

## FORD FMC1278 at a glance

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

The relating standards:



FORD FMC1278  
 FORD EMC-CS-2009.1  
 ISO 7637-2  
 MIL-STD-461E

FMC1278 is applicable for all 12V / 24V DC electrical and electronic components and subsystems that are planned for use on 2020 FORD vehicle programs and beyond.

### FMC1278 – Table 7-1: 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>	An electronic module operated from a regulated power supply (e.g. 3V <sub>DC</sub> , 5V <sub>DC</sub> ) located in another module like sensors providing input to a controller
<b>AM:</b>	An electronic module that contains magnetically sensitive elements or is connected to an external magnetically sensitive element
<b>AX:</b>	An electronic module that controls an inductive device (e.g., DC-brush motors, electronically controlled motors, solenoids, relays, etc.) internal or external to its package, ignition coils
<b>AW:</b>	An electronic module with no external wiring (e.g. RKE keys)
Electric Motors	
<b>BM:</b>	A brush commutated dc electric motor with no additional electronic control
<b>EM:</b>	An electronically controlled brush commutated electric motor with embedded electronic control (e.g. brushless electric motor)
Other devices	
<b>D:</b>	Module or assembly containing only diodes, resistor ladder networks, NTCs, PTCs with or without mechanical switches (e.g. Display LEDs, telltales, switches with internal backlighting LEDs)
<b>R:</b>	Includes but not limited to relays and solenoids

### FMC1278 – Table 7-2: Requirement selection matrix

Requirement type	Req. ID	Component Category								
		Electronic modules					Electric Motors		Other devices	
		A	AS	AM	AX	AW	BM	EM	D	R
Conducted AF	CE 421	✓		✓	✓			✓		
Conducted Transients	CE 410				✓		✓	✓		✓
Magnetic field Immunity	RI 140			✓		✓				
Coupled disturbances	RI 130	✓	✓	✓	✓			✓	✓	
	RI 150	✓	✓	✓	✓			✓		
Continuous disturbances	CI 210	✓		✓	✓			✓		
	CI 220	✓		✓	✓			✓	✓	
Transients	CI 221	✓	✓	✓	✓	✓		✓	✓	
	CI 222	✓	✓	✓	✓	✓		✓	✓	
	CI 230	✓		✓	✓			✓		
Power cycles	CI 231	✓		✓	✓			✓		
	CI 250	✓	✓	✓	✓			✓		
Ground offset	CI 260	✓	✓	✓	✓			✓		
Voltage dropout	CI 260	✓	✓	✓	✓			✓		
Voltage overstress	CI 270	✓		✓	✓		✓	✓	✓	✓

#### 5.5.4 POWER SUPPLY REQUIREMENTS

*“the regulated DC supply shall be a linear type to minimize test setup ambient noise”*

#### 10.0 CONDUCTED EMISSIONS CE 421

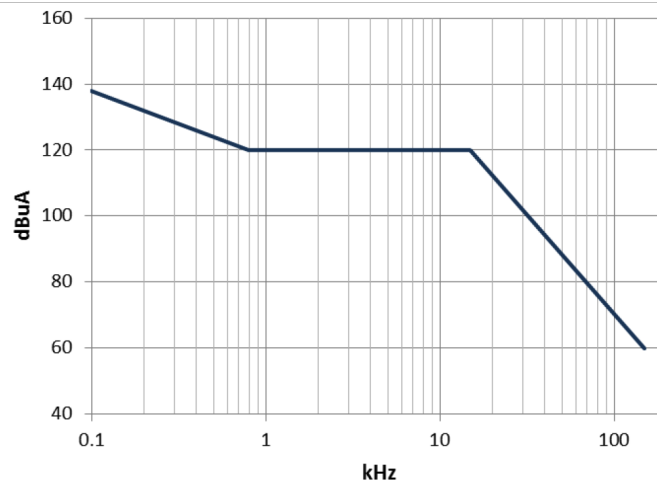
*Used to check the emission limits of unintentional low frequency conducted emissions on the DUT's power supply circuits.*

**FMC1278 CE 421**  
**Fig. 10-1**

*Requirements for  
 conducted emissions:  
 0.1 – 150kHz*

*Measurement receiver  
 shall be fully compliant  
 to CISPR 16-1-1*

*Measurement  
 Bandwidth (MBW):  
 0.2 – 1 kHz*



*Frequency step size:  
 0.5 \* MBW  
 Dwell time per step:  
 >= 0.02 sec*

Frequency Range (kHz)	Limits (dBuA)*
0.1 – 0.8	138-20Log(f/0.1)
0.8 – 15	120
15 – 150	120-60Log(f/15)*
*: f=frequency in kHz	

#### 11.0 CONDUCTED TRANSIENT EMISSIONS CE 410

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

**FMC1278 CE 410**  
**Table 11-1**  
**Transient voltage  
 emission limits**

Polarity of Pulse amplitude	12V <sub>DC</sub> Systems	24V <sub>DC</sub> Systems
Positive	+75	+150
Negative	-100	-450

*The emission tests shall be carried out with a digital oscilloscope set to a trigger level of 80% of the above transient limits. The requirements of the oscilloscope are defined in the ISO 7637-2(2004).*

*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.*

### 13.0 MAGNETIC FIELD IMMUNITY RI 140

Used to verify the immunity against off-board and on-board magnetic fields in the frequency range 50Hz ... 100kHz.

FMC1278 RI 140  
Fig. 13-1

Magnetic Field  
Immunity  
Requirements:

DUT performance shall  
be verified acc. to  
MIL-STD-461E, RS101

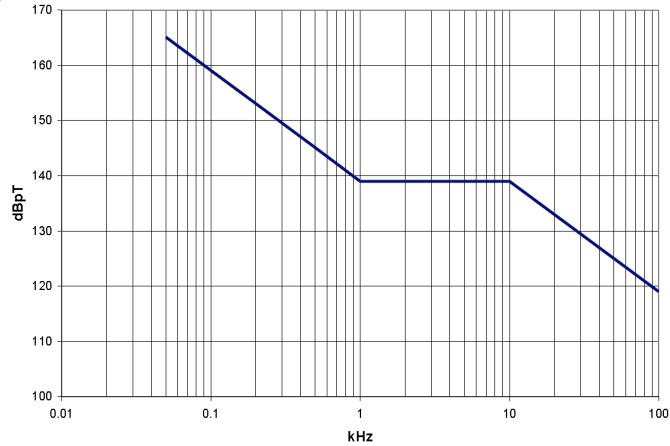


Table 13-1:

Test Frequency  
Requirements:

Test Frequency Range (kHz)

0.05 – 1

>1 – 10

>10 – 100

Frequency step (kHz)

0.05

0.5

5

Frequency (kHz)

0.05 – 1

1 – 10

10 – 100

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

165-20Log(f/0.05)

139

139-20Log(f/10)\*

\*: f=frequency in kHz

Radiating Loop Method:

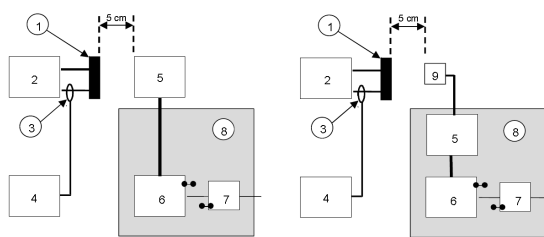
Prior to performing testing the radiation loop shall  
be calibrated acc. to the procedures delineated in  
the MIL-STD-461E, RS101

Helmholtz Coil Method:

Prior to performing testing the Helmholtz Coil shall  
be calibrated acc. to the procedures delineated in  
the MIL-STD-461E, RS101

Fig. 13-2 Test Setup:

Dwell time is at least 2 sec or according to longer function response times of the DUT



Configuration for Testing DUT only

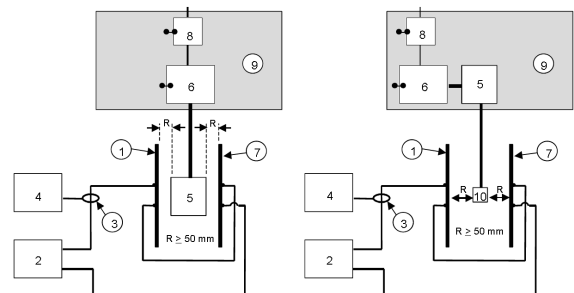
Configuration for Testing DUT  
with attached Magnetic Sensors

Key:

1. Radiating Loop
2. Signal Source
3. Current Probe
4. Measurement Receiver
5. DUT

6. Load Simulator
7. Artificial Network
8. Ground Plane
9. Magnetic Sensor

Fig. 13-3 Test Setup:



Configuration for Testing DUT only

Configuration for Testing DUT  
with attached Magnetic Sensors

Key:

1. Radiating Loop A
2. Signal Source
3. Current Probe
4. Measurement Receiver
5. DUT

6. Load Simulator
7. Radiating Loop B
8. Artificial Network
9. Ground Plane
10. Magnetic Sensor

## 14.0 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.

FMC1278 RI 130 Table 14-1	Timing mode	Type of pulse
	2	A2-1
		A2-2
	3	A2-1
		A2-2

Coupled Immunity Requirements:

The test pulses which are to use are the pulses A2-1 and A2-2 as described in the Annex D of the FMC1278, respectively in the Chapter "Annex D: Transient waveform descriptions and application modes for RI 130, CI 220, CI 221, CI 222" later in this document.

