EMC LABORATORY
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IMMUNITY TO TRANSIENTS ON POWER LINES PULSE #3A & #3B TEST PROCEDURE

ISO-7637-2:2004 PULSES #3A, #3B & OEM EQUIVALENT

1. PURPOSE

1.1. To provide specific test method setup configuration instructions in full compliance with OEM specifications and international standards.

2. SCOPE

2.1. To establish consistency and repeatability in test method results using the equipment and technical resources available in EMC laboratory inventory.

3. RESPONSABILITY

3.1. EMC laboratory authorized personnel.
See **201709** *EMC LAB TEST EQUIPMENT COMPETENCY MATRIX* and **201705** *EMC LAB COMPETENCY MATRIX*.

4. EQUIPMENT & MATERIALS

4.1. All test equipment that requires calibration shall be within its calibration period and shall be traceable to A2LA certified labs. EMC lab personnel must ensure that certificates of calibration are obtained when equipment is sent out for calibration or repair. *(See REFERENCES section in document for equipment specific internal procedures and records).*

4.2. **Power supply**
* Ri of less than 0,01 Ω d.c.
* Zi = Ri for frequencies less than 400 Hz.
* output deviation =< 1 V from 0 to maximum load (including inrush current) and shall recover 63% of its maximum excursion within 100 µs.
* superimposed ripple voltage Ur =< 0,2 V peak-to-peak and shall have a minimum frequency of 400 Hz.
* simulates the low internal impedance of the battery
* battery voltages 13,5 V and 27 V, respectively.

4.3. **Oscilloscope:**
* digitizing oscilloscope (single sweep sampling rate >=2 GHz/s, bandwidth 400 MHz, input sensitivity: at least 5 mV/div.)
* analog storage oscilloscope may be used if:
  - bandwidth d.c. to at least 400 MHz;
  - writing speed of at least 100 cm/µs;
  - input sensitivity of at least 5 mV/division.

4.4. **Voltage probe:**
* attenuation of 100/1,
* maximum input voltage of at least 1 kV,
* input impedance Z and capacitance C according to Table 2 ;
* maximum probe cable length of 3 m;
* maximum probe ground length of 0,13 m.

f[MHz]	z[kΩ]	C[pF]
1	>40	<4
10	>4	<4
100	>0.4	<4

4.5. **Test pulse generator:**
* peak voltage U_s tolerance of +10% / -0%
* timing (t) tolerance of ± 20%
* internal resistance (Ri) tolerance of ± 20%

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Fig.4-1

Test Level	
Open circuit voltage	25 V - 1,000V ± 10%
On a 50 ohm load	13V - 500V ± 10%
Pulse shape	5/100 ns
Risetime tr	5 ns ± 30%
Pulse width td on 50 Ohm	100 ns to 200 ns
Pulse width td with no load	100 ns to 200 ns
Source impedance	50 Ohm ± 20%
Polarity	Positive (3b) / negative (3a)

Trigger	
Automatic	Automatic release of the pulses
Manual	Manual release of a single pulse
External	External release of a single pulse
Burst duration	t4 = 0.1 ms – 999.9 ms
Burst repetition rate	t5 = 10 ms – 9,999 ms
	t5 9,999 ms ⇒ Auto Trigger
	t5 = > 9,999 ms ⇒ Man Trigger
Spike frequency	f = 0.1 kHz – 200 kHz
	t1 = 2 µs – 10 ms (time between pulses)
Frequency Sweep	10kHz-100kHz as per Renault
Test duration	T = 0:01 min – 999.59 min
	T > 999.59 min - endless
Output	
+/- output	Safety laboratory plugs
50 Ω	To connect external couplers and clamp
Coupling	Capacitively to the battery +line
Decoupling	Via inductor
DUT supply	max. 60V / 25A
CRO Trigger	15V oscilloscope trigger signal; burst duration and pulse frequency can be checked

Tbl.4-1

Idx	Equipment Description	Model	Maker	INV#
1.	Coupling Network	CNA200B2	EMTEST	2167
2.	Pulse #3a & #3b Burst Generator	EFT200B	EMTEST	2161
3.	Power Supply 0V – 60V, 0A – 50A	VDS200B2	EMTEST	2171
4.	Oscilloscope	TDS784A	TEKTRONIX	2161
5.	Voltage probe	CNA200B2	TEKTRONIX	2167
6.	ISMISO software	Rev 4.22	EMTEST	2176

5. SUMMARY OF TEST METHOD

5.1. Evaluates DUT's immunity from conducted transients on power and control circuits connected directly to the vehicle's battery or indirectly by a switch or load (e.g. pull-up resistor).

