I N F R A N O R

OPERATING MANUAL

SERIES SMTBD1

OPTIONAL FUNCTIONS

(Version 2.0)

European version 2.0

STEPPING MOTOR EMULATION

OPTION "C"

This manual describes the option "C" of the SMT-BD1 amplifier: **Stepping motor emulation**. The general information about the digital amplifier commissioning are described in the standard SMT-BD1 manual.

Maintenance procedures should be attempted only by highly skilled technicians using proper test equipment. Read your warranty provision carefully before attempting to adjust or service the unit.

RECEIVING AND HANDLING

Upon delivery of the equipment, inspect the shipping containers and contents for indications of damages incurred in transit. If any of the items specified in the bill of lading are damaged, or the quantity is incorrect, do not accept them until the freight or express agent makes an appropriate notation on your freight bill or express receipt.

Claims for loss or damage in shipment must not be deducted from your invoice, nor should payment be withheld pending adjustment of any such claims.

Store the equipment in a clean, dry area. It is advisable to leave the equipment in its shipping container until ready for use. Each amplifier is checked carefully before shipment. However, upon receipt, the user should make sure that the amplifier received corresponds to or is properly rated in terms of rated voltage and current for the type of motor which is to be driven. The descriptive label affixed to the amplifier specifies electrical ratings.

OPERATING MANUAL
INFRANOR
SERIES SMTBD1
OPTION "C"
(July 1997)

1.0.0 **GENERAL DESCRIPTION**

Applications with positioning in stepping motor emulation require the **SMT-I2** daughter board on the **SMT-BD1** amplifier as well as the firmware EPROM 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 are two TTL level signals (0 to 5 V): one pulse train (PULSE) indicating the shaft motion and one direction signal (DIR) indicating the direction. These signals are connected to the X2 position connector. This kind of input allows a direct interfacing with an indexer or a PLC board, as shown below.
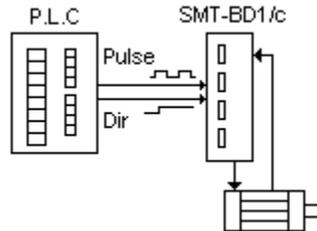
- All indexers which are compatible with the above described inputs can be used, but some important specifications of the indexer should be checked in order to obtain satisfying results.

- For "soft" motions (without motor jerking, without saturation in the amplifier and without important overshoot) the indexer MUST generate acceleration / deceleration ramps during the motion (trapezoidal shape).
- The maximum output pulse train frequency of the indexer 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) x Motor position resolution (ppr)/60

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

- The shaft initializing procedures are completely controlled by the indexer and the various possibilities are depending on the indexer capability.

- 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 follows the input pulses sent by the indexer. 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.

2.0.0 SPECIFICATIONS

2.1.0 Technical specifications

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 x 4
Programmable motor encoder resolution	Max. 8192 ppr up to 900 rpm Max. 4096 ppr up to 3600 rpm Max. 1024 ppr up to 14000 rpm
Drive position repeatability	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 Adjustable numerical gains
Position loop bandwidth	Cut-off frequency for 45° phase shift Selectable: 50 Hz, 75 Hz or 100 Hz
Logic outputs	POS : Position following error indication

