

*Application note*  
*April 1st, 2010*

# ServoPac-A TTA-PRO Positioner

## Hiperface/Endat absolute encoder feedback

### 1) INTRODUCTION

This application note is dedicated to the commissioning of ServoPac-A range drives running a motor equipped with an Hiperface or Endat Absolute Encoder. Only the specific information concerning the Hiperface or Endat encoder setting are described in this document. The complete information for the TTA-PRO amplifier commissioning and parameterization can be found in the pertaining manuals. A TTA-PRO application with Hiperface or Endat absolute encoder requires the amplifier firmware version 529.C8 or higher.

The parameterization for an application with Hiperface or Endat absolute encoder requires the VDSsetup software tool version 3.67 or a higher release.

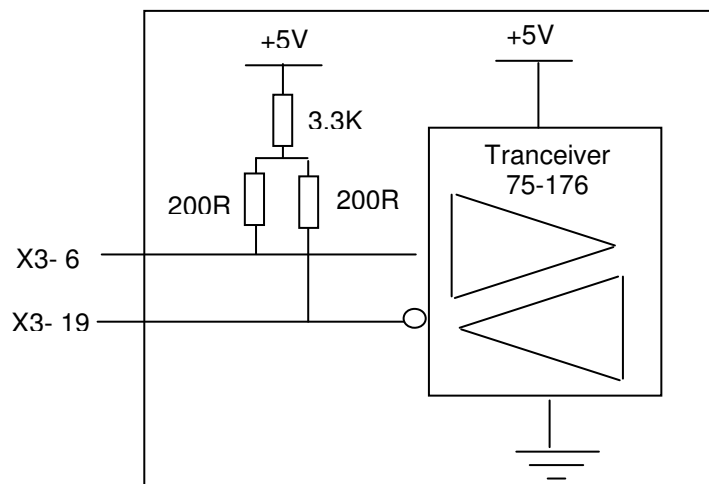
### 2) X3 CONNECTOR FOR HIPERFACE ABSOLUTE ENCODER (Sub D 25 pins female)

The "Hiperface Absolute Encoder" configuration (Stegmann or compliant) is software selectable and stored in the amplifier EEPROM.

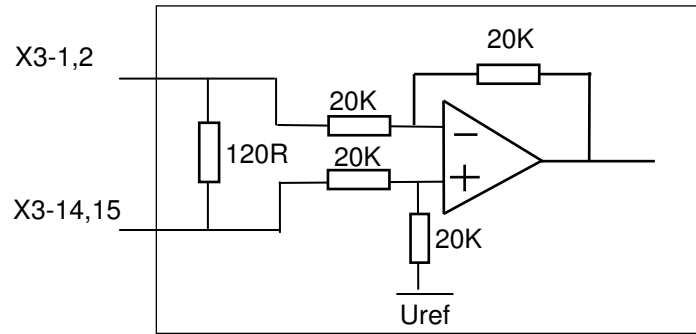
The corresponding X3 connector pin functions are described below.

| PIN    | FUNCTION | REMARKS  |
|--------|----------|--|
| 19     | Data-    | Differential input of the Hiperface encoder channel Data-                    |
| 6      | Data+    | Differential input of the Hiperface encoder channel Data+                    |
| 14     | Sin-     | Differential input of the Hiperface encoder channel Sin-                     |
| 1      | Sin+     | Differential input of the Hiperface encoder channel Sin+                     |
| 15     | Cos-     | Differential input of the Hiperface encoder channel Cos-                     |
| 2      | Cos+     | Differential input of the Hiperface encoder channel Cos+                     |
| 10     | +12V     | Encoder supply voltage: output impedance = 9 $\Omega$ , max 150 mA available |
| 23     | GND      | Encoder supply GND   |
| 9      | TC+      | Motor thermal sensor input   |
| 22     | TC-      | Motor thermal sensor input   |
| others | reserved |  |