- 1 DUT
- 2a DUT Circuit Wire to be Tested
- 2b DUT Wire Harness
- 3 Load Simulator
- 4 Artificial Network
- 5 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 ( $> 10\text{ MHz}$ ,  $30\text{ A}$ )

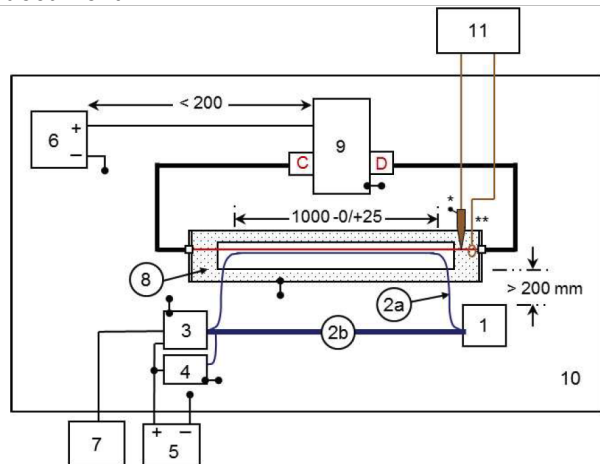


Fig. 14-1: RI 130 Default Test Setup

## 15.0 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.

FMC1278 RI 150

Fig. 15-1:

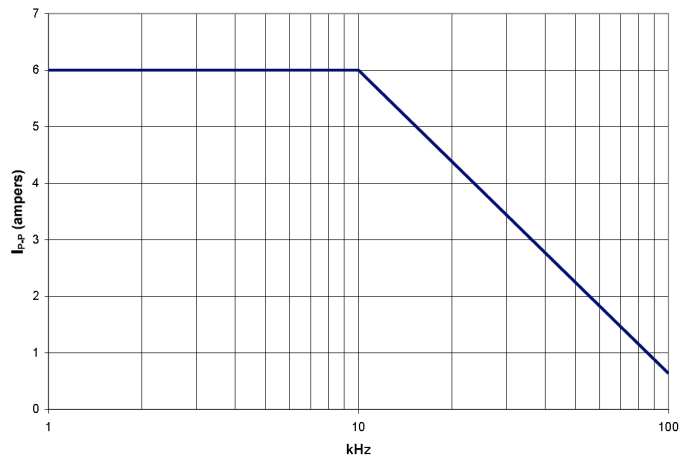
Coupled Immunity Requirements:

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)

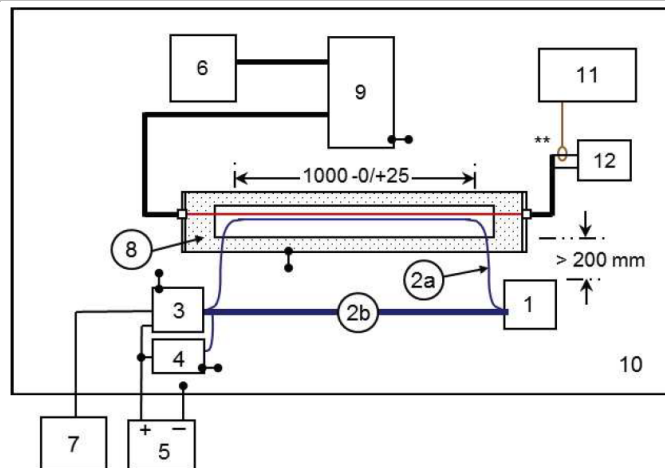


Fig. 15-2: RI 150 Default Test Setup

Table 15-1: 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.

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

## 16.0 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.

FMC1278 CI 210

Fig. 16-1:

**Stress levels Requirement 1:**

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

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

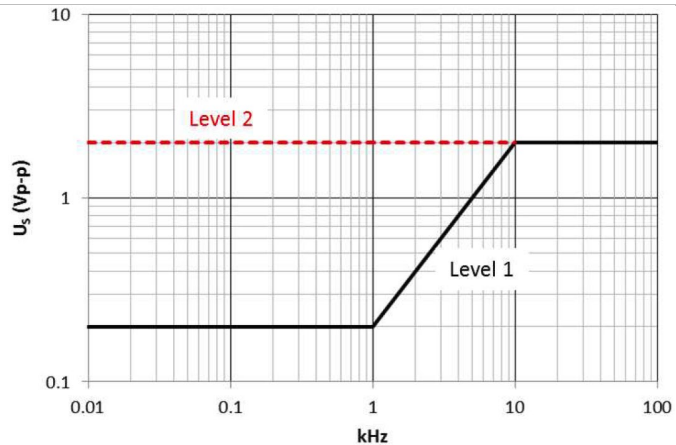
10 ... 100 kHz:  $2.0 V_{pp}$

**Stress levels Requirement 2:**

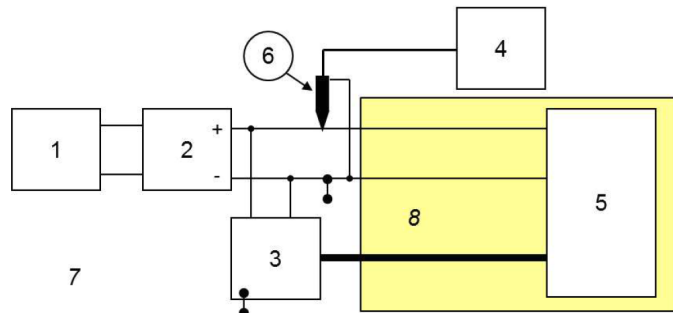
0.01 ... 1 kHz:  $2.0 V_{pp}$

1 ... 10 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 ( $>1\text{Mohm}$ ,  $C < 10\text{ pf}$ )
7. Ground Plane
8. Dielectric Support



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.

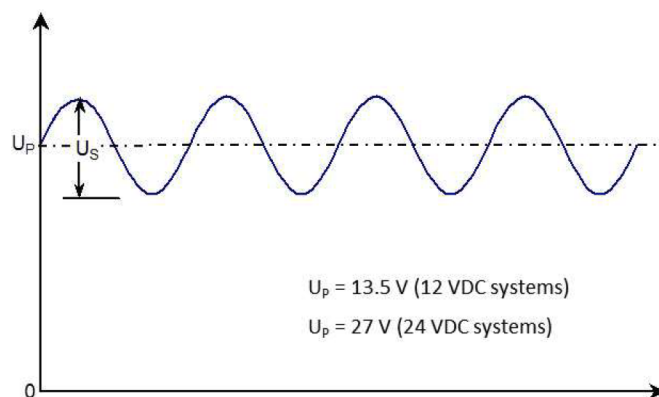


Table 16-1: CI 210 Test Frequency Requirements

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

## 17.0 IMMUNITY FROM TRANSIENT DISTURBANCES CI 220 - 12V<sub>DC</sub> ONLY

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.

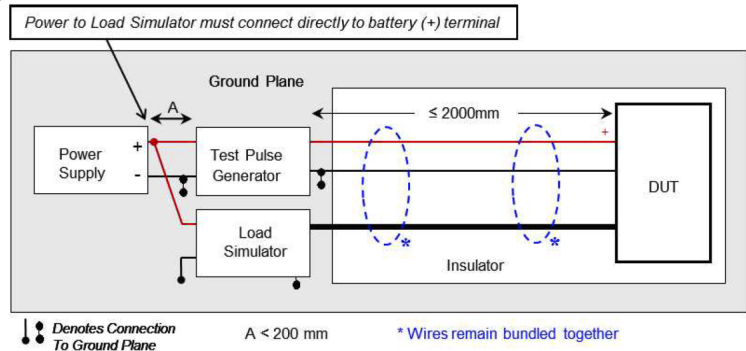
**FMC1278 CI 220**  
**Table 17-1:**  
**Transient Immunity**  
**Requirements:**

The required test pulses are described in the Annex D of the FMC1278, respectively in the Chapter "Annex D: Transient waveform descriptions and application modes for RI 130, CI 220, CI 221, CI 222" later in this document.

