Compensation of the stationary position error by means of a switching integrator

The concept of a "switching integrator" is an integral part of control technology in hydraulics.

This special integrator is normally used in conjunction with position controllers.

But let's start at the beginning. The hydraulic position control loop has an integrating behaviour just like the electric one.

This means that a proportional controller must be used to control the position (a controller with an integral component usually generates an oscillation, since the series connection of the two integral components results in a phase shift of 180°).

If all components would offer an ideal behaviour, there would be no position error.

In practice, however, the following inaccuracies exist which influence the positioning exactness:

1. Signal resolution of the position measurement
2. Zero offset of the valve
3. Temperature-dependent changes
4. Sensitivity / Hysteresis of the valve
5. Signal resolution of the valve / the valve control
6. Force and friction errors due to a limited pressure gain

The error (1) cannot be compensated by control technology. The error sources (2) and (3) are static or slowly changing ones. The points (4) and (5) can be solved by suitable components (the products are so good today that this only becomes relevant in the case of very high requirements), the error source (6) is process-dependent and compensation is required in each cycle.

How to improve the accuracy?

In order to compensate these effects, a "switching integrator" can be used. The special attributes compared to a classic PI controller are:

- It operates relatively slowly so that the stability of the system is not negatively affected.
- It is only activated when the drive is close to the target position (to prevent unwanted integration).
- It is stopped when the desired position window is reached (so that no limit cycling can occur).

By the use of a switching integrator, positioning accuracies in the µm range are possible.

Is there anything better?

Still one restriction exists. If the valve has a zero point offset (2+3) and the actuator must be positioned against a force (6), the positioning process takes a relatively long time in one direction and in the other direction the position is exceeded first and then corrected.

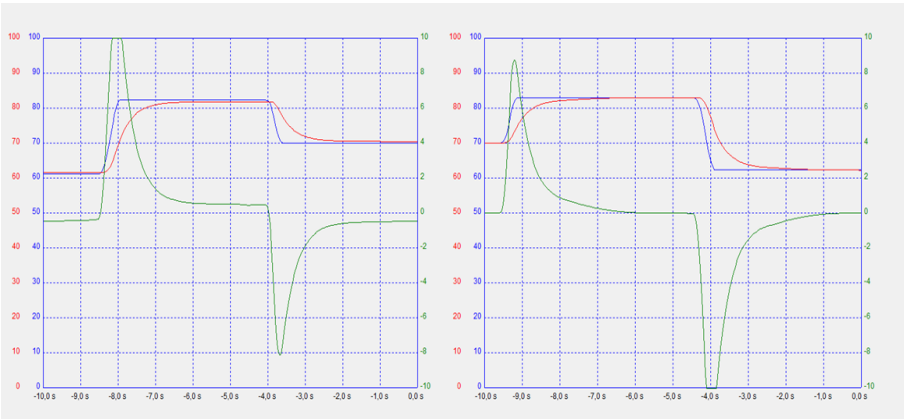
This can be easily solved by using two "switching integrators". The first is used to compensate for slow, practically constant effects, and the second is used for the cyclical, process-dependent influences.

Summary:

The use of a switching integrator allows very precise positioning.

If overshoot-free positioning is desired, the error causes must be treated individually and the use of two switching integrators (one for drift compensation and one for fine positioning) must be considered.

The drift compensation is activated via the machine control-unit at defined times, the fine positioning operates automatically during each positioning process.



RED = actual value, BLUE = setpoint, GREEN = control deviation. Left: Positioning against a load force without fine positioning Right: fine positioning is activated

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