I N F R A N O R

OPERATING MANUAL

SERIES SMTBD1

OPTIONAL FUNCTIONS

(Version 2.0)

European version 2.0

MASTER/SLAVE TENSION CONTROL

OPTION “E”

This manual describes the option "E" of the SMT-BD1 amplifier: **Master / Slave tension control**. 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.

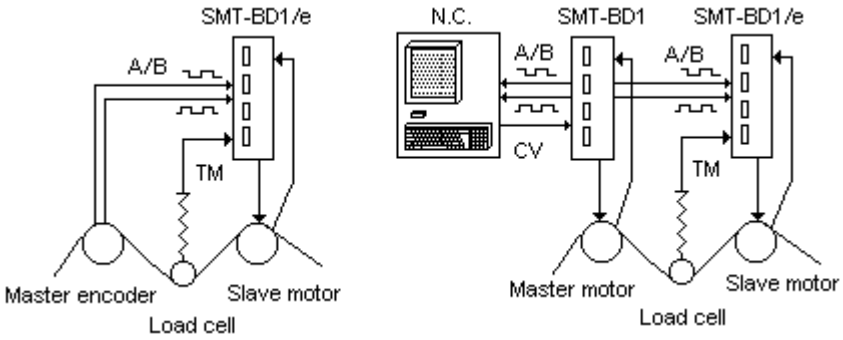
Claims for loss or damage in shipment must not be deducted from your invoice, nor should payment be withheld pending adjustment of any such claims.

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 "E"
(July 1997)

1.0.0 GENERAL DESCRIPTION

The master / slave tension control function require the **SMT-I3** 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 are connected to the X2 position connector. The load cell tension value TM is received as a +/- 10 V analog voltage. This signal is connected to the X4 command connector. 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 factor ratio (from 1 to 0. 25). 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. Material braking can be detected when the load cell voltage is below the minimum voltage value defined by the **Tension input threshold** parameter. At this time, the **TER** output is activated.

2.0.0 SPECIFICATIONS

2.1.0 Technical specifications

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	Ratio 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. 8192 ppr up to 900 rpm Max. 4096 ppr up to 3600 rpm Max. 1024 ppr up to 14000 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 PI^2	Sample period: 0,5 ms Integrator antisaturation system Adjustable digital gains Antiresonance filter
Speed loop bandwidth	Cut-off frequency for 45° phase shift Selectable: 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

