EMC Compliance Procedure For Electrical/Electronic Components and Subsystems

Foreword

The modern automobile represents an extremely harsh electromagnetic environment. Full compliance with this procedure will help ensure electromagnetic compatibility (EMC) between all electrical and electronic components located within the vehicle and between each component and the external electromagnetic environment of the vehicle.

This procedure is intended as a reference for JLR EMC personnel and component engineers or full service suppliers. It affects all active electronic modules and sensors (i.e. incorporating IC's and transistors), motors, generators, solenoids and passive modules.

Date	Version	Written/Revised	Revision
01/05/10	1	G. Robbins	First Release
01/11/10	2	G. Robbins	Management of Change Section added.
20/06/12	3	M Beetlestone	Changes to test plan template, MOC and lab accreditation

Table of Contents:

1. EMC Component Compliance.

The flow chart shown in Fig 1 provides an overview of the component EMC process, a more detailed description is as follows:

New Components

A new component is identified by the APC or PMT. The details necessary for the EMC database are provided by the electronic submission of the component information via the EMC eTracker found at: http://www.etracker.jlr.ford.com/default.asp?ProjectID=EMCTRACK this is completed by the responsible component engineer prior to <PTCC>.

If the part already exists on the MIRA database or eTracker, i.e. carry over from a previous platform, the new programme will be added to the allocated test plan number. If the component is a new part, a test plan number will be allocated to the part and all relevant details will be added to the database.

Component EMC Test Plan

The Supplier must provide a test plan for each component or sub-system applicable for EMC testing. JLR EMC must approve the test plan prior to test commencement.

A guide for producing a Test plan is shown in **Section 3** and is also available for download at http://www.jaguarlandrover.com/emc

The test plan should be submitted at least 20 days prior to **M1DJ** for under body components and at least 20 days prior to **FDJ** for upper body components.

When a test plan is received, the test plan front sheet will be signed by the JLR EMC, component owner and the Supplier. The eTracker status will then be changed to No Test Results.

Component EMC Test Facility

The EMC test facility shall be one approved by JLR EMC and the process for this approval is detailed on the website http://www.jaguarlandrover.com/emc

The JLR EMC engineer may accept test data at their discretion from a test facility during the period between applying for and receiving final approval. This decision will be influenced by any National or International accreditation or approval already held by the test facility (e.g. UKAS in the UK) and whether or not a test facility report, as described in EMC-CS-2010JLR has been submitted.