Transient Pulse <sup>(1)</sup>	Application	Stress Level (Volts) <sup>(1,2)</sup>		Transient Mode <sup>(1)</sup>	Minimum # of pulses or Test Duration	Functional Performance Status
		$U_A$	$U_S$			
ISO Pulse 1	All Power Supply Circuits or Control Circuits $\geq 5$ amperes	13.5	-100 <sup>(4)</sup>	n/a	24 pulses	II
Pulse A1 <sup>(2)</sup>	All Power Supply Circuits with Maximum Current $< 5$ amperes	See Annex D		Mode 1	120 sec	II
	Control Circuits			Mode 2	20 sec	II
Pulse A2-1 <sup>(2)</sup>	All Power Supply Circuits with Maximum Current $< 5$ amperes			Mode 1	120 sec	II
Pulse A2-2 <sup>(2)</sup>	Control Circuits			Mode 2	20 sec	II
Pulse A2-3 <sup>(2)</sup>	Control Circuits			Mode 3	20 sec	II
Pulse C-1 <sup>(2)</sup>	All Power Supply Circuits ( $< 15A$ ) <sup>(3)</sup>			Mode 2	20 sec	I
Pulse C-2 <sup>(2)</sup>	Control circuits.			Mode 3	20 sec	I

**FMC1278 CI 220**  
**Fig. 17-1:**  
**Test setup for devices with a single Power Supply Circuit:**

Test setups for other circuits are given in Fig. 17-2, 17-3 and 17-4 in the FMC1278.



FMC1278 Figure 17-2 illustrates the test setup for devices with two supply circuits. FMC1278 Figure 17-3 illustrates the setup used for testing of control circuits. Further detail of this configuration is illustrated in FMC1278 Figure 17-4.

## 18.0 IMMUNITY FROM TRANSIENT DISTURBANCES CI 221

Used to verify the immunity from conducted transients on both switched and unswitched power supply circuits.

**FMC1278 CI 221**  
**Table 18-1:**  
**Transient Immunity**  
**Requirements:**

The required test pulses are described in the Annex D of the FMC1278, respectively in the Chapter "Annex D: Transient waveform descriptions and application modes for RI 130, CI 220, CI 221, CI 222" later in this document.

ISO Test Pulse	Application	Stress Level (Volts) <sup>(1,2)</sup>				Minimum # of pulses or Test Duration	Repetition time	Functional Performance Status
		12 VDC System		24 VDC System				
		$U_A$	$U_S$	$U_A$	$U_S$			
1	Switched Power Supply Circuits	13.5	-75	27	-450	5000 pulses	0.5 sec	II
2a	All Supply Circuit	13.5	+37	27	+37	5000 pulses	0.2 sec	I
2b	Supply Circuits connected in parallel with an electric motor	13.5	+10	27	+20	10 pulses	0.5 sec	II
3a	All Supply Circuit	13.5	-112	27	-150	1 hour	90 msec	I
3b	All Supply Circuit	13.5	+75	27	+150	1 hour	90 msec	I

## 19.0 IMMUNITY FROM LOAD DUMP CI 222

Used to verify the immunity from Load Dump conditions.

FMC1278 CI 222

Table 19-1:

Load Dump Requirements:

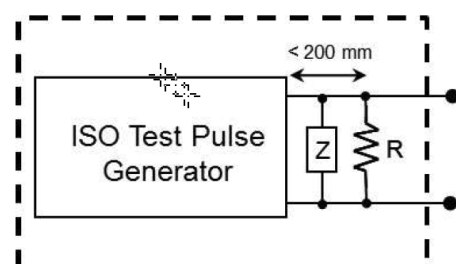
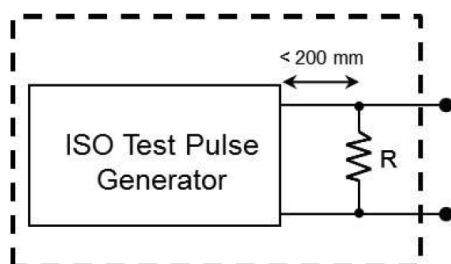
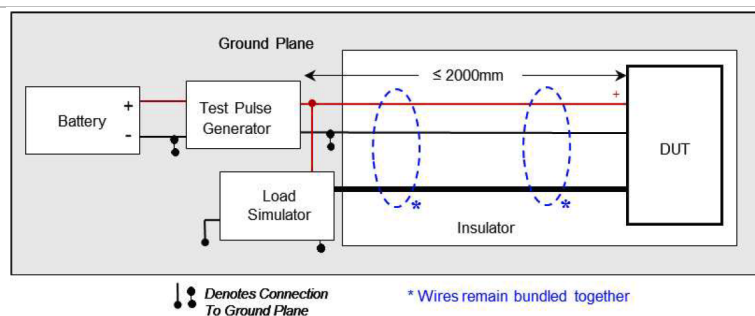
ISO Test Pulse	Application	Stress Level ( Volts )					Minimum # of pulses	Repetition time	Functional Performance Status	
		12 VDC System			24 VDC System				Class A & B	Class C
		$U_A$	$U_S$	$U_S^{* (B)}$	$U_A$	$U_S$				
5a <sup>(1)</sup>	All power supply circuits Control circuits	13.5	+60 <sup>(2)</sup>	n/a	27	+120 <sup>(3)</sup>	5	60 sec	III	II
5b <sup>(1)</sup>	All power supply circuits Control circuits	13.5	+30 <sup>(3)</sup>	+21.5 (-1/+0)	n/a		5	60 sec	III	II

The required test pulses are described in the Annex D of the FMC1278, respectively in the Chapter "Annex D: Transient waveform descriptions and application modes for RI 130, CI 220, CI 221, CI 222" later in this document.

FMC1278 RI 150

Fig. 19-1:

Test setup



## 20.0 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

FMC1278 CI 230

Table 20-1

Requirements for Power cycling:

Waveform <sup>(1)</sup>	Application	Duration	Functional Performance Status <sup>(2)</sup>
A	Switched Power & control circuits that are activated at initiation and duration of the start event	2 cycles separated by cooling period (see section 20.3)	II
B	Power circuits connected directly to Battery (i.e. unswitched)		II

(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.

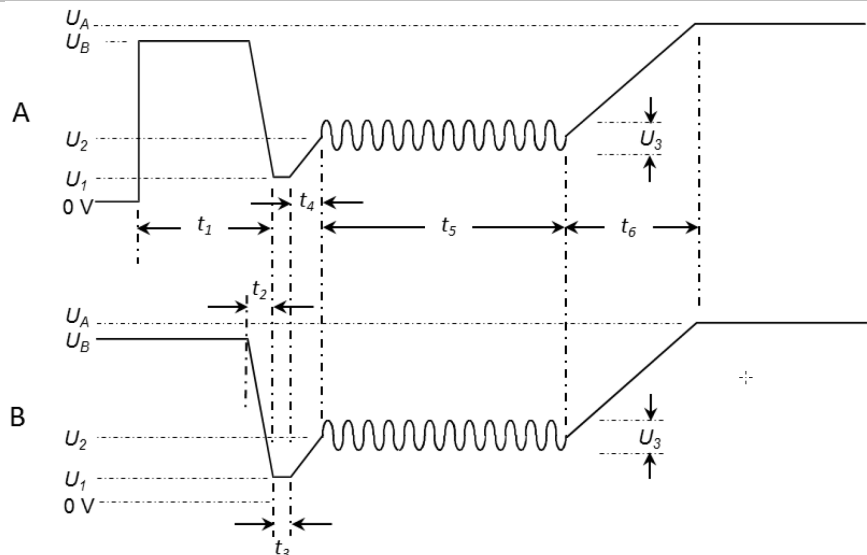
- The test harness connecting the DUT to the Load Simulator and transient pulse generator shall be < 2000 mm in length.
- Power to the DUT and Load Simulator is provided by Signal Sources A and B. Circuits within the Load Simulator shall be identified in the EMC test plan as to which signal source they will be powered from.
- Testing shall be performed with the DUT placed in a thermal chamber with the ability to facilitate testing at -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

FMC1278 CI 230  
Fig. 20-1

$t_1 = 200 \text{ msec}$   
 $t_2 = 5 \text{ msec}$   
 $t_3 = 15 \text{ msec}$   
 $t_4 = 50 \text{ msec}$   
 $t_5 = 10 \text{ sec}$   
 $t_6 = 500 \text{ msec}$

