINT USING Col1
2300   PRINT USING Col2
2310   PRINT USING Col3m
2320   FOR I=1 TO Nfmf
2330     Total_mw=FNPower(Table_f(1,I))+FNPower(Table_f(2,I))+FNPower(Table_f(3,I
))
2340     Total_dbm=10*LGT(Total_mw)
2350     Ef=Total_dbm+107+Afact_f(I)
2360     Pd=(10^(Ef/20)/1E6)^2/3.77
2370     Sumpd_f=Sumpd_f+Pd
2380     PRINT USING Ffm,Calls_fm$(I),Freqz_f(I),Table_f(1,I),Table_f(2,I),Table_
f(3,I),Total_dbm,Afact_f(I),Ef,Pd
2390   NEXT I
2400   PRINT USING Total,Sumpd_f,Squared$,Squared$,Sumpd_f*3.77
2410   !
2420   ! TV data
```

```
2430  '
2440 Video     '
2450  IF Ntvf=0 THEN Am_stat
2460  PRINT USING Vidtitle
2470  PRINT USING Vid_ast
2480  PRINT USING Col1
2490  PRINT USING Col2
2500  PRINT USING Col3m
2510  FOR I=1 TO Ntvf
2520    Total_mw=FNPower(Table_v(1,I))+FNPower(Table_v(2,I))+FNPower(Table_v(3,I
))
2530    Total_dbm=10*LGT(Total_mw)
2540   ' video only - subtract 4 dB for RMS electric field
2550    Ef=Total_dbm+107+Afact_v(I)-4
2560    Pd=(10^(Ef/20)/1E6)^2/3 77
2570    Sumpd_v=Sumpd_v+Pd
2580    PRINT USING Ftv,Calls_tv$(I),Freqz_v(I),Table_v(1,I),Table_v(2,I),Table_
v(3,I),Total_dbm,Afact_v(I),Ef,Pd
2590  NEXT I
2600  PRINT USING Total,Sumpd_v,Squared$,Squared$,Sumpd_v*3 77
2610  PRINT USING Note4
2620 Audio     '
2630  PRINT USING Audtitle
2640  PRINT USING Col1
2650  PRINT USING Col2
2660  PRINT USING Col3m
2670  FOR I=1 TO Ntvf
2680    Total_mw=FNPower(Table_a(1,I))+FNPower(Table_a(2,I))+FNPower(Table_a(3,I
))
2690    Total_dbm=10*LGT(Total_mw)
2700    Ef=Total_dbm+107+Afact_a(I)
2710    Pd=(10^(Ef/20)/1E6)^2/3 77
2720    Sumpd_a=Sumpd_a+Pd
2730    PRINT USING Ftv,Calls_tv$(I),Freqz_a(I),Table_a(1,I),Table_a(2,I),Table_
a(3,I),Total_dbm,Afact_a(I),Ef,Pd
2740  NEXT I
2750  PRINT USING Total,Sumpd_a,Squared$,Squared$,Sumpd_a*3 77
2760  !
2770  ! sum TV and FM power densities
2780  !
2790  IF Nfmf=0 THEN Am_stat
2800  Sumpd=Sumpd_f+Sumpd_v+Sumpd_a
2810  PRINT USING Line
2820  PRINT USING Ttvfm,Sumpd,Squared$,Squared$,Sumpd*3 77
2830  !
2840  ! AM data
2850  !
2860 Am_stat   '
2870  IF Namf=0 THEN File_save
2880  PRINT USING Amtitle
2890  PRINT USING Col1
2900  PRINT USING Col2
2910  PRINT USING Col3k
2920  FOR I=1 TO Namf
2930    Total_mw=FNPower(Table_s(1,I))+FNPower(Table_s(2,I))+FNPower(Table_s(3,I
))
2940    Total_dbm=10*LGT(Total_mw)
2950    Ef=Total_dbm+107+Afact_s(I)
2960    Pd=(10^(Ef/20)/1E6)^2/3 77
2970    Sumpd_s=Sumpd_s+Pd
```

```
2980    PRINT USING Fam,Calls_am$(I),Freqz_s(I),Table_s(1,1),Table_s(2,1),Table_s(3,1),Total_dbm,Afact_s(1),Ef,Pd
2990   NEXT I
3000   PRINT USING Total,Sumpd_s,SQR(Sumpd_s*3 77)
3010   !
3020   ! image statements
3030   !