2.3.0 Stored default

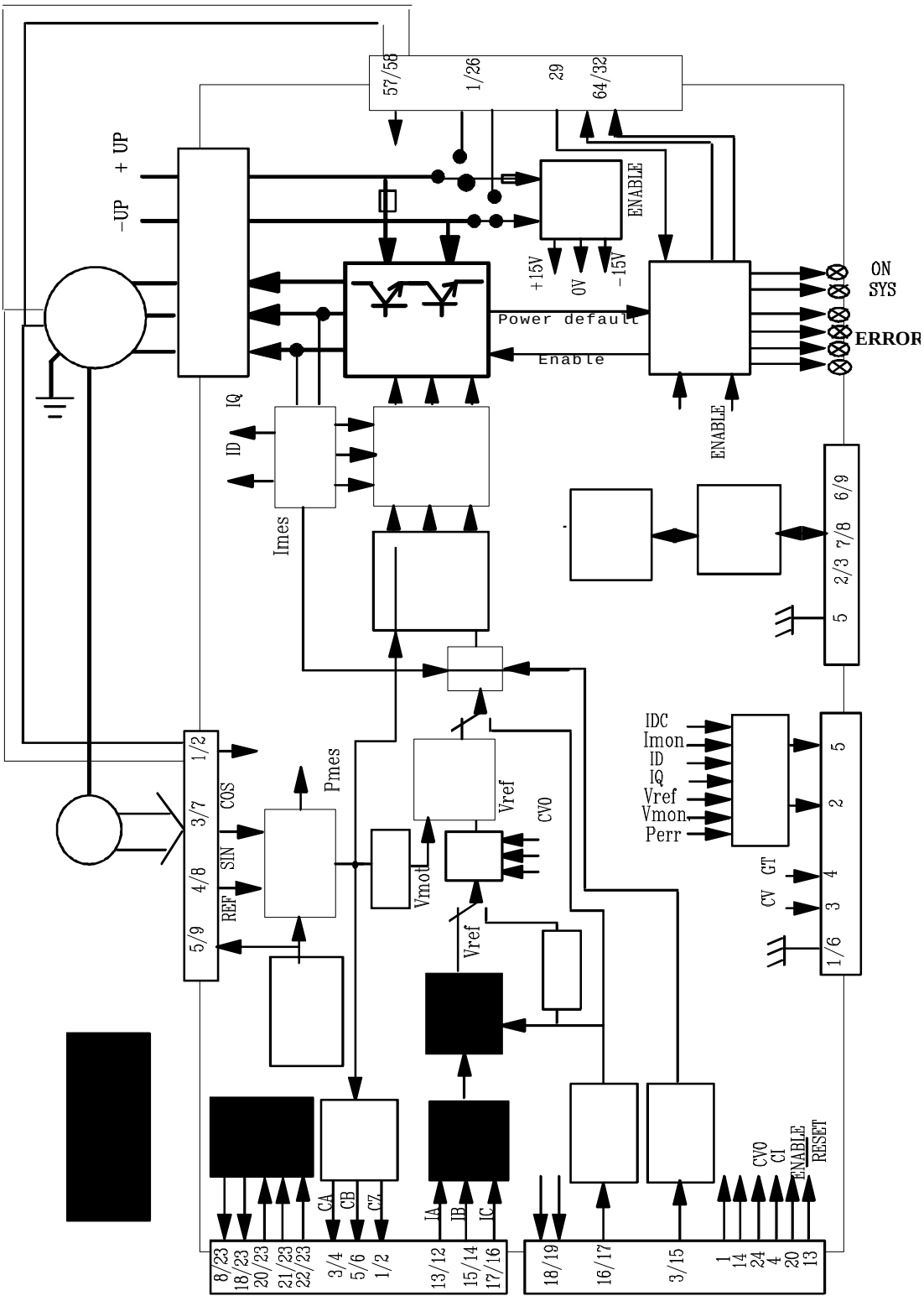
The **Speed following error** default is not stored and the amplifier is not disabled.

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

* ○ = LED is unlit; ● = LED is lit.

Note: The **Speed following error** default is not stored and the amplifier is not disabled.

2.2.0 Amplifier block diagram



3.0.0 INPUTS - OUTPUTS

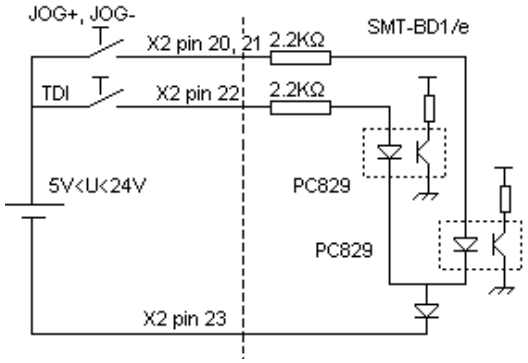
3.1.0 X2 Position connector

3.1.1 Terminal connections

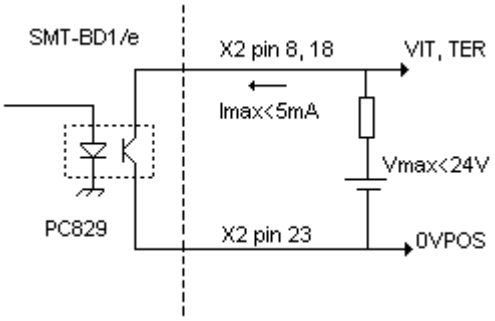
PIN	FUNCTION	I/O	REMARK
1	CZ/	O	Motor encoder output channel Z/ (5V max. current 20mA)
2	CZ	O	Motor encoder output channel Z
3	CA/	O	Motor encoder output channel A/ (5 V max. current 20 mA)
4	CA	O	Motor encoder output channel A
5	CB/	O	Motor encoder output channel B/ (5 V max. current 20 mA)
6	CB	O	Motor 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	IZ/	I	Master encoder input channel Z/ (if used)
17	IZ	I	Master encoder input channel Z (if used)
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)

3.1.2 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 default occurs. The application scheme is shown below. The maximum output current is 5 mA.



