METHODS OF TORQUE SHARING FOR THE YAW CONTROL OF WIND TURBINES

Wind turbines are getting bigger and bigger and for this reason the control of the nacelle orientation requires more performance. On a small wind turbine the movement might be realised by a single motor but larger turbines, because of mechanical reasons, need to be controlled by multiple motors.

KEB has experience in yaw control for wind turbines since more than a decade. In the beginning, it was typically one inverter for one or multiple yaw motors in parallel. In the last years, controlling each yaw motor with an individual inverter became more and more popular. Since 2013, KEB applies various algorithms to share the torque between all yaw motors, while keeping their speeds (nearly) equal.

Using these algorithms smoothes yaw movements while reducing mechanical stress and wear of many mechanical turbine components, e. g. yaw drives and gearboxes, tower and others.

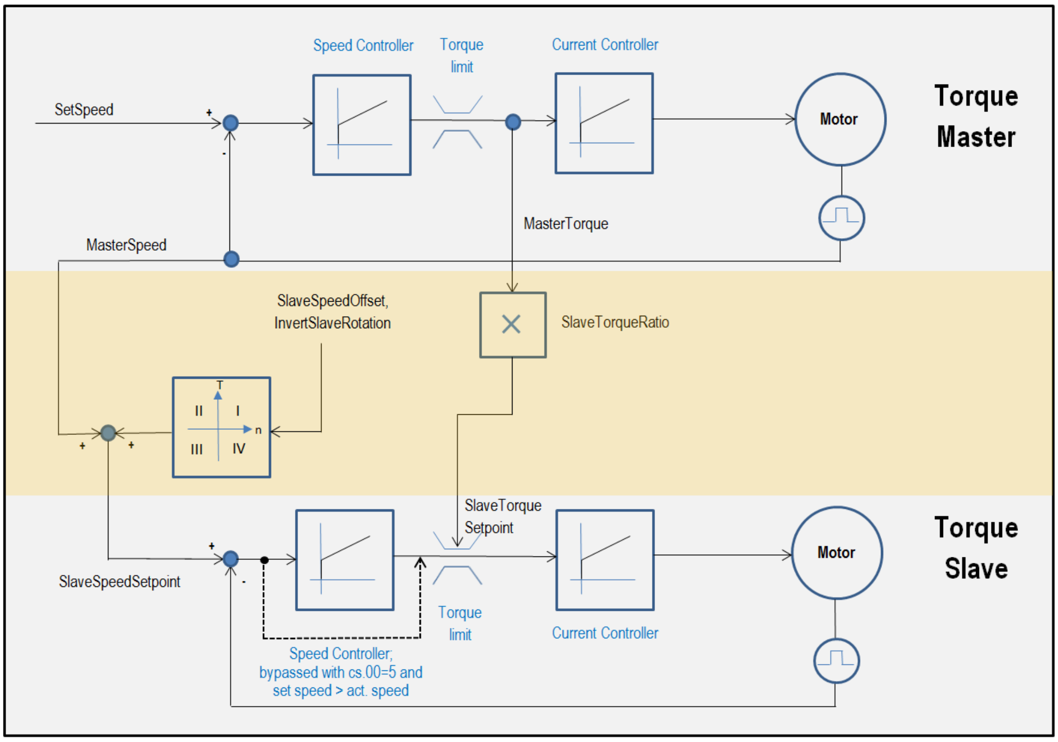
KEB has developed a function block (FB) to control a scalable number of electrical yaw motors in torque sharing mode. This FB is the core of the KEB Yaw Library and the basis for the motion control of a yaw system.

The FB manages the torque sharing algorithm between the yaw drives. Typically one drive operates as a torque master and the other drives as torque slaves. The master is always operated in speed controlled mode. The slaves follow either in torque controlled mode or in speed controlled mode with torque balancing.

Alternatively the master can be simulated in the control unit or PLC and all drives can be operated as torque slaves in speed controlled mode using the average load torque as a reference.

The different control methods are described as follows:

