

This manual describes the **option "e"** of the **SMT-BD1** amplifier: **Master/slave tension control application**. 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.

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OPTION "e"

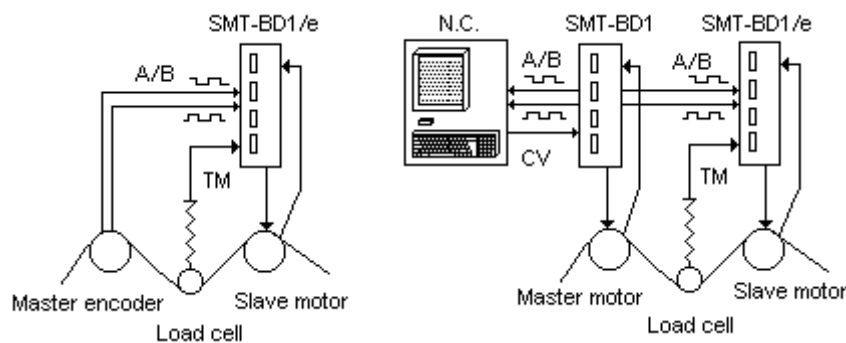
MASTER/SLAVE TENSION CONTROL APPLICATIONS

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CHAPTER 1 - GENERAL DESCRIPTION

The master / slave tension control applications require the **SMT-I3-BD1** daughter board and the **X.X E** version of the firmware memory on the **SMT-BD1** amplifier. In this configuration, the **SMT-BD1/e** amplifier controls the slave motor speed with regard to the master axis speed and the material tension value given by the load cell. The master axis speed input command is received as two differential encoder signals: **A**, **/A** and **B**, **/B** in quadrature. These signals enter the amplifier position connector **X2**. The load cell tension value **TM** is received as a +/- 10 V analogue voltage. This signal enters the amplifier command connector **X4**. The system configuration is described below.



The rated speed ratio between both master and slave motors is defined by the encoder resolution ratio of each motor multiplied by an adjustable ratio factor parameter (from 0,01 % to 100 %). The slave motor encoder resolution is programmable between 1 and 8192 ppr.

The master / slave speed ratio is continuously adjusted by the PID tension controller according to tension error in order to provide a constant material tension value when the tension controller is enabled (**TDI** input not activated).

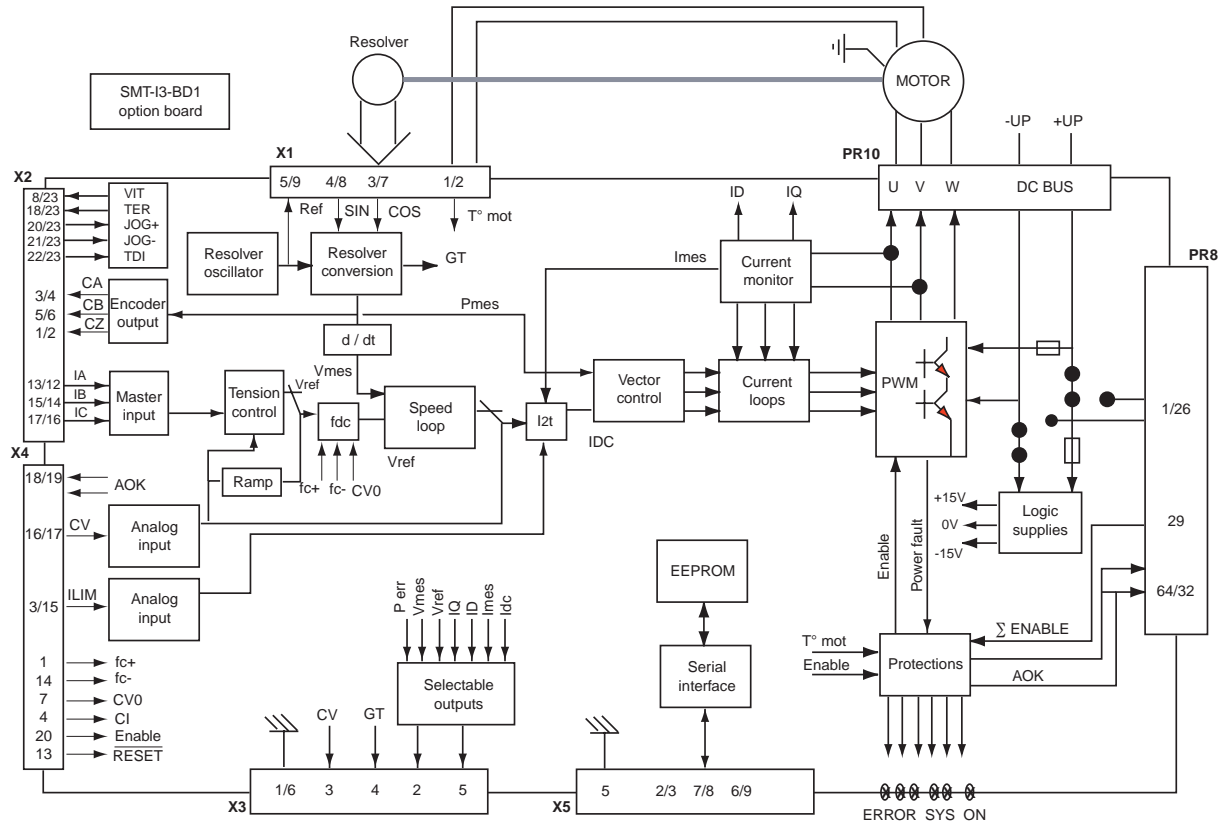
It is possible to make a manual tension adjustment at standstill by using the **JOG+** and **JOG-** inputs. These inputs are connected with two push buttons and allow to move the slave motor in the positive or negative direction when they are activated. The tension set point value is stored in the amplifier and a soft start can be provided when the amplifier is enabled thanks to the tension set point ramp. Material braking can be detected when the load cell voltage is below the threshold defined by the "**tension input threshold**" parameter; at this moment, the **TER** output is disabled.