Component EMC Test Results

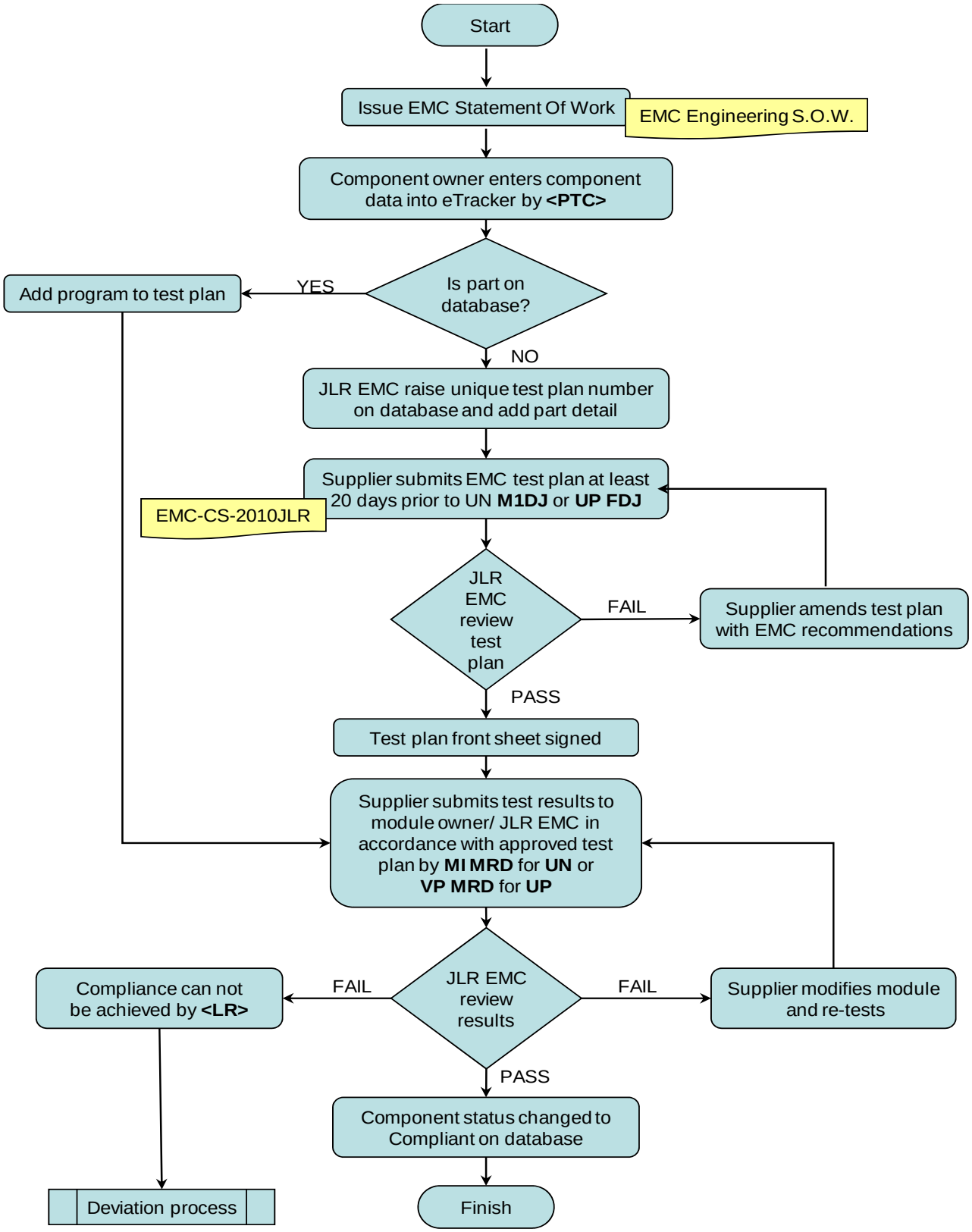
Test reports shall comply with the requirements of ISO 17025.

The report shall contain a summary page showing the compliance status of each test.

Test results must be submitted to JLR EMC by **M1 MRD** for under body and **VP MRD** for upper body components. If the results comply with all the requirements of EMC-CS-2010JLR and have been obtained in accordance with the procedures and test methods described in the approved component test plan then JLR EMC may approve the results. The results are attached to the eTracker and the part marked as compliant.

If the results of one or more tests fail the requirements of EMC-CS-2010JLR, then the supplier is expected to resolve the issue and re-test the module in accordance with the approved test plan and re-submit test results. **If compliance can not be achieved by the appropriate gateway then the component engineer will be responsible for raising a deviation in accordance with the JLR deviation Procedure in SDOTS.**

Fig 1.0 EMC Component Compliance Flowchart



2. Test Plan Guide

In general the completed test plan should be a self-contained document i.e. it should not reference other design specifications. The plan should be sufficiently detailed to provide an EMC test technician, who is not familiar with the product, with all the necessary information to perform testing and evaluate the results for all tests listed in the plan.

The Test Selection Matrix is contained in the EMC standard EMC-CS-2010JLR in table 6.1.

3. Description of the Test Plan Sections

Product Name

The name of the component or module must match that used in the eTracker.

Product Supplier Name

Provide manufacturers name and address, indicate first and second tier supplier where applicable.

Approved EMC Test Facility

Indicate test facility(s) to be used. **The lab must be Ford/A2LA recognized or approved by JLR following the process detailed on the website** www.jaguarlandrover.com/emc Test results from non-approved labs cannot be used and will be rejected.

