1.0 INTRODUCTION

This test procedure is used to verify Passenger Car and Light Truck compliance to the following Ford Motor Company Attribute Requirements (ARL's) for electromagnetic compatibility (EMC):

Ford Motor Company Trustmark ARLs

09-0411	Off-Board Radiated Immunity (Level 1)
09-0414	Off-Board Broadband Radiated Emissions
09-0419	Off-Board Narrowband Radiated Emissions
09-0426	Electrostatic Discharge

Ford Motor Company non-Trustmark ARLs

09-0418	On-Board Narrowband Radiated Emissions (70MHz – 108MHz)
09-0422	Load Dump
09-0425	Reverse Battery
09-0467	Off-Board Radiated Immunity (Level 2)
09-0468	Off-Board Radiated Immunity (Level 3)

In addition, the following procedures are included, whose associated limits and performance requirements must be detailed either within a "brand specific" Attribute Requirement or within the Test Plan:

Additional tests

On-Board Radiated Emissions (CISPR 25 –150kHz to 2.5GHz)

Radiated Immunity to on-board mobile transmitters

Radiated Immunity to on-board hand-held transmitters

24 Volt Jump Start

Under Voltage

Over Voltage

1.1 COMMONALITY

This is a CONTROL TEST and can be used to qualify vehicles throughout the world. The test may be conducted at any location having the necessary equipment and facilities. Proposed revisions to this procedure must be submitted per FAP03-179.

1.2 EXCLUSIONS

Detailed EMC analysis of individual subsystems and components is beyond the scope of this procedure and shall be conducted separately as described in ES-XW7T-1A278-xx Component and Subsystem EMC Worldwide Requirements and Test Procedures (Note: xx represents the currently released version of this specification).

1.3 SCOPE

This procedure applies to all electrical and electronic systems on passenger cars and light trucks, with each system's Functional Importance Classification being as defined within Attribute Requirement number (ARL) 09-0445.

2.0 INSTRUMENTATION

2.1 All test and measurement equipment, within Ford owned test facilities, must be calibrated and maintained per FAP03-015, Control, Calibration, and Maintenance of Measurement and Test Equipment.

2.2 All test and measurement equipment, within external test facilities, must be calibrated and maintained using a procedure traceable to national standards.

2.3 All applicable safety guidelines and procedures must be followed.

3.0 EQUIPMENT AND FACILITIES

EMC Testing will be conducted only in facilities owned by Ford or providing priority EMC Testing for Ford. Hence, a list of equipment and facilities is not required within this CETP.

4.0 SAMPLE PREPARATION

To ensure a valid engineering sign-off test and demonstrate compliance to the applicable Ford Motor Company ARL's outlined in paragraph 1.0, the requesting activity shall provide all necessary Test Plan information to the test activity and insure that the test vehicle is to the required build standard, that all systems are functional, and that any unnecessary instrumentation has been removed prior to submittal of the vehicle for testing. Record the part numbers of systems of specific interest.

4.1 EMC TEST PLAN

The procedures described in this document are general and have been designed to enable flexibility in the choice of EMC test equipment and methodology. The procedures, therefore, may not include specific requirements for an individual vehicle.

The provision of a formalized EMC Test Plan prevents uncertainties in procedure that may obscure the effects of modifications made during the development process. Sufficient information must be supplied to allow for the compilation of a detailed Test Plan, which will describe the vehicle systems and test strategy, and will include the following information:

a. List of systems and functions to be tested in the Radiated Immunity test.

b. Detailed operational information for each system or function to be tested, showing:

- Operational condition(s) of the vehicle (i.e., idle - running on dynamometer - ABS activated - cruise control – etc.)
- Operator controls to be energized / operated.
- Equipment and method for applying external stimulus signals – if required.
- Specification of mechanical or electrical loading – if required.
- Equipment and methods that will be used to monitor operation during testing.
- Performance criteria for the system or function.
- Specification of diagnostic data queries to be performed, interval for performing queries, and method of clearing status codes.
- Details of any "slow response" systems that may require a longer dwell time during radiated immunity testing.

c. Operator-controlled systems to be subjected to the Radiated Emissions, Electrostatic Discharge, and Over Voltage tests.

d. Additional data required for testing and/or diagnosis, such as:

- Fuse panel layouts.
- Wiring schematics.
- Instrument cluster diagrams.

e. A description of new or complex vehicle systems, including operational characteristics; diagnostic procedures; self-test routines; details of the build level; software release; etc…

f. Evidence of compliance of components to ES-XW7T-1A278-xx Component and Subsystem EMC Worldwide Requirements and Test Procedures (xx represents the currently released version), or identification of remedial actions intended to correct non-compliance.

g. Details of any deviations from the test procedures detailed in the following sections of this test procedure

A pro forma Test Plan will be provided by the relevant department into which all pertinent data may be entered.

4.2 VEHICLE PRE-DELIVERY CHECK LIST

Ensure that the following checks are done prior to vehicle delivery:

a. Check battery terminals and remove any corrosion.

b. Verify that all electrical systems are operational and to the latest design level. Ensure that the vehicle has no additional instrumentation or wiring.

c. Provide the test activity with any additional data required to perform the test (e.g., operational limits and specifications for individual components).

d. Note any deviations from the above on the Test Plan.

e. Run self-tests on all subsystems capable of self-test. Record and clear status codes.

4.3 VEHICLE PRE-TEST CHECK LIST

The following checks must be performed prior to each of the requested tests:

a. Verify functionality of all subsystems to be tested.

b. Record and clear status codes.

5.0 WHOLE VEHICLE TESTING

5.1 GENERAL

5.1.1 Test Temperature

The chamber ambient temperature shall be monitored and maintained within the range 22 ± 5 °C. Sufficient forced-air cooling shall be provided to ensure that the vehicle engine does not overheat during tests with the engine running.

If practical considerations prevent the maintenance of the temperature within this range, the test requestor shall be notified at the earliest opportunity, and actual ambient temperature recorded during the test shall be presented within the test report.

5.1.2 Vehicle DC Supply Voltage

For tests where the vehicle engine is not running, the vehicle battery supply voltage shall not fall below 12V for a 12V system vehicle and 24V for a 24V system vehicle. For tests where the vehicle engine is running, the vehicle charging system shall be fully functional.

5.1.3 Monitoring Equipment

The Test Plan will define any special monitoring equipment to be used to monitor the vehicle during the test, ensuring that no unintentional electrically conductive path exists between the vehicle and the test chamber.

During the radiated immunity test, an isotropic field probe *may* be placed either within, or close to the vehicle, to provide confirmation that a field is being generated within the chamber.

CCTV cameras shall be used both inside and outside the vehicle, to monitor vehicle systems. These shall be positioned such that all systems defined within the Test Plan, together with other potential victim systems, are adequately monitored during the test.

Suitably positioned microphones shall also be used to facilitate audio monitoring of the vehicle. These will be connected to the control room via fiber optic or suitably filtered, high impedance, links.

Other monitoring equipment shall be utilized as defined within the Test Plan or as dictated by the functionality of the systems to be monitored.

5.1.4 Vehicle Operation During Testing

The precise operational conditions required for the test shall be defined within the Test Plan.

Where the Test Plan requires operation under simulated driving conditions, the vehicle shall be positioned on the test facility dynamometer and secured by suitable means. The vehicle shall be operated as near as is possible to a "normal driving situation", with doors, bonnet (hood) and boot (trunk) closed.

The speed of the vehicle on the dynamometer, and the operational condition of other vehicle systems, shall be as defined in the Test Plan.

The EMC chamber shall be cleared of personnel and any unnecessary equipment prior to commencing the test.

5.2 RADIATED IMMUNITY TESTING

5.2.1 EXTERNAL FIELD

Immunity testing of the whole vehicle, to the effects of externally generated fields, shall be performed in a semi-anechoic chamber in general accordance with specifications ISO 11451-1 and ISO 11451-2, using the procedures, test methods and equipment defined therein, with the modifications detailed in the following paragraphs.

a. Field Generating Antenna Polarization and Position,

The field-generating antenna shall be vertically polarized. Additional testing may be optionally performed with the antenna polarized horizontally, for frequency range(s) and illumination position(s) specified in the Test Plan.