CHAPTER 2 - SPECIFICATIONS

1 - TECHNICAL DATAS

Speed input command of the slave motor	Two encoder pulse trains A and B Max. frequency = 250 KHz
Speed ratio between master and slave motors	Scale factor x MER / SER Scale factor resolution = 0,01 % MER= Master encoder resolution SER= Slave encoder resolution
Programmable encoder resolution of the slave motor	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
Material tension measurement	Analogue input - 10 V to + 10 V Resolution: 12 bit (16 bit optional) Adjustable low pass filter frequency
Tension regulator PID	Sample period: 0,5 ms Adjustable numerical gains Adjustable input command ramp
Speed regulator P or PI	Sample period: 0,5 ms Integrator ant saturation system Adjustable digital gains Antiresonance filter
Speed loop bandwidth	Adjustable cut-off frequency: 50 Hz, 75 Hz or 100 Hz
Logic outputs	VIT : Speed following error indication TER : Tension input error indication
Logic inputs	JOG+ : Positive speed jog JOG- : Negative speed jog TDI : Tension controller disable input

2 - AMPLIFIER BLOCK DIAGRAM



3 - DISPLAYED FAULT

PROTECTION	DISPLAY CODE	LED
Speed following error (blinking display)	POS	● ● ● ☼

● = LED is unlit ☼ = LED is lit

Note:

The "speed following error" fault is not stored and the amplifier is not disabled.