5.2. The switching of inductive loads connected to the battery supply of vehicles creates both positive and negative pulses which electronics connected to the battery supply must be able to withstand. An example of transient would be the release of stored energy during the operation of a relay and/or other loads connected to the battery while starting and/or turning off the vehicle.

6. SAFETY PRECAUTIONS

6.1. Only EMC laboratory personnel mentioned in 201709 EMC LAB TEST EQUIPMENT COMPETENCY MATRIX is allowed to handle the EMTEST equipment.

7. TEST PLAN

7.1. For FlexAutomotive products the EMC test plan is generated using LMS004 and OEM template.

7.2. The test plan should indicate:
1) DUT, harness, I/O loads configuration and position relative to ground plane.
2) DUT activation and monitoring method, expected FPSC, and pass/fail criteria.

7.3. In the absence of an EMC test plan use information provided by the test requester in 201696 INTERNAL TEST REQUEST FORM. This approach is applicable for "engineering development" testing.

8. RECORDS

8.1. **Test reports** including plots and data files are saved over over the LAN in a dedicated folder:
\\nmknt062\apps\e-ecn\emclab\tresult\project#\job#\test group
Example of grouping test results per job#: CTI, CTE, RE, CE, BCI, ESD, TP, PT, TRENDS.

8.2. In a similar manner the EMC **test plans** (TP), **proficiency testing** (PT), **trends** are stored under a **project#\job#** folder.

8.3. The intranet application EMC LAB SCHEDULER database is used to maintain and provide fast access to testing related records. The application is available via this link: **http://nmknt063/emclab/labscheduler/**

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PULSE #3A & #3B TEST PROCEDURE

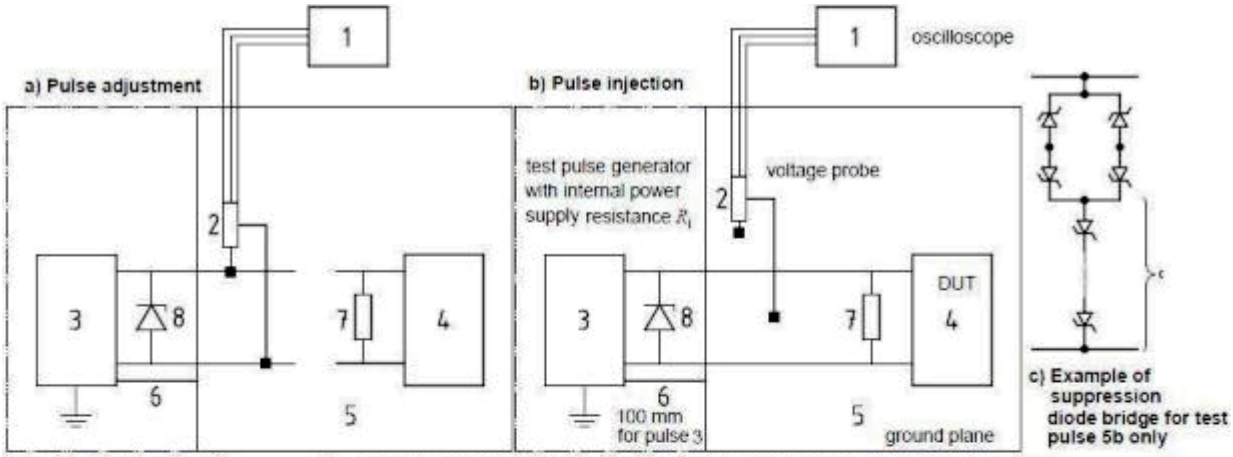
9. TEST SETUP

9.1. Prior to start testing verify that all samples are labeled per 900712 EMC LAB LABELS. The default list of required equipment is pull-out at the time the test method is selected (721179 EMC LAB, TEST REPORTS DATABASE).

9.2. A default list of required equipment is pull-out at the time the test method is selected (721179 EMC LAB, TEST REPORTS DATABASE).

9.3. The EMC test operator must ensure the testing is carried out based on the latest OEM specifications. In case of conflict the following documents may over-ride this procedure in order:
1) The latest revision of OEM specification (including corrections).
2) OEM approved EMC test plan, which can over-ride the OEM specification.