The field-generating antenna shall be positioned such that the test field illuminates the majority of the vehicle. This may require illumination of the vehicle from the front, sides and the rear. The required positions of illumination shall be detailed within the Test Plan.

b. Reference Position

Tests with the field generating antenna at the front of the vehicle shall use the "Vehicle Reference" position calibration data, whilst tests with the field generating antenna at the rear shall use the "Vehicle Rear Reference Position". Tests utilizing a field generating transmission line, or a field generating antenna at the sides, may use either the "Vehicle Reference" or the "Facility Reference" position calibration data.

For a field generating antenna at the rear of the vehicle, the Vehicle Rear Reference position is defined at 0.2 m (+/- 0.2M) in front of the rear axle (i.e. toward the vehicle center), along the vehicle's line of longitudinal symmetry.

Within ISO 11451-2, the Facility Reference position is defined as being "at the centre of the test region", from which it *may* be assumed that it is also intended to be coincident with the centre of the test vehicle. In order to ensure adequate illumination of potential victim systems, however, it *may* be necessary to redefine the Facility Reference position at an alternative position along the vehicle's line of longitudinal symmetry.

If the required location of the Facility Reference position is NOT at the approximate centre of the vehicle, then it's precise location shall be detailed within the Test Plan.

c. Maximum Frequency Step Sizes

The following frequency steps are the <u>maximum</u> that shall be used in each of the frequency bands defined:

1 MHz to 30 MHz	-	Step size = 500 kHz
30 MHz to 200 MHz	-	Step size = 2 MHz
200 MHz to 500 MHz	-	Step size = 5 MHz
500 MHz to 1 GHz	-	Step size = 10 MHz
above 1 GHz	-	Step size = 20 MHz

If an enhanced frequency resolution is required, (e.g. to more accurately define a susceptibility event), these step sizes may be reduced. The Test Plan will include details of any required enhancements to the frequency resolution.

d. Dwell Times

At each frequency step, the RF field shall be applied to the vehicle for a minimum of 2 seconds each, for the carrier wave and modulated test signals.

Where the reaction time of specific systems on the vehicle is known to exceed this time period, the dwell time may be increased. Any system requiring an extended dwell time will be detailed within the Test Plan.

e. Calibration Method

The calibration and test procedures detailed herein are based upon the FORWARD POWER applied to the test antenna, as the reference parameter.

The test chamber shall be pre-calibrated using the substitution method, with both vertically polarized and, where applicable, horizontally polarized field-generating antennas. The field probes shall be positioned as detailed within ISO 11451-2, using a combination of single field probe and four field probes at the reference point, as detailed below:

1 MHz to f_P :	single field probe
f_P and above :	four field probes

The breakpoint f_P shall be in the range 20 MHz to 100 MHz and shall be reported in the test plan if not coincident with the transition from a transmission line system to a broadband antenna.

Note: Below 100 MHz, the four probes tend to perform as a single probe, but at the lower average height of 0.875m.

If calibration is performed using a probe configuration differing from that specified above, it shall be fully described in the Test Plan.

Calibration measurements shall be made at the reference position with sufficient frequency increments to ensure the required level of frequency resolution, during both the initial test and any subsequent susceptibility profiling.

If the distance between the Vehicle Reference point and field-generating antenna is maintained constant, and they move simultaneously for differing vehicle wheelbases, a single calibration may be used for a range of Vehicle Reference positions (even varying by more than 0.2 m), if the calibrations have been shown to be equivalent over that range.

f. Test Field Strength and Profile

The level of the RF field to be applied to the test vehicle shall be as defined by the Attribute Requirement specified in the Test Plan.

At low frequencies, (typically from 20 MHz up to about 50 MHz), limitations in the design of broadband antennas *may* prevent the generation of a test field at the levels specified within the Attribute Requirement. Where the required field is <u>not</u> achieved, the actual field level shall be detailed within the test report.

The applied field shall be increased up to the applicable test level as rapidly as the control system will permit, commensurate with the requirement to avoid excessive "overshoot" of the field beyond the test limit.

The field shall be maintained at the test limit, for the duration of the dwell period, for each of the modulated and un-modulated conditions.

During frequency transitions the test field shall be reduced by at least 20 dB before moving to the next test frequency.

g. Determination of Susceptibility Thresholds

If any susceptibility events are detected during testing, all symptom(s) shall be recorded and sufficient measurements made to ensure that the profile is adequately described, in terms of both the amplitude and frequency of the interfering signal.

When a susceptibility event is detected, the threshold shall be determined as follows:

1) The RF level shall be lowered until the susceptibility disappears,

2) The RF level shall be increased until the susceptibility re-appears.

This last level is defined as the susceptibility threshold.

Either manual or automatic methods may be used to determine the profile of the susceptibility event, provided that sufficient resolution is employed to define the profile.

At each frequency, where an event is detected, the susceptibility threshold shall be recorded in terms of the calculated field strength at the reference point.

The threshold data shall be presented in the Test Report in graphical and/or tabular format.

5.2.2 ON-BOARD MOBILE TRANSMITTER SIMULATION

Testing of the whole vehicle, to demonstrate immunity to on-board mobile transmitters, shall be performed in either a shielded absorber-lined chamber, or outdoor test site. (Regulatory authorization is normally required for outdoor testing.) Testing shall be in general accordance with specifications ISO 11451-1 and ISO 11451-3, using the procedures, test methods and equipment defined therein, with the modifications detailed in the following paragraphs.

This procedure describes simulation of a mobile transmitter installation, using an off-board RF source. See Figure 1 for setup. Alternatively, an on-board commercial transmitting source may be used if specified in the test plan.

The following test parameters shall be specified in the Test Plan:

- **Net power to be delivered to the antenna.**
- **Antenna position(s) and type. See paragraph e.**
- **Test frequency(s). See paragraph g.**
- **Test signal modulation(s) and exposure sequence.**

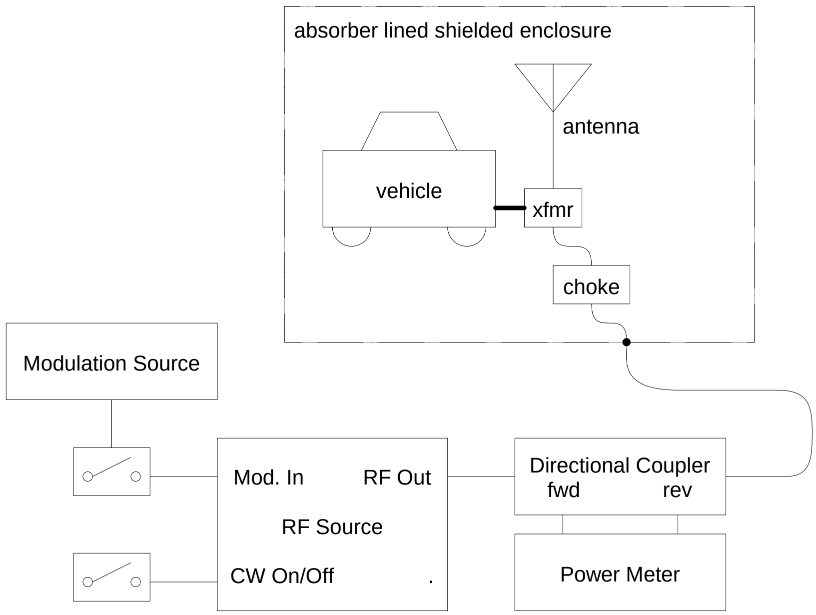


Figure 1 - Mobile transmitter simulation setup

a. Reference Parameter

The reference parameter for the test is forward power. The required forward power is that which causes the specified net power (from the Test Plan) to be delivered to the antenna feed-point. The formulas provided in Attachment 10.2 are used to calculate the required forward power based on the ratio of reflected to forward power, and the transmission line loss. When modulation is applied, the power is expressed in terms of the RMS value based on Peak Conservation (see ISO 11451-1).

b. RF Source

The off-board RF source must have adjustable output power sufficient to overcome cable loss and antenna mismatch loss. This can be accomplished with a signal generator and broadband amplifier, or a high power transceiver (e.g., 200 Watt Kenwood TS-480HX for $1.8 \leq f < 30$ MHz).

