5.19 RS103, radiated susceptibility, electric field, 2 MHz to 40 GHz.

5.19.1 RS103 applicability.

This requirement is applicable to equipment and subsystem enclosures and all interconnecting cables. The requirement is applicable as follows:

a.	2 MHz to 30 MHz	Army ships; Army aircraft, including flight line; Navy (except aircraft); and optional* for all others
b.	30 MHz to 1 GHz	all
c.	1 GHz to 18 GHz	all
d.	18 GHz to 40 GHz	optional* for all

*Required only if specified in the procurement specification

The requirement at the tuned frequency of an antenna-connected receiver is 20 dB above the RE102 limit associated with the particular platform application.

5.19.2 RS103 limit.

The EUT shall not exhibit any malfunction, degradation of performance, or deviation from specified indications, beyond the tolerances indicated in the individual equipment or subsystem specification, when subjected to the radiated electric fields listed in Table VII and modulated as specified below. Up to 30 MHz, the requirement shall be met for vertically polarized fields. Above 30 MHz, the requirement shall be met for both horizontally and vertically polarized fields. Circular polarized fields are not acceptable.

5.19.3 RS103 test procedures.

5.19.3.1 Purpose.

This test procedure is used to verify the ability of the EUT and associated cabling to withstand electric fields.

5.19.3.2 Test Equipment.

The test equipment shall be as follows:

a. Signal generators

b. Power amplifiers

c. Receive antennas

   (1) 1 GHz to 10 GHz, double ridge horns

   (2) 10 GHz to 40 GHz, other antennas as approved by the procuring activity

d. Transmit antennas

e. Electric field sensors (physically small - electrically short)

f. Measurement receiver

g. Power meter

h. Directional coupler

i. Attenuator

j. Data recording device

k. LISNs

5.19.3.3 Setup.
The test setup shall be as follows:

a. Maintain a basic test setup for the EUT as shown and described in Figures 1 through 5 and 4.3.8.

b. For electric field calibration, electric field sensors are required from 2 MHz to 1 GHz. Either field sensors or receive antennas may be used above 1 GHz (see 5.19.3.2c and 5.19.3.2e).

c. Configure test equipment as shown in Figure RS103-1.

d. Calibration.

(1) Placement of electric field sensors (see 5.19.3.3b). Position sensors 1 meter from, and directly opposite, the transmit antenna as shown in Figures RS103-2 and RS103-3 and a minimum of 30 cm above the ground plane. Do not place sensors directly at corners or edges of EUT components.

(2) Placement of receive antennas (see 5.19.3.3b). Prior to placement of the EUT, position the receive antenna, as shown in Figure RS103-4, on a dielectric stand at the position and height above the ground plane where the center of the EUT will be located.

e. EUT testing.

(1) Placement of transmit antennas. Antennas shall be placed 1 meter from the test setup boundary as follows:

(a) 2 MHz to 200 MHz

1 Test setup boundaries $\leq$ 3 meters. Center the antenna between the edges of the test setup boundary. The boundary includes all enclosures of the EUT and the 2 meters of exposed interconnecting and power leads required in 4.3.8.6. Interconnecting leads shorter than 2 meters are acceptable when they represent the actual platform installation.

2 Test setup boundaries > 3 meters. Use multiple antenna positions (N) at spacings as shown in Figure RS103-3. The number of antenna positions (N) shall be determined by dividing the edge-to-edge boundary distance (in meters) by 3 and rounding up to an integer.

(b) 200 MHz and above. Multiple antenna positions may be required as shown in Figure RS103-2. Determine the number of antenna positions (N) as follows:

1 For testing from 200 MHz up to 1 GHz, place the antenna in a sufficient number of positions such that the entire width of each EUT enclosure and

the first 35 cm of cables and leads interfacing with the EUT enclosure are within the 3 dB beamwidth of the antenna.

2 For testing at 1 GHz and above, place the antenna in a sufficient number of positions such that the entire width of each EUT enclosure and the first 7 cm of cables and leads interfacing with the EUT enclosure are within the 3 dB beamwidth of the antenna.

(2) Maintain the placement of electric field sensors as specified in 5.19.3.3d(1) above.

5.19.3.4. Procedures.

The test procedures shall be as follows:

a. Turn on the measurement equipment and EUT and allow a sufficient time for stabilization.

b. Assess the test area for potential RF hazards and take necessary precautionary steps to assure safety of test personnel.

c. Calibration.

(1) Electric field sensor procedure. Record the amplitude shown on the electric field sensor display unit due to EUT ambient. Reposition the sensor, as necessary, until this level is < 10% of the applicable field strength to be used for testing.

(2) Receive antenna procedure (> 1 GHz).

(a) Connect a signal generator to the coaxial cable at the receive antenna connection point (antenna removed). Set the signal source to an output level of 0 dBm at the highest frequency to be used in the present test setup. Tune the measurement receiver to the frequency of the signal source.

