Gearing Mode – What it is, What it's not

Abstract

In long production lines drives must be operated in sync with each other. For example, in configurations as shown in Figure 1: A conveyor belt with several drives.
This paper describes how this can be implemented using Faulhaber motors

Applies To

FAULHABER Motion Controllers of generation V2.5 with RS232 interface.

Description

The Gearing-mode, or the Stepping-mode, of Faulhaber Motion Control of systems lend themselves to applications where multiple axes must be operated in sync with each other. An example is the conveyor system shown in Figure 1.

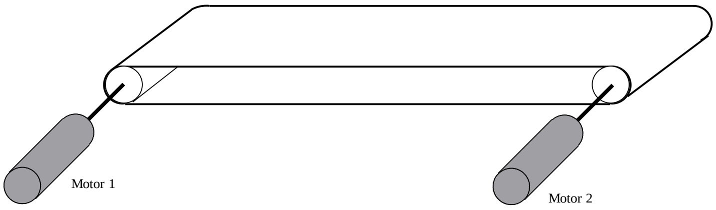

Figure 1: Conveyor Belt with Several Drives

Depending on how the different actuators are controlled they can have significantly different operating characteristics.

Application	Electronic Axle	Master-Slave
Steady State Speed	Works well	With limitations
Synchronous Angular Operation	Works well	Works but with lag

Fixed Angle Synchronous Mode (Electronic Axle)

A strict angular synchronous operation of the motors can be achieved if the rules are set and all the drives can be kept to the same angle compared to the reference input (Figure 2).

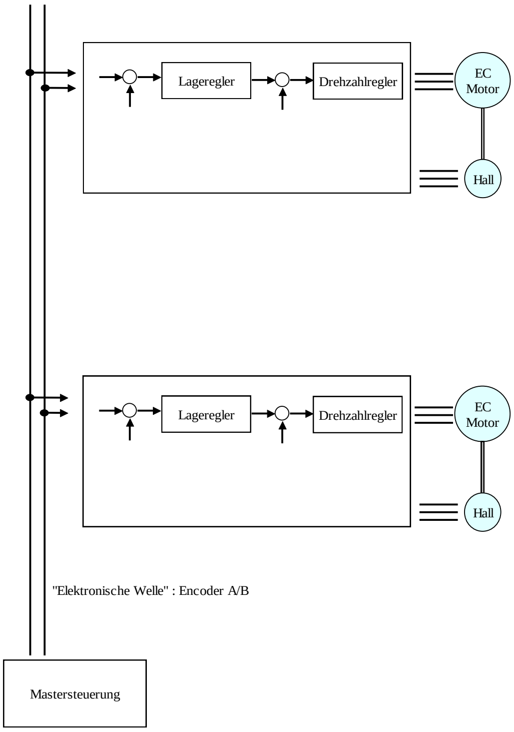

Figure 2: Synchronous operation mode as electronic gearing shaft (rigid coupling)

The prerequisite is that all drives are configured in gearing mode and a master controller drives all the drives together using a pair of reference quadrature signals.
Alternatively, the drives can be configured in the stepper mode and the target value is defined using a frequency signal.
It is important that synchronously operated drives are all run in the same mode at the same nominal value.

Soft Linking (Master-Slave)

If two drives, as part of traversing operation, are moving to the same end position and during movement a slip between the angular positions of the drives can be tolerated, the drives can be configured in the master-slave mode (Figure 3).

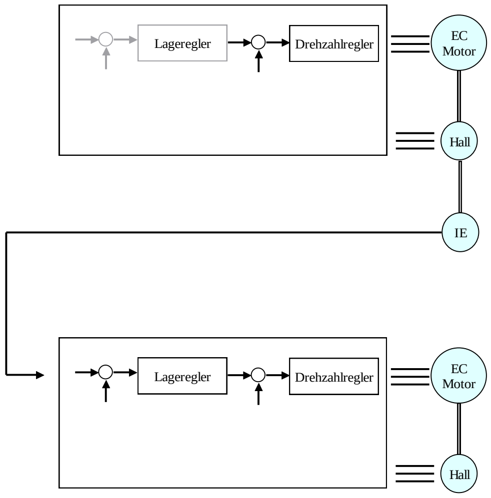

Figure 3: Master Slave operation of two axes (soft linking)

Configuring the Master Controller

In a Master/Slave configuration the Master motor should be either a DC motor with an encoder, a Brushless motor (Electronic Commutation) utilizing the controllers ENC mode, or a Brushless motor with analog Hall sensor signals for commutation and position. The Master controller can be used in either the position control mode or speed control mode. It does not matter for the Master/Slave mode of operation.

