Absolute Encoder support with the SM-EZMotion Module

Objective

Demonstrate how to use the absolute encoder setup and to show why the two methods of calibrating the range of the encoder travel are needed.

Solution Summary

Absolute encoders come in a variety of protocols (Endat, SSI, Hiperface). Control Techniques most common absolute encoder is the Sin Cos Hiperface with Stegmann comms. The encoders also come in another variation: Single Turn or Multi-turn. Multi-turn absolute encoders have the ability to maintain absolute position information over their entire multi-turn range (commonly 4096 revolutions, but others are available), even when power is removed from the drive/encoder.

With PowerTools Pro 4.1 (or higher) and SM-EZMotion firmware release A9 (or higher), the user has the option to turn on the Absolute Position calculation function. This allows the drive to read the encoder position at power up and calculate the actual machine's position based on the encoder position and the encoder/machine offset value. The encoder/machine offset value is determined when a homing routing is performed. The homing routine (in theory) only needs to be performed once for the life of the machine, provided the motor/machine mechanical relationship is not changed and the PowerTools file is not downloaded after the home routine is complete.

Some users of absolute encoders will not need to travel the full length of their multi-turn encoder (e.g. a short ball screw driven axis using less than 4096 motor turns). If the full travel is needed, then the SM EZ Motion will need to know how the encoder travels and where it rolls over points are in relation to the machine.

Other uses may need the encoder to continually roll over its multi-turn value and must take this into account for proper machine operation (e.g. a rotary indexing table that only travels in one direction).

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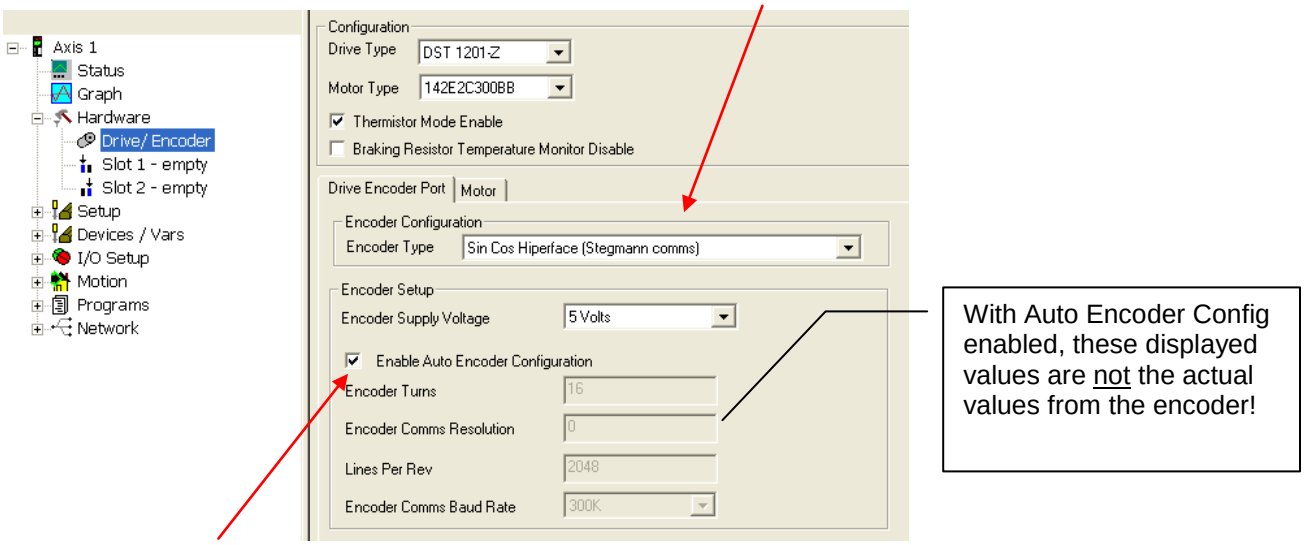
Configure the Absolute Encoder View

Using PowerTools Pro, expand the Hardware branch on the hierarchy tree, and select the Drive/Encoder view. This view is used to select and configure the drive and motor feedback device to be used in the application. Select the type of absolute encoder the motor has from the drop down list of available encoder types. Control Techniques motor's most commonly use the Sin Cos Hiperface (Stegmann comms) option.

