

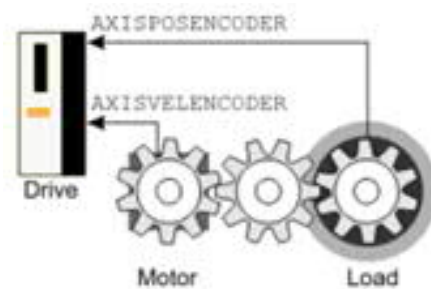
Application note

Dual encoder feedback control on motion drives

AN00262

Rev A (EN)

Using standard functionality and hardware built into the motion drives we can accurately position loads using dual encoder feedback. We are able to use the motor encoder for commutation and velocity control and an additional encoder mounted on the load for position control. This allows us to easily overcome problems caused by compliance in the mechanics to accurately position the load



Introduction

This application note explains how to configure ABB motion drives to allow them to operate in dual encoder mode.

Dual encoder feedback is a technique where two encoders are used to control a single axis. One of the encoders is attached to the load and the other to the motor. To provide good positional accuracy, the encoder attached to the load is used to measure the position (i.e. 'close the position loop' in the drive's control system). The encoder attached to the motor is used only to measure the motor's operation (i.e. 'close the current and velocity loops' in the drive's control system). This combination provides high positional accuracy, and eliminates stability problems associated with mechanical compliance, backlash and to some extent slip.

Pre-requisites

The MotiFlex e180 or MicroFlex e190 drive being used should have firmware version 5868.7.0 (or later) running on it.

<http://abbmotion.com/support/SupportMe/default.asp>

You should be running Mint Workbench build 5854 or later to configure the motion drive

http://www.abbmotion.com/support/SupportMe/productsupport.asp?ID=WB_55

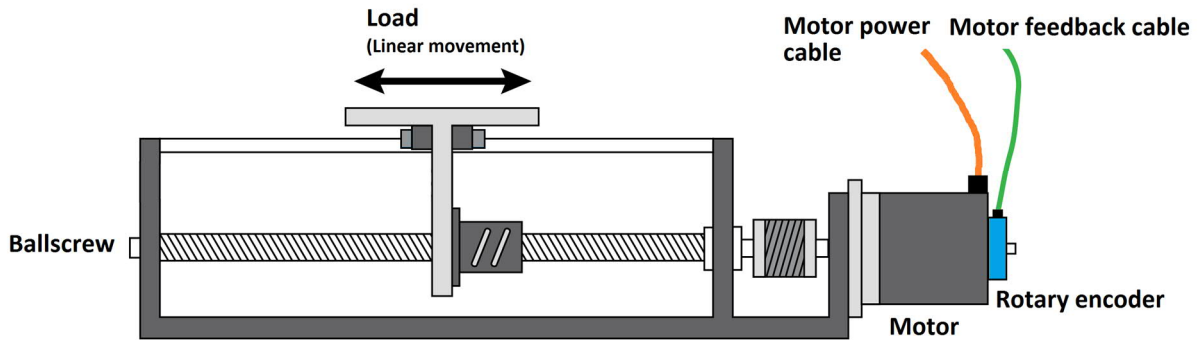
It is assumed that the reader is capable of setting up and commissioning a motion drive using a single encoder. The purpose of this application note is to explain the principle of dual encoder operation and show how simply it can be set up.

If the reader needs information on how to set up and commission a motion drive they should refer to AN00250 - Tuning drives for servo motors using Mint Workbench.

System explanation

For this application note we are going to use a linear positioning system driven by a ballscrew as an example.

Here is a diagram of a standard system set up using a single encoder.



