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Application note
December 11ᵗʰ, 2017

CD1a / CD1k servo drives

Hiperface/EnDat absolute encoder feedback

1) INTRODUCTION

This application note is dedicated to the commissioning of CD1 drives range 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 CD1-a or CD1-k amplifier commissioning and parameterization can be found in the pertaining manuals. A CD1-a application with Hiperface or EnDat absolute encoder requires the amplifier firmware version 12.3C or higher. CD1-k applications with Hiperface or EnDat absolute encoder require the amplifier firmware version 112.33 or higher. The parameterization for an application with Hiperface or EnDat absolute encoder requires the VDSetup software tool version 4.0 or a higher release.

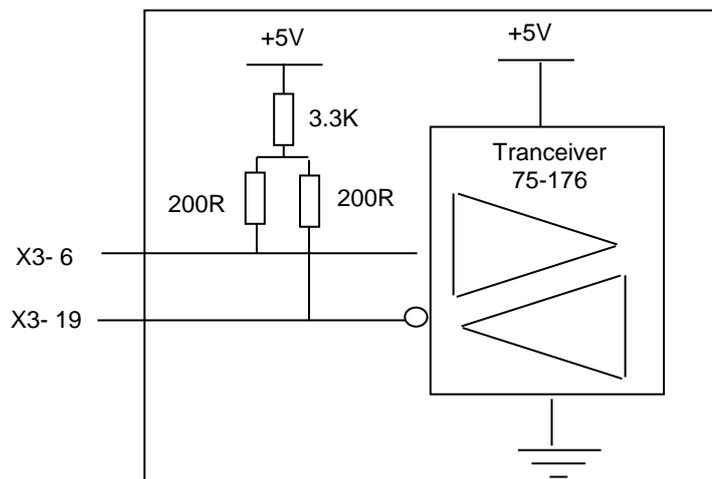## 2) X3 CONNECTOR FOR HIPERFACE ABSOLUTE ENCODER (Sub D 25 pins female)

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

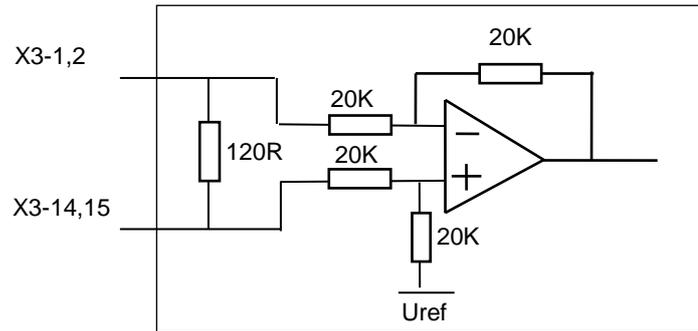The corresponding X3 connector pin functions are described below.

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 Ω, max 150 mA available [1]
23	GND	Encoder supply GND
9	TC+	Motor thermal sensor input
22	TC-	Motor thermal sensor input
others	reserved	

(1): For the CD1-a amplifier, the sum of the currents consumed by both X2 connector, pin 21 and X3 connector, pin 10 must not exceed 150 mA.