c. Power Meter

The power meter shall provide the means to directly measure power based on Peak Conservation. If indirect means of determining modulated peak power are to be used, they shall be described in the test plan.

d. Transmission Line & Choke

A common mode choke is utilized in the transmission line at the point of connection to the antenna feed assembly. See Attachment 10.0 for choke details applicable for $1.8 \leq f < 30$ MHz. For $f \geq 30$ MHz, a group of 10 or more ferrite beads with $\mu_r \geq 800$ is required. The loss of the transmission line (including choke) between the directional coupler and antenna feed must be measured at established facility calibration intervals.

e. Antenna

For the frequency range $1.8 \leq f < 30$ MHz and unless otherwise specified in the test plan, the antenna position and type shall be as described in Attachment 10.0. For $f \geq 30$ MHz, magnetically mounted quarter wave monopoles shall be used unless otherwise specified in the test plan.

f. Antenna Analyzer

For the frequency range $1.8 \leq f < 30$ MHz, use of a portable antenna impedance analyzer (e.g. MFJ-259B) at the antenna is recommended for antenna tuning, based on RF safety and speed considerations. Do not bypass the antenna choke when connecting the analyzer to the antenna for tuning. For $f \geq 30$ MHz, an antenna analyzer is not required.

g. Test Frequencies

For the frequency range $1.8 \leq f < 30$ MHz, the test frequencies are as given in Table 1 unless otherwise specified in the Test Plan.

Freq (MHz)	tolerance (kHz)
1.8	+50 / -0
2.0	+0 / -50
3.5	+50 / -0
4.0	+0 / -50
7.0	+/- 1
7.3	+/- 1
10.125	+/- 1
14.2	+/- 1
18.1	+/- 1
21.2	+/- 1
24.95	+/- 1
29.0	+/- 1

Table 1- Default test frequencies

h. Performing the Test

Install the antenna.

Adjust antenna, if necessary, to obtain SWR $\leq$ 2:1 at antenna. For 1.8 $\leq f <$ 30 MHz, use or bypass the matching transformer as needed. For $f \leq$ 4 MHz, adjust the antenna so that the minimum SWR frequency occurs within the allowable frequency tolerance and record that frequency for testing. For $f >$ 4 MHz, use the specified test frequency.

Note: **For safety, disconnect antenna from transmitter cable before adjusting. Using an antenna analyzer enables antenna adjustment at safe power levels.**

Re-connect transmitter feed cable to antenna choke.

Set RF source frequency and modulation.

Adjust forward power to a level less than the net power specified in the Test Plan. Read and record forward and reflected power levels.

Calculate the forward power required to deliver the net power specified in the test plan, using formulas provided in Attachment 10.0.

Adjust RF source to obtain the required forward power within $\pm$ 0.2 dB.

Apply the exposure sequence defined in the Test Plan. Observe and record any vehicle effects.

If required, turn off the RF source, change modulation, and re-establish forward power for each modulation specified. Observe and record any vehicle effects.

Repeat test for each of the test frequencies.

5.2.3 ON-BOARD HANDHELD TRANSMITTER SIMULATION.

Testing of the whole vehicle, to demonstrate immunity to on-board hand-held transmitters, shall be performed in either a shielded absorber-lined chamber, or a screened room. Testing shall be in general accordance with specifications ISO 11451-1 and ISO 11451-3, using the procedures, test methods and equipment defined therein, with the modifications detailed in the following paragraphs.

This test is intended to simulate handheld transmitters with <u>integral</u> antennas only. Tests that simulate transmitters with <u>external</u> antennas are beyond the scope of this section of the test procedure.

a. Handheld Transmitter Mimic

The elevated RF power levels required by this test can not be generated using commercially available, "off the shelf" mobile transmitters and, hence, an alternative method of field generation has been identified.

As suggested within ISO 11451-3, a method of simulating the threat from a portable transmitter with integral antenna, is to use a suitable transmitter "mimic", located at various positions within the vehicle and energized with RF power generated by a broadband RF amplifier and signal generator.

The construction details of this mimic are not well defined within the ISO standard however, and Attachment 10.3 to this document offers some clarification.

b. Frequency Bands and Step Sizes

The test shall be performed across a series of discrete frequency bands, as identified within the applicable Attribute Requirement, or the Test Plan. The frequency of the applied signal shall be incremented in step sizes also as detailed within the Attribute Requirement or Test Plan.

c. Test Positions

During the test, the mimic shall be placed at various pre-determined locations within the vehicle, as detailed within the Test Plan, and energized at the power levels stated either within the Attribute Requirement or the Test Plan.

(Attachment 10.4 to this document gives guidance upon the identification and selection of the mimic test positions.)

d. Power Level and Equipment Calibration

During this test the vehicle must only be exposed to RF signals, as detailed within the applicable Attribute Requirement or Test Plan. Unless specified otherwise within the Attribute Requirement or Test Plan, continuous wave signals at the full test level must not be applied to the vehicle, as this may cause significant over testing and could produce erroneous susceptibilities.

The level of modulated RF power to be applied to the mimic during the test is related to the "free space performance" of the antenna system and, as the test is performed with the antenna in close proximity to the vehicle metal work, a pre-calibration procedure may be required to establish the appropriate signal generator drive levels.

Attachment 10.5 to this document describes a calibration procedure.

e. Dwell Times:

At each frequency step, the RF power shall be applied to the mimic for a minimum of 2 seconds. Where the reaction time of the specific system under test is known to exceed this time period, the dwell time may be increased.

Any system requiring an extended dwell time shall be detailed within the Test Plan

f. Performing The Test

The method described below has been written to ensure that the vehicle will not be exposed to over-testing during the performance of this test. Alternative methods may be used, however, provided they meet the intention of this test and DO NOT expose the vehicle to test levels greater than 0.5 dB higher than those specified. Approval of alternative test methods shall be sought before proceeding with the test.

Fit the appropriate ¼ wave antenna to the mimic and place it at one of the predetermined test positions.

Set the signal generator to the first frequency step of the band to be tested, set it's output to CW, and adjust the RF level to a value <u>10 dB less</u> than that established during the calibration process.

Switch on the RF output and measure and record the forward and reverse power readings, shown on the power meter. This will allow subsequent assessment of antenna match and allow calculation of the amplifier gain at each frequency, to facilitate thresholding of any susceptibilities. Switch off the signal generator output.

Set the signal generator modulation in accordance with requirements for the frequency band under test, as detailed by the Attribute Requirement or within the Test Plan. Increase the RF output level to the value determined during the calibration process. Apply the modulated signal for the appropriate dwell period and monitor the vehicle system.

If any susceptibilities are noted, when the vehicle is exposed to the modulated signal, record all symptoms and determine the threshold in terms of frequency extent, and signal generator drive.

At each frequency step across the susceptibility event, calculate the gain of the amplifier, (using the data gathered in the first step of the test), and hence, obtain the RF power output of the amplifier for each of the recorded signal generator drive levels.

Deduct the loss in the antenna feed cable and, therefore, establish the RF power level actually applied to the antenna base at the threshold of susceptibility.

The implication of any susceptibility shall be assessed in accordance with the Functional Importance Classification, Performance Classification and Test Level, as described within the Attribute Requirement or Test Plan, for inclusion in the test report.

Repeat the test for each frequency band identified in the Attribute Requirement, and for every test position identified, changing mimic antennas as necessary.

5.3 EMISSIONS TESTING

5.3.1 ON-BOARD RADIATED EMISSIONS – 150kHz to 2.5GHz

This part of the test procedure specifies the method for "on-board" measurement of radiated emissions over the frequency range 150kHz to 2.5GHz, and is used for verifying the EMC performance of all vehicle systems, when combined as a complete vehicle. The permissible level of emissions and detector type(s) will be as detailed within the applicable Attribute Requirement or the Test Plan.

The method to be used for this test is as defined within CISPR 25 and involves measurement of the output voltage from the antenna of the vehicle system being protected. If there are multiple broadcast reception antennae, (e.g., as used by a diversity antenna system), the measurement procedure shall, where possible, be repeated with the EMI receiver connected in turn to each antenna structure.

