INSTRUCTION MANUAL

MODEL 246A

EMI SNIFFER

Radar Engineers Inc.
9535 NE Colfax Street
Portland, Oregon 97220

SAMPLE POWER PLANT SOUND FILES
ON THUMB DRIVE

DISCHARGE SOUNDS: SPARKING/ARCING/CORONA/PD

- #1. ISO PHASE BUS Discharges #62
- #2. ISO PHASE BUS Discharges 6.6 kV
- #3. ISO PHASE BUS Discharges #65
- #4. ISO PHASE BUS Discharges taken
  at Collector End of Generator.
- #5. 4 kV Cable Discharges
- #6. ID Fan Shaft Discharges
- #7. Bouncing Commutator Brush Discharges
- #8. 23 kV PT Cabinet Discharges
- #9. Steam Generator Discharges

NON DISCHARGE SOUNDS

- #10. Process Carrier Tones
- #11. Static Exciter Tones
- #12. Exciter Tones
- #13. Brushless Exciter Tones
- #14. Machine Background Noise

RADAR ENGINEERS INC
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MODEL 246A MANUAL

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I. SAFETY NOTE

The Model 246A and antennas are not insulated. Maintain safe working distances from energized devices.

The Model 246A is not a voltage or current sensor and will not indicate whether a device is energized.

The Model 246A is not intrinsically safe for explosive atmospheres.

Exercise caution at all times. Follow all utility and regulatory safe work practices.

II. INTRODUCTION

The Model 246A EMI SNIFFER is a handheld instrument designed to detect and help localize the source of fast transient discharges in power plants or any facility with apparatus operating at 2400 volts or greater while the equipment remains online with no interruption of service. It is a simple yet sensitive device. The 246A is an upgrade to the model 246. Like its predecessor the 246A does not predict time to failure. Nor can it detect every defect.

Many kinds of plant insulation defects create fast transients such as corona or partial discharges and combinations of these. Mechanical and conductor defects create arcing and sparking. These defects include but are not limited to loose connections, slip ring sparking, bearing and oil seal rubs. The discharges can be extremely fast (in the range of a few nanoseconds) and they create an electromagnetic disturbance that could disrupt other plant equipment. The EMI (electro-magnetic interference) resulting from the discharges ranges in frequency from kilohertz to over a gigahertz depending on the source.

The 246A is utilized while the equipment is on-line. It is a non-intrusive test that does not introduce any signals into the system, thus eliminating the potential for tripping plant equipment.

The results can help provide pertinent condition information for a plant engineer or technician to make informed decisions on the health of each component being tested and the planning of any maintenance that may be needed. Reducing or eliminating failures is always the ultimate goal for any facility; measuring radiated EMI is one technique. Other technologies such as electromagnetic signature analysis, (EMSA), IR, Vibration and Ultrasonic (to name a few) are also valuable techniques to supplement or confirm defect detection, severity and location.

Finally, some of the information in this manual, and especially in section V is based on customer field feedback and comments. We encourage new customers to use the information presented as background, recognizing that their experiences may differ somewhat in this interesting area of troubleshooting.

III. CONTROLS, BAR GRAPH AND SOUND

1. ON/SLIDE SWITCH – Use this control to turn the instrument On/Off.

2. LOW BATT. LED – This LED turns green when the Model 246A is on. The LED will change color to red when the 9V alkaline battery is getting low and has about 1-2 hours of operation left. The Sniffer will turn off automatically when the battery is too low for dependable results.

3. GAIN SWITCH – There are 12 gain switch positions. Each detent change in the gain switch represents ~5dB which provides ~ 55dB of gain control. When high signal levels are encountered reduce the gain until a mid-scale reading results. As the readings change adjust the gain as needed to keep the bar graph readings near mid-scale.

