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FOREWORD

National Grid's vision is to be a world-class safety organization, with zero injuries every day. A critical component of achieving this vision is the careful development, implementation and maintenance of Safety Procedures. This document, the Radiofrequency (RF) Safety Procedure, includes safety practices and training requirements for personnel who work in proximity to RF sources. This procedure also describes the process by which Safety and Health Services shall conduct RF exposure assessments in response to requests/concerns from management, their employees, and contractors.

This procedure does not replace or cover other Federal Communications Commission (FCC) regulatory requirements. Issues related to antenna site locations and FCC permitting is addressed by other Departments and Procedures. Relay and Telecom Operations Group (RTOG) has developed an RF Safety Awareness Program that should be used as a reference and guiding document by other National Grid Departments to comply with FCC regulations. This document can be found on the Infonet at :

<http://wbromg01:2008/Relay%20and%20Telecom%20Operating%20Group/default.htm>

Refer to the "Telecom" section of the RTOG web page then "Documents and Forms" section; then look under "Radio/AVL" for the "RF Health and Safety Awareness Program".

By following this procedure, personnel can reduce the risk of injury from exposure to RF energies. These efforts will help prevent the occurrence of work-related injuries caused by exposure to RF sources and will comply with applicable guidelines and regulations such as the Federal Communication Commission's guidelines for controlling exposure to RF sources and the Occupational Safety and Health Administration's (OSHA) standard for non-ionizing radiation (29 CFR 1910.97).

Questions regarding this procedure should be referred to the National Grid USA's Safety and Health Services Department.

Record of Change

Date of Review/Revision:

Revision	Date	Description

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1.0 INTRODUCTION

1.1 Purpose

The purpose of this document is to provide direction to safely work in areas containing Radiofrequency (RF) emitting equipment. For the purposes of this procedure, RF energy can refer to any non-ionizing radiation (NIR) in the range of 0 to 300 GHZ. However, the range of most concern for health effects is Very High Frequency Range (VHF) between 30-300 MHz.

The second part of this procedure provides specific technical guidance to Safety and Health Services staff regarding exposure assessment methodology including predictive modeling.

These efforts will help prevent the occurrence of work-related injuries caused by exposure to RF energies.

This procedure was developed under the direction of the Policies and Procedures Subcommittee of the National Grid USA Executive Safety Committee.

1.2 Applicability

This procedure applies to all National Grid and contractor employees having reason to access areas, which contain RF emitting equipment. Safety and Health Services has primary responsibility for maintaining this procedure, soliciting comment from stakeholders, and revising as necessary.

This procedure includes safety practices and training requirements for personnel who work in proximity to RF sources. This procedure also describes the methods by which Safety and Health Services shall conduct RF exposure assessments in response to requests from management, their employees, and contractors.

This procedure does not replace or cover other Federal Communications Commission (FCC) regulatory requirements. Issues related to antenna site locations and FCC permitting is addressed by other Departments and Procedures. Relay and Telecom Operations Group (RTOG) has developed an RF Safety Awareness Program that should be used as a reference and guiding document by other National Grid Departments to comply with FCC regulations. This document can be found on the Infonet at:

<http://wbromg01:2008/Relay%20and%20Telecom%20Operating%20Group/default.htm>

Refer to the "Telecom" section of the RTOG web page then "Documents and Forms" section; then look under "Radio/AVL" for the "RF Health and Safety Awareness Program".

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This procedure supercedes SHP 3.01, *Communications Facilities*.

The requirements of this procedure, or any future revision thereof, shall be effective the date of its issue unless otherwise noted.

1.3 Review/Revisions

This procedure shall be reviewed periodically and revised as required. Revisions of this procedure may be made as a result of a management review, a change in safety management guidance, or company policies. The dates of reviews and revisions will appear on the front page of the procedure in the section titled "Record of Change".

1.4 Documentation

Documentation related to this procedure and subsequent reviews and revisions will be maintained by Safety and Health Services. This procedure will be accessible to field operations both in paper and electronic format. The paper versions of the procedure will not be document controlled. The official, current version of this procedure and all procedures prepared under this guidance will be on the National Grid internal intranet site(s).

