

**IMMUNITY TO RADIATED ELECTROMAGNETIC FIELDS -
(REVERBERATION METHOD)
EMC - COMPONENT TEST PROCEDURE
GM9120P**

1 SCOPE.

1.1 Vehicle electrical/electronic systems may be affected when immersed in an electromagnetic field generated by sources such as radio and TV broadcast stations, radar and communication sites, mobile transmitters, cellular phones, etc. Reverberation method is used to evaluate the immunity of electronic devices in the frequency range of 500 MHz - 2.0 GHz, with possible extensions from 200 MHz - 10 GHz. At a later date, pulse modulation capability will be added for testing above 1 GHz. This method is used as an extension of the Bulk Current Injection (BCI) method (see GM9112P).

1.2 This document provides the component design and test engineers with a test procedure and the performance requirements necessary to evaluate the immunity of electronic devices to radiated electromagnetic fields early in the design stage as well as pilot and production stages. Ensuring electromagnetic compatibility early in the development stage will minimize costly changes later in the program and will prevent excessive component level hardening during full-vehicle level testing.

1.3 The reverberation test method performs a dual function:

1.3.1 The primary function of the method is to provide a bench test procedure correlatable to vehicle-level radiated immunity testing in the anechoic chamber and mobile transmitter sites.

1.3.2 The method can also be used to evaluate the relative performance of different designs of the same device.

1.4 This document is one of a series of component EMC test procedures. See GM9100P for information on the complete series. Successfully passing the component tests will increase the chances of passing the full-vehicle tests. Where a component passes the component-level tests but does not meet the vehicle-level tests, the component supplier shall cooperate with GM in determining a root cause and resolution for the condition.

2 REFERENCED STANDARDS.

GM9100P GM9112P

3 PERFORMANCE OBJECTIVES.

3.1 The performance objectives for the DUT are defined in Figure 1. These objectives are applied in accordance with the functional status classifications as defined in Appendix A. Currently, the performance objectives pertain to CW RF fields from 500 MHz - 2.0 GHz.

3.2 Performance objectives for 200 MHz - 500 MHz, 2 GHz - 10 GHz, and for pulse-modulated RF fields above 1 GHz will be added later, relative to the procedure publication date.

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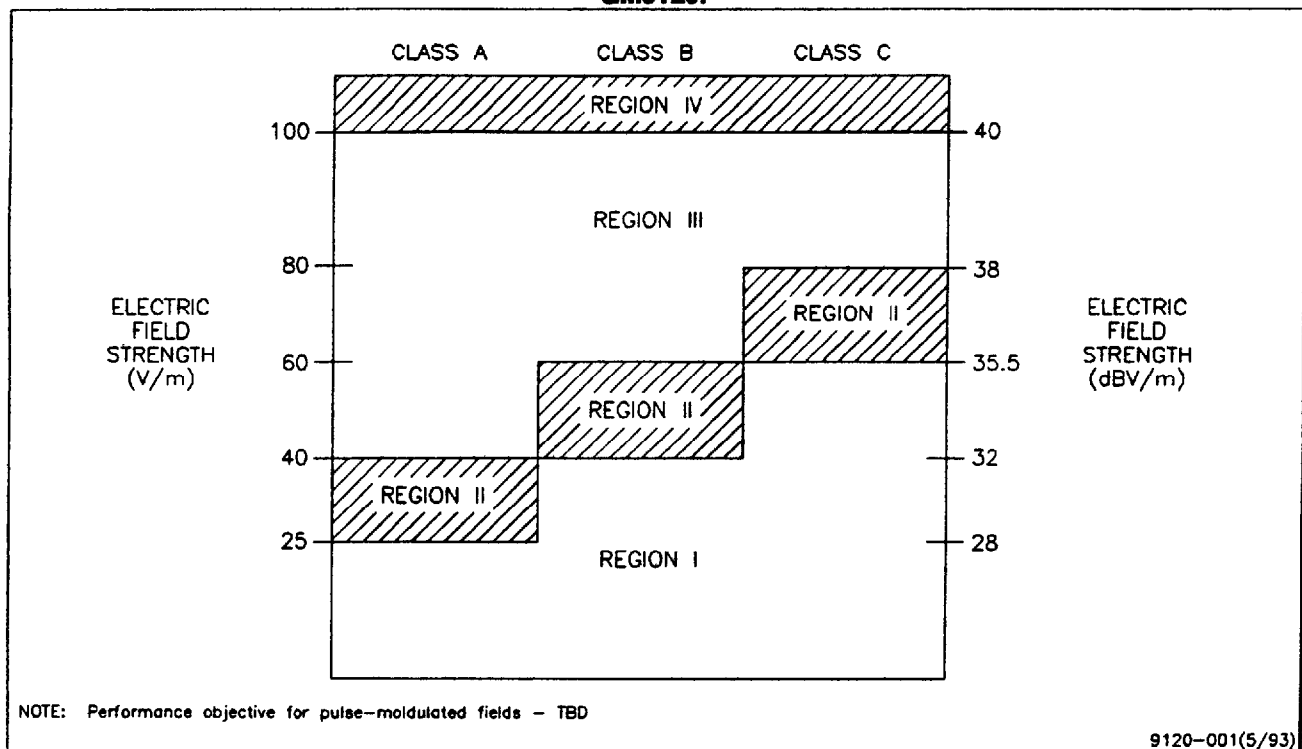