Where access to the antenna is impractical, (for example, where it is integral within an ECU, or located behind non-removable trim), or in the case of vehicles where an antenna is not already installed, then a similar antenna may be used for the measurement, located as close as possible to the actual system antenna. A suggested antenna type is a quarter wave monopole, mounted over a suitable ground plane, i.e. a quarter-wave radius disc. During measurements the antenna shall be as close as possible to the "normal operating position".

Although this test covers the frequency range 150kHz to 2.5GHz, measurements will only be made across the bands specified within the Attribute Requirement or Test Plan issued for the specific vehicle platform.

The frequency range 1 GHz to 2.5 GHz is not covered by CISPR 25, and the following parameters shall be used for measurements in the extended frequency range.

	Swept Receivers	**Stepped Receivers**
Detector	Peak or Average	Peak or Average
Measurement Bandwidth	9 – 10 kHz	9 – 10 kHz
Video Bandwidth	100 kHz	
Frequency Sweep Rate	1 sec/MHz	
Maximum Frequency Step Size.		½ Meas. Bandwidth.
Measurement Time per Frequency Step		5 ms

Table 2 – On-board emission measurement parameters

In general, measurements of emissions shall be made with the vehicle functioning in all potential operating conditions, i.e., – ignition off, ignition 1 - (auxiliary), ignition 2 - (ignition key immediately before the "crank" position). Measurements of broadband emissions from the engine and ignition system will be made with the engine running at 1500 ±200 RPM. The precise operational condition of the test vehicle shall be detailed within the Test Plan.

For short duration systems, (e.g., – window lift motors), the individual frequency sweeps defined within CISPR 25 shall be sub-divided into smaller segments, in order to ensure a complete emissions profile is captured for each vehicle system.

The effect of all emissions upon the vehicle's broadcast reception systems may alternatively be assessed by performing the Audio Test, detailed within the document "Audio System Vehicle-Level EMC Test Plan and Requirements" (AV-EESE-EMC-03-100-02) also known as ARL 09-0433.

5.3.2 OFF-BOARD RADIATED EMISSIONS – BROADBAND & NARROWBAND

This part of the test procedure specifies the method for measurement of off-board radiated emissions.

The test method to be used for this measurement is as defined within European Directive 95/54/EC. Broadband measurements shall be made in accordance with the procedure detailed in Annex IV of the Directive, whilst Narrowband measurements shall be made in accordance with Annex V.

Both test methods permit the use of either an enclosed test facility or an Open Area Test Site, with either 3m or 10m antenna separation distances. For 10m sites utilizing conducting ground planes, correlation factors are provided in Attachment 10.6.

If a specific test method is required, this shall be stated within the Test Plan. The actual test method selected shall be detailed within the test report.

The results of the measurement shall be assessed against the appropriate performance requirement.

5.4 UNDER VOLTAGE

5.4.1 Instrumentation, Equipment, and Facilities

a. Adjustable power supply capable of providing 0 to 13 VDC.

b. Cables of appropriate gauge, length, and terminations for connection to vehicle battery cables.

c. Voltmeter

d. Ford/Rotunda diagnostic tool or equivalent for retrieving subsystem status codes.

5.4.2 Test Setup

a. Install vehicle on dynamometer.

b. Check, record, and clear any diagnostic codes.

c. Turn the ignition and all accessories OFF.

d. Disconnect the positive and negative vehicle battery leads from the battery terminals and disconnect the alternator from the positive battery lead.

e. Connect power supply to vehicle battery leads.

f. Connect voltmeter to vehicle battery terminals. Do not connect to power supply leads at power supply end.

5.4.3 Conducting the Test

a. Turn "on" power supply and adjust voltage to 13 VDC.

b. Start vehicle and accelerate to 35 MPH. Engage Vehicle Speed Control (VSC) or maintain speed manually.

c. Activate all vehicle electronics that are to be tested, as specified in the Test Plan.

d. Record any non-functioning devices.

e. Reduce the power supply voltage by 0.5 V. Record any non- functioning devices.

f. Repeat step e until vehicle stalls.

g. Stop the vehicle, place it in neutral, turn all the loads off, and turn off the ignition.

h. Re-adjust voltage to 13 VDC.

5.4.4 Post-test Evaluation

a. Verify that all tested electrical systems are undamaged and fully operational. Record any changes in operation.

b. Check, record, and clear codes using the diagnostic tool.

c. If fault indicators or codes were induced because the test was not performed using a 4-wheel dynamometer (e.g., with ABS), then clear the indicators or codes and repeat the test with the vehicle in neutral idle.

d. Turn ignition OFF.

e. Turn adjustable power supply OFF.

f. Disconnect the Under Voltage fixtures from vehicle and reconnect vehicle battery.

5.5 OVER VOLTAGE

5.5.1 Instrumentation, Equipment, and Facilities

a. Adjustable power supply capable of providing 0 to 19 VDC (required only if the test is conducted using the Power Supply Method).

b. Voltmeter

c. Ford/Rotunda diagnostic tool or equivalent for retrieving subsystem status codes.

d. Alternator test point extension wire with grounding clip.

5.5.2 Test Setup

a. Disconnect battery negative or positive terminal. (For safety reasons, the terminal connected to vehicle chassis is preferably disconnected.)

b. Install alternator test point extension wire, if necessary. This provides a means to ground the test point when conducting paragraph 5.5.3c without power supply. Alternator removal and disassembly may be required to solder extension wire to the test point.

Note: For testing an integral alternator/regulator system using the full field method (par. 5.5.3), install vehicle transient fixture per Figure 2 to measure voltage and current during the test. For other tests, use appropriate test connections.

c. Re-connect battery negative terminal.

d. Check, record, and clear codes using the diagnostic tool.

e. With ignition switch in "run" position, turn on and verify operation of all vehicle electronic systems to be tested, per the Test Plan.

5.5.3 Conducting the Test – Full Field Method

a. Drive vehicle for five minutes and then turn off all operator-controlled vehicle electronics. Turn ignition off.

b. Verify that vehicle battery is fully charged (see paragraph 6.1).

c. Enable maximum alternator output by grounding alternator test point.

d. Start and drive vehicle at 40 MPH with VSC (if equipped) for five minutes. Record the maximum voltage and amperage readings, and any changes in the functionality of devices tested per the Test Plan.

e. Stop the vehicle and turn off the ignition.

5.5.4 Conducting the Test – Power Supply Method

a. Operate vehicle for five minutes and then turn off all operator-controlled vehicle electronics. Turn ignition off.

b. Disconnect the positive and negative vehicle battery leads from the battery terminals and disconnect the alternator from the positive battery lead.

c. Connect power supply to vehicle battery leads.

d. Connect voltmeter to vehicle battery terminals. Do not connect to power supply leads at power supply end.

e. Set power supply as follows:

1) Voltage as read previously

2) Current limit set to maximum available from vehicle alternator. If this current rating is not available, the actual current limit used shall be documented in the test report.

f. Start and operate vehicle at 40 MPH with VSC (if equipped) for five minutes. Increase the power supply from nominal voltage in increments of 0.5 V. Record any changes in the functionality of devices tested per the Test Plan, at each individual increment up to 19 V.

5.5.5 Post-test Evaluation

a. Disconnect the alternator test point from ground.

b. Start the vehicle and verify charging system operation.

c. Verify operation of all vehicle electronic systems to be tested, per the Test Plan.

d. Check, record, and clear codes using the diagnostic tester.

e. Turn ignition off. Disconnect battery negative terminal. Remove test fixtures and/or modifications to alternator. Re-connect battery negative terminal.

f. Start the vehicle and verify charging system operation.

g. Clear codes using the diagnostic tool.

5.6 ALTERNATOR LOAD DUMP

5.6.1 Instrumentation, Equipment and Facilities

a. Storage oscilloscope.

b. DC voltmeter.

c. Ford/Rotunda diagnostic tool or equivalent for retrieving subsystem status codes.

d. Vehicle transient fixture (See Figure 4 for a suggested configuration).

e. Resistive or Active Load Boxes.