(b) Verify that the output indication is within ±3 dB of the applied signal, considering all appropriate losses. If larger deviations are found, locate the source of the error and correct the deficiency before proceeding.

(c) Connect the receive antenna to the coaxial cable as shown in Figure RS103-4. Set the signal source to 1 kHz pulse modulation, 50% duty cycle. Using an appropriate transmit antenna and amplifier, establish an electric field at the test start frequency. Gradually increase the electric field level until it reaches the applicable limit.

(d) Scan the test frequency range and record the required input power levels to the transmit antenna to maintain the required field.

(e) Repeat procedures 5.19.3.4.c(2)(a) through 5.19.3.4(2)(d) whenever the test setup is modified or an antenna is changed.

d. EUT Testing.

(1) E-Field sensor procedure.

(a) Set the signal source to 1 kHz pulse modulation, 50% duty cycle, and using appropriate amplifier and transmit antenna, establish an electric field at the test

start frequency. Gradually increase the electric field level until it reaches the applicable limit.

(b) Scan the required frequency ranges in accordance with the rates and durations specified in Table III. Maintain field strength levels in accordance with the applicable limit. Monitor EUT performance for susceptibility effects.

(2) Receive antenna procedure.

(a) Remove the receive antenna and reposition the EUT in conformance with 5.19.3.3a.

(b) Set the signal source to 1 kHz pulse modulation, 50% duty cycle. Using an appropriate amplifier and transmit antenna, establish an electric field at the test start frequency. Gradually increase the input power level until it corresponds to the applicable level recorded during the calibration routine.

(c) Scan the required frequency range in accordance with the rates and durations specified in Table III while assuring the correct transmitter input power is adjusted in accordance with the calibration data collected. Constantly monitor the EUT for susceptibility conditions.

(3) If susceptibility is noted, determine the threshold level in accordance with 4.3.10.4.3 and verify that it is above the limit.

(4) Perform testing over the required frequency range with the transmit antenna vertically polarized. Repeat the testing above 30 MHz with the transmit antenna horizontally polarized.

(5) Repeat 5.19.3.4d for each transmit antenna position required by 5.19.3.3e.

5.19.3.5 Data Presentation.
Data presentation shall be as follows:

a. Provide graphical or tabular data showing frequency ranges and field strength levels tested.

b. Provide graphical or tabular data listing (antenna procedure only) all calibration data collected to include input power requirements used versus frequency, and results of system check in 5.19.3.4c(2)(c) and 5.19.3.4c(2)(d).

c. Provide the correction factors necessary to adjust sensor output readings for equivalent peak detection of modulated waveforms.

d. Provide graphs or tables listing any susceptibility thresholds that were determined along with their associated frequencies.

e. Provide diagrams or photographs showing actual equipment setup and the associated dimensions.

5.19.4 RS103 alternative test procedures – reverberation chamber (mode-tuned).
These procedures may be substituted for the 5.19.3 procedures over the frequency range of 200 MHz to 40 GHz. The lower frequency limit is dependent on chamber size. To determine the

lower frequency limit for a given chamber, use the following formula to determine the number of possible modes (N) which can exist at a given frequency. If, for a given frequency, N is less than 100 then the chamber should not be used at or below that frequency.

$$N = \frac{8\pi}{3} a\,b\,d\,\frac{f^3}{c^3}$$

where: a, b, and d are the chamber internal dimensions in meters

f is the operation frequency in Hz

c is the speed of propagation (3×10^8 m/s)

5.19.4.1 Purpose.
This test procedure is an alternative technique used to verify the ability of the EUT and associated cabling to withstand electric fields.

5.19.4.2 Test equipment.
The test equipment shall be as follows:

a. Signal generators

b. Power amplifiers

c. Receive antennas

(1) 200 MHz to 1 GHz, log periodic or double ridge horns.

(2) 1 GHz to 18 GHz, double ridge horns.

(3) 18 GHz to 40 GHz, other antennas as approved by the procuring activity.

d. Transmit antennas

e. Electric field sensors (physically small - electrically short), each axis independently displayed

f. Measurement receiver

g. Power meter

h. Directional coupler

i. Attenuator, 50 ohm

j. Data recording device

k. LISNs

5.19.4.3. Setup.
The test setup shall be as follows:

a. Install the EUT in a reverberation chamber using the basic test setup for the EUT as shown and described in Figures 2 through 5 and 4.3.8. The EUT shall be at least 1.0 meter from the chamber walls, the tuner, and antennas.

b. For electric field calibration, electric field sensors (5.19.4.2.e) are required from 200 MHz to 1 GHz. Either field sensors or receive antennas may be used above 1 GHz (see 5.19.4.2c and 5.19.4.2e).

c. Configure the test equipment as shown in Figures RS103-5 and RS103-6. The same configuration is used for both calibration and EUT testing. Both the transmit and receive antennas shall be present in the chamber for all calibration and EUT testing, including for the electric-field probe technique. Unused receive antennas shall be terminated in 50 ohms.

