

PROJECT OF THE EVALUATION AND CLASSIFICATION SYSTEM OF VEHICLES AND AUTOMOBILE DEVICES IN ASPECT OF ELECTROMAGNETIC COMPATIBILITY

Slawomir Lukjanow, Boguslaw Pijanowski, Michal Kolodziejczak

*Automotive Industry Institute
Jagiellonska 55, 03-301 Warsaw, Poland
tel./fax. +48 22 8114219
e-mail: ble@pimot.org.pl*

Abstract

In the paper have been discussed project of the system of evaluation and classification of vehicles and automobile devices in aspect of electromagnetic compatibility (EMC). There have been presented additional criteria concerning emission of electromagnetic disturbances and immunity to the disturbances as well as means to classify the quality of tested vehicles and automobile devices, in purpose of improving road traffic safety and protection of electromagnetic environment. It has been presented proposals of EMC integrated evaluation methods for vehicles and automobile devices. For the vehicles it comprises five categories where evaluation is carried out for three components: broadband and narrowband emission and immunity to electromagnetic radiation. For devices there are also proposed five categories where evaluation is carried out for four components: broadband and narrowband emission, immunity to electromagnetic radiation and to electrical transients. There are also presented the examples that illustrate proposed system of automobile and devices classification in aspect of EMC and algorithm of the verification and evaluation of vehicles according to project. Proposed criteria of integrated evaluation of vehicles and automobile devices enables evaluation of quality, what can contribute in engineering of high competitive products.

Keywords: *vehicles, electromagnetic compatibility, testing*

1. Introduction

Electromagnetic compatibility (EMC) in motorization means ability of vehicles and automobile devices to work properly in the presence of existing internal and external electromagnetic disturbances (immunity to disturbances) without introduction to electromagnetic environment unacceptable disturbances. Because more and more control functions of vehicle and its assemblies is done by electronic devices it is growing importance of EMC of this devices in road traffic safety and electromagnetic environment protection. The EMC requirements for vehicles and automobile devices have been stated in Directive 2004/104/WE and ECE Regulation No 10. The documents specify minimal requirements which fulfilment is necessary to obtain type approval certificate that is indispensable for production and distribution of vehicles and automobile devices. The purpose of the proposed evaluation and classification system is choice of additional criteria, enabling quality classification of vehicles in aspect of EMC, what can have influence to manufacture high quality vehicles. Moreover proposed criteria may be used in special vehicles to raised requirements concerned with specific jobs. Application of elevated requirements my be recommended for vehicles and automobile devices, that are performing especial work in security of transported persons and goods, as emergency cars, police cars, money transporting vans etc.

2. Requirements of homologation

Application range of ECE Regulation No 10 and of Directive 2004/104/WE comprises:

- Vehicles of M, N, O category (passenger cars, trucks, buses, trailers),
- Electric/electronics elements and "technical units" intended to be part of vehicle.

Regulation and Directive require measuring of the radiated emission by devices and vehicles in the frequency range from 30 MHz to 1 GHz for broadband and narrowband disturbances and testing immunity of devices and vehicles to radiated disturbances in the range from 20 MHz to 1GHz (Regulation) and from 20 MHz to 2 GHz (Directive), by electric field of intensity of 30V/m. Permissible emission levels of radiated disturbances and field intensity levels for testing immunity of vehicles and devices are the same in ECE Regulation No 10 and in Directive 2004/104/WE. Test conditions provide, that emission radiated by vehicle can be measured by antenna with antenna - vehicle separation 10m or 3m. Emission radiated by devices is measured by antenna from distance of 1m.

Directive 2004/104/WE requires additionally testing of: - immunity of devices to electrical transients conducted by supply lines (according to standard ISO 7632-2), - emission of disturbances by devices to supply lines (according to standard ISO 7632-2).

3. Proposals of vehicle evaluation criteria in aspect of EMC

Criteria of the vehicles evaluation in respect of electromagnetic disturbance emission

ECE Regulation No 10 as well as Directive 2004/104/WE accept as a criterion of vehicles and automobile devices, in respect of electromagnetic disturbance emission, not to cross the limits value of broadband and narrowband emissions, defined in function of frequency, separately for vehicles and devices.