5.6.2 **Test Setup**

Install vehicle transient fixture for the integral alternator/regulator system. See Figure 2. For other alternator/regulator configurations use appropriate test connections. Do not disconnect battery at this time.

Set oscilloscope time base to 10 ms/div.

5.6.3 **C**onducting the test

Turn OFF all electrical loads and start engine then carefully disconnect the battery negative(-) lead and idle engine for 1 minute. Record any change in function. **IF THE ENGINE STALLS, TERMINATE THIS TEST IMMEDIATELY AND NOTIFY THE REQUESTER. ATTEMPT TO CONTINUE CONDUCTING THE OTHER REQUESTED TESTS.**

Otherwise, operate the engine at 2000 RPM ± 200 RPM for approximately 1 minute. Adjust the load so that the total current into the load is approximately 100 % of the alternator's rating. For each of the following items (if present), run the vehicle at 2000 rpm ± 200 rpm for 1 minute, activate the transient fixture,, capture and save load dump transient with the oscilloscope, and record any changes in function:

a. All vehicle electrical loads OFF.

b. Defrost ON with fan set to highest speed on VENT position and temperature set to HIGH.

c. Automatic temperature control ON with blower on lowest speed.

d. Radio ON.

e. Communications equipment ON.

f. Wipers ON at highest speed.

g. Any other items specified in the "Alternator Load Dump" section of the Test Plan.

5.6.4 Post-Test Evaluation

Remove the resistive load box and oscilloscope. Verify that all electrical/electronic systems/subsystems are functional after test is completed. Record any changes in vehicle functions. Record and clear any diagnostic codes. Report any damaged systems in the test report.

5.7 REVERSE BATTERY

5.7.1 Instrumentation, Equipment and Facilities.

a. Digital storage oscilloscope.

b. Ford/Rotunda diagnostic tool or equivalent for retrieving subsystem status codes.

c. Reverse battery fixture (typical schematic shown in Figure 5).

5.7.2 Test Setup

a. Verify that vehicle battery is fully charged (see paragraph 6.1).

b. Turn ignition to RUN.

c. Turn ON items specified in the “Reverse Battery” section of the Test Plan.

d. Turn ignition OFF.

e. Disconnect battery cables.

f. Install reverse battery fixture and oscilloscope as shown in Figure 3. Connect one oscilloscope channel to an alternator output lead (typically the “A” lead terminal gap at the voltage regulator). Connect another oscilloscope channel to the “supply” terminal on the vehicle fuse panel. Set both oscilloscope channels to 5 V/div and 200 ms/div. Set the oscilloscope to trigger when the reverse battery test fixture is switched to TEST.

g. Turn reverse battery fixture ON.

5.7.3 Conducting the Test

a. Turn ignition to RUN but do not start the engine.

b. Initiate the reverse battery test.

c. Capture and save reverse battery traces.

d. Turn ignition and all accessories OFF.

e. Return the vehicle to normal battery connections.

5.7.4 Post-Test Evaluation

Verify that all electrical/electronic systems/subsystems are functional after test is completed. Record any changes in vehicle functions. Record and clear all diagnostic codes. Report any damaged systems in the test report.

5.8 ELECTROSTATIC DISCHARGE TESTS

ESD testing of the Whole Vehicle shall be performed in accordance with the applicable sections of specification ISO 10605, using the procedures, test methods and equipment defined therein, with the additional information contained in the following paragraphs. The required levels of vehicle immunity to ESD will be as detailed within the applicable Attribute Requirement or the Test Plan.

WARNING:-
HIGH VOLTAGE LEVELS PRODUCED BY THE ELECTROSTATIC DISCHARGE SIMULATOR CAN CAUSE EXTREME SHOCK AND MAY BE FATAL. OBSERVE THE SAFE OPERATING PROCEDURES DETAILED IN THE ESD SIMULATOR MANUAL.

5.8.1 Preliminary

Ensure that no high levels of petrol vapor are present in the vicinity of the vehicle under test and the exhaust extraction system is running.

5.8.2 ESD Test Temperature and Humidity

The test facility ambient temperature shall be monitored, and if possible, maintained within the range 23 ± 5 °C. The humidity level within the test facility shall be monitored, and if possible, maintained between 30% and 60%. If practical considerations prevent the maintenance of the temperature or humidity within this range, the test requestor shall be notified at the earliest opportunity, and the actual temperature and humidity recorded during the test shall be presented within the test report.

5.8.3 ESD Test Procedure

For each discharge position, three positive and three negative polarity discharges shall be applied. Allow at least 2 seconds between each discharge.

Each subsystem shall be enabled prior to attempting to apply discharges (e.g., headlights should be "on" before attempting to discharge to headlight switch). Exceptions or additional test conditions shall be specified in the test plan.

The vehicle shall be tested in the following mode:

1. Engine at idle, transmission in Neutral; hazard indicators, headlamps, wipers, entertainment systems, all "on".

The following optional modes may be specified in the test plan:

2. Ignition on, hazard indicators, headlights, wipers and entertainment equipment on.
3. All doors locked, alarm armed and bonnet (hood) closed.
4. Doors closed, engine off and bonnet (hood) up.

For modes 1, 2 and 3 allow at least 10 seconds between each discharge. For mode 4 allow at least 20 seconds between each discharge.

5.8.4 ESD Test Levels and Generator Settings

Two versions of the ESD generator are specified for this test, both having a 2k ohm series resistor (R), but with either a 330 pF or a 150 pF parallel capacitor (C.)

The applicable test levels and corresponding values of R and C are specified within the attribute requirement or the Test Plan, together with the acceptable standards of system performance during and after the discharge.

5.8.5 Discharge Points

The Test Plan will list the required ESD discharge points, showing their accessibility and discharge voltage level.

5.9 24 VOLT JUMP START

5.9.1 Instrumentation, Equipment, and Facilities

a. 24 Volt Jump Start Fixture: A fixture capable of providing 24 VDC. Jumper cables 3.6m (12 Ft) long and appropriate gauge terminated with alligator clamps to connect to vehicle battery cables. Connections within the fixture are via a permanent terminal connection.

b. Digital storage oscilloscope or equivalent.

c. Ford/Rotunda diagnostic tool or equivalent for retrieving subsystem status codes.

d. Voltmeter

e. Temperature indicator.

5.9.2 Test Setup

a. If the vehicle is equipped with an electronic automatic temperature control set it to "manual" mode.

b. Turn the ignition and all accessories OFF. Disable the start circuit to allow engine cranking without permitting the engine to start. The preferred method is by disabling the fuel pump inertia switch. If this is not feasible, consult the test requester and document the method used in the test report.

c. Disconnect or remove the battery from the vehicle. Install "dead battery" with less than 6 volts open circuit voltage.

d. Perform the following pre-test set-up:

1) Ensure that the ignition switch is in "RUN" position.

2) Set heater/defroster fan to high blower position.

3) Set windshield wiper to "interval" position.

4) Ensure that parking brake is not engaged (Canadian daytime running light ON).

5) Set auto lamps to OFF position (if applicable).

6) Ensure that headlamp switch is in OFF position.

7) If vehicle is equipped with air suspension, measure ride height between wheel rim and fender. With air suspension switch OFF, ballast to low ride height. Then set air suspension switch to ON position.

5.9.3 Conducting the Test

NOTE: This procedure assumes negative (-) ground. For vehicles with positive (+) ground, modify this procedure as appropriate.

a. Ensure that the 24 volt jump start test fixture is OFF. The test fixture should be at AMBIENT temperature prior to jump start. Connect the fixture as follows:

1) Connect the positive RED (+) end of the fixture cable to the positive (+) terminal of the test vehicle's battery cable. Connect the negative BLACK (-) end of the fixture cable to an engine bolt, good metallic contact spot on the engine or other ground point.

2) DO NOT connect jumper cables to fuel lines. Make sure the jumper cables are not in the way of moving engine parts. Do not allow the positive (+) test fixture cable to contact the negative (-) test fixture cable.