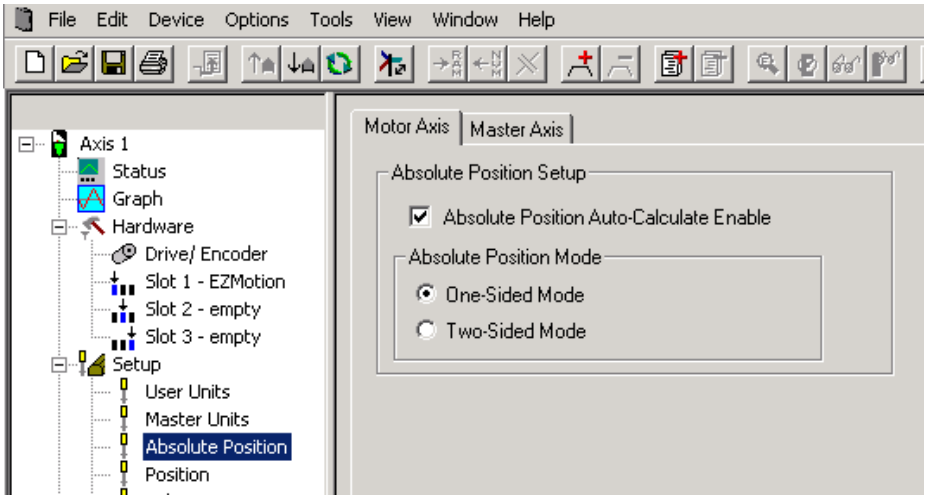


With Auto Encoder Config enabled, these displayed values are <u>not</u> the actual values from the encoder!

Enable Auto Encoder Configuration - The encoder has the ability to communicate with the drive and automatically set these items that follow. When this box is checked, the user does not need to set them. The values received from the encoder will not automatically populate these entry boxes!

Turn on the Absolute Position Auto-Calculate function

Expand the Absolute Position view. Check the Absolute Position Auto-Calculate Enable check box. Note that unless an absolute encoder has been selected in the Drive/Encoder view, this tab will be grayed out. Note that there are identical tabs for both motor axis and master axis setting. Setup is similar between the two tabs.



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Absolute Position Auto-Calculate Enable

If this check box is unchecked, the SM-EZMotion module will only read the position from the absolute feedback device on power-up and then set the machine position equal to that value – this will be the encoder's position and not the machine's position! The SM-EZMotion module will NOT take into account any previously defined home position. Prior to A9 firmware (previous to the release of this feature), this is how the firmware functioned; the user would have to create a user program to offset the machine position from the encoder position. If you have already achieved the desired absolute position calculations by creating a user program, and you wish to continue using that method (instead of this new method), leave the checkbox unchecked.

When the check box is checked, the SM-EZMotion module will calculate the correct machine position at power up in user units based on a previously defined home position and the position feedback from the absolute feedback device-provided a homing routine has been performed or the DefineHome function was executed.

Absolute Position Mode

The Absolute Position Mode radio buttons are then used to determine the method used for calculating the position feedback on power-up or after a warm-start. Select either the One-Sided Home or the Two-Sided Home.

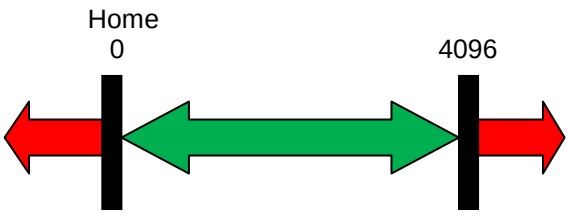
One-Sided Mode

One-Sided Mode implies that once the absolute home position has been defined, the user wishes to utilize the full multi-turn resolution of the encoder in <u>one</u> direction from the home point. Using the example of a 12-bit multi-turn absolute encoder, the motor could then travel 4096 revolutions in the positive direction without experiencing any problems due to absolute rollover.

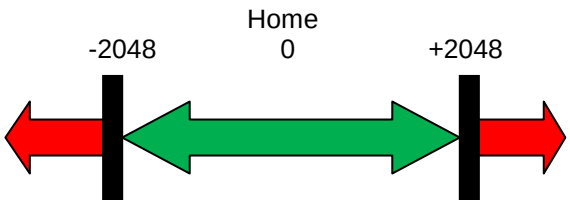
Two-Sided Mode

Two-Sided Mode implies that once the absolute home position has been defined, the user wishes to utilize up to half of the multi-turn resolution of the encoder in <u>both</u> directions from the home point. Using the example of a 12-bit multi-turn absolute encoder, the motor could then travel 2048 revs in the positive and 2048 revs in the negative direction without experiencing any problems due to absolute rollover.