4. LED BAR GRAPH – A 10 segment LED bar graph indicates the received signal strength. The higher the numbered segment the stronger the signal for each gain setting. The bar graph has ~30dB of dynamic signal range. Each bar graph segment represents ~3dB**.**

5. OVERLOAD INDICATION – If the received signal saturates the #246A the LED Bar Graph will flash and a series of beeps will be heard. Reduce gain as necessary.

6. SPEAKER – A built in speaker reproduces the distinctive sound associated with EMI sources.

7. USB THUMB DRIVE – Included in the Sniffer carry case is a USB thumb drive. It contains sound clips of EMI discharges taken in power plants as well as other common sounds that are not discharges (man made noises). Played back on a computer the recordings are a good tool to train your ear to distinguish EMI discharges from man-made tones.

8. HEADPHONES – Using headphones is recommended because of the high background noise environment in power plants. Plugging into the 1/8" headphone jack on the left side of the receiver disables the speaker**.**

9. AC LINE - The yellow AC Line LED turn**s** on when the received signal is synchronous with the powerline frequency (50/60 Hz). To minimize false positives the AC Line LED will only turn on if the signal level is at least 3 bars.

10. MODE SWITCH AND ANTENNAS

A) E Probe Antenna Mode– A **"**rubber ducky" style antenna detects the electric field from discharges and is located on the left side of the chassis.

a. Low Frequency (LF) Center Frequency ~ 3 MHz – Start your search in this position.

b. High Frequency (HF) Center Frequency ~ 30 MHz- If you are able to detect discharges in the LF position or if the readings are very high try HF. HF can provide better location resolution than LF.

c. Ultra-High Frequency (UHF). Center Frequency ~ 360 MHz. Many sources in motors and generators will not be detectable at UHF frequencies. However, many sources in switchyards and substations will be detectible at UHF frequencies. UHF provides the opportunity for better location resolution than LF or HF.

B) H Probe – The probe is located at the top right side of the chassis. It is selected by moving the slide switch to the far right position. The "H" probe detects the magnetic field generated by current discharges. The "H" field setting corresponds to the lowest frequency range on the Model 246A (VLF). Center frequency about 225 KHz. It is also the least sensitive scale and current flow is needed at the EMI source to generate the magnetic field.

11. BATTERY – The Model 246A uses one 9V alkaline battery. Battery life is about 8 hours (depending on the severity of the EMI fields generated). DO NOT use Lithium batteries.

IV. OPERATION

Manual checking for EMI with the 246A could include the following steps: Create a plan, check the locations specified in the plan, record the observations on a "map" of the area of interest, compare new observations with the results of previous checks or results taken the same day from similar machines, and report findings. Learn by experience. There is no substitute for practice.

Many discharges occur inside of metal enclosures which reduce detectable EMI levels. If the metal cladding or enclosures in plants were "Faraday Cages" no EMI would be able to escape. Fortunately it is very difficult to create a perfect Faraday Cage. As a consequence, much of the EMI created inside of the metal enclosures in plants will be detectable outside of the enclosures.

For example, "seams" where plates are bolted to each other can leave gaps for EMI to escape and be detected. Other examples include the shafts exiting a motor or generator. EMI internal to a machine can couple on to the shaft and be conducted outside the machine where it is detectable. Glass or plastic windows in a metal cabinet pose little obstacle to EMI radiation and its detection.

Different kinds of defects with different rise/fall times create EMI detectable at different frequencies. Some defect discharges that are detectable in the LF range will not be detectable in the HF or UHF ranges. Arcing defects where there is measurable current flow are detected with the H range.

Distance from a source also plays a role. The farther the Sniffer is from a source the lower the readings will be.

The EMI Sniffer is sensitive to a broad range of frequencies in each band. When the operator is scanning for discharges it is often not known what kind of discharge will be encountered or how distant its location. To cover all discharge contingencies best practice is to take readings at all frequency settings.