Fig.9-1



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IMMUNITY TO TRANSIENTS ON POWER LINES PULSE #3A & #3B TEST PROCEDURE

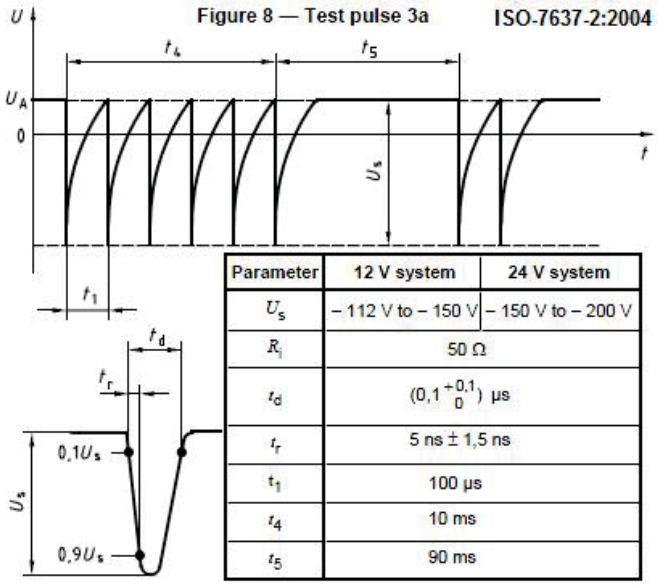
10. ISO-7637-2:2004 PULSES #3A & #3B

10.1. Pulses 3a & 3b simulatie transients which occur as a result of the switching processes. The characteristics of these transients are influenced by distributed capacitance and inductance of the wiring harness (see ISO-7637-2:2004 Annex F).

10.2. EMTEST to DUT leads (0.5 ± 0.1 m length) are laid out in a straight parallel line 50 (+10/0) mm above the ground plane.

Fig.10-1

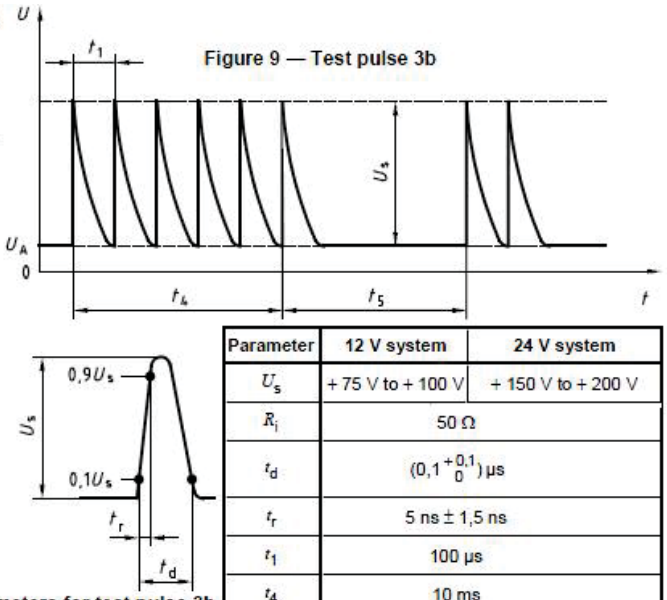
Figure 8 — Test pulse 3a ISO-7637-2:2004



Parameter	12 V system	24 V system
U_s	− 112 V to − 150 V	− 150 V to − 200 V
R_i	50 Ω	
t_d	$(0{,}1\ ^{+0{,}1}_{0})$ µs	
t_r	5 ns ± 1,5 ns	
t_1	100 µs	
t_4	10 ms	
t_5	90 ms	

Table 6 — Parameters for test pulse 3a

Figure 9 — Test pulse 3b



Parameter	12 V system	24 V system
U_s	+ 75 V to + 100 V	+ 150 V to + 200 V
R_i	50 Ω	
t_d	$(0{,}1\ ^{+0{,}1}_{0})$ µs	
t_r	5 ns ± 1,5 ns	
t_1	100 µs	
t_4	10 ms	
t_5	90 ms	

Table 7 — Parameters for test pulse 3b

Table A.1 — Suggested test levels for 12 V system

Test pulse[a]	Selected test level[b]	Test level, U_s[c] V				Min. number of pulses or test time[f]	Burst cycle/pulse repetition time	
		I	II	III min.	IV max.		min.	max.
1		g	g	− 75	− 100	5 000 pulses	0,5 s	5 s
2a		g	g	+ 37	+ 50	5 000 pulses	0,2 s	5 s
2b		g	g	+ 10	+ 10	10 pulses	0,5 s	5 s
3a		g	g	− 112	− 150	1 h	90 ms	100 ms
3b		g	g	+ 75	+ 100	1 h	90 ms	100 ms
4		g	g	− 6	− 7	1 pulse	d	d
5[e]		g	g	+ 65	+ 87	1 pulse	d	d

a Test pulses as in 5.6.
b Values agreed to between vehicle manufacturer and equipment supplier.
c The amplitudes are the values of U_s as defined for each test pulse in 5.6.
d Since the minimum number of test pulses is 1, no pulse cycle time is given. When several pulses are to be applied, a minimum delay of 1 min between pulses shall be allowed.
e See 5.6.5 c). The test levels reflect the situation of load dump at generator rated speed. If a central load dump protection is used, apply test pulse 5b as defined in Figure 12 and use the values in table 10.
f The number of pulses/time is for durability test purposes.
g The former levels I and II were deleted because they do not ensure sufficient immunity in road vehicles.