#### 2-1. DATA ENCODER CHANNEL SPECIFICATION



2-2. SIN/COS ENCODER CHANNELS SPECIFICATION



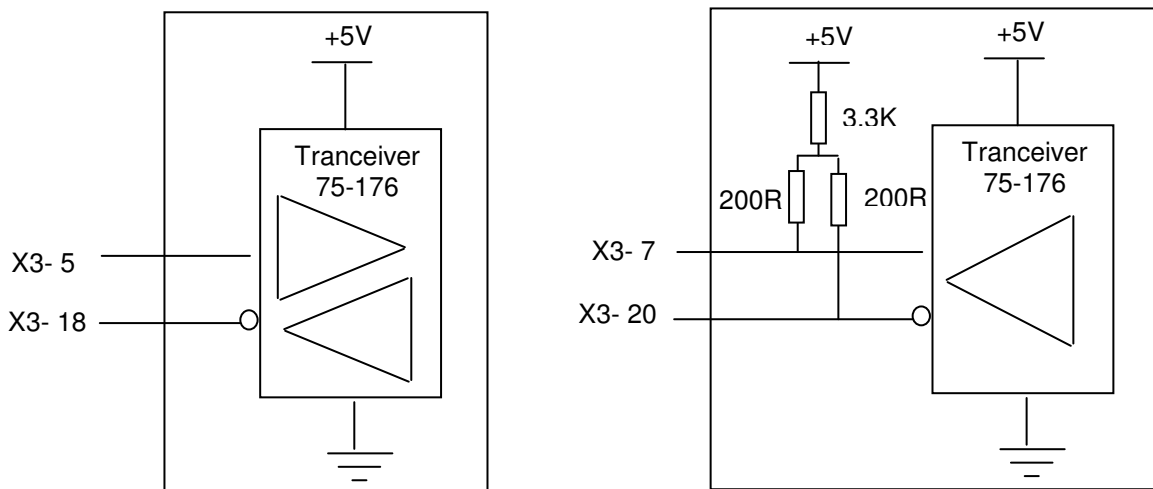
3) X3 CONNECTOR FOR ENDAT ABSOLUTE ENCODER (Sub D 25 pins female)

The “ Endat Absolute Encoder” configuration (Heidenhain or compliant) is software selectable and stored in the amplifier EEPROM.

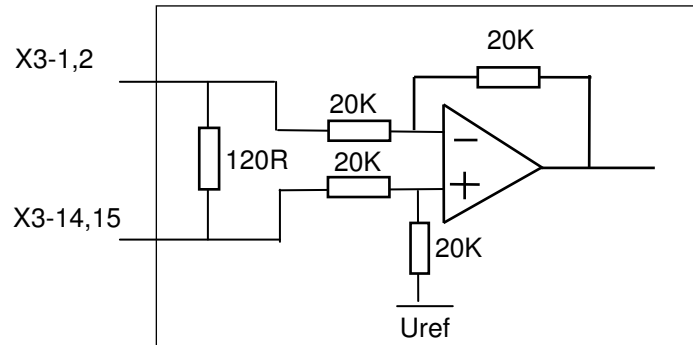
The corresponding X3 connector pin functions are described below.

| PIN    | FUNCTION | REMARKS   |
|--------|----------|---|
| 18     | Data-    | Differential input of the Endat encoder channel Data-   |
| 5      | Data+    | Differential input of the Endat encoder channel Data+   |
| 20     | Clock-   | Differential output of the Endat encoder channel Clock- |
| 7      | Clock+   | Differential output of the Endat encoder channel Clock+ |
| 14     | Sin-     | Differential input of the Endat encoder channel Sin-    |
| 1      | Sin+     | Differential input of the Endat encoder channel Sin+    |
| 15     | Cos-     | Differential input of the Endat encoder channel Cos-    |
| 2      | Cos+     | Differential input of the Endat encoder channel Cos+    |
| 8      | +5V      | Encoder supply voltage: max 300 mA available            |
| 21     | GND      | Encoder supply GND                                      |
| 9      | TC+      | Motor thermal sensor input                              |
| 22     | TC-      | Motor thermal sensor input                              |
| others | reserved |   |

3-1. DATA AND CLOCK ENCODER CHANNELS SPECIFICATION



### 3-2. SIN/COS ENCODER CHANNELS SPECIFICATION



## 4) ENCODER CABLES

The encoder inputs A, B, C, D, Z and R require a pair twisted and shielded cable. The shield must have a "360°" connection via metallic collars at both ends. If the shield is connected by means of a pig tail, it must be connected at one end to the GND pin of the connector on the amplifier side with a connection as short as possible.