3040 Id1    IMAGE /80A/
3050 Id2    IMAGE "FOISD Full Scale Setting ",3D,"(V/m)",28X,8A,3X,8A
3060 Fmtitle   IMAGE //"FM Radio Station Measurements"/
3070 Vidtitle  IMAGE //"TV Video Measurements"/
3080 Audtitle  IMAGE //"TV Audio Measurements"/
3090 Amtitle   IMAGE //"AM Radio Station Measurements"/
3100 Vid_ast   IMAGE 68X,"*"
3110 Col1   IMAGE "                                              Total    Antenna   Electric      Power  "
3120 Col2   IMAGE " Call   Frequency    Px      Py      Pz      Power     Factor      Field      Density"
3130 Col3m  IMAGE " Sign      (MHz)      (dbm)  (dBm)  (dBm)    (dBm)      (dB)     (dBuV/m)    (uW/cm^2)"/
3140 Col3k  IMAGE " Sign      (kHz)      (dbm)  (dBm)  (dBm)    (dBm)      (dB)     (dBuV/m)    (uW/cm^2)"/
3150 Ffm  IMAGE 1X,4A,4X,4D D,4X,3(DDZ DD,1X),4D DD,3X,DDD DD,5X,DDD DD,1X,6D DDDD
3160 Ftv  IMAGE 1X,4A,3X,4D DD,4X,3(DDZ DD,1X),4D DD,3X,DDD DD,5X,DDD DD,1X,6D DDDDD
3170 Fam  IMAGE 1X,4A,6X,4D,4X,3(DDZ DD,1X),4D DD,3X,DDD DD,5X,DDD DD,1X,6D DDDDD
3180 Total  IMAGE 71X,"---------"//38X,"Total Power Density             ",5D DDDDD//38X,"Total Electric Field (V/m)   ",5D DDDDD
3190 Note4  IMAGE /7X,"*  4 dB subtracted from peak electric field to obtain RMS electric field"
3200 Line   IMAGE 71X,"---------"
3210 Ttvfm  IMAGE 71X,"---------"//32X,"TV & FM Power Density              ",5D DDDDD//32X,"TV & FM Electric Field (V",A,"/m",A,")       ",5D DDDDD
3220  !
3230  ! SAVE DATA TO FILE
3240  !
3250 File_save    !
3260   PRINTER IS 16
3270   Yorn$="Y"
3280   INPUT "Do You Wish To Save The Data?  YES or NO",Yorn$
3290   IF Yorn$<>"Y" THEN No_save
3300   CALL File_name(Date$,Time$,"ZO",File$)
3310   ASSIGN #1 TO File$&Data_msus$,Ret_code
3320   IF Ret_code<>1 THEN File$=File$[1;5]&"1"
3330   ASSIGN #1 TO *
3340   CREATE File$&Data_msus$,25
3350   ASSIGN #1 TO File$&Data_msus$
3360   PRINT #1,Mdesc$,Date$,Time$,Fss
3370   PRINT #1,Nfmf
3380   IF Nfmf<>0 THEN PRINT #1;Calls_fm$(*),Freqz_f(*),Afact_f(*),Table_f(*),Sumpd_f
3390   PRINT #1,Ntvf
3400   IF Ntvf<>0 THEN PRINT #1,Calls_tv$(*),Freqz_v(*),Afact_v(*),Table_v(*),Sumpd_v
3410   IF Ntvf<>0 THEN PRINT #1,Freqz_a(*),Afact_a(*),Table_a(*),Sumpd_a
3420   PRINT #1,Namf
3430   IF Namf<>0 THEN PRINT #1,Calls_am$(*),Freqz_s(*),Afact_s(*),Table_s(*),Sumpd_s
```

```
3440  PRINTER IS 0
3450  PRINT "File Name  ",File$
3460 No_save    !
3470  PRINTER IS 16
3480  DISP "PROGRAM COMPLETE "
3490  END
3500  !
3510 Foisd  !
3520  Atten_ex=0
3530  IF Fss=1 THEN Atten_ex=-39
3540  IF Fss=2 THEN Atten_ex=-33
3550  IF Fss=5 THEN Atten_ex=-25 6
3560  Sp$="D"
3570  IF Fss=10 THEN INPUT "All Switches UP or DOWN",Sp$
3580  IF (Fss=10) AND (Sp$="D") THEN Atten_ex=-20 25
3590  IF (Fss=10) AND (Sp$="U") THEN Atten_ex=-19 6
3600  IF Fss=20 THEN Atten_ex=-13 95
3610  IF Fss=50 THEN Atten_ex=-6 05
3620  !