CHAPTER 3 - INPUTS - OUTPUTS

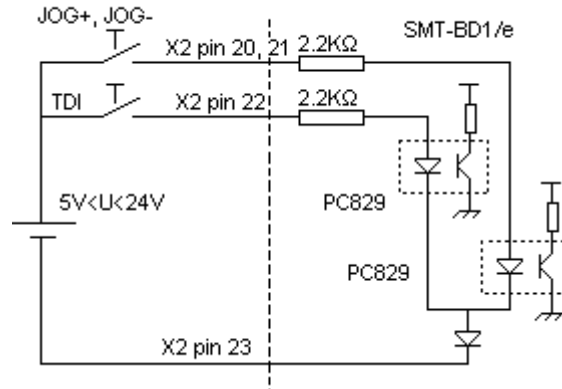
1 - X2 POSITION CONNECTOR

1.1 - PIN REFERENCE

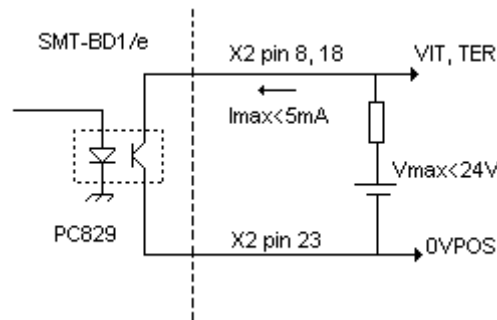
PIN	FUNCTION	I/O	REMARK
1	CZ/	O	Motor encod. output of the zero pulse Z/ (5V max. current 20mA)
2	CZ	O	Motor encoder output of the zero pulse Z
3	CA/	O	Motor encoder output channel A/ (5 V max. current 20 mA)
4	CA	O	Motor encoder output channel A
5	CB/	O	Motor encoder output channel B/ (5 V max. current 20 mA)
6	CB	O	Motor encoder output channel B
7,10,11	0 V		GND
12	IA/	I	Master encoder input channel A/ (5 V input current 2 mA)
13	IA	I	Master encoder input channel A
14	IB/	I	Master encoder input channel B/ (5 V input current 2 mA)
15	IB	I	Master encoder input channel B
16, 17	Reserved		Reserved
9,19	Reserved		Reserved
8	VIT	O	Logic output VIT: Speed following error indication
18	TER	O	Logic output TER : Tension input error
20	JOG+	I	Logic input JOG+ : Positive direction jog
21	JOG-	I	Logic input JOG- : Negative direction jog
22	TDI	I	Logic input TDI : Tension controller disable
23	0 V I/O		0 Volt logic inputs and outputs
24	+ 5 V	O	+/- 5 % 300 mA available with jumper 5 V closed
25	0 V		for master encoder supply (if necessary)

1.2 - LOGIC INPUTS/OUTPUTS SPECIFICATIONS

The **JOG+**, **JOG-** and **TDI** inputs are "optocoupled" and operate in positive logic, as shown below. The input voltage corresponding to level 1 is between 5 and 24 V.



The **VIT** and **TER** outputs (error indication) are "open collector" and "optocoupled". The transistor is inhibited when a fault occurs. The traditional application scheme is shown below. The maximum output current is 5 mA.



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 \pm maximum speed
4	Speed signal GT	± 8 V for $\pm 14\ 000$ rpm
5	DAC 2 output	± 10 V resolution 8 bits, linearity: 2 % (IDC, Imon., ID, IQ, Vref, Vmon., Pos err) *

* See part "Digital oscilloscope" of the "**BPCW** Options" manual.

Linearity: 10 % on logic boards 01612A, 01612B and 01612C.

3 - X4 COMMAND CONNECTOR

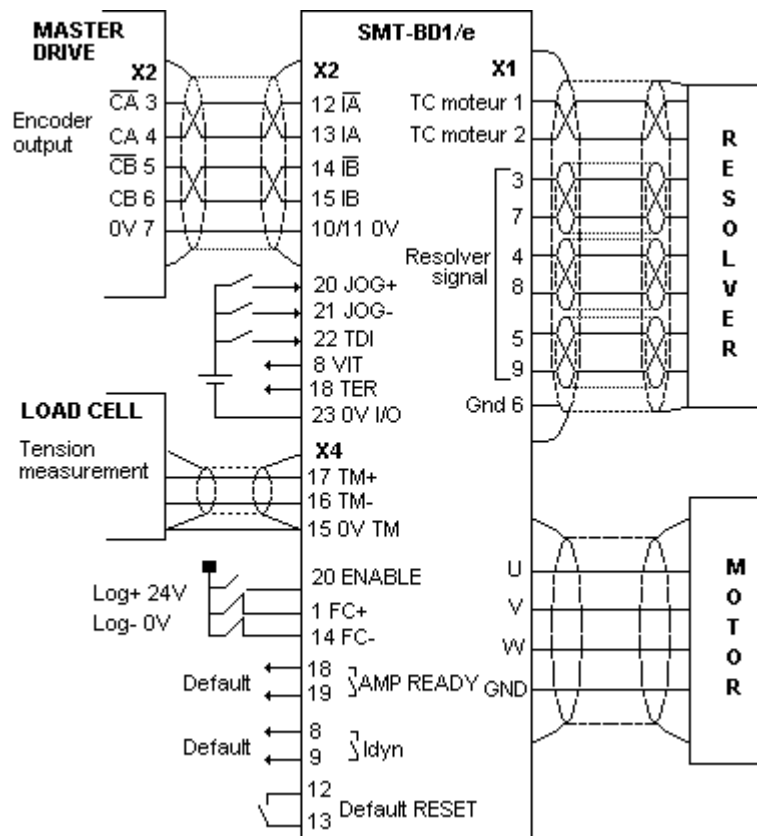
PIN	FUNCTION	I / O	REMARK
17	Tension input TM+	I	+/- 10 V load cell signal for tension control application
16	Tension input TM-	I	
15	0 Volt tension input	I	

For other pins please see the **SMT-BD1** standard manual.