1.5 Quality Assurance and Audit

- Internal self-assessment and quality assurance activities are performed through peer review of field measurements and modeling data assumptions and safe approach distance calculations.
- The use of this procedure is subject to audit and it is anticipated that the Company's Legal Department and/or Internal Audit will periodically review the implementation of this procedure.

2.0 RESPONSIBILITIES

2.1 General Responsibilities

The Executive Safety Committee has delegated responsibilities for safety and health policies and procedures to the Safety Policies and Procedures Subcommittee. The Safety Policies and Procedures Subcommittee will review this procedure. The owner of this procedure shall be Safety and Health Services.

This department shall be responsible for maintaining and implementing this procedure, soliciting comment from stakeholders, and revising as necessary.

2.2 Safety and Health Services

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Safety and Health Services shall maintain and update this RF Safety Procedure and provide support services to all National Grid operations where RF sources are present or areas where RF source installation will be anticipated.

2.3 Supervision and Management

- Ensure that employees who have occupational/controlled exposure to RF energies receive RF training.
- Ensure that appropriate control measures are in place to protect workers and the general population.
- Inform Safety and Health Services of any major additions, or changes to RF sources for all property and operations controlled or serviced by National Grid personnel.
- Enforce the requirements of this procedure;
- Provide contractors with RF hazard information if applicable.

2.4 Employees

- Comply with the requirements of this RF Safety Procedure.

3.0 RF Safety Practices

RF sources typically range from 3 kilohertz (kHz) - 300 Megahertz (MHz). The microwave (MW) portion of the electromagnetic spectrum is between 300 MHz - 300 gigahertz (GHz). The primary health effect of RF/MW energy is a result of heating. The absorption of RF energy varies with frequency. Microwave radiation is absorbed near the skin, whereas RF radiation may be absorbed in deep body organs. As stated before, the human body is most sensitive to RF energies within the 30-300 MHz range. Exposure standards of western countries are based on preventing thermal tissue injuries and take into consideration human RF sensitivities. Use of RF/MW radiation includes radios, cellular phones, communications transmitters, and radar transmitters.

3.1 General

- Any RF Approach Distances should not be confused with Electrical Safety Minimum Approach Distances.
- Antennae shall be considered active unless proven otherwise, such as Locked/Tagged Out.

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- Personnel with implanted medical devices, such as pacemakers, should consult with their medical doctor and identify themselves to their supervisor prior to working in the vicinity of RF emitting equipment.
- Personnel should select the procedure section which applies to their work.

3.2 Roof Tops

- Personnel working on a rooftop (such as HVAC, roof maintenance), which is in the vicinity of RF emitting equipment, shall obey any posted RF signage.
- Personnel who are not RF trained shall keep 10 feet from any emitting surfaces. Exception - Other distances may apply if reviewed and approved by Safety and Health Services.
- Personnel working on rooftop RF emitting equipment shall be authorized and qualified.
- A Job Briefing including RF Safety shall be conducted prior to work.
- Personnel may be required to wear RF dosimetry as prescribed by Safety and Health Services.
- If the work cannot be completed safely as described above, the equipment shall be Locked/Tagged Out.

3.3 Transmission and Distribution Structures

- All personnel shall be RF trained prior to the start of work involving RF emitting equipment.
- A Job Briefing including RF Safety shall be conducted prior to work.
- Minimal hazards exist while traveling by a RF emitting omni-directional (whip) or behind a directional antenna.
- Personnel working for greater than six minutes near any RF emitting omni-directional (whip) antenna shall stay at least three feet away from the antenna. Exception - Other distances may apply if reviewed and approved by Safety and Health Services.
- Personnel working for greater than six minutes near any RF emitting surface (front) of a directional antenna shall stay at least eight feet away from that emitting surface. Exception - Other distances may apply if reviewed and approved by Safety and Health Services.
- Personnel may be required to wear RF dosimetry as prescribed by Safety and Health Services.

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- If the work cannot be completed safely as described above, the equipment shall be Locked/Tagged Out.

