

# Jaguar Land Rover JLR-EMC-CSv1.0A4 at a glance

- automotive test standard –  
Conducted / Radiated Immunity tests  
Conducted Emission tests

The relating standards:



JLR-EMC-CSv1.0A4  
JLR EMC-CS-2010.1.2  
ISO 7637-2  
FORD EMC1278

**JLR-EMC-CSv1.0A4 – Table 6-1: Electrical and electronic component categories:**  
**Electronic Modules**

<b>A:</b>	An electronic module that contains active electronic devices like analog op-amp circuits, switching power supplies, microprocessor controllers and displays
<b>AS:</b>	A module operated from a regulated power supply located in another module. This is usually a sensor providing input to a controller
<b>AM:</b>	A module that contains magnetically sensitive elements or is connected to an external magnetically sensitive element
<b>AX:</b>	A module that contains an electric or electronically controlled motor or other inductive device within its package or controls an external inductive device including electric or electronically controlled motor(s)
<b>AY:</b>	A module that contains a magnetically controlled relay within its package
<b>AW:</b>	An module with no external wiring (e.g. RKE keys)

**Electric Motors**

<b>BM:</b>	A brush commutated dc electric motor. Motors that operate for less than 200 mS and are used as a latch function will be categorized as an Inductive Device (R)
<b>EM:</b>	An electronically controlled electric motor

**Other devices**

<b>P:</b>	A passive electrical module consisting of only passive components including resistor, capacitor, inductor, blocking or clamping diode, Light Emitting Diode (LED), thermistor
<b>R:</b>	Relays, solenoids and horns

Requirement type	Req. ID	Component Category									
		Electronic modules						Electric Motors		Other devices	
		A	AS	AM	AX	AY	AW	BM	EM	P	R
Conducted Transients	CE 410				✓	✓		✓	✓		✓
Magnetic field Immunity	RI 140			✓	✓	✓		✓	✓		
Coupled disturbances	RI 130	✓	✓	✓	✓	✓			✓		
	RI 150	✓	✓	✓	✓	✓			✓		
Continuous disturbances	CI 210	✓		✓	✓	✓			✓		
Transients	CI 220	✓		✓	✓	✓			✓	✓	
Power cycles	CI 230	✓		✓	✓	✓			✓		
Ground offset	CI 250	✓		✓	✓	✓			✓		
Voltage dropout	CI 265	✓	✓	✓	✓	✓			✓		
Voltage overstress	CI 270	✓	✓	✓	✓	✓		✓	✓	✓	✓

## 9.0 CONDUCTED TRANSIENT EMISSIONS CE 410

Used to check the emission limits of conducted transient emissions on the DUT's power supply circuits.

CE 410

Table 9-1

Conducted Transient  
Emission Requirements

DUT	Characteristic	Limit
e.g. relays, electric motors, solenoid valves	$\leq 2\text{ms}$	+75 V / -80 V
	$> 2\text{ms}$	20 V (and agreement JLR EMC)

Any DUT shall meet the requirements of CE410 at room temperature AND also at -45 degrees or the coldest specified ambient temperature of the DUT.

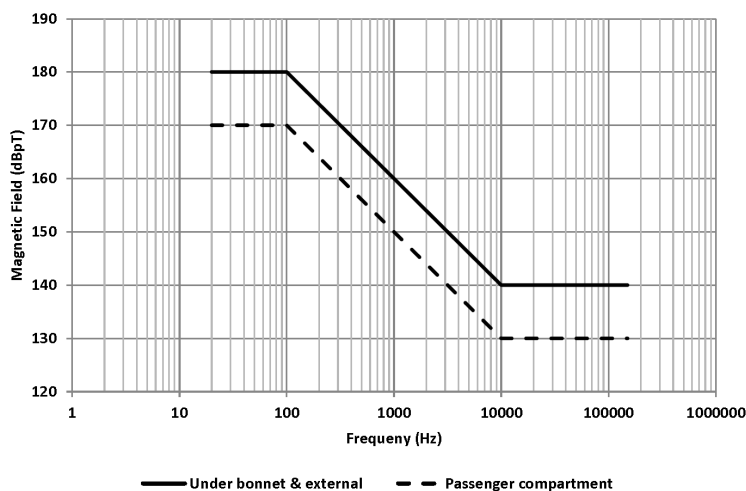
## 12.0 MAGNETIC FIELD IMMUNITY RI 140

Used to verify the immunity against off-board and on-board magnetic fields in the frequency range 20Hz ... 150kHz.

RI 140

Fig. 12-1

Magnetic Field  
Immunity  
Requirements:



Under bonnet &  
external

Frequency (Hz)

Level (dBpT<sub>rms</sub>)\*

20 – 100

180

100 – 10000

$180 - 20\log(f/100)$

10000 – 150000

140

\*: f=frequency in Hz

Passenger  
compartment

Frequency (Hz)

Level (dBpT<sub>rms</sub>)\*

20 – 100

170

100 – 10000

$170 - 20\log(f/100)$

10000 – 150000

130

\*: f=frequency in Hz

Table 12-1:

Test Frequency Range (Hz)

Frequency step (kHz)

20 – 100

0.05

100 – 10000

0.5

10000 – 150000

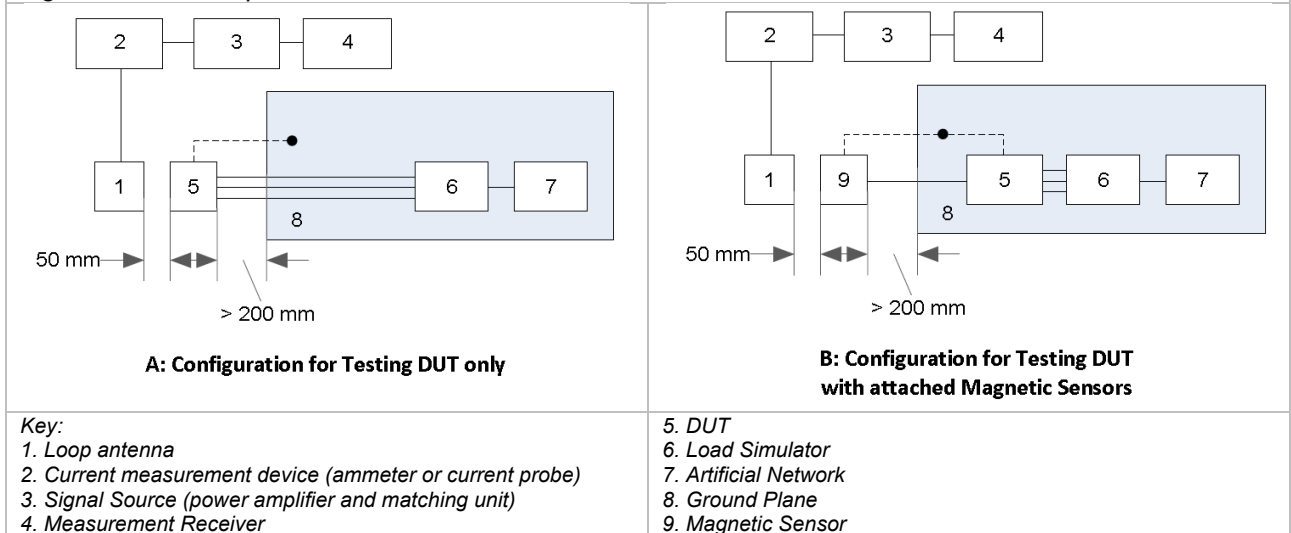
5

Test Frequency  
Requirements:

### Radiating Loop Method:

Prior to performing testing the radiation loop shall be calibrated acc. to the procedures delineated in the British Defense Standard 59-411 Part 3 Issue 1 Am 1, Section 6.22.9. Dwell time at least 2 sec or according to longer function response times of the DUT

Fig. 12-2 Test Setup:



## 13.0 IMMUNITY FROM WIRE-TO-WIRE COUPLING RI 130

Used to verify that the component / subsystem shall operate without deviation when exposed to unintended transient disturbances from wire-to-wire coupling.

RI 130

Table 13-1

Coupled Immunity Requirements:

Timing mode	Type of pulse
2	A2-1
	A2-2
3	A2-1
	A2-2

The test pulses to use are the pulses A2-1 and A2-2 as described in the Annex C of the JLR-EMC-CSv1.0A4, respectively in the Chapter "Annex C: Transient waveform descriptions" later in this document.