3630  IF (Atten_ex<>0) OR (Fss=100) THEN 3670
3640  DISP "INVALID SCALE SETTING   RETRY"
3650  STOP
3660  IF Nfmf=0 THEN Anttv
3670  FOR Index=1 TO Nfmf
3680    F=Freqz_f(Index)
3690    IF F<320 THEN Afact_f(Index)=50 4
3700    IF F>=320 THEN Afact_f(Index)=55 23- 027636*F+3 7033E-5*F*F
3710    Afact_f(Index)=Afact_f(Index)+Atten_ex
3720  NEXT Index
3730 Anttv    !
3740  IF Ntvf=0 THEN Antam
3750  FOR Index=1 TO Ntvf
3760    F=Freqz_v(Index)
3770    IF F<320 THEN Afact_v(Index)=50 4
3780    IF F>=320 THEN Afact_v(Index)=55 23- 027636*F+3 7033E-5*F*F
3790    Afact_v(Index)=Afact_v(Index)+Atten_ex
3800    F=Freqz_a(Index)
3810    IF F<320 THEN Afact_a(Index)=50 4
3820    IF F>=320 THEN Afact_a(Index)=55 23- 027636*F+3 7033E-5*F*F
3830    Afact_a(Index)=Afact_a(Index)+Atten_ex
3840  NEXT Index
3850 Antam    !
3860  IF Namf=0 THEN Goback
3870  FOR Index=1 TO Namf
3880    F=Freqz_s(Index)/1000      ! AM in kHz
3890    IF F<320 THEN Afact_s(Index)=50 4
3900    IF F>=320 THEN Afact_s(Index)=55.23- 027636*F+3 7033E-5*F*F
3910    Afact_s(Index)=Afact_s(Index)+Atten_ex
3920  NEXT Index
3930 Goback.   !
3940  RETURN
3950  !
3960  SUB Get_date_time(Year$,Date$,Time$)
3970    DIM Date_time$[14],Aorp$[1]
3980    INTEGER Hour
3990    OUTPUT 9,"Request time"
```

```
4000     ENTER 9,Date_time$
4010     IF (Date_time$[1,2]="88") OR (ERRN=163) THEN Clock_err
4020     Date$=Date_time$[1,2]&"/"&Date_time$[4,2]&"/"&Year$
4030     Hour=VAL(Date_time$[7,2])
4040     Aorp$="A"
4050     IF Hour>11 THEN Aorp$="P"
4060     IF (Hour>12) OR (Hour=0) THEN Hour=ABS(Hour-12)
4070     Date_time$[7,2]=VAL$(Hour)
4080     IF Hour<10 THEN Date_time$[7,2]=" "&VAL$(Hour)
4090     Time$=Date_time$[7,5]&" "&Aorp$[1]&"M"
4100     SUBEXIT
4110 Clock_err       !
4120     INPUT "Clock Malfunction, Enter Date  MM/DD/YY",Date$
4130     INPUT "Enter Time  HH MM xM",Time$
4140   SUBEND
4150   !


4160   SUB File_name(Date$,Time$,Prog_id$,File$)
4170     DIM Month$[1],Day$[1],Hour$[1],Minute$[1]
4180     Month$=CHR$(64+VAL(Date$[1,2]))
4190     Day=VAL(Date$[4,2])
4200     Day$=CHR$(64+Day)
4210     IF Day>26 THEN Day$=CHR$(70+Day)
4220     Hour=VAL(Time$[1,2])
4230     IF (Hour=12) AND (Time$[7,1]="A") THEN Hour=0
4240     IF (Hour<12) AND (Time$[7,1]="P") THEN Hour=Hour+12
4250     Hour$=CHR$(65+Hour)
4260     Minute=VAL(Time$[4,2])
4270     Minute$=CHR$(65+Minute)
4280     IF Minute>25 THEN Minute$=CHR$(71+Minute)
4290     IF Minute>51 THEN Minute$=CHR$(Minute-2)
4300     File$=Prog_id$&Month$&Day$&Hour$&Minute$
4310   SUBEND
```

APPENDIX C

Detailed Narrowband Results

File Name ZOGB07

Site 1 repeat

FOISD Full Scale Setting 20(V/m) 07/02/87 2 57 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-36.40	-34 37	-36 29	-30 81	36.45	112 64	04870
KPPL	630	-62 57	-61.36	-62 07	-57.20	36 45	86 25	00011
KJRB	790	-32 12	-29 40	-31 18	-25 98	36 45	117 47	14017
KXLY	920	-31 72	-29 48	-31 54	-26 02	36 45	117 43	14605
KZZU	970	-46 65	-44 57	-46 74	-41 09	36 45	102 36	00456
KEYF	1050	-27 45	-24.08	-26 10	-20 88	36.45	122 57	47913