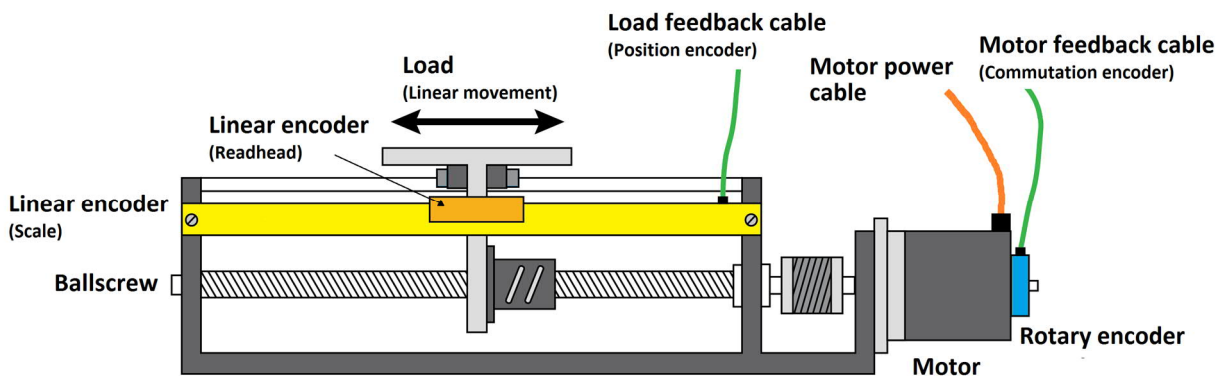
In the diagram you can see there is a rotary servo motor, fitted with a built in rotary encoder. This encoder is used for commutation of the motor as well as torque, velocity and position control.

The motor is connected to a ballscrew that drives a load back or forth depending on motor direction.

Using this setup we know the motor position accurately thanks to the motor encoder, this feedback device could take on a number of different feedback technologies including; Incremental encoder + Halls, Resolver, BiSS, SSi, SmartAbs, EnDat or Hiperface.

However we may not know the load position as accurately if we consider the following; Motor coupling flex or slip, thrust bearing deflection, ballscrew pitch variation, backlash/compliance, drive train wear and thermal expansion. We can consider the load position to be an estimated value calculated from the known motor position.

To improve our load position accuracy we can setup a system using dual encoders.



In this diagram we can see an additional linear encoder has been added. This linear encoder provides accurate position information about the load. This load encoder will not suffer from the previous issues listed as it is directly coupled to the load.

Example system details:

- Motion drive is a MotiFlex e180, MFE180-04AN-016A-4 with FB-02 Serial + Sin/Cos feedback module
- Motor is a BSM80N-375AF this has a 10,000 counts/rev (2500ppr) incremental encoder with halls
- Load encoder is a linear SSi encoder, 5µm resolution
- Ball screw pitch is 5mm
- Incremental encoder connected to Encoder in 2 (X11)
- Linear SSi encoder connected to Encoder in 0 (X13)

Please refer to the ABB product manuals for connection details of your products.

NOTE - In this example the MotiFlex e180 will need to perform a phase search so it can commutate the motor. This is because we will not be able to connect the hall signals. This is explained further in the next section. However, we have an absolute encoder on the load so we will not need to home the axis.

Compatible feedback configurations

The motion drives have a number of different encoder inputs that support different feedback types. The table below shows the possible configurations that can be used for dual encoder operation.

NOTE - Either the commutating or load encoder will need to be an incremental encoder, this is Feedback device 2 in the table below. Look for your other feedback device in the first column to see what feedback option should be fitted to your motion drive.

You may find your motor encoder does not connect to the main encoder input as it typically would. This is not a problem, the motion drives are capable of commutating from any of the encoder inputs. This allows the load encoder to be something other than an incremental encoder to give a high accuracy, absolute position on the load.

