Parallel Operation of Multiple Transformers

A. Eberle REG-D and REG-DA voltage regulators from HV Power have a special feature which enables the operation of multiple transformers in parallel, even when the transformer's ratings are different. A. Eberle's approach is to use one REGulator for each transformer. Their paralleling strategies can cater for situations where transformers have:

- Different voltages per tap step
- Different number of taps
- Different transformer power ratings
- Impedance differences (less than 10 %)

Usually when unmatched transformers are paralleled, a reactive circulating current will flow. This current, which is independent of the load current, generates losses and should therefore be minimised as far as possible.

In the case of transformers operating in parallel on one bus bar, the bus voltage of all transformers is the same, even if tap positions are different between transformers. This is why voltage alone cannot be used as the sole regulation criterion. To control unmatched transformers switched in parallel on one bus bar requires supplementing the voltage regulation with circulating current monitoring. As an example - in one mode, to minimise the reactive component of the total circulating current, each regulator measures the reactive portion of the load current for each transformer. It then calculates the reactive circulating current of its transformer and the regulator sets its tap change position in such a way as to minimise that transformer's reactive circulating current. All the regulators in that paralleling group communicate with each other across an E-LAN interface. In the event of E-LAN failure, all the regulators revert to an "Emergency mode" in which all tap changers are independently controlled by their associated regulators to maintain as near as possible the network power factor that existed prior to the loss of communication.

HV Power has such confidence and has had such success with the circulating current (Delta I sin phi) mode, that we recommend this as the default paralleling method (even for identical transformers). This mode offers finer control of transformers (half tap step voltage changes), simple setup and less operational requirements for operators.

Changing Topology

Each voltage regulator features "ParaGramer", a self-learning program through which individual voltage regulators continuously check which transformers are feeding which bus bars by sharing information across an E-LAN with other regulators. On a Large LCD screen on each regulator, ParaGramer displays a single line diagram showing the transformers, and status of the associated circuit breakers, isolators, bus couplers and sectionalisers.

On the basis of the status of each switch, the system automatically recognises which transformers are paralleled to which bus bar and regulates all the transformers accordingly. As the network configuration changes, the system automatically adapts to the new configuration. Settings within each regulator determine just how quickly a regulator initiates tap changes when a Transformer is switched between one parallel group of Transformers and another.

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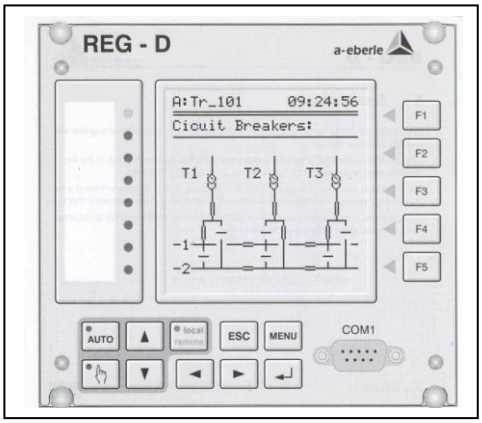

Figure 1. REG-D/DA ParaGramer display of transformer and bus topology.

In Figure 1, transformers T1 and T3 are paralleled on bus bar 1 while T2 is connected to bus bar 2. This information is available locally at the substation, displayed on the front of each regulator. It can also be displayed remotely at the SCADA control centre.

Up to 10 transformers can be operated in parallel using ParaGramer.

Theory into Practice

A significant feature of the A. Eberle REGulator system is the ability to simulate the voltage regulation system prior to installation and commissioning using REGSim™ software. Simulation of parallel connections of multiple transformers with combinations of network load is possible. This allows engineers to predetermine how the regulators will behave when in service. REGSim operates in real time and uses exactly the same algorithms and settings that are used in the actual regulators. System reliability is maximised because by using REGSim, the scheme can be proven before putting it into operation.

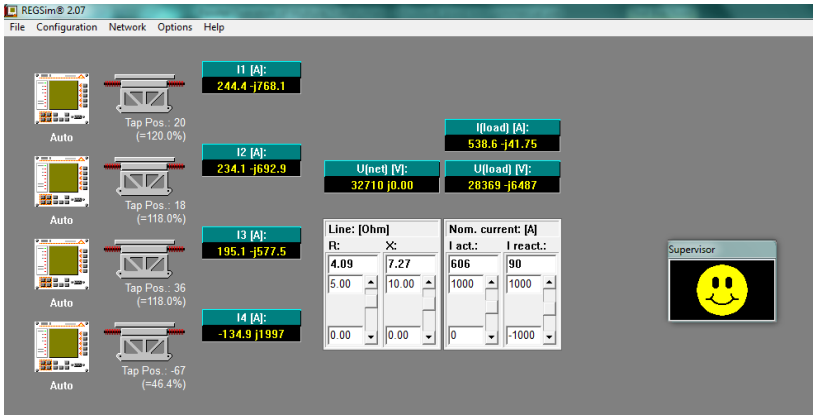

Figure 2. REGSim for simulation of parallel transformer control.

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