Product part number(s)

JLR part numbers are required for all DUT's covered by the testing in this plan. If the DUT is only supplied as part of a larger assembly then the assembly part number can be given.

Vehicle and Model Year

List **all programs and model years** where part(s) covered in this plan are used.

EMC Specification Used

Show which EMC test specification will be adhered to during test set-up and testing e.g. EMC-CS-2010JLR v1.1 01/01/11.

For any new components, the older AA, AB and AC specs cannot be used.

Introduction

This section provides JLR with general information about the Device under test (DUT) to be submitted for test.

Product Family Description

DUT may be part of a family of related devices such as those on earlier or other programs. If so provide similarities and differences between them, systems diagrams including power and control signals may be helpful for this purpose. The information provided here may help to justify test sample surrogate selection (see section 2.3 of the template). For example an electro-chromatic interior rear view mirror may be one of a family of three: Electrochromatic only, electrochromatic with compass and electrochromatic with compass and automatic head lamp control.

Theory of Operation

Provide a description of the DUT operation, suitable for those not familiar with the product. **Avoid references to other specifications** (which the reader may not have easy access to).

- What does the DUT do?
- How and when does it operate?
- **Include a block schematic diagram that shows the connections to the vehicle, particularly the power supply**.

Physical Construction

General information regarding module/PCB construction. e.g. housing material, number of connectors, PCB material and number of layers. **It is particularly important to show connector diagrams with pin location and assignment details. Add a picture of the DUT and include its major dimensions**.

EMC Requirements Analysis

This section provides an understanding of which circuits are likely to be a risk in terms of susceptibility or emissions. Obviously those signals or circuits where operation is critical ought to be a priority for monitoring during immunity testing and likewise during emissions tests it is important that those circuits likely to cause high emissions are active.

Critical Interface Signals

Signals listed here are potentially susceptible or critical to correct operation. This may be all of the signals or just a few, but must include power and ground; otherwise the DUT will not operate.

Potential Sources of Emissions

Circuits or signals, which are a possible emissions risk. i.e. PWM signals, oscillators, high frequency circuits, data signals, high current or voltage signals, inductive or capacitive switching etc.

Test Sample / Surrogate selection

It may be acceptable to test a single part variant **(remember two samples minimum!)** to represent all other variants in a family of related devices. Test results from this part will then provide surrogate data for the other parts. This will obviously reduce the cost and effort required and will therefore be an attractive route for achieving component EMC compliance. **However technical justification will be required**. For example it may be acceptable to only test the most comprehensive variant of a range of Electrochromatic mirrors. Justification for doing so would be necessary, as an example it may be the case that all mirrors in the family have the same PCB layout with identical housing construction and materials the only difference being minor component population differences.

Test Design and Requirements.

This is the core of the test plan including DUT Modes and Functions, test requirements and input/output requirements for each test.

DUT Operating Modes/Functional Classifications

This section is often completed incorrectly so please read the following carefully;

This section essentially provides a master reference for all DUT 'Modes' and 'Functions' names that appear throughout the rest of the plan. **All Mode and Functions listed in the plan must be classified and defined in this section; this ensures consistency and avoids any misunderstandings**. **The JLR Product Development Component Owner(s) and their supplier(s) shall be responsible for developing these classifications and performance requirements.**

Table 3.1 is where the overall DUT functionality is broken down into 'Modes' and 'Functions'. Think of a 'Mode' as the state that the DUT or system is in and a 'Function' as something that is capable of being performed in that particular 'Mode'. Examples of modes could be 'ON', 'OFF' and 'Standby'. Several 'Functions' may be active in any given 'Mode'. Examples of 'Function' names are:- 'Purge valve opened', 'Ignition', 'CAN communications', 'LED illumination', 'PWM motor drive active', 'Read ADC' etc..

The possible 'Functions' for each of the modes listed should be classified as either Class A (convenience), B (enhance vehicle operation and control) or C (essential to vehicle operation and control) by entering the function names under the appropriate column of table 3.1. (For full functional importance classification definitions see Section 3.0 in EMC-CS-2010JLR).