Check that the voltage drop in the power supply lines of the encoder cable complies with the encoder technical specifications. The voltage drop value for a given cable is calculated as follows:

$$\Delta U[V] = 40 \cdot 10^{-6} \cdot \frac{Lc[m] \cdot I[mA]}{S[mm^2]}$$

With

- ΔU: voltage drop in volts
- Lc: cable length in metres
- I: encoder current in milliamps ( see technical specifications)
- S: cross section in square millimetres

Due to this voltage drop:

- an encoder with a large power supply voltage range should be preferred,
- if the encoder has a power supply sense feedback lines, they could be connected with the power supply lines in order to reduce voltage drop by the half (the sense feedback signal is not used in the ServoPac-A range).
- if both solutions above cannot be used, the user has to power the encoder by an external power supply.

### Example:

If the application requires a Heidenhain linear encoder powered by 5V±5% / 300mA with 25m cable length:

Min. power voltage: 5V ±5% ⇒ ΔU<sub>max</sub> = 0.25V ⇒ Min. cross section: S = 1.2mm<sup>2</sup>

Such a large cross section is difficult to get, so the user can :

- either connect the sense feedback signal lines with power supply lines and the needed wires cross section will be the half (0.6mm<sup>2</sup>)
- or the user can use the same encoder type but the version which allows its power supply voltage from 3.6V to 5.25V / 300mA. Min. power voltage 3.6V ⇒ ΔU<sub>max</sub> = 1.4V ⇒ Min. cross section: S = 0.21mm<sup>2</sup>

## 5) MOTOR PHASING WITH HIPERFACE OR ENDAT ABSOLUTE ENCODER

The motor phasing must be executed only one time after the encoder has been mounted on the motor shaft. This must be renewed if the encoder has been demounted and remounted on the motor shaft.

The motor phasing allows to get always the same phasing parameters (encoder offset, phase order) for a given motor range. However, remember that the phasing parameters value also depends on the motor and encoder wiring.

### 5-1. Preliminary tests

- Select **Hiperface encoder** or **Endat encoder** and **Encoder feedback** in the **Resolver / Encoder configuration** window of the VDSetup software.
- Enter the encoder resolution value and select **Pulse interpolation** in the **Servo motor** window.

- If the **Busy** error or the **Com. Channel** error are displayed, save the parameters into the EEPROM, switch off the amplifier and switch it on again, in order to start the encoder/amplifier communication.
- Start the motor with auto-phasing and auto-tuning and test its operation in digital speed mode.
- Quit the VDSetup software and start the ASCII terminal.

### 5-2. Encoder / motor phasing

- Deactivate the **Enable** input.
- Enter the **MS1** and **AR** commands.
- Activate the **Enable** input.
- Send the **AP** command (auto-phasing) if not done before.
- Send the **CA5555** phasing command.
- Check for no amplifier fault after the execution of the command (**ER=0**).
- Check that the **PN** value (encoder absolute position) is close to 0 (+/- 10 pulses).
- Switch off the amplifier.

### 5-3. Final test

- Switch on the amplifier.
- Start the motor with auto-phasing and auto-tuning and test its operation in digital speed mode.
- Save the phasing parameters into the EEPROM if required.

## 6) ERROR COMPENSATION FOR LOW RESOLUTION SIN/COS ENCODERS

For the compensation of the SinCos encoder errors (offset and amplitude difference between the Sin and Cos signals), proceed as described below. The error compensation operation is only necessary for low resolution encoders (number of Sin and Cos periods per revolution less than 128). This operation allows to reduce the motor speed ripples which frequency is equal to the Sin and Cos signal frequency (number of Sin and Cos signal periods per revolution x motor speed in rpm / 60) and to improve the position accuracy. It must be renewed if the motor encoder is changed for maintenance.