**FIGURE 1 - COMPONENT ELECTRIC FIELD PERFORMANCE OBJECTIVE REVERBERATION METHOD -
500 MHz - 2 GHz CW FIELDS**

4 DEFINITIONS.

4.1 REVERBERATION CHAMBER. A high Q shielded room (cavity) whose boundary conditions are continuously changed via a rotating stirrer. This results in a time-averaged uniform electromagnetic field. See Appendix B for additional information.

4.2 TUNER OR STIRRER. A rotating metallic reflector which changes the boundary conditions in a reverberation chamber as it rotates. As the stirrer rotates, the nulls and maximums in the field change location, ensuring the DUT is exposed to a time-averaged uniform field.

4.3 MODE STIR. A reverberation method which rotates the stirrer continuously while sampling the reference antenna received power, field probe response, and DUT response at rates much faster than the stirrer revolution rate.

4.4 BENCH TESTING. Component testing performed in a laboratory.

4.5 DEVICE UNDER TEST (DUT). The device which is being evaluated.

4.6 FIELD STRENGTH. The maximum electric field measured during a complete revolution of the stirrer.

4.7 DUT IMMUNITY THRESHOLD. The minimum field strength level at which a DUT performance deviation occurs.

4.8 CHAMBER QUALITY FACTOR (Q). A measure of a cavity's ability to reverberate (see B1.2). Q, for a cavity, is defined as:

$$Q = \frac{\omega * \text{energy stored}}{\text{average power dissipated}}$$

where $\omega = 2\pi * f$ (radians/sec)
 $f = \text{frequency (Hz)}$

4.9 Q_w . Theoretical Q with losses of walls included.

4.10 Q_a . Theoretical Q with losses of antennas included.

4.11 Q_{wa} . Theoretical Q with losses of antennas and walls included.

4.12 Q' . Empirical Q, which is the measured cumulative Q of the cavity. This value takes into account chamber loading effects such as the DUT and monitoring equipment (see B1.2).

IMMUNITY TO RADIATED ELECTROMAGNETIC FIELDS - (REVERBERATION METHOD) EMC - COMPONENT TEST PROCEDURE

GM9120P

4.13 K FACTOR. The ratio of an unloaded chamber theoretical quality factor, Q_{unl} , to the chamber empirical quality factor, Q' .

$$K = \text{Theoretical } Q_{unl} / \text{Empirical } Q$$

4.14 F_c . The cutoff frequency above which cavity losses are primarily due to wall losses instead of antenna losses.

4.15 L - CHAMBER LOSS. The ratio (in dB) of the maximum received power (in watts) to the transmitted net power (in watts).