KRSS	1230	-66 06	-63 30	-65 43	-59 99	36 45	83 46	00006
KUDY	1280	-43 63	-42 36	-44 33	-38 59	36 45	104 86	00812
KMBI	1330	-36 38	-35 31	-36 69	-31 31	36 45	112 14	04337
KGA	1510	-7.75	-6 81	-7 49	-2 56	36 45	140.89	32 55464

Total Power Density: 33 43372

Total Electric Field (V/m): 11 22698

File Name ZOGBRn

Site 1 Vehicle Facing West

FOISD Full Scale Setting 20(V/m) 07/02/87 5·39 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-37.41	-34 76	-36.81	-31.40	36.45	112.05	04251
KPPL	630	-63.35	-61 97	-62.54	-57.81	36.45	85.64	00010
KJRB	790	-33 12	-30 09	-31.92	-26.76	36.45	116.69	12385
KXLY	920	-32.85	-30 25	-32 56	-26.95	36.45	116.50	11843
KZZU	970	-47 59	-45 32	-47.54	-41.91	36 45	101.54	00378
KEYF	1050	-28 58	-24.53	-26.85	-21 56	36 45	121 89	40950
KRSS	1230	-66.72	-63 80	-66.03	-60.56	36 45	82 89	00005
KUDY	1280	-44.54	-43.01	-45.04	-39.34	36.45	104.11	00684
KMBI	1330	-37.23	-36 21	-37 31	-32.12	36.45	111.33	.03606
KGA	1510	-8.40	-7.56	-8.32	-3.31	36 45	140.14	27 42378

Total Power Density: 28 16491

Total Electric Field (V/m): 10 30445

File Name ZOGBRv

Site 1 Vehicle Facing North

FOISD Full Scale Setting 20(V/m) 07/02/87 5 47 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-38 68	-34 65	-35.85	-31 32	36 45	112 13	04334
KPPL	630	-63 92	-60 95	-62 73	-57 59	36.45	85.86	00010
KJRB	790	-33.99	-30 41	-30 83	-26 71	36 45	116 74	12533
KXLY	920	-34.36	-30 07	-31 12	-26 73	36 45	116 72	12463
KZZU	970	-49 05	-44 72	-45 98	-41 46	36 45	101 99	00419
KEYF	1050	-29 44	-25 79	-25 35	-21 74	36 45	121 71	39280
KRSS	1230	-68.06	-63 85	-64 37	-60.30	36 45	83 15	00005
KUDY	1280	-46 12	-41.78	-43 80	-38 80	36.45	104 65	00773
KMBI	1330	-38 46	-34.73	-36 83	-31 63	36 45	111 82	04030
KGA	1510	-9.30	-6 02	-8 32	-2.88	36.45	140 57	30 21758

Total Power Density: 30.95607

Total Electric Field (V/m): 10 80298

File Name: ZOGBR2

Site 1 Vehicle Facing East

FOISD Full Scale Setting 20(V/m) 07/02/87 5 52 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-38.66	-35.81	-34.94	-31.43	36 45	112 02	04222
KPPL	630	-64 79	-61.02	-61 65	-57 43	36.45	86 02	00011
KJRB	790	-33 41	-31 35	-30.80	-26 95	36 45	116 50	11842
KXLY	920	-34 08	-31.39	-30 59	-27.01	36 45	116 44	11601
KZZU	970	-49 03	-46.16	-45.17	-41 73	36.45	101.72	00394
KEYF	1050	-28 32	-27.15	-25.82	-22 21	36 45	121 24	35327
KRSS	1230	-67 42	-65 19	-64.03	-60 56	36 45	82.89	00005
KUDY	1280	-46.84	-42 93	-42.41	-38.89	36.45	104.56	00758
KMBI	1330	-39.44	-35.36	-35 35	-31.57	36.45	111.88	04089
KGA	1510	-10.60	-6.25	-6.76	-2.72	36.45	140 73	31.41165

Total Power Density: 32 09514

Total Electric Field (V/m): 10 99994

File Name ZOGBR6

Site 1 Vehicle Facing South

FOISD Full Scale Setting 20(V/m) 07/02/87 5 56 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-37.13	-36 28	-35 90	-31 64	36 45	111 81	04028
KPPL	630	-64 20	-61 95	-61 45	-57.61	36.45	85 84	00010
KJRB	790	-32.63	-31 22	-31.69	-27 04	36 45	116 41	11614
KXLY	920	-32 67	-31 88	-31 51	-27 22	36 45	116 23	11128