- 1 DUT
- 2a DUT Circuit Wire to be Tested
- 2b DUT Wire Harness
- 3 Load Simulator
- 4 Artificial Network
- 5 Automotive Battery or linear power supply
- 6 Automotive Battery
- 7 DUT Monitor/Support Equipment
- 8 Coupling Test Fixture
- 9 Transient Generator
- 10 Ground Plane
- 11 DSO ( $\geq 1\text{GS/S}$ ,  $\geq 8\text{Msamples}$ )
- \* 1:100 high impedance probe ( $C < 4\text{ pf}$ ) per ISO 7637-2.
- \*\* Current Probe ( $> 10\text{ MHz}$ , 30 A)

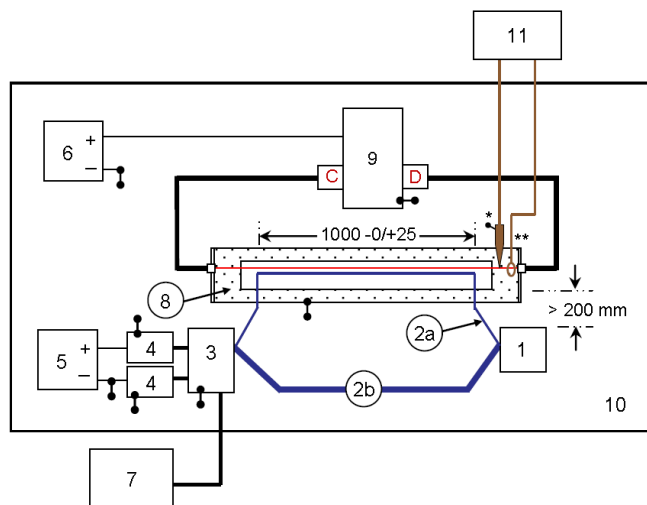


Fig. 13-1: RI 130 Default Test Setup

## 14.0 IMMUNITY FROM WIRE-TO-WIRE COUPLING RI 150

These requirements are related to component immunity from wire-to-wire coupling of unintended continuous disturbances. These disturbances originate from high current PWM sources and the vehicles charging and ignition system and cover the frequency range from 50 Hz to 100 kHz.

RI 150

Fig. 14-1:

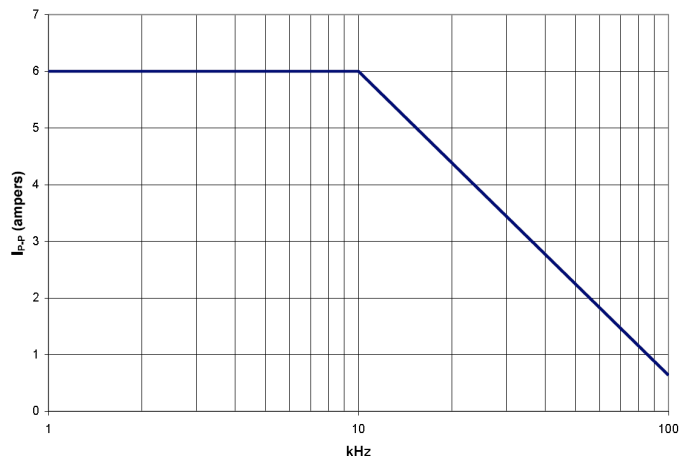
Coupled Immunity Requirements:

Stress levels:

1 ... 10 kHz:  $6A_{pp}$

10 ... 100 kHz:  $6 \cdot 5.4 \log(f/10) A_{pp}^*$

\*  $f$  in kHz



- 1 DUT
- 2a DUT Circuit Wire to be Tested
- 2b DUT Wire Harness
- 3 Load Simulator
- 4 Artificial Network
- 5 Power supply
- 6 Signal Generator
- 7 DUT Monitor/Support Equipment
- 8 Coupling Test Fixture
- 9 Amplifier 1 ... 100kHz
- 10 Ground Plane
- 11 DSO ( $\geq 1GS/S$ ,  $\geq 8Msamples$ )
- 12 Amplifier Load Resistance
- \*\* Current Probe ( $> 10 MHz$ , 30 A)

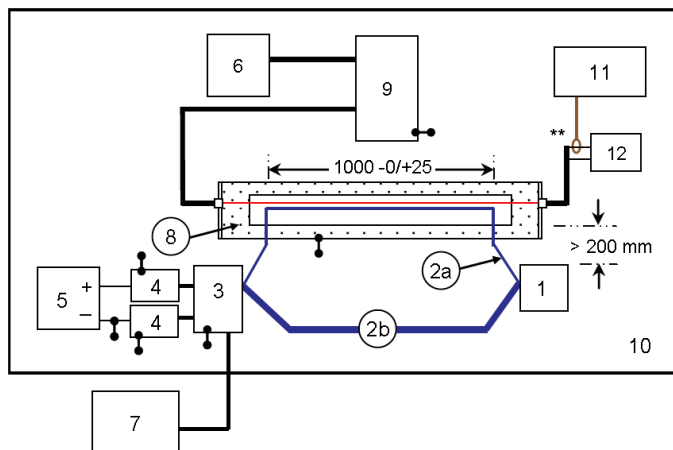


Fig. 14-2: RI 150 Default Test Setup

At each test frequency increase the peak to peak current to the corresponding stress level listed in Figure 14-1. Use the frequency steps listed in Table 15-1.

Table 14-1: RI 150 Test Frequency Requirements

Test frequency range (kHz)	Frequency step (kHz)
> 1 ... 10	0.5
> 10 ... 100	5

Dwell time shall be 10 seconds. A longer dwell time may be necessary if DUT function response times are expected to be longer.

### 14.3 IMMUNITY FROM CONTINUOUS POWER LINE DISTURBANCES CI 210

Used to verify the immunity from sinusoidal disturbances on the vehicles power distribution system in the frequency range 50Hz ... 100kHz.

Fig. 14-3:

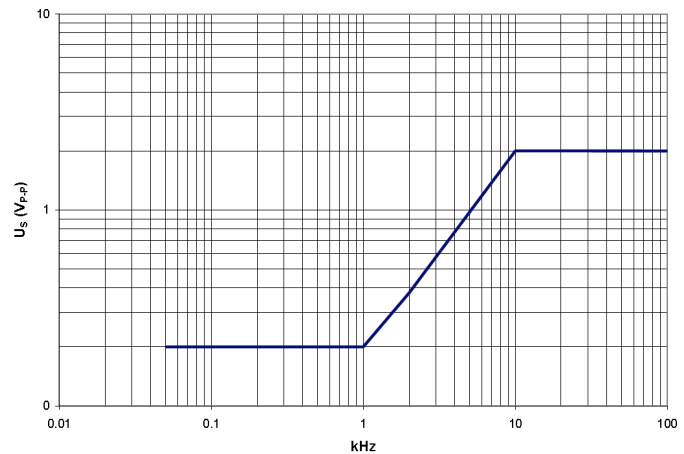
**Stress levels Requirement 1:**

0.01 ... 1 kHz:  $0.2 V_{pp}$

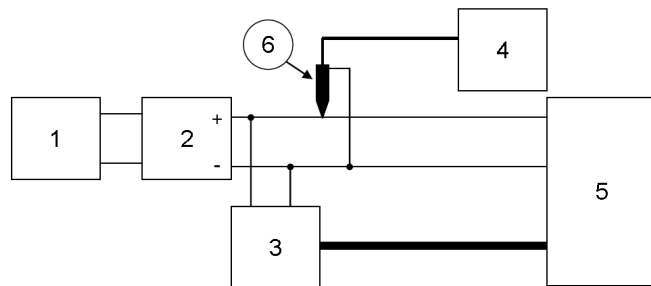
1 ... 10 kHz:  $0.2 \cdot f V_{pp}^*$

10 ... 100 kHz:  $2.0 V_{pp}$

\*  $f$  in kHz



1. Signal Source
2. Modulated Power Supply
3. Load Simulator
4. Oscilloscope
5. DUT
6. Passive High Impedance Probe ( $>1\text{Mohm}$ ,  $C < 10\text{ pf}$ )



At each test frequency adjust and record the signal generator output required to achieve the specified modulation voltage level  $U_s$  with the DUT disconnected (open circuit).

At each test frequency, apply the signal generator levels recorded before to the DUT and the Load Simulator such that all power and control circuits are exposed to the disturbance.

The dwell time shall be at least 2 seconds. A longer dwell time may be necessary if DUT function response times are expected to be longer.

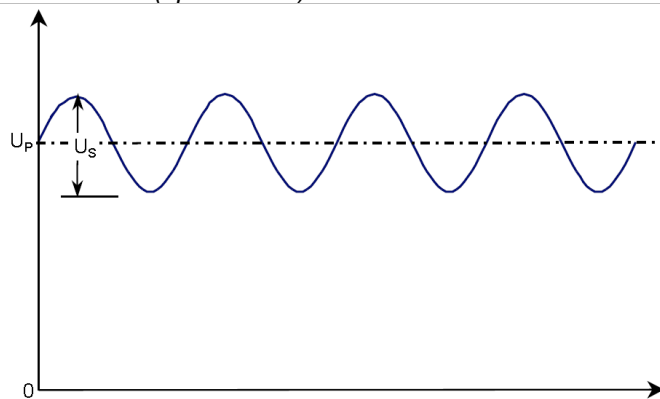


Table 14-2: CI 210 Test Frequency Requirements

Test frequency range (kHz)	Frequency step (kHz)
0.05 ... 1	0.05
> 1 ... 10	0.5
> 10 ... 100	5

## 15.0 IMMUNITY FROM TRANSIENT DISTURBANCES CI 220

Used to verify the immunity from conducted transients on 12V<sub>DC</sub> power supply circuits in addition to control circuits connected directly or indirectly (by switch or load) to the vehicles 12V<sub>DC</sub> battery.

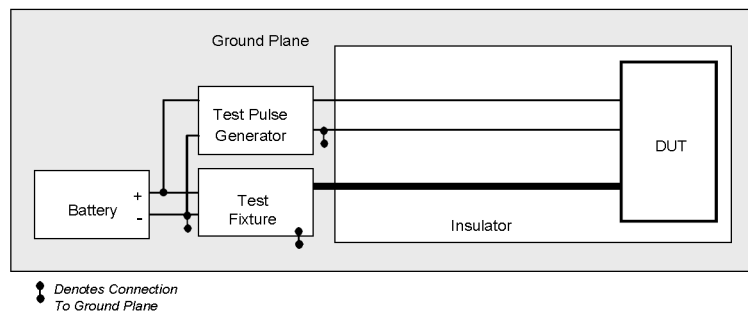
**Table 15-1:**  
Transient Immunity Requirements:

The required test pulses are described in the Annex C of the JLR-EMC-CSv1.0, respectively in the Chapter “Annex C: Transient waveform descriptions and application modes for RI 130, CI 220, CI 221, CI 222” later in this document.