5 TEST EQUIPMENT.

5.1 RF signal generator 500 MHz - 2.0 GHz (200 MHz - 10 GHz optional). Pulse modulation capability optional.

5.2 BROADBAND POWER AMPLIFIER(S). 500 MHz - 2.0 GHz (200 MHz - 10 GHz optional). Power requirements: 50 W minimum below 1 GHz, 250 W above 1 GHz (pulse capability optional). The amplifier should be able to drive a load of any impedance mismatch without damage to itself for at least 15 s.

5.3 ANTENNAS.

5.3.1 Log periodic 500 MHz - 1 GHz (200 MHz - 1 GHz optional). Two antennas are needed, one for transmission and one for reception.

5.3.2 Double ridged guide 1 GHz - 2.0 GHz (1 GHz - 12.4 GHz available). Two antennas are needed, one for transmission and one for reception.

5.4 SPECTRUM ANALYZER. 500 MHz - 2.0 GHz (200 MHz - 10 GHz optional).

5.5 DIRECTIONAL COUPLERS. 500 MHz - 2.0 GHz (200 MHz - 10 GHz optional). Average power 500 W, peak power 10 kW, coupling factor 20 dB minimum, and directivity 20 dB minimum.

5.5.1 Three directional couplers are needed for the following use:

Transmit forward power
Transmit reflected power
Receive power

Typical bands:

.05 - 1 GHz
1 - 4 GHz
4 - 10 GHz (optional)

5.6 10 dB ATTENUATOR. 500 MHz - 2.0 GHz (200 MHz - 10 GHz optional), power rating 50 W average, 1 kW peak.

5.7 POWER METER. 500 MHz - 2.0 GHz (200 MHz - 10 GHz optional), including power sensor heads (peak power sensor heads optional).

5.7.1 Two power meters are needed, one for transmit forward power and one for transmit reflected power.

5.8 COMPUTER CONTROL (RECOMMENDED).

5.9 Reverberation chamber with a stirrer (see Appendix B). The room shall be constructed of steel (preferably galvanized, but cold rolled steel is allowed). Room dimensions should not be integer multiples of one another. Minimum recommended room dimensions are 16' x 12' x 10' (approximately 4.88 x 3.66 x 3.05 m). Key characteristics of the chamber shall be verified to ensure an accurate and valid test (see Appendix C). Smaller shielded rooms may be used but only at higher frequencies (see Appendix C).

5.10 TWO BROADBAND FIELD STRENGTH PROBES. Probe response shall be faster than 10 Hz.

5.11 STIRRER. A three-dimensional, asymmetrical stirrer is recommended. The stirrer shall be made of conductive material (i.e., aluminum or galvanized steel). An example is shown in Figures B.1 and B.2.

6 TEST SETUP.

6.1 A general layout of a reverberation chamber is shown in Figure 2. An equipment setup configuration is shown in Figure 3.

6.2 The DUT shall be operated in its designed modes. Appropriate control signals shall be provided. Actual loads should be used for a subsystem test and simulated loads may be used for a component test.

6.3 DUT nominal condition and deviation criteria shall be clearly defined in the test plan. Appropriate instrumentation for monitoring the deviation(s) and actuating the DUT shall be provided by the component supplier.

6.4 Steps shall be taken to prevent RF energy from coupling into control and monitoring equipment to prevent erroneous readings. This may require RF hardening of the simulator and the control/monitoring equipment. The simulator may be placed outside the room. Either filtering or fiber optic cables may be required. If filters are used, care should be taken to ensure that the filters do not present additional loading or affect the immunity of the DUT.