KZZU	970	-47 60	-46 86	-46 38	-42 15	36.45	101 30	00358
KEYF	1050	-27 18	-26 22	-27 36	-22 12	36 45	121 33	36035
KRSS	1230	-65 96	-65.17	-65 32	-60 70	36 45	82 75	00005
KUDY	1280	-45 17	-44 45	-43.29	-39 46	36.45	103 99	00664
KMBI	1330	-38 21	-36 86	-35 73	-32 05	36 45	111 40	03665
KGA	1510	-9 74	-7.75	-6 50	-3 03	36 45	140.42	29.22941

Total Power Density: 29 90450

Total Electric Field (V/m): 10 61791

File Name ZOGBSF

Site 2 Intersection of 63rd and Cook

FOISD Full Scale Setting: 20(V/m) 07/02/87 6.05 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-40 34	-37 79	-40.10	-34.48	36 45	108 97	02093
KPPL	630	-65 56	-63 65	-63.06	-59.19	36.45	84 26	00007
KJRB	790	-38 50	-35 54	-38.37	-32.47	36.45	110 98	03323
KXLY	920	-36.22	-34 02	-37 40	-30.88	36 45	112 57	04796
KZZU	970	-49.13	-47 10	-48.88	-43.50	36.45	99.95	00262
KEYF	1050	-26.11	-23 16	-23.67	-19.36	36 45	124 09	67949
KRSS	1230	-67 97	-64 90	-64 60	-60 81	36.45	82.64	.00005
KUDY	1280	-43.52	-41.00	-41 25	-37.01	36 45	106.44	.01168
KMBI	1330	-38.98	-37.06	-36.76	-32 72	36.45	110.73	.03135
KGA	1510	-13.21	-11.48	-11.55	-7.24	36.45	136.21	11 08652

Total Power Density: 11.91389

Total Electric Field (V/m): 6.70189

File Name ZOGBSK

Site 3

FOISD Full Scale Setting 20(V/m) 07/02/87 6 10 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-39 73	-37.47	-37 53	-33 35	36.45	110 10	02713
KPPL	630	-67 98	-66 19	-66 93	-62 20	36 45	81 25	00004
KJRB	790	-40.84	-39 58	-35 78	-33 40	36.45	110 05	02682
KXLY	920	-35 48	-32 82	-32 49	-28 64	36.45	114 81	00037
KZZU	970	-50.01	-47 43	-48 37	-43 71	36 45	99 74	00250
KEYF	1050	-26 28	-23 83	-22.59	-19 21	36.45	124 24	70462
KRSS	1230	-69 18	-66 80	-66 04	-62 38	36 45	81 07	00003
KUDY	1280	-43.44	-41 24	-42.13	-37 41	36 45	106.04	01067
KMBI	1330	-37 47	-35.17	-36 31	-31 44	36 45	112 01	04209
KGA	1510	-11 42	-9.93	-11 81	-6 20	36 45	137.25	14 06830

Total Power Density 14 96256

Total Electric Field (V/m): 7 51058

File Name· ZOGBSP

Site 4 In Front of KEY

FOISD Full Scale Setting· 20(V/m) 07/02/87 6 15 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-39.95	-38 02	-38 19	-33 87	36.45	109.58	.02410
KPPL	630	-67.03	-64 99	-65.55	-61 00	36.45	82.45	00005
KJRB	790	-32.09	-29 67	-29 41	-25.46	36.45	117 99	14686
KXLY	920	-35 82	-33 92	-33.67	-29.60	36.45	113 85	06439
KZZU	970	-51.70	-49 24	-49 94	-45 40	36.45	98 05	00169
KEYF	1050	-12.77	-10 79	-11.16	-6.72	36.45	136.73	12 49033
KRSS	1230	-68 36	-65.77	-65.90	-61 75	36.45	81.70	.00004
KUDY	1280	-47.38	-44.85	-45.55	-41 03	36.45	102.42	00463
KMBI	1330	-41.91	-40.48	-40.58	-36 17	36.45	107.28	.01417
KGA	1510	-20.14	-18.52	-19 64	-14.61	36.45	128.84	2 03156

Total Power Density: 14 79782

Total Electric Field (V/m): 7.46912

File Name· ZOGBSV

Site 5 5517 Berry

FOISD Full Scale Setting. 20(V/m) 07/02/87 6 21 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-36 73	-33 34	-36 02	-30 33	36.45	113 12	.05435
KPPL	630	-65 44	-62 61	-65 14	-59 43	36 45	84 02	00007
KJRB	790	-16 77	-13 86	-16 26	-10.66	36 45	132 79	5 03740