3.4 Communication Towers

- Only authorized and qualified personnel may access Communication Towers.
- Due to the complexity of radio tower work, supervision shall control access and work on these towers.
- A Job Briefing including RF Safety shall be completed prior to accessing the tower.
- Personnel may be required to wear RF dosimetry as prescribed by supervision or Safety and Health Services.
- If the work cannot be completed safely as described above, the equipment should be Locked/Tagged Out.

4.0 Training

Training is an integral component of an RF Safety Awareness Program. Training provides employees, supervisors and managers with a broad technical background relating to RF radiation, a review of the FCC exposure standards and the biological effects of RF exposure to the human body. The RTOG has a training program as does Safety and Health Services. Either Department can provide training as needed.

Documentation of training will be maintained along with other Company safety training records.

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Employees will be trained to understand the RF exposure hazards to which they may be subjected to as a result of their employment and how to prevent harm to themselves and others from the exposure. This training may be conducted as part of line mechanic progression training or as needed. Contact Safety and Health Services for specific guidance.

Contractor Training

All contractors who perform work at National Grid antenna sites must understand RF exposure guidelines and practice antenna site safety procedures while working near antennas. This is especially important for contractors and/or National Grid employees who install antennas and radio equipment on buildings and/or towers. On-site job briefings will be conducted prior to beginning work at any active antenna site. This pre-job brief shall cover RF safety issues.

5.0 RF Warning Devices and Signage

Personnel trained in RF awareness need to be able to recognize and understand various RF warning devices. RF warning devices may include signs, barriers, fencing, cones, flashing lights, area monitors and roped off areas. These warning devices may be placed at the site so that they are visible from all directions of approach.

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Examples of typical signage can be found in the Niagara Mohawk RF Safety Booklet as well as training material provided by the Relay and Telecom Operations Group. Contact Safety and Health Services for a copy of the booklet.

Yellow Guidelines Placard

This signage is used to remind RF workers of work practices at sites. It is placed on either entry to or inside equipment rooms, or on cabinet doors of outside weatherproof equipment enclosures.

Notice Sign

This signage is placed where the general public might enter an area where an RF transmission facility is located. This signage may be mounted on the gate entrance of the fence or affixed to a tree or post on the property line surrounding an entire tower site.

Caution Sign

This signage is placed where RF emissions may exceed the standards, such as the door to the rooftop with antennas or the front gate/door to the fence surrounding the base of a tower and equipment shelter. Also applies to rooftop entrances with antennas where air conditioning units and window washing equipment is located and those workers may access. Also applies to towers where other workers might replace tower lighting. In no case should workers enter and work in these areas without understanding and following all necessary procedures and guidelines.

Warning Sign

This signage is placed on rooftop areas where RF emissions are known to exceed the standards and where RF protective clothing may be required; it may be placed in a tower elevator or ladder access of a tower; it may be placed on fences surrounding rooftop antennas where access to the rooftop cannot be secured due to fire codes or local regulations, and; it may be placed on doors to equipment rooms/shelters where the monitor continually alarms.

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TECHNICAL SECTION – Primarily for Safety and Health Services Staff

6.0 Important Terms

An **antenna** is a specialized transducer that converts radio-frequency (RF) fields into alternating current (AC) or vice-versa. They have two basic functions: the receiving antenna, which intercepts RF energy and delivers AC to electronic equipment, and the transmitting antenna, which is fed with AC from electronic equipment and generates an RF field.

Gain (G) refers to the ratio of the power required at the input of a loss-free reference antenna to the power supplied to the input of the given antenna to produce, in a given direction, the same field strength at the same distance. Antenna gain is usually expressed in **dB**i. Unless otherwise specified, the gain refers to the direction of maximum radiation.

An **isotropic radiator** is an “ideal” loss-free antenna that produces useful electromagnetic field output in all directions with equal intensity, and at 100-percent efficiency, in three-dimensional space. If used for signal reception, the device is equally sensitive in all directions.

The expression **dB**i is used to define the gain of an antenna system relative to an isotropic radiator at radio frequencies. The symbol is an abbreviation for "decibels relative to isotropic."