An 'X' should be placed in the appropriate 'Vehicle Operating Modes' column to indicate in what vehicle mode the DUT Functions can be active.

Finally 'Mode' and 'Function' definitions should be described in a manner suitable for those not familiar with the product i.e. what each mode and function is or does.

A simplified example of the modes and functions that might be available for an instrument cluster is shown below;

DUT Mode	DUT Functions			Vehicle Operating Modes			
	Class A	Class B	Class C	Off	Accessory	Start	Run
Operating		Vehicle speed			X		X
		Warning lamps			X		X
	Message centre				X		X
Standby		Fuel level					X
	Ambient Temperature				X		X

Note: modes and function listed above are for illustration only and not necessarily correct for a real instrument cluster.

Mode Description(s):

Operating – cluster is fully operational providing speed, rev counter and warning lamp information

Standby – cluster is in standby mode with ignition in accessory position, providing fuel level and temperature readings.

Function Description(s):
Vehicle speed – the cluster is decoding CAN messages provided by the braking system and displaying a reading of the current vehicle speed on the speedometer. etc…

Test Requirements

This section lists which tests are applicable to the DUT and what Modes and Functions will be activated and monitored for each test. **This table should only contain the modes and function names already defined in section 3.1 to avoid confusion.**

A "Y" or "N" shall be placed in the "Test Applies" column to indicate whether or not the test listed in the table is applicable. See section 6.0 of the component EMC specification, EMC-CS-2010JLR for help assessing the applicability of each EMC test. The "Interface to be tested" column should be used to indicate which circuits the test applies to and whether or not multiple interfaces/circuits shall be tested combined or separately - denoted by placing a "C" or "S" after the interface name.
Finally, the last column should include which Modes or Functions (listed in section 3.1) are to be activated during each test applicable, but shouldn't include details of the actual tests.

Test Description	Test applies (Y/N)	Functional Class & Functional Status			Interface to be tested	S/C[1]	Operating Mode(s) to be used for indicated test
		A	B	C			
Radiated Immunity – RF							
RI 112 Level 2 BCI	Y	II	II	I	All circuits	C	

Note: it may not be feasible or practical to operate all available modes and functions listed in table 3.1 for each test. However in the case of immunity tests all Class C modes must be exercised. During emissions testing the Mode/functions likely to cause the worst case emissions should be active.

A technical justification is required for any test marked as not applicable.

Input Requirements

Sufficient information should be included here for a technician who is not familiar with the product to be able to configure the DUT in the Modes/Functions necessary for each test. This may be in the form of electrical inputs (e.g. Bat, GND, Control signals, CAN messages etc) to be entered in the table provided or other non electrical inputs such as a sequence of key presses or other mechanical inputs.

For each operating mode chosen is section 3.2, list all the input signals that are required to place the DUT in the required operating mode in the table provided. List the EMC tests to which the mode applies in the "Test" column**. State the connector pin numbers to which the signals are applied and include details of waveform, amplitude, frequency, pulse width, duty cycle and any other details necessary to accurately produce the signal required.**

Output Requirements

This section should be used to define what electrical signals or other indicators will be used to monitor and verify correct operation of each mode and function being activated during each test. Electrical parameters should be listed in the table provided. For non-electrical indicators the format is free provided that "Nominal" (N) and "Acceptance criteria" (A) parameters are provided. Examples of non-electrical indicators are position, rpm, pressure, brightness etc.

Note: if the electrical signals to be monitored apply to all tests then "All" can be written in the "Test" column to indicate this rather than listing all tests names separately **– please do not leave blank**. The table may be split or expanded to cover each function or test separately if this helps to simplify the table.

For each parameter to be monitored, the Nominal parameter (N) and Acceptance criteria (A) together, define what is essentially functional performance status I (i.e. operate as designed). See Section 3.0 of EMC-CS-2010JLR for a full definition.

The acceptance criteria parameter (A) should be chosen such that the allowable deviation is equal to the upper limit where the degradation in functionality becomes perceivable to the customer.