2-1. DATA ENCODER CHANNEL SPECIFICATION

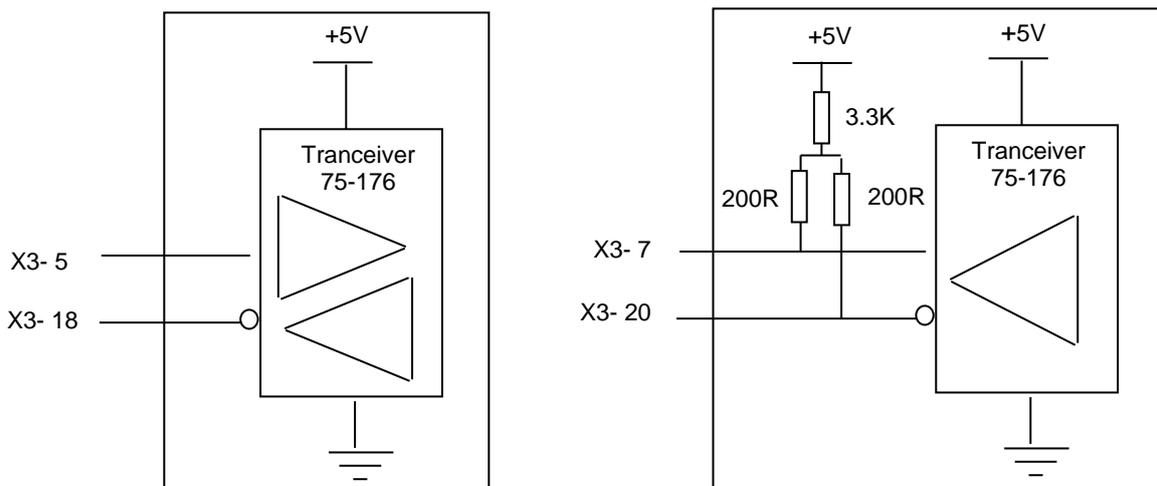## 2-2. SIN/COS ENCODER CHANNELS SPECIFICATION

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

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3-2. SIN/COS ENCODER CHANNELS SPECIFICATION
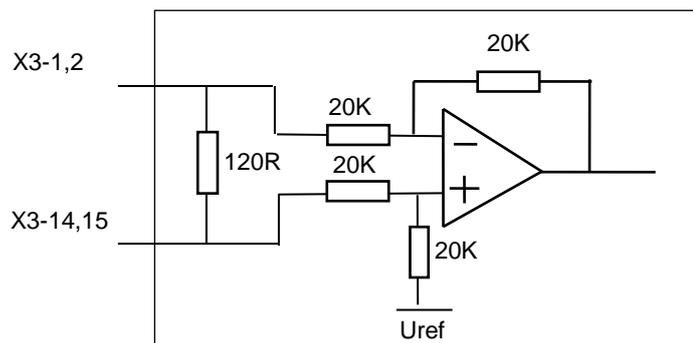
4) ENCODER CABLES

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:

$$\Delta U[V] = 40.10^{-6} \cdot \frac{Lc[m].I[mA]}{S[mm^2]}$$

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 CD1 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_{max} = 0.25V ⇨ Min. cross section: S = 1.2mm²
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 (0.6mm²)
- 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_{max} = 1.4V ⇨ Min. cross section : S = 0.21mm²

5) CD1-a APPLICATION WITH HIPERFACE OR ENDAT ABSOLUTE ENCODER

5-1. AMPLIFIER 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 amplifier commissioning and the parameterization can be found in the CD1-a amplifier manual.

5-2. AMPLIFIER 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.

On a CD1-a amplifier, the capabilities of an absolute multi-turn encoder cannot be fully exploited because the CD1-a operating modes are incremental: analog speed mode or pulse following mode (stepper emulation / electronic gearing). In this case, a single-turn absolute encoder is should be preferred.

6) CD1-k APPLICATION WITH ABSOLUTE HIPERFACE OR ENDAT ENCODER

6-1. AMPLIFIER 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 are 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 information for the amplifier commissioning and the parameter setting can be found in the CD1-k Installation and User manuals.

6-2. AMPLIFIER 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.

In a CD1-k amplifier, in the Profile position or Interpolated position modes, an absolute multi-turn encoder avoids the homing displacement after the amplifier power up. In this case, the absolute position value over the axis travel range is available after power up and the axis position control can be immediately started. However, the following conditions must be fulfilled when an absolute multi-turn encoder application is designed:

- For a rotary motor, the axis travel range must be smaller than the motor absolute position range. The motor absolute position range can be read in object 3218.

- The encoder zero position must be adjusted out of the operation travel range in order to avoid absolute position roll-over. Object 3215 allows to set the encoder absolute position value at 0 or at the max. value / 2 (centre of the absolute position range). The corresponding encoder position offset value can be read in object 3219. It must be saved in the amplifier EEPROM.