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PULSE #3A & #3B TEST PROCEDURE

11. DC10614:2005 PULSES #3A & #3B

11.1. Pulses #3a and #3b shall be applied for one half hour each (1800000 applications for each of pulses #3a and #3b).
For DUTs with one supply voltage connection, refer to ISO 7637-2 for the test setup.
For devices with 2 supply voltage connections refer to DC-10614:2010 Fig-20 & Fig-21.

Fig.11-1

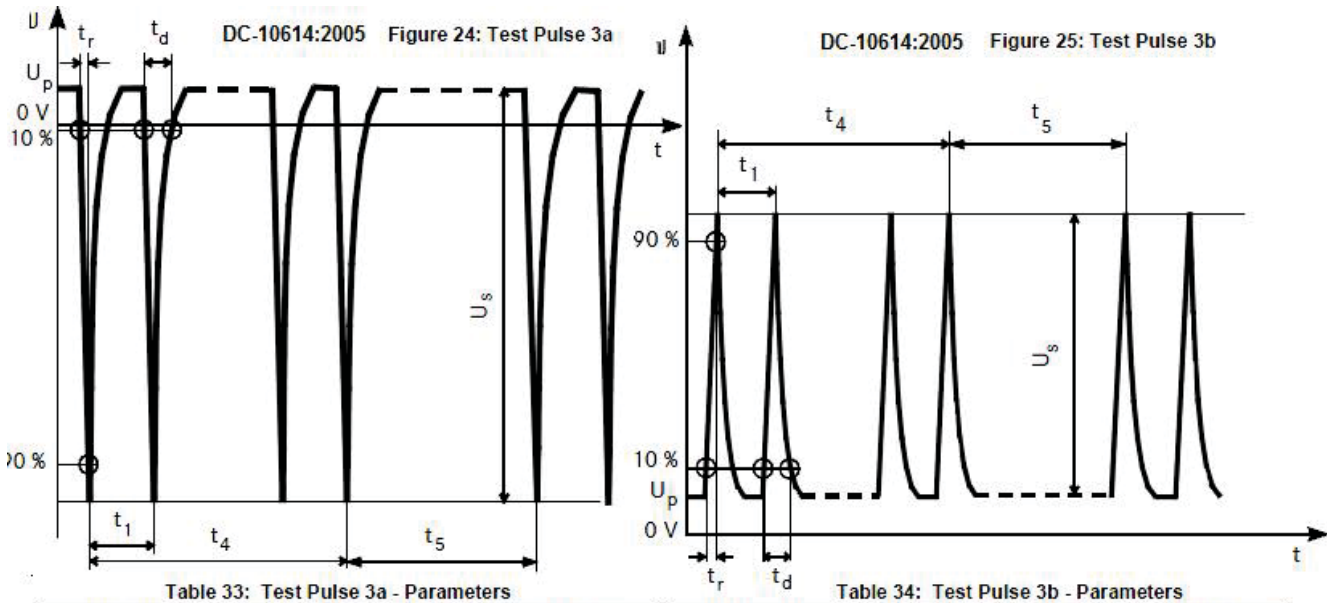

Table 33: Test Pulse 3a - Parameters

Parameters	12 V System	24 V System	42 V System
U_p in V	13.5	27	42
U_s in V	-150	-200	-150
τ_r in ns	5	5	5
τ_d in µs	0.1	0.1	0.1
τ_1 in µs	100	100	100
τ_4 in ms	10	10	10
τ_5 in ms	90	90	90
R_i in ohms	50	50	50
Test duration in h	0.5	0.5	0.5

Table 34: Test Pulse 3b - Parameters

Parameters	12 V System	24 V System	42 V System
U_p in V	13.5	27	42
U_s in V	100	200	100
τ_r in ns	5	5	5
τ_d in µs	0.1	0.1	0.1
τ_1 in µs	100	100	100
τ_4 in ms	10	10	10
τ_5 in ms	90	90	90
R_i in ohms	50	50	50
Test duration in h	0.5	0.5	0.5

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PULSE #3A & #3B TEST PROCEDURE