- Start the servo drive commissioning and parameterization according to the appropriate ServoPac-A amplifier Installation and User manuals.
- Connect the RS-232 serial link and start the ASCII terminal.
- Deactivate the **Enable** input.
- Send the **MS1** and **AR** ASCII commands.
- Activate the **Enable** input.
- Send the **OC** ASCII command for starting the execution of the Sin and Cos channels error compensation procedure. The procedure duration is about few minutes. Do not disable the drive before the end of the procedure (amplifier front panel leds are flashing during the procedure execution).
- If the BUSY fault is continuously displayed after the execution of the compensation procedure, the procedure has failed because of an external cause and the compensation is not valid. Check that the **Enable** input is activated. Check that the limit switches inputs are not activated. Send the **OC** ASCII command again to start the compensation procedure and check that the procedure has been correctly executed.
- The Sin and Cos channel compensation parameters are automatically saved in the amplifier internal memory at the end of the procedure.

## 7) POSITIONER APPLICATION WITH HIPERFACE OR ENDAT ABSOLUTE ENCODER

### 7-1. Positioner configuration

Select "Hiperface encoder" or "Endat encoder" and "Encoder feedback" in the "Resolver / Encoder configuration" window of the VDSetup software. If the **Busy** error or the **Com. Channel** error is displayed, save the feedback sensor configuration into the EEPROM. Then, switch off the amplifier and switch it on again, in order to start the encoder / amplifier communication.

The complete informations for the positioner commissioning and the parameter setting can be found in the appropriate installation manual and the appropriate user manual.

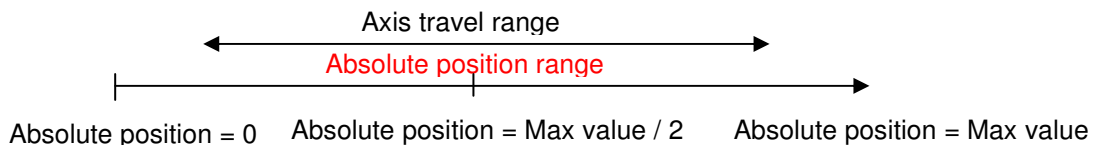
### 7-2. Positioner operation

With an Hiperface or Endat absolute encoder feedback, the motor absolute position value over one revolution is available and the servo motor can immediately be enabled after the amplifier power up. The servo drive behaviour at the amplifier power up is similar to a resolver sensor feedback

For a positioner, a multi-turn absolute encoder allows to avoid the homing sequence after the power up. In this case, the absolute position value over the axis travel range is available at the power up and the positioning can be immediately started. However the following conditions must be respected when a multi-turn absolute encoder application is designed :

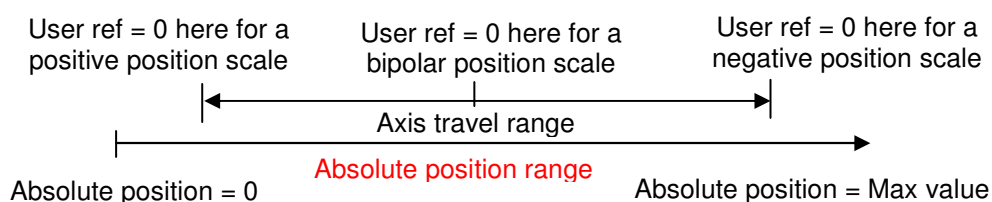
-For a rotating motor, the axis travel range must be lower than the motor absolute position range. The motor absolute position range can be read in the PNU 853 (Instance ID 154).

-The encoder zero position must be adjusted out of the operation travel range in order to avoid absolute position roll over. The PNU 854 (Instance ID 155) allows to set at 0 the encoder absolute position value. The PNU 859 (Instance ID 160) allows to set the encoder absolute position value at the max value / 2 (center of the absolute position range). The corresponding encoder position offset value can be read in the PNU 855 (Instance ID 156), it must be saved in the amplifier EEPROM.



-The user position reference value can be adjusted inside the operation travel range by using the PNU 856 (Instance ID 157) and the PNU 767 (Instance ID 68). The position reference value is entered in the PNU 767 (Instance ID 68), this value is then loaded in the user position counter by using the PNU 856 (Instance ID 157). The corresponding motor position offset value can be read in the PNU 857 (Instance ID 158), it is automatically saved in the amplifier EEPROM when the PNU 856 (Instance ID 157) is written. In this case, the homing procedure is no more necessary at the next amplifier power up.

-The user position reference value can also be adjusted inside the operation travel range by using an homing sequence. After the homing sequence execution, the motor position offset value can be read in the PNU 857 (Instance ID 158), it is saved automatically in the amplifier EEPROM when the PNU 860 (Instance ID 161) is written. In this case, the homing procedure is no more necessary at the next amplifier power up.



