CLASSIFICATION OF IMUNITY OF CONSUMERS TO SHORT VOLTAGE DROPS AND INTERRUPTIONS

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ABSTRACT

This article is focused on the short voltage events in the supply networks and their influence on the single-phase electric appliances' operation connected and the immunity of these against to such type of electromagnetic disturbance. In the next part of the paper there is a proposal of valuation of immunity single-phase electric equipments to the real voltage. The proposal is substantiated by the immunity measurements on given appliance.

1. INTRODUCTION

At the same as all commodities the electric energy has certain characteristics which describe their quality. At the electric energy there are mainly the voltage in specified bounds, distortion of voltage to harmonic wave, unbalanced voltage in three-phase alternating systems, fluctuating of frequency and so on. Companies distributing the electric energy to customers must make precautions to meeting above mentioned quality criteria of electric energy. If the quality of electric energy is not executed there is a change function of all connected devices. Short voltage drops and short voltage dips are ones of the frequent undesirable phenomena in the public supply networks. There are random phenomena which rise at common operation - switching processes, faults and so on.

2. DEVICES' IMMUNITY IN AGREEMENT WITH EN 61000-4-11

The tests of immunity electric devices against the short voltage events are found with a knowledge nominal voltage of concrete electric device (V_N). There are preferred following voltage levels during immunity tests: $0\%V_N$, $40\%V_N$, $70\%V_N$, $80\%V_N$ (voltage levels are seen at Tab.1, Tab.2). The changes of voltage are very quick and they can start and finish in any phase-angle of voltage. All above-mentioned voltage levels are supposing nearly square wave of voltage event (Figure 1). The length of falling and rising is 1÷5μs. Voltage event comes from nominal voltage of supply network and after the finish this voltage event the voltage returns to nominal voltage. The immunity of electric devices is tested for each testing voltage levels. The results must be classified in agreement with a loss functions or a downgrade operations of the tested device. The evaluation is done by following criteria:

A normal function without changes
B transient losses function or downgrade operations which finished after stopping distur-

bance. Normal function of tested device is regenerated without action by human op erator.

C transient losses function or downgrade operations which require action by human operator.

D losses function or downgrade operations which is not renewable. Usually it is caused by damage of the technical or software equipment.

Class[a]	**Preferred voltage levels and time durations for short voltage drops**				
Class 1	No specified, depends for a tested device				
Class 2	(0 ; ½)[b]	0 ; 1	70 ; 25/30[c]		
Class 3	0 ; ½	0 ; 1	40 ; 10/12[c]	70 ; 25/30[c]	80 ;250/300[c]
Class X[d]	X	X	X	X	X

[a] … Classes of electromagnetic environment by IEC 61000-2-4 [3].
[b] …. „(0 ; ½)“ zero percent during a half period.
[c] … „25/30 period“ means 25 periods for 50Hz networks and 30 periods for 60Hz networks.
[d] … Specified to definition by product committee. The appliance directly connected or no directly connected to public supply network mustn't have a fewer level than for class 2.

Table 1: The preferred voltage levels and time durations for short voltage drops.[1]

Class[a]	**Preferred voltage levels and time durations for short voltage interruptions**
Class 1	No specified, depends for a tested device
Class 2	0 % during 250/300[c] periods
Class 3	0 % during 250/300[c] periods
Class X[b]	X

[a] ….Classes of electromagnetic environment by IEC 61000-2-4 [3].
[b] ….Specified to definition by product committee. The appliance directly connected or no directly connected to public supply network mustn't have a fewer level than for class 2.
[c] …„250/300 period“ means 250 periods for 50Hz networks and 300 periods for 60Hz networks.

Table 2: The preferred voltage levels and time duration for short voltage interruptions.[1]

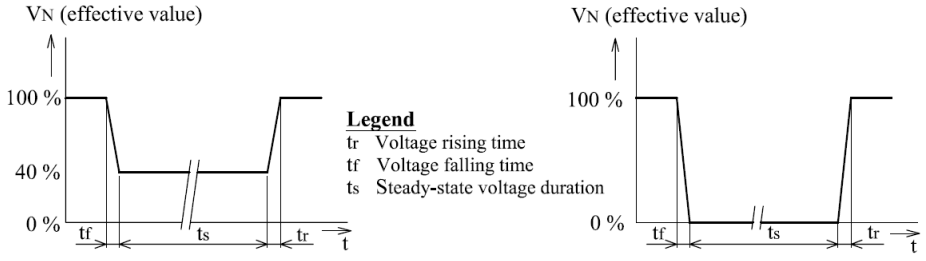

Figure 1: The course of the effective value of short voltage drop to 40% V_N in a) and short voltage interruption in b).

3. PRACTICAL DEVICES' IMMUNITY LIMIT

Determination the practical immunity limit of concrete device isn't primitive. We must know a tested device – function principles and its output characteristics. Then we can start the measurement in which we test a concrete output parameter. The measurement is practiced at the following way. In the first we search a minimal effective value of voltage, whereat the device is able to work without changing its output characteristics and then we search a time-limit of short voltage interruption which doesn't cause affecting of the tested equipment. Subsequently these found values are charted to diagram (Figure 2) which evidently describes the real immunity level of tested equipment to the short voltage events. The chart curve encloses two areas – the area over the chart curve means the function of tested equipment without change parameters and the area under the chart curve means a change or fail of tested output parameter.