12. DC11224:2007 PULSES #3A & #3B

12.1. Test pulses 3a and 3b simulate the pulse bursts generated during switching operations (e.g. in relays).

12.2. Note that the pulse application time was reduced to 10 minutes from 1/2 h hour in DC-10614.

Fig.12-1

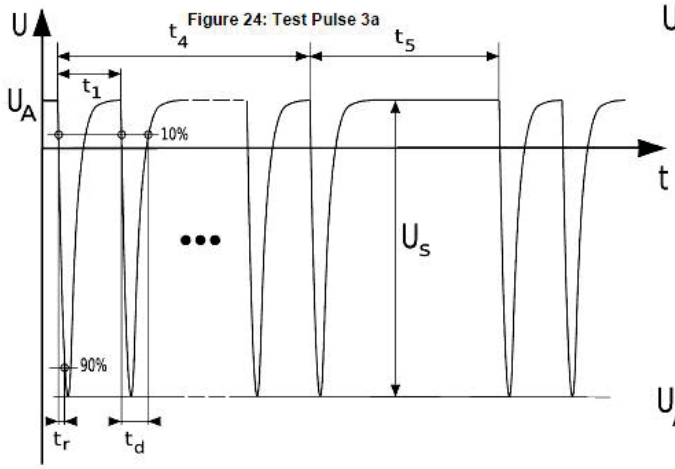


Figure 24: Test Pulse 3a

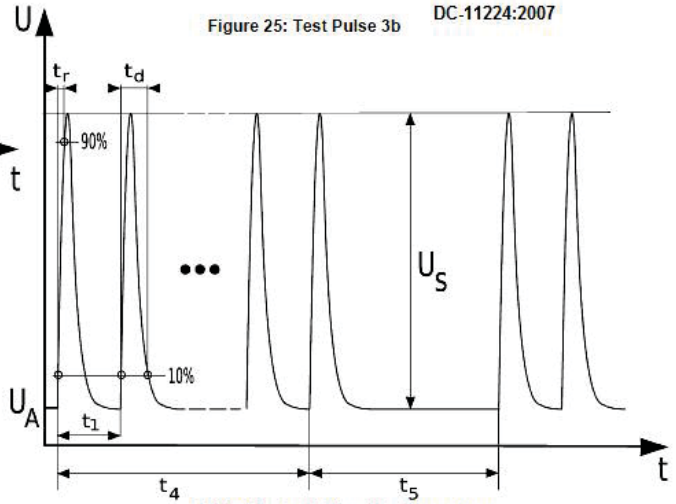


Figure 25: Test Pulse 3b

DC-11224:2007

Table 23: Test Pulse 3a - Parameters

Parameters	12 V System	24 V System	42 V System
U_A in V	13.5	27	42
U_s in V	-150	-200	-150
t_r in ns	5	5	5
t_d in µs	0.1	0.1	0.1
t_1 in µs	100	100	100
t_4 in ms	10	10	10
t_5 in ms	90	90	90
R_i in ohms	50	50	50
Test duration in min	10	10	10

Table 24: Test Pulse 3b - Parameters

Parameters	12 V System	24 V System	42 V System
U_A in V	13.5	27	42
U_s in V	100	200	100
t_r in ns	5	5	5
t_d in µs	0.1	0.1	0.1
t_1 in µs	100	100	100
t_4 in ms	10	10	10
t_5 in ms	90	90	90
R_i in ohms	50	50	50
Test duration in min	10	10	10

13. CS-11809:2009 PULSES #3A & #3B

13.1. The test equipment and test methods per ISO 7637-1 and ISO 7637-2. Test pulses are applied individually to all DUT battery, ignition, accessory and appropriate I/O lines. Lines between the DUT and the test pulse generator shall be routed at a height of 50 mm above the ground plane and shall be less than or equal to 500 mm in length.

Fig.13-1

CS-11809:2009 TABLE 20: TRANSIENT CONDUCTED IMMUNITY ON SUPPLY LINE LIMITS

Pulse No.	Test Voltage U_s [V]		Level 1 Status	Level 2 Status	Test Duration (min)
	12 V	24V			
1	-100	-600	II	II[1)]	10
1b	30	50	I	I	10
2a	100	150	I	I	10
3a	-150	-200	I	I	10
3b	100	200	I	I	10

NOTE 1: Powertrain controllers shall return to normal operation after the disturbance is removed. A reset upon application of one key cycle is not allowed.

14. CS-11979:2010 PULSES #3A & #3B

14.1. All pulses are applied both on all power supply lines tied together and on each power supply line (individually). Lines between the DUT and the test pulse generator shall be routed at a height of 50 mm above the ground plane and shall be less than or equal to 500 mm in length.