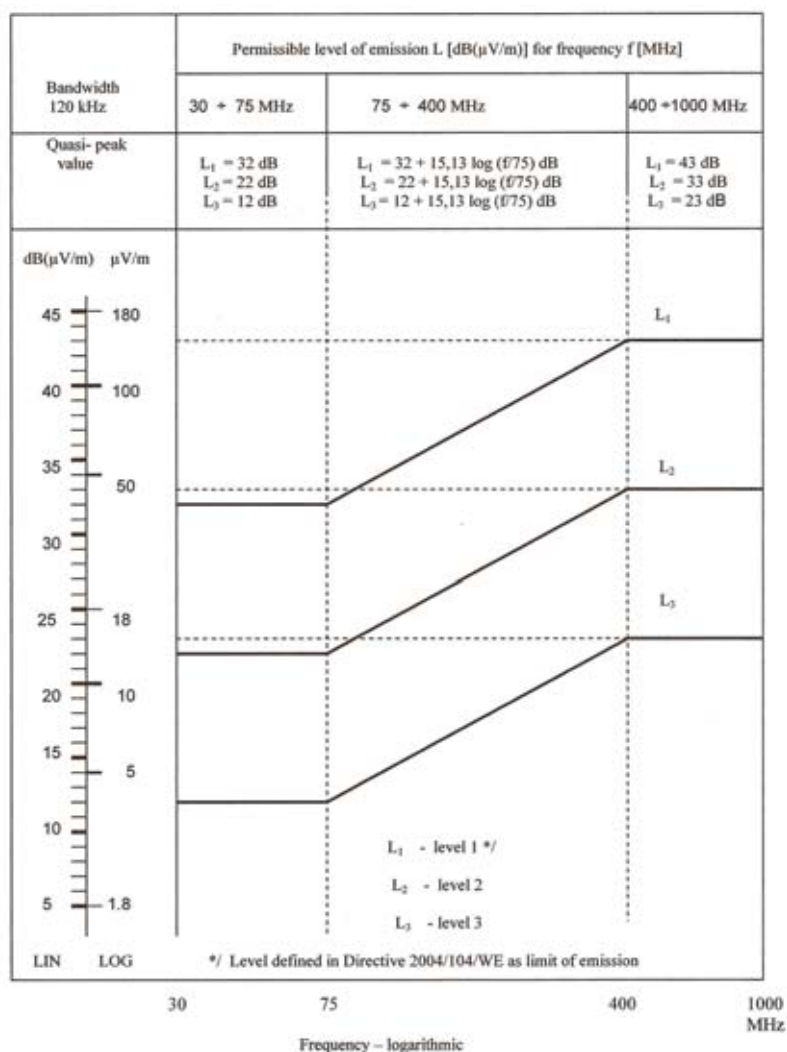


Fig. 1. Proposed level of broadband emission for vehicles (Antenna – vehicle separation: 10 m)

However both tested vehicles and devices that comply this criterion, differs each other in respect of the level of electromagnetic disturbances emission. In purpose of comparative evaluation there could be defined three levels of emission: level defined in Directive 2004/104/WE and levels lowered by 10 dB ($\mu\text{V/m}$) and 20dB ($\mu\text{V/m}$). Proposals of these levels for broadband and for narrowband emission for vehicles are presented on pictures 1 and 2. Level 1 is the level defined in Directive 2004/104/WE, level 2 is the level lowered by 10 dB($\mu\text{V/m}$) and level 3 is the level lowered by 20 dB($\mu\text{V/m}$).

