Welcome to the position control training module for the DCS800, ABB DC drives.
If you need help navigating this module, please click the Help button in the top right-hand corner. To view the presenter notes as text, please click the Notes button in the bottom right corner.
Objectives

After completing this module, you will know:

- What position control means,
- Positioning options with the DCS800,
- Available function blocks for positioning applications,
- Commissioning procedure and
- Typical positioning applications

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What is positioning? This question is answered on this slide. The complete training module describes how positioning applications can be implemented with the DCS800.

An example of a positioning application is shown in the picture.

A platform in a theatre has to be adapted to the requirements for the artists. Normally there are many platforms in a theatre, which are used to change the stage quickly and easily to suit the actual scene. The adaptation of these platforms is done via motors, which are position controlled. That means the height of each platform can be selected by the artists. Some platforms can be adapted crosswise like shown in the picture.
Realization of positioning applications

How can it be implemented with the DCS800?

- The absolute position of the platform has to be calculated to the revolutions of the driving motor.
- That means information about the actual angle of the rotor is needed, which is used for additional calculations.

Conclusion

- All positioning applications need a encoder!

The realization of positioning applications is the next topic in this training module.

How can positioning applications be implemented with the DCS800?

- It is necessary to have the actual position of the motor shaft. Then the absolute position of the platform has to be calculated to the revolutions of the driving motor.
- That means information about the actual angle of the rotor is needed, which is used for additional calculations.

In conclusion, all positioning applications need an encoder, which delivers the actual angle of the motor shaft. Basically, there is no need to mount the encoder on the motor shaft. It is also possible to have a gear box in between.
Typical applications

- Linear motion
  - Adjustment of platform height
  - Adjustment of components in one dimension
  - Adjustment of components in multiple dimensions

- Rollover axis
  - Cable wound machines
  - Adjustment of rolling mills to zero point
  - Balance control for metal plate transportation

The typical applications for positioning can be split into linear motion and rollover motion.

Examples for linear motion are:
- Adjustment of platform height
- Adjustment of components in one dimension
- Adjustment of components in multiple dimensions

Examples for rollover motion are:
- Cable wound machines where two motors should work in angular synchronism
- Adjustment of rolling mills to zero point
- Balance control for metal plate transportation

This is only a brief overview about applications. There are more than one-hundred additional examples, which require a positioning application program.
Synchronous motion

- Two or more machines should work in common
- Motor shafts are not coupled!
- Therefore an encoder must be mounted on each machine
  - Result of the encoders must be evaluated by drive software
  - Requires a special software program inside the drive

Synchronous motion is the word which is often used when talking about positioning. It means that two or more machines have to work in common with a given angle reference value. This is needed when the motor shafts of two motors are not coupled. Therefore, an encoder must be mounted on each machine, which provides the essential angle information!

The result of the encoders must be evaluated by the drive software. This requires a special software program inside the drive.

Conclusion: There is a need for the drive system to connect two encoders directly to get this information!
Speed synchronous

- Speed synchronous
  - Two or more motors work at same speed
  - No evaluation of the angle

Example: Speed synchronous motion

To get an overview about several synchronization concepts, it is necessary to understand the difference between speed and angular synchronism.

Speed synchronous means two or more motors work at same speed. There is no need to evaluate the angle of the motor shaft.

The animation shows an example of a speed synchronous motion:

- Both motors turn with same speed but the angle of the axis is not the same, because there is no evaluation of the angle!
- These kinds of applications are easy to realize, because the main topic the speed and not the angle. Therefore, a position controller is not needed.
Angular synchronous is the other option dealt with in this module.

- Angular synchronous means that two or more motors work at the same angle.
- For these kinds of applications, it is necessary to evaluate the angle of each motor.
- Sometimes gear box functionality can be used to transfer angle information by a defined factor.

The animation shows an example of angular synchronous motion:

- Both motors turn with a given speed, but the angle of the motor shaft is also equal.
- These kinds of applications need additional software to calculate the position and a position control loop!
Further functions

- Gear box
  - Realization of a software gear ratio calculation

- Position correction by command
  - Several functionalities to shift or set the position counter

- Position latch
  - Latch position values by using a touch probe

- Homing
  - User defined homing functionality

Oftentimes, additional functions besides the position control loop are required in positioning applications. The following functions are available with the DCS800:

- Gear box functionality, realized by software gear ratio calculations
- Position correction by command to shift or set the position counter
- Position latch is used for flying referencing using a touch probe
- Homing functionality can be defined by the user
Control structure

- Cascade control of a DC drive system
- DCS800 Firmware structure
  - Current controller as inner loop
  - Speed controller as outer loop
- DCS800 Control Builder (CoDeSys)
  - Position controller

- Basically, the control structure of a DC drive system uses cascade control.
- The DCS800 firmware structure includes the current controller for the inner loop and the speed controller for the outer loop. These parts are calculated mains synchronous.
- Additionally, the DCS800 Control Builder must be used to implement the position controller. This part is excluded in an application program based on CoDeSys, which is calculated within 5 milliseconds.
When working with positioning applications, discussions often deal with accuracy. But answering this question is not easy, because a lot of points have to be considered.