Fig.14-1 CS-11979, Change A, 2010-04-13

TABLE 26: TRANSIENT IMMUNITY PULSE REQUIREMENTS

#	Reference	Internal generator resistance Ri	Amplitude Vs (Us)	Pulse parameter	MINIMUM Number of pulses (MINIMUM test time)	Permitted behavior
A	**Pulse 1 :** generated at key-off with inductive loads present (ISO 1)	10 Ω	-100 V	td=2 ms	500 pulses	M1(1)
A1	**Pulse 1b :** generated at key-off with inductances in series with loads or electrical motors running	10 Ω	+43.5 V	td=2 ms tr=0.001ms t_1=5s	500 pulses	M1
B	**Pulse 2 :** generated at key-off with inductances in series with loads or electrical motors running (ISO 2a)	2 Ω	+100 V	td=0,05 ms	500 pulses	M1
C	**Pulse 3a :** generated by bounces and/or arcs at activation of switches or relays (ISO 3a)	50 Ω	-150 V	tr=5 ns td=100 ns t1=0,1 ms t4=10ms t5=100ms	15 min	M1
D	**Pulse 3b :** generated by bounces and/or arcs at activation of switches or relays (ISO 3b)	50 Ω	+100 V	tr=5 ns td= 100 ns t1=0,1 ms t4=10ms t5=100ms	15 min	M1
E	**Pulse 5b :** generated by a disconnected battery terminal while current is supplied from generator to battery (load-dump) (ISO 5b)	1 Ω	+ 40 V(2)	td=400 ms	15 pulses	M1, M2(3)

NOTE 1: Operation M3 permissible during negative portion of pulse.
NOTE 2: Test shall be carried out with a suppressor at Load Dump generator output clamping the pulse (Us=70V according Figure 11 of ISO 7637-2:2004) to +40V peak (ISO 5b).
NOTE 3: Where required, M1 operating mode to be ensured.

NOTE: The test duration in Table 26 is the minimum for testing against damage. It is responsibility of the supplier to test thoroughly against functional sensitivity to these types of disturbances.

15. ES-XW7T-1A278-AC:2003 (ISO-7637-2:2004 PULSES #3A & #3B NOT REQUIRED)

15.1. All pulses are applied both on all power supply lines tied together and on each power supply line (individually). Lines between the DUT and the test pulse generator shall be routed at a height of 50 mm above the ground plane and shall be less than or equal to 500 mm in length.

16. EMC-CS-2009:2010 (ISO-7637-2:2004 PULSES #3A & #3B NOT REQUIRED)

16.1. N/A

17. GMW3097:2006 PULSES #3A & #3B

17.1. GMW3097:2006 3.5.2 CI, Transients on Power Lines applies to battery+ (B+) and switched battery lines (e.g. Ignition, Accessory). It also applies to I/O lines that are connected to an inductive load, where that load is fed by B+ or switched battery. The test pulses shall be applied to B+, each switched battery line and I/O lines fed by either B+ or switched battery separately. In addition, B+ and switched battery lines and I/O lines fed by either B+ or switched battery shall be tested simultaneously.

17.2.
- Perform the test using pulses 1, 2a, 2b, 3a, 3b, and 4 in accordance with ISO 7637-2.
- The waveform amplitude for Pulse 3a, 3b is determined from the average of the waveform peak voltages.
- For this standard, the injection levels shall be established across a 50 ohm load instead of the open-circuit condition per ISO 7637-2.

Fig.17-1

GMW3097:2006 Table 18: Requirements Levels for the Immunity to Transients on Power Lines

Pulse No.	Level	Minimum Number of Pulses or Application Time	Pulse Cycle Time (min.) default	Pulse Cycle Time (max.)	Comments
1	-150 Vpeak	500 pulses	0.5 s Note 1	5 s	One or more functions of the DUT can go beyond specified tolerance as long as all functions return within normal limits after the exposure is removed. Memory functions shall perform as designed
2a	+50 Vpeak	500 pulses	0.5 s	5 s	2Ω transient generator internal source impedance
2b	+10 Vpeak	10 pulses	0.5 s Note 1	5 s	There shall be 10 pulses, beginning at 200 ms pulse width, then increasing pulse width by 200 ms steps until 2000 ms is achieved
3a	-200 Vpeak	10 minutes	90 ms	110 ms	Injection level established into a 50 ohm load (as opposed to the open-circuit measurement as specified in ISO 7637-2)
3b	+100 Vpeak	10 minutes	90 ms	110 ms	Injection level established into a 50 ohm load (as opposed to the open-circuit measurement as specified in ISO 7637-2)
4	See Table 19	1 pulse of each severity level	0.5 s	15 s	Voltage levels and Performance Criterion for Pulse 4 (crank pulse) see Table 19.
5b	(34 +0/-1) Vpeak	10 pulses	15 s	2 min	No permanent DUT performance deviations shall be observed after exposure to a load dump pulse with a suppressed open circuit voltage of (34 +0/-1) V, Ri=2 Ω
7	-50 Vpeak	500 pulses	0.5 s	5 s	2 Ω transient generator internal source impedance

Note 1: the minimum time must be long enough for the DUT's return to normal operation.