Mode Diagrams



One Sided Home example:
Encoder Position Travel Range 0-4096



Two Sided Home example:
Encoder Position Travel Range -2048 - +2048 revs

IMPORTANT NOTE: In either mode, if the motor moves beyond the range defined (from the home position), the absolute encoder would "rollover" and the SM-EZMotion module cannot detect this condition upon power up. For example in a one-sided mode: if the motor was at the 0 position and went to the -1 position, upon power up the encoder would report a position of 4095 (4096-1). The absolute machine position would be incorrectly calculated as 4095.

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Determining if your system needs One or Two Sided Absolute Position Mode

If your system travels less than the encoder rollover value, then the choice depends upon where the home position is in relation to the machine's travel.

If the home position is near the one end of the mechanical travel, use the One Sided mode and make sure the rollover point (either 0 or 4096) cannot be crossed. Moving the rollover point outside of the mechanical travel can be done by decoupling the motor from the machine, indexing the motor to a point well within the rollover range and then coupling the motor back to the machine when the machine is near its home location and then perform a home routine. This will force the rollover points outside of the machine's mechanical travel.

If your home position is in the center of the mechanical travel, use the Two Sided home position. With the encoder near its zero point, couple the motor to the machine near its home position and home the machine. This will force the rollover points outside of the machine travel

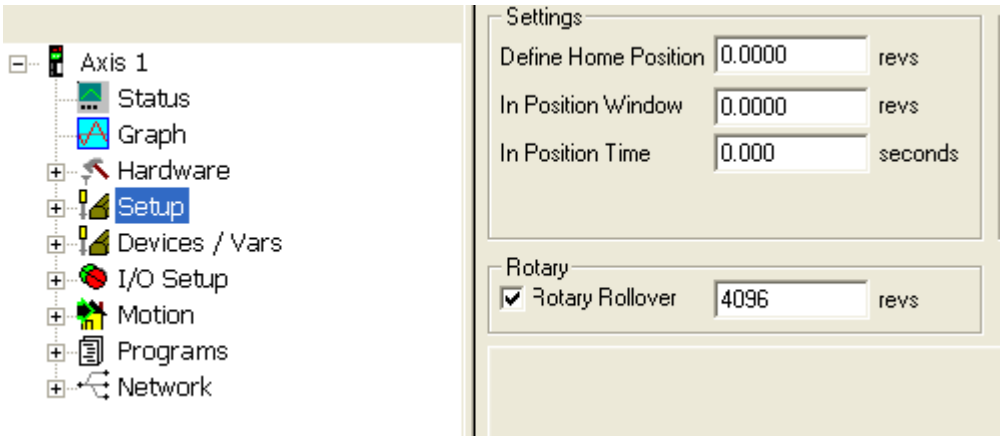
Systems that need to move past their encoder rollover values

When Rotary Rollover is enabled and Absolute Position Auto-Calculate enabled, the firmware will store the number of encoder rollovers through a power cycle. Upon power up, the rollover count is used in the calculation to determine the actual machine position. Set the Rollover value at the desired value.

Warning: Systems that move past a rollover when power is off will cause the calculation to incorrectly report the machine position!

This technique can also be used on linear axes that have mechanical travel greater than the encoder rollover travel, check the Rotary Rollover checkbox and put the Rollover Position at a value higher than the mechanical travel allows, this will force the firmware to save the rollover count and yet not rollover the position value, since the Rotary Rollover position is never reached.

Checking Rotary Rollover will force the Absolute Position mode to One Sided.