3) Connect necessary instrumentation to record voltage at battery cables.

b. Ensure adequate exhaust and ventilation for test fixture.

c. Start the test fixture and adjust the throttle until the voltage at the jumper cables read 24 Volts (± 0.5 V). DO NOT attempt to crank vehicle engine.

d. After 1 minute, crank vehicle engine for ~10 seconds. After crank, leave key in RUN position for ~15 seconds.

e. Repeat 10 second crank and 15 second pause for a total of three times. Record any changes in operation.

f. Turn the test fixture OFF. Disconnect jumper cables.

5.9.4 Post-test Evaluation

a. Reinstall and reconnect vehicle battery. Reconnect inertia switch, or otherwise re-establish original configuration of the start circuit (according to the way the starting circuit was disabled in step 5.7.2.b).

b. Verify that all electrical systems are undamaged and fully operational. Record any changes in operation.

c. Run self-tests to determine whether the engine or related systems have been damaged or affected. Record all diagnostic codes.

d. If vehicle is equipped with air suspension, measure ride heights between wheel rim and fender. Compare ride heights measured in step 5.7.2.d.7.

e. Verify that the alternator and regulator are functioning properly by connecting the voltmeter to the battery terminals and observing a minimum of 13 Volts with the engine running.

6.0 GENERAL INSTRUCTIONS/DEFINITION

6.1 A Fully Charged Battery is one with electrolyte at a specific gravity of 1.260. A maintenance free battery shall have a minimum terminal voltage of 12.4 volts after removing surface charge.

6.2 Engine idle speed is the manufacturer's recommended value for a warm engine, unless otherwise specified.

7.0 PRESENTATION OF DATA

7.1 All data shall be clearly labeled with the vehicle tag number, model year, engine displacement, date of test, and test number assigned by the test activity.

7.2 All test data shall be electronically stored and accessible in an online database where possible.

7.3 All final reports shall include all data showing monitored voltages, transient waveforms, etc., from the test. Data should be presented and grouped by component or subsystem function.

8.0 REFERENCES

8.1 **COUNCIL DIRECTIVE 95/54/EC** (\\pdc00024\proj\wwemc\Standards\95-54-EC.pdf)

8.2 FCC Rules Part 15 (Code of Federal Regulations Title 47, Part 15).

8.3 CAN/CSA-C108.4-M92 Limits and Methods of Measurement of Radio Interference Characteristics of Vehicles, Motor Boats and Spark-Ignited Engine-Driven Devices, Canadian Standards Association

8.4 CISPR 25 (2002-08) Radio disturbance characteristics for the protection of receivers used on board vehicles, boats, and on devices - Limits and methods of measurement

8.5 ANSI C63.4-2003 American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

8.6 RE Site Correlation Factor Analysis (2003-09) (\\pdc00024\proj\wwemc\Radiated Emissions\RE_corrFactorAnalysis.doc)

8.7 ISO 9001 Quality management systems -- Requirements

8.8 ISO 11451-1 Road vehicles -- Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy -- Part 1: General and definitions

8.9 ISO 11451-2:2001 Road vehicles -- Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy -- Part 2: Off-vehicle radiation sources

8.10 ISO 11451-3:1994 Road vehicles -- Electrical disturbances by narrowband radiated electromagnetic energy -- Vehicle test methods -- Part 3: On-board transmitter simulation

8.11 ISO 10605:2001 Road vehicles -- Test methods for electrical disturbances from electrostatic discharge

8.12 ANSI C95.1-1999 IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz

8.13 Ford Motor Company Trustmark ARL's 09-0411, 09-0414, 09-0419, and 09-0426 for both Passenger Cars and Light Trucks.

8.14 Ford Motor Company non-Trustmark ARL's 09-0418, 09-0422, 09-0425, 09-0467, and 09-0468 for both Passenger Cars and Light Trucks.

8.15 FAP03-015, Control, Calibration, and Maintenance of Measurement and Test Equipment.

8.16 FAP03-179, Developing Corporate Engineering Test Procedures.

8.17 ES-XW7T-1A278-AC Component and Subsystem Electromagnetic Compatibility Worldwide Requirements and Test Procedures, Ford Motor Company.

9.0 RECORD OF REVISIONS

See metadata field "Review Note".

Technical changes in 2005 edition:

5.1.1 Lowered nominal test temperature from 23 to 22 °C
5.2.1 Horizontal polarization made optional
Reference position specified for antenna and TLS
Vehicle Rear Reference position defined
1 - 2 GHz maximum frequency step size defined
Calibration method (single & 4-probe) described with increased detail
Reporting requirement introduced for scan achieved field deviations
Reporting requirement removed for threshold forward and reflected power
5.2.2 On Board Mobile Transmitter Simulation added (with new Attachments 10.1 and 10.2 for antenna system and reference parameter definition)
5.3.1 On-board radiated emissions detector specification deferred to ARL or Test Plan
5.3.2 For on-board radiated emission measurements over conducting ground planes, correlation factors are provided in new Attachment 10.6
5.4 Under voltage procedure added
5.5 Over voltage procedure added
5.6 Removed requirement for fully charged battery in Load Dump setup.
Modified default Load Dump vehicle test conditions
5.8 Contingency defined for temperature and humidity variations
Reduced time between ESD discharges from 10 to 2 seconds
Modified default ESD vehicle test conditions

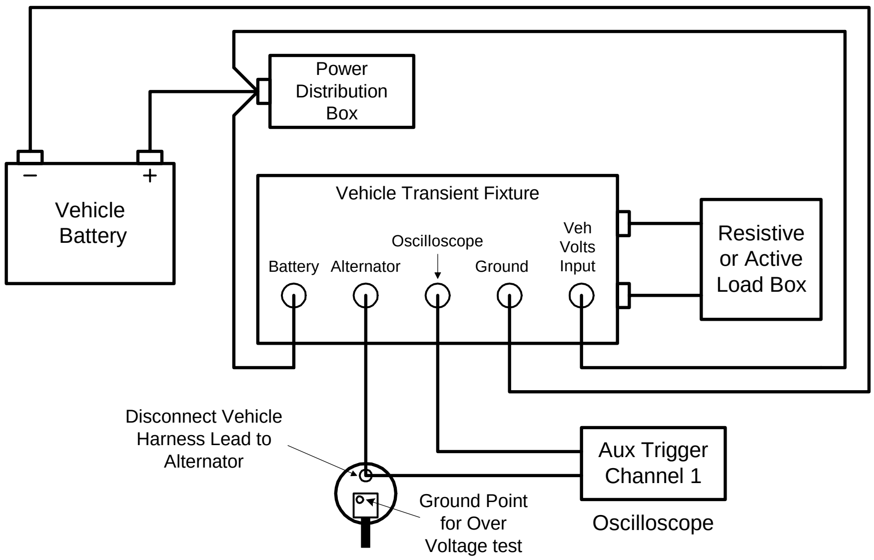
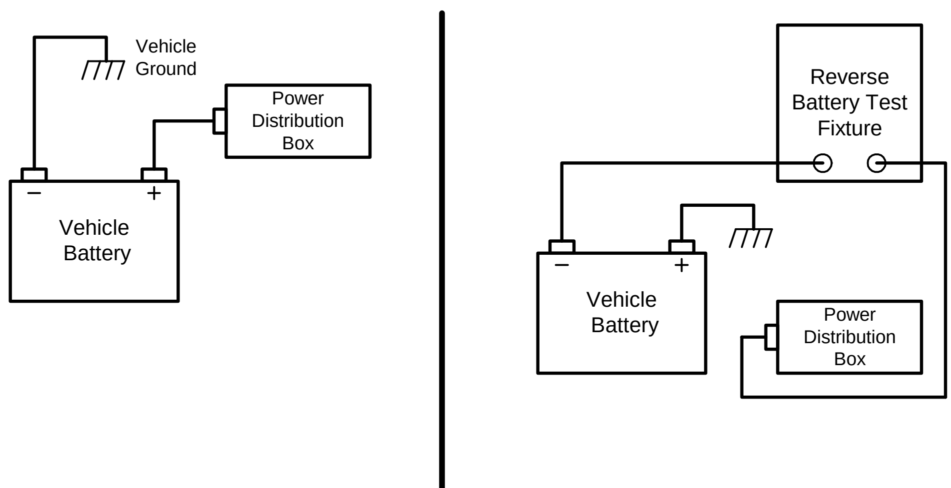