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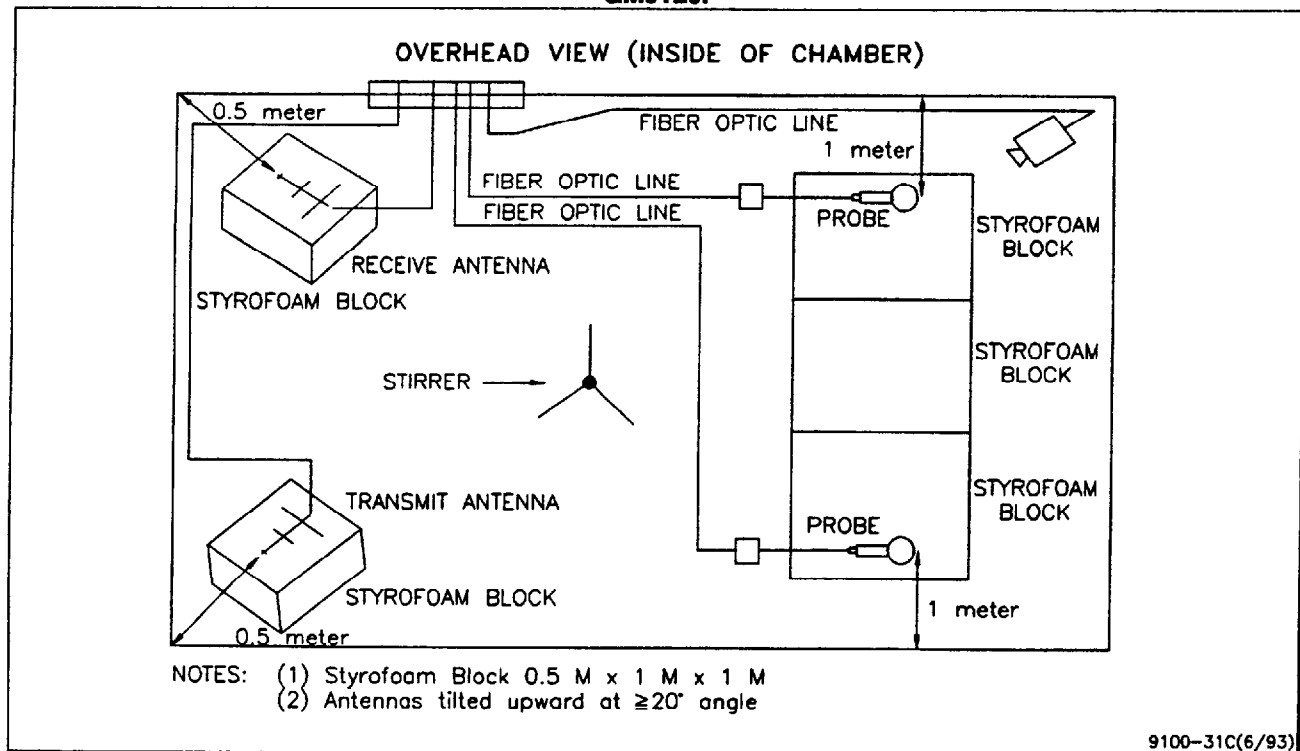


FIGURE 2 - TYPICAL REVERBERATION CHAMBER LAYOUT

6.5 If the outer case of the DUT is intended to be grounded to the vehicle metal structure, the DUT should be mounted to a ground plane during testing. The ground plane should be placed at a distance not less than $\lambda/3$ (at the lowest frequency) above the floor level (preferably on a styrofoam block). Large DUTs may be placed directly on the floor. The ground plane shall be placed at least $\lambda/3$ from any wall. If the DUT is not grounded to the vehicle metal structure, the DUT and harness shall be placed directly on a styrofoam block.

6.5.1 The ground plane shall be constructed from either copper, brass or galvanized steel.

6.5.2 The minimum thickness of the ground plane shall be 0.5 mm. The minimum dimension shall be 2.25 m² with the smaller side no less than 0.75 m. The minimum size of the ground plane depends upon the size of the system under test and shall allow for complete harness and system component placement.

6.5.3 The ground plane shall be bonded to the chamber wall with a bonding strap with a minimum width of 7.6 cm.

6.6 A 1-3 meter harness shall be used, unless otherwise specified in the test plan. The length of the wiring harness shall be documented in the test plan.

6.7 Antennas, probes, and the DUT shall be placed at distances not less than $\lambda/3$ from the chamber walls and corners. The DUT shall be at least $\lambda/6$ away from the stirrer.

6.8 Antennas shall be aimed at different corners of the room. An upward tilt of 20° or more should be used. Antenna polarization is not critical, but for standardization, horizontal polarization is suggested.

6.9 Antennas and probes should be placed on styrofoam supports, at least $\lambda/3$ above the floor.

6.10 All unnecessary RF absorbing material shall be removed from the room (e.g., wooden tables, carpeting, extra equipment, etc.).