Table 16: Open Circuit Load Dump Pulse Parameters Specifications

Parameter	Unsuppressed	Suppressed
Transient Amplitude	+100 V ± 10%, (U_a + U_A)	(+34 +0/-1) V, (U_a + $U_{A'}$)
t_d	400 ms ± 30%	400 ms ± 30%
t_r	≤ 10 ms	≤ 10 ms

Table 17: Two Ohm Loaded Load Dump Voltage Pulse Parameter Specifications

Parameter	Suppressed
U_a + U_s'	(+34 +0/-1) V

Figure 4: Setup for Pulse 7 (Simulation of Wiper Motor Switching Transient)

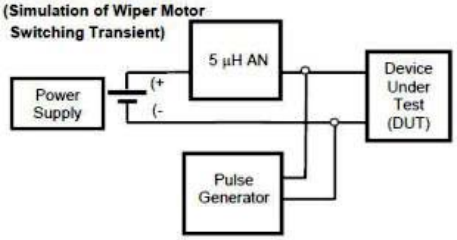


Table 19: Requirements Levels for the Immunity to Pulse 4: Crank Pulse

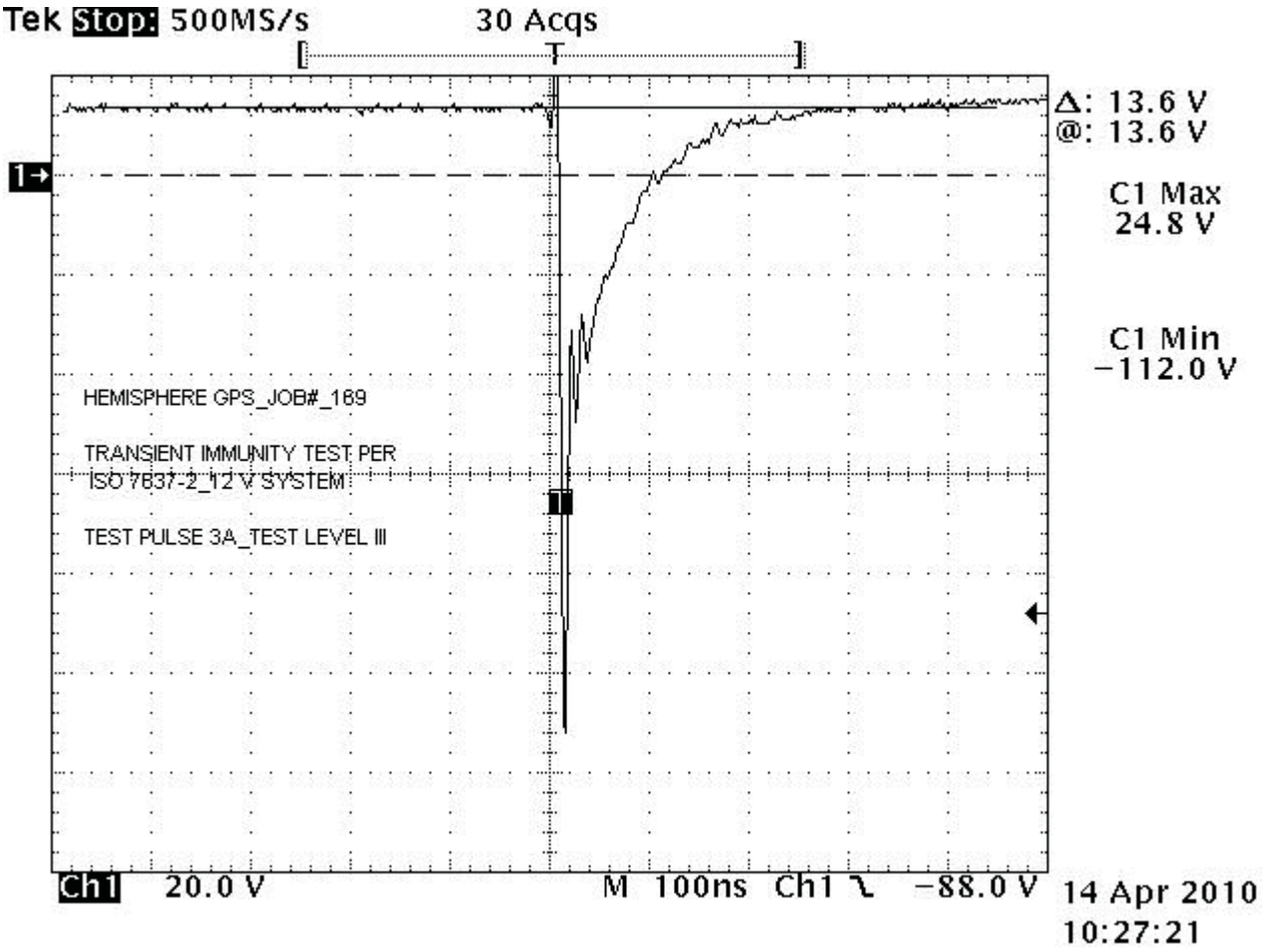
Pulse Severity	U_s Note 1	U_a Note 1	t_6 Note 1	t_{11} Note 1	Performance Criterion
I	4 V	2.5V	1 s	40 ms	One or more functions of the DUT can go beyond specified tolerance as long as all functions automatically return within normal limits after the exposure is removed. Memory functions and functions required to start an engine shall perform as designed.
II	5 V	3 V, 2.5 V	2 s	60 ms	
III	6 V	4 V, 3 V, 2.5 V	5 s	80 ms	
IV	7 V	5 V, 4 V, 3 V, 2.5 V	10 s	100 ms	