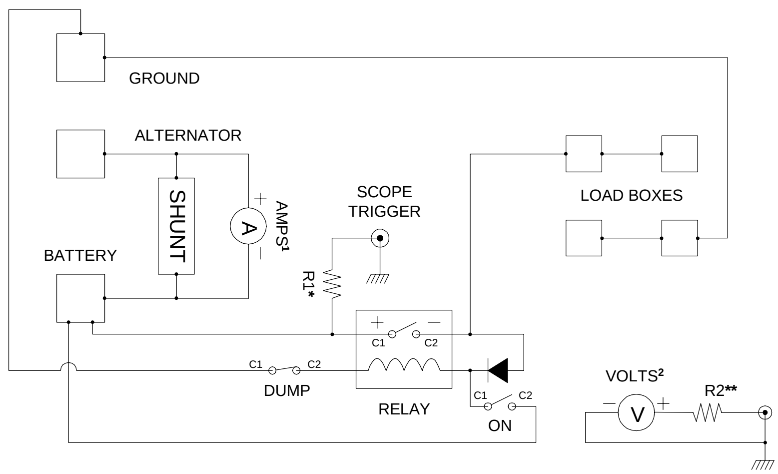
Figure 2 - Load Dump Connections



Normal Battery Connection

Reverse Battery Connections

Figure 3 - Reverse Battery Connections



AMPS[1] -- SIMPSON Amp-meter, Model#: 1327

VOLTS[2] -- SIMPSON DC Volt-meter, Model#: 1327

R1* -- 1kOhm, 0.25W

R2* -- 220 Ohm, 0.5W

Figure 4 - Typical Vehicle Transient Fixture Schematic

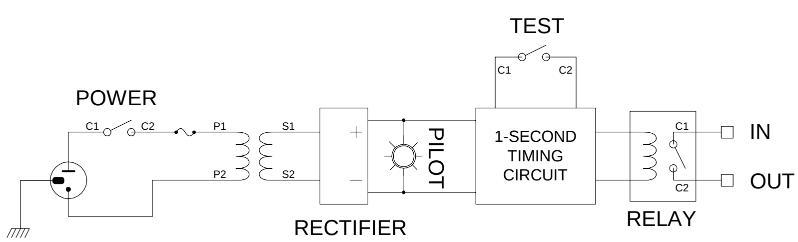


Figure 5 - Typical Reverse Battery Fixture Schematic

10.0 ATTACHMENTS

10.1 LAND MOBILE TRANSMITTER SIMULATION ANTENNA SYSTEM

10.1.1 Antenna

For the low HF land mobile frequencies, especially 4 MHz and below, antenna design and quality can significantly affect efficiency and test severity. A physically large loading coil and capacitive hat are generally required in order to reduce Ohmic losses in the coil, due to the low radiation resistance of an electrically short monopole. Antenna efficiency comparisons can be based on two port (s_{12}) measurements between the antenna and a current probe on vehicle wiring. An efficient antenna can be constructed using the following parts (from GLA Systems http://www.texasbugcatcher.com/index.html):

42" mast
#6160 coil (63 turns of 12 gauge wire, 6 turns-per-inch)
12" extension (between coil and capacity hat)
20" diameter capacity hat
59" whip (above capacity hat)

This antenna is tuned by shorting the required number of coil turns to achieve resonance. For higher frequencies, motorized inductor antennas work efficiently and enable rapid tuning (e.g., the HS-1800 (from High Sierra Antennas, http://www.cq73.com/FramePages/hsaSet.htm).

10.1.2 Antenna Matching

For an efficient HF mobile antenna, the feed impedance will approach 10 Ohms or less for low frequencies. A SWR of 2:1 or less can be obtained at all frequencies by mounting a 50:12.5 Ohm unbalanced-to-unbalanced (UNUN) transformer at the antenna feed, along with a means to connect or bypass it as needed. An example is part # W2FMI-4:1-HCU50 from Amidon Associates.

10.1.3 Transmission Line Choke

A common mode choke is required on the antenna transmission line at the antenna base, to prevent RF current from being diverted from the vehicle chassis, which is part of the mobile antenna system. A suitable choke can be constructed by passing 4 turns of RG-223 cable through four large ferrite beads (Fair-Rite #2643251002 or equiv.). Sufficient choke impedance is verified using a portable antenna impedance analyzer connected at the antenna feed. With the choke connected to the transmission line, there should be no change of antenna impedance when the choke cable shield is connected to the antenna feed shield.

10.1.4 Antenna mounting

The antenna base shall be located just behind the center of the rear bumper and grounded to the vehicle chassis with two 1" wide braid straps or equivalent, of minimum length. For testing on a dynamometer, the antenna may be supported by an adjustable cart of dielectric material.

10.2 MOBILE TRANSMITTER REFERENCE PARAMETER TARGET CALCULATION

This Attachment derives the target value for the forward power reference parameter, to produce the desired net power at the antenna. The cable between the power meter and antenna introduces cable loss and changes the observed antenna mismatch loss.

The cable attenuation *A* is described by:

$$A = \frac{P_{ant,FWD}}{P_{meas,FWD}}$$

where Pant,FWD is the forward power at the antenna and Pmeas,FWD is the measured forward power, i.e., the reference parameter. The reflection coefficient measured at the power coupler is:

$$\left|\rho_{meas}\right|^2 = \frac{P_{meas,REFL}}{P_{meas,FWD}}$$

The net power to the antenna is:

$$P_{ant,NET} = P_{ant,FWD} - P_{ant,REFL}$$

$$P_{ant,NET} = A \cdot P_{meas,FWD} - \frac{1}{A} \cdot P_{meas,REFL}$$

$$P_{ant,NET} = P_{meas,FWD} \cdot \left(A - \frac{\left|\rho_{meas}\right|^2}{A} \right)$$

For 100 Watts net power at the antenna, the reference parameter target value is:

$$P_{meas,FWD} = \frac{100}{\left(A - \frac{\left|\rho_{meas}\right|^2}{A} \right)}$$

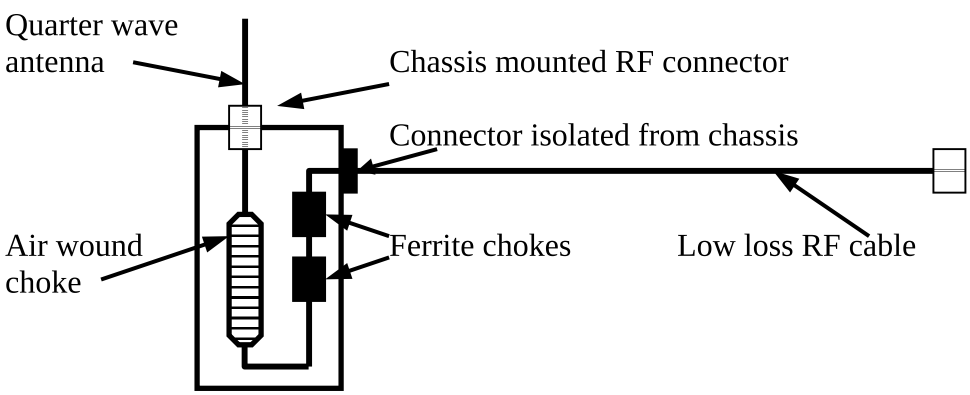
The value of A is measured prior to performing the land mobile simulation test. The value of $\left|\rho_{meas}\right|^2$ is obtained from forward and reflected power readings taken at reduced power, after antenna setup.

10.3 PORTABLE TRANSMITTER MIMIC

The mimic is constructed from a metal die cast box, having dimensions of 110mm x 60mm x 30mm. For each band to be tested, a quarter wave whip antenna, (or an antenna representative of the actual type used by the transceiver), is attached to a suitable RF socket, and mounted on the chassis of the box.

The antennas shall be designed to have a VSWR of no greater than 1.5:1 across each test band, (measured with the mimic in isolation from the effect of external structures.)

To reduce potential RF screen currents on the coaxial cable connection to the mimic, the cable is routed from the RF connector, through an air wound choke and two ferrite chokes, before it exits the box via an electrically isolated connection. See the diagram below.



By constructing the mimic in this way, the effects of the feed cable are minimized.