Step 1. Scan: Utilize all the probe settings

A) Turn on the 246A

B) Select “E” Probe, “LF” frequency. Start with gain at max (12). Reduce gain as necessary to display around 5 bars. Take measurements and adjust the gain slightly as necessary. Measurements would include the frequency selection (in this case LF), the gain, the number of bars and if it is in sync with the power line frequency.

C) Make a sketch of the equipment, machine, transformer, bus or cabinet. Scan with the sniffer and note your readings on the drawing.

D) Whether or not you detect noise with the “LF” setting then try the “HF” and “UHF”. Next the “H” probe. (It may be useful to think of the probe setting in terms of frequency rather than “E” or “H”. The “H” probe is the lowest frequency setting and the “E” probe UHF position is the highest frequency. When scanning with the H probe (the one that looks like a “T”), ensure you scan in both directions with “T” as the magnetic field may not always be in the same direction.

Step 2. Compare LED and Gain Setting Levels

A) Example Motor:

For example, if discharge noise is detected at an outboard motor bearing then test at the motor terminal box then test the inboard motor bearing. Compare signal levels. The location that yields the highest signal level is most likely to be closest to the source of the spark discharge detected by the 246A. If both motor bearings have similar high readings, and the reading rises and falls in a steady manner, then this may indicate broken rotor bars in induction motors.

B) Similar Machines:

Comparisons can also be made at the same location on similar machines, for example the shaft bearings on several motors. If one machine has significantly higher levels than the others it deserves more attention.

Step 3. Analyze

The LED bar graph provides relative signal levels only and does not indicate time to failure. Nevertheless, it is fair to say that a source which pegs the LED's at gain setting of 1 usually deserves much more attention than a source that only lights up one LED at gain setting of 12. See Appendix A: LF Chart

Step 4. Discriminate

The Model 246A will detect electronic sources as well as arcing/partial discharge sources. For example, generator exciters, variable speed drives, UPS systems, triacs in heater controls, DC Motor commutators all create "pulse" like signals that can be detected by the 246A. Operators will need to teach themselves to discriminate between those electronic sources and 50/60 cycle discharges. The best way to do that is practice. Use the Model 246A in your office on various electronic devices. You will soon learn that electronic sources have a "man-made" predictable tone quality to them whereas arcing and partial discharge tend to be less predictable and sound more like static. Of course, these audio distinctions are not always easy but combined with common sense and knowledge of where electronic sources may be located will serve to guide the operator.

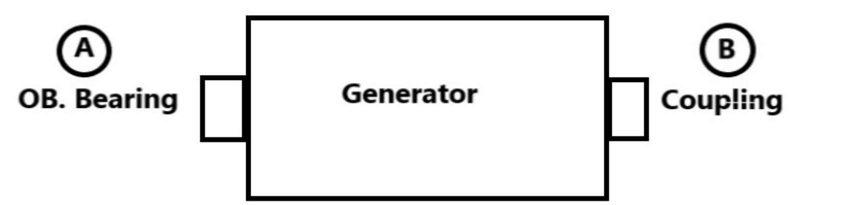
The Line Sync LED is also an aid in discriminating between discharges, electronic sources and carriers. For example, AM radio signals will not cause the Line Sync LED to turn on. Similarly, most, (but not, all) electronic sources will not be Line Synchronous. One electronic exception is often fluorescent lights. On the other hand, most, but not all, discharges will be line synchronous. One common discharge exception is discharges from a shaft that will probably not be Line Synchronous.

Step 5. Monitor Over Time/Trend

Another way to evaluate the seriousness of an EMI source with the 246A is to perform periodic scans and note the signal levels. A significant change in levels is a red flag. If you do compare signal levels over time it is important to make all measurements with the same probe mode setting at the same gain setting and from the same location.

While using the Model 246A, discharges of varying signal levels will be detected. The mere presence of a low level discharge may not be cause for immediate action. Best practices include trending over time and/or comparison of signal levels from similar machines. If that kind of information is not available then the detected signal level and where it originates gains importance. If Gain is set to max of 12 and only a couple bar graph segments light up that level would not usually, without more information, merit much attention. On the other hand if Gain is set at ~ 7 and segments light up attention is likely required. See Appendix A.