t_{10}, t_6 and t_7 as defined in ISO 7637-2. Default value for t_7 shall be 15 ms.
Default value for t_6 shall be 50 ms. All severity levels shall be tested.
Note 1: As defined in ISO 7637-2.

18. REPORT

18.1. Report pulse parameters, severity level, and DUT FPSC response. Include pulse verification waveform (no load, U_A = 13.5 ± 0.5 V) acquired prior to test and test setup pictures, order of injection for each of the waveform amplitudes, number (repetitions) of the pulse applied, pulse period (interval between pulses), any deviation from a standard pulse waveform, point of application of pulse (pin number, letter, or name), exact characteristics of any disturbance during injection of the pulse.

Fig.18-1



Tbl.18-1

	Parameter	12V system	Tolerance	
1.	U_s	− 112V	− 112V to − 150V	
2.	R_i	50 Ω	50 Ω	
3.	t_d	0.1	0.1 (+0.1/-0) µs	
4.	t_r	5 ns	5 ns ± 1.5 ns	
5.	t_1	100 µs	-	per test plan
6.	t_4	10 ms	-	
7.	t_5	90 ms	-	

19. PROFICIENCY TESTING

19.1. Follow instructions and scheduler provided in LMS011 EMC LAB PROFICIENCY TESTING PROGRAM and ISO-7637-2:2004 Annex-D (Test pulse generator verification procedure).

19.2. U_A = 0V.

Tbl.19-1

	Pulse Verification	U_s	t_r	t_d
1.	Pulse 3a - No load (12/24 V)	– 200 V ± 20 V	5 ns ± 1,5 ns	150 ± 45 ns
2.	Pulse 3a - 50 Ω load (12/24 V)	– 100 V ± 20 V	5 ns ± 1,5 ns	150 ± 45 ns
3.	Pulse 3b - No load	+ 200 V ± 20 V 5	5 ns ± 1,5 ns	150 ± 45 ns
4.	Pulse 3b - 50 Ω load	+ 100 V ± 20 V	5 ns ± 1,5 ns	150 ± 45 ns

20. TRENDS

20.1. Follow instruction provided in 721179 EMC LAB, TEST REPORTS DATABASE and 721186 EMC LAB, TRENDS AND STATISTICS.

21. DEFINITIONS

21.1. Use definitions per ISO 7637-1.

21.2. FPSC = Function Performance Status Classification

REFERENCES

LMS007			*EMC LAB, EQUIPMENT CONTROL*
LMS011			*EMC LAB, PROFICIENCY TESTING PROGRAM*
201707			*EMC LAB, APPROVED EQUIPMENT SUPPLERS LIST*
201711			*EMC LAB, EQUIPMENT INVENTORY*
201728			*EMC LAB, APPROVED CALIBRATION SUPPLIERS LIST*
201709			*EMC LAB, TEST EQUIPMENT COMPETENCY MATRIX*
201705			*EMC LAB, COMPETENCY MATRIX*
201696			*INTERNAL TEST REQUEST FORM*
900712			*EMC LAB LABELS*
721179			*EMC LAB, TEST REPORTS DATABASE*
721186			*EMC LAB, TRENDS AND STATISTICS*
201724			*CALIBRATION SUPPLIER EVALUATION FORM*
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SAE J1113-11		Jun 2007	*Immunity to Conducted Transients on Power Leads*

REVISION CHANGES

Dec 14, 2009	A	Release		Christian Rosu
Apr 16, 2010	B	Updated references & CS-11979 addition		Christian Rosu
Apr 22, 2010	C	Updated Test Setup section		Christian Rosu

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IMMUNITY TO TRANSIENTS ON POWER LINES PULSE #3A & #3B TEST PROCEDURE

END-USER FEEDBACK

○ very satisfied ○ satisfied ○ neutral ○ dissatisfied ○ very dissatisfied

Please rate your overall satisfaction with this LMS document and input your suggestions or comments.
Your opinion is very important for us.

Survey Date