Suppose an antenna *A* produces an electromagnetic field of intensity I_A milliwatts per square centimeter (I_A mW/cm²) in its favored direction at a point located some distance away. Also, suppose an isotropic antenna *Q* produces an electromagnetic field of intensity I_Q mW/cm² at the same distance. Then the gain *G* of antenna *A*, in dB*i*, is:

$$G = 10 \log_{10} (I_A / I_Q)$$

A **dipole** antenna is a straight electrical conductor measuring 1/2 wavelength from end to end and connected at the center to a radio-frequency (RF) feed line. This antenna, also called a *doublet*, is one of the simplest types of antenna, and constitutes the main RF radiating and receiving element in various sophisticated types of antennas. The dipole is inherently a balanced antenna, because it is bilaterally symmetrical. A dipole antenna, for example, has signal output and sensitivity approximately 2.15 decibels greater, in its favored directions, than the output and sensitivity of an isotropic antenna.

Effective Isotropically Radiated Power (EIRP) is the arithmetic product of the power supplied to an antenna and its gain. In other words, EIRP is the net power resulting after all losses are subtracted and gains added.

Power Density (S) is expressed as power per area (mW/cm²). Maximum Permissible Exposures (MPEs) are expressed in terms of power density. The frequency of the RF source must be known in order to determine the MPE. As referenced in the MPE tables,

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the MPE from frequencies in the range of 1500-100,000 MHz is 1.0 mW/cm² for general population and is 5.0 mW/cm² for an occupational population.

Radius (R) is the distance between the RF source and the individual.

7.0 Exposure Assessment

7.1 General

- The FCC recognizes both field measurements and prediction models as valid forms of routine RF exposure assessments.
- Prediction models are generally not adequate for the assessment of sites with multiple and different RF sources.
- Actual or suspected employee exposure in excess of the Maximum Permissible Exposure (MPE) shall be reported via the One Call Safety System (1-866-322-5594).
- Any reported over exposure shall be documented and maintained in the employee's medical file.
- Any resulting medical monitoring shall be documented and maintained in the employee's medical file.

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7.2 Field Measurements and Standards

The FCC-adopted limits for MPE are generally based on recommended exposure guidelines published by the National Council on Radiation Protection and Measurements (NCRP). The Occupational Safety and Health Administration (OSHA) bases enforcement decisions on these limits. A complete explanation of these MPEs can be found in the FCC, Office of Engineering and Technology (OET) *OET Bulletin 65*, Appendix A.

The MPE limits are two tiered: One set of MPE values is for occupational/controlled exposure and another set of MPEs is for the general population/uncontrolled exposure. All MPE measurements are based on a percentage of the MPE for occupational exposure.

The MPE of interest is the power density, expressed in milliwatts (mW) per square centimeter area (mW/cm²). The frequency in megahertz (MHz) determines the MPE for both controlled and uncontrolled populations as referenced in the tables below.

LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

(A) Limits for Occupational/Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm ²)	Averaging Time E ² , H ² or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	1842/f	4.89/f	(900/f ²)*	6
30-300	61.4	0.163	1.0	6
300-1500	---	---	f/300	6
1500-100,000	---	---	5	6

f = frequency in MHz

*Plane-wave equivalent power density

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(B) Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) (mW/cm ²)	Averaging Time E ² , H ² or S (minutes)
0.3-3.0	614	1.63	(100)*	30
3.0-30	824/f	2.19/f	(180/f ²)*	30
30-300	27.5	0.073	0.2	30
300-1500	---	---	f/1500	30
1500-100,000	---	---	1.0	30

f = frequency in MHz

*Plane-wave equivalent power density

NOTE 1: **Occupational/controlled** limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2: **General population/uncontrolled** exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

Equipment to Conduct Field RF Measurements

The *Narda* Model A8742A shaped probe and survey meter automatically integrates and calculates these percentages of the MPE based on the RF power density across a wide range of frequencies. Specific instructions for this meter can be found in the appendices. The MPE for the general population is 20% of the MPE for the occupational population. Values that average less than 20% over a 30 minute period are considered safe for the general population. Values in excess of 100% as averaged over a six-minute period exceed the FCC MPE for occupational exposure.