5.19.4.4 Procedure.

The test procedures shall be as follows:

a. Calibration. Use the following procedure to determine the electric field strength that will be created inside the chamber when a fixed amount of RF energy is injected into the chamber.

(1) Receive antenna procedure.

(a) Adjust the RF source to inject an appropriate forward power (unmodulated) into the chamber at the start frequency of the test.

(b) Measure the level at the receive antenna using the measurement receiver.

(c) Rotate the tuner 360 degrees using the minimum number of steps required from Table VIII. Allow the paddle wheel to dwell at each position for a period corresponding to a minimum of 1.5 times the response time of the measurement receiver.

(d) Record the maximum amplitude of the signal received and use the following formula to derive a calibration factor for the field strength created inside the chamber. ($P_{r\text{-}max}$ and $P_{forward}$ in watts; λ in meters).

$$\text{Calibration factor} = \frac{8\pi}{\lambda}\sqrt{5\left(\frac{P_{r-\max}}{P_{forward}}\right)} \qquad \text{V/m (for one watt)}$$

(e) Repeat the procedure in frequency steps no greater than 2% of the preceding frequency until 1.1 times the start frequency is reached. Continue the procedure in frequency steps no greater than 10% of the preceding frequency, thereafter.

(2) Electric field probe procedure.

(a) Adjust the RF source to inject an appropriate forward power ($P_{forward}$) (unmodulated) into the chamber at the start frequency of the test.

(b) Rotate the tuner 360 degrees using the minimum number of steps required from Table VIII. Allow the tuner to dwell at each position for a period corresponding to a minimum of 1.5 times the probe response time.

(c) Record the maximum amplitude from the receive antenna ($P_{r\text{-}max}$) and from each element of the probe and use the following formula to derive a calibration

factor for the field strength created inside the chamber. (Probe reading in V/m and $P_{forward}$ in watts).

$$\text{Calibration factor} = \sqrt{\left(\frac{E_{x-\max} + E_{y-\max} + E_{z-\max}}{3}\right)^2 \Big/ P_{forward}} \text{ V/m (for one watt)}$$

(d) Repeat the procedure in frequency steps no greater than 2% of the preceding frequency until 1.1 times the start frequency is reached. Continue the procedure in frequency steps no greater than 10% of the preceding frequency, thereafter.

b. EUT testing. The same antennas used for calibration shall be used for EUT testing.

(1) Turn on the measurement equipment and allow a sufficient time for stabilization.

(2) Set the RF source to the start frequency of the test with 1 kHz pulse modulation, 50 % duty cycle.

(3) Calculate the amount of RF power needed to create the desired field strength by determining the difference (in dB - decibel differences are the same for both field strength and power, there is a square law relationship between field strength and power in real numbers) between the desired field strength and the field strength obtained during the calibration. Adjust the chamber peak forward power to this value. Interpolation between calibration points is required.

(4) Adjust the measurement receiver to display the received signal at the receive antenna to verify that an electric field is present.

(5) Rotate the tuner 360 degrees using the minimum of steps shown in Table VIII. Allow the tuner to dwell at each position for the duration specified in Table III. As the tuner rotates, maintain the forward power required to produce field levels at the applicable limit as determined from the calibration.

(6) Scan the required frequency range in accordance with the maximum frequency step sizes and durations specified in Table III. Monitor EUT performance for susceptibility effects.

(7) If susceptibility is noted, determine the threshold level in accordance with 4.3.10.4.3 and verify that it is above the limit.

5.19.4.5 Data Presentation.

Data presentation shall be as follows:

a. Provide graphical or tabular data showing frequency ranges and field strength levels tested.

b. Provide graphical or tabular data listing of all calibration data collected to include input power requirements used versus frequency and results of calibration in 5.19.4.4a(1)(d) and 5.19.4.4.a(2)(c).

c. Provide the correction factors necessary to adjust sensor output readings for equivalent peak detection of modulated waveforms.

d. Provide graphs or tables listing any susceptibility thresholds that were determined along with their associated frequencies.

e. Provide diagrams or photographs showing the actual equipment setup and the associated dimensions.

f. Provide the data certifying the baseline performance of the shielded room as a properly functioning reverberation chamber over a defined frequency range.

TABLE VII. RS103 limits.