Transient Pulse (1,2,3)	Application <sup>(2)</sup>	Transient Mode <sup>(1,3)</sup>	Duration	Functional Performance Status		
				Class A	Class B	Class C
Pulse A1	Switched power supply circuits with maximum current < 5 amperes	Mode 1	120 sec	II	II	II
	Control Circuits	Mode 2	20 sec	II	II	II
Pulse A2-1	Switched power supply circuits with maximum current < 5 amperes	Mode 1	120 sec	II	II	II
Pulse A2-1 Pulse A2-2	Control Circuits	Mode 2 Mode 3	20 sec	II	II	II
Pulse C-1 Pulse C-2	All power supply circuits & Control Circuits.	Mode 2 Mode 3	20 sec	I	I	I
Pulse E	Switched power supply circuits ≥ 5 amperes	n/a	24 pulses	II	II	II
	Control Circuits			II	II	II
Pulse F1 <sup>(4)</sup>	All power supply circuits	Mode 1	500 pulses	I	I	I
Pulse F2 <sup>(4)</sup>	All power supply circuits	Mode 1	10 pulses	II	II	II
Pulse G1 <sup>(5)</sup> Load Dump	All power supply circuits	n/a	5 pulses	III	III	II
Pulse G2 Central Load Dump <sup>(5)</sup>	Control Circuits			III	III	II

**Fig. 15-1:**  
Test setup for devices with a single Power Supply Circuit:

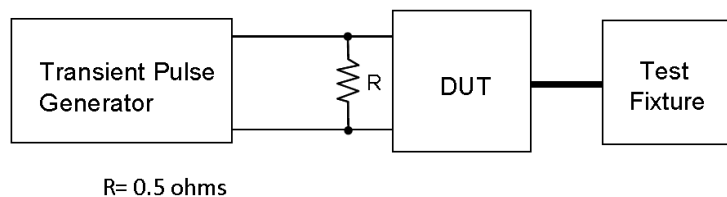
Test setups for other circuits are given in Fig. 15-2, 15-3 and 15-4 JLR-EMC-CSv1.0.



JLR-EMC-CSv1.0 Figure 15-2 illustrates the test setup for devices with two supply circuits. JLR-EMC-CSv1.0 Figure 15-3 illustrates the setup used for testing of control circuits. Further detail of this configuration is illustrated in JLR-EMC-CSv1.0 Figure 15-4.

JLR-EMC-CSv1.0

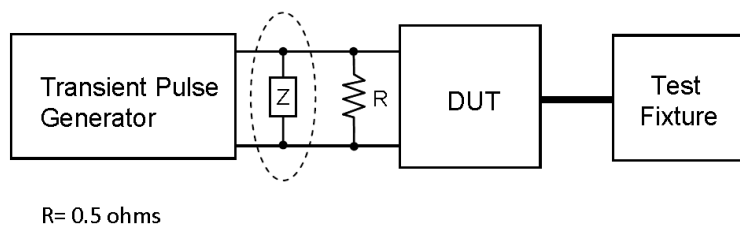
**Fig. 15-5:**  
Test setup for pulse G1:  
Load Dump



For details see JLR-EMC-CSv1.0

JLR-EMC-CSv1.0

**Fig. 15-5:**  
Test setup for pulse G2:  
Central Load Dump



## 16.0 IMMUNITY FROM POWER CYCLING CI 230

Used to verify that the component / subsystem shall operate without deviation when exposed to voltage fluctuation during starting of the vehicles engine. Application to Switched & Unswitched Battery Circuits

Table 16-1

### Requirements for Power cycling:

(1) Waveforms applied simultaneously to all power supply and control circuits.  
(2) Any degradation in performance shall not inhibit the ability of the vehicle to start.

Waveform <sup>(1)</sup>	Application	Duration	Functional Performance Status <sup>(2)</sup>		
			Class A	Class B	Class C
A	Power & control circuits connected to battery via the IGN 1 (RUN) contact of the ignition switch. (i.e. circuits active in RUN but not START).	2 cycles separated by cooling period	II		
B	Power & control circuits connected to battery via the IGN 2 (RUN/START) contact of the ignition switch (i.e. circuits active during RUN and START). Also includes connections to battery through a relay switch.				
C	Power & control circuits connected to battery via the START contact of the ignition switch. (i.e. circuits active only during engine START).				
D	Power & control circuits connected directly to Battery				

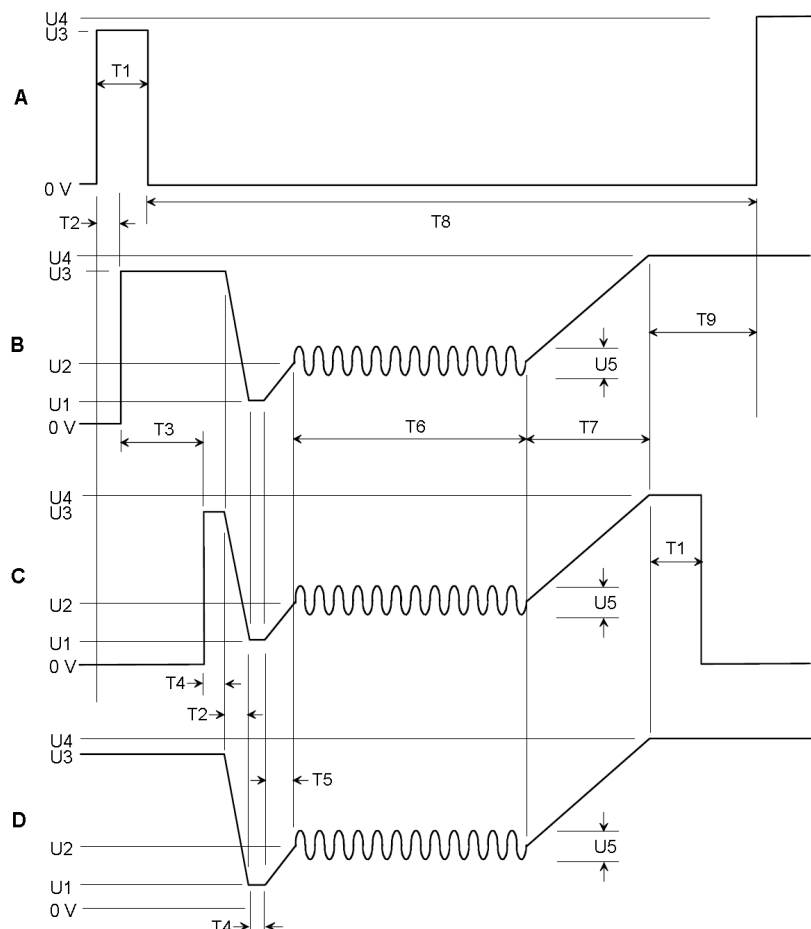
- The test harness connecting the DUT shall be < 2000 mm in length.
- Testing shall be performed -40 +0 / - 5 degrees C or the coldest temperature specified in component's engineering specification. The temperature shall be documented in the EMC test plan.
- The DUT shall be placed on a dielectric support 50 mm above the metal floor of the thermal chamber.

## Test procedures: Power Cycling Waveforms and Timing sequence

Fig. 16-1

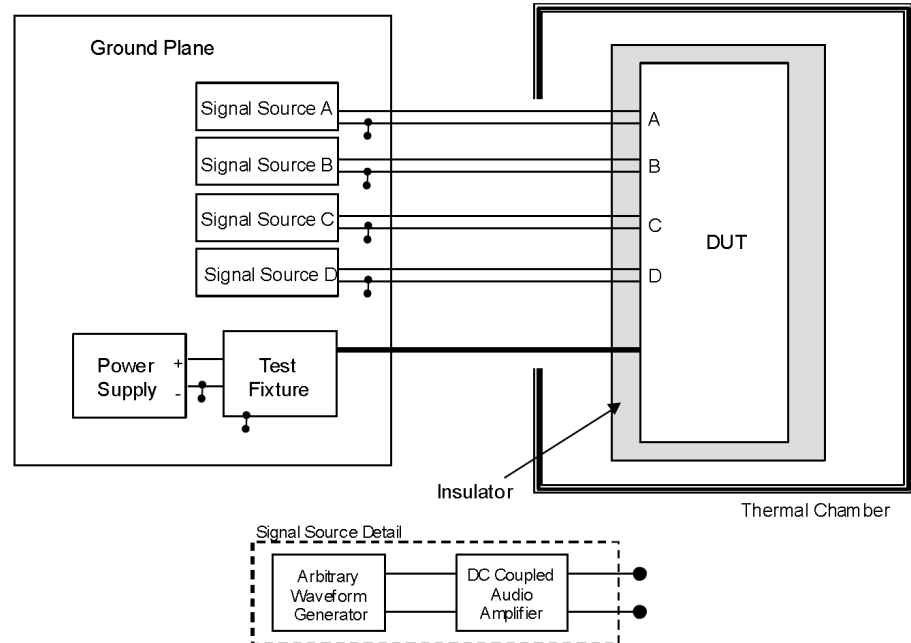
$T_1 = 100 \text{ msec}$   
 $T_2 = 5 \text{ msec}$   
 $T_3 = 185 \text{ msec}$   
 $T_4 = 100 \text{ msec}$   
 $T_5 = 50 \text{ msec}$   
 $T_6 = 10 \text{ sec}$   
 $T_7 = 500 \text{ msec}$   
 $T_8 = 11 \text{ sec}$   
 $T_9 = 325 \text{ msec}$