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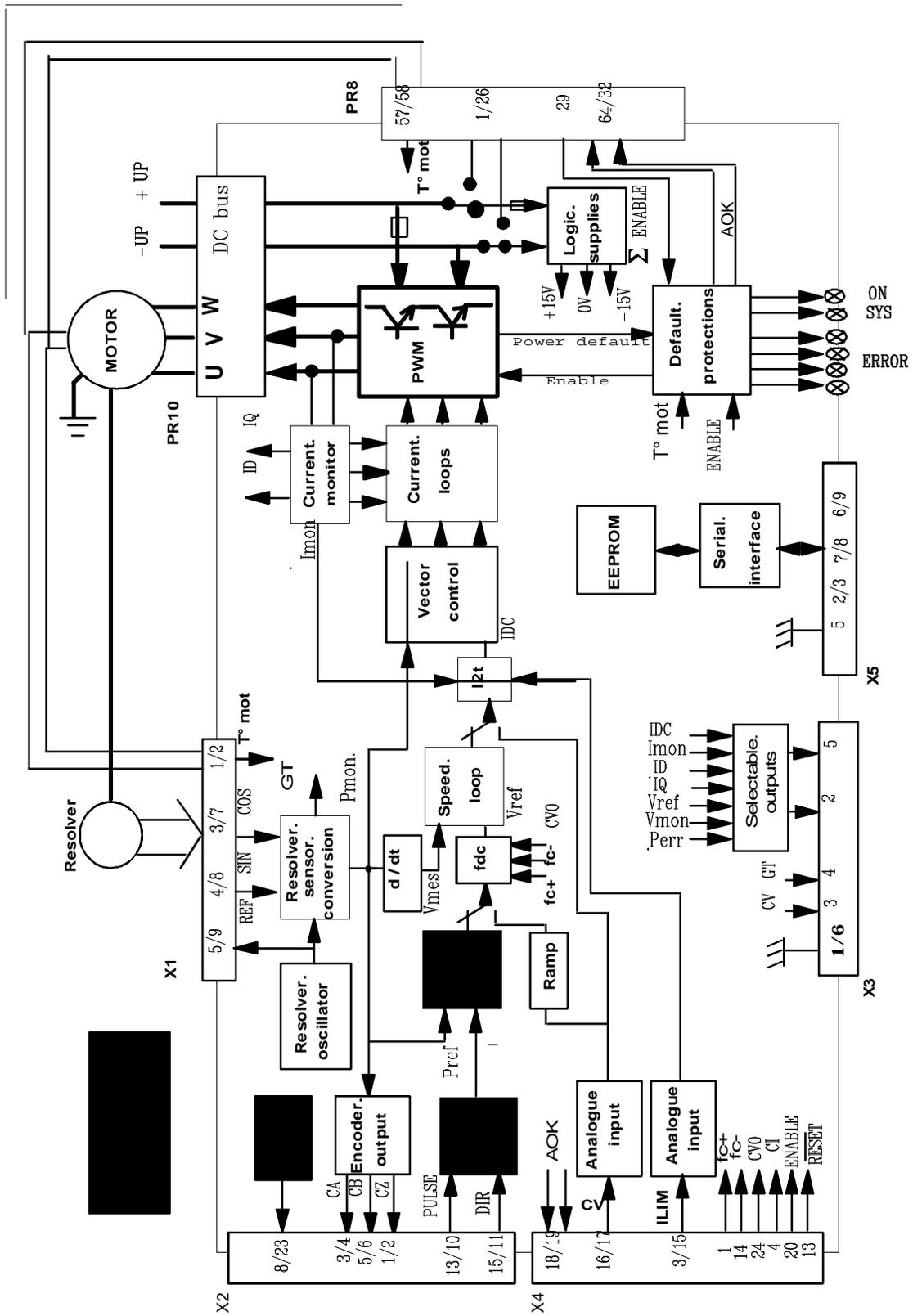
2.2.0 Stored default

The stored default can be reseted: - by the RESET function of the BPCW software,
- by the default 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.

2.3.0 Amplifier block diagram

3.0.0 INPUTS - OUTPUTS

3.1.0 X2 Position connector

3.1.1 Terminal connections

| PIN	FUNCTION	I/O	REMARK
1	CZ/	O	Motor encoder output marker pulse Z/ (5 V, 20 mA max)
2	CZ	O	Motor encoder output marker pulse Z
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 : following error indication
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 (see chapter 3.1.3)
12	PULSE/	I	Indexer PULSE/ signal input (see chapter 3.1.3)
15	DIR/	I	Indexer DIR signal input (see chapter 3.1.3)
14	DIR/	I	Indexer DIR/ signal input (see chapter 3.1.3)
16,17,18,19	Reserved		Reserved
9	Reserved		Reserved
20,21,22	Reserved		Reserved
24,25	Reserved		Reserved

3.1.2 Logic outputs specification

The POS output (following error indication) is an "open collector" and "optocoupled". The transistor is disabled if a default occurs. The application scheme is shown below. The maximum output current is 5 mA.


