This manual describes the **option "c"** of the **SMT-BD1** amplifier: **Positioning in stepping motor emulation**. The general information about the digital amplifier commissioning are described in the standard **SMT-BD1** manual. This manual may be used in conjunction with appropriate and referenced drawings pertaining to the various specific models.

Maintenance procedures should be attempted only by highly skilled technicians (EN 60 204.1 standard) using proper test equipment.

The conformity with the standards and the "CE" approval are only valid if the items are installed according to the recommendations of the racks and amplifiers manuals.

Any contact with electrical parts, even after power down, may involve physical damage.

Wait for 30 seconds after power down before handling the rack or the amplifiers (residual voltage).

INFRANOR does not assume any responsibility for any physical or material damage due to improper handling or wrong descriptions of the ordered items.

Infranor reserves the right to change any information contained in this manual without notice.

This manual is a translation of the original document and does not commit INFRANOR's responsibility. The french manual is the only reference document.

Updating index: 2.01

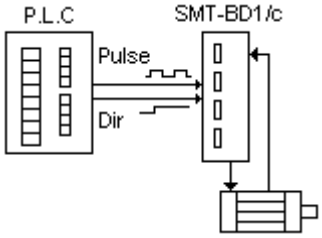
Option "c"

POSITIONING IN STEPPING MOTOR EMULATION WITH SMT-BD1/c AMPLIFIER

CONTENTS

CHAPTER 1 - GENERAL DESCRIPTION

Applications with positioning in stepping motor emulation require the **SMT-I2-BD1** daughter board on the **SMT-BD1** amplifier as well as the firmware memory version X.XC. In this configuration, the **SMT-BD1/c** amplifier controls the motor shaft position by means of the resolver sensor with a programmable resolution of 4 to 32 768 ppr. The position input command is received as two TTL level signals (0 to 5 V): one pulse train (PULSE) indicating the shaft motion and one direction signal (DIR) indicating the motion direction. These signals enter the amplifier X2 position connector. This kind of input allows a direct interfacing with an indexer or a PLC board, as shown below.



All boards which are compatible with the above described inputs can be used, but some important specifications of the board should be checked in order to obtain satisfying results.

For "soft" motions (without motor jerking, without saturation in the amplifier and without important overshoot) the board MUST generate acceleration / deceleration ramps during the motion (trapezoidal shape).
The maximum output pulse train frequency of the board limits, at the same time, the motor maximum speed and the position resolution according to the formula below:

Max. PULSE signal frequency (pps) = Max. motor speed (rpm). Motor position resolution (ppr)/60

The maximum value of each motion in number of pulses (Pulses) is also depending on the board.

The shaft initializing procedures are completely controlled by the board and the various possibilities are depending on the board.

When the amplifier is disabled (**ENABLE** input not active), the input pulses are not counted. When activating the **ENABLE** input, the motor is enabled at its current position and follows the input pulses emitted by the board. The motor shaft motion depends on the selected position resolution.

The position error between input command and motor is controlled in the amplifier. The position regulator also allows to reduce the following error during the motions, if necessary.