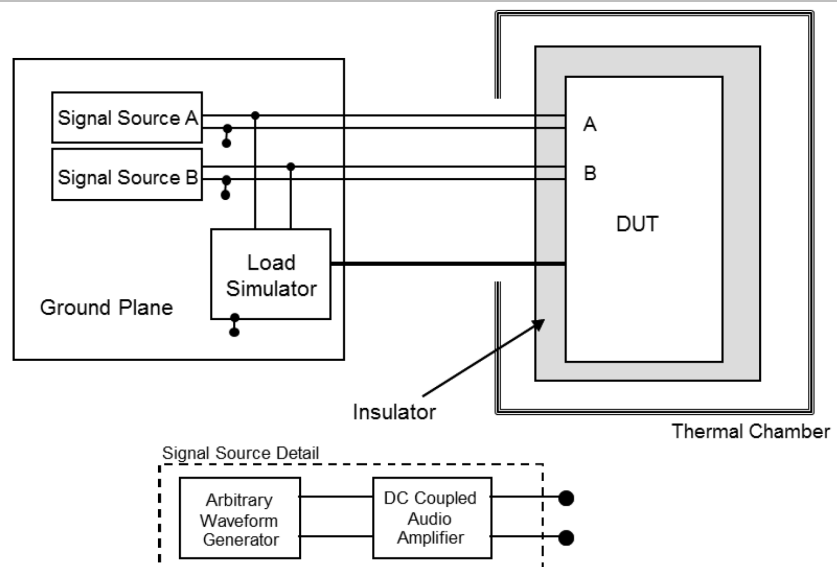


$U_A = 13.5 \text{ V}$     $U_B = 12.5 \text{ V}$     $U_1 = 5 \text{ V}$     $U_2 = 9 \text{ V}$     $U_3 = 2 \text{ Vp-p @ } 4 \text{ Hz}$

## Test procedures: Power Cycling Test setup

FMC1278 CI 230  
Fig. 20-2

- 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 17.2 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).

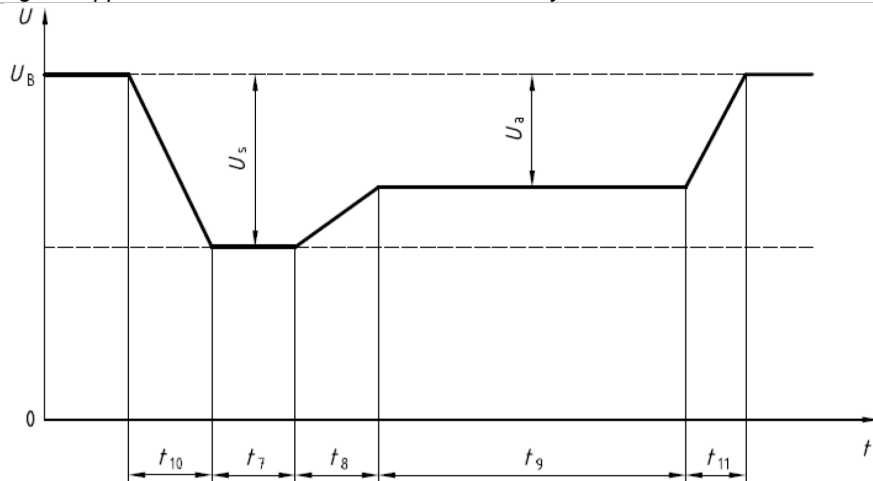
## 21.0 IMMUNITY FROM POWER CYCLING CI 231

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

FMC1278 CI 231  
Fig. 21-1

Requirements for  
Power cycling:

2 cycles separated by  
30 min



$U_B$	$U_S$	$U_a$	$R_i$	$t_7$	$t_8$	$t_9$	$t_{10}$	$t_{11}$
12 V	-6V	-3.5	$< 0.02\Omega$	15 msec	$\leq 50$ msec	10 sec	5 msec	100 msec
24 V	-12V	-7	$< 0.02\Omega$	50 msec	$\leq 50$ msec	10 sec	10 msec	100 msec

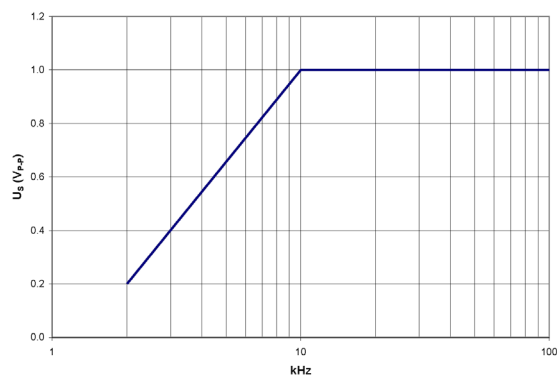
(1) Any degradation in performance shall not inhibit the ability of the vehicle to start

## 22.0 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

FMC1278 CI 250  
Fig. 22-1

Requirements for  
continuous  
disturbances:



Frequency Range (kHz)	$U_S (V_{P-P})$
2 – 10	$1.0 + 1.14 \log\left(\frac{f}{10}\right)$
10 – 100	1.0

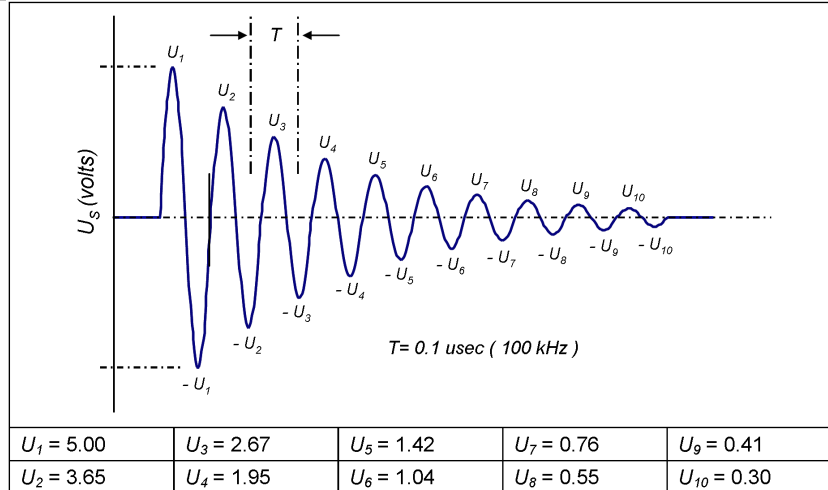
### Test procedures: sinusoidal disturbances superimposed to the supply voltage

	2kHz to 10kHz, step is 0.5kHz		10kHz to 100kHz, step is 5kHz	
	Frequency (kHz)	Amplitude ( $V_{pp}$ )	Frequency (kHz)	Amplitude ( $V_{pp}$ )
Calculated sinusoidal disturbances	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

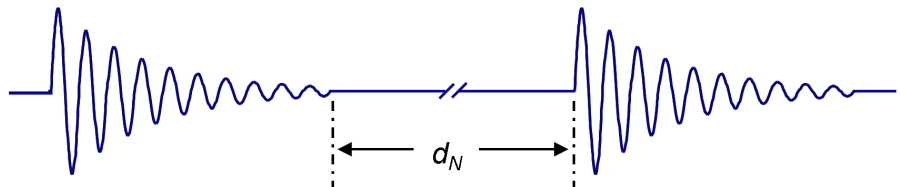
FMC1278 CI 250  
Fig. 22-2

Transient pulse detail:



FMC1278 CI 250  
Fig. 22-3

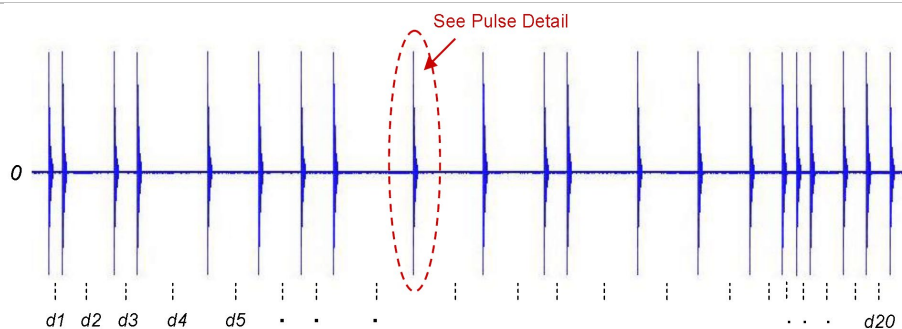
Transient pulse delay detail:



FMC1278 CI 250

Fig. 22-4

Transient disturbance  
sequence:



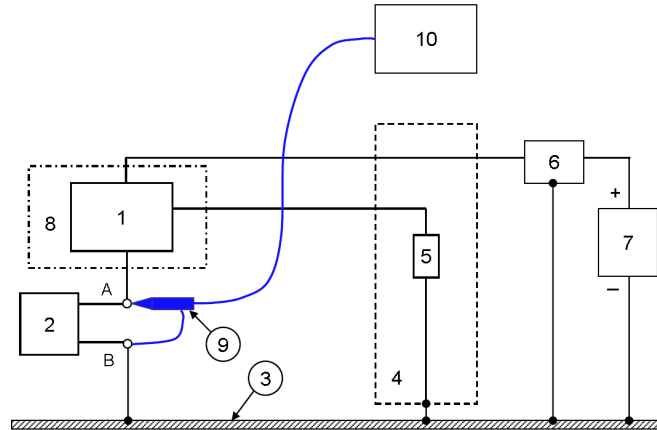
FMC1278 – CI 250 Table 22-1: Delay time sequences 1-4

<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*

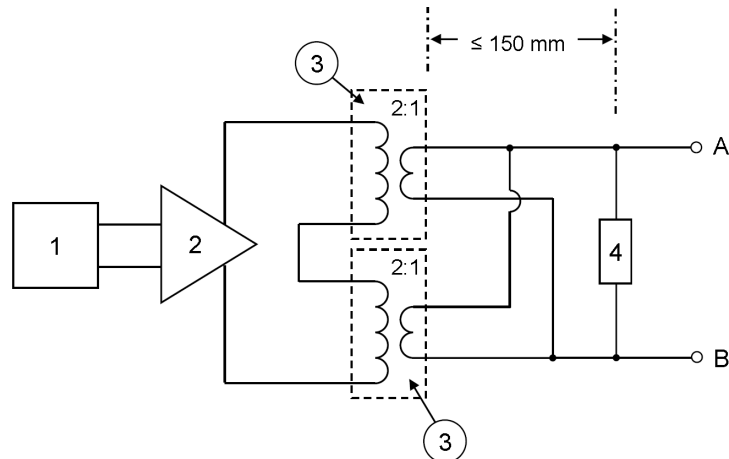
FMC1278 – CI 250 Fig. 22-5: Generic test setup, for details see FMC1278 22.2

- 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  
( $> 100\text{ MS/s}$ ,  
 $> 6MB$  memory depth)

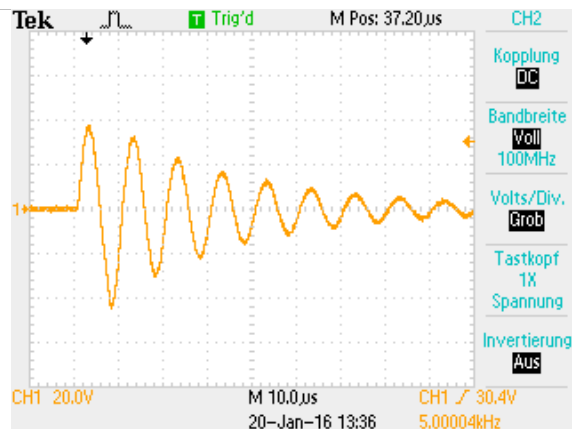


FMC1278 – CI 250 Fig. 22-6: Signal source requirements, for details see FMC1278 22.2

- 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)



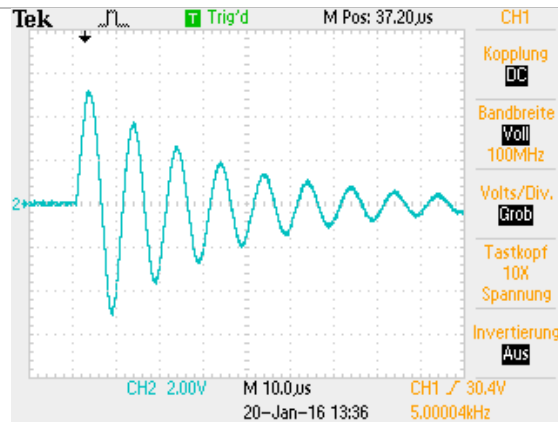
- Test setup oscillogram
- Output Voltage of the  
Power Amplifier LVA
- $0.5\Omega$  (250W) non-  
inductive Resistive Load



Test setup oscillogram

Output Voltage at the  
Terminals A and B

0.5Ω (250W) non-  
inductive Resistive Load



### 23.0 IMMUNITY TO VOLTAGE DROPOUT CI 260

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

FMC1278 CI 260  
Table 23-1

Voltage Dropout  
Requirements:

Performance Status checked  
after each waveform cycle  
(applies to Status II response  
only)

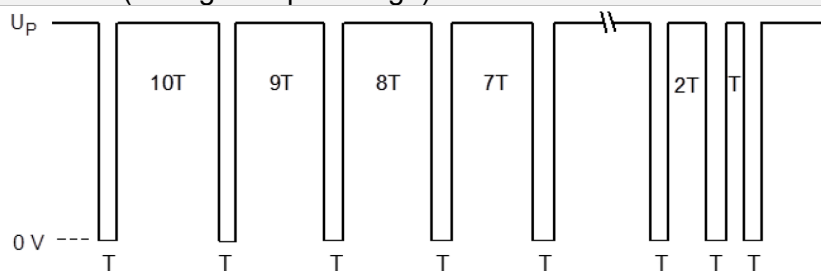
Waveform	Application	Level	Duration	Functional Performance Status <sup>(1)</sup>		
				Class A	Class B	Class C
A Voltage Dropout: High	All Power Supply and Control Circuits	See Figure 23-1	3 cycles separated by 20 s	II	II	II
B Voltage Dropout: Low	All Power Supply and Control Circuits	See Figure 23-2	3 cycles separated by 20 s	II	II	II
C Single Voltage Dropout	All Power Supply and Control Circuits	See Figure 23-3	3 cycles separated by 20 s	I	I	I
D Voltage Dip	All Power Supply and Control Circuits	See Figure 23-4	10 cycles separated by 20 s	II	II	II

Test procedures: CI 260 Waveform A (Voltage Dropout: High)

Fig. 23-1:

(1) Waveform  
transition times are  
approx.. 10 μs

(2) Voltage selected  
dependent on use  
of 12 or 24 VDC  
systems

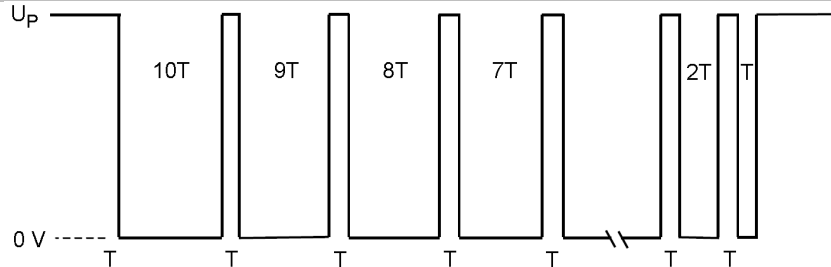


	Power from Vehicle Battery				Regulated Power from another Module			
	13.5V, 27V <sup>(2)</sup>				Nominal Supply Voltage (e.g. 5 Vdc, 3 Vdc)			
U <sub>P</sub>								
T <sup>(1)</sup>	100 μs	300 μs	500 μs	2 ms	100 μs	300 μs	500 μs	2 ms
	5 ms	10 ms	30 ms	50 ms	5 ms	10 ms	30 ms	50 ms

**Test procedures: CI 260 Waveform B (Voltage Dropout: Low)**
**Fig. 23-2**

(1) *Waveform transition times are approx.. 10  $\mu$ s*

(2) *Voltage selected dependent on use of 12 or 24 VDC systems*

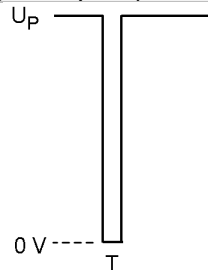


	Power from Vehicle Battery				Regulated Power from another Module			
$U_P$	13.5V, 27V <sup>(2)</sup>				Nominal Supply Voltage (e.g. 5 Vdc, 3 Vdc)			
$T^{(1)}$	100 $\mu$ s	300 $\mu$ s	500 $\mu$ s	2 ms	100 $\mu$ s	300 $\mu$ s	500 $\mu$ s	2 ms
	5 ms	10 ms	30 ms	50 ms	5 ms	10 ms	30 ms	50 ms

