

ELEC-E8422 An Introduction to Electric Energy

Homework 9: Power Quality

Explain shortly the following PQ factors and the limits given to them in standards:

- a) Voltage level
- b) Fast voltage fluctuation
- c) Harmonic voltages
- d) Unsymmetry.

Voltage level

Std 50160: limits for 10 minute values

- 95% must be in the band $U_n \pm 10\%$

Measurement for one complete week

In addition, all the 10 min values must be between $-15 \dots +10 \%$

In LV-system, according to association of utilities (sener):

- good quality: 10 min values between 220...240 V
- normal quality: 10 min values between 207...244 V
- standard quality: 10 min values between 207...253 V

In MV-system, according to association of utilities (sener):

- good quality: 10 min values between $U_n \pm 4\%$
- normal quality: 10 min values between $U_n \pm 10\%$
- standard quality: 10 min values between $U_n \pm 10\%$

Voltage level is determined by voltage drop due to load current, on-load tap-changer, off-load tap-changer and compensation.

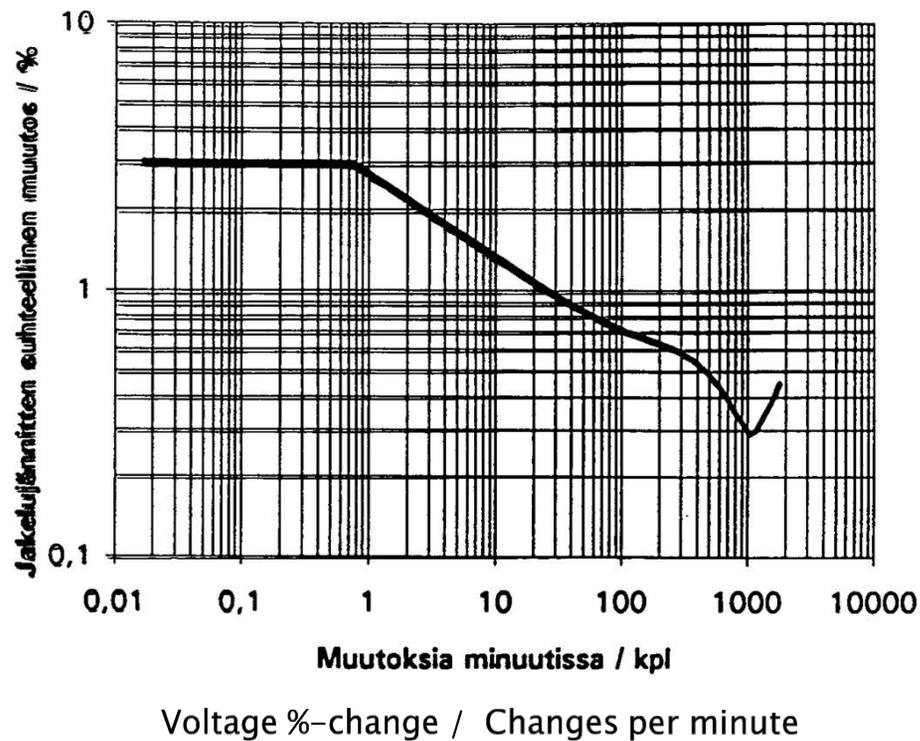
Fast voltage fluctuation (flicker)

Affects especially lighting and hence vision.
Also electronic equipment may be disturbed.

Fast voltage fluctuation is caused by,

- control of on-load tap-changer
- motor starting
- welding equipment

Limits according to CENELEC:



Harmonic voltages

Std 50160: limits for 10 minute mean values.
total harmonic distortion THD 8% at maximum

$$\text{THD} = \sqrt{\sum_{h=2}^{40} (U_h)^2}$$

Other harmonics:

Maximum allowed harmonics as % of the nominal voltage in LV-connection point. Limits given up to the order 25.

odd harmonics				even harmonics	
not multiple of 3		multiple of 3		order n	voltage %/UN
order n	voltage %/Un	order n	voltage %/Un		
5	6 %	3	5 %	2	2 %
7	5 %	9	1,5 %	4	1 %
11	3,5 %	15	0,5 %	6...24	0,5 %
13	3 %	21	0,5 %		
17	2 %				
19	1,5 %				
23	1,5 %				
25	1,5 %				

Voltage unsymmetry

Std 50160: limits for 10 minute values:

95% of the time the negative sequence component must be less than 2% of the positive sequence component.

Unsymmetry is caused by:

- uneven load between the three phases
- one-phase LV-faults (blown fuse)