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ANALYSIS OF HIGHER-ORDER HARMONIC COMPENSATION SCHEMES BASED ON VECTOR MEASUREMENT DEVICES

The presence of harmonic components, as well as voltage and frequency deviations negatively affect the operation of local power supply systems and the efficiency of electricity use. Therefore, the problem of monitoring and ensuring the quality of electrical energy was investigated using the example of detection and suppression of harmonics of high orders of currents and voltages in different sections of the network. The principles of building a monitoring system and implementing a methodology based on the use of vector measurement devices (VMD) have been developed. A method of determining the optimal values of reactive resistances for reducing the level of harmonic oscillations in local networks using a dynamic voltage distortion compensator has been developed.

Based on the analysis of the distribution of harmonics of higher orders in different parts of the power system, it is possible to create a control scheme for the operation of controlled capacitor compensating devices, active and passive filters [1]. To carry out this procedure, it is possible to use VMD. To do this, sensors are installed at the nodal points of the power system to measure instantaneous values of currents and voltages. After processing this information, a decision is made about the influence of the dynamic compensator of voltage distortions on the controlled reactive elements.

Using the method of successive approximations consists in arbitrarily changing one of the parameters, for example, the adjustable inductance.

The ratio of the power of the main harmonic H_1 to the power of harmonics of higher orders H_{HO} is used as the target function.

$$\frac{\mathrm{H}_2}{\mathrm{H}_{\mathrm{HO}}} = f(x_1, x_2, x_3, \dots x_n) \quad (1)$$

where: x_1, x_2, x_3,, ... x_n – values of variable reactive elements affecting the frequency properties of the network.

x_1, x_2, are variable values that can be changed remotely. The values of x_3, x_4, etc. are quasi-constant and change in the process of changing the operating modes of the system [2-4].

In fig. 1.a presents a simplified scheme for replacing the local power supply system. To demonstrate the approach, as an example in calculations, it is assumed that only the third harmonic is present in the voltage. It is generated by both the source e_g

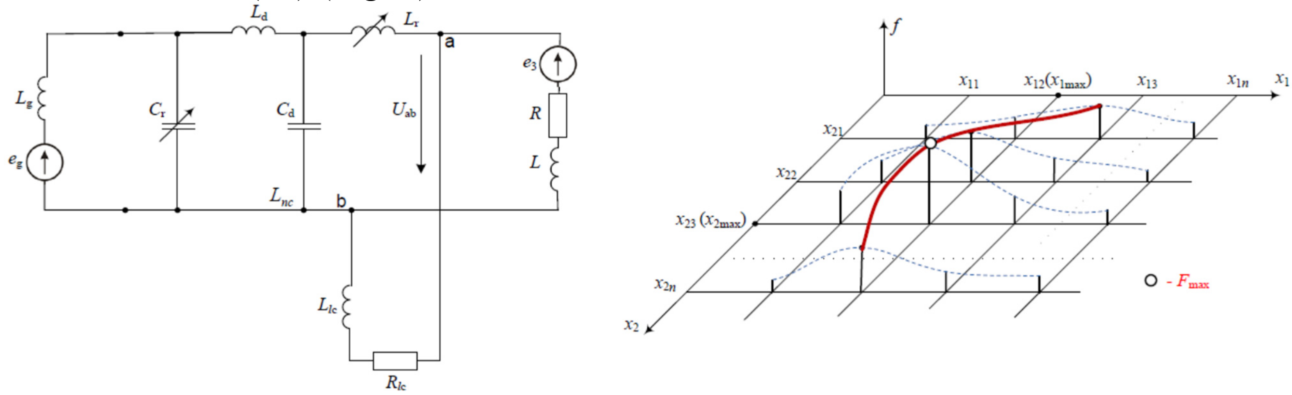
and the non-linear load e_3, and there are also two variable reactive elements: capacitance C_r, inductance L_r.

In order to determine the possibility of setting variables and explain the approach, a special case is considered. It is necessary to ensure the highest possible quality of electrical energy at the connection point (*ab*) of the linear receiver. Assume that the inductance of the generator L_g, the distributed capacity C_d, the distributed inductance L_d and the inductance of consumers L_{nc} and L_{lc} are unchanged. And the regulated capacity C_r, the inductance of the regulated reactor L_r, are considered variable values.

In fig. 1.b graphically shows the procedure for determining the maximum of the objective function with two variable parameters of the network [5].

In this case, x_1 is a variable capacitance, and x_2 is a variable inductance. Initial numerical parameters of constant values x_3, x_4 and others, as well as minimum values of the range of variables x_1 and x_2 are entered into this model.

Then, fixing the first value of variable x_2 at the beginning of the given range (x_{21}), we increase variable x_1 with a step of Δx_1, from the minimum to the maximum value of the range. For each value of the x_1 parameter, the H_I/H_{HO} ratio is calculated on the network section (*ab*) (Fig. 1).



a) b)

Fig. 1. a – the scheme of replacing the local power supply system
b – determining the maximum of the target function

We find the value of x1max, which corresponds to the maximum objective function (1), given the value of x_{21}. Next, the increment of variable x_2 with a step of Δx_2 is specified:

$$x_{21} + \Delta x_2 = x_{22} \quad (2)$$

Next, the operation of changing x_1 is repeated again for the entire range. As a result, we find the value of x_{1max2} at x_{22}. This process continues until the variable x_2 reaches the upper limit of the range of its change. The final values $x_{1\max}$, $x_{2\max}$ are determined through the obtained data array. These values correspond to the highest of the maxima of the objective function. Based on these data, a control scheme for the executive mechanisms of the dynamic voltage distortion compensator is formed. In turn, the device for dynamic voltage distortion compensation changes the values of f_1 and f_2 to f_{max1} and f_{max2}.

Conclusion

Based on the analysis of the distribution of harmonics of higher orders with the help of vector measurement devices located at various points of the power system, and measuring the instantaneous values of currents and voltages, the most effective use of the dynamic compensator of voltage distortions when working by the method of successive approximations becomes possible.

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ПОТОЧНИЙ СТАН БАЛАНСУЮЧИХ ПОТУЖНОСТЕЙ

У більшості країн, також як і в ОЕС України зростання потужностей енергосистем здійснювалося за рахунок введення потужних ТЕС і АЕС, обладнаних високо економічними базовими енергоблоками. При цьому одночасно вводилися високоманеврові потужності, такі як ГАЕС, з метою регулювання графіка навантажень в енергосистемах, забезпечення надійної й економічної експлуатації ТЕС і АЕС.

Електроенергія є особливим товаром з обмеженими можливостями зберігання й транспортування при незбалансованому попиті та пропозиції. Керування режимами, що балансують ринок електроенергії, забезпечення якості електроенергії досягається за рахунок так званих системних послуг, надати ці послуги в самому широкому спектрі й оперативно здатні тільки ГАЕС. Маючи