Configuring the Slaved Controllers

Brushless motors used as slave drives will use their analog Hall sensor signals and for DC motors an encoder is used for local control. The reference for the slave drives comes from the master drive encoder signals in the Gearing Mode.

Estimating the angular deviation between the Master and Slave

In a master / slave configuration the slave will always lag behind the master in angular position. The reason for this is the shared use of position or speed information of the master with the slave drives (Figure 4). This lag between the master and slave can be compensated for if the error known

It is crucial that in gearing or stepper mode to determine the deviation between target position and actual position in order to compensate the tracking error.

$$\mathbf{n}^{*}_{\mathbf{Slave}} = \frac{\mathbf{PP}}{\mathbf{k}}\left(\mathbf{TargetPosition} - \mathbf{ActualPosition}\right) = \frac{\mathbf{PP}}{\mathbf{k}}\left(\mathbf{TrackingError}\right) \quad (1)$$

Actual position is the position of the slave drive; target position is the position of the master drive. The factor k is an internal scaling of the controller parameter PP.

For analog hall sensors k = 32. For drives with encoders the numerical value of k depends on the encoder resolution. The resulting tracking error in motor revolutions is independent of the encoder resolution if all drives use the same encoding.

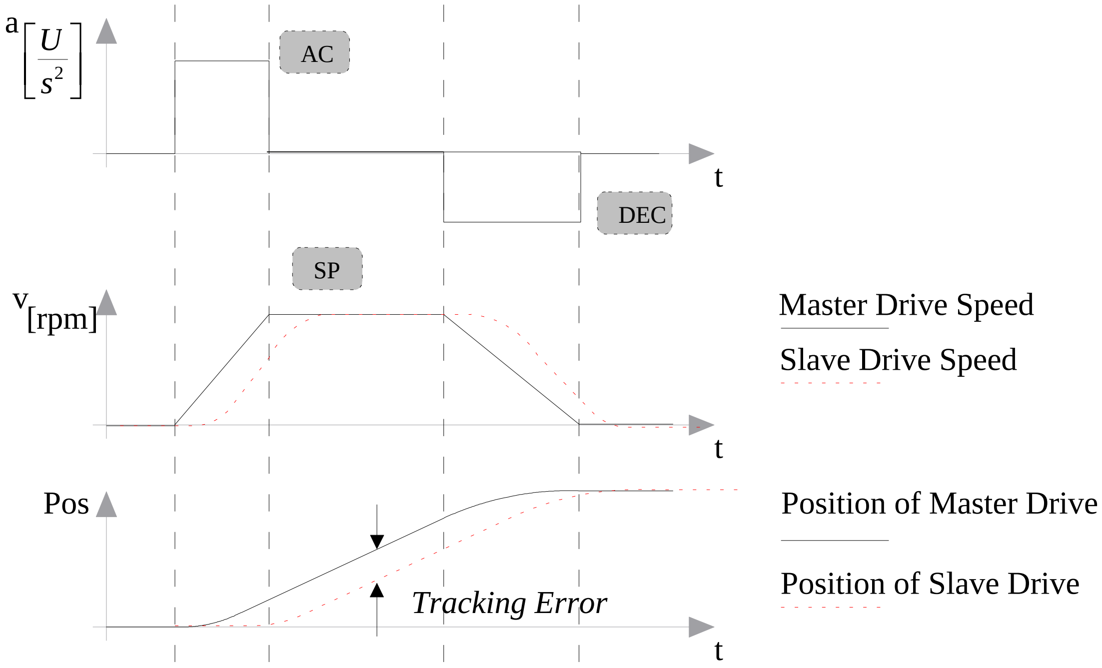

Figure 2: Speed and Position of the Master and Slave

Sample Calculation:

In this case we will calculate the tracking error for a movement sequence running steady state at 3000 rpm. The slave motor is a Brushless motor using analog Hall sensors with 3000 positions per revolution. The proportional gain is set PP = 10.

Steady state will be both master and slave at 3000 rpm.

The tracking error is:

$$3000\,\mathbf{rpm} = \mathbf{n}^{*}_{\mathbf{Slave}} = \frac{\mathbf{PP} = 10}{\mathbf{k} = 32}\left(\underbrace{\mathbf{TargetPosition} - \mathbf{ActualPosition}}_{\mathbf{TrackingError}}\right) \qquad (2)$$

The tracking error calculates to 9600 increments corresponding to 3.2 turns!

Influencing Variables-Reducing Tracking Error

The only way to influence the tracking error in Master/Slave systems is through the use of the Proportional Position (PP) gain term. Increasing the PP gain will decrease the tracking error. If the PP term is too high it can cause problems with overshoot and instability. If PP cannot be increased enough to reduce the Master/Slave lag to an acceptable level then it is better to use the Fixed Angle Synchronous Mode described above.

Rechtliche Hinweise

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