7
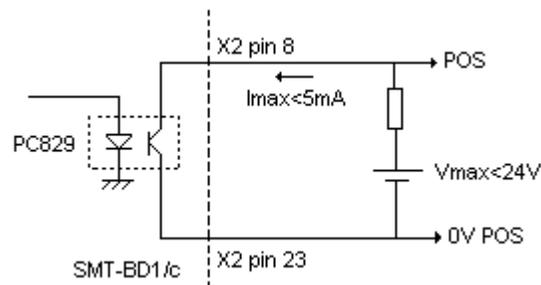
3.1.3 Indexer input specification

The TTL PULSE and DIR inputs are connected to the amplifier as shown below:
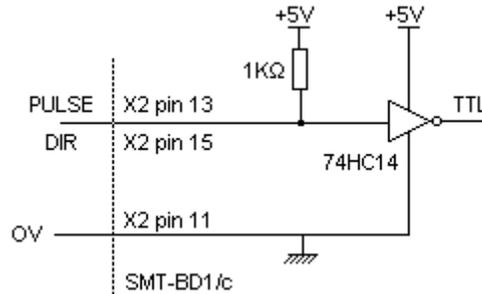
For indexers with open collector output and operating at high frequencies (> 100 kHz), a pull-up resistor corresponding to the transistor output current must be wired in the X2 connector, as shown below (the pull-up resistor is mounted in parallel to the 1 kΩ resistor in the amplifier).
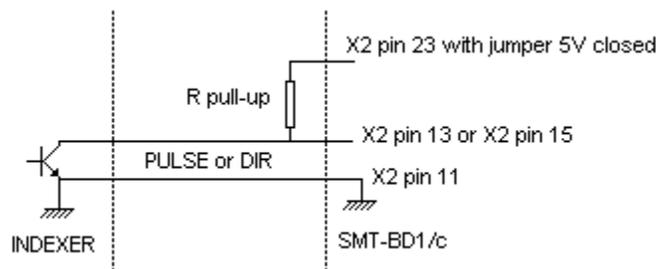
The differential PULSE and DIR inputs are connected to the amplifier as shown below:
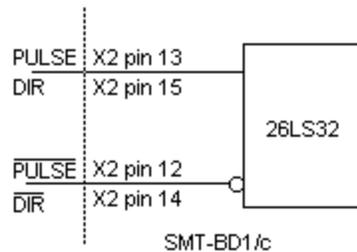
This type of input is suitable for long indexer-amplifier connections (a 26LS31 driver is recommended).

3.2.0 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 boards 01612A, 01612B and 01612C

4.0.0 CONNECTIONS

4.1.0 Connection diagrams

4.1.1 TTL Indexer signals
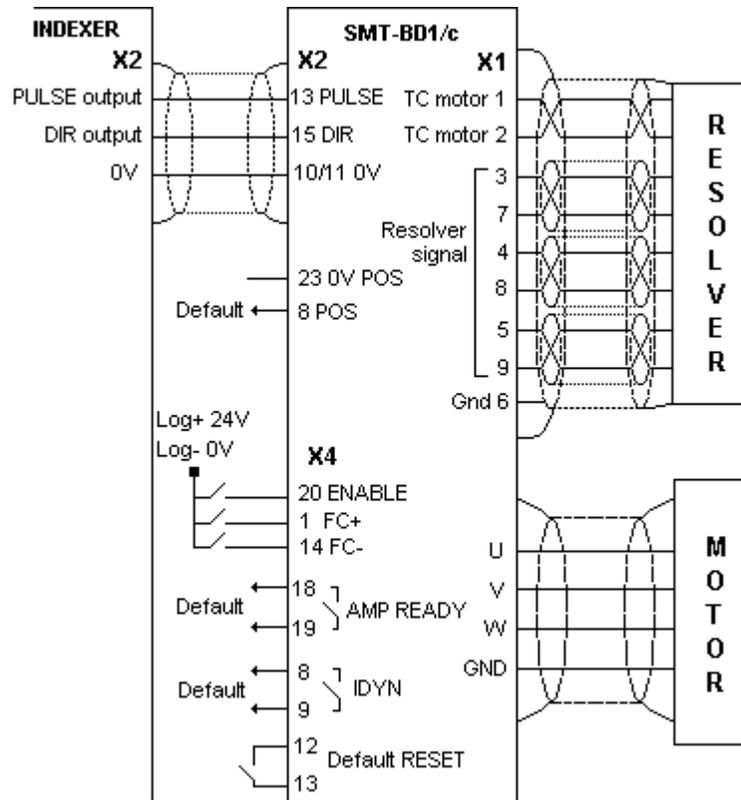
4.1.2 Differential indexer signals
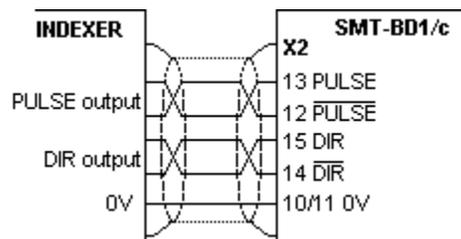
4.2.0 Wiring recommendations

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 0Volt 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.