KXLY	920	-34 64	-31.45	-34 12	-28 40	36 45	115.05	00494
KZZU	970	-62 89	-59 82	-62 60	-56 77	36 45	86 68	00012
KEYF	1050	-34 40	-32 97	-35 86	-29 48	36 45	113 97	06617
KRSS	1230	-64 46	-60 91	-62 62	-57 65	36 45	85 80	00010
KUDY	1280	-47 46	-44 02	-46 94	-41 09	36 45	102 36	00457
KMBI	1330	-41 11	-38 10	-41 21	-35 11	36 45	108 34	01808
KGA	1510	-28 44	-26 59	-29.34	-23 20	36.45	120.25	28113

Total Power Density: 5 54693

Total Electric Field (V/m): 4 57296

File Name· ZOGBSc

Site 6 Pittsburg and 46th

FOISD Full Scale Setting· 20(V/m) 07/02/87 6 28 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-35.17	-31 37	-32 72	-28 05	36 45	115 40	09205
KPPL	630	-68 24	-64.21	-66 10	-61 11	36.45	82.34	00005
KJRB	790	-33 03	-30 38	-32.79	-27.12	36 45	116 33	11388
KXLY	920	-31 34	-27 31	-29 61	-24.33	36.45	119.12	21639
KZZU	970	-60 69	-56 32	-58 13	-53.26	36 45	90.19	00028
KEYF	1050	-38 23	-34 95	-37.56	-31 90	36 45	111.55	03790
KRSS	1230	-65.71	-63 17	-63.58	-59.25	36.45	84.20	00007
KUDY	1280	-43 32	-39 32	-41.40	-36 27	36 45	107.18	01305
KMBI	1330	-40 80	-37.05	-38.99	-33.91	36.45	109 54	.02387
KGA	1510	-30 58	-26 75	-29.66	-23.90	36 45	119 55	23891

Total Power Density: .73725

Total Electric Field (V/m): 1 66717

File Name ZOGBSk

Site 7 Stone and 50th

FOISD Full Scale Setting 20(V/m) 07/02/87 6·36 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-29 89	-27 38	-28 62	-23 74	36 45	119 71	24818
KPPL	630	-63 70	-60 97	-62 28	-57 40	36 45	86.05	00011
KJRB	790	-31 62	-29.48	-31 05	-25 85	36.45	117 60	15269
KXLY	920	-17.71	-14 93	-16 54	-11 47	36 45	131 98	4 18327
KZZU	970	-51.39	-48 69	-49 89	-45 08	36 45	98.37	00182
KEYF	1050	-31 92	-29.35	-30 91	-25 83	36 45	117.62	.15351
KRSS	1230	-63 15	-61 09	-61 91	-57.20	36 45	86.25	00011
KUDY	1280	-40 25	-37.27	-38 81	-33 84	36 45	109 61	02427
KMBI	1330	-39 30	-36.11	-37 76	-32.76	36 45	110 69	.03111
KGA	1510	-23.86	-21 09	-22 80	-17 66	36.45	125 79	1 00616

Total Power Density. 5 80124

Total Electric Field (V/m) 4.67661

File Name ZOGBSs

Site 8 55th Ave. Between Crestline and Regal

FOISD Full Scale Setting 20(V/m) 07/02/87 6 44 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-34.23	-31.54	-30.92	-27.24	36.45	116.21	11084
KPPL	630	-66.41	-63 49	-66 00	-60.33	36.45	83.12	00005
KJRB	790	-34 39	-32 25	-32 86	-28.31	36.45	115 14	.00671
KXLY	920	-26 72	-24.35	-25.56	-20.66	36 45	122.79	50371
KZZU	970	-43.82	-41 10	-39.33	-36.27	36.45	107.18	.01384
KEYF	1050	-29 92	-27 91	-28.69	-23.99	36 45	119.46	23415
KRSS	1230	-63 08	-61 08	-59.33	-56.13	36 45	87.32	00014
KUDY	1280	-40.30	-37.51	-38.58	-33.88	36.45	109.57	.02403
KMBI	1330	-36.41	-33.08	-37.40	-30.45	36.45	113.00	05298
KGA	1510	-18.94	-16 39	-16 48	-12.35	36.45	131.10	3 41747

Total Power Density: 4 44394

Total Electric Field (V/m): 4.09312

File Name· ZOGBSz

Site 9 44th and Regal

FOISD Full Scale Setting 20(V/m) 07/02/87 6 51 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-25 22	-23 10	-23 86	-19 20	36.45	124 25	70534
KPPL	630	-64 31	-61 76	-63 77	-58 36	36 45	85.09	00009