Feedback device 1			Feedback device 2 ¹	
Encoder in 0	MotiFlex e180 feedback option	MicroFlex e190 feedback option	Encoder in 1 (24V) / Encoder in 2 ²	Encoder splitter OPT-MF-200 ³
Incremental encoder + halls	FB-01 Encoder + Halls	Standard	Incremental encoder only ⁴	Not compatible
EnDat v2.1, Hiperface, SinCos ⁴	FB-02 Serial + Sin/Cos	Standard		
Hiperface DSL	FB-04 DSL	Not supported		
Incremental encoder only ⁴	FB-01 Encoder + Halls	Standard		Incremental encoder only ⁴
BiSS, SSi, SmartAbs, EnDat v2.2	FB-02 Serial + Sin/Cos	Standard		
Resolver	FB-03 Resolver	Resolver adapter OPT-MF-201		

¹ Either an Encoder splitter or Encoder in 2 can be used but not both simultaneously.

² Encoder in 1 formed from digital inputs is a 24V dc incremental encoder input. All other incremental encoder inputs are 5V line driver (RS422).

³ Splitter compatible with MicroFlex e190 only.

⁴ Incremental encoder only or SinCos feedback will require a phase search if used for motor commutation (velocity encoder).

NOTE - If using either 'incremental encoder only' (no halls) or SinCos for the commutation/motor encoder a phase search will be required the first time the drive enables the motor after powering up. Consideration of this needs to be taken when selecting the feedback types used for dual encoder systems.

The phase search algorithm applies current to the stator windings to generate a magnetic field in a known orientation. The magnets in the rotor are then allowed to align freely with this field. After allowing a suitable period for motion to settle, the rotor is assumed to be in the same orientation as the field. This information is used to set up commutation. In practice, the phase search algorithm available on motion drive products implements measures to improve the accuracy of alignment, and to detect if an end stop or limit switch has been hit during the alignment process.

Example system 1: ESM motor with SmartAbs feedback, rotary incremental encoder attached to load.

SmartAbs connects to Encoder channel 0 for commutation and velocity control.

Incremental encoder connects to Encoder channel 2 for position control.

No phase search is required as SmartAbs provides absolute position for commutation.

We do not have absolute position feedback on the load so homing may be required.

Example system 2: BSM motor with incremental encoder and halls feedback, rotary BiSS encoder attached to load.

Incremental encoder only (no halls connected) connects to Encoder channel 2 for commutation and velocity control.

BiSS encoder connects to Encoder channel 0 for position control.

A phase search is required because we have no absolute position on the commutation encoder.

We have absolute position feedback on the load so homing may not be required. Dependent on load travel and absolute position range of load encoder.

Example system 3: HDS motor with incremental encoder and halls feedback, linear incremental encoder attached to load.

Motor incremental encoder and halls connect to Encoder channel 0 for commutation and velocity control.

Linear incremental encoder on load connects to Encoder channel 2 for position control.

No phase search is required as we have hall sensors connected on the commutation encoder.

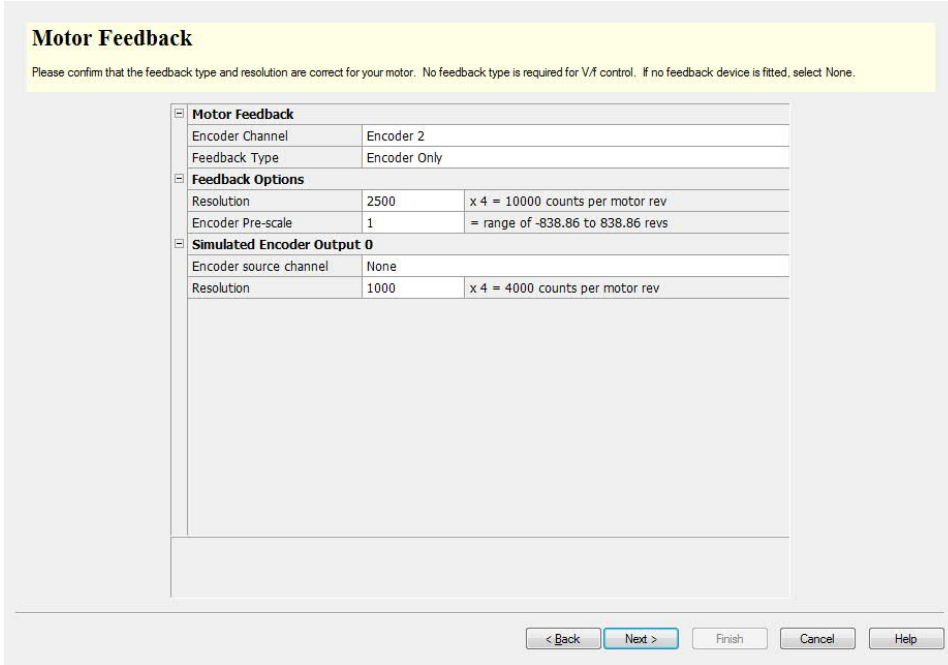
We do not have absolute position feedback on the load so homing may be required.