FREQ. RANGE / PLATFORM		LIMIT LEVEL (VOLTS/METER)							
		AIRCRAFT (EXTERNAL OR SAFETY CRITICAL)	AIRCRAFT INTERNAL	ALL SHIPS (ABOVE DECKS) AND SUBMARINES (EXTERNAL)*	SHIPS (METALLIC) (BELOW DECKS)	SHIPS (NON-METALLIC) (BELOW DECKS)	SUBMARINES (INTERNAL)	GROUND	SPACE
2 MHz ↓ 30 MHz	A	200	200	200	10	50	5	50	20
	N	200	200	200	10	50	5	10	20
	AF	200	20	-	-	-	-	10	20
30 MHz ↓ 1 GHz	A	200	200	200	10	10	10	50	20
	N	200	200	200	10	10	10	10	20
	AF	200	20	-	-	-	-	10	20
1 GHz ↓ 18 GHz	A	200	200	200	10	10	10	50	20
	N	200	200	200	10	10	10	50	20
	AF	200	60	-	-	-	-	50	20
18 GHz ↓ 40 GHz	A	200	200	200	10	10	10	50	20
	N	200	60	200	10	10	10	50	20
	AF	200	60	-	-	-	-	50	20

KEY: A = Army
N = Navy
AF = Air Force

* For equipment located external to the pressure hull of a submarine but within the superstructure, use SHIPS (METALLIC)(BELOW DECKS)

TABLE VIII. Required number of tuner positions for a reverberation chamber.

Frequency Range (MHz)	Tuner Positions
200 - 300	50
300 - 400	20
400 - 600	16
Above 600	12

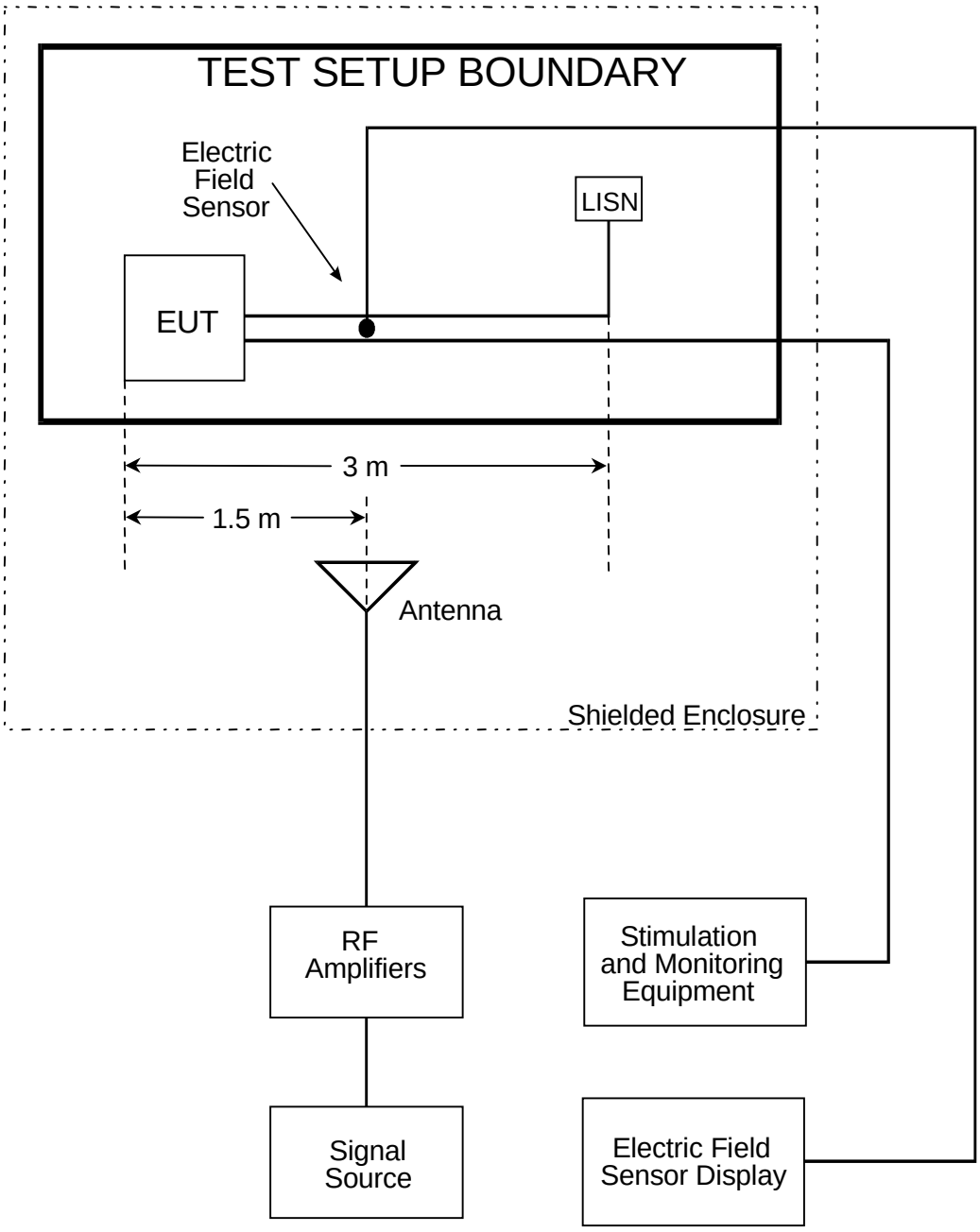

FIGURE RS103-1. Test equipment configuration.