**Test procedures: CI 260 Waveform C (Single Voltage Dropout)**
**Fig. 23-3**

(1) *Waveform transition times are approx. 10  $\mu$ s*

(2) *Voltage selected dependent on use of 12 or 24 VDC systems*

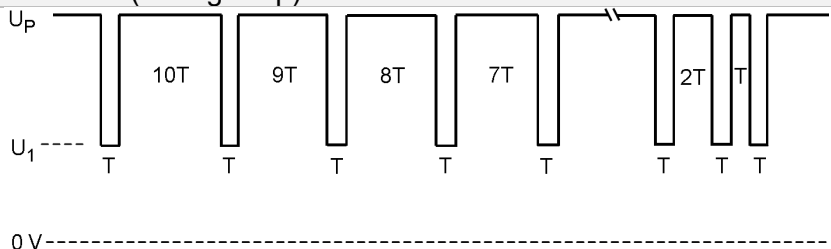


	Power from Vehicle Battery			Regulated Power from another Module		
$U_P$	13.5V, 27V <sup>(2)</sup>			Nominal Supply Voltage (e.g. 5 Vdc, 3 Vdc)		
$T^{(1)}$	100 $\mu$ s	300 $\mu$ s	500 $\mu$ s	100 $\mu$ s	300 $\mu$ s	500 $\mu$ s

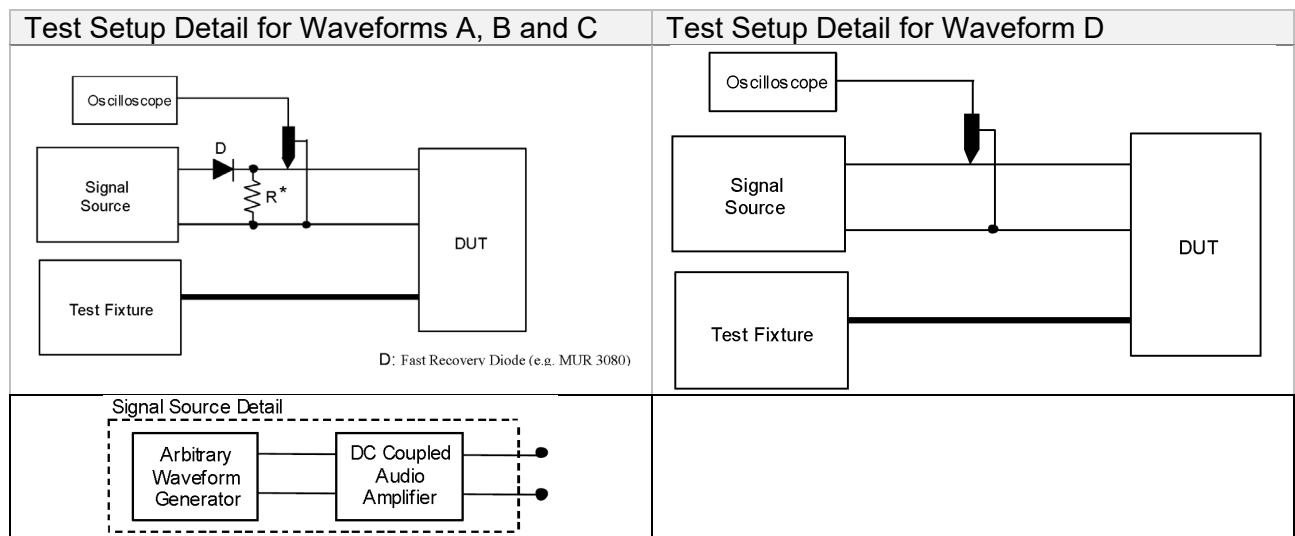
**Test procedures: CI 260 Waveform D (Voltage Dip)**
**Fig. 23-4**

(1) *Waveform transition times are approx. 10  $\mu$ s*

(2) *Voltage selected dependent on use of 12 or 24 VDC systems*



	Power from Vehicle Battery				Regulated Power from another Module			
$U_P$	13.5V, 27V <sup>(2)</sup>				Nominal Supply Voltage (e.g. 5 Vdc, 3 Vdc)			
$U_1$	5 V				80% of Nominal Supply Voltage			
$T^{(1)}$	100 $\mu$ s	300 $\mu$ s	500 $\mu$ s	2 ms	100 $\mu$ s	300 $\mu$ s	500 $\mu$ s	2 ms
	5 ms	10 ms	30 ms	50 ms	5 ms	10 ms	30 ms	50 ms



## 24.0 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.*

<b>FMC1278 CI 270</b> <b>Table 24-1</b>  <b>Voltage Overstress Requirements:</b>	Requirement		Functional Performance Status	
	Amplitude (V)	Duration	Class A	Class B and C
	-14 (+0, -0.5)	≥ 2 min	III	III
	19 (+0.95, -0)	≥ 60 min	III	II
	27 (+0, -1)	≥ 60 sec <sup>(1)</sup>	III	II

*(1). For devices connected only to the start circuit, the duration time may be reduced to 15 sec.*

### 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.*

<b>For these tests, the power supply shall have minimum short circuit capacity of 100 amperes.</b>	<ul style="list-style-type: none"> <li>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.</li> <li>Repeat step a) with 27 volts. Duration time may be reduce to 15 seconds if the DUT is normally connected to the vehicle start circuit. This shall be documented in the EMC test plan.</li> <li>Apply +19 volts to all power and control circuits. All circuits shall be tested simultaneously. Verify functionality per Table 24-1.</li> </ul>
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## ANNEX D: TRANSIENT WAVEFORM DESCRIPTIONS AND APPLICATION MODES FOR RI 130, CI 220, CI 221, C I222

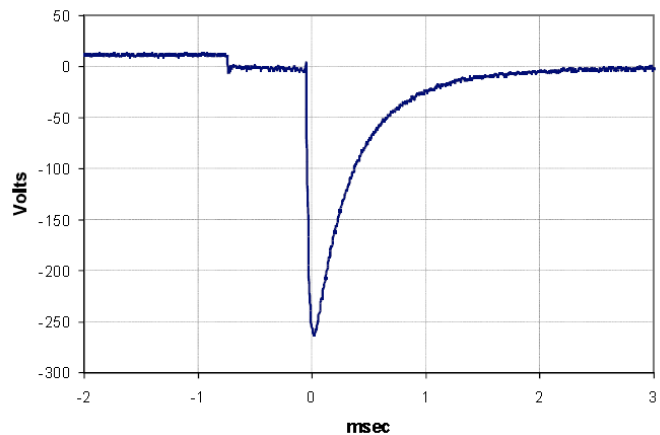
The Annex D specifies transient pulses both as standard ISO 7637-2 version as well as non-standard pulses which are not covered by the ISO 7637-2. These pulses are prevalent in the vehicles electrical power distribution system.

### Test pulse A1 Composite Waveform

FMC1278 Fig. D-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

FMC1278 Fig. D-3

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

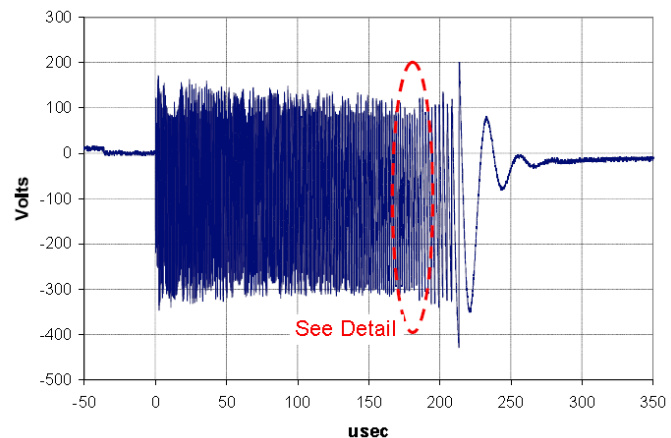
Pulse A2-1 occurs, when the circuit consists only of the DUT and the switched inductive load.

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

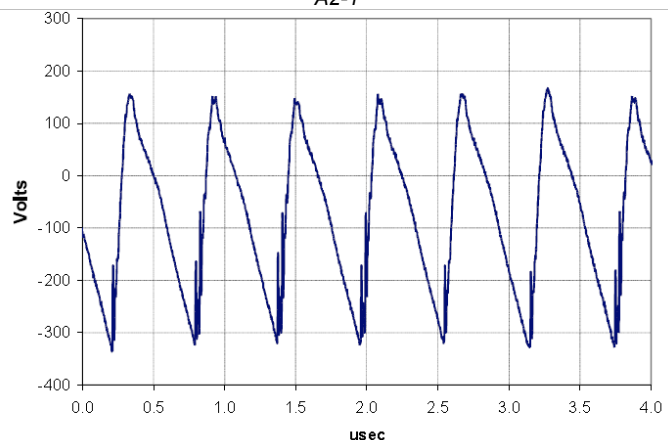
Peak negative pulse voltage:  
-280V ... -500V

Pulse duration 100ns ... 1µs

"showering arc transients"