Axis travel range
Absolute position range

Absolute position = 0   Absolute position = Max. value / 2   Absolute position = Max. value
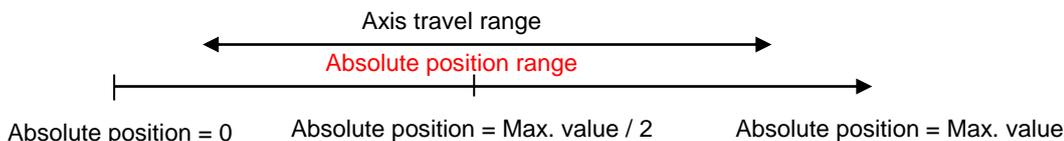
- It is recommended to use the Software position limits Min and Max for limiting the motor travel range. The Software position limits are activated when a linear axis type is selected in object 3360. The Software position limits Min and Max values can be adjusted in object 607D, sub-indexes 1 and 2.

At the amplifier power up, the motor absolute position value can be read in object 6064. This position is displayed according to the motor position polarity (object 607E) and the motor position resolution (object 608F sub index 1). The encoder absolute position value can be read in object 3216, sub-index 3. This position is displayed according to the encoder position polarity (which depends on the encoder wiring) and the encoder absolute position resolution (object 3216, sub-indexes 1 and 2).

6-3. AMPLIFIER ADJUSTMENT

Perform the amplifier commissioning and the parameterization according to the appropriate CD1-k amplifier manuals (Installation and User Guides).

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 centre 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 (centre of the absolute position range). This adjustment allows to overcome the roll-over phenomenon when the absolute position range limits (max. value or 0 value) are reached.

For a linear encoder:
- Move the axis aproximately 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 resetting the encoder absolute position value (origin of the absolute position range). Linear encoders are not concerned by the roll-over phenomenon.

Execute the command "**Save parameters to EEPROM**" before switching off the 24 V supply in order to save the encoder absolute position adjustment.

The user reference position can then be adjusted inside the axis travel range by using the internal position offset. The internal position offset value (object 3211h), is calculated inside the amplifier when the axis homing procedure is performed. The internal position offset value (object 3211h), can also be calculated by the host controller as described below, if the homing procedure is not performed.

- Move the axis to its reference position inside the operation travel range.

- Calculate the internal offset value (object 3211h) according to the following formula:

$$Offset \text{ (object 3211h)} = RawPos \text{ (object 3210h)} - RefPos$$

RawPos (object 3210h) is the absolute position in the axis resolution (object 608F sub index 1)
RefPos is the desired reference position value in the user frame.

When the internal position offset value (object 3211h) has been calculated, an axis homing procedure is no more necessary at the next amplifier power up. The internal position offset value must be saved inside the host controller and sent to the amplifier at each power up, in order to get the axis position (object 6064h) displayed in the user reference frame. The default value of the internal position offset at the amplifier power up is 0.

Remark: The axis position (object 6064h) is calculated inside the drive according to the following formula:

$$AxisPos \text{ (object 6064h)} = RawPos \text{ (object 3210h)} - Offset \text{ (object 3211h)}$$

7) TROUBLESHOOTING

7.1 - "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.

7.2 - "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.

7.3 - "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.

7.4 - "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.

7.5 - "2ND SENSOR" FAULT IN THE HIPERFACE OR ENDAT ENCODER FEEDBACK CONFIGURATION

If the 2nd 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 2nd sensor fault is displayed only when the encoder is moving:
- Change the "Reversed wiring" selection, in the "2nd sensor" window, accessible in the "Application Setup" menu.
- Check that the encoder-amplifier-motor ground connections and shield answer the requirements.