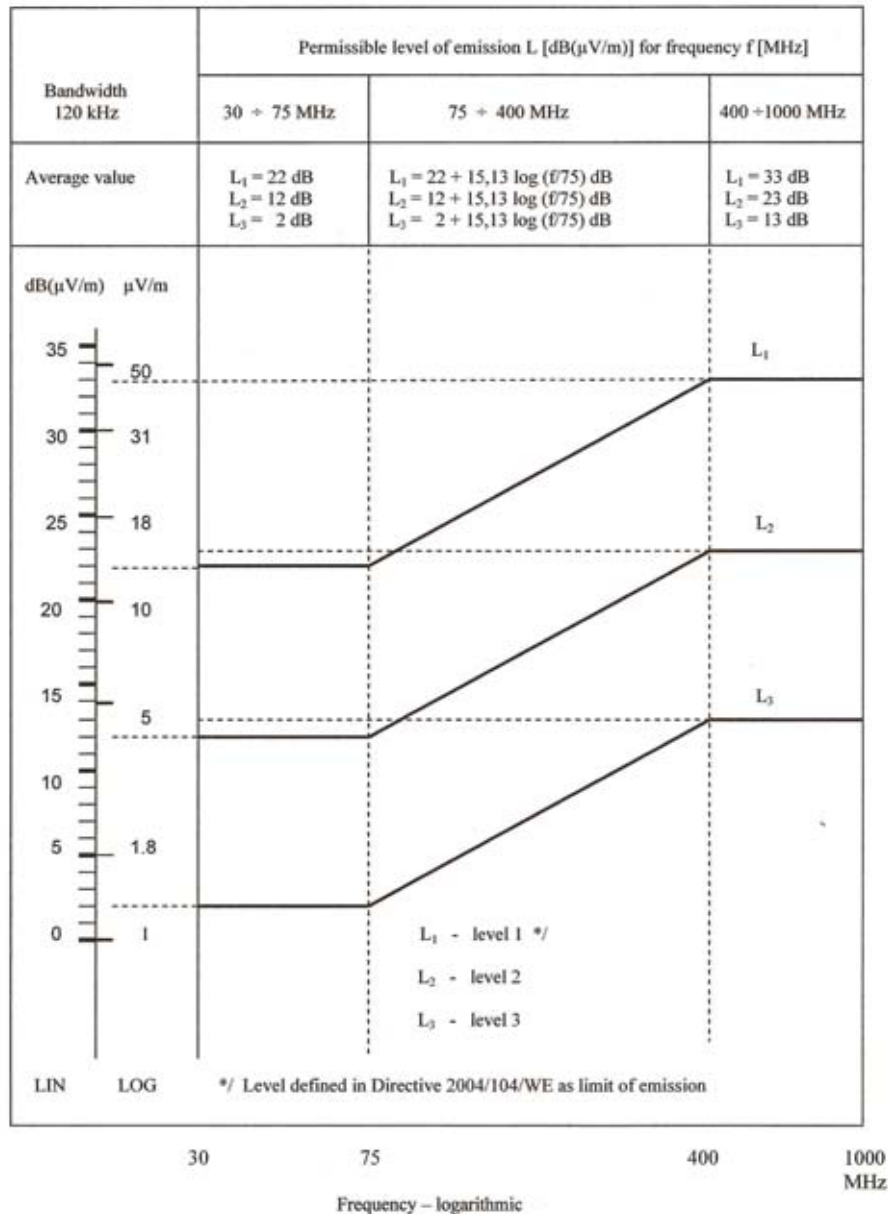


Fig. 2. Proposed level of narrowband emission for vehicles (Antenna-vehicle separation: 10m)

Criteria of evaluation the vehicle operation in respect of immunity to electromagnetic radiation

Immunity of the vehicles to electromagnetic radiation is better defined in Directive 2004/104/WE than in ECE Regulation No10. Directive specifies 12 functions of vehicle that can be controlled by electronic devices and criteria of the lack of approval. In the case of vehicle testing to immunity for electromagnetic radiation, comparative evaluation of vehicles can be done by using elevated testing field intensity. There are proposed three levels of immunity to electromagnetic radiation, presented in the Table 1.

Tab. 1. Proposed vehicle immunity levels to electromagnetic radiation

Test method	Vehicle immunity level		
	Level 1	Level 2	Level 3
Open area test site or an absorber-lined shielded enclosure (CISPR 16-2)	30 V/m	50 V/m	75 V/m
Bulk current injection (ISO 11451-4)	60 mA	100 mA	150 mA

4. Proposals of automobile devices evaluation criteria in aspect of EMC

Criteria of the devices evaluation in aspect of electromagnetic disturbances emission

Proposals of the three levels of broadband and narrowband emission for devices have been presented on Figures 3 and 4. Level 1 is the level defined in Directive 2004/104/WE, level 2 is the level lowered by 10 dB($\mu\text{V}/\text{m}$) and level 3 is the level lowered by 20 dB($\mu\text{V}/\text{m}$).