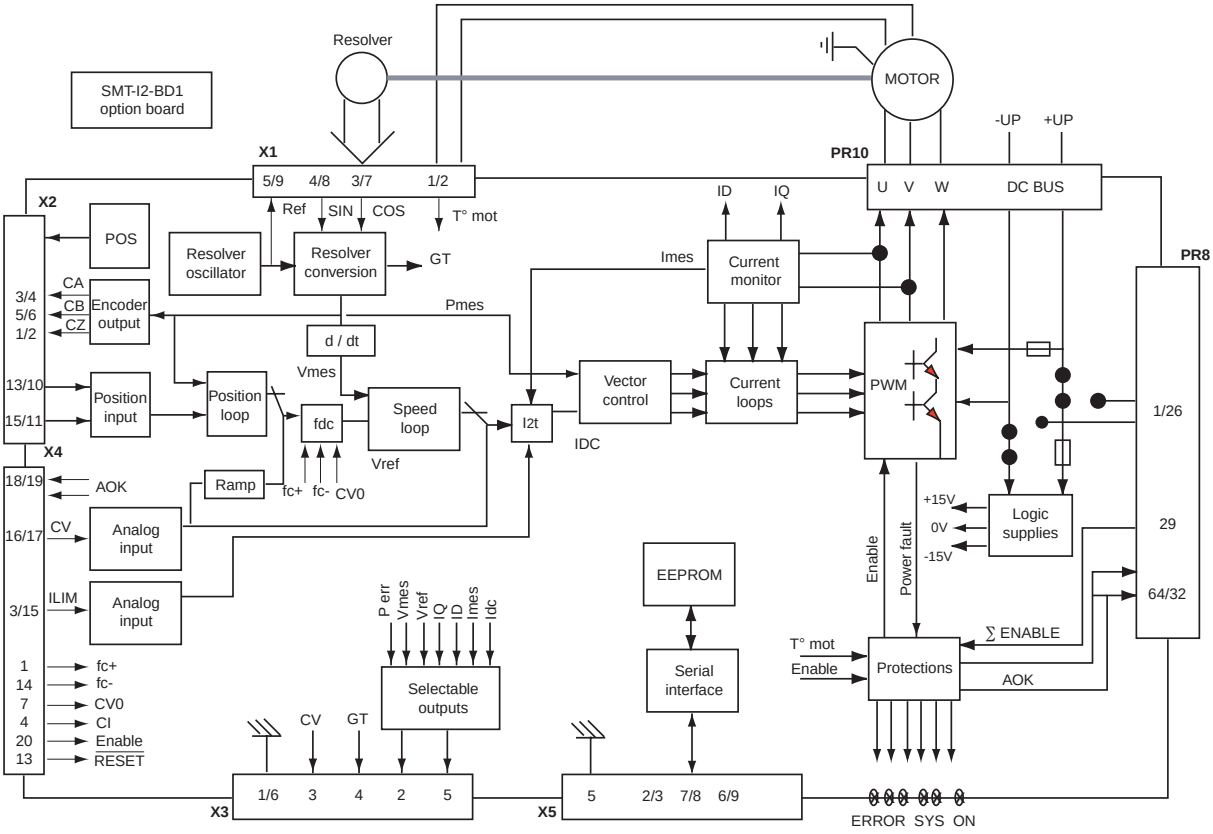
CHAPTER 2 - SPECIFICATIONS

1 - TECHNICAL DATAS

Motor position input command	One pulse train (f) + one direction signal Maximum frequency: f = 1 MHz
Number of steps per motor revolution	Motor encoder resolution . 4
Programmable motor encoder resolution	Max. 8 192 ppr up to 900 rpm Max. 4 096 ppr up to 3 600 rpm Max. 1 024 ppr up to 14 000 rpm
Drive position repetability	1 step
Drive position accuracy (*)	8 Arc mins + 1 step in standard (2 Arc mins + 1 step on special request)
Position regulator PIV + Feedforward	Sample period: 0,5 ms Integrator antisaturation system Antiresonance filter Adjustable digital gains
Position loop bandwidth	Cut-off frequency for 45° phase shift Selectable: 50 Hz, 75 Hz or 100 Hz
Logic outputs	POS : Position following OK

(*) The resolver accuracy must be taken into account for the total accuracy.

2 - AMPLIFIER BLOCK DIAGRAM



3 - STORED FAULT

The stored fault can be cancelled:

- by the RESET function of the **BPCW** software,
- by the fault RESET input (pin 13 of X4),
- by turning off the amplifier supply.