Here is an example of a short hand data log map that can be used for comparison of signal levels.



DATE

MEASUREMENT LOCATION	H	LF	HF	UHF
A	G12:0	G10:5	G10:4	G10:5
B	G12:0	G12:2	G12:1	G12:0

Where, for example:

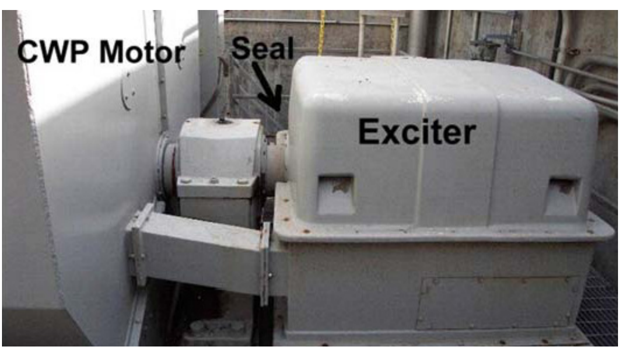
G12:0= Gain of 12 with 0 LED
G10:5= Gain of 10 with 5 LED

In this case position "A" has the highest readings and is likely closer to the source.

V. Examples of locations where the 246A and the 246 EMI Sniffer (246A predecessor) have been used to detect defects

A. Exciter Seal

A plant had four synchronous motors driving circulating water pumps with shaft driven brushless exciters. There was a history of motor and pump bearing damage due to circulating currents. Shaft grounding brushes had been added but the problem persisted.



The EMI Sniffer detected "sparking" at the brushless exciter housing weather seal. Further inspection and analysis revealed that contact between this metal weather seal and shaft shorted the shaft to ground and circulating shaft currents through the motor and pump bearings resulted.

The handheld EMI Sniffer also detected activity at a pump drive end bearing. This indicates there was also damage from circulating currents at this pump bearing. The shaft voltage was very small but circulating currents were high enough to burn off the grounding brush that had been added between the motor and the pump.

B. Pump and Fan Bearings

Generally speaking pump and fan bearings should emit little if any detectable EMI. If sparking is detected shaft currents are likely present and damage can result. Further investigation would be appropriate. Some types of fans generate a static charge that must be grounded to prevent bearing damage.

Pump Bearing

C. Grounding Brushes

With some designs, sparking at the generator shaft grounding brush between the generator and turbine is a common problem. This sparking usually indicates the grounding brush is not working as it should. Low levels of EMI are not necessarily cause for concern. However, higher levels of EMI can indicate a serious problem that warrants further investigation.

D. Motor Bearings

There should be little EMI detected at a good bearing. If high levels on the LF, HF or H scales are detected a problem is present that should be investigated. Today, many bearings contain data transmitters that can be detected with the 246A. This tone is easy to recognize.

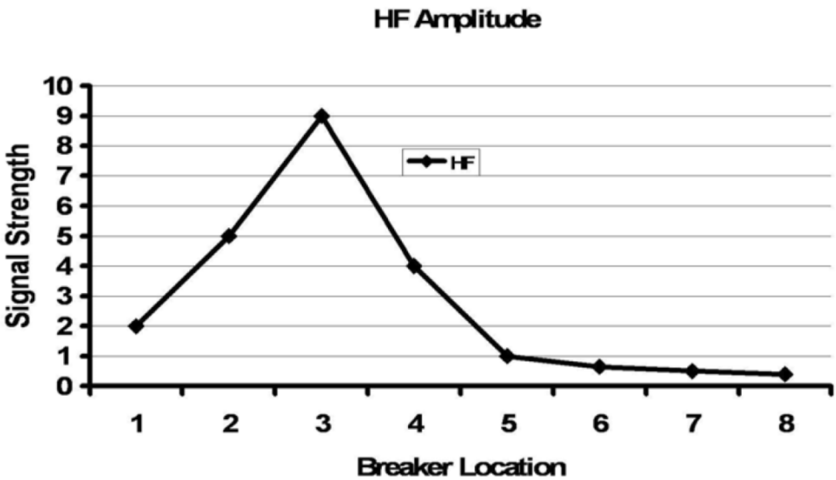
EMI Sniffer is placed near the outboard motor bearing on a feed pump motor.

