EXTENSION OF THE PULSED POWER SUPPLY NETWORK OF ASDEX UPGRADE BY A SET OF COMPACT MODULAR GENERATORS

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Some years ago, ASDEX Upgrade (AUG) examined its future power supply needs. The ohmic heating transformer and the poloidal field coils are supplied by thyristor converter units with an installed apparent power of about 600 MVA. Further, the HV power supplies for Additional Heating (AH) (NBI, ICRH, ECRH) have a total installed apparent power of about 100 MVA. These systems are supplied by two large flywheel generators EZ3 and EZ4. The pulsed 10.5 kV, 110-85 Hz energy network of these generators has a total apparent power of 364 MVA and a deliverable energy of 1265 MJ. The ASDEX Upgrade experimental program could make use of an extension of the IPP pulsed energy storage, both to allow new scenarios at higher current to be investigated, as well as to allow longer plasma flat-top time. Studies performed in 2001 and 2002 by IPP and external collaborators showed that an attractive solution for this extension is a parallel connection of commercially available compact flywheel generators.

The Compact Modular Energy Storage System, called EZ5, has been designed comprising of up to five Energy Storage Units (ESU's), each rated 8 MW / 32 MJ. The system is aimed at being operated in parallel to one of the generators EZ3 or EZ4 as well as being able of "stand-alone" operation. One of the five units has been built and is in service during AUG operation since June 2008 and with AH Power Supplies in stand-alone operation since March 2009.

The EZ5 has to fulfil three main objectives:

- Modularity and flexibility: An ESU consists of four Energy Storage Modules (ESM's). It is possible to operate the ESU with some ESM's out-of-service for repair or fault finding. The same principle extends to the ESU's when the system includes several of them in parallel.
- Parallel operation: The EZ5 operates in parallel to one of the big flywheel-generators without system instabilities, taking account of the AUG transient loads. The acceleration of the ESU to operational speed between AUG pulses is achieved by deriving power, through the 10.5 kV, 100 Hz network, from the drive system of EZ3 or EZ4.
- Stand-alone operation: The Energy Storage System is capable of maintaining a stable system voltage free of voltage fluctuations on the 10.5 kV, 100 Hz busbar for testing purposes. If there will be more than one ESU available, the EZ5 will have enough power to supply individual modules of the HV power supplies for additional heating test beds.

Especially the following challenges will be explained in the paper:

- Accurate synchronization of the Modules and Units among each other and with EZ3 / EZ4.
- The requirement to maintain low impedance in a pulsed system for electro-mechanical and voltage stability while at the same time coping with the large short-circuit power.
- The need to achieve a fast and accurate voltage control, while the generator includes a rotating exciter.

Further on, the paper will present the parallel and stand-alone mode of operation, analyses the results of measurements obtained during commissioning, compares them to the calculated design values and reports on the performance achieved during AUG plasma experiments and Additional Heating operation.