Of course, the Status I performance is not applicable to every test or function; in each test section of the EMC component specification the expected performance status (I, II or III) appropriate to each Functional Importance Classification (A, B or C) is provided - see section 3.0 of EMC specification for full definition of importance classifications.

Note: it is not necessary to define the conditions required to meet performance status II or III performance criteria since by definition, deviating outside the limits defined for the status I criteria means by default that the function will be operating to either a class II (if recovery on removal of test condition is automatic) or class III (if recovery requires operator intervention) performance status. Conditions for Class I, II and III performance status are fully defined in Section 3.0 in EMC-CS-2010JLR.

For emissions tests use this section to state what parameters, in the form N ±A, are monitored to verify that the DUT is functioning representatively for the duration of the emissions frequency sweep. e.g. use the current drawn by a dc motor to verify that it is operating at the correct torque, motor RPM could be monitored by using an optical or magnetic sensors positioned close to the motor's shaft.

In the case of the time domain emissions test, use this section to state the parameters to monitor just before the switching event. i.e. for a solenoid or motor state the nominal (N) operating current together with the allowable deviation (A). This is an important check since the current disconnected will have a significant effect on the voltage transient measured, V= -Ldi/dt.

Load Box/Test Support Requirements

This section is used to describe the requirements for the load box/test fixture. The test fixture is necessary to provide the input stimulus and output loadings necessary to represent as near as practical actual vehicle installation e.g. **all output drive circuits within the load box should be representative of the real drive circuits used on the vehicle and all load values should also be representative in terms of resistance, capacitance and inductance.**

Details of the test fixture should be entered in the table provided. Information including DUT pin numbers, names, and descriptions and whether each pin is an input or output must be entered. If a pin is loaded, indicate by placing an 'X' in the appropriate column, whether it is connected to a real or simulated termination. Information on additional support

hardware/software requirements should be included where applicable. Note: where possible the content of the load box/test fixture should be passive so as not to influence the test performance.

A test fixture diagram may be used in place of the table provided sufficient detail is provided on the electrical loading applied to each input and output pin of the DUT.

DUT Test Set-up

The information presented in this section should permit reproduction of the same test set-up by another test laboratory.

It is recognised that approved test facilities are capable of component/sub-system setup within the test environments shown in the EMC specification EMC-CS-2010JLR.

The approved test facility shall provide details of the setup as part of the formal test report.

Specific test exceptions / differences to these test requirements shall be documented in this section.

Standard setup sheets have been provided for convenience and may be used to document this information.

ESD test points shall be included even if there is no deviation from the specified test method.

4. Process for Repeat EMC Testing

Changes to the component's original production design may often impact its EMC characteristics. Often some additional EMC testing needs to be repeated to verify there is no negative impact. Information provided in this annex presents a process for assessing what EMC testing shall be required when specific component design changes are being considered.

Information provided in Tables 4.0 to 4.4 shall be used by the Component Owner and the Supplier to determine what EMC tests shall be required to validate the design changes. The Supplier shall notify the owner of the component and the JLR EMC department prior to commencement of testing. The component's original EMC test plan shall be used to facilitate the testing. Deviations from this process shall be pre-approved by the JLR EMC department.

Table 4.0 Electrical interconnect changes on Printed Circuit Boards, hybrid boards, or flat wire interconnects.

Interconnect	Planned Changes	Required Test(s)	Section
I/O to external connectors	Location change ≥ 0.152 mm Width change ≥ 0.152 mm	RE RI ESD	7.0 10.0 20.0
Mux Lines (e.g. SCP, CAN)	Location change ≥ 0.152 mm Length ≥ 0.152 mm	RE	7.0
Reset Lines	Location change ≥ 0.152 mm Length ≥ 0.152 mm	RI Coupled Immunity	10.0 12.0
Low Level Analog	Location change ≥ 0.152 mm Length ≥ 0.152 mm	RI Coupled Immunity	10.0 12.0
Ground Plane	Any Change	RE RI Coupled Immunity ESD	7.0 10.0 12.0 20.0
General	Location change ≥ 0.152 mm Thickness/width change ≥ 0.152 mm	RE	7.0
Supply Lines/ High Current	Location change ≥ 0.152 mm Width ≥ 0.152 mm	RE RI	7.0 10.0