PROTECTION	DISPLAY CODE	LED
Position following error	Position	● ● ● ☼

● = LED is unlit ☼ = LED is lit

CHAPTER 3 - INPUTS - OUTPUTS

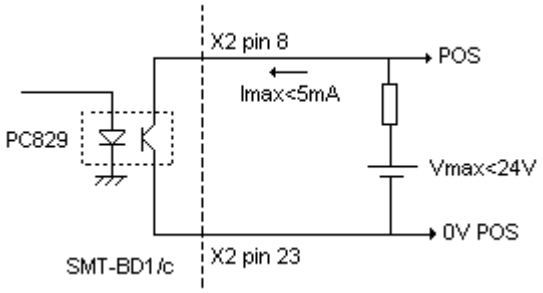
1 - X2 POSITION CONNECTOR

1.1 -PINS REFERENCE

PIN	FUNCTION	I/O	REMARK
1	CZ/	O	Motor encoder output of the zero pulse/ (5 V, 20 mA max)
2	CZ	O	Motor encoder output of the zero pulse
3	CA/	O	Motor encoder output channel A/ (5 V, 20 mA max)
4	CA	O	Motor encoder output channel A
5	CB/	O	Motor encoder output channel B/ (5 V, 20 mA max)
6	CB	O	Motor encoder output channel B
7	0 V		GND
8	POS	O	Logic output POS : position following OK
23	0 V POS	O	0 V POS output
10	0 V		GND
11	0 V	I	Indexer 0 V input
13	PULSE	I	Indexer PULSE signal input (Chapter 3, § 1.3)
12	PULSE/	I	Indexer PULSE/ signal input (Chapter 3, § 1.3)
15	DIR/	I	Indexer DIR signal input (Chapter 3, § 1.3)
14	DIR/	I	Indexer DIR/ signal input (Chapter 3, § 1.3)
16,17,18,19	Reserved		Reserved
9	Reserved		Reserved
20,21,22	Reserved		Reserved
24,25	Reserved		Reserved

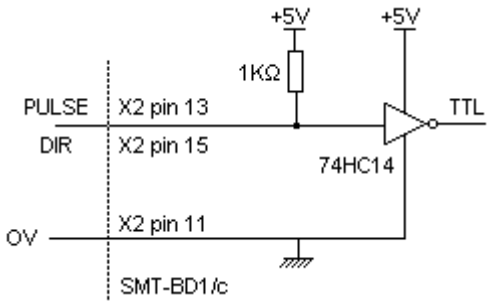
1.2 - LOGIC OUTPUTS SPECIFICATION

The POS output is an "open collector" and "optocoupled". The transistor is disabled if a fault occurs. The traditional application scheme is shown below. The maximum output current is 5 mA.

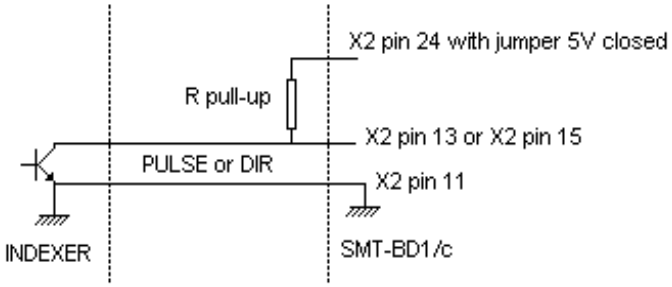


1.3 - INDEXER INPUT SPECIFICATION

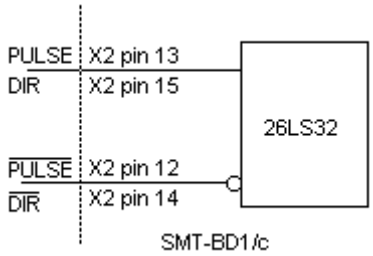
The TTL **PULSE** and **DIR** inputs are connected to the amplifier as shown below:



For indexers with open collector output and operating at high frequencies (> 100 kHz), a pull-up resistor corresponding to the transistor output current must be wired in the X2 connector, as shown below (the pull-up resistor is parallel mounted to the 1 kΩ resistor in the amplifier).



The differential **PULSE** and **DIR** inputs are connected to the amplifier as shown below:



This type of input is suitable for long indexer-amplifier connections (a 26LS31 driver is recommended).