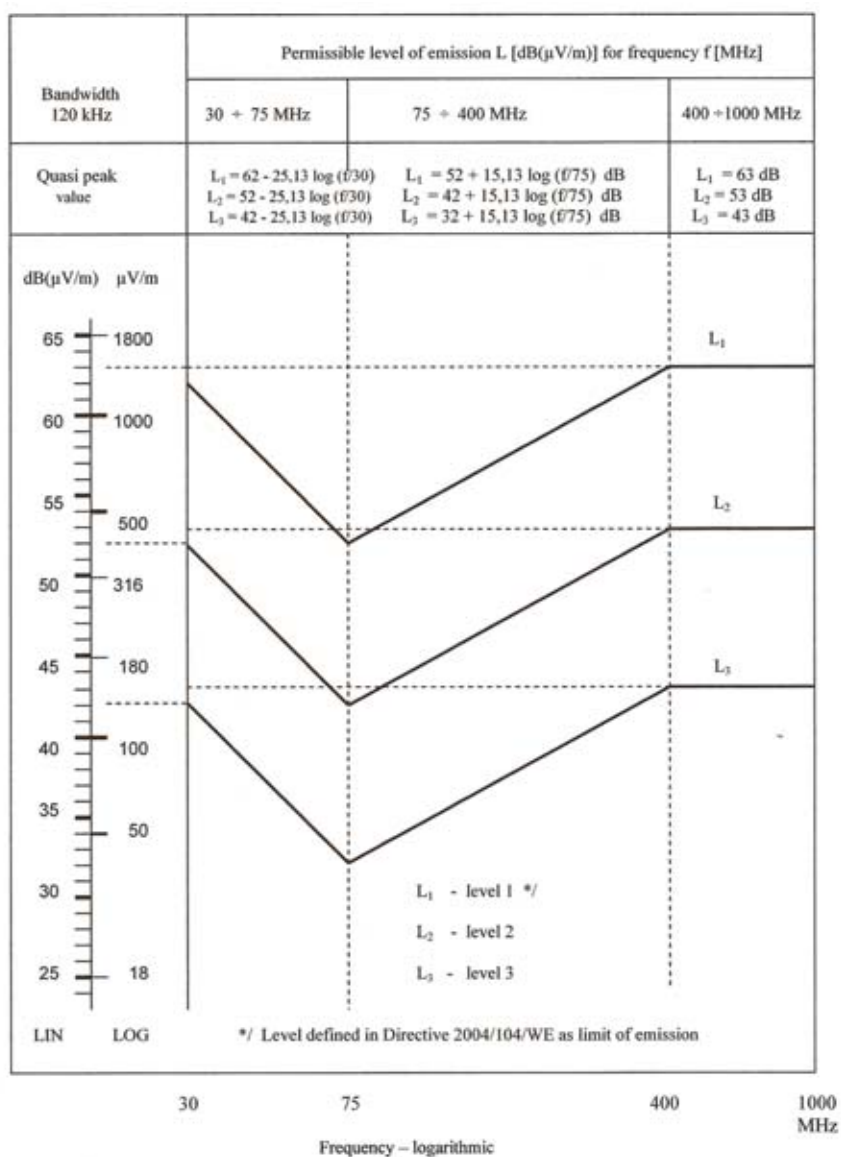


Fig. 3. Proposed broadband disturbances emission levels for devices

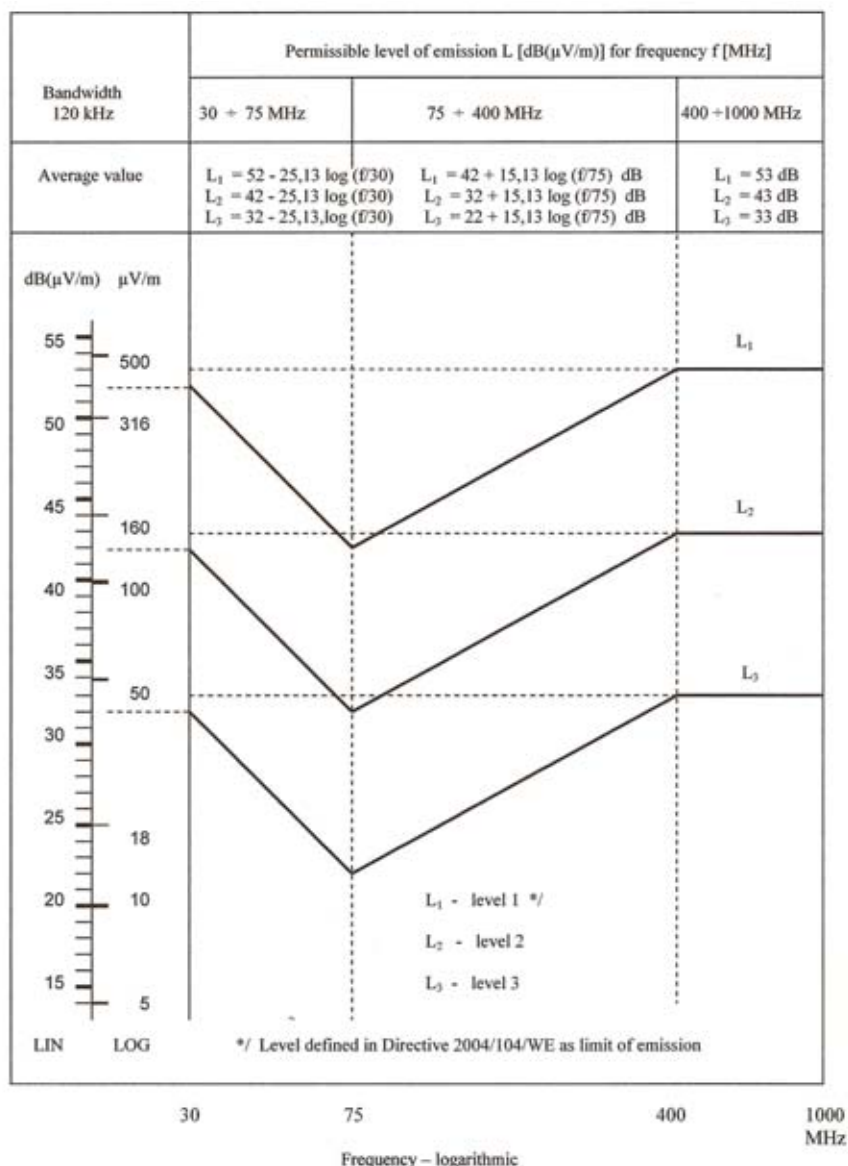


Fig. 4. Proposed narrowband disturbances emission levels for devices
 Criteria of the devices evaluation in aspect of immunity to electromagnetic radiation
 Proposals of the levels of hazards during testing the devices immunity to electromagnetic radiation have been presented in Table 2.

Tab. 2. Proposed devices immunity levels to electromagnetic radiation

Test method:	Device immunity level		
	Level 1*/	Level 2	Level 3
Stripline 150 mm	60 mA	100 mA	200 mA
Stripline 800 mm	15 V/m	25 V/m	50 V/m
TEM cell	75 V/m	100 V/m	200 V/m
Bulk current injection (BCI)	60 mA	100 mA	200 mA
Open area test site	30 V/m	50 V/m	100 V/m

*/ Immunity level defined in Reg. Nr 10 and Directive 2004/104/WE
 Devices that have influence on functions involved in immunity should during the test save at least the class B status of functionality and not to present the functioning that could produce any hazard to driver and others road users or degrade the vehicle's driving ability.

Criteria of the devices evaluation in aspect of immunity to electrical transients conducted along the supply lines

Criteria of comparative evaluation of the devices immunity to electrical transients conducted along the supply lines could be done on the base of functionality status and testing levels (test pulses amplitudes). Proposed devices immunity levels to electrical transients along the supply lines have been presented in Table 3.