Commissioning a dual encoder system

To commission a dual encoder system we start by using the Workbench Commissioning wizard to commission the drive with just the motor encoder considered. We will then add in the additional load encoder later on and set up the ratio between motor encoder and load encoder.

Motor feedback

Start working through the commissioning wizard until you get to the Motor Feedback page.



On this page we need to set the Encoder channel to the one used for motor commutation and velocity control (the AXISVELENCODER). For Encoder channels 1 & 2 there is only one Feedback type that can be selected, 'Encoder only'. For channel 0 the options will depend on the drive type and feedback module fitted.

Enter the appropriate resolution of the encoder as normal. Encoder pre-scale is not typically required for this encoder as it will eventually only be our velocity encoder.

For our example we need to enter the data as shown in the image.

Our motor encoder is connected to Encoder in 2 so we select encoder channel 'Encoder 2'.

We have a standard 2500ppr incremental encoder (10,000 counts/rev) so we select this for the resolution.

Although the motor is fitted with an incremental encoder with halls we have no way to connect the halls. The halls can only be connected if using Encoder in 0 which we are using for the linear SSI encoder. This means we have to select 'Encoder only' as the feedback type and a phase search will need to be performed by the drive.

Application max speed

Work through the commissioning wizard for a couple more screens until you get to the Application Limits page. On this page you need to set an application max speed. The application max speed entered writes to the DRIVESPEEDMAX keyword. It is worth noting that this is entered in motor rpm but will be stored in DRIVESPEEDMAX in user units.

Be sure to enter the motor speed in rpm required to achieve the correct max speed required at the load (considering gearing etc).