5.0.0 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.

5.1.0   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 sent by the indexer board is received as an incremental input command on the X2 connector.

5.2.0   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 maximum value of this parameter according to the maximum motor speed (Maximum speed) is indicated in the chart below:

| MAXIMUM SPEED (rpm)	900	3600	14000
MAXIMUM ENCODER RESOLUTION	8192	4096	1024

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

Following error parameter defines the maximum 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 default (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 default (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 32767 steps.

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 32767 steps.

5.3.0 <u>Position regulator parameters</u>

The regulator structure used for the Indexer control is described below:
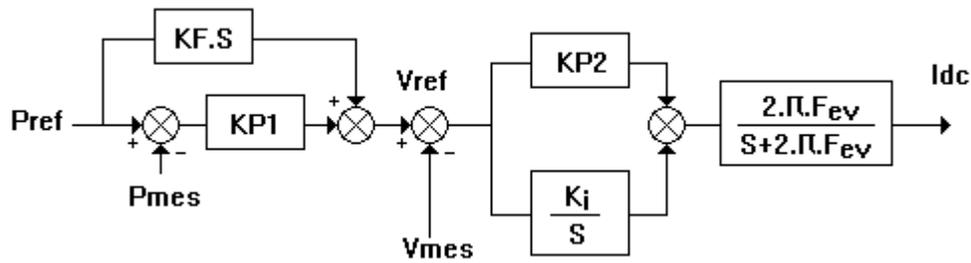
The Controller parameters function in the Advanced functions menu of the BPCW software allows the access to all regulator parameters.

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.

Proportional speed gain parameter defines the proportional regulator gain (KP2) acting upon the speed error. The adjustment range is between 0 and 4095.

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

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

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.

6.0.0 COMMISSIONING

6.1.0 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** daughter board between both logic and power boards (see chapter 8.0.0).

6.2.0 Applying power

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

6.3.0 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 **PI ^{2}** speed regulator before executing the **Autotuning** function in the **Controller** module.

  In case of loud noise in the motor at standstill or when running, check the transmission rigidity between motor and load (backlashes and elasticities in gearings and couplings).
  If necessary, redue the **AUTOTUNING** procedure by choosing a lower bandwidth (**Bandwidth = Medium** or **Low**). If the problem remains, redue the **AUTOTUNING** 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 2.1.0 for limitations).

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

  Motor position resolution (steps) = 4 x **Encoder resolution** (steps)

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

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

- 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 sent by the indexer board. When the amplifier is disabled (ENABLE input not activated), the input pulses of the master axis are not counted.

- Check that the noise in the motor is not too loud during the motions. If so, reduce the **Feedforward position gain** which is initialized at 1 (when the value of the Encoder resolution parameter is less than 1024, this gain generates high current steps in the rotating motor). A reduction of this term is detrimental to the **Following error**, but it has no influence on the motor position regulation at standstill (shaft stiffness).

- Adjust the **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 stiffer system 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 eliminate standstill oscillations due to backlashes in the coupling 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 axis displacement, if necessary. If one of the limit switches FC+ or FC- is activated, the motor will stopped in the appropriate direction and the position error will quickly increase.

7.0.0 FAULT FINDING

7.1.0 Position default

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 Analog Input module. Otherwise, increase the maximum motor speed defined by the **Maximum Speed** parameter or reduce the speed input command sent 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.

7.2.0 Operating problems

7.2.1 Loud crackling noise in the motor at standstill

Check that the Motor-Amplifier-Controller ground connections meet the requirements in chapter 4.0.0.
Check that the wiring of the incremental position input command meet the requirements in chapter 4.0.0.

7.2.2 Loud noise in the motor at standstill and when running

Check for the rigidity of the mechanical coupling between motor and load (backlashes and elasticityís in the gearboxes and couplings).
Execute the **Autotuning** function again by selecting a lower bandwidth (Medium or Low) .
If the problem remains, redue the **AUTOTUNING** 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**.

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 5.2.0) and to the indexer maximum frequency (Chapter 6.3.0)

Reduce the **Feedforward position gain** and readjust the threshold of **Following error**.

7.2.4 Motor position oscillation at standstill

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

8.0.0 <u>APPENDIX</u>

LOCATION DIAGRAM OF THE HARDWARE OPTIONS