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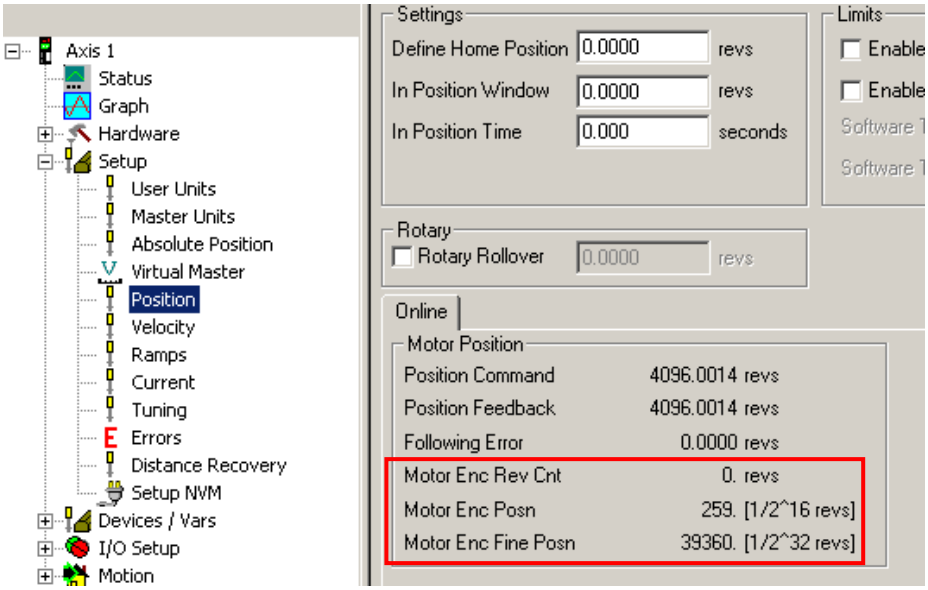
Determining the Encoder's Zero Position

To determine where the encoder's absolute position is, use the PowerTools Pro Position view:

When the Rev Count is at zero and the Posn value is close to 0, the encoder is near its zero position.



Within the red box shows the actual position information from the encoder.

The encoder (whether absolute or incremental) is displayed with 3 values:

1. Rev Count = equal to the number of single turns from the encoder's zero position
2. Posn = the encoder position within a single encoder revolution, displayed in units such that 1 rev = 65636
3. Fine Position = encoder position within a single count of the Posn value. 1 Posn = 65636 Fine Position

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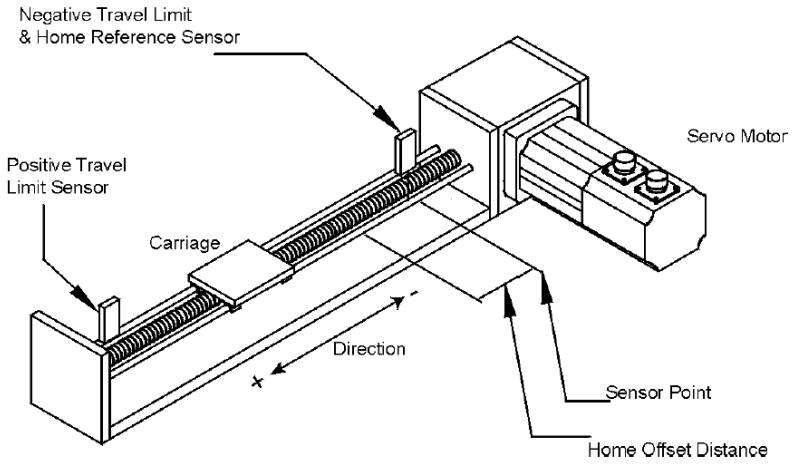
Appendix

In order to show why the software is designed for a one-sided or two-sided home, we will need to show some example calculations that shed some light on this Motion Made Easy approach. The rest of the document deals with explaining the operation of the two modes.

The following abbreviations will be used:

- PM - Position feedback of the Machine
- PA - Position feedback of the Absolute Encoder
- PMH - Position Feedback of Machine when at Home
- PAH - Position Feedback of Absolute Encoder when at Home
- Ehalf - Half the resolution of the encoder

One-Sided Example: The user homes the motor to a sensor. When the sensor activates, the motor is at the machine home position PM = 0 revs (assume the Home Offset Distance=0). When the motor is at the home position of 0 revs, the absolute encoder reads PA = 700 revs. Therefore, the SM-EZMotion module now uses this relationship of PMH and PAH to calculate the machine position (PM) on power up.