- It is recommended to use the Software position limits Min and Max for limiting the motor travel range. The Software position limits Min and Max values can be adjusted in the PNU 747 (Instance ID 48) and 748 (Instance ID 49). The Software position limits can be activated in the PNU 742 (Instance ID 43).

The encoder absolute position value can be read in the PNU 852 (Instance ID 153). This position is displayed according to the encoder position polarity (depends on the encoder wiring) and the encoder absolute position resolution: PNU 850 (Instance ID 151) and 851 (Instance ID 152).

The complete informations for the PROFIBUS communication can be found in the TTA-PRO PROFIBUS communication profile manual.

### 7-3. Positioner adjustment

Perform the positioner commissioning and the parameter setting according to the appropriate positioner manuals (installation and user)

The encoder absolute position is first adjusted inside the axis travel range as described below.

For a rotary encoder:

- Move the axis approximately at the center of its travel range in operation.
- Open the "**Scaling**" window accessible in the "**Application Setup**" menu; and execute the **Set** command for setting the encoder absolute position value at the max value / 2 (center of the absolute position range). This adjustment allows to overcome the roll over phenomena when the encoder max value or 0 value (limits of the absolute position range) are reached.

For a linear encoder:

- Move the axis approximately at the desired 0 position over its travel range in operation.
- Open the "**Scaling**" window accessible in the "**Application Setup**" menu; and execute the **Reset** command for setting to 0 the encoder absolute position value (origin of the absolute position range). Linear encoders are not concerned by the roll over phenomena.

The user reference position can then be adjusted inside the axis travel range by using an homing sequence or by setting its value manually if the homing sequence is not performed.

If the user reference position is adjusted by using an homing sequence proceed as described below:

- Execute the homing sequence
- Execute the "**Save homing**" command in order to activate the "**Absolute mode**" and save the user reference position in the amplifier EEPROM.

If the user reference position is set manually proceed as described below:

- Move the axis to its reference position inside the operation travel range.
- Open the "**Safety limits**" window accessible in the "**Positioner Application Setup**" menu.
- Select "**Absolute mode**" in the "**Position initialisation**" module and enter the user reference position value in the field "**Absolute position**". Execute then the "**Set**" command, the user reference position is automatically saved in the amplifier EEPROM.

When the user reference position has been adjusted, an axis homing procedure is no more necessary at the next amplifier power up.

Enter the software position limit values in the field "**Software position limit**" and select both positive and negative limits.

Execute the command "**Save parameters to EEPROM**" before switching off the positioner (24V).

## 8) TROUBLESHOOTING

### 8.1 - "ENCODER" FAULT IN THE HIPERFACE OR ENDAT ENCODER FEEDBACK CONFIGURATION

- Check the encoder supply connection on the amplifier X3 connector.
- Check the encoder SIN channel and COS channel connections on the amplifier X3 connector.

### 8.2 - "BUSY" FAULT IN THE HIPERFACE OR ENDAT ENCODER FEEDBACK CONFIGURATION

If the **Busy** fault is displayed after the Hiperface or Endat encoder selection, the encoder/amplifier communication does not started.

- Save the encoder selection by using the command "Save parameters to EEPROM".
- Switch off the amplifier and switch it on again, in order to start the encoder/amplifier communication.

If the Busy fault is displayed after the amplifier power up, the encoder/amplifier communication has not started.

- Check that the encoder Data+ and Data- channels are correctly wired on the amplifier X3 connector.
- Check for the correct encoder supply voltage value (5V for Endat and 12V for Hiperface).

Then, switch off the amplifier and switch it on again in order to restart the communication between the amplifier and the encoder.

### 8.3 - "COM. CHANNEL" FAULT IN THE HIPERFACE OR ENDAT ENCODER FEEDBACK CONFIGURATION

- Check that the encoder Data+ and Data- channels are correctly wired on the amplifier X3 connector.
- Check also that the encoder Clock+ and Clock- channels are correctly wired for an Endat encoder.
- Check for the correct encoder supply voltage value (5V for Endat and 12V for Hiperface).
- Check for the correct **Motor encoder resolution** parameter value.
- Check that the encoder-amplifier-motor ground connections and shield answer the requirements.