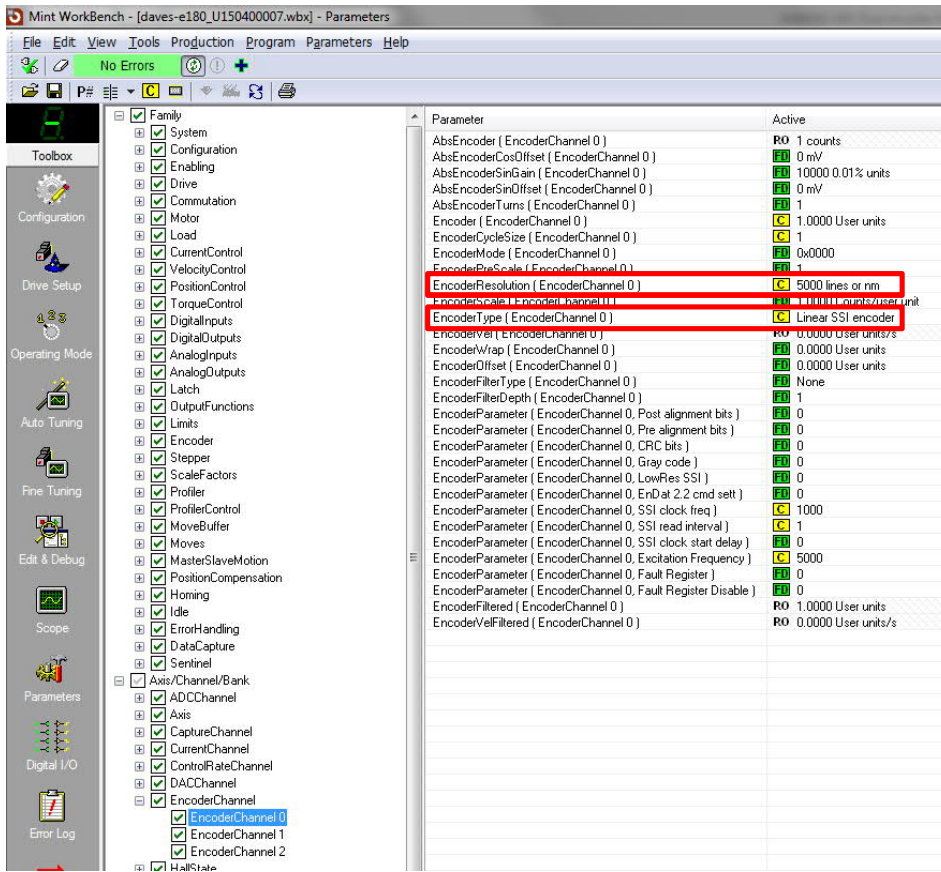
Auto tune

We can now continue through the commissioning wizard as normal until we get to the Auto tune page.

Perform the Auto tuning tests at the end of the commissioning wizard and at this point you should be able to run the motor using only the motor encoder. Remember at this point if you use set a SCALEFACTOR it should be calculated using the motor encoder, this is the only encoder we are using at this point.

Load feedback

The next step is to configure the encoder channel used for the load encoder (position encoder), as shown below. This can easily be done using the parameter viewer, select the Parameters icon on the left hand side of WorkBench. Now using the navigation tree select 'Axis/Channel/Bank > EncoderChannel > EncoderChannel x'. For our example we need to select EncoderChannel 0:



For our example we again enter the data as shown in the image. EncoderType is set to Linear SSI encoder. EncoderResolution is set to 5000 nm (equal to 5µm as stated previously)

Encoder direction

At this point we should check that the two encoders are counting in the same direction. Ideally you can move the load by hand and should see that both of your encoders count in the same direction (positive or negative). If you cannot do it by hand you can do a short test move using the fine tuning screens, noting the encoder positions before you start.

If the encoders do not count in the same direction then modify ENCODERMODE of your load/position encoder so that bit 0 (`_emCOUNT_DIRECTION`) is inverted.

Feedback ratio

The final step is to configure the relationship between the motor/velocity encoder and the load/position encoder.

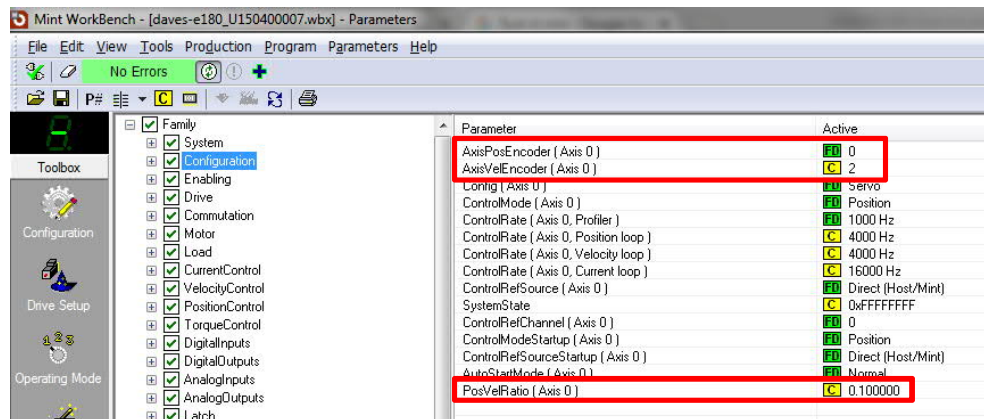
This is done using the Mint keywords `AXISPOSENCODER`, `AXISVELENCODER` and `POSVELRATIO`.