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 ±14000 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

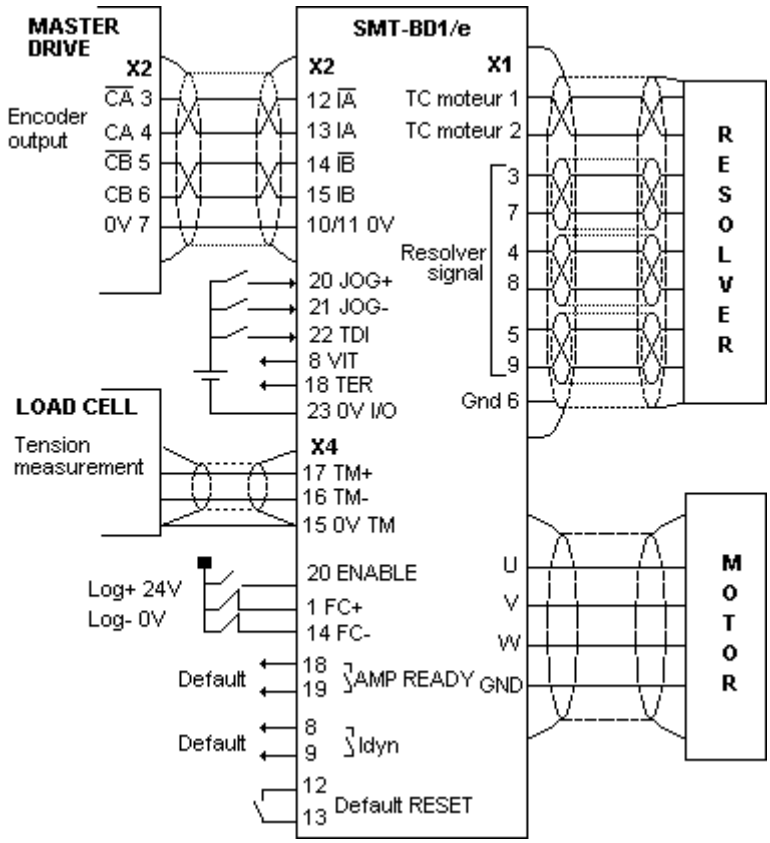
3.3.0 X4 Command connector

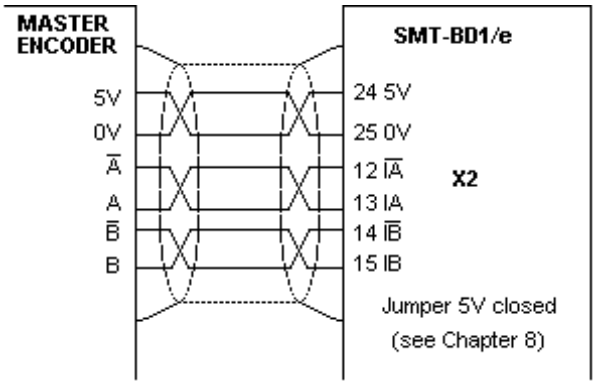
PIN	FUNCTION	I / O	CHARACTERISTICS
17	Tension input TM+	I	+/- 10 V load cell signal for tension control
16	Tension input TM-	I	+/- 10 V load cell signal for tension control
15	0 Volt tension input	I	

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

4.0.0 CONNECTIONS

4.1.0 Connection diagram





4.2.0 Wiring recommendations

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 together.

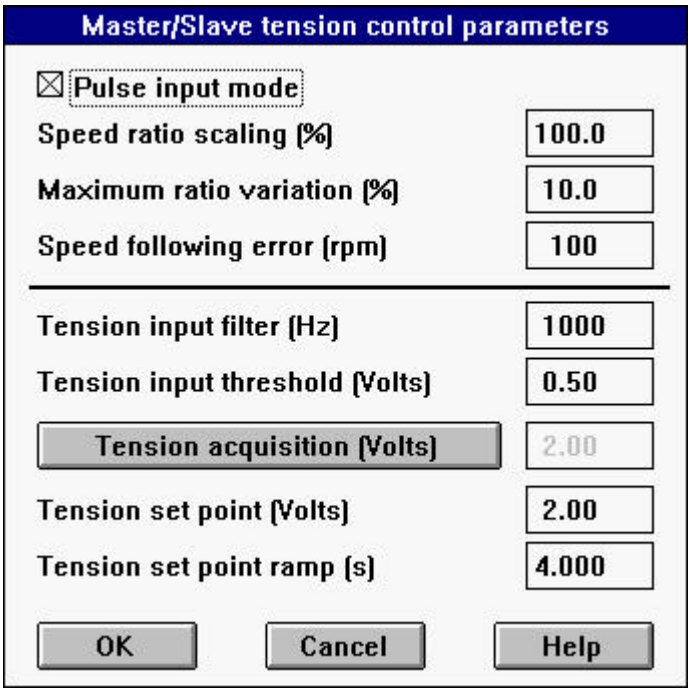
The crossing of the A and B, A and A/ or B and B/ signals on the master axis incremental input changes the rotation direction of the slave motor with regard to the master motor.