### 8.4 - "COUNTING" FAULT IN THE HIPERFACE OR ENDAT ENCODER FEEDBACK CONFIGURATION

If the counting fault is displayed when the encoder is at standstill:

- Check that the **Motor encoder resolution** parameter value is correct or select again the Hiperface or Endat encoder in the **Resolver / Encoder configuration** window of the VDSetup software.

If the counting fault is displayed when the encoder is moving:

- Check for the correct encoder supply voltage value
- Check for the correct encoder-amplifier-motor ground and shield connections with regard to the recommendations of the Installation manual.
- Check for the correct encoder A channel and B channel signal waveforms.
- Check for the correct encoder Data channel and Clock channel signal waveforms.

### 8.5 - "2<sup>nd</sup> SENSOR" FAULT IN THE HIPERFACE OR ENDAT ENCODER FEEDBACK CONFIGURATION

If the 2<sup>nd</sup> sensor fault is displayed when the encoder is at standstill:

- Check the encoder supply connection on the amplifier X3 connector.
- Check the encoder SIN channel and COS channel connections on the amplifier X3 connector.
- Check that the encoder Data+ and Data- channels are correctly wired on the amplifier X3 connector.
- Check also that the encoder Clock+ and Clock- channels are correctly wired for an Endat encoder.
- Check for the correct encoder supply voltage value (5V for Endat and 12V for Hiperface).
- Check that the encoder-amplifier-motor ground connections and shield answer the requirements.

If the 2<sup>nd</sup> sensor fault is displayed only when the encoder is moving:

- Change the "Reversed wiring" selection, in the "2<sup>nd</sup> sensor" window, accessible in the "Application Setup" menu.
- Check that the encoder-amplifier-motor ground connections and shield answer the requirements.



## 9) TTA-PRO PROFIBUS COMMUNICATION

| PNU | Parameter                       | Unit  | Min. | Max.         | Size   | R/W | Saving | Default value |
|-----|---------------------------------|-------|------|--------------|--------|-----|--------|---------------|
| 850 | Absolute encoder resolution     | ppr   | 0    | $2^{31}$     | double | R   | C      | 0             |
| 851 | Absolute encoder revolutions    | rev   | 0    | 65535        | word   | R   | C      | 0             |
| 852 | Absolute encoder position value | pulse |      |              | double | R   |        | 0             |
| 853 | Absolute encoder position limit | pulse | 0    | $2^{31}$     | double | R   |        | 0             |
| 854 | Absolute position reset         |       |      |              | -      | W   |        |               |
| 855 | Encoder position offset         | pulse | 0    | $2^{32} - 1$ | double | R/W | E      | 0             |
| 856 | Set user reference position     |       |      |              | -      | W   |        |               |
| 857 | User position offset            | pulse | 0    | $2^{32} - 1$ | double | R/W | E      | 0             |
| 858 | Position initialisation mode    |       |      |              | word   | R/W | E      | 0             |
| 859 | Absolute position range setting |       |      |              | -      | W   |        |               |
| 860 | Save homing                     |       |      |              | -      | W   |        |               |
| 865 | SinCos encoder compensation     |       |      |              | -      | W   |        |               |

**Notes** R/W Reading / Writing  
 E These parameters are saved in the EEPROM by instruction 729.  
 C These parameters are saved in the absolute encoder.

### 9-1. Reading of the absolute position range

#### **Absolute position limit**

**PNU :** **853**

This parameter defines the maximum value for the absolute position according to the user position resolution (PNU 740) and the encoder revolutions (PNU 851) for a rotary absolute encoder. The minimum value for the absolute position is 0. Absolute position control is only possible between these limits. A position roll over phenomena occurs when moving over these limits. A linear absolute encoder is not concerned by the position roll over, in this case, the returned value for this parameter is 0xFFFFFFFF (full encoder position range).

*Parameter* double word.  
*Range* 0 to  $2^{32} - 1$   
*Unit* user units (depends on the position resolution)  
*Note* Read only parameter

### 9-2. Reading of the encoder absolute position value

#### **Encoder absolute position resolution**

**PNU :** **850**

This parameter defines the number of increments for one encoder revolution, in the absolute position channel for a rotary absolute encoder type. For a linear absolute encoder type this parameter is giving the encoder pitch value in nano-meters for the absolute position channel.