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Position display at Home:

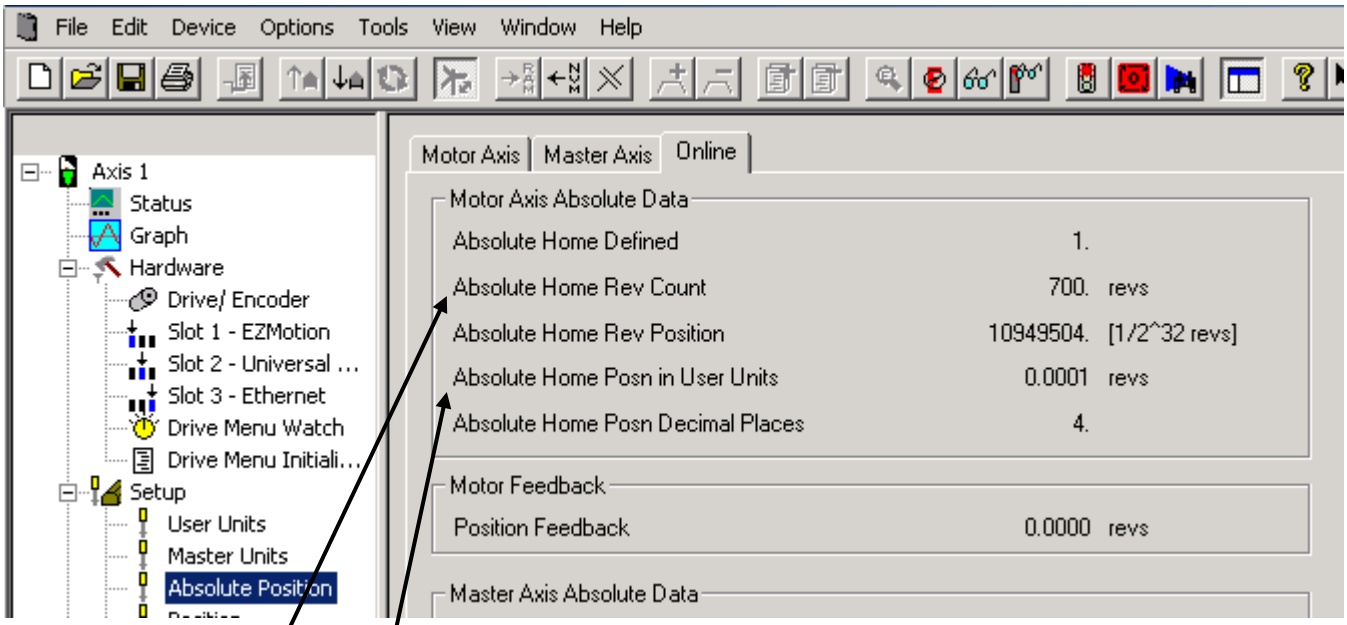

Figure 4

Position Feedback of Machine when at Home = PMH = 0

Position Feedback of Absolute Encoder when at Home = PAH = 700

If the motor then moves 100 revs in the positive direction, PM will be PMH + 100 or PM = 100,and PA is PAH + 100 or PA = 800. If the machine is powered-down and then back up, the SM-EZMotion module would read the position from the absolute encoder PA, subtract the position of the absolute encoder at the home position PAH, and then add the position feedback of the machine at the home position PMH, to get PM.

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Calculation #1: Used when PA > PAH