2 - X3 TEST CONNECTOR

PIN	FUNCTION	CHARACTERISTICS
1 - 6	0 V	
2	DAC 1 output	±10 V resolution 8 bits, linearity: 2 % (IDC, Imon., ID, IQ, Vref, Vmon., Pos err) *
3	Speed input command CV	±10 V for ± maximum speed
4	Speed signal GT	±8 V for ±14 000 rpm
5	DAC 2 output	±10 V resolution 8 bits, linearity: 2 % (IDC, Imon., ID, IQ, Vref, Vmon., Pos err)*

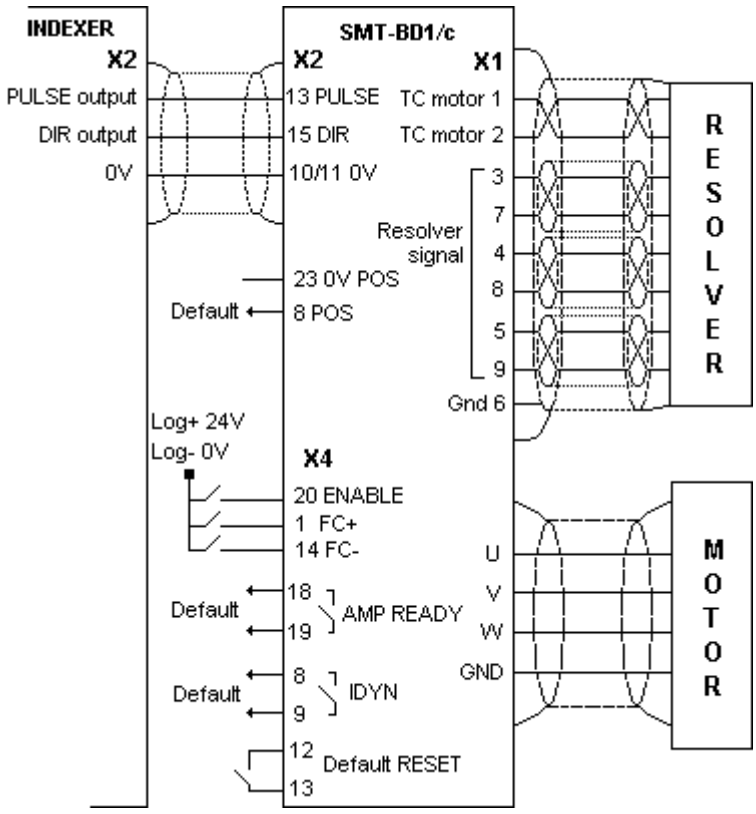
* : See "BPCW Options" manual, part "Digital oscilloscope".

Linearity = 10 % on logic board types 01612A, 01612B and 01612C.