*Parameter* double word.  
*Range* 512 to  $2^{31}$   
*Note* Read only parameter. This parameter value is readed in the absolute encoder via the communication channel.

#### **Encoder absolute position revolutions**

**PNU :** **851**

This parameter defines the number of encoder revolution for a rotary absolute multi turn encoder. For a linear encoder or an absolute single turn encoder this parameter value is equal to 0.

*Parameter* word.  
*Range* 0 to 65535 (0 for absolute single turn encoder or linear encoder)  
*Note* Read only parameter. This parameter value is readed in the absolute encoder via the communication channel.



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**Encoder absolute position value** **PNU :** **852**


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Reading of the encoder absolute position value, for an absolute encoder type.

Parameter double word.

Range The max value (modulo) for an absolute single turn encoder is PNU 850 value. The max value (modulo) for an absolute multi turn encoder is PNU 850 value x PNU 851 value.

Unit The scaling is given by the PNU 850 (number of increments per revolution).

Note This position value is only valid when the encoder is at standstill. When the encoder is moving, this position value is wrong because of the acquisition delay via the encoder communication channel (up to 60 ms).  
The polarity of this position depends on the encoder wiring and can be reversed with regards to the polarity of the motor position feedback (PNU 774). In this case, if necessary, use the PNU 722 to reverse the position feedback polarity.

### 9-3. Encoder absolute position reset

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**Encoder absolute position reset** **PNU :** **854**


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Parameter None.

Limitation Writing only.

Execution With disabled positioner

Note This procedure allows to set at 0 the encoder absolute position value. The absolute position offset value is calculated accordingly.



With an absolute rotating encoder, this operation must be executed out of the operation travel range in order to avoid absolute position roll over (see PNU 853).

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**Encoder absolute position range setting** **PNU :** **859**


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Parameter None.

Limitation Writing only.

Execution With disabled positioner

Note This procedure allows to set the encoder absolute position value at the center of the encoder absolute position range. The absolute position offset value is calculated accordingly.



This operation is only valid for an absolute rotating encoder; it must be executed at the middle point of the axis travel range. This adjustment allows to overcome the roll over phenomena (see PNU 853).

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**Encoder absolute position offset** **PNU :** **855**


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Reading of the encoder absolute position offset value. This offset value is calculated when the position reset procedure is executed (PNU 854 or PNU 859).

Parameter double word.

Range The max value (modulo) for an absolute single turn encoder is PNU 850 value. The max value (modulo) for an absolute multi turn encoder is PNU 850 value x PNU 851 value.

Unit The scaling is given by the PNU 850 (number of increments per revolution).

### 9-4. User reference position adjustment

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**User reference position setting** **PNU :** **856**


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Parameter None.

Limitation Writing only.

Execution With disabled positioner

Note This procedure allows to set and save the user reference position. The user reference position offset value (PNU 857) is calculated according to the reference position value entered in the PNU 767, and the absolute mode (PNU 858) is automatically activated. These parameters are automatically saved in the amplifier EEPROM. The homing procedure is no more necessary at the next amplifier power up.



This operation must be executed for an absolute encoder inside the operation travel range. The reference position value is entered in the PNU 767 in the user units.

**User reference position offset****PNU :** **857**

Reading of the user reference position offset value. This offset value is calculated when the user reference position setting procedure is executed (PNU 856) or when an homing sequence is executed.

*Parameter* double word.

*Range* 0 to  $2^{32} - 1$

**Position initialisation mode****PNU :** **858**

*Parameter* 1 word.

*Conversion* 0 homing mode.  
1 absolute mode (without homing).

*Note* The absolute mode is automatically activated when the user reference position setting procedure is executed (PNU 856) or when the save homing procedure is executed (PNU 860).

**Save homing****PNU :** **860**

*Parameter* None.

*Limitation* Writing only.

*Execution* With disabled positioner

*Note* This command allows to save the user reference position value after the execution of an homing procedure. The user reference position offset value (PNU 857), and the absolute mode (PNU 858) are automatically saved in the amplifier EEPROM. The homing procedure is no more necessary at the next amplifier power up.