In principle, the accuracy depends on the encoder used, the mechanics and the complete control process.

The encoder:
- Essential for an encoder is the number of pulses. The DCS800 can detect up to 300 kilohertz, which should be calculated by multiplying the maximum speed and the encoder pulses per revolution.
- The connection between the motor shaft and encoder should also be absolutely fixed.

The mechanics:
- All mechanical components should be connected tightly.
- Means loose connections cause inaccuracy and oscillations of the drive system.

The control process:
- Accuracy also depends on the complete control process.
- It is recommended to do a frequency analysis and tests to find the optimal controller settings.

Only if all these arguments are checked, discussions about accuracy make sense.
CoDeSys programming is needed to implement positioning applications. Modifications of the current and speed controller are easy to make in the DCS800 firmware.

The position control loop must be added by CoDeSys programming. This is the position controller as well as the logic combinations. CoDeSys is freely programmable and offers users optimal conditions to do their own modifications.
ABB offers a CoDeSys positioning library, which contains function blocks for positioning applications.

This library contains a position controller, as well as rescaling function blocks between linear motion and revolutions from the motor.

The positioning library only works in combination with the DCS800 Drive Library!

More information about these function blocks is available in the DCS800 Position Control Manual.
This library primarily deals with function block “Positioning”. It can be used to realize linear applications. This function block is an interpolator and a position controller in one package.

- It calculates the traverse distance by using the maximum speed of the system and maximum acceleration and deceleration.

- The position controller itself has a feed forward preselection and the underlying process control.
Function block *Positioning* (2)

- **Input values**
  - Target position
  - Position speed
  - Position acceleration and deceleration
  - Controller parameters

- **Output values**
  - Speed reference
  - Target distance
  - Following error

- This block works with relative values to reduce processor load

Function block “Positioning” input and output values are explained on this slide:

**Input values for this function block are:**
- Target position,
- Position speed,
- Position acceleration and deceleration as well as
- Controller parameters

**Output values are:**
- Speed reference
- Target distance
- Following error

This function block only works with relative values to reduce the processor load.
Function block *PosSynchron*

- Synchronous rollover applications
- Position controller
  - Feed forward
  - Process control
- Input values
  - Start command
  - Controller parameters

Oftentimes, the complete functionality of function block “Positioning” is not needed.

- Therefore, the function block “PosSynchron” only offers a small amount of functions to realize synchronous rollover applications.
- The function block “PosSynchron” includes a feed forward preselection and the underlying process control.
- Input values are the start command and the gain for the controller.
Further function blocks

- Recalculations are necessary inside CoDeSys

- Function block *PosScaleIn*
  - Feed constant
  - Calculate from linear to revolutions

- Function block *PosScaleOut*
  - Feed constant
  - Calculate from revolutions to linear

Additional important function blocks of the positioning library are described on this slide:

- Often recalculations between values are necessary to calculate from linear to revolution values and vice versa.

- The function block “PosScaleIn” is used to rescale from linear motion to revolution units by using the feed constant.

- The opposite function block “PosScaleOut” scales from revolution units to linear motion.
ABB DC Drives offer a second CoDeSys library, which contains function blocks for positioning applications. This library is called DCS800 Lib.

The subfolder “Positioning blocks” contains function blocks for several positioning functionalities, which are implemented in the DCS800 firmware.

Note: This library is implemented in the DCS800 firmware. Therefore, firmware version 3.5 or higher must be used. Please check always the software compatibility table!
Positioning blocks

- **Function block Position**
  - Actual position counter value of encoder 1
  - Actual position counter value of encoder 2
  - Difference between encoder 1 and 2
  - Speed of encoder 2
  - External position reference

- **Function block PosGearSet**
  - Gear ratio between motor shaft to load
  - Gear ratio between encoder 1 to motor shaft
  - Gear ratio between encoder 2 and encoder 1
    (angle synchronous applications)

The positioning blocks, which are included in the DCS800 library, are described on this slide:

- One of the most important function blocks is called “Position”. This block delivers the actual position counter of encoder 1 and 2. The difference between encoder 1 and 2 will also be calculated. Its special functionalities are the calculation of the encoder 2 speed and the external connection of a position reference value.