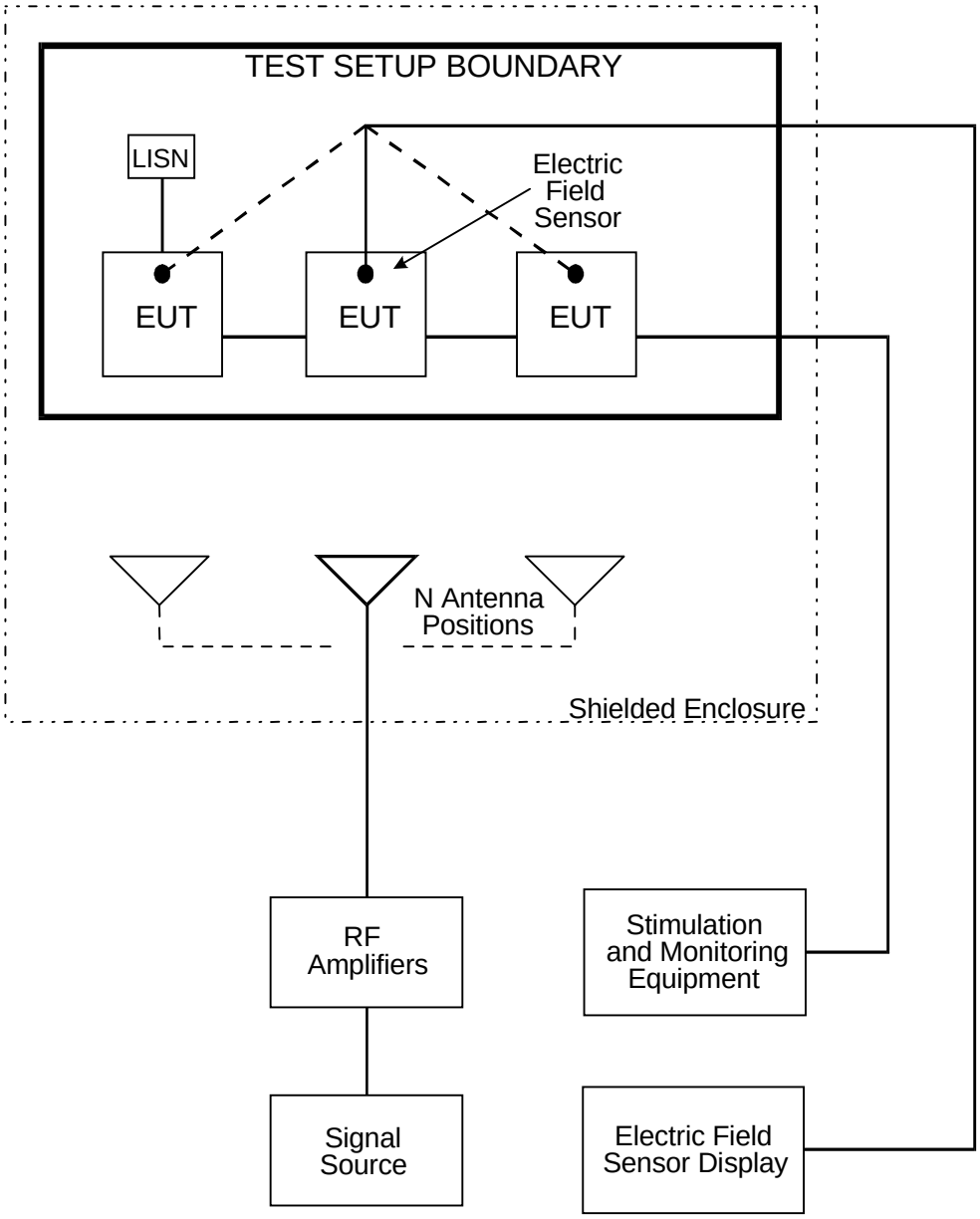

FIGURE RS103-2. Multiple test antenna locations for frequency > 200 MHz.