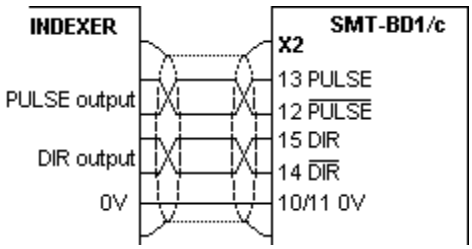
CHAPTER 4 - CONNECTIONS

1 - CONNECTION DIAGRAMS

1.1 - TTL INDEXER SIGNALS



1.2 - DIFFERENTIAL INDEXER SIGNALS



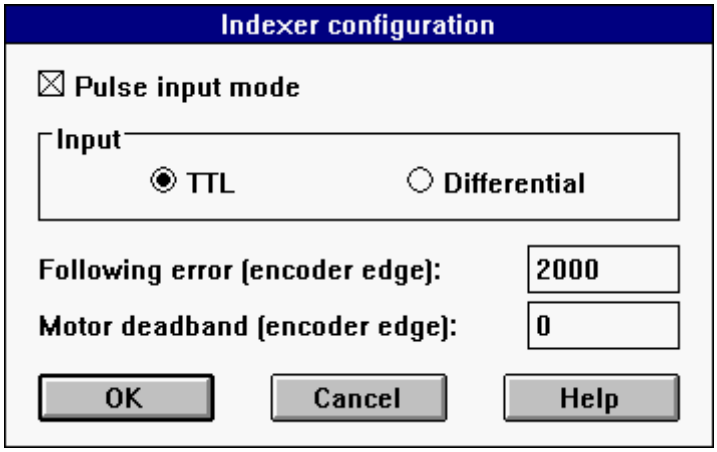
2 - MANDATORY WIRING

For the incremental position input command signals **Pulse** and **Direction** of the indexer-amplifier connection, use a cable with a **360° shield connection via the metal plated connectors** at both cable ends (see standard manual of the SMT-BD1 digital amplifier, chapter 8, part 6) **and connect the 0 Volt of both indexer and amplifier** (pin **GND** on the **X2** connector).

Be careful about the polarity between indexer and amplifier for the **TTL** signals **Pulse** and **Direction**.

CHAPTER 5 - ADJUSTABLE PARAMETERS

The parameters used for positioning in stepping motor emulation are accessible via **the Indexer / Electronic Gearbox** submenu of the **Advanced functions** menu, in the **BPCW** software.



1 - OPERATION MODE

The operation in stepping motor emulation is selected by the **Pulse input mode** function in the **Indexer / Electronic Gearbox** menu of the **Advanced functions** menu.

This mode corresponds to the motor position control with a PIV + feedforward regulator. The position input command emitted by the indexer board is received as an incremental input command on the X2 connector.

2 - APPLICATION PARAMETERS

The **Encoder resolution** parameter is accessible in the **ENCODER RESOLUTION** module of the adjustment panel in the **BPCW** software. It defines the number of encoder pulses for one revolution of the motor shaft. The limit value of this parameter according to the maximum motor speed (**Maximum speed**) is indicated in the chart below:

MAXIMUM SPEED (rpm)	900	3 600	14 000
MAXIMUM ENCODER RESOLUTION	8192	4096	1024

The following parameters are accessible via the **Indexer / Electronic Gearbox** submenu of the **Advanced functions** menu.

The **Following error** parameter defines the maximum permissible value of the position error. When the position error reaches half of this value, the **POS** output is disabled and the following error fault (**Position** error) is blinking on the amplifier front panel. When the position error reaches the value defined by the **Following error** parameter, the following error fault (**Position** error) is released and the amplifier is disabled. This parameter is expressed as motor steps (motor resolution encoder pulses x 4). The adjustment range is between 0 and 32 767 steps.

The **Motor deadband** parameter defines a tolerance range of the position input command, where the position loop is open. This parameter is expressed as motor steps (motor resolution encoder pulses x 4). The adjustment range is between 0 and 32 767 steps.

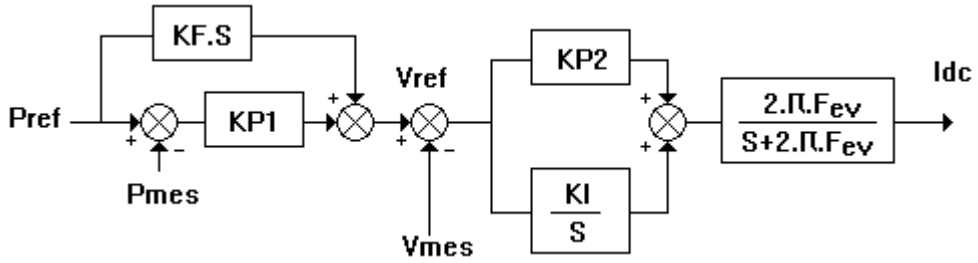
The following parameters are accessible via the **Indexer / Electronic Gearbox** submenu of the **Advanced functions** menu.

The **Following error** parameter defines the maximum permissible value of the position error. When the position error reaches half of this value, the **POS** output (following error indication) is activated and the following error fault (Position error) is blinking on the amplifier front panel. When the position error reaches the value defined by the **Following error** parameter, the following error fault (**Position** error) is released and the amplifier is disabled. This parameter is expressed as motor steps (motor resolution encoder pulses x 4). The adjustment range is between 0 and 32 767 steps.

