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B. Valov, S. Heier

The complete use of receiver capacity of a grid through the control of the power generation units

SECTION 6 "Power Engineering"

The rapid development and use of power generation units (PGU) changes the grid structure (Fig. 1) and its operation conditions. A lot of quantity of PGU in low and middle voltage grids results in change of direction of load flows. Such grids provide not only for energy transfer from external power plants to the customer but also they transfer energy from small and middle power generation units to the external grid. On such circumstances, the system is designed e.g. in respect to voltage increment by worst-case (more solar irradiation, higher wind velocity and low heat demand). Such conditions occurred rarely in the grid (Fig. 2) and shows that the grid has practically enough receiving capacity every time. If to deviate from this way and to allowed a connection of PGU with more power as this give the equations in [1,2] that could be increased the degree of technical and economic efficiency of grid and PGU.

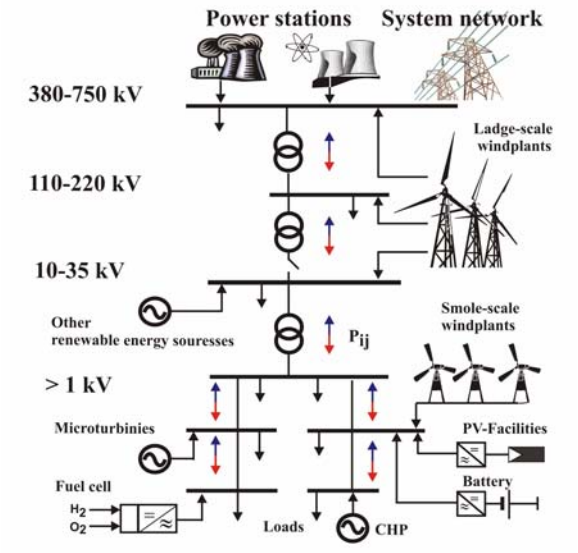


Fig.1: New structure of grid with low- and middle voltage power generation units

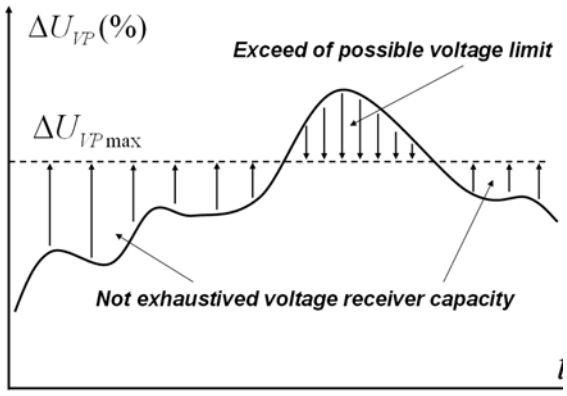


Fig.2: voltage variation in customer connection point of grid

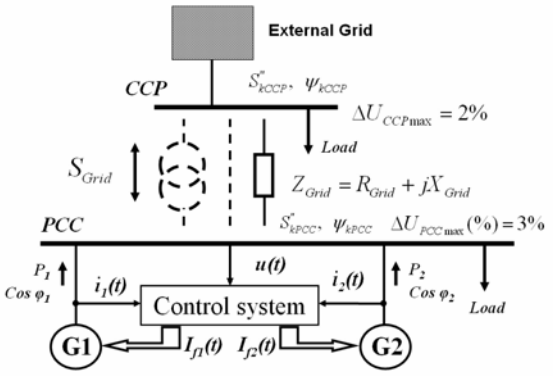
The basic instructions for system design with worst-case way were given in the code [1,2]. The evaluation of equations of these codes is not required:

- full control characteristic of PGU,
- parallel operation of different PGU in the same point of common coupling (PCC),
- parallel operation of PGU in different grid points,
- control algorithm of PGU.

For full use of free grid capacity can be continued to develop for control of PGU the suitable mathematical basics. As objective function of the control system for these equipments may be a voltage garantee at the customer connection point (CCP).