$U_1 = 5 \text{ V}$   
 $U_2 = 7 \text{ V}$   
 $U_3 = 12.5 \text{ V}$   
 $U_4 = 13.5 \text{ V}$   
 $U_5 = 2 \text{ V}_{p-p} @ 4 \text{ Hz}$



## Test procedures: Power Cycling Test setup

Fig. 16-2



- Verify the waveforms prior to application to the DUT.
- With the DUT and Load Simulator unpowered, soak the DUT at the coldest operating temperature specified in component's engineering specification or at  $-40 \pm 5$  degrees C for one hour prior to testing unless otherwise stated in the EMC test plan. See section 16.2 for details.
- Apply the test waveform(s) illustrated in Figure 20-1. Monitor DUT functions before, during and after application of the waveform(s). Functional verification must be completed within 20 minutes after waveform application. Monitor and record the time taken to perform the functional verification.
- When functional verification is complete remove power from the DUT and Load Simulator
- Without disturbing the DUT (i.e DUT not removed from thermal chamber), soak the DUT at the same temperature from step b) for 60 minutes plus the time recorded from step c) to perform the functional verification.
- Repeat step c).



## 17.0 IMMUNITY TO GROUND VOLTAGE OFFSET CI 250 CONTINUOUS DISTURBANCES

Used to verify that the component / subsystem shall operate without deviation when exposed to continuous sinusoidal electromagnetic disturbances in the frequency range 2kHz up to 100kHz

Fig. 17-1

Requirements for continuous disturbances:

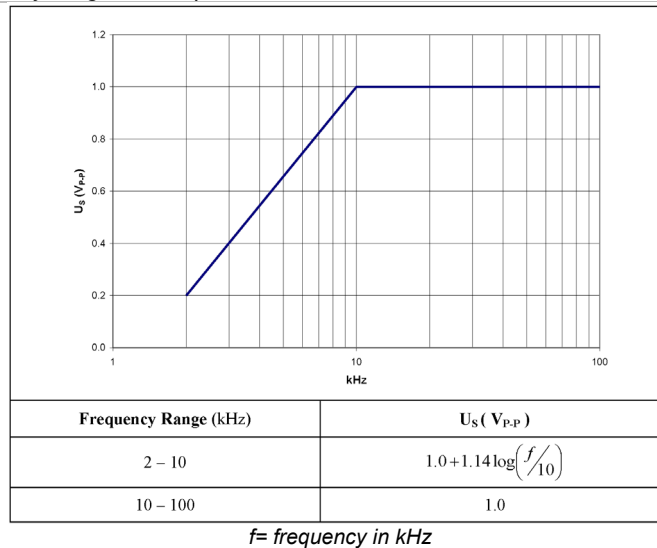


Fig. 17-2

Transient pulse detail:

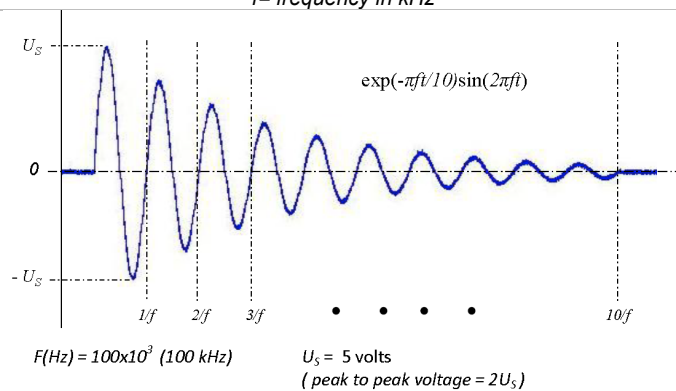


Fig. 17-3

Transient pulse delay detail:

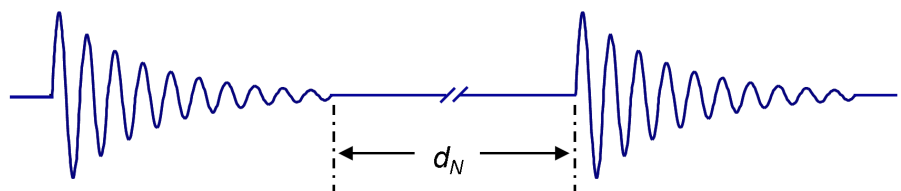
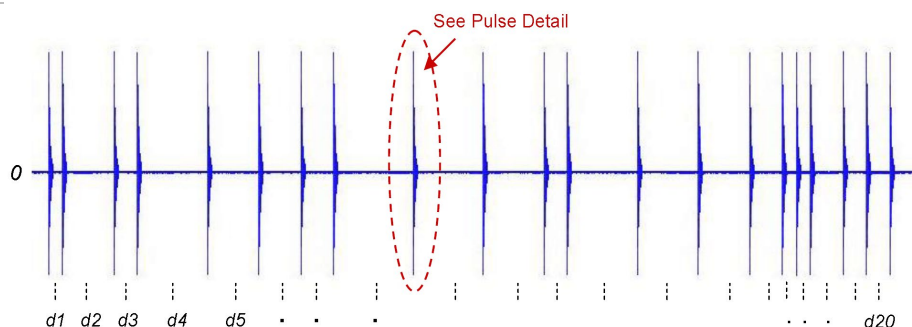


Fig. 17-4

Transient disturbance sequence:



**Test procedures: sinusoidal disturbances superimposed to the supply voltage**

	2kHz to 10kHz, step is 0.5kHz		10kHz to 100kHz, step is 5kHz	
	Frequency (kHz)	Amplitude (V <sub>pp</sub> )	Frequency (kHz)	Amplitude (V <sub>pp</sub> )
<i>Calculated sinusoidal disturbances</i>	2	0.20	15	1.00
	2.5	0.31	20	1.00
	3	0.40	25	1.00
	3.5	0.48	30	1.00
	4	0.55	35	1.00
	4.5	0.60	40	1.00
	5	0.66	45	1.00
	5.5	0.70	50	1.00
	6	0.75	55	1.00
	6.5	0.79	60	1.00
	7	0.82	65	1.00
	7.5	0.86	70	1.00
	8	0.89	75	1.00
	8.5	0.92	80	1.00
	9	0.95	85	1.00
	9.5	0.97	90	1.00
	10	1.00	95	1.00
			100	1.00

*Each step dwell time is at least 2sec*

**CI 250 Table 17-2: Delay time sequences 1-4**

<b>Sequence 1</b>	d1	0.1 ms	d6	0.4 ms	d11	0.2 ms	d16	0.1 ms
	d2	0.5 ms	d7	0.3 ms	d12	0.3 ms	d17	0.1 ms
	d3	0.2 ms	d8	0.4 ms	d13	0.6 ms	d18	0.3 ms
	d4	0.7 ms	d9	0.6 ms	d14	0.5 ms	d19	0.4 ms
	d5	0.5 ms	d10	0.6 ms	d15	0.3 ms	d20	0.2 ms
<b>Sequence 2</b>	d1	0.2 ms	d6	0.8 ms	d11	0.4 ms	d16	0.2 ms
	d2	1.0 ms	d6	0.6 ms	d12	0.6 ms	d17	0.2 ms
	d3	0.4 ms	d8	0.8 ms	d13	1.2 ms	d18	0.6 ms
	d4	1.4 ms	d9	1.2 ms	d14	1.0 ms	d19	0.8 ms
	d5	1.0 ms	d10	1.2 ms	d15	0.6 ms	d20	0.4 ms
<b>Sequence 3</b>	d1	0.5 ms	d6	2.0 ms	d11	1.0 ms	d16	0.5 ms
	d2	2.5 ms	d6	1.5 ms	d12	1.5 ms	d17	0.5 ms
	d3	1.0 ms	d8	2.0 ms	d13	3.0 ms	d18	1.5 ms
	d4	3.5 ms	d9	3.0 ms	d14	2.5 ms	d19	2.0 ms
	d5	2.5 ms	d10	3.0 ms	d15	1.5 ms	d20	1.0 ms
<b>Sequence 4</b>	d1	1 ms	d6	4 ms	d11	2 ms	d16	1 ms
	d2	5 ms	d6	3 ms	d12	3 ms	d17	1 ms
	d3	2 ms	d8	4 ms	d13	6 ms	d18	3 ms
	d4	7 ms	d9	6 ms	d14	5 ms	d19	4 ms
	d5	5 ms	d10	6 ms	d15	3 ms	d20	2 ms

*dn represents the delay between consecutive pulses*

Fig. 17-5: Generic test setup, for details see JLR-EMC-CSv1.0

- 1: DUT
- 2: Signal Source
- 3: Ground Plane
- 4: Load Simulator
- 5: DUT External Load
- 6: Artificial network
- 7: Power Supply
- 8: Dielectric Support
- 9: 10X Probe  
( $1M\Omega$ ,  $C < 10pf$ )
- 10: Digital Oscilloscope  
( $> 100\text{ MS/s}$ ,  
 $> 6\text{MB}$  memory depth)