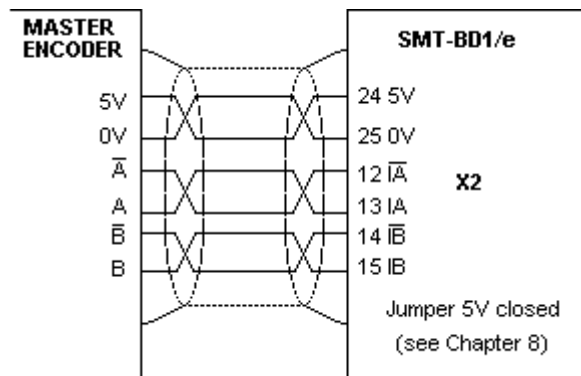
CHAPTER 4 - CONNECTIONS

1 - CONNECTION DIAGRAMS

1.1 - CONNECTION OF THE MASTER AMPLIFIER



1.2 - CONNECTION OF THE MASTER ENCODER



2 - MANDATORY WIRING

It is recommended to use a shielded cable for the master axis incremental input signals **A** and **B**. Cable ends should have a **360° shielded connection by means of the metallic X2 connector** (refer to Chapter 8, section 6 of the **SMT-BD1** standard manual). **The amplifier Zero Volt (X2, pins 10/11) and the master Zero Volt (Gnd) must be connected by means of a wire.**

The crossing of the **A** and **B**, **A** and **A/** or **B** and **B/** signals on the master axis incremental input changes the rotation direction of the slave motor with regard to the master motor.

It is recommended to use a shielded cable for the analogue tension measurement signal **TM**. Cable ends should have a **360° shielded connection by means of the metallic X4 connector** (refer to Chapter 8, section 6 of the **SMT-BD1** standard manual). The amplifier Zero Volt (**X4, pin 15**) and the load cell Zero Volt (**Gnd**) must be connected by means of a wire.

The load cell signal (**TM**) wiring must be made according to the polarity between the load cell and the amplifier (**TM+** on "diff high" of the load cell). If required, the load cell signal sign can be changed by a software using the tension controller parameters (see tension controller parameters, chapter 5, section 3).

CHAPTER 5 - ADJUSTABLE PARAMETERS

The parameters used for master/slave tension control applications are accessible via the **Tension control** parameters and **Tension loop adjustment** submenus of the **Advanced functions** menu, in the **BPCW** software.

Master/Slave tension control parameters	
<input checked="" type="checkbox"/> Pulse input mode	
Speed ratio scaling (%)	100.0
Maximum ratio variation (%)	10.0
Speed following error (rpm)	100
<hr/>	
Tension input filter (Hz)	1000
Tension input threshold (Volts)	0.50
Tension acquisition (Volts)	2.00
Tension set point (Volts)	2.00
Tension set point ramp (s)	4.000
OK Cancel Help	

Tension loop adjustment	
Sensibility	
<input type="radio"/> 1/100 <input type="radio"/> 1/1000 <input type="radio"/> 1/10000 <input checked="" type="radio"/> 0.01	
Tension error scaling (%)	100.00 ← →
<input type="checkbox"/> Reverse tension error sign	
Proportional tension gain	1.50 ← →
Integral tension gain	0.1500 ← →
Derivative tension gain	0.02 ← →
Close Help Validate	

1 - OPERATION MODE

The operation as a master/slave tension control is selected by the **Pulse input mode** function in the **Tension control parameters** submenu of the **Advanced functions** menu.

This mode corresponds to the slave motor speed control with a P or **PI** regulator. The speed reference is received as an incremental pulse emitted by the master motor and the speed ratio is modified by the PID tension controller according to the analogue load cell signal input.

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 slave motor shaft. The limit value of this parameter according to the maximum motor speed (**Maximum speed**) is indicated in the chart below:

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

The following parameters are accessible via the **Tension control parameters** submenu of the **Advanced functions** menu.

The **Speed ratio scaling** parameter defines the reduction factor acting on the master/slave speed ratio set by the slave and master encoder resolutions. The adjustment range is between 0 % and 100 %.