E. Switchgear

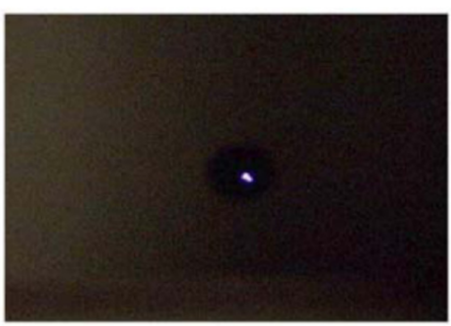
With a handheld EMI Sniffer the breaker cubical with an arcing PT connection could be isolated from 3 other rows and seven cabinets.

The High Frequency (HF) Electric field amplitude increased at cubicle 3 and decreased on either side. The correct row of switchgear was selected from the others with the same method.

Note a shielded cable with a short exposed probe was used to locate this high level EMI source.



When the PT cabinet rear door was opened discharges could be heard and arcing was visible through a small existing opening. The loose high voltage PT connector was repaired during a short outage the following weekend.



F. Motor Conduit

The EMI Sniffer can be used on motor conduit to help track the source of discharges. Begin with the gain set to a reading of 4-5 LED's near the motor. Observe the changes in the bar graph segments as the sniffer is moved along the conduit away from the motor. If indications increase as the sniffer is moved away from the motor the problem is likely located in the cable. If they decrease as the sniffer is moved away from the motor then the problem is likely in or near the motor junction box.

Please note, that especially for the H probe and E Probe LF, HF frequency range of the Model 246A, discharges in a cable can be detected some distance from their source. Care needs to be taken not to misidentify as a source a point of high radiation or a standing wave. The UHF band usually provides better proximity resolution. The UHF content from a discharge does not propagate as far in a cable as the LF or HF content.

Higher signal level for a constant gain setting indicates the source originates in/near the motor.

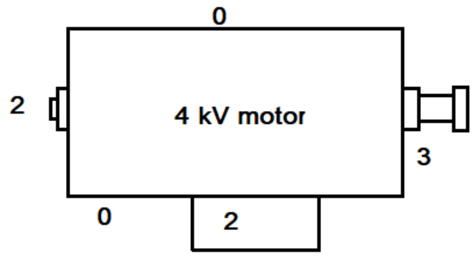
G. The Bus

Discharges occurring inside of the bus system represent a relatively high percentage of all discharges. They range from partial discharges on the surface of insulators to shunt arcing. As a general rule, discharges inside of a bus tend to have more VHF and UHF content than discharges from inside of machines. The defective shunt with multiple cracked leaves was detected by EMSA.

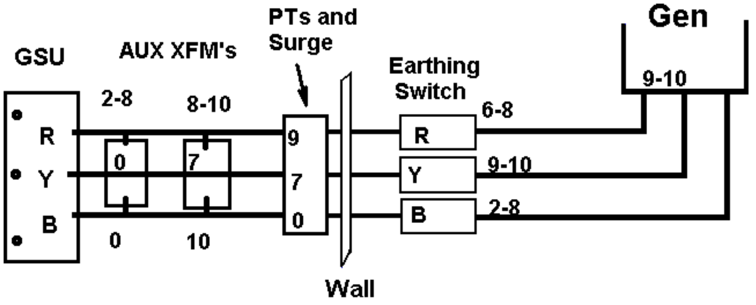
Scanning the radiated EMI along each bus enclosure helps with localizing the source. Where the bus is not elevated it can be scanned along or near its surface to help identify the general area of the discharge. The H range can also be used to help isolate the source location, such as inside cabinets and terminal boxes.