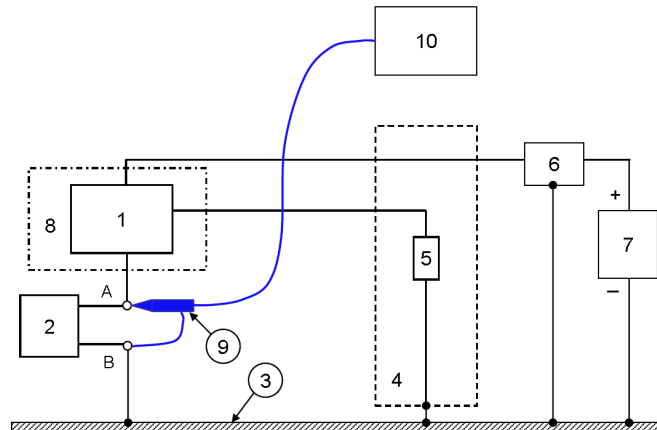
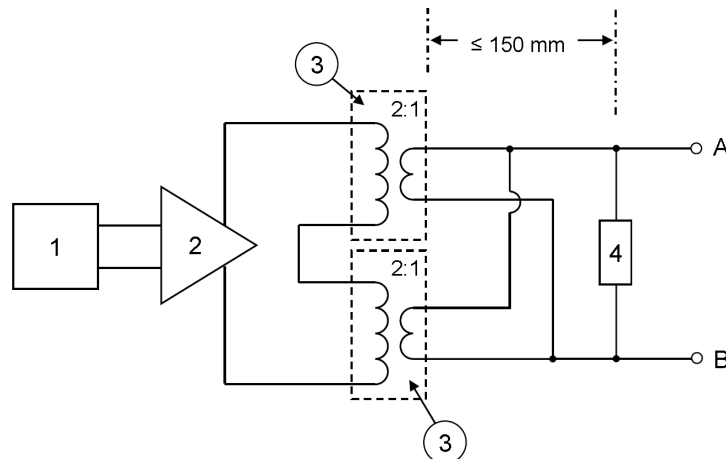
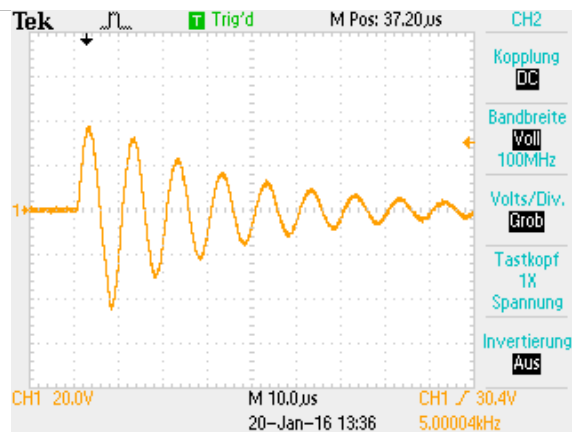


Fig. 17-6: Signal source requirements, for details see JLR-EMC-CSv1.0

- 1: Arbitrary waveform generator
- 2: Amplifier LVA
- 3: Isolation Transformer  
Solar 6260-1A or  
equivalent
- 4:  $0.5\Omega$  (250W) non-  
inductive Resistive Load  
(Dale NH-250 or  
equivalent)



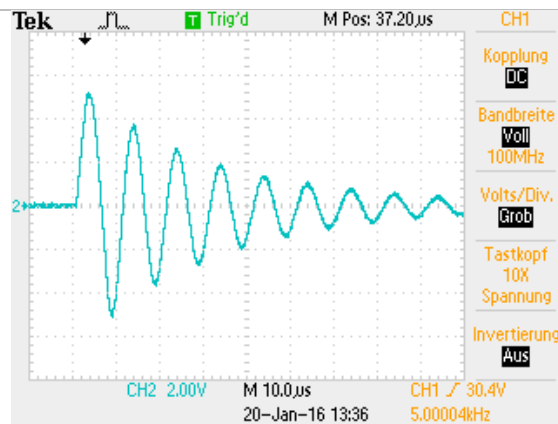
- Test setup oscillogram
- Output Voltage of the  
Power Amplifier LVA
- $0.5\Omega$  (250W) non-  
inductive Resistive Load



Test setup oscillogram

Output Voltage at the  
Terminals A and B

0.5Ω (250W) non-  
inductive Resistive Load



## 18.0 IMMUNITY TO LOW VOLTAGE TRANSIENTS CI 265

Used to verify that the component / subsystem shall operate without deviation when exposed to random voltage dropouts The purpose of this test is the verification of controlled recovery of hardware and software from power interruptions.

Table 18-1

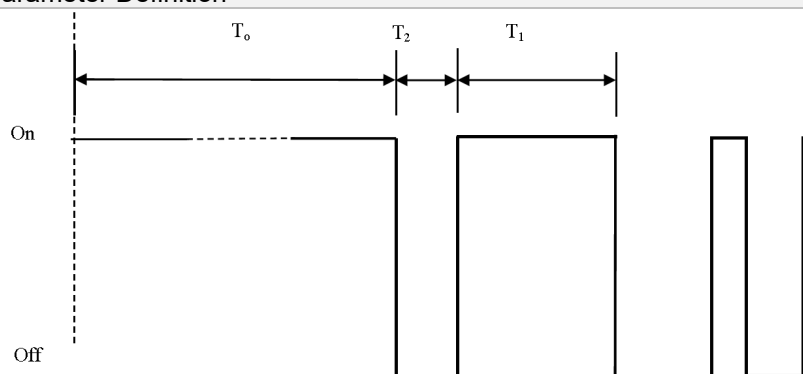
Applicability  
Requirements:

Requirement	Application	Test Duration	Functional Performance Status		
			Class A	Class B	Class C
<b>Waveform A</b> Fast Transient Burst Noise (FTBN)	All Power Supply Circuits	13 separate bursts of 5 minute duration	II		
<b>Waveform B</b> Random Crank	All Power Supply Circuits	8 hours <sup>(1)</sup>			
<b>Waveform C</b> Ramp Down/Up	All Power Supply Circuits	Approx 18 Hours <sup>(2)</sup>	I		
<b>Waveform D</b> Single Voltage Dropout	All Power Supply and Control Circuits	3 Cycles separated by 20 s			

**Note:**<sup>1</sup> 1 hour observed, 7 hours unobserved for DUTs with memory or functions that can be recorded at the end of the test.  
**Note:**<sup>2</sup> Test duration is dependent on the settings of T<sub>1</sub> and T<sub>2</sub> (see note in key of Fig 18-3)

### 18.1: CI 265 FTBN Waveform Parameter Definition

Fig. 18-1:

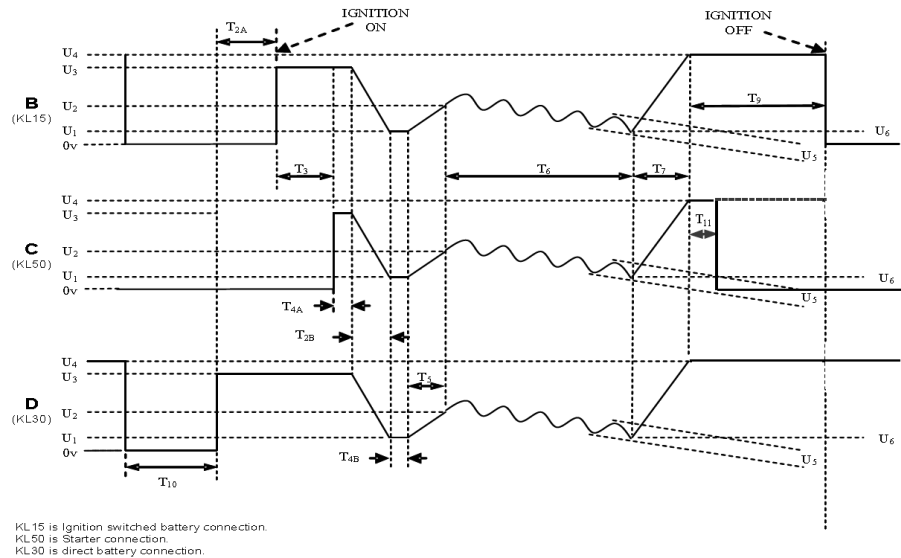


Switching Parameter	Values
Total Test Time	5 min
Power Supply Voltage	12 V
T <sub>0</sub>	60 sec
T <sub>1</sub> min = T <sub>2</sub> min	2 ms
T <sub>1</sub> max = T <sub>2</sub> max <sup>(1)</sup>	3, 6, 9, 12, 18, 24, 36, 48, 60, 100, 200, 1000, 20000 ms
Resolution	100 µs
Distribution <sup>(2)</sup>	1/x <sup>2</sup> distribution of pseudo random timing

## 18.2: CI 265 Crank Waveform

Fig. 18-2

All pseudo random values to be generated using a uniform random distribution. The pseudo-random sequences generated must be repeatable. These tests are designed to tease out software problems and hardware races. T10 should be repeated every cycle as it is there to allow the unit to complete a full re-set. However, if it can be shown that the DUT has completed this function in a shorter time, then T10 can be reduced. Other ways to reduce test time is to consider U3 and U1. Again if it can be shown that the DUT is always fully operational at a certain value of U3, then the full value of 14V need not be used, and similarly if the DUT definitely stops working at some level above 0V, then this value can be used in the test. The above criteria can also be carried across to Waveform C.