KJRB	790	-40.41	-38.81	-41 03	-35 21	36 45	108.24	01769
KXLY	920	-28 73	-26 87	-28 15	-23 07	36.45	120.38	28921
KZZU	970	-44 90	-43 09	-41 69	-38 26	36 45	105 19	00876
KEYF	1050	-41 62	-39 31	-42.06	-36 05	36 45	107.40	01458
KRSS	1230	-64 20	-61 97	-63 75	-58.42	36 45	85 03	00008
KUDY	1280	-28.11	-24.65	-28.93	-22.04	36.45	121.41	36703
KMBI	1330	-32.70	-29 44	-33 19	-26 67	36.45	116 78	12647
KGA	1510	-27.31	-24.40	-28.85	-21 68	36 45	121.77	.39869

Total Power Density· 1 92793

Total Electric Field (V/m): 2 69598

File Name: ZOGBTA

Site 10 Palouse and Ferrall

FOISD Full Scale Setting 20(V/m) 07/02/87 7·00 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-32 79	-30 83	-33 35	-27 41	36.45	116.04	.10651
KPPL	630	-61 37	-58.86	-61.17	-55 54	36 45	87.91	00016
KJRB	790	-38.83	-36 77	-39.59	-33 46	36 45	109.99	.02649
KXLY	920	-30.04	-28.00	-30 60	-24 63	36 45	118.82	.20233
KZZU	970	-42.01	-40 31	-42 30	-36 68	36 45	106 77	01262
KEYF	1050	-36.20	-34 16	-37.19	-30 89	36 45	112.56	04782
KRSS	1230	-55.90	-53.79	-56 77	-50.53	36.45	92.92	.00052
KUDY	1280	-17.07	-15.21	-17.88	-11.80	36.45	131.65	3.87771
KMBI	1330	-19.36	-16.69	-19.66	-13.58	36.45	129.87	2 57300
KGA	1510	-23.31	-21.24	-24.38	-18 01	36.45	125.44	.92929

Total Power Density: 7.77644

Total Electric Field (V/m): 5 41454

File Name· ZOGBTV

Site 11 Joel E Ferris High School Parking Lot

FOISD Full Scale Setting 20(V/m) 07/02/87 7 21 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-25 99	-23.15	-23 74	-19 36	36 45	124 09	68014
KPPL	630	-62 02	-59.46	-59 37	-55 35	36 45	88 10	00017
KJRB	790	-39.70	-36.90	-37 69	-33 17	36 45	110.28	.02827
KXLY	920	-34.04	-31.14	-31 81	-27 39	36 45	116.06	10700
KZZU	970	-30 00	-27 03	-27.46	-23 21	36 45	120 24	28030
KEYF	1050	-41 07	-38 20	-39 05	-34.51	36 45	108 94	02078
KRSS	1230	-60 90	-58 63	-59 12	-54.67	36 45	88 78	00020
KUDY	1280	-36 80	-33.82	-34.06	-29 93	36 45	113 52	05967
KMBI	1330	-40.13	-36 88	-37.43	-33 16	36 45	110 29	02035
KGA	1510	-32 00	-28 85	-29.51	-25.15	36 45	118 30	17925

Total Power Density: 1.38421

Total Electric Field (V/m)· 2 28439

File Name ZOGBTZ

Site 12 Intersection of Rebecca and 35th

FOISD Full Scale Setting 20(V/m) 07/02/87 7 25 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-34 30	-32.30	-33 60	-28.55	36.45	114.90	08200
KPPL	630	-63 08	-59.78	-61 26	-56.40	36.45	87 05	00013
KJRB	790	-43.64	-41 76	-43.22	-38 03	36 45	105 42	00925
KXLY	920	-37 33	-35.23	-36.85	-31.60	36.45	111.85	04059
KZZU	970	-42.39	-40 53	-42.26	-36 87	36 45	106.58	01207
KEYF	1050	-48.38	-46.19	-48.88	-42.88	36 45	100 57	00302
KRSS	1230	-59.82	-58.22	-58.21	-53.92	36 45	89.53	.00024
KUDY	1280	-35.97	-33.84	-35.77	-30.31	36 45	113.14	.05464
KMBI	1330	-42.71	-40.20	-42.62	-36.91	36.45	106.54	01196
KGA	1510	-34.38	-32.50	-34.37	-28.89	36.45	114.56	.07588

Total Power Density: .28979

Total Electric Field (V/m): 1 04524

File Name ZOGBTp

Site 13 Next to KGA Tower on 63rd

FOISD Full Scale Setting 50(V/m) 07/02/87 7 41 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-43.50	-40 88	-42 15	-37 28	44 35	114.07	06779