A2-1



A2-1 Detail

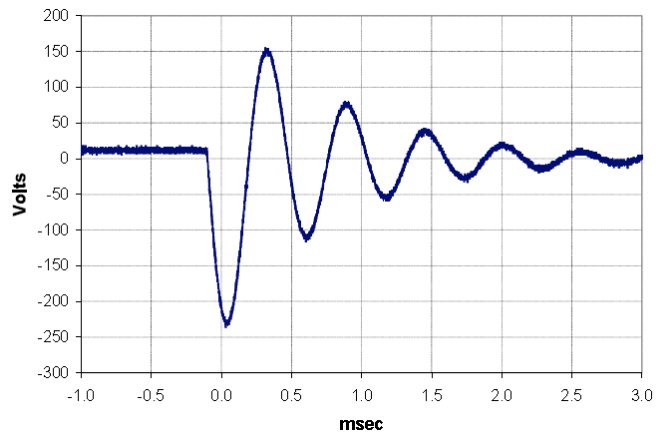
**FMC1278 Fig. D-4**

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

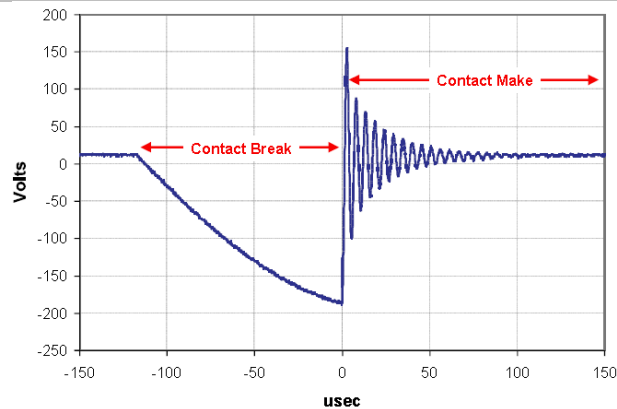
*Peak positive pulse voltage:  
+100V ... +300V*

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

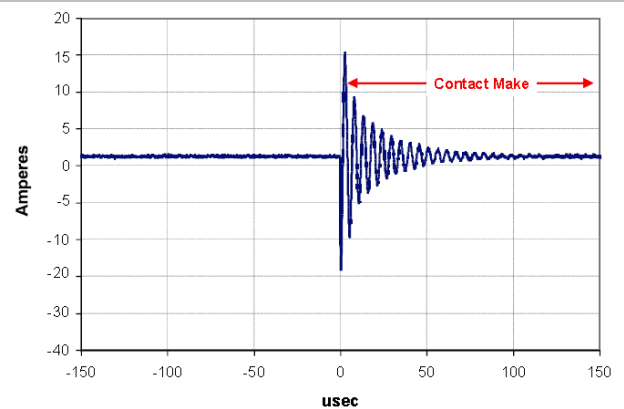
*Pulse duration 100ns ... 1μs*



**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 ( $f_{res} \sim 180\text{kHz}$ )**

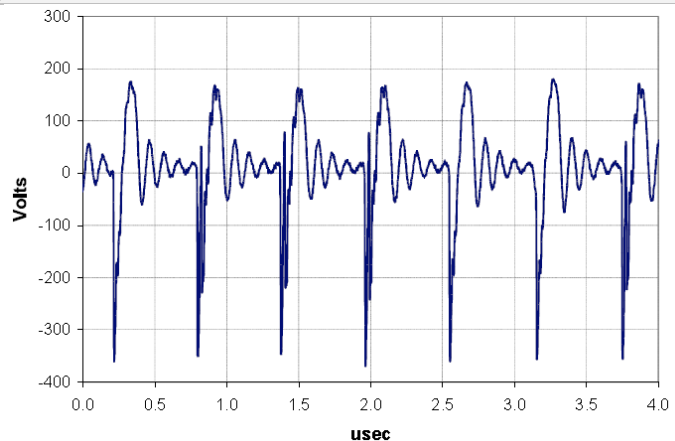
### **Test pulses C-1 and C-2 Contact Arcing and Bounce**

**FMC1278 Fig. D-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  $f_{res} \sim 10\text{MHz}$**

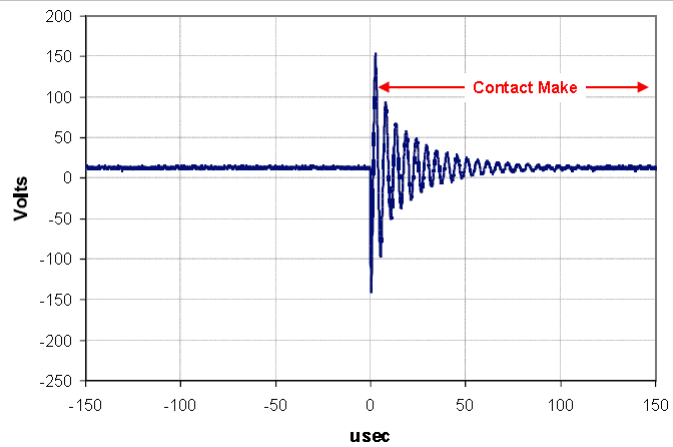
**FMC1278 Fig. D-5d**

*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*



*Lower frequency damped oscillation  $f_{res} \sim 180\text{kHz}$*

### ISO Test pulses 1, 2a, 2b, 3a, 3b Contact Arcing and Bounce

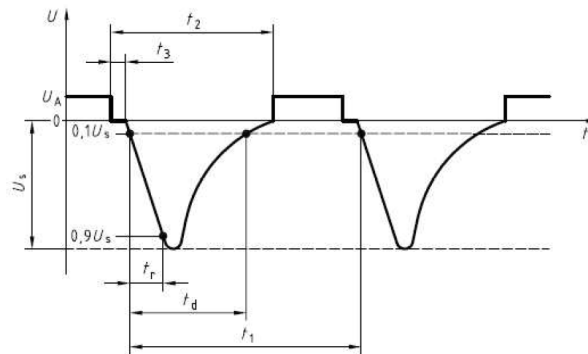
*Waveform voltage begins and ends at  $U_A$ , Parameters are for open circuit*

**FMC1278 Fig. D-6**

*Voltage transient produced during switching of a higher current (> 5 ampere) inductive load that shares the same circuit with the DUT*

$U_A$	See Tables 17-1, 18-1
$U_s$	
$R_i$	10 ohms
$t_d$	2 ms
$t_r$	1 µs
$t_1$	5 s
$t_2$	200 ms
$t_3$	$\leq 100 \mu\text{s}$

**ISO pulse 1:**

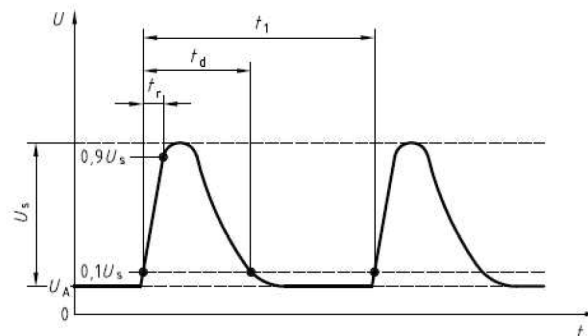


**FMC1278 Fig. D-7**

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

$U_A$	See Table 18-1
$U_s$	
$R_i$	2 ohms
$t_d$	0.05ms
$t_r$	10 (-0.5 / +0) µs
$t_1$	0.2 - 5 s

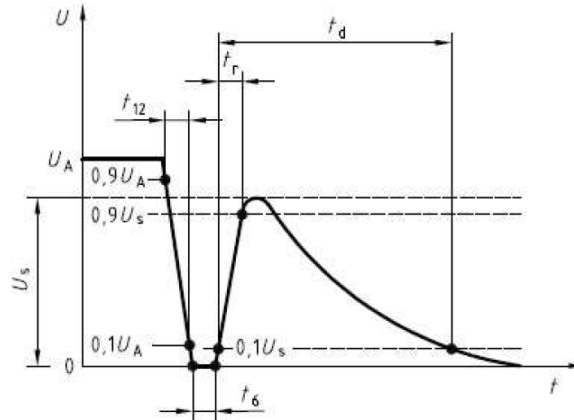
**ISO pulse 2a:**



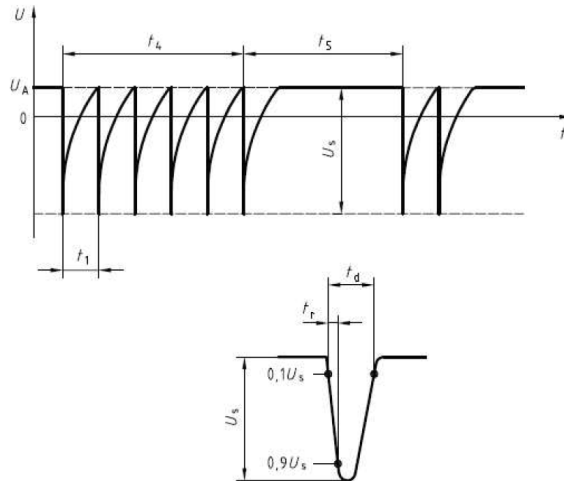
**FMC1278 Fig. D-8**

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

$U_A$	See Table 18-1
$U_s$	
$R_i$	< 0.05 ohms
$t_d$	0.2 – 2 s
$t_{12}$	1ms $\pm$ 0.5 ms
$t_r$	1ms $\pm$ 0.5 ms
$t_6$	1ms $\pm$ 0.5 ms