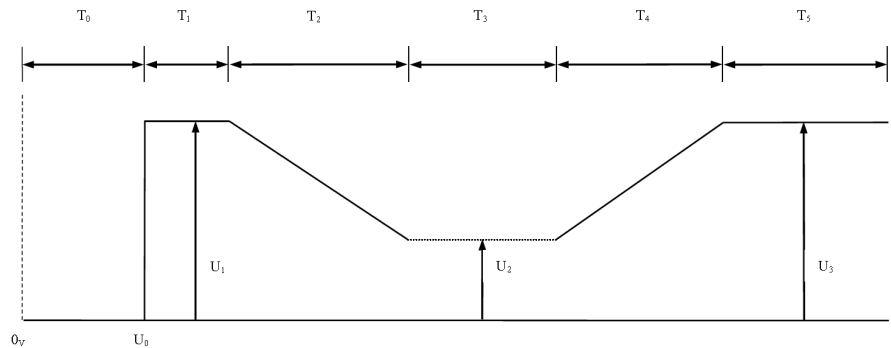


Parameter	Min	Nom	Max	Minimum Resolution	Units	Total Steps	Comments
T <sub>1</sub>		N/A					
T <sub>2A</sub>		10			s		Can be extended for special requirements where the boot-up time is longer e.g. CD Auto-changer.
T <sub>2B</sub>		5			ms		
T <sub>3</sub>	0		19999	1	ms	19999	
T <sub>4A</sub>		15			ms		
T <sub>4B</sub>	5		105	0.5	ms	200	
T <sub>5</sub>	20		150	0.5	ms	260	
T <sub>6</sub>	1		31	0.05	sec	600	
T <sub>7</sub>		500			ms		
T <sub>8</sub>		N/A					
T <sub>9</sub>		N/A					This is defined by the time needed for results analysis e.g. DTC read and clear operations.
T <sub>10</sub>		10			s		Can be extended for special requirements e.g. Airbag capacitor discharging
T <sub>11</sub>		100			ms		End of crank sequence
U <sub>1</sub>	1		8	0.05	V	140	
U <sub>2</sub>	4		9	0.05	V	100	
U <sub>3</sub>	10		14	0.05	V	80	
U <sub>4</sub>		12			V		
U <sub>5</sub>	1		2	0.05	V	20	@ 4Hz
U <sub>6</sub>	3		8	0.05	V	100	

	Power from Vehicle Battery			Regulated Power from another Module		
U <sub>P</sub>	13.5V, 27V <sup>(2)</sup>			Nominal Supply Voltage (e.g. 5 Vdc, 3 Vdc)		
T <sup>(1)</sup>	100 us	300 us	500 us	100 us	300 us	500 us

### 18.3: CI 265 Ramp Waveform

Fig. 18-3

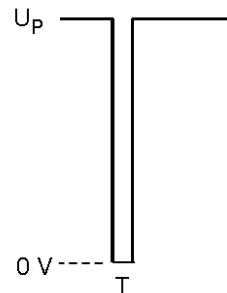


$T_0 = 10 \text{ s}$	$T_5 = 60 \text{ s}^{(1)}$
$T_1 = 60 \text{ s}^{(1)}$	$U_0 = 0 \text{ V}$
$T_2 = 30 \text{ s/V} \times (12 \text{ V} - U_2)$	$U_1 = 12 \text{ V}$
$T_3 = 1 \text{ s}$	$U_2 = 10 \text{ V to } 0 \text{ V in } 0.05 \text{ V steps}$
$T_4 = 5 \text{ s/V} \times (12 \text{ V} - U_2)$	$U_3 = 12 \text{ V}$
<b>Note:</b> <sup>(1)</sup> If it can be shown that the module is fully operational within a shorter time period, then these times can be reduced as appropriate.	

### 18.4: CI 265 Single Voltage Dropout

Fig. 18-4

(1) Waveform transition times are approx. 10  $\mu\text{s}$

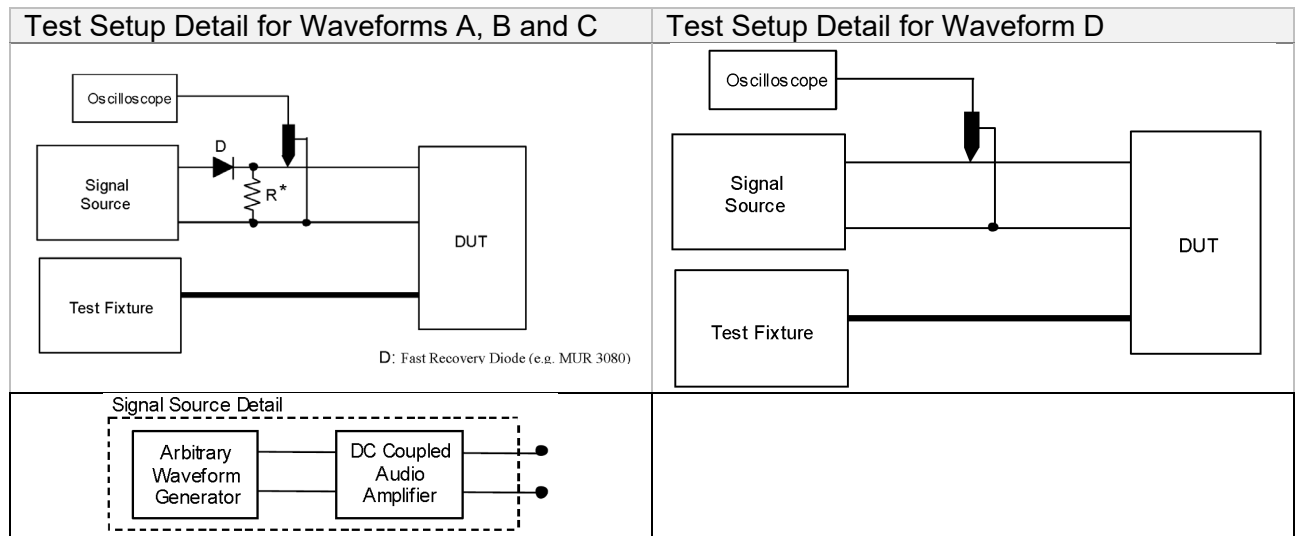


	Power from Vehicle Battery			Regulated Power from another Module		
$U_P$	13.5 V DC			Nominal Supply Voltage (e.g. 5 V DC, 3 V DC)		
$T^{(1)}$	100 $\mu\text{s}$	300 $\mu\text{s}$	500 $\mu\text{s}$	100 $\mu\text{s}$	300 $\mu\text{s}$	500 $\mu\text{s}$

(1) Waveform transition times are approximately 10  $\mu\text{s}$

Waveforms A, B and C shall be generated using the test circuit shown in Appendix I. The test harness connecting the DUT to the Test Fixture and transient pulse generator shall be  $\leq 2000 \text{ mm}$  in length. Waveform D shall be applied using the test circuit shown in Figure 18-5. The DC level shall be set to 13.5 volts with the DUT disconnected.

Connect and activate the DUT. Verify that it is functioning correctly. Record any DTC that may be permanently logged. Apply each waveform listed in Table 18-1 to each DUT power circuit for the specified period.



## 19.0 IMMUNITY TO VOLTAGE OVERSTRESS CI 270

*Used to verify that the component / subsystem shall operate without deviation when exposed to DC voltage overstress conditions that may occur during the assembly process, potential failure of the alternator regulator or assisted starting (i.e. jump start) with a 24 VDC supply. These requirements are applicable only to 12 VDC systems.*

**Table 19-1**

### Voltage Overstress Requirements:

Requirement		Functional Performance Status	
Amplitude (V)	Duration	Class A	Class B and C
-14 (-0.7, +0)	≥ 60 sec	III	III
19 (+0.95, -0)	≥ 60 min	III	II
28 (+1, -0)	≥ 60 sec <sup>(1)</sup>	III	I/II <sup>(2)</sup>

**Note:** <sup>1</sup> Applicable to devices connected directly to battery or via the ignition switch. For devices connected only to the start circuit, the duration time may be reduced to 15 sec.  
**Note:** <sup>2</sup> Status I required for devices required for engine start (e.g.; PATS)

### Test procedures: CI 270

*A device that is reverse battery protected with a fused power circuit and a reverse biased diode in parallel with the device shall be tested in a configuration representative of the vehicle. Example: If a vehicle fuse is used to protect the device, testing shall be performed with the same fuse type. The fuse type shall be documented in the component engineering specification and the EMC test plan.*

*For these tests, the power supply shall have minimum short circuit capacity of 100 amperes.*

- Apply -14 volts only to power circuits with direct battery connections. After 60 seconds, the same potential shall then be applied to the remaining switched power and control circuits for 60 seconds while maintaining the same potential on the direct battery connections. After completion of this test, apply normal +13.5 volts and verify that the DUT powers up and functions properly.
- Repeat step a) with 28 volts. Duration time may be reduced to 15 seconds if the DUT is normally connected to the vehicle start circuit. This shall be documented in the EMC test plan.
- Apply +19 volts to all power and control circuits. All circuits shall be tested simultaneously. Verify functionality per Table 19-1.