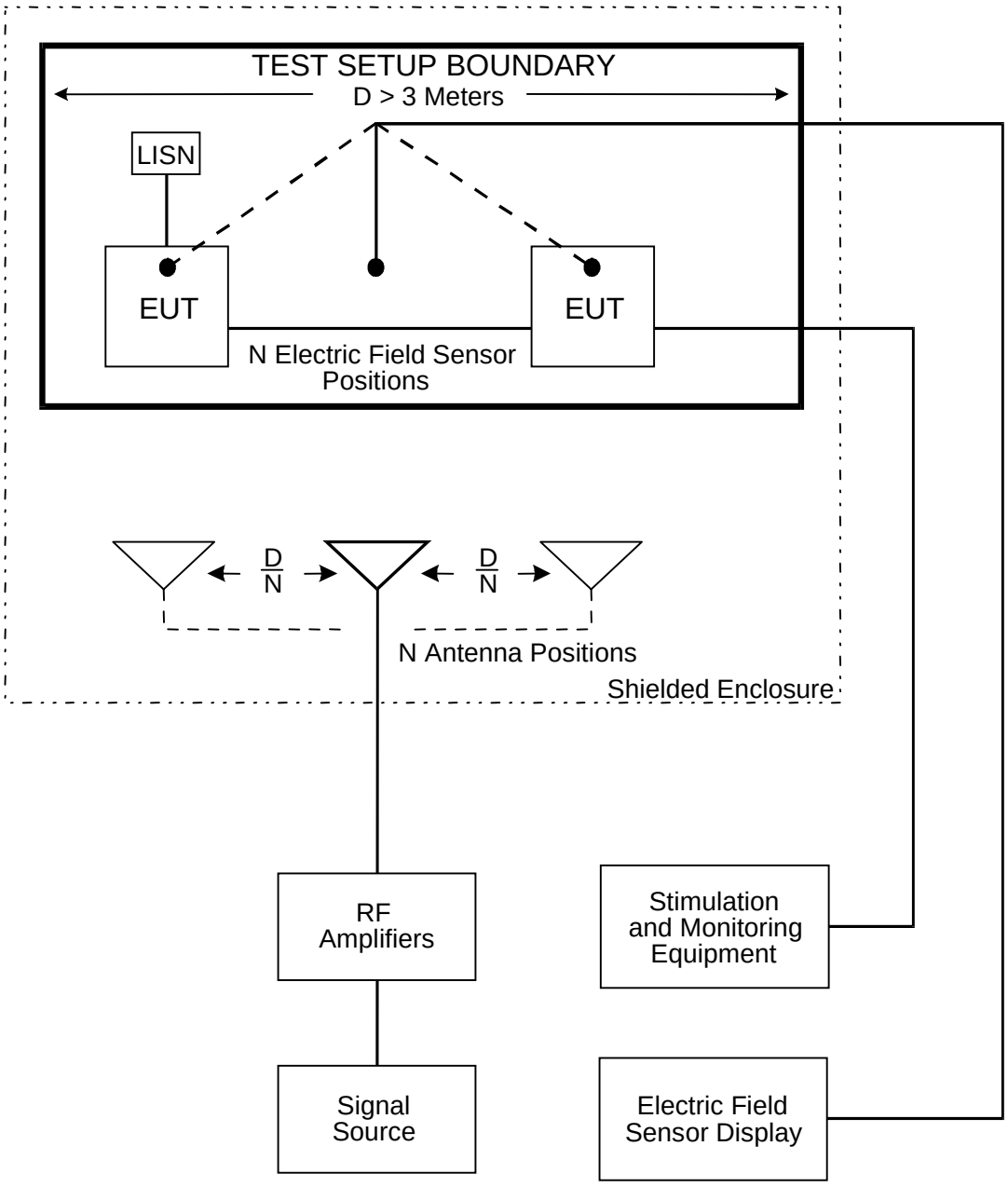

FIGURE RS103-3. Multiple test antenna locations for N positions, D > 3 meters.