These keywords can either be entered at the command line or the parameter table can be used to enter them.

To enter them in the parameter table use the navigation tree to select 'Family > Configuration'.

You will see that currently both `AXISPOSENCODER` and `AXISVELENCODER` are set to the same value, in our example this is 2 as this is the encoder channel we are using for the motor encoder, the one drive is currently tuned with.

Below are the settings we need to enter for our example:



Firstly we change the AxisPosEncoder to use 0, for Encoder in 0, which the linear SSI load encoder is connected to.

Next we need to set the PosVelRatio, this is the ratio of the position/load encoder to the velocity/motor encoder. This is calculated as the position scalefactor divided by the velocity scalefactor, where the scaled units of both are the same. We don't need to actually set any scalefactor keywords, we are just looking to calculate a ratio. For example either of these would work:

$$\text{PosVelRatio} = \frac{\text{Position counts per revolution}}{\text{Velocity counts per revolution}} = \frac{\text{Position counts per mm}}{\text{Velocity counts per mm}}$$

For our example we have:

$$\text{Position scalefactor} = \frac{1 \text{ count of load encoder}}{5\mu\text{m for each count of load encoder}} = \frac{1 \text{ count}}{0.005\text{mm}} = 200 \text{ counts/mm}$$

$$\text{Velocity scalefactor} = \frac{10000 \text{ counts per motor revolution}}{5\text{mm travel per motor revolution}} = 2000 \text{ counts/mm}$$

$$\text{PosVelRatio} = \frac{\text{Position scalefactor}}{\text{Velocity scalefactor}} = \frac{200}{2000} = 0.1$$

NOTE - The position and velocity scalefactor we use here to calculate our ratio are not the same as our POSSCALEFACTOR and VELSCALEFACTOR keywords used for scaling in the motion drive.

Scaling

Now that the AxisPosEncoder and PosVelRatio have been set we may want to update the scalefactor keywords (SCALEFACTOR or POSSCALEFACTOR, VELSCALEFACTOR, and ACCELSCALEFACTOR). We are now using the linear SSI encoder for positioning so this encoder needs to be considered when calculating all of these scalefactors.

NOTE - The load/position encoder is used for scaling of all commands/keywords whether in position or velocity control.

So for example loading a JOG (position control) or VELREF (velocity control) will both be scaled in terms of the load/position encoder. However position and velocity values can be scaled differently if required using POSSCALEFACTOR and VELSCALEFACTOR. For example you may want position values in millimetres and velocity values in metres/minute. Using our example this would mean setting a POSSCALEFACTOR of 200 (5µm per count encoder) and a VELSCALEFACTOR of 3333.3 (= 200 x 1000 / 60). With these scalefactors set we could perform a JOG or VELREF of 10 and the load would move at 10 m/min. We could also issue a MOVER of 20 with a SPEED of 5 and the load would move 20mm reaching a speed of 5 m/min (assuming it accelerated to SPEED in the travel distance). The same thing can be done for acceleration/deceleration values using the ACCELSCALEFACTOR keyword.

Following error

Because of the change of encoder from motor to load the setting of FOLERRORFATAL will likely need updating. It will have been set previously scaled using the motor encoder, now we are using the load encoder the value will need updating for the new scaling.

Fine tune

If the PosVelRatio has been calculated correctly you should now be able to run your motor through some test moves in the Fine tuning screen. Only small changes should be required as the PosVelRatio will ensure your previous tuning gains when using the motor encoder only are correctly scaled internally for the new load encoder.

Perform some test moves and fine-tune as required. Because of the differences in mechanical behaviour the two encoders are subject to, minor changes may be needed to the gains (not the current loop gains). Refer to AN00250 - Tuning drives for servo motors using Mint Workbench for details on fine tuning.

NOTE - Don't forget to save your parameters to the drive when you are finished. You can use Tools > Store Drive Parameters to save any changes in configuration.

Contact Us

For more information please contact your local ABB representative or one of the following:

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