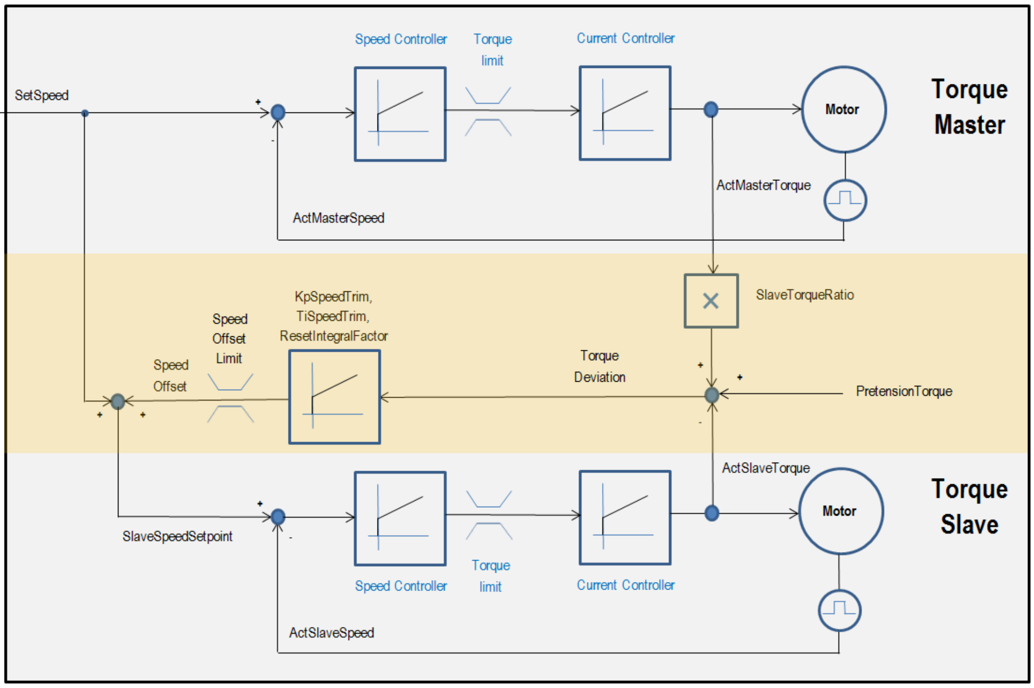
a) Torque sharing in torque controlled mode



In order to guarantee that all slave drives run at the torque limit which they get from the master drive, the speed setpoint of the slaves must be higher than the master speed. Therefore a slave speed offset, which is added to the actual master speed, should be significantly greater than 0%.

The ramps for starting and stopping can be adjusted by FB inputs. Internally all ramps of the slave drives are set to zero and the slave drives are operated in torque control mode.

b) Torque sharing in speed controlled mode with torque balancing and one drive as torque master



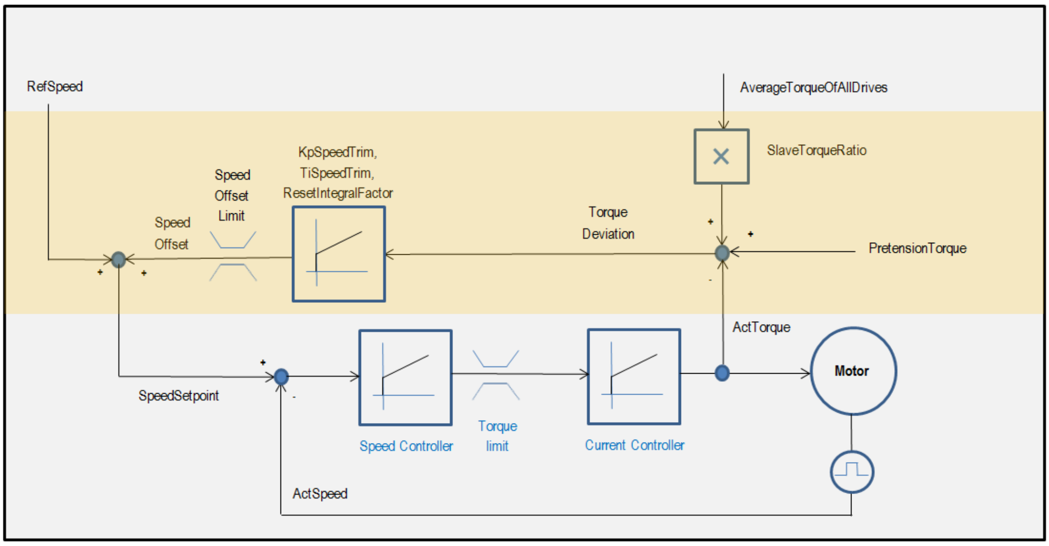
The ramps for starting and stopping are defined by FB inputs. They are automatically adjusted at all drives as well as the speed controlled operation mode.

The torque balancer is designed as a PI controller which can be adjusted by FB inputs. Normally the integral part is not needed. An FB input **"ResetIntegralFactor"** resets the integral part of the torque balancer.

The FB input **"SlaveSpeedOffset"** serves as a limitation for the torque balancer output.

The FB input **"PretensionTorque"** allows to adjust a torque offset (in %) on each slave drive. If there is no load torque, the slave torque will be compensated by the other drives. Thus the drives could work against each other in order to compensate the backlash of the gearboxes.

c) Torque sharing in speed controlled mode with torque balancing and without torque master



This method is very close to the method described before but the torque master is replaced by an algorithm where the AverageTorqueOfAllDrives is calculated and is used as torque master.

As every method has not only advantages, it is always important to choose the most suitable method. The solution depends very much on both mechanical and electrical characteristics of the yaw system (Type of motor used, ratio of the gearbox, number of drives, backlash etc.). KEB is offering all three methods and a proof on a real equipment is necessary.

The FB is kept as universal as possible to allow a changeover between the methods b) and c) during operation at any time.

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