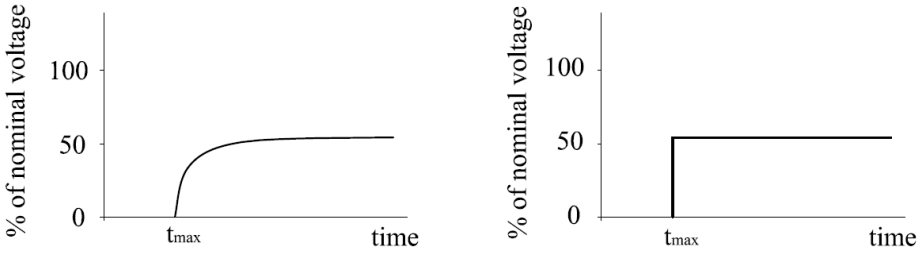

Figure 2: Practical chart curve of device (in left) and used simplification (in right).

4. PHENOMENA AFFECTING THE RESULTS OF EXAMINATIONS

4.1. THE COURSE OF VOLTAGE EVENT

The standard EN 61000-4-11 uses the square course of voltage events to classification devices' immunity level but practical voltage events in the public supply networks has also different courses. The square course is defined by voltage drop and drop's time-limit and it typically occurs together with fault conditions in supply networks. The square course is a simplified voltage event which has the worst effects for all connected equipments. Others frequently voltage events are voltage drops caused by starting big induction motors (Figure 3). The other course of voltage events has a fundamental effect to result of device's immunity level. We suppose the device's immunity level tested with non square course of voltage event.

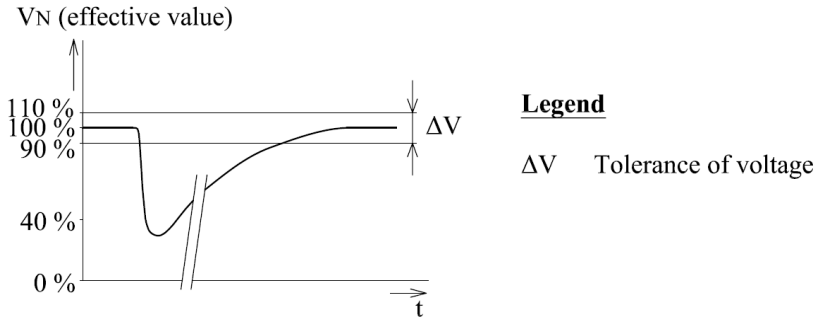

Figure 3: The course of voltage event caused by starting induction motors.

4.2. VOLTAGE FLUCTUATING

The voltage fluctuating is the next properties of the practical voltage events in the public supply networks. The effective value of voltage fluctuates at a granted interval ±10% V_N (nominal voltage). Voltage fluctuating causes a different initial value of voltage at a voltage drop's or interruption's time. We suppose again that the device's immunity level tested with initial effective value increased about 10% V_N will be better than the immunity level tested with nominal initial effective value of voltage.

4.3. THE FORM OF VOLTAGE CURVE, VOLTAGE DISTORTION

The distortion of harmonic supply voltage is caused among others high harmonic voltages. These ones are generated by equipments containing power switching elements (thyristors, converters and so on). There are too many types of voltage distortion in the public supply networks but for the immunity level classification there are two essential types of all – *top flat* (Figure 4a) and *over swing* (Figure 4b). The most of equipments connected to public supply network contains electronic circuits which are made from operating amplifiers, semiconductor triodes, capacitors and other elements whose correct function depends on the form of voltage curve. Some of electric devices work as detectors of maximum voltage value others devices work as detectors effective voltage value. It depends that supply voltages with the same effective values but different courses affect the correct functions all connected equipments by different manners.

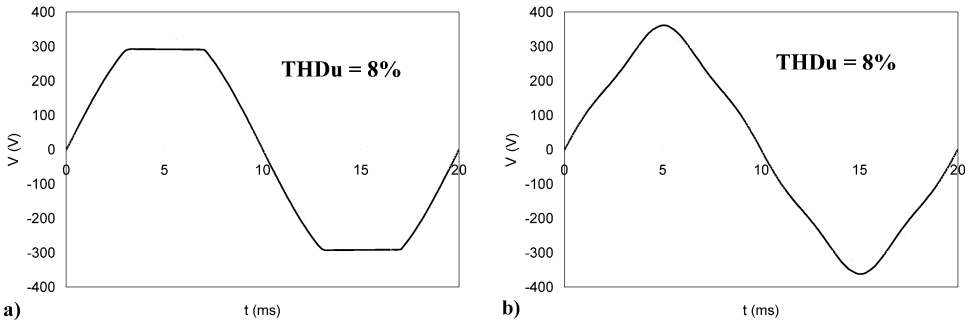

Figure 4: The types of voltage distortion – a) FLAT TOP b) OVER SWING

4.4. LOAD OF TESTED APPLIANCE

The next parameter interacts the result of immunity level is actual load of tested device during the voltage event. The appliance working with a nominal power during the voltage event will have a less immunity ability than the appliance working at a sleep-mode.