Where the bus is elevated, place the "E" field probe next to each supporting structure. Record the levels at each metal support. The levels taken at the support may be higher than if taken in air at ground level. The metal supports conduct and concentrate the EMI from the bus's internal discharges. The structure with the highest readings indicates the source is most likely closest to it.

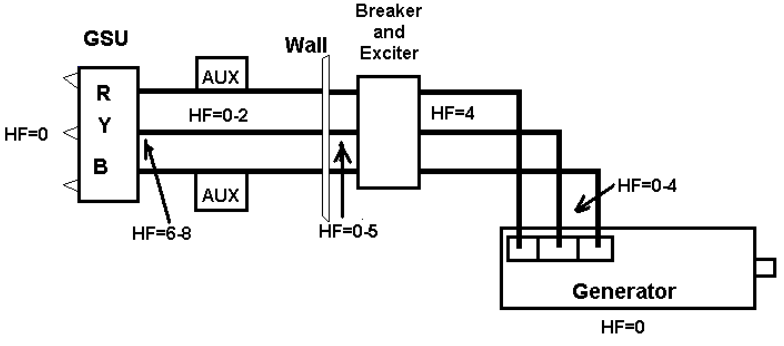
Sample surveys of hypothetical EMI Sniffer readings follow. PLEASE NOTE that these are for illustrative purposes only.



LF scale gain of 12: 2-3 bars
Trend/monitor, but immediate action not required.



All readings with HF scale and gain set to about 7. Significant bus related discharges are indicated at several locations. All connections to the Aux and PT transformers, generator and earthing switch recommended for inspection.



HF scale. Gain about 7. Several problems with the bus are indicated. Connections to the generator, breaker and GSU transformer should be inspected soon.

H. Other: Following are examples of conditions identified by customers as creating EMI

Steam Turbine Generator Conditions

1. Slot discharges resulting from side packing deterioration
2. Slot discharge resulting from stator bar coating deterioration
3. Loose end windings (broke ties)
4. Broken stator bar sub-conductors (strands)
5. Shaft oil/hydrogen seal rub
6. Arcing shaft grounding brush
7. Shaft currents through bearings
8. Verify shaft grounding maintenance eliminated bearing currents
9. Arcing alternator exciter or main field slip-rings
10. High DC exciter commutator segment

Induction & Synchronous Motor Conditions

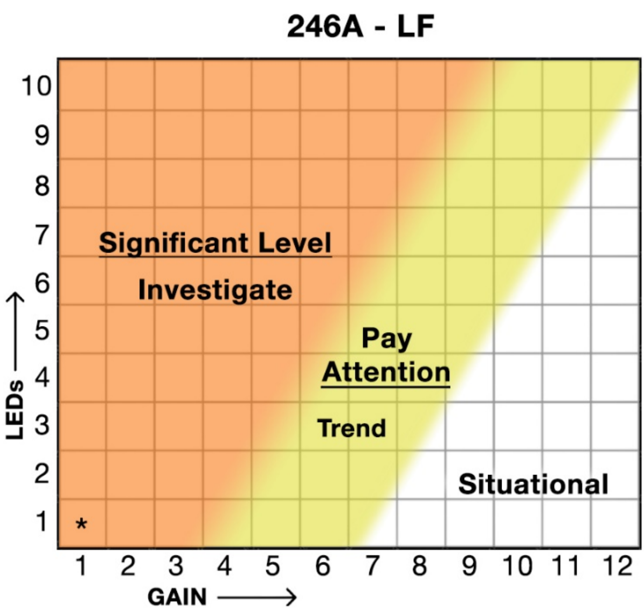
1. Dirty stator windings
2. Loose windings in slots and end-arms
3. Broken rotor bars
4. Rotor not set on magnet center
5. Wiped bearings
6. Defective outboard insulation (or insulation shorted)
7. Bearing oil seal rub
8. Exciter drive shaft weather seal rub
9. Coupling miss-alignment with driven gear box, pump, fan
10. Defective or missing coupling insulation
11. Circulating currents in driven pumps, coal mills, gearboxes, fans
12. Magnetized gear box shafts / gears
13. Loose neutral connections
14. Loose crimp / bolted line connections
15. Loose surge / power factor capacitor connections
16. Defective motor lead insulation
17. 13 kV cable stress cone deterioration
18. Verify correct maintenance was or was not performed