## 9-5. SinCos encoder error compensation

**SinCos encoder error compensation****PNU :** **865**

*Parameter* None.

*Limitation* Writing only.

*Execution* With positioner disabled and **Enable** input activated.

*Note* This command allows to execute the SinCos encoder error compensation procedure (compensation of the offsets and amplitude difference between the Sin and Cos signals). This procedure is only necessary for low resolution encoders (number of Sin and Cos periods per revolution less than 128). This operation allows to reduce the motor speed ripples at the Sin and Cos signal frequency (number of Sin and Cos signal periods per revolution x motor speed in rpm / 60) and improve the position accuracy. This operation must be renewed if the motor encoder is changed for maintenance. The compensation parameters are automatically saved in the amplifier internal memory at the end of the procedure.

**Appendix A: HIPERFACE encoders list**

| Encoder reference | Incremental resolution | Absolute resolution       | Number of revolutions |
|-------------------|------------------------|---------------------------|-----------------------|
|                   | periods per revolution | increments per revolution |                       |
| SEK 52            | 16                     | 512                       | 1                     |
| SKS 36            | 128                    | 4 096                     | 1                     |
| SCS 60/70         | 512                    | 16 384                    | 1                     |
| SHS 170           | 512                    | 16 384                    | 1                     |
| SRS 50/60/64/660  | 1 024                  | 32 768                    | 1                     |
| SCS KIT 101       | 1 024                  | 32 768                    | 1                     |
| SCK 25 à 53       | 1 024                  | 32 768                    | 1                     |
| SKM 36            | 128                    | 4 096                     | 4096                  |
| SCM 60/70         | 512                    | 16 384                    | 4096                  |
| SRM 50/60/64      | 1 024                  | 32 768                    | 4096                  |
| SCM KIT 101       | 1 024                  | 32 768                    | 4096                  |
| SCL 25 à 53       | 1 024                  | 32 768                    | 4096                  |

**Appendix B: ENDAT encoders list**

| Encoder reference | Incremental resolution | Absolute resolution       | Number of revolutions |
|-------------------|------------------------|---------------------------|-----------------------|
|                   | periods per revolution | increments per revolution |                       |
| ECI 1312          | 32                     | 2 048                     | 1                     |
| ROC 413-512       | 512                    | 8 192                     | 1                     |
| ECN 413-512       | 512                    | 8 192                     | 1                     |
| ECN 1313-2048     | 2 048                  | 8 192                     | 1                     |
| ECN 113-2048      | 2 048                  | 8 192                     | 1                     |
| ROC 413-2048      | 2 048                  | 8 192                     | 1                     |
| ROC 417           | 8 192                  | 131 072                   | 1                     |
| ECN 1317          | 8 192                  | 131 072                   | 1                     |
| RCN 220           | 16 384                 | 1 048 576                 | 1                     |
| RCN 723-823       | 32 768                 | 8 388 608                 | 1                     |
| EQI 1324          | 32                     | 2 048                     | 4 096                 |
| ROQ 425-512       | 512                    | 8 192                     | 4 096                 |
| EQN 425-512       | 512                    | 8 192                     | 4 096                 |
| ROQ 425-2048      | 2 048                  | 8 192                     | 4 096                 |
| EQN 425-2048      | 2 048                  | 8 192                     | 4 096                 |
| EQN 1325-2048     | 2 048                  | 8 192                     | 4 096                 |
|                   |                        |                           |                       |
| Linear encoder    | Incremental pitch      | Absolute pitch            |                       |
| LC 181            | 16, µm                 | 0,1 µm                    | --                    |
| LC 481            | 20, µm                 | 0,1 µm                    | --                    |

For other absolute encoder reference, please contact the factory.

**Appendix C: ServoPac-A range hardware indexes for absolute encoder feedback**

The following hardware indexes are required in the ServoPac-A amplifiers in order to support the Hiperface / Endat absolute encoder feedback functionality.

|              |                    |                  |              |                 |              |
|--------------|--------------------|------------------|--------------|-----------------|--------------|
| Drive rating | 230 / 2.25 to 16.5 | 400 / 1.8 to 7.2 | 400 / 14     | 400 / 30 and 45 | 400 / 70     |
| TTA-PRO      | O or greater       | L or greater     | N or greater | K or greater    | A or greater |