Maximum values recorded using the survey meter with the shaped probe that do not exceed 20% can be used in lieu of 30-minute time weighted averages to document compliance with general public MPE.

The *Narda* personal dosimeters are used to measure worker and task-specific assessment of exposure. This equipment operates similar to the RF survey meter in that dose is expressed as a percentage of the occupational (FCC) standard.

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7.3 Prediction Modeling

Another way of determining FCC compliance is to calculate safe approach distances or to determine if there are conditions where RF exposure may exceed FCC MPEs.

When using predictive models, it is necessary to understand the terminology, equation variables, and use of the correct units of measure and conversion factors.

Information about the EIRP, antenna frequency, Gain, and antenna type, need to be provided in order to calculate R or S.

Unit Conversion

Units can be expressed in milliwatts, watts, or kilowatts; however, the numbers can get rather big and unmanageable, and so many engineers convert watts or milliwatts into logarithmic references. It does not matter which base you choose -- whether it is milliwatts, watts or kilowatts -- the formula is the same:

dBy = 10 Log₁₀ y where y = power in milliwatts, watts, or kilowatts.

- The logarithmic value of milliwatts (mW) is **dBm**.
- The logarithmic value of watts (W) is **dBW**.
- The logarithmic value of Kilowatts (KW) is **dBK**.

Example: The EIRP is found to be 300,000 mW. What is the logarithmic value (dBm)?

$$dBy = 10 \log_{10} 300,000$$

$$dBy = 54.77 \text{ dBm}$$

Use the following formula to convert from the logarithmic value to a numeric value in mW, W, or KW is as follows: **y = 10^(dBy/10)**

Therefore: y = 10^(54.77/10) y = 300,000 mW because log value was dBm

There is a 3 dB increase each time the power doubles. So, if the gain doubles to 600,000 mW, the logarithmic value increases by 3 dB from 54.77 to 57.77.

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GAIN Considerations

Under near field conditions, gain can have a damping effect on the total power density emitted from the RF source(s). For this reason, we ask antenna manufacturers to provide maximum Gain and EIRP. Gain must be divided into the EIRP to yield a corrected EIRP total.*

Equation 1: $EIRP(\text{corrected}) = EIRP / \text{Gain}$ where all values are in mW

Equation 2: $R^2 = EIRP / [(4)(\pi)(S)]$

R = distance from source in centimeters (cm)

EIRP = power in milliwatt (mW)

S = power density in mW/cm²

* This equation was derived by Richard Tell, technical contributor to the FCC OET Bulletin 65 via personal communication. While this step is not referenced by the FCC, its accuracy as been validated by field measurements. By not using this formula, the model can overestimate the safe approach distance.

Equation 2 can be used to:

1. Determine safe approach distances
2. Determine the power density of a source at a known distance and EIRP.

Determine Safe Approach Distances (Solve for R)

Step 1:

Review frequency and select an MPE based on protection for either occupational or general population exposure and in accordance with the FCC chart (frequency-dependent). In this example, use the MPE for occupational exposure.

Step 2:

Adjust EIRP using equation 1. Remember to convert all values to mW from dB first.

Step 3

Using Equation 2, solve for R:

- Convert EIRP to mW if the value is expressed in dBm
- If the operating power is expressed as Effective Radiated Power (ERP), multiply this value by 1.64. For example: $EIRP = (1.64)(ERP)$

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Sample Problem: What is the safe approach distance for the following antenna?