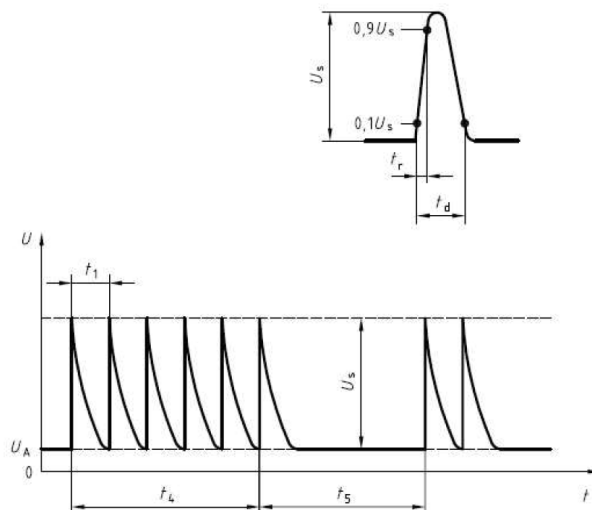
**ISO pulse 2b:**

**FMC1278 Fig. D-9**

$U_A$	See Table 18-1
$U_s$	
$R_i$	50 ohms
$t_d$	0.1us -0/+0.1us
$t_r$	5ns $\pm$ 1.5 ns
$t_i$	100 us
$t_d$	10 ms
$t_s$	90 ms

**ISO pulse 3a:**


Pulses 3a and 3b represent the voltage transient which is the result of switch contact arching and contact bounce during switching of an inductive load.

The transient pulses are simplistic representations of Pulse C.

**ISO pulse 3b:**

**FMC1278 Fig. D-10**

$U_A$	See Table 18-1
$U_s$	
$R_i$	50 ohms
$t_d$	0.1us -0/+0.1us
$t_r$	5ns $\pm$ 1.5 ns
$t_i$	100 us
$t_d$	10 ms
$t_s$	90 ms

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

Pulse 5a represents the transient produced due to sudden disconnection of the battery from the alternator. Pulse 5b represents a voltage clamped transient produced due to sudden disconnection of the battery from an alternator fitted with Central Load Dump Protection.

#### Pulse 5a Parameters<sup>(1)</sup>

Open Circuit Conditions	
$U_A$	See Table 19-1
$U_s$	
$R_i$	0.5 Ohms
$t_d$	300 ms $\pm$ 20%
$t_r$	10 ms $-5$ / $+0$ ms

Loaded Conditions ( $R_L = R_i$ )	
$U_A$	See Table 19-1
$U_s$	$0.5 \cdot U_s$ (Open Circuit)
$R_i$	0.5 Ohms
$t_d$	150 ms $\pm$ 20%
$t_r$	10 ms $-5$ / $+0$ ms

#### Pulse 5b Parameters<sup>(1)</sup>

$U_A$	See Table 19-1.
$U_s^{(2)}$	
$U_s^{*(2)}$	
$R_i$	0.5 Ohms
$t_r$	10 ( $-5$ / $+0$ ) ms
$t_d$	150 ms $\pm$ 20%

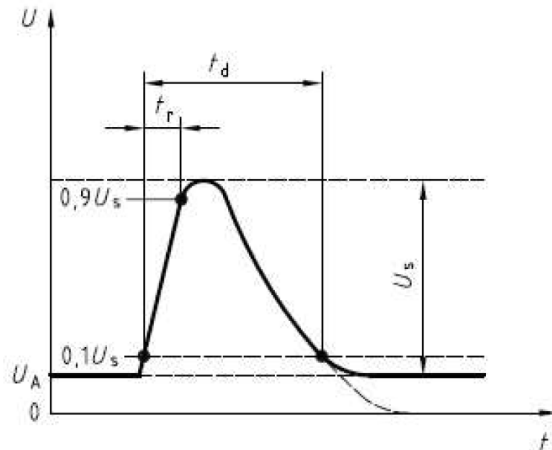
(1) All voltage values are with respect to 0 volts unless otherwise specified.

(2)  $U_s$  and  $U_s^*$  based on 0.5 ohm resistive load ( $R_L = R_i$ ).

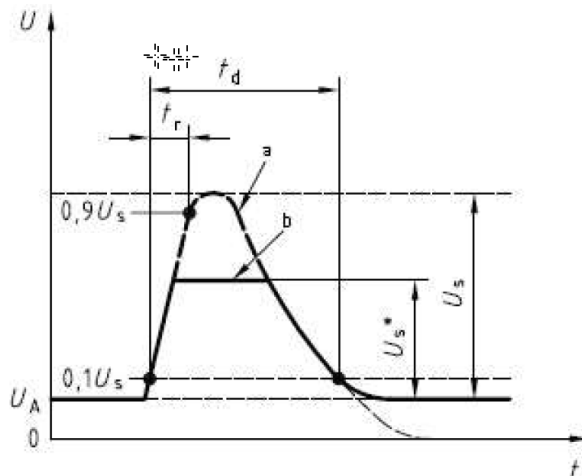
a: Unsuppressed pulse

b: Suppressed pulse

#### ISO pulse 5a:



#### ISO pulse 5b:



### Annex D-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.

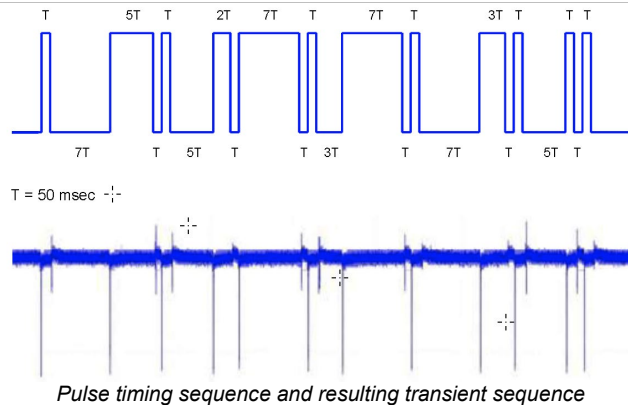
#### Mode 1: Table D-1

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		

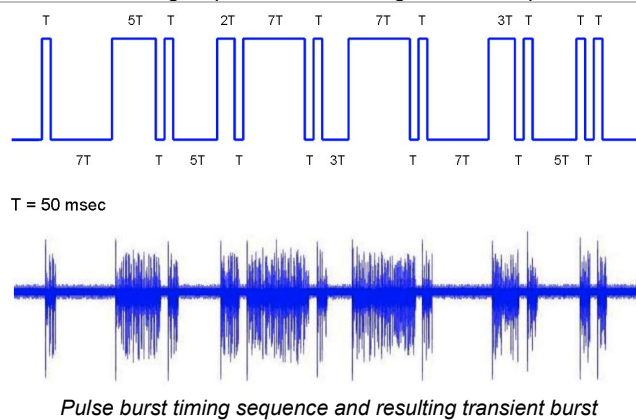
### Mode 2: Fig. D-13

Mode 2 represents a condition where test pulses are applied using a pseudo-random timing sequence as illustrated in Fig. D-13. Mode 2 is only used with test pulse A1 when applied to DUT inputs.



### Mode 3: Fig. D-14

Mode 3 represents a condition where test pulses are applied using pseudo-random bursts as illustrated Figure D-14. 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.



## FMC1278 TEST PRODUCT MATRIX:

FMC1278 Test combinations	CE 421	CE 410	RI 140	RI 130	RI 150	CI 210	CI 220	CI 221	CI 222	CI 230	CI 231	CI 250	CI 260	CI 270
LVA	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Load Dump Generator									✓					
Transient Generator				✓	✓		✓	✓						
Coupling network	✓	✓	✓	✓	✓		✓					✓		
Coupling transformer												✓		
Measurement receiver	✓		✓											
Oscilloscope		✓		✓	✓	✓						✓	✓	
Current probe	✓		✓		✓									
Magnetic coil			✓											
Magnetic sensor			✓											
High Impedance probe		✓		✓		✓						✓	✓	
Load simulator	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
Resistive load												✓		
Dielectric support	✓	✓				✓								
Ground plane		✓	✓	✓	✓	✓	✓			✓		✓		
Software	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
SPS_Automotive														