Table 4.1 Software Changes

Attribute	Change	Required Test(s)	Section
PLL	Frequency	RE RI	7.0 10.0
O/P Slew Rate	Increase or Decrease	RE CE	7.0 8.0
Watchdog, Reset, Interrupt	Any	RI Power Dropout	10.0 18
General	Any	RE	7.0

Table 4.2 E/E Component changes on PCBs, hybrid boards, or flat wire interconnects.

Component	Change[(1) (2)]	Required Test(s)	Section
I/O Capacitor	Value Change (10X)	RE RI ESD	7.0 10.0 20.0
Regulator Capacitor (I/P)	Value Change (10X)	RE RI Continuous Disturbances Transient Disturbances Power Cycle	7.0 10.0 14.0 15.0 16.0
IC Decoupling Capacitor	Value Change (10X)	RE	7.0
Slew Rate Capacitors	Value Change (10X)	RE RI	7.0 10.0
Op Amp Input Capacitors	Value Change (>10%)	RI	10.0
I/O Series Resistor	Value Change (>10%)	RE RI ESD	7.0 10.0 20.0
Slew Rate Resistors	Value Change (>5%)	RE RI	7.0 10.0
Zener or MOV on Battery	Voltage rating	Transients Disturbances Voltage Overstress	15.0 19.0
Microprocessor	OTP to ROM	RE RI	7.0 10.0
Oscillator	Frequency	RE Power Dropout	7.0 18.0
PWM Controller	Slew Rate or Current	RE CE (RF)	7.0 8.0

(1). This includes changes in Supplier of the component. Contact JLR EMC department for determination of specific tests to repeat.

(2) Other components such as I.Cs, inductors, LEDs and capacitors shall be reviewed by the EMC dept to determine the extent of re-testing.

Table 4.3 Packaging or Mechanical changes

Attribute	Change	Required Test(s)	Section
Packaging material	Conductivity	RE RI ESD	7.0 10.0 20.0
Grounding	Impedance or location	RE RI ESD	7.0 10.0 20.0
Heatsink	Size, location, Grounding	RE (grounding only) ESD	7.0 20.0
Apertures	Size or Location	ESD	20.0

Table 4.4 Loading changes

Attribute	Change	Required Test(s)	Section
Solenoids, motors, Relays	Impedance	CE (Transient)	7.0
Active Sensors	Sensor Impedance	RI Voltage Offset	10.0 17.0

5. Management of change for EMC

The purpose of this document is to give guidance to suppliers for assessing the impact of design changes on electromagnetic compatibility and choosing appropriate tests to repeat. The website www.jaguarlandrover.com/emc contains a template, which should be completed and submitted to the relevant responsible JLR Component Engineer and then the EMC team for approval.

Every change, no matter how minor, may have an influence on the electromagnetic performance so it is essential that every change is evaluated. It is a regular dilemma as to which EMC tests to repeat if any at all. Repeating all tests is the safest answer but it is not always necessary or a cost effective approach. This document sets out a process for selecting tests to be repeated based on past experience.

Evaluating the exact impact of a change on the final EMC performance is not easy and requires in depth understanding of both electronic and electromagnetic characteristic of the module. Sometimes, this may require some simplified back-to-back testing. The Supplier engineers, designers and the EMC experts, are best placed to analyse the change and decide which EMC tests to repeat. Here at JLR, we expect to be advised by the supplier as to what is changed, the analysis of the expected impact on EMC characteristics and what tests shall be repeated. We will review supplier's analysis and any supporting data used for selecting which tests to repeat if any. The JLR EMC team reserved the right to request additional tests based on the information provided. It is however the responsibility of the supplier to ensure that their components remain compliant and that proof of this compliance can be demonstrated at a later date if required.

