Experimental filter setting for position controller with cascade speed controller

The following description is for the boards APCI-8001 and APCI-8008.
This instruction is only valid for drive systems with servo speed controllers. For other drive systems, like current regulated systems or stepper motor systems, this procedure cannot be used.
The settings are made in the mcfg.exe program. To check the system behaviour, a "Graphic Analysis" window is required. Settings and traverse commands are made in a "Motion Tools" window. For the position display, an "Axis Status" window may also be helpful. Before the check, the correct axis must be selected with the windows used. To save the determined controller parameters as resident, the "System Data" window has to be used. The respective axis does not have to be selected for saving in this window, because the parameters of all axes are always saved.
The displayed filter parameters on the "Digital Filter" tab in the "Motion Tools" window are temporary values. If required, these can be retrieved from the "System Data" mask via the "Load Data from System" button. Before the values determined here are saved, these temporary values must be transferred into the "System Data" mask via the "Update System Data" button. Changes made on the "Digital Filter" tab in the "Motion Tools" window take effect in the position controller only after you have clicked on the "Update Filter" button. This must not be forgotten before checking the behaviour of new set values.

Standard controllers

When using a speed controller, the following filter parameters must be set: Kp, Ki, kfcv.
All other parameters stay on 0. The setting can be improved with Kd only in insufficiently damped systems. This instruction requires that the user knows the menus and terminology of the program mcfg under Win 32. The procedure for taking over the modified filter parameters (Update Filter) and for starting and running back the trapezoidal profiles as well as the display of the traverse movement in a graphical interface must be known.
Furthermore, it is required that the user is aware that the axes are sometimes traversed uncontrolled and that this is possible at any time and that, for example, because of a wrong entry, unexpected traverse movements occur. Therefore, it must be guaranteed that the respecting motor can turn freely and that a Stop by the emergency shutdown is guaranteed at any time.

Presettings

Firstly, the traverse movement is recorded in the open loop. Here, it must be checked if the turn direction is correct (positive output values must cause positive count direction) and if the transient response of the speed control corresponds with system in accordance with the rules (comparable with the e-function of the transient response of the actual speed). It may be necessary to start by setting the speed controller correctly. Otherwise, it may only be possible to set the overlaid position controller to a limited extent.

Setting of Kp

The axis is traversed with a trapezoidal speed profile with adequate acceleration ramps and adequate maximum speed. The traverse distance should be so long that for the acceleration range, the linear traverse range and the braking range always 1/3 of the traversing time is required. Now the proportional factor Kp is calculated experimentally: Starting with small values (approx. 0.1) until the actual value follows the set value at its best, but without an obvious deterioration of stability. Realistic values range between 0.1 and 10. The found value for Kp is written down.

Setting of kfcv

Afterwards, Kp is set to 0 again and the speed pre-regulation coefficient kfcv is calculated in a similar way to Kp. However, in this case the value starts with 1. Realistic values here range between approximately 10 and 200. This parameter is adjusted in such a way that the maximum velocity is on the same level for the actual value and set value courses. The found value is written down.

Notice: When this setting is used, the system will be operated only in a controlled way, this means that a speed set value is put out and the set speed course is proportional (trapezoidal course). In some cases, overshooting can be noted, especially after the end of the acceleration and braking phase. Furthermore, due to inadequately selected factors, unexpected big or fast traverse movements are possible. In addition, the system may not stay unattended, as otherwise the axes would drift away and cause damage. After the calculation of kfcv, the control loop should be opened in order to prevent traverse movements in jumps by the reactivation of the proportional controller.

Common setting of Kp and kfcv

At Kp and kfcv, the values that were written down are entered. When traversing, the axis should be stable. The actual velocity course should follow the set velocity course without any significant deviation. Only at the end of the acceleration and braking ramp, overshoots or transient processes may be noted. In general, the value of Kp must be modified slightly downwards here in order to improve the controlling behaviour or to find an optimum. However, optimum does not mean that the overshoot is eliminated.

Optional D-part

If the oscillation behaviour cannot be set without overshoot, these can often be eliminated by adding a D element (Kd). When this value has been determined, Kp can normally be increased still further. Realistic values are between 0.001 and 1.
For experimental setting, we first determine Kp and kfcv as described in this application note and set them in such a way that the target point is reached with an overshoot (position and/or velocity). We then add a D element using Kd. This should start with a low value, e.g. 0.001. The value is then progressively doubled and the control behaviour observed. The correct value is found when the overshoot is minimised.
Notice: At any value, the position control loop can be destabilised by just a slight increase.
When a suitable value has been found, Kp can generally be increased further also, increasing the rigidity of the control loop.

Setting of Ki

In order to compensate the input offset of the speed controller, an I-part can be added. This is required, especially then, when the position precision in the position control is not sufficient. Here it must be considered that they can change as consequence of temperature and long-term conditions. If there is no deviation after traverse profiles, the I-part can normally stay with the value 0.
Also Ki must be calculated experimentally. Realistic values range between 0.1 and 100. The values are increased slowly. Stability and transient response may not be deteriorated.

The filter parameter kpl

In most cases, the value of kpl can be left on 0 and thus has no effect. However, if required, two different controller options can be activated with this value. The sign of the value determines which of these options is activated.

Positive values in kpl

If there are positive values in kpl, this value stands for a delay time constant for a real D-part. Especially in case of short scan times and high controller hardness, it may easily be that the manipulated value of the controller gets into override and that the controller therefore shows a non-linear behaviour. With this time constant, the period of a D-step response is extended, but the amplitude is diminished. The unit of kpl is seconds. Realistic values are between 0.0002 and 0.01 s.

Negative values in kpl

If there are negative values in kpl, this value stands for a delay time constant in the manipulated value channel. In many cases, it helps to reduce or completely prevent overshooting during the target position running-in. Firmly set drive systems in particular tend to overshooting, even if the pre-control is optimally set. However, the freedom of overshooting is “paid dearly for” by a time shift between the actual value and set value signals. The unit of kpl is seconds. Realistic values are between -0.0002 und -0.01 s.

Changing the scan time

Changing the scan time of a system affects the speed pre-regulation coefficient kfcv. If this is not to be experimentally redetermined, it can also be calculated.
The kfcv value has to be decreased or increased at the same ratio as the scan time is increased or decreased. If, for example, the scan time is halved, kfcv must be doubled. Where required, the acceleration pre-regulation coefficient needs to be adapted as well, however using the square of the ratio. Generally, all other filter parameters can remain unchanged.

Taking over the value into the file SYSTEM.DAT

After finding the optimal settings, the found values must be saved. Hereto, click firstly on the button „Update System Data“. Herewith, the values are taken over into the window „System Data“. Afterwards, this window must be opened, for example, with Ctrl+S. Now you can save it, for example, by clicking on the floppy disk icon. Herewith, the values will be saved in SYSTEM.DAT and are available for the next session or application.