CURRENT INJECTION IN THREE-PHASE RECTIFIERS, test questions

In all of the subsequent questions, "the rectifier" would refer to a three-phase diode bridge rectifier with the output voltage of $V_{OUT} = 540\,\text{V}$ and the rated output current of $I_{OUT} = 40\,\text{A}$, built using diodes with the forward voltage drop of $V_D = 0.8\,\text{V}$ and the on-resistance of $R_D = 0.02\,\Omega$.

Topic 1, Introduction

1. Compute conducting power losses in the diode bridge of the rectifier and the rectifier efficiency.

2. Compute the amplitude of the phase voltages the rectifier is connected to.

3. Compute amplitudes of the 1st, the 5th and the 7th harmonic of the input current.

4. Compute the RMS value of the input currents.

Topic 2, Current Injection

1. The optimal third harmonic current injection is applied in the rectifier. Compute the power loss in the diode bridge and determine its increase in comparison to the case the current injection had not been applied.

2. Determine the input power of the rectifier in the case the third harmonic current injection is applied and the power taken by the current injection network. Assume that the power taken by the current injection network is dissipated. In the analysis neglect losses in the diodes.

3. Aiming optimization of the rectifier power factor, determine $k_{opt}(\phi)$ that maximizes the power factor.

Topic 3, Current Injection Devices

1. A single-phase core is rated $S = 240\,\text{VA}$ at $f_0 = 50\,\text{Hz}$, and it should be used to build an inductor intended to operate with the sine-wave current of the maximum amplitude of $I_m = 10\,\text{A}$. Which would be the maximum of the inductance that can be achieved using this core?

2. The rectifier should be equipped with a current injection system that uses a zigzag connected current injection device (CID #3). Determine the VA-rating of the device and the amplitude of the voltages across its windings.

Topic 4, Current Injection Networks

1. Current injection network #3 is intended to be applied in the rectifier, with $Q = 3$. Determine L, C, and R, and the VA-rating of the 1:1 transformer.

Topic 5, The Optimal Current Injection

1. The optimal current injection is intended to be applied in the rectifier. Determine the amplitude of the input current I_m, resistors R_{odd} and R_{even}, and the power dissipated on each of these two resistors.

Topic 6, Switching Current Injection Device

1. The optimal current injection is applied in the rectifier, using the switching current injection device and the current injection network consisting of two resistors, R_1 and R_2 (reference to the presentation slides). Determine the amplitude of the input current, the resistance emulated at the rectifier input, R_1, R_2, and the power that each of these resistors dissipates.

2. Determine the power dissipated in the diode bridge.

Topic 7, The Discontinuous Conduction Mode

1. In the rectifier, the third harmonic current injection in the discontinuous conduction mode has been applied, relying on the losses on the parasitic resistance of $R = 0.1\,\Omega$. Estimate the rectifier output voltage and the rectifier efficiency using the δ impulse approximation.

Topic 8, Passive Resistance Emulation

1. The current loaded resistance emulator presented in the figure operates with $I_{OUT} = 10\,\text{A}$, $n = 4$ and $v_{RE} = 20\,\text{V}\cos(\omega_0 t)$. Applying the sinusoidal approximation, determine the emulated resistance.