Frequency = 866 MHz EIRP = 107,000 mW Gain = 13.6 dBi
Antenna Type: Directional

Step 1: Determine MPE based on the frequency of this power source.
Power Density (S) = $866\text{MHz}/300 = 2.89 \text{ mW/cm}^2$

Step 2: Convert Gain to mW: $y = 10^{(13.6/10)} = 22.9 \text{ mW}$

Step 3: Divide Gain into EIRP: $107,000/22.9 = 4,672 \text{ mW}$

Step 4: Use Equation 2 to solve for R: $R^2 = \text{EIRP}/[(4)(\pi)(S)]$

$R = [4,672 \text{ mW}/(4)(3.14)(2.89)]^{1/2} = 11.3 \text{ cm x inch}/2.54\text{cm x foot}/12\text{in}$

R = 0.37 ft

Without correcting for gain, the safe approach distance would calculate as: **1.8 ft**

$R^2 = \text{EIRP}/[(4)(\pi)(S)] = [107,000\text{mW}/(4)(3.14)(2.89)]^{1/2} = 1.8 \text{ feet}$

To determine the power density (S), it is necessary to know the EIRP, Gain, and distance (R) from the source.

Sample Problem: The general public can get as close as 5 feet to an antenna due to a barrier. Is this distance in compliance for this antenna? Antenna Information: 1962.5 MHz; EIRP = 1,258,925, Gain = 18 dBi Type: directional

Step 1: Determine MPE based on the frequency of this power source.
Power Density (S) = 1 mW/cm² (Refer to MPE table)

Step 2: Convert Gain to mW: $y = 10^{(18/10)} = 63.1 \text{ mW}$

Step 3: Divide Gain into EIRP: $1,258,925/63.1 = 19,951 \text{ mW}$

Step 4: Use Equation 2 to solve for R: $R^2 = \text{EIRP}/[(4)(\pi)(S)]$

$R = [19,951 \text{ mW}/(4)(3.14)(1)]^{1/2} = 39.9 \text{ cm x inch}/2.54\text{cm x foot}/12\text{in}$

R = 1.3 ft. Yes. The 5 foot barrier is in compliance with the FCC standard.

8.0 References

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- Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, OET Bulletin 65 Edition 97-01.
- Radio-Frequency (RF) Health and Safety Awareness Program, Rev 3. Relay and Telecom Operations Group (RTOG).
- Niagara Mohawk RF Safety Booklet.

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APPENDIX: Quick Instructions for the Narda RF Survey Meter

Purpose: Evaluate compliance with FCC limits for radiofrequency (RF) exposure

Equipment components for FCC compliance assessment:

- Survey meter (Model 8718B)
- Shaped Probe (Model A8742D) with connecting cable

Power Source: Ni-Cad battery or via charger

Meter Operation

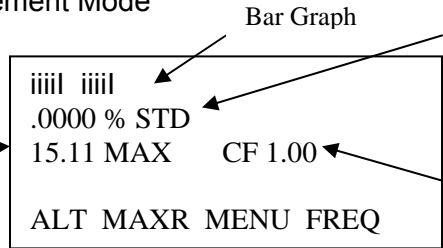
1. Turn ON
2. Attach Probe with or without connecting cable
3. Press F1 which starts the measurement process
4. Press “Enter” key. Screen should appear as follows →
5. Press F1 (to indicate Yes)
6. Zero the Probe

A8742D SN -02518
300kHz- 3GHz E-FLD
600% STD SHAPED
YES NO MENU

- Position the probe in the storage case with the 2 arrows visible above the foam.
- With the case open, press the “Enter” key.
- The meter will take about 15 seconds to zero itself and go directly to measurement Mode.

7. Measurement Mode

Maximum Value
Indicates max value (% STD) that has occurred since you began making measurements



Field Strength: Indicates actual measured value

- Unit of measure is always % STD for shaped frequency response probes
- Floating decimal. Full Scale equals 600% of STD

Correction Factor

Notes:

- ALT display mode is not applicable for FCC compliance testing.
- Pressing F2 resets the Max Value to the current field strength.
- Pressing F3 takes you to main menu.
- FREQ changes are not applicable for FCC compliance testing.
- Press “ESC” key to return to measurement screen view.

8. Test the Probe

- Press “Test Source” on meter key pad.
- Hold the probe parallel to right side of the meter.
- Place any metal contact point against the microwave window.
- Look for any deflection on the bar graph.
- No response means that the probe is damaged.

Meter Calibration: Meter and probe are factory-calibrated annually.