The **Maximum ratio variation** defines the maximum value of the differential speed (BM) given by the PID tension regulator to control the material tension. The adjustment range is between 0 % and 100 % of the **Maximum speed** parameter.

The **Speed following error** parameter defines the maximum permissible value of the slave motor speed error. When the speed error reaches this value, the **VIT** output (following error indication) is activated and the following error fault (**Pos error**) is blinking on the amplifier front panel. The adjustment range is between 0 rpm and the **Maximum speed** parameter.

The **Tension input filter** parameter defines the cut-off frequency at -3db (Fcv) of a first order low pass filter acting on the tension measurement signal issued from the load cell. The value of this parameter is chosen according to the analogue load cell signal noise and disturbances. The adjustment range is between 20 Hz and 1000 Hz.

The **Tension input threshold** parameter defines the threshold of the tension measurement, in Volts, for a material braking detection. When the tension value emitted by the tension sensor is dropping below this value, the **TER** output (tension input error indication) is disabled. The adjustment range is between - 10 V and + 10 V.

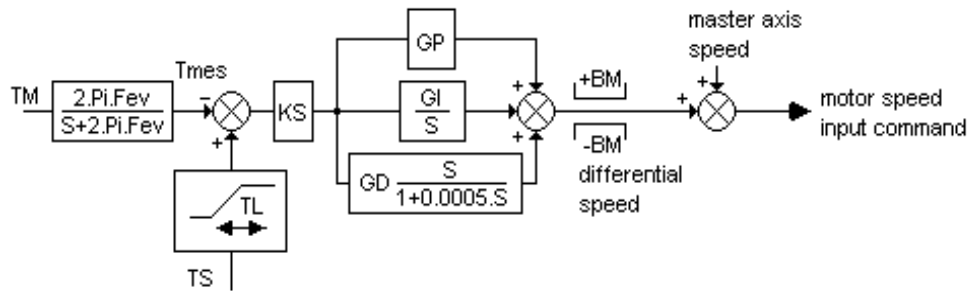
The **Tension acquisition** parameter defines the voltage measured by the load cell device. The range is between - 10 V and + 10 V.

The **Tension set point** parameter defines the tension reference (**TS**) for the tension controller. The adjustment range is between - 10 V and + 10 V.

The **Tension set point ramp** parameter defines the minimum possible response time (**TL**) for a variation of the tension set point between 0 and the maximum value (10 V). The adjustment range is between 0 and 32 seconds.

3 - TENSION CONTROLLER PARAMETERS

The tension controller structure used for tension control applications is described below:



The **Tension loop adjustment** submenu in the **Advanced functions** menu of the **BPCW** software allows the access to all regulator parameters.

The **Tension error scaling** parameter defines the reduction factor (**KS**) acting on the servo loop tension error to adapt the gain scale of the tension regulator to the application specifications. The adjustment range is between 10 % and 100 %.

The **Reverse tension error sign** function allow to reverse the tension regulator error sign according to the polarity of the tension measurement voltage issued by the load cell to ensure servo loop stability.

The **Proportional tension gain** parameter defines the proportional gain (**GP**) of the tension regulator. The adjustment range is between 0 and 128.

The **Integral tension gain** parameter defines the integral gain (**GI**) of the tension regulator. The adjustment range is between 0 and 1.

The **Derivative tension gain** parameter defines the derivative gain (**GD**) of the tension regulator. The adjustment range is between 0 and 2048.

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-I3-BD1** daughter board between both logic and power boards (see chapter 8 for the hardware configuration).

Check that the **E** and **S** jumpers are open on the logic board (see chapter 8 for hardware configuration)

Check for the version of the firmware memory that must be **X.X E**.

If using an external encoder for the master motor, check that the **5 V** jumper is correctly made on the logic board for the encoder supply (see Chapter 8: Hardware location diagram).

2 - POWERING

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

3 - MASTER/SLAVE STARTING 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 **AUTO-TUNING** 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, paragraph 2 for the limitation of this parameter according to the motor maximum speed).

The maximum speed ratio between both master and slave motors is equal to the ratio of the following resolutions:

$$\text{Maximum speed ratio} = \frac{\text{Encoder resolution of the master motor (ppr)}}{\text{Encoder resolution of the slave motor (ppr)}}$$

The **Maximum speed** of the slave motor is equal to the product of the **Maximum speed** of the master motor by the maximum speed ratio:

Maximum Speed of the slave motor (rpm) = **Maximum Speed** of the master motor (rpm) x **Maximum speed ratio**

Select the **Tension control** parameters submenu in the **Advanced functions** menu of **BPCW** software.