KPPL	630	-75.15	-74 22	-74 56	-69 86	44 35	81.49	.00004
KJRB	790	-46 65	-43 92	-45 90	-40 56	44.35	110 79	03101
KXLY	920	-43.82	-41 62	-43 11	-37 90	44 35	113 37	05763
KZZU	970	-56 88	-55.09	-56 27	-51 24	44 35	100 11	00272
KEYF	1050	-38 02	-34 84	-36 83	-31 59	44.35	119 76	25096
KRSS	1230	-75.51	-72.89	-74 65	-69 44	44 35	81 91	00004
KUDY	1280	-46.72	-44 83	-46 41	-41 13	44 35	110 22	02788
KMBI	1330	-42 31	-40 78	-41 97	-36 86	44 35	114 49	07451
KGA	1510	-4.49	-1.92	-3 95	1.46	44 35	152.81	507 11676

Total Power Density: 507 63014

Total Electric Field (V/m): 43 74661

File Name: ZOGBTw

Site 14 61st at end of Mt. Vernon

FOISD Full Scale Setting 50(V/m) 07/02/87 7:48 PM

Call Sign	Frequency (kHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KLSN	590	-45.74	-41 71	-42.23	-38 13	44.35	113.22	05571
KPPL	630	-72 56	-69 43	-70 66	-65 93	44.35	85.42	00009
KJRB	790	-41.82	-39.30	-38 15	-34 73	44.35	116 62	12175
KXLY	920	-43 14	-38.10	-39 28	-34 93	44.35	116 42	.11635
KZZU	970	-56.61	-51 38	-53.13	-48.44	44.35	102 91	00510
KEYF	1050	-35.83	-33 52	-32 32	-28 89	44.35	122 46	46765
KRSS	1230	-76.69	-72.35	-72.26	-68.57	44.35	82 78	00005
KUDY	1280	-49.65	-45.33	-47.73	-42 44	44 35	108.91	02064
KMBI	1330	-41 96	-38.26	-40.42	-35.17	44.35	116.18	.10994
KGA	1510	-13.76	-13.26	-13.08	-8.59	44.35	142.76	50.12506

Total Power Density: 51 02243

Total Electric Field (V/m): 13.86920

File Name ZOGCLU

Mica Peak Instrument Comparison Site, Isolated

FOISD Full Scale Setting 100(V/m) 07/03/86 11·20 AM

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KPBX	91.1	-21.68	-17.04	-10 29	-9.20	50.40	148 20	175 06729
KDRK	93 7	-15 08	-7.81	-20 12	-6 85	50.40	150 55	300 78991
KKPL	96.1	-11 60	-28 83	-7 83	-6 28	50.40	151 12	343 00172
KMBI	107 9	-25.90	-36.39	-33 90	-24 94	50 40	132.46	4 67531

Total Power Density: 823 53623

Total Electric Field (V^2/m^2)· 3104.73159

File Name· ZOGCLf

Mica Peak Instrument Comparison Site, Perturbed

FOISD Full Scale Setting 100(V/m) 07/03/86 11 31 AM

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KPBX	91 1	-24.27	-17 08	-10.50	-9 49	50 40	147 91	163 92155
KDRK	93 7	-20.52	-7 71	-19.80	-7 24	50.40	150.16	275 17367
KKPL	96 1	-10.62	-19 94	-8.66	-6.33	50 40	151.07	339 60710
KMBI	107.9	-26.36	-41.24	-32.73	-25.35	50.40	132.05	4 25721

Total Power Density: 782 95960

Total Electric Field (V^2/m^2): 2951 75771

File Name ZOGCN6

Mica Peak Instrument Comparison Site, Isolated

FOISD Full Scale Setting 100(V/m) 07/03/86 1 56 PM

Call Sign	Frequency (MHz)	Px (dbm)	Py (dBm)	Pz (dBm)	Total Power (dBm)	Antenna Factor (dB)	Electric Field (dBuV/m)	Power Density (uW/cm^2)
KPBX	91 1	-20.28	-17.56	-10 42	-9 29	50 40	148 11	171 56240
KDRK	93 7	-13 38	-8 15	-20 82	-6 83	50 40	150 57	302 10621
KKPL	96 1	-11.58	-38 15	-7 22	-5 86	50 40	151.54	378 01143
KMBI	107 9	-26 00	-36.25	-34 71	-25.10	50.40	132.30	4 49995

Total Power Density: 856 26000

Total Electric Field (V^2/m^2): 3228 10019