6.11 Stirrer revolution rate is typically 10 - 20 seconds per revolution (3-6 rpm). This rate shall be adjusted accordingly for probe and DUT response time.

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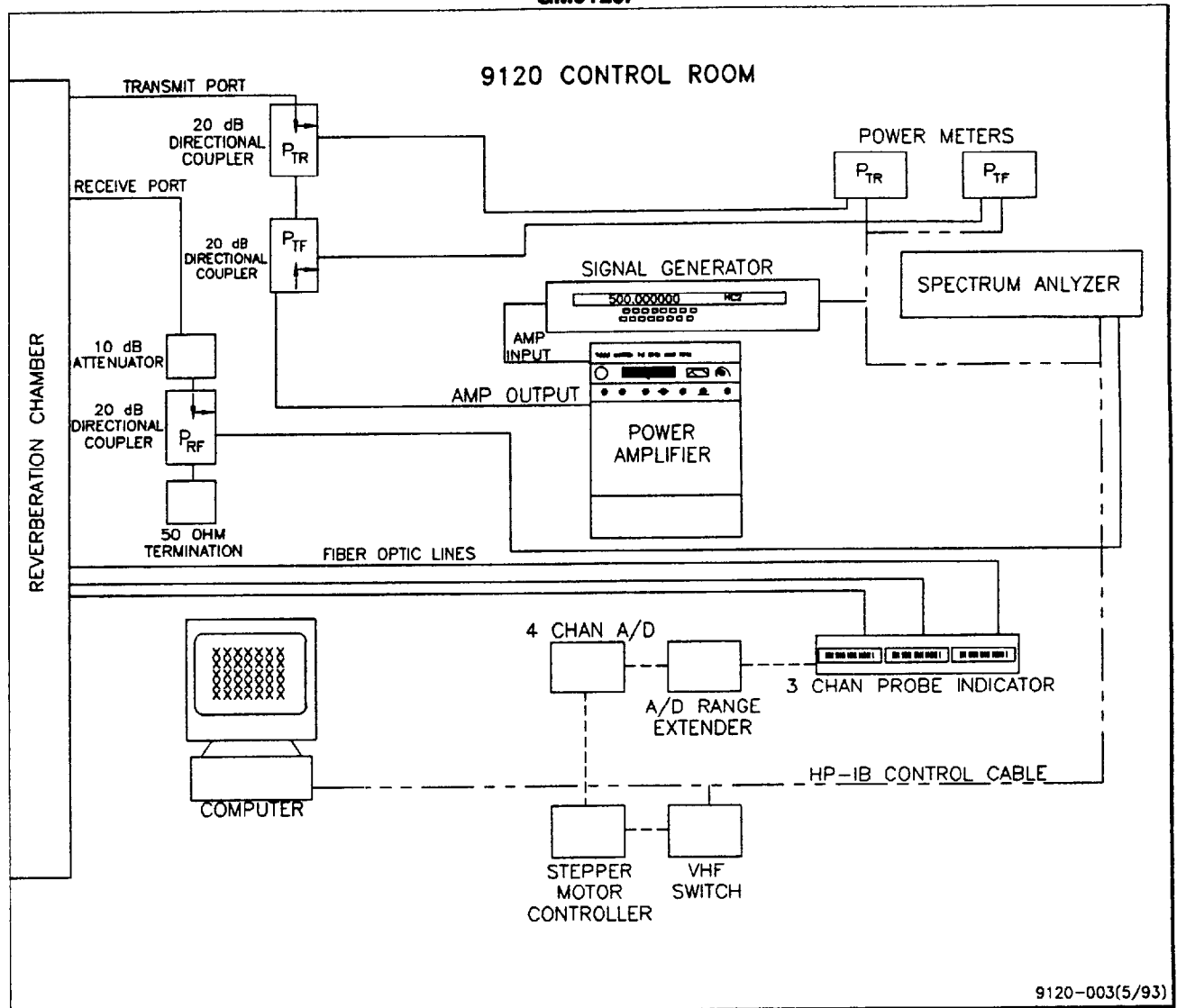


FIGURE 3 - REVERBERATION EQUIPMENT SETUP