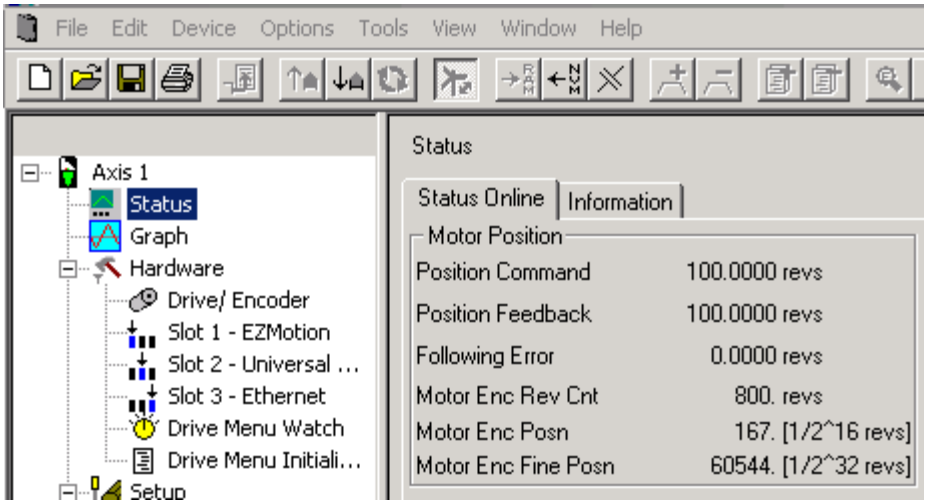

Figure 5

PM = PA – PAH + PMH = 800 – 700 + 0 = 100 revs

If the motor then moves an additional 3500 revs in the positive direction, PM will be PMH + 3600 or PM = 3600. PA would be PAH + 3600 or PA = 4300. However, we know that since this is a 12-bit multi-turn absolute encoder, the absolute encoder rev counter will reach 4096 and rollover to 0. Therefore, we will never get a value of 4300 on the absolute encoder. In this case, the absolute encoder would read PA = 4300 – rollover position = 4300 – 4096 = 204 revs. Since the user has defined the application type to use One-Sided Mode, the SM-EZMotion module can interpret this position from the absolute encoder to properly calculate the correct machine position. If the machine was powered-down, and then back up, the PM would be calculated as follows:

Calculation #2: Used when PA < PAH

PM = (Maximum Encoder Multi-Turn Resolution – PAH) + PA + PMH = (4096 – 700) + 204 + 0 = 3600 revs

3600 revs is exactly the result that we wanted! Notice that even though PA rolled over when it reached 4096, we can still calculate the correct position since the user has defined that the application is running in One-Sided Mode.

If the motor moves an additional 1400 revs in the positive direction, PM will be PMH + 5000 or PM = 5000. PA would be PAH + 5000 or PA = 5700. Again, since the 12-bit encoder cannot exceed 4096, we need to recalculate PA as PA = 5700 – 4096 = 1604. Notice that when PA = 1604, we should use Calculation #1 above since 1604 > 1604. Therefore, our PM is as follows:

PM = PA – PAH + PMH = 1604 – 700 + 0 = 904 revs

Note: that this value is NOT correct. This is because after 5000 revs, we have exceeded the absolute resolution of the encoder in a single direction.

So you can see that when using One-Sided Mode, as long as the motor does not move more than 4096 revolutions in the positive direction from the home position, the SM-EZMotion module can correctly calculate the absolute machine position on power up.

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Two-Sided Mode

Two-Sided Mode implies that once the absolute home position has been defined, the user wishes to distribute the full multi-turn resolution of the encoder evenly in BOTH DIRECTIONS from the home point. Using the example of a 12-bit multi-turn absolute encoder, the motor could then travel 2048 revs in either the positive or negative direction without experiencing any problems due to absolute rollover. IMPORTANT NOTE: In Two-Sided mode, if the motor moves in excess of 2048 revs in either direction from the home position, the SM-EZMotion module cannot detect this condition, and therefore the absolute position would be incorrectly calculated on the next power up.

Example: The user homes the motor to a sensor. When the sensor activates, the motor is at the machine home position PM = 0 revs. When the motor is at the home position of 0 revs, the absolute encoder reads PA = 700 revs (where PA is the Position feedback of the Absolute Encoder). Therefore, the SM-EZMotion module now uses this relationship of PM and PA at the home position to calculate the machine position (PM) on power up.

Position Feedback of Machine when at Home = PMH = 0

Position Feedback of Absolute Encoder when at Home = PAH = 700

We then need to calculate the value equal to half the resolution of the encoder (Ehalf), and the position that distributes the encoder resolution in half. This is the position feedback of the absolute encoder at the rollover point (or PAR).

Ehalf = Max Resolution / 2 = 4096 / 2 = 2048

PAR = PAH + Ehalf = 700 + 2048 = 2748

PAR must be within the max resolution of the encoder, so if PAR calculated above is > Max Encoder Resolution we need to subtract the max resolution:

PAR = PAR – Max Resolution

If the motor then moves 100 revs in the positive direction, PM will be PMH + 100 or PM = 100,and PA is PAH + 100 or PA = 800. If the machine is powered-down and then back up, the SM-EZMotion module would read the position from the absolute encoder PA, subtract the position of the absolute encoder at the home position PAH, and then add the position feedback of the machine at the home position PMH, to get PM.

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Calculation #1: Used when PAR > Ehalf AND PA < PAR

PM = PA – PAH + PMH = 800 – 700 + 0 = 100 revs

If the motor is again at the home position and then moves 100 revs in the negative direction, PM will be PMH – 100 or PM = -100. If we power down, and then back up, PA would be PAH - 100 or PA = 600. Once again, the conditions for Calculation #1 are met, so we will use it again to find PM.