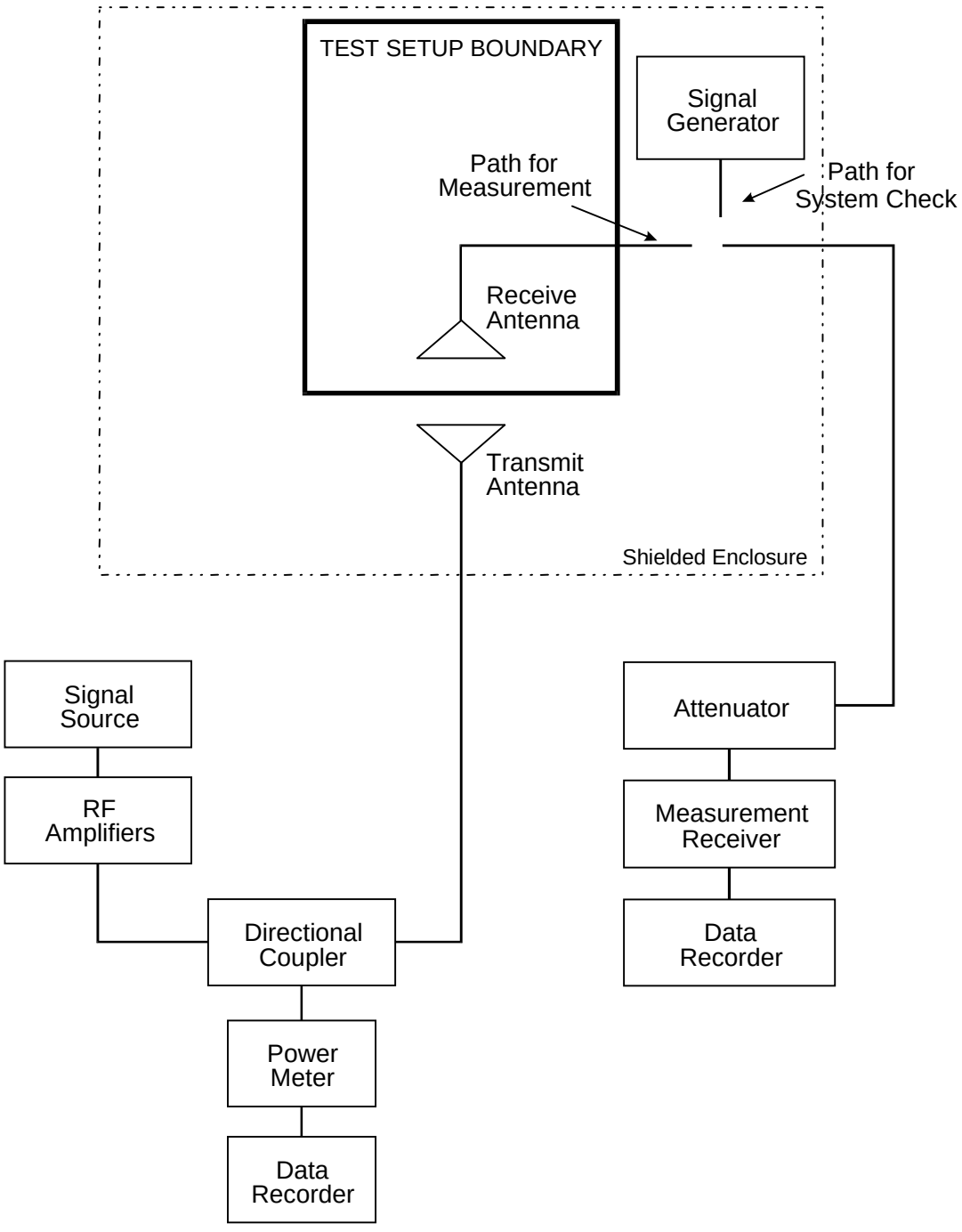

FIGURE RS103-4. Receive antenna procedure (1 to 40 GHz).