## ANNEX C: TRANSIENT WAVEFORM DESCRIPTIONS

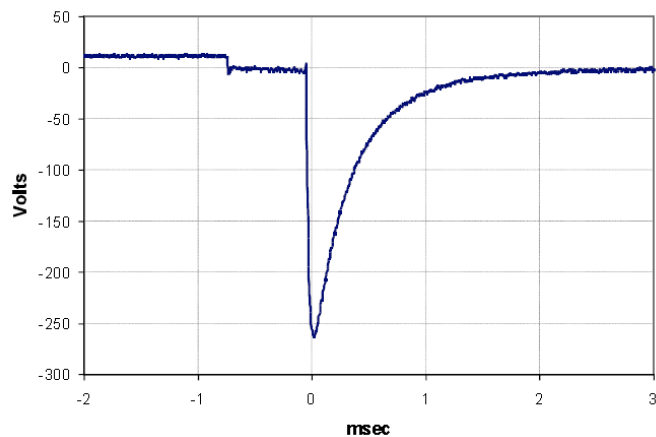
The Annex C specifies transient pulses both as standard ISO 7637-2 version as well as non-standard pulses which are not covered by the ISO 7637-2. These pulses are prevalent in the vehicles electrical power distribution system.

### Test pulse A1 Composite Waveform

Fig. C-2

Produced during switching of higher current (1-5A) inductive loads in the same circuit than the DUT

Peak pulse voltage:  
-250V ... -300V



### Test pulses A2-1 and A2-2 Contact Break + Bounce

Fig. C-3

Produced during switching of lower current (<1A) inductive loads in the same circuit than the DUT

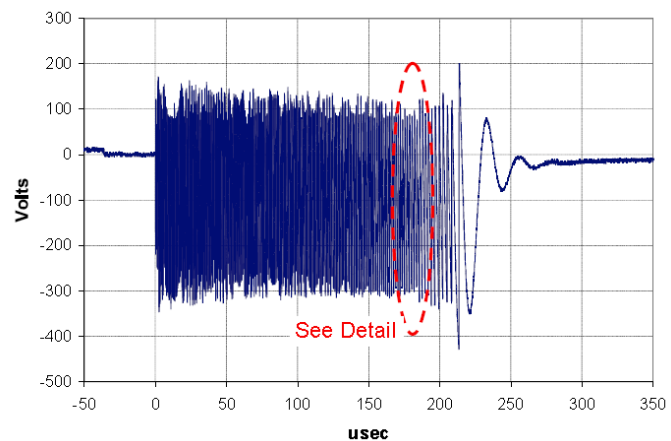
Pulse A2-1 occurs, when the circuit consists only of the DUT and the switched inductive load.

Peak positive pulse voltage:  
+100V ... +300V

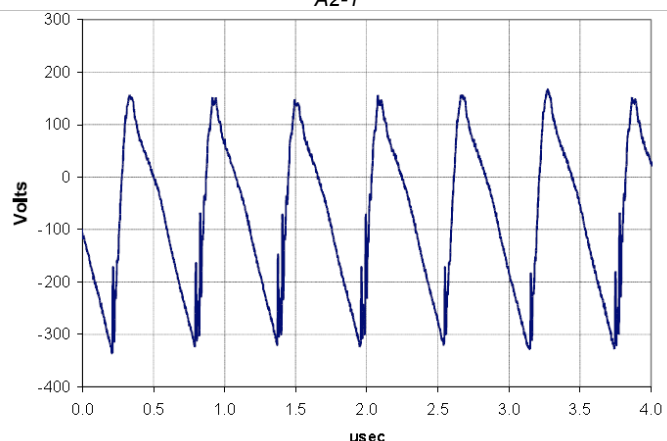
Peak negative pulse voltage:  
-280V ... -500V

Pulse duration 100ns ... 1µs

"showering arc transients"



A2-1



A2-1 Detail



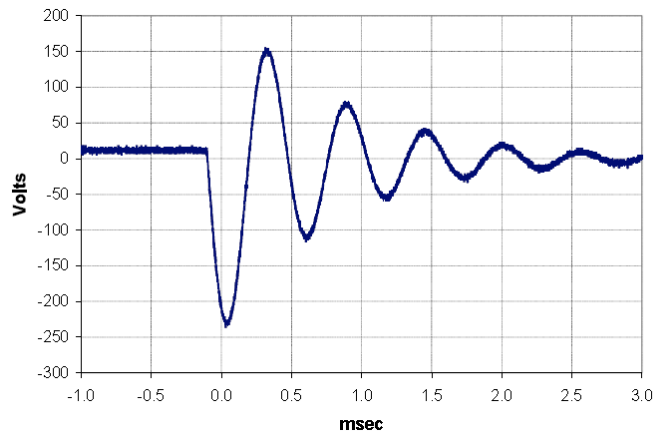
**Fig. C-4**

Pulse A2-2 occurs, when the circuit includes other electrical loads (predominantly capacitive), the DUT and the switched inductive load.

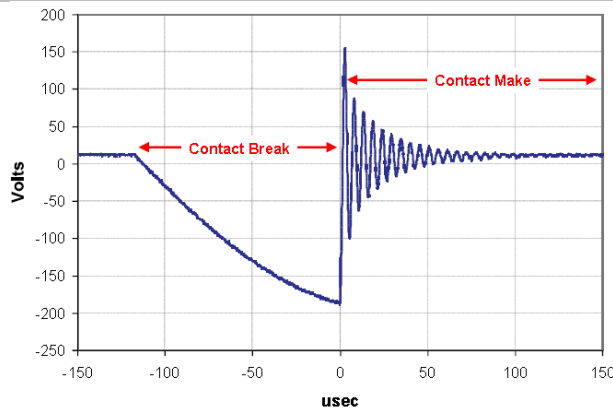
Peak positive pulse voltage:  
+100V ... +300V

Peak negative pulse voltage:  
-280V ... -500V

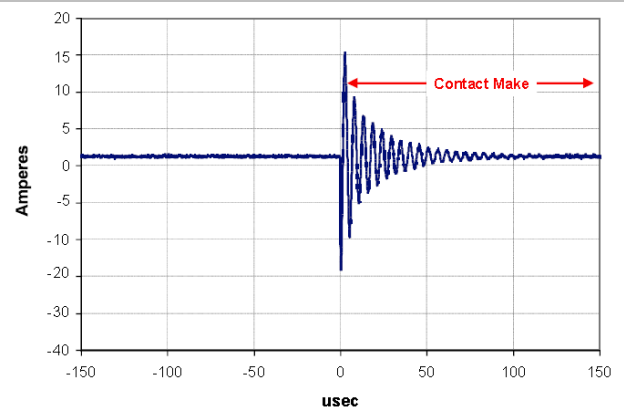
Pulse duration 100ns ... 1µs



A2-2: Contact Break ( $f_{res} \sim 2\text{kHz}$ )



A2-2: Contact Bounce Voltage ( $f_{res} \sim 180\text{kHz}$ )



A2-2: Contact Bounce Current ( $f_{res} \sim 180\text{kHz}$ )

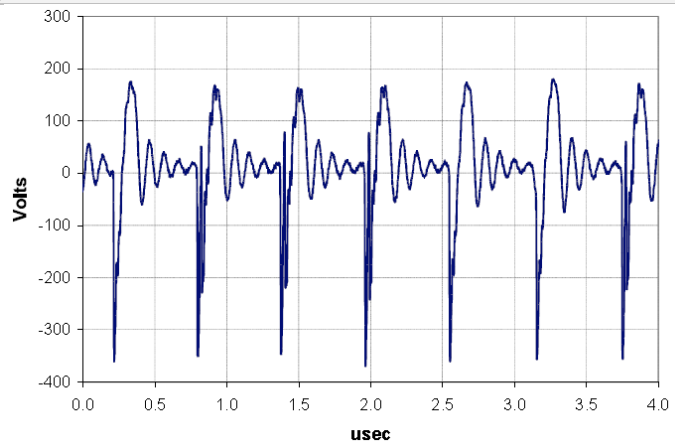
### Test pulses C-1 and C-2 Contact Arcing and Bounce

**Fig. C-5b**

Pulse C-1 corresponds to pulse A2-1 and is a function of the wiring inductance and the produced current flow

Peak positive pulse voltage:  
+150V ... +250V

Peak negative pulse voltage:  
-280V ... -400V



High frequency damped oscillation  $f_{res} \sim 10\text{MHz}$

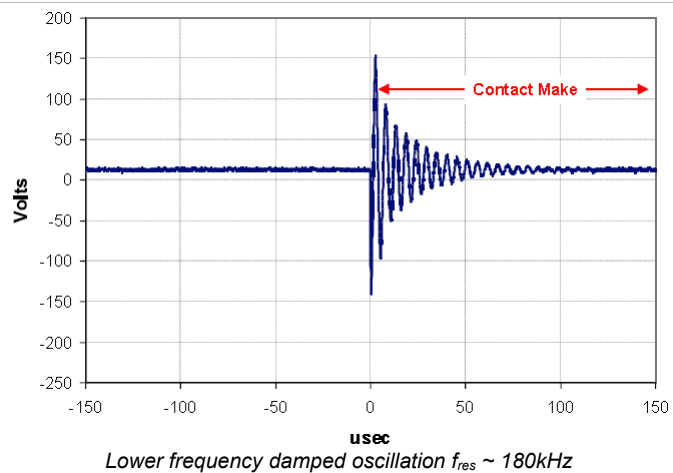
**Fig. C-5d**

Pulse C-2 corresponds to pulse A2-2 and is a lower frequency damped oscillation

Peak positive pulse voltage:  
+150V

Peak negative pulse voltage:  
-150V

Pulse duration ~ 50µs



**JLR Test pulses E, F1, F2 Contact Arcing and Bounce**

**ISO Test pulses 1, 2a, 2b Contact Arcing and Bounce**

Waveform voltage begins and ends at  $U_A$ , Parameters are for open circuit

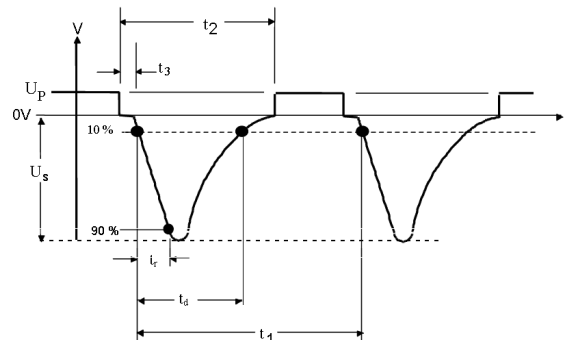
**Fig. C-6**

Voltage transient produced during switching of higher current (> 5 A)