8) CD1-k CANOPEN COMMUNICATION PROFILE

8-1. READING OF THE ABSOLUTE POSITION RANGE

Object 3218h: Absolute Position Range

Index	3218h
Description	Absolute position range
Data Type	Unsigned32
Access	ro
PDO Mapping	No
Default Value	0

This parameter defines the maximum value for the absolute position according to the user position resolution (object 608F sub index 1) and the encoder revolutions (object 3216 sub index 2) for an absolute rotary encoder. The minimum

value for the absolute position is 0. Absolute position control is only possible between these limits. A position roll-over phenomenon occurs when moving beyond these limits. An absolute linear encoder is not concerned by the position roll-over. In this case, the returned value for this parameter is 0xFFFFFFFF (full encoder position range).

8-2. READING OF THE ENCODER POSITION VALUE

Object 3216h: Encoder Position

Index	3216h
Name	Encoder Position
Object Code	ARRAY
Number of Elements	3

Value Description

Sub Index	1
Description	Encoder Increments per Revolution
Data Type	Unsigned32
Object Class	all
Access	ro
PDO Mapping	No
Unit	inc
Value Range	200h .. 1000 0000h
Default Value	0

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

Sub Index	2
Description	Encoder Revolutions
Data Type	Unsigned32
Access	ro
PDO Mapping	No
Default Value	0

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

Sub Index	3
Name	Encoder Position Actual Value
Object Code	VAR
Data Type	Integer32
Object Class	all
Access	ro
PDO Mapping	No
Unit	Inc

This object returns the absolute position value, for an absolute encoder type, or the incremental position value, for an incremental encoder type. For an absolute encoder type, 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).

Remark: The polarity of the encoder position (object 3216 sub 3) depends on the encoder wiring and can be reversed with regard to the polarity of the position loop feedback (object 6064). In this case, if necessary, use the object 607E to reverse the position loop feedback polarity, in order to get the same polarity in both positions.

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8-3. ENCODER ABSOLUTE POSITION RESET

Object 3215h: Absolute position Reset procedure

Index	3215h
Name	Absolute position Reset procedure
Object Code	VAR
Data Type	Unsigned32
Object Class	-
Access	wo
PDO Mapping	No

Writing to this object will execute the reset procedure for the absolute position. In order to avoid running the absolute position reset procedure by mistake, the procedure is only executed when a specific signature is written to this object.

If the signature is 'razp', the procedure sets at 0 the encoder absolute position value. The absolute position offset value is calculated accordingly. For an absolute rotary encoder, this operation must be executed out of the operation travel range in order to avoid absolute position roll-over.

Signature	MSB			LSB
ASCII	p	z	a	r
hex	70h	7Ah	61h	72h

If the signature is 'setp', the procedure sets the encoder absolute position value at the centre of the encoder absolute position range. The absolute position offset value is calculated accordingly. This operation is only valid for an absolute rotary encoder. It must be executed at the middle point of the axis travel range. This adjustment allows to overcome the roll-over phenomenon.

Signature	MSB			LSB
ASCII	p	t	e	s
hex	70h	74h	65h	73h

Object 3219h: Absolute Position offset

Index	3219h
Description	Encoder absolute position offset
Data Type	Unsigned32
Access	rw
PDO Mapping	No
Default Value	0

This parameter defines the encoder absolute position offset value. This offset value is calculated when the absolute position reset procedure is executed. The max. value (modulo) for an absolute single-turn encoder is object 3216 sub 1 value. The max. value (modulo) for an absolute multi-turn encoder is object 3216 sub 1 value x object 3216 sub 2 value. The scaling is given by object 3216 sub 1 (number of increments per revolution). This parameter is saved in the amplifier EEPROM.

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Appendix A : HIPERFACE encoder 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 encoder 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 references, please contact the factory.

Appendix C : CD1 range hardware indexes for absolute encoder feedback

The following hardware indexes are required in the CD1 amplifier 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
CD1-a version	α H or greater	α J or greater	α D or greater	R or greater	all values
CD1-k version	α D or greater	α D or greater	α F or greater	α R or greater	all values