Tab. 3. Proposed devices immunity levels to electrical transients conducted along the supply lines

Testing level **/	Functional status */											
	III						IV					
Test pulse **/	1	2a	2b	3a	3b	4	1	2a	2b	3a	3b	4
(Devices that perform functions connected with immunity)												
Level 1	C	B	C	A	A	B/C*	-	-	-	-	-	-
Level 2	B	A	A	A	A	A/B*	-	-	-	-	-	-
Level 3	-	-	-	-	-	-	C	B	C	A	A	B/C*
(Devices that don't perform functions connected with immunity)												
Level 1	D	D	D	D	D	D	-	-	-	-	-	-
Level 2	B	B	B	B	B	B	-	-	-	-	-	-
Level 3	A	A	A	A	A	A	-	-	-	-	-	-
*/ Higher state of functionality valid for devices that must operate during start of engine **/ In agreement to ISO 7637-2 standard Level 1 is defined in Directive 2004/104/WE as minimal												

5. Proposals of integrated comparative evaluation of vehicles and devices in aspect of EMC

If to each level of emission of disturbances and level of immunity is assigned number of points adequate to number of the level, than adding the number of points achieved during the test of the vehicle it can be proposed to classify the vehicle under test in regard to the sum of the achieved points. Minimal number of points required to acceptance of vehicle according to Directive 2004/104/WE equals 3 and maximal number of points to be achieved during the test equals 9. Proposed classification of vehicle in respect to EMC has been presented in Table 4 and the examples of the evaluation in Table 5. Algorithm of the vehicle testing and evaluation in aspect of EMC is presented on Figure 5. Classification relays only to vehicles that in each kind of test gained at least level "1" of emission and immunity.

Tab. 4. Proposed integrated comparative evaluation of vehicles in aspect of EMC

Category of vehicle evaluation	I	II	III	IV	V
Number of asterisks	****	****	***	**	*
Sum of the achieved points	9	8	7	5	3

Tab. 5. Examples of the proposed integrated comparative evaluation of vehicles in aspect of EMC

Kind of test	Vehicle "x"	Vehicle "y"	Vehicle "z"
Broadband emission	level 1	level 2	level 1
Wideband emission	level 2	level 3	level 1
Immunity to electromagnetic radiation	level 2	level 2	level 1
Sum of the points	5	8	3
Category of evaluation	IV	II	V
Number of asterisks	**	****	*