Isolated Phase Bus, AUX Bus, Sub Station Conditions

1. Loose & broken support insulators
2. Loose and corroded generator ISO bus hardware
3. Defective bus potential transformer connections
4. Loose AUX transformer connections
5. Loose GSU transformer core ground
6. Defective surge capacitor connections
7. Loose GSU transformer core ground
8. Loose disconnect switch components
9. Defective lightning arrester
10. Loose safety ground on unused 230 kV line
11. Verify correct maintenance was / was not performed

I. APPENDIX A

The graph below is for power plants only. In the absence of trending data, machine history, or the ability to compare EMI levels at similar machines, detected signal levels take on added import. In extremely general terms, the graph below may provide some guidance. It is not intended to be definitive, as a predictor of a "time to failure", or a replacement for careful consideration of all information available to the operator.



Notwithstanding the foregoing chart, there will be situations where small levels of detected EMI should trigger increased attention. Examples include:

A. CABLE <= 4KV..........2 + LED's at max gain.
B. SWITCH GEAR ....2+ LED's at max gain.
C. INDUCTION MOTOR SLEEVE BEARINGS........3 + LED's at max gain

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* The bar graph LEDs may flicker. Do not consider them "on" until steady.

VI. SPECIFICATIONS

Typical Detection Distance	_ _	~2’-20’ Directly from source range can be decreased to 0.5 – 1.0 ft. using sensitivity control
Center Frequency		
H Field	-	~ 225 KHz
E Field		
LF	-	~ 3 MHz
HF	-	~ 30 MHz
UHF	-	~ 360 MHz
Dynamic Signal Range	-	~ 85dB
Gain Control Range	-	~55dB, ~ 5db/step
LED Bar Graph	-	~3dB/Segment
AC Line	-	LED turns on for AC synchronous signals when the signal level is at least 3 segments.
Battery	-	9V Alkaline
Battery Life	-	~8 Hours
Mechanical		
Box Dimensions	-	5.5” x 3.25” x 1.5” (Less Antennas)
Weight	-	13 oz.

VII. WARRANTY AND NOTICE TO PURCHASER

All products manufactured by Radar Engineers Inc. are warranted against defects in material and workmanship for a period of one year following shipment. Our liability is specifically limited to replacing or repairing, at our option, defective equipment. THIS WARRANTY IS MADE IN LIEU OF ANY OTHER WARRANTY, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Neither seller nor manufacturer shall be liable for any injury, loss or damage, direct or consequential, arising out of the use of this product.

All statements, technical information and recommendations contained herein are based on information believed to be reliable, but the accuracy or completeness thereof is not guaranteed. Before using, the user shall determine the suitability of the product for his intended use, and user assumes all risk and liability whatsoever in connection therewith.

VII. REPAIRS AND CUSTOMER SERVICE

Radar Engineers maintains a complete instrument repair service. Should this instrument ever require repairs return to:

RADAR ENGINEERS INC
9535 N.E. Colfax Street
Portland, Oregon 97220

When returning the instrument for repairs, it should be shipped Prepaid and Insured. Include a note describing the defect and the name and phone number of the person to contact in case additional information is needed.

If you have questions regarding the operation of this instrument, call Radar Engineers Inc. at: (503) 256-3417 or email us at sales@radarengineers.com

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