- To realize a software gear ratio, the function block “PosGearSet” can be used. The user can use this block to calculate the gear ratio between:
  - Motor shaft and load,
  - Encoder 1 and motor shaft as well as
  - Encoder 2 and encoder 1, used for angle synchronous applications.
Position correction

- Function block *PosCorrect*
  - Selection between encoder 1 and encoder 2
  - Set command
  - Shift command

- Function block *PosLatch*
  - Selection between encoder 1 and encoder 2
  - Latch mode
  - Used for flying referencing

Further function blocks are needed for position correction. This is described on this slide:

- Often there is a need to correct the position counter in the drive. This is possible by using the function block “PosCorrect”:
  - First, encoder 1 or 2 must be selected.
  - Then the position counter value can be set or shifted by command.

- Another way to influence the position counter is called latching. This is possible with the function block “PosLatch”:
  - First, select between encoder 1 and encoder 2,
  - Then choose one of the latch modes.
  - This can be used for flying referencing, for example with a touch probe.
Example: Synchronous motion

- Two motors should run in angular synchronism
  - Motor 2 works speed controlled (Master Drive)
  - Motor 1 works position controlled (Follower)
- Encoder of motor 2 must be connected to both drives
- Position control loop has to be added

This slide shows an example of a synchronous motion application.

- Two motors should run in angular synchronism.
  - Motor 2 works speed controlled, which gets the speed reference from an external source.
  - Motor 1 works position controlled and follows the position of motor 2.
- Therefore, the encoder of motor 2 must be connected to both drives.
- For the realization of this application, a CoDeSys program must be added, which includes the position control loop for motor 1.

An overview about the complete system is shown in the picture. There you can see that there is no need to connect a position control loop to motor 2.
Example: Linear motion

- Component should be moved from position 1 to the new position 2
- This application works with absolute position values
- The application program gets a reference position and drives to this position automatically

Another example of linear motion is described on this slide.

- A component should be moved from position 1 to the new position 2.
- In contrast to the last example, this one works with absolute position values.
- The application program gets a reference position and drives to this position automatically.

Note that in such applications a start and end point is defined, which must be considered to avoid any mechanical disturbances!
Commissioning hints (1)

- Basic drive system
- Auto tuning of controllers
  - Field current controller
  - Armature current controller
  - Start-up assistant (Wizard)
- Parameterization afterwards
  - Fault functions
  - Main contactor
  - Standstill-time
  - Brake logic
  - Emergency stop

The following slides explain the commissioning process for position control applications.

The commissioning process can be split into two parts: the basic drive system and the position control application.

- First, the basic drive system with the standard DCS800 firmware has to be configured.
  - It is recommended to tune the controllers for the field current and armature current.
  - This can be done via the start-up assistant, the panel wizard or manually.

- Afterwards, other parameterizations can be done:
  - The required fault functions should be enabled and set depending on the requirements.
  - It is recommended to control the main contactor via the DCS800 firmware.
  - For DC motors, it is important to observe the standstill-time. That means the motor gets current but the rotor is not turning for an extended period of time. This can damage the machine! This means that the mechanical brake must be closed if the motor is at the correct position and the armature current has to be switched-off.
  - Important for all drive applications is the emergency stop function. This functionality must be available at all times and configured corresponding to legal standards.
Commissioning hints (2)

- Position control system
- Check position control loop
  - Enable application program
  - Adaption of settings for
    - Speed controller
    - Position controller
- Linear motion check
  - Configure position interpolator
  - Set position value and give start command
  - Check the control behavior of the process

The next commissioning step is the position control loop. If the field current controller, armature current controller and the speed controller are working properly, then the position control system can be configured.

- The functionality of the position control loop has to be configured first.
  - This means the application program has to be enabled and an adaptation of the speed controller and position controller can be done.
- Then the linear motion should be checked.
  - Configure the position interpolator with maximum speed, acceleration and target position.
  - Set the position value and give the start command. Then the motor will drive to the new position.
  - Check the control behaviour of the process and adapt the controller parameters.
Summary

Key points of this module:

- What position control means
- Positioning opportunities with the DCS800
- Function blocks for positioning applications
- Typical applications

The key points of this module are:

- What position control means
- Positioning options with the DCS800
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- Typical applications
Possible encoder connections

- Differential (e.g. A+ / A-)
- Single ended
  - Open collector
  - Push pull

- Voltage levels
  - 24 V
  - 12 V (only with POW-4)
  - 5 V
Second encoder input

- DCS800 offers one encoder input as standard
- If a second encoder input is needed RTAC-Option module can be added
- Voltage levels
  - 24 V
  - 15 V
  - 5 V
Additional information

Technical Manuals:

- DCS800 Firmware (3ADW000193)
- DCS800 Position Control (3ADW000348)
- DCS800 Application Program (3ADW000199)