It may be necessary to validate some changes at the vehicle level and JLR EMC team will advise after considering all relevant data. If a module/system is changed after JLR has validated it in a vehicle, the supplier is responsible for funding these repeated vehicle level tests.

Selecting EMC tests to repeat after a change:

It is recommended that the following process is used for establishing which tests to repeat. Only tests that were applicable in the initial validation should be considered. Suppliers may perform back-to-back tests in any facility using any method while evaluating the impact of the change. Test data from such experiments may be used as evidence to support why a test SHALL NOT be repeated. However, if a test IS to be repeated it shall be conducted in accordance with a previously approved test plan and in an approved facility.

Radiated Immunity (RI):

RI 11X

Modules with Class C[1] functions,

If one or all of the following statements are correct, it is expected that the supplier shall carry out a detailed analysis or conduct preliminary tests to determine if RI11X tests should be repeated:

The change involves a software modification [2],

The change results in a modified printed circuit board (PCB),[3]

Changes in any clock or PWM frequency, duty rate or other relevant parameter.

If the module is in a metallic housing and it is modified in some way.

There were RI failures in the original test.

[1] Class C: Any function that controls or affects the essential operation of the vehicle or could confuse other road users.

[2] Any modifications to module's software that influences the core operating routine, general operating strategy, power supply management, communications, input output management or any other part which can reasonable be expected to result in different radiated emissions profile.

[3] Any modifications to printed circuit board (PCB), which result in a change of the substrate material, number of layers, addition, deletion of components, any changes to copper area, rerouting tracks, redefining earth fills, movement, deletion or addition of vias (layer to layer interconnections).

Any other change that can reasonably be expected to influence radiated immunity response.

All Other modules

If the change involved any of the modifications listed above, run radiated emissions tests first. If the results are markedly different (maximum of +/- 3 dB in amplitude and +/- 5% in frequency of any individual spectral peak) compared to the original data then repeat the RI11x series of Radiated Immunity tests.

RI130, R150, RI140

For all modules

Consider the need for repeating reactive coupled radiated immunity test (RI130 and RI150) if the change impacts any aspect of input / output interface (changes to hardware or software).

Consider the need for repeating Magnetic filed immunity (RI140) if the change involves any items that are sensitive to magnetic fields

Radiated Emissions:

Consider repeating RE tests after ANY change to the module. In case of uncertainty, carry out some back to back measurements to identify potential impact.

Conducted immunity:

Repeat CI210, CI220, CI230, CI240, CI 250, CI265 and CI270 tests if the change influences any circuit, which interfaces directly or indirectly to the vehicle supply network.

- Changes to the component specification such as package size, value or rating.
- The placement or routing changes influencing component specifically intended for EMC mitigation.
- Change of voltage regulator or any associated circuitry such as capacitors, resistors, indictors or active components such as diodes, transistors or supply voltage watchdogs.

In addition consider repeating CI265 if there has been software changes that results in a different operating loop time or influences the core or power supply or reset management.

Electrostatic Discharge

- Repeat CI280 (Unpowered) if the change involved any modification to parts or PCB associated or within close proximity (within 25mm) of external connector pins.
- Repeat CI280 (Powered) tests if there has been a change to module packaging such as changing case material type, addition of metallic labels, and changing aperture sizes
- It is also necessary to consider the impact of PCB changes if the PCB is part of the man machine interface such as boards that contain displays or push buttons.

Conducted Emissions:

CE420 Frequency domain.

Repeat if RE 310 is run and the results are different (+/- 3 dB in amplitude and +/- 5% in frequency) in the band of 0.15 – 108 MHz

Or

If the change involves any parts that are used for controlling conducted emissions such as suppression components.

Or

Any other change that can reasonably be expected to influence conducted emissions profile.

CE410 Time Domain

Repeat if any of the conditions listed above for Conducted immunity are relevant.

If the change is to address a previously known EMC test failure, this test must be repeated in addition to the tests identified by following the process outlined here.