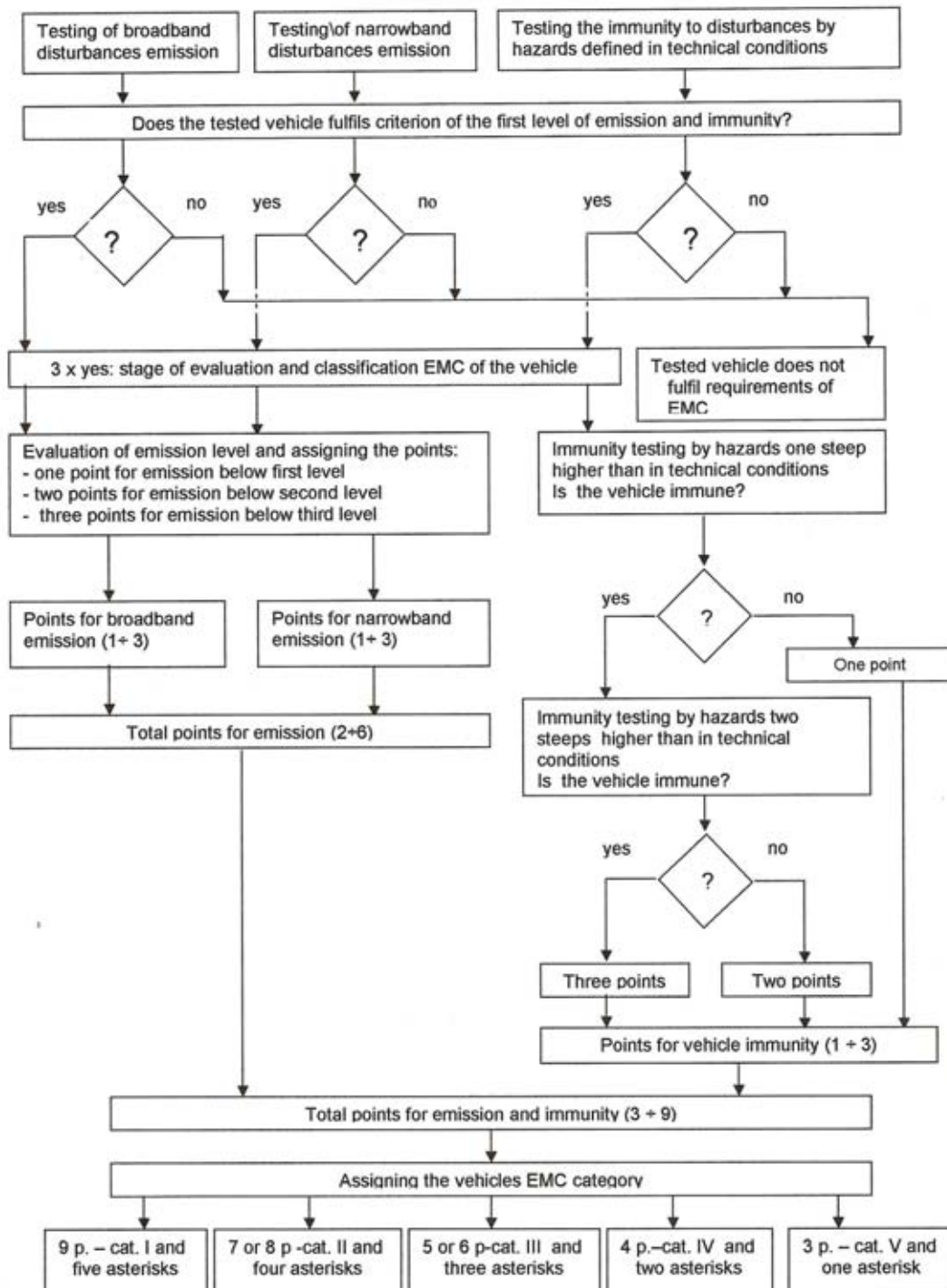


Fig. 5. Algorithm of testing and evaluation the vehicle in aspect of EMC

6. Proposals of devices comparative evaluation criteria in aspect of EMC

If to each level of emission of disturbances and level of immunity is assigned number of points adequate to number of the level, than adding the number of points achieved during the test of the device it can be achieved from 4 to 12 points. Minimal number of points required to acceptance of device according to Directive 2004/104/WE equals 4 and maximal number of points to be achieved during the test equals 12. In these limits can be defined the classification of devices in aspect of EMC. Proposed classification of devices in aspect of EMC has been presented in Table 6 and the examples of evaluation in Table 7. Classification relays only to devices that in each kind of test gained at least level “1” of emission and immunity.

Tab. 6. Proposed integrated comparative evaluation of devices in aspect of EMC

Category of device evaluation	I	II	III	IV	V
Number of asterisks	****	****	***	**	*
Sum of the achieved points	12	10	8	6	4

Tab. 7. Examples of the proposed integrated comparative evaluation of devices in aspect of EMC

Kind of test	Device “u”	Device “v”	Device “w”
Broadband emission	level 1	level 2	level 3
Wideband emission	level 1	level 3	level 3
Immunity to electromagnetic radiation	level 1	level 1	level 3
Immunity to electrical transients in supply lines	level 1	level 1	level 3
Sum of the points	4	8	12
Category of evaluation	V	III	1
Number of asterisks	*	***	****

7. Summary

In the paper have been presented project of evaluation and classification system of vehicles and automobile devices in aspect of electromagnetic compatibility (EMC). Used up to now evaluation criteria of EMC have some disadvantages. Vehicles and devices are, concerning to EMC, “good” or “bad”. Requirements are minimal – in this case it can’t be distinguished higher or very high class. In result of carried out in this paper analysis they have been presented new criteria, where current criteria have been accepted as minimal. New proposals of vehicles evaluation in aspect of EMC have been presented in point 3, while new proposals evaluation of devices have been presented in point 4 of the paper. Either has been presented proposals of EMC integrated evaluation, both for vehicles and devices in the points 5 and 6 of the paper. Integrated evaluation divides vehicles and devices onto five categories dependently of gained sum of points and is presented in Table 4 (vehicles) and Table 6 (devices) of the work. Proposed criteria of integrated evaluation of vehicles and automobile devices enables evaluation of quality, what can contribute in engineering of high competitive products. Moreover proposed criteria can be used in special and specialised vehicles to elevate the requirements due to specification of work. Use of elevated EMC requirements can be recommended, on base of prepared criteria, to special vehicles and devices carrying out special jobs in aspect of security of transported persons and goods, as for examples emergency cars, police cars, money transporting vans and others.

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