$U_p$	13.5 V
$U_s$	-100 V
$t_r$	1 µs
$t_d$	2 ms
$t_1$	5 s
$t_2$	200 ms
$t_3$	≤ 100 µs
$R_i$	10 ohms

Waveform voltage begins and ends at  $U_p$

**JLR pulse E / ISO pulse 1:**



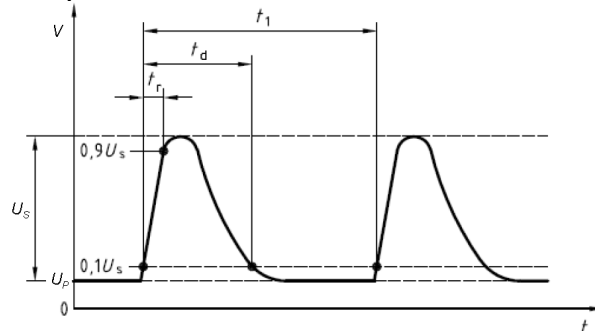
**Fig. C-7**

Simulates the interruption of a current through an inductance switched in series with the DUT.

$U_p$	13.5 V
$U_s$	37 V
$t_r$	1 (-0.1 / +0) µs
$t_d$	50 µs
$t_1$	0.2 - 5 s
$R_i$	2 ohms

Waveform voltage begins and ends at  $U_p$

**JLR pulse F1 / ISO pulse 2a:**

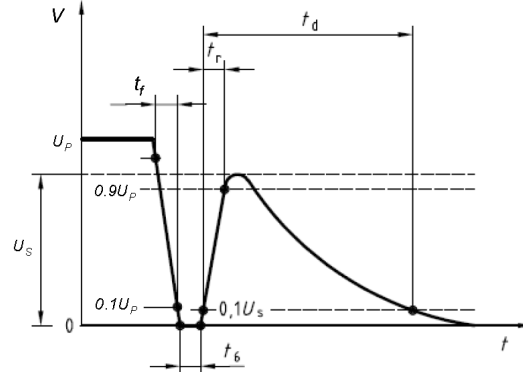


**Fig. C-8**

*Simulates the interruption in current to brush commutated motor, which is low-side switched.*

$U_p$	13.5 V
$U_s$	10 V
$t_r$	$1 \pm 0.5$ ms
$t_f$	$1 \pm 0.5$ ms
$t_b$	$1 \pm 0.5$ ms
$t_d$	0.2 – 2 s
$R_i$	< 0.5 ohms

**JLR pulse F2 / ISO pulse 2b:**



**JLR-EMC-CSv1.0 Test pulses G1, G2 Load Dump**

**ISO Test pulses 5a, 5b Load Dump**

*Pulse G1 represents the transient produced due to sudden disconnection of the battery from the alternator. Pulse G2 represents a voltage clamped transient produced due to sudden disconnection of the battery from an alternator fitted with Central Load Dump Protection.*

**Pulse G1 Parameters<sup>(1)</sup>**

Open Circuit Conditions	
$U_p$	13.5 V
$U_s$	60 V
$t_r$	10 ( -5 / +0 ) ms
$t_d$	300 ms +/-20%
$R_i$	0.5 Ohms

**Loaded Conditions (  $R_L = R_i$  )**

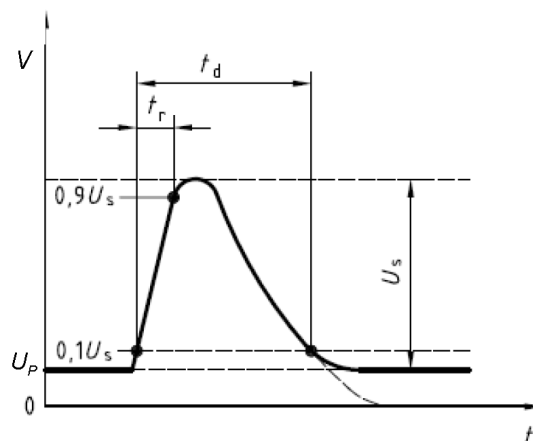
$U_p$	13.5 V
$U_s$	30 V
$t_r$	10 ( -5 / +0 ) ms
$t_d$	150 ms +/-20%
$R_i$	0.5 Ohms

**Pulse G2 Parameters<sup>(1)</sup>**

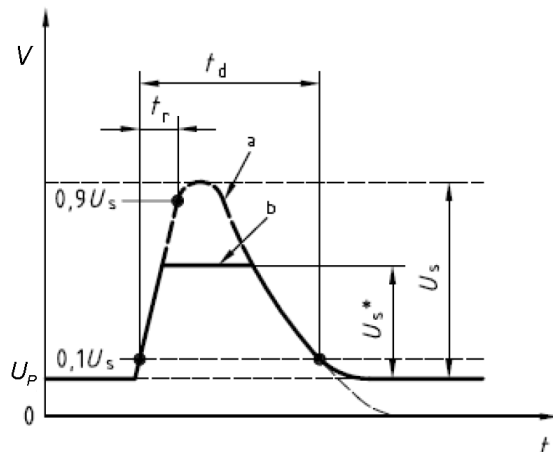
Loaded Conditions ( $R_L = R_i$ )	
$U_p$	13.5 V
$U_s$	30 V
$U_s^*$	21.5 (-1/+0) V 19.5 (-1/+0) V 17.5 (-1/+0) V 15.5 (-1/+0) V 13.5 (-1/+0) V 11.5 (-1/+0) V
$t_r$	10 ( -5 / +0 ) ms
$t_d$	150 ms +/-20%
$R_i$	0.5 Ohms

**a: Unsuppressed pulse**  
**b: Suppressed pulse**

**JLR pulse G1 / ISO pulse 5a:**



**JLR pulse G2 / ISO pulse 5b:**



<sup>(1)</sup> All voltage values are with respect to 0 volts unless otherwise specified.

<sup>(2)</sup>  $U_p$  and  $U_s^*$  based on 0.5 ohm resistive load ( $R_L = R_i$ ).

### Annex C-4: Transient Application Modes (Pulses A1, A2 and C)

Application of transient pulses A1, A2 and C to the DUT are facilitated using three different operating modes.

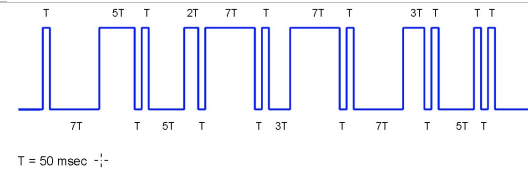
#### Mode 1: Table C-1

Mode 1 represents a condition where the test pulse is applied at a fixed repetition rate as shown in Table D-1

Transient Pulse	Pulse Repetition Rate (PRR)	Duration
A1	0.2 Hz, 10% duty cycle	120 sec
A2-1		

#### Mode 2: Fig. C-11

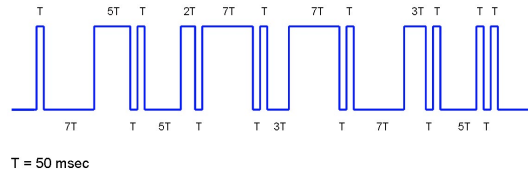
Mode 2 represents a condition where test pulses are applied using a pseudo-random timing sequence as illustrated in Fig. C-11. Mode 2 is only used with test pulse A1 when applied to DUT inputs.



Pulse timing sequence and resulting transient sequence

#### Mode 3: Fig. C-12

Mode 3 represents a condition where test pulses are applied using pseudo-random bursts as illustrated Figure C-12. The timing sequence is identical to that used for Mode 2. Mode 3 is used only with test pulses A2-1, A2-2, C-1, and C-2.



Pulse burst timing sequence and resulting transient burst

### JLR-EMC-CSv1.0A4 TEST PRODUCT MATRIX:

Test combinations	CE410	RI 140	RI 130	RI 150	CI 210	CI 220	CI 230	CI 231	CI 250	CI 265	CI 270
LVA	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Load Dump Generator											
Transient Generator			✓	✓		✓					
Coupling network	✓	✓	✓	✓		✓			✓		
Coupling transformer									✓		
Oscilloscope	✓		✓	✓	✓				✓	✓	
Current probe		✓		✓							
High Impedance probe	✓		✓	✓	✓				✓	✓	
Load simulator	✓	✓	✓	✓	✓	✓	✓				
Resistive load									✓		
Dielectric support	✓				✓						
Ground plane	✓	✓	✓	✓	✓	✓	✓		✓		
SPS_Automotive	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