5. PRACTICAL CHECKING OF THEORETIC SUPPOSALS

The measurements were realized by CTS system (Compliance Test System) CI 15003 which is provided by the programmable power source California Instruments CI 15003iX. It is a power simulator of supply network which is intended to testing the electric appliances for all possible phenomena which are possible at the public supply networks. CTS system makes a simulated network which is separated from the public supply network, so it is protected before all disturbances in.

The computer with a source FR 200W was used as a tested arrangement. It was supplied by CTS system CI 15003. The measurement was in progress by the process described at

part 3 of this article. Measuring data was processed to diagrams (Figure 5) where we can see the influence of the several types of voltage events with regard to voltage event defined by EN 61000-4-11.

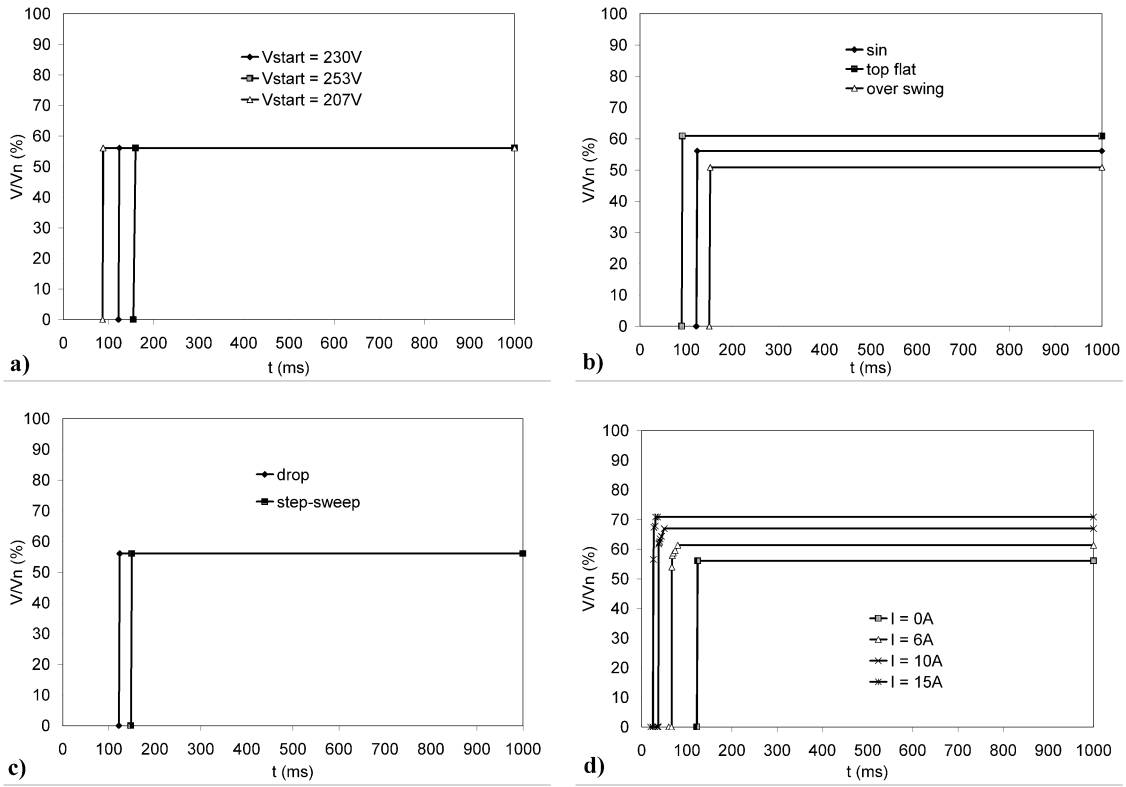

Figure 5: Limiting curves of computer source FR 200W at various types of disturbing influences: a) effective value of voltage; b) distortion of voltage; c)course of voltage event; d) load of source

6. CONCLUSION

The classification of arrangements' immunity level to short voltage events at EN 61000-4-11 is not sufficiently described because there are not included all kinds of disturbing factors which are possible in the public supply networks. The classification of arrangements' immunity level would be evaluated by the real voltage events in the public supply networks. The results will have a better predicative ability above the tested device.

REFERENCES

[1] EN 61000-4-11 ed.2 Electromagnetic compatibility (EMC). Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests.

[2] EN 61000-2-2 ed.2 Electromagnetic compatibility (EMC). Environment. Compatibility levels for low-frequency conducted disturbances and signaling in public low-voltage power supply systems.

[3] EN 61000-2-4 ed.2 Electromagnetic compatibility (EMC). Environment. Compatibility levels in industrial plants for low-frequency conducted disturbance.