For further construction details on this equipment, contact the Land Rover EMC department.

10.4 IDENTIFICATION OF HAND-HELD TRANSMITTER TEST POSITIONS

These should be identified before the test and detailed within the Test Plan.

As guidance, the following selection process is suggested.

Identify the positions of all ECUs and sensors within the vehicle passenger and luggage compartments.

Establish the possible positions that a hand held transceiver could be deliberately placed, plus any areas where it may reasonably be expected that the transceiver could become unintentionally located. (For example, deliberately placed on the passenger seat by the driver, but dislodged to become trapped between the passenger door and the seat base)

Using the above information, identify the situations where the handheld transceiver may be located within 150mm of an ECU or a sensor.

The value of 150mm spacing, between the transceiver and ECU / sensor, is derived from an investigation performed at Land Rover Gaydon, into comparisons between component tests and exposure to cell phones. At separation distances greater than 150mm, the incident field is considered to be less severe than that experienced during Whole Vehicle Susceptibility and Component Testing.

These locations will become the positions in which the handheld mimic shall be placed during the test.

Some examples of likely positions are as follows:

Top of facia drivers and passengers side.

In front of instrument pack.

On centre console.

In cup holders.

In glove boxes.

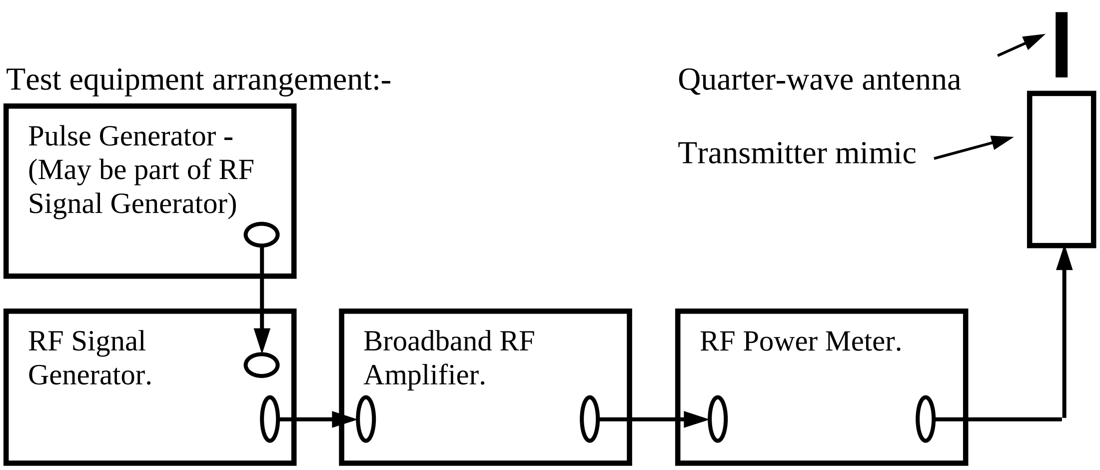
Held against centre of steering wheel

Alternately, there may already be information on potential problem areas, from sources such as customer feedback, and these positions shall also be detailed within the Test Plan.

10.5 CALIBRATION OF HAND-HELD TRANSMITTER TEST SET-UP

In order to generate a known power at the hand held transmitter mimic antenna base, the test equipment shall be calibrated as follows.

Test equipment arrangement:-



Prior to connecting the transmitter mimic to the power meter, measure and record the insertion loss in the mimic cable, from it's connection at the power meter through to the connector at the base of the ¼ wave antenna. Measure the loss for each test frequency of every band to be tested, using appropriate calibrated test equipment.

Using these insertion loss figures, calculate the required power meter indication to ensure the correct power is delivered to the base of the ¼ wave antenna. (i.e. with a cable insertion loss of 3 dB, and a required antenna power of 6 watts, the indication on the power meter will be 12 watts.)

Connect the correct antenna to the mimic for the frequency band under test and mount it on a non-conducting support, with the antenna vertically polarized, at a height greater than 1 meter above the ground plane and at least 1 meter from any other conducting surfaces.

The 1 meter height limit will ensure that the mimic is radiating in a "free field environment" and, therefore, that its impedance will be unaffected by the environment. This will minimize any reflected power from the antenna and allow the calibration to be based upon a measurement of incident (forward) power only, thus simplifying the process.

Set the RF signal generator output to CW and it's RF output level to minimum.

Adjust the frequency to the initial step of the band to be tested and increase the signal generator drive level until the required forward power, (as calculated previously), is indicated on the power meter.

Record the signal generator RF level required to obtain this power reading.

Adjust the signal generator frequency to the next step in the band, and repeat the above procedure.

Continue until the full frequency range for the antenna in use has been calibrated. Repeat the above procedure for all antennas to be used during the test.

10.6 RADIATED EMISSION SITE GROUND PLANE CORRELATION FACTORS

The vehicle RE annexes of regulation 95/54/EC (ref 8.1) stipulate that the measuring location shall be "free from electromagnetic reflecting surfaces", but that "Enclosed test facilities may be used if correlation can be shown between the enclosed test facility and an outdoor site." The same stipulation appears in CAN/CSA-C108.4 (ref. 8.3). Correlation of a typical absorber lined shielded enclosure (ALSE) with reflecting floor to an outdoor site can be performed in two steps:

1. Correlate the ALSE with ground plane, to an open area test site (OATS) with ground plane. The ANSI C63.4 (ref 8.5) site attenuation measurement is a standard method to demonstrate equivalence between ALSE and OATS sites with ground planes.
2. Correlate OATS with ground plane to outdoor test site without ground plane. In this step, correlation factors must be determined, since the two types of sites are not expected to be equivalent in general.

The second step is accomplished in reference 8.6 wherein a validated numerical simulation is used to determine the average effect of the difference in ground types, over a range of source heights from 0.2 to 1.5 m. The particular range of source heights was chosen based on typical vehicle structure and wiring locations. The resulting correlation factors can be applied to data from a radiated emissions test site with reflecting ground plane, for correlation to an outdoor site without ground plane.

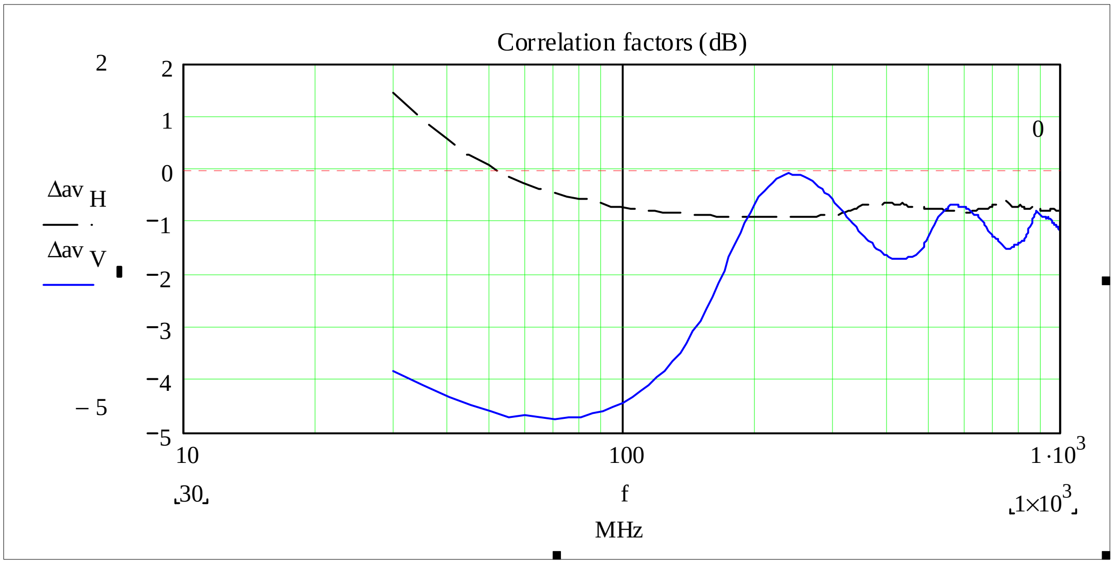


Figure 6 Ground plane correlation factors for Vert. & Horiz. polarizations