The developed mathematical specification complete the references in [1,2]. Per according control of power energy systems are showed the general conditions for the voltage garantee in PCC or in CCP. The following points are considered:

1. Supply und demand depends on combined equipments, which have the electrical energy as the second product only (combine heat and power unit etc.) and therefore the increasing electrical power temporal variable and is conditional controllable (G_1).



$i_1(t)$, $i_2(t)$, u(t) – Measured data, $I_{f1}(t)$ and $I_{f2}(t)$ – Induction current of generators G1 und G2

S''_{kCCP} und Ψ_{kCCP} – short circuit power and grid impedance angle in CCP

S''_{kPCC} und Ψ_{kPCC} – short circuit power and grid impedance angle in PCC

Fig. 3: Schematic diagram of grid

2. The power generation and demand for power systems like wind, hydrogen, water, PV is independent of equipment.

The increment in power from such systems is regulated (G_2).The voltage level in PCC is ascertained through simultaneous influence of loads and independence of connection units between PCC and external CCP (Fig. 3). The influence of PGU on the voltage in PCC is described by following equation [3]. The voltage level in PCC is ascerttained through simultanuois influence of loads and of impedent of connection units between PCC and external CCP (Fig. 3). Thereby is described the influence of the PGU on the voltage in PCC through followed equation [3]:

$$\Delta U_{PCC}\ (\%) = 100 \cdot \frac{\Delta U_{PCC}}{U_N} = -100 \cdot \frac{P_{PGU} \cdot c}{S''_{kPCC}} \cdot \left[\cos\ \psi_{kPCC} - tg\ \varphi \cdot \sin\ \psi_{kPCC}\right].$$

Where are S''_{kPCC} - a subtransient short circuit power in PCC (this is calculated in grid calculation software as standard), P_{PGU} and Q_{PGU} - active and reactive increase

power into grid. A separate consideration in this equation of angle of PGU φ and angle of grid ψ_{kPCC} shows the control influence on the voltage level in PCC. By over sizing PGU just opposite as referred in [1,2] it is guaranteed that the voltage level is maintained always below its limit. It is very important that the model to be based upon real technical characteristics of PGU and grid dates. In order to make possible a simple use in the practice are clarified the mathematical equations via draws (e.g. Fig. 3). By using the mathematic transformations, it can be shown that if use in equation above the subtransient short circuit power S''_{kCCP} and grid impedance angle ψ_{kCCP} of CCP then will estimate the control efficiency of PGU in PCC on voltage variations in a far-off grid point CCP. On the basis of such calculations may be detected the possible increase power from PGU in order to exhaustive the "voltage voids" (Fig. 1) until voltage limit. Therefore the technical and economical efficiency of PGU use are raised. The voltage in far-off customer connection point is directly controlled through measured data from PCC, consequence is that the voltage does not crosses the limits in CCP or other grid points. The developed ways does not need extra communication channels between CCP and PCC for measuring the voltage and current in the far-off CCP and for transferring the measured date to the control systems of PGU.

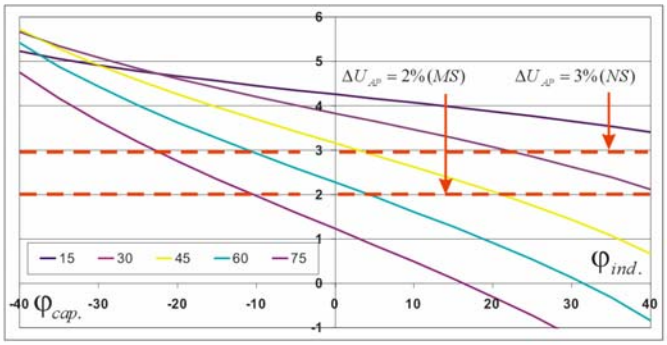


Fig. 4: Voltage variation in PCC through control of angle by power energy system

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