The **Motor deadband** parameter defines a tolerance range of the position input command, where the position loop is open. This parameter is expressed as motor steps (motor resolution encoder pulses x 4). The adjustment range is between 0 and 32 767 steps.

3 - POSITION REGULATOR PARAMETERS

The regulator structure used for the **Indexer / Electronic Gearbox** control is described below:



The **Controller parameters** function in the **Advanced functions** menu of the **BPCW** software allows the access to all regulator parameters.

The **Speed error low pass filter** parameter defines the cut-off frequency a - 3 db (Fev) of the 1st order filter acting upon the speed error. The value of this parameter depends on the selected bandwidth.

The **Proportional speed gain** parameter defines the proportional regulator gain (KP2) acting upon the speed error. The adjustment range is between 0 and 4 095.

The **Integral 1 speed gain** parameter defines the integral regulator gain (KI) acting upon the speed error. The adjustment range is between 0 and 255.

The **Proportional position gain** parameter defines the proportional gain acting upon the position error (KP1). The adjustment range is between 0 and 1.

The **Feedforward position gain** parameter defines the amplitude of the anticipation term (KF) corresponding to the speed input command (position input command derivation). This anticipation term allows to reduce the following error during the motor acceleration and deceleration phases. The adjustment range is between 0 and 1.

All these gain parameters are automatically calculated during the execution of the **AUTOTUNING** function.

CHAPTER 6 - COMMISSIONING

1 - CHECKING THE CONFIGURATION

Check the amplifier standard configuration as described in Chapter 6 of the standard **SMT-BD1** manual.

Check for the presence of the **SMT-I2-BD1** daughter board between both logic and power boards (see chapter 8 (Appendix): Location diagram of the hardware options).

2 - POWERING

Turn on the amplifier as described in Chapter 6 of the standard **SMT-BD1** manual.

3 - START AND ADJUSTMENT

Start the amplifier commissioning and adjustment procedure as described in Chapter 6 of the standard **SMT-BD1** manual, by means of the **BPCW** software.

Select the **PI²** speed regulator before executing the **AUTOTUNING** function in the **CONTROLLER** module.

In case of loud noise in the motor at standstill and when running, check the transmission rigidity between motor and load (backlashes and elasticities in gearings and couplings).

If necessary, renew the **AUTO-TUNING** procedure by choosing a lower bandwidth (**Bandwidth = Medium** or **Low**). If the problem remains, renew the **AUTO-TUNING** procedure by activating the antiresonance filter (**Filter** = **Antiresonance**). The antiresonance filter is accessible from the **BPCW** software version **2.6** and the amplifier EPROM version **5.7**.

Execute the **MODIFY** function in the **ENCODER RESOLUTION** module and select the **Encoder resolution** parameter (see Chapter 2, part 1 for the limitation of this parameter according to the motor maximum speed).

The position resolution on the motor shaft (in steps) is:

$$\text{Motor position resolution (steps)} = 4 \cdot \textbf{Encoder resolution} \text{ (steps)}$$

The maximum frequency of the pulses emitted by the indexer for the motor maximum speed is:

$$\text{Maximum indexer pulse frequency (Hz)} = \frac{\textbf{Maximum Speed} \text{ (rpm)}}{60} \cdot \text{Motor position resolution (ppr)}$$

Execute the **Programmation** function of the **ENCODER RESOLUTION** module in order to confirm the choice of the **Encoder resolution** parameter.

Display the **Indexer / Electronic Gearbox** module accessible in the **Advanced functions** menu.

Select the **Pulse input mode** function in the **Indexer / Electronic Gearbox** module.

Initialize the parameter **Motor deadband** at 0 and the parameter **Following error** at its maximum value in the module **Indexer / Electronic Gearbox**.

Select the **Indexer input (TTL)** function or **Indexer input (Differential)** in the **Indexer / Electronic Gearbox** module according to the type of input signals used.

Save the input signal type configuration (**TTL** or **Differential**) by means of the function "**Save parameters to EEPROM**" in the menu **Files**.