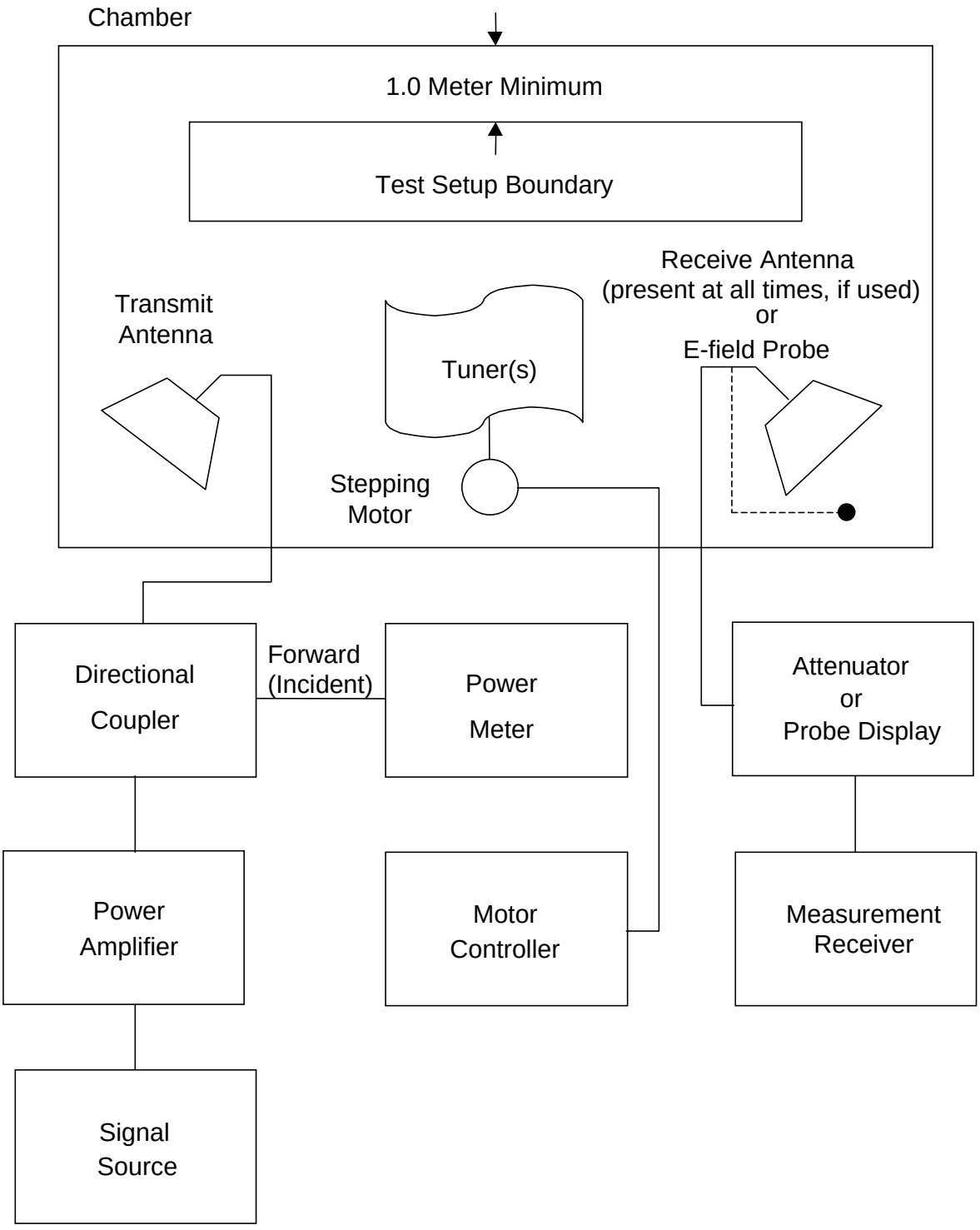

FIGURE RS103-5. Reveberation chamber setup.

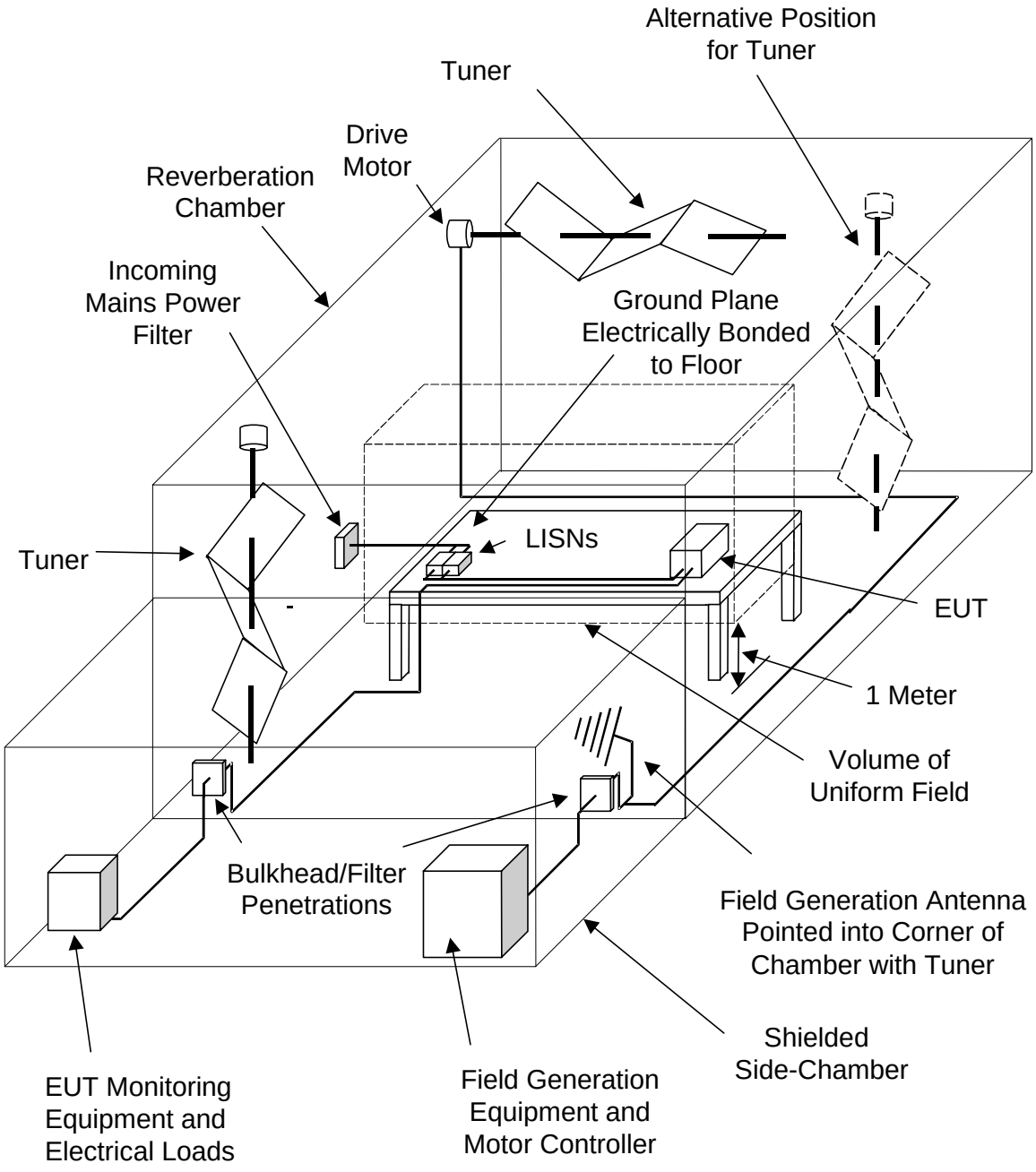

FIGURE RS103-6. Reverberation Chamber Overview.