PM = PA – PAH + PMH = 600 – 700 + 0 = -100 revs

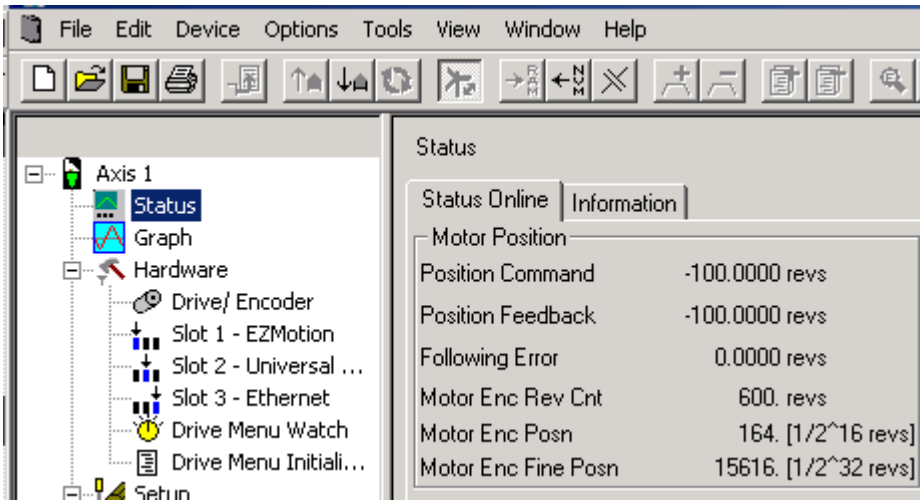

Figure 6

If we now start from the home position again, and move the motor 2000 revs in the negative direction, PM will be PMH – 2000 or PM = -2000. If we power down and then back up, PA should be PAH – 2000, or PA = -1300. However, we know that since this is a 12-bit multi-turn absolute encoder, when traveling in the negative direction, the absolute encoder rev counter will reach 0 and rollover to 4096. Therefore, we will never get a value of -1400 on the absolute encoder. In this case, the absolute encoder would read PA = (PAH – 2000) + Max Encoder Resolution = 2796. Since the user has defined the application type to utilize Two-Sided Mode, the SM-EZMotion module can interpret this position from the absolute encoder to calculate the correct machine position. If the machine was powered-down, and then back up, the PM would be calculated as follows:

Calculation #2: Used when PAR > Ehalf AND PA > PAR

PM = PA – PAH – Max Enc Resolution + PMH = 2796 – 700 – 4096 + 0 = -2000 revs

-2000 revs is exactly the result that we wanted! Notice that even though PA rolled over when it reached 0, we can still calculate the correct position since we know that the application is running in Two-Sided Mode.

If the motor moves an additional 200 revs in the negative direction, PM will be PMH - 2200 (because we already moved -2000 before) or PM = -2200. PA would be PAH – 2200 + Max Encoder Resolution or PA = 2596. Notice that with PA = 2596 we no longer match the conditions of Calculation #2, but now instead match those of Calculation #1. Therefore, PM is calculated as follows

PM = PA – PAH + PMH = 2596 – 700 + 0 = 1896 revs

Note: that this value is NOT correct. The desired result of the calculations is -2200. This is because after 2048 revs in either given direction from the home position, we have exceeded half of the absolute resolution of the encoder in that direction.

We could test the same scenario in the positive direction. If the motor starts from the original home position and moves 2200 revs in the positive direction. PM at that point would be PMH + 2200 or PM = 2200. If we power the system down and then back up, we find PA = PAH + 2200 = 2900. In this case, we match the conditions for Calculation #2 and therefore use it to calculate PM.

PM = PA – PAH – Max Enc Resolution + PMH = 2900 – 700 – 4096 + 0 = -1896 revs

Again, -1896 is NOT the correct position since we expected to get 2200 revs instead.

So you can see that when using Two-Sided Mode, as long as the motor does not move more than 2048 revolutions in either direction from the home position, the SM-EZMotion module can correctly calculate the absolute machine position on power up.

It should be noted that there is a different set of calculations used to find PM when PAR is < Ehalf. These calculations are as follows:

Calculation #3: Used when PAR < Ehalf AND PA < PAR

PM = Max Enc Resolution – PAH + PA + PMH

and

Calculation #4: Used when PAR < Ehalf AND PA > PAR

PM = PA – PAH + PMH