ELEC-E8422 An Introduction to Electric Energy

Exercise Session 8: Power Quality

EX1 Current Distortion

The current of a conductor is obtained as ($\omega = 2\pi 50$):

$i = 4 + 50 \sin \omega t + 30 \sin 3\omega t + 10 \sin 5\omega t + 5 \sin 7\omega t$ (A)

Calculate the total harmonic distortion of the current (THD)

EX2 Flicker

The voltage is of form $u(t) = (170 + 2\cos(0.2t)) \cos \omega t$ ($\omega = 2\pi 50$)

Calculate a) Flicker factor, b) voltage fluctuation (per unit), c) frequency of the fluctuation, d) assess the human tolerance to this flicker.

EX3 Voltage Sag

400 V network short circuit power is 1000 kVA (reactive). A 10 kW induction motor is connected. The motor takes 6-times nominal current when started (assume inductive current). Calculate the voltage drop as a) per unit value, b) per cent value, c) volts in line voltage, d) volts in phase voltage.

EX4 Harmonic Resonance

400 V substation is fed by a distribution transformer the inductance of which (together to primary side network) is 41,6 µH. In the substation, there is a 3-phase compensation capacitor of 250 kVAr. At which frequency the capacitor is in resonance with the network inductances?

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Solution:

Idc = 4A

I1 = 50/Sqrt2 = 35,36A

I3 = 30/Sqrt2 = 21,21A

I5 = 10/Sqrt2 = 7,07A

I7 = 5/Sqrt2 = 3,54A

$IH = Sqrt(4^2 + 21{,}21^2 + 7{,}07^2 + 3{,}54^2) = 23$ A

THD = IH/I1 = 23/35,36 = 65%

EX2 Flicker

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Calculate a) Flicker factor, b) voltage fluctuation (per unit), c) frequency of the fluctuation, d) assess the human tolerance to this flicker.

a) F = Vfmax/Vsmax = 2/170 = 0,012
b) VF = 2F = 0,024 (2,4%)
c) $f = 0.2/2\pi = 0{,}032$ Hz
d) Flicker frequency is about 2 per minute. Fig. 13.4 of the book: Irritation limit is about 0,5%

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Network reactance $Xv = U^2/Sk = 400^2/1000\,000 = 0{,}16\ \Omega$

Motor reactance $Xm = U^2/(6*Sn) = 400^2/(6*10\,000) = 2{,}667\ \Omega$

Voltage drop = $Xv/(Xv+Xm) = 0{,}056$ (= 5,6 %)

In line voltage (400 V) voltage drop is 22,4 V

In phase voltage (230 V) voltage drop is 12,9 V

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$Qc = 3Uv^2\ Yc = Up^2\ Yc = Up^2\ \omega\ C = Up^2\ 2\pi 50\ C \Leftrightarrow C = 4{,}96$ mF

$fr = 1/(2\pi\ Sqrt(LC)) = 350$ Hz (= 7. harmonic component!)