Switch off the amplifier and switch it on again in order to confirm the input signal type configuration (**TTL** or **Differential**).

Activate the **ENABLE** input: the motor is controlled at its current position and must follow the input pulses emitted by the indexer board. When the amplifier is disabled (**ENABLE** input not activated), the input pulses of the master axis are not counted any more.

Check that the noise in the motor is not too loud during the motions; otherwise, reduce the anticipation term gain (**Feedforward position gain**) which is initialized at 1 (when the value of the **Encoder resolution** parameter is less than 1 024, the anticipation gain generates high current steps in the rotating motor). A reduction of the anticipation term is made detrimental to the following error but it has no influence on the motor position regulation at standstill (shaft stiffness).

Adjust the following error threshold (**Following error**) at its minimum value in order to avoid a triggering during a rotation at maximum speed.

Check for the shaft stiffness at standstill. If necessary, it is possible to get a higher stiffness by increasing at first the speed loop gain by means of the **Stability Gain** function in the **Controller** module and then the **Proportional position** gain in the **Controller parameters** menu.

If necessary, enter a position deadband by means of the **Motor deadband** parameter. This will cancel standstill oscillations due to backlashes in the transmissions between motor and load.

Save the parameters by means of the function "**Save parameters to EEPROM**" in the menu **Files** before leaving the **BPCW** software.

Use the amplifier limit switch inputs (**FC+** and **FC-**) for limiting the slave axis displacement, if necessary. If one of the limit switches **FC+** or **FC-** is activated, the motor displacement will be stopped in the appropriate direction and the position error will quickly increase.

CHAPTER 7 - FAULT FINDING

1 - POSITION FAULT

Check that the limit switches **FC+** and **FC-** are not activated.

Increase the value of the **Following Error** parameter in the **Indexer / Electronic Gearbox** menu accessible via the **Advanced Function** module.

Check that the motor speed does not reach the maximum speed defined by the **Maximum Speed** parameter of the **Analogue Input** module. Otherwise, increase the maximum motor speed defined by the **Maximum Speed** parameter or reduce the speed input command emitted by the indexer board.

Check that the current input command **IDC** does not reach the maximum value defined in the **Maximum current** parameter of the **Current** module. Otherwise, increase the **Maximum Current** parameter or increase the acceleration and deceleration times in the indexer board.

2 - OPERATING PROBLEMS

2.1 - LOUD CRACKLING NOISE IN THE MOTOR AT STANDSTILL

Check that the Motor-Amplifier-Controller ground connections answer the requirements in Chapter 4.
Check that the wiring of the incremental position input command answers the requirements in Chapter 4.

2.2 - LOUD NOISE IN THE MOTOR AT STANDSTILL AND WHEN RUNNING

Check for the rigidity of the mechanical coupling between motor and load (backlashes and elasticities in the gearboxes and couplings).
Execute the **AUTO-TUNING** function again by selecting a lower bandwidth (**Medium** or **Low**).
If the problem remains, renew the **AUTO-TUNING** procedure by activating the antiresonance filter (**Filter** = **Antiresonance**). The antiresonance filter is accessible from the **BPCW** software version **2.6** and the amplifier EPROM version **5.7**.

2.3 - LOUD NOISE IN THE MOTOR WHEN RUNNING

Select a higher position resolution on the motor (**Encoder resolution**) according to the maximum rotation speed (see chart of Chapter 5, paragraph 2) and to the indexer maximum frequency (Chapter 6, paragraph 3).

Reduce the anticipation gain (**Feedforward position gain**) and readjust the triggering threshold of the following error (**Following error**).

2.4 - MOTOR POSITION OSCILLATIONS AT STANDSTILL

Check for the rigidity of the mechanical coupling between motor and load (backlashes and elasticities in the gearboxes and couplings).
Increase the value of the **Motor Dead band** parameter in the **Indexer / Electronic Gearbox** menu accessible via **Advanced Functions**.

CHAPTER 8 - APPENDIX

LOCATION DIAGRAM OF THE HARDWARE OPTIONS