Select **Pulse input mode** in the **Tension control** module.

Adjust the **Speed ratio scaling** parameter in order to obtain the desired master/slave speed ratio:

$$\text{Speed ratio} = \frac{\text{Encoder resolution of the master motor (ppr)}}{\text{Encoder resolution of the slave motor (ppr)}} \times \frac{\text{Speed ratio scaling (\%)}}{100}$$

Set the **Maximum ratio variation** parameter at 0 % in order to disable the tension controller and to test first the master/slave system with a fixed ratio.

Activate the **ENABLE** signal: the slave motor must follow the master motor speed with the desired ratio. If the rotation direction is not correct, change it by using the **Reverse movement** function in the **ANALOGUE INPUT** module.

Adjust the **Speed following error** parameter at its minimum value in order to avoid the **VIT** output to be activated during the normal duty cycle.

4 - TENSION CONTROL ADJUSTMENT

Preliminary remark: It is advisable to limit the motor torque (parameter **Maximum current**) during the commissioning phase in order to avoid a material braking if the tension regulator becomes instable.

Engage the material in the machine and fasten it to the downstream traction system.

Select the **Tension control parameters** submenu accessible via the **Advanced functions** menu of the **BPCW** software.

Initialize the **Maximum ratio variation** parameter at 1 %.

The material tension is manually adjusted by using the **JOG+** and **JOG-** inputs to move only the slave axis.

When the optimum material tension is reached, read the load cell voltage by means of the **Tension acquisition** function.

Make the **Tension set point** parameter equal to the **Tension acquisition** parameter.

Initialize the **Tension input threshold** parameter to detect material braking.

Initialize the **Tension set point ramp** parameter in order to get a progressive material tension.

Initialize the **Tension input filter** parameter at 1000 Hz.

Select the submenu **Controller parameters** in the menu **Advanced functions** of **BPCW**.

Set at 0 the **Integral 2 speed gain** of the module **Controller parameters**.

Select the **Tension loop adjustment** submenu accessible via the **Advanced functions** menu of the **BPCW** software.

Initialize the **Tension error scaling** parameter to its maximum value (100 %).

Initialize the **Integral tension gain** and the **Derivative tension gain** parameters to 0.

Initialize the **Proportional tension gain** parameter at its minimum value.

Disable the **TDI** input to enable the tension regulator and activate the **ENABLE** input.

If the tension regulator is instable (continuous material unwinding or maximum tension), select the **Reverse error sign** function.

If the system is oscillating, reduce the value of the **Tension error scaling** parameter until the system remains stable.

When the system is stable, increase the **Proportional tension gain** parameter until the value you had when the system became unstable; at this point, reduce the **Proportional tension gain** in order to ensure the system stability.

In order to optimize the dynamic response of the tension regulator, increase progressively the parameter **Derivative Tension gain**.

Note

It is also possible to select a proportional speed gain (by setting at zero the **Integral 1 speed gain**) and to use the **Integral tension gain** parameter for adjusting the tension regulator.

If the tension regulator generates some noise or disturbances in the master/slave system, use the **Tension input filter** parameter to filter the tension measurement issued from the load cell device.

When the adjustment procedure is over, select **SAVE PARAMETERS TO EEPROM** function before quitting **BPCW**.

CHAPTER 7 - FAULT FINDING

1 - "Speed following error" FAULT

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

Increase the value of the **Speed Following Error** parameter in the **Tension control** parameters module accessible via the **Advanced Functions** menu.

Check that the slave motor speed does not reach the maximum speed defined by the **Maximum Speed** parameter of the **Analogue Input** module. Otherwise, increase the maximum slave motor speed defined by the **Maximum Speed** parameter or reduce the master axis speed.

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

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 input answers the requirements in Chapter 4.

Check that the wiring of the load cell device 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 **AUTOTUNING** 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 the highest position resolution on the slave motor (**Encoder resolution**) according to the maximum rotation speed (see chart in Chapter 5, paragraph 2). It is also necessary to modify the master motor resolution in order to keep the same reduction ratio.

Decrease the **Tension input filter** parameter value (in the **Tension control** parameters module accessible via the **Advanced Functions** menu) to filter the tension measurement, if necessary.

CHAPTER 8 - APPENDIX

LOCATION DIAGRAM OF THE HARDWARE OPTIONS