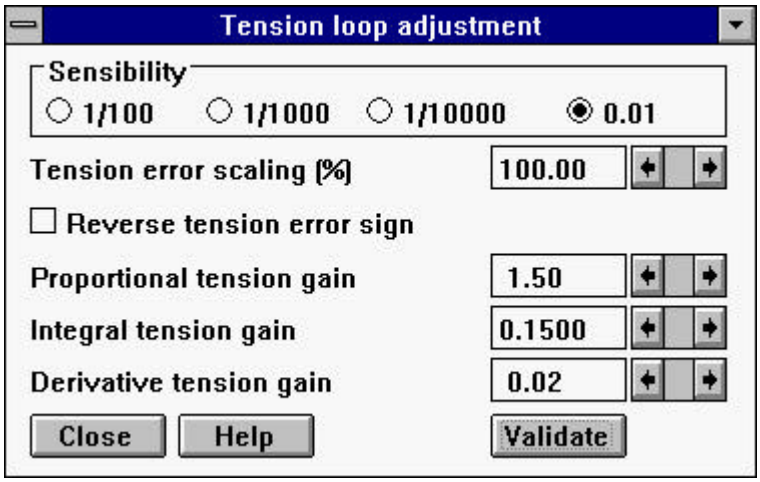
It is recommended to use a shielded cable for the analogue tension measurement signal TM. Cable ends should have a **360° shielded connection by means of the metallic X4 connector** (refer to Chapter 8, section 6 of the SMT-BD1 standard manual). The amplifier Zero Volt (X4, pin 15) and the load cell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

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 software using the tension controller parameters (see chapter 5.3.0).

5.0.0 ADJUSTABLE PARAMETERS

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





5.1.0 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 sent by the master motor and the speed ratio is modified by the PID tension controller according to the analogue load cell signal input.

5.2.0 Application parameters

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	3600	14000
MAX. ENCODER RESOLUTION	8192	4096	1024

The following parameters are accessible via the **Master / Slave tension control parameters** submenu of the Advanced functions menu.

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

Maximum ratio variation defines the maximum slave speed variation given by the tension regulator to control the material tension. The adjustment range is between 0 % and 100 % of the **Maximum speed** value for the slave motor.

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 default (Pos error) is blinking on the amplifier front panel. The adjustment range is between 0 rpm and the **Maximum speed** value for the slave motor.

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 analog load cell signal noise and disturbances. The adjustment range is between 20 Hz and 1000 Hz.

Tension input threshold parameter defines the minimum permissible value of the tension measurement issued from the load cell device in Volts to detect material braking. When the tension input absolute value drops below this value, the **TER** output (tension input error indication) is activated. The adjustment range is between 0 and 10 V.

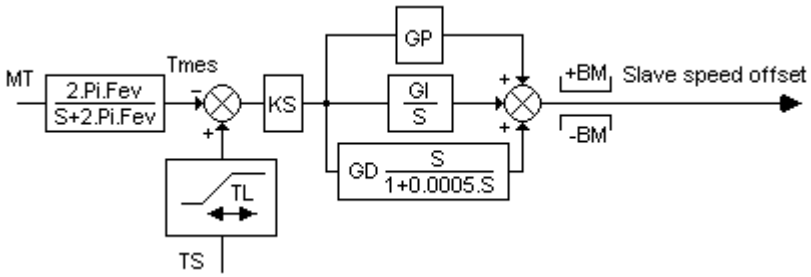
Tension acquisition parameter defines the tension measurement in Volts (TM) issued from the load cell device. The range is between - 10 V and + 10 V.

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

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

5.3.0 Tension controller parameters

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



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

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

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. When this command is selected the **Tension set point** value sign must also be changed to match the **Tension acquisition** value sign.

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

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

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

6.0.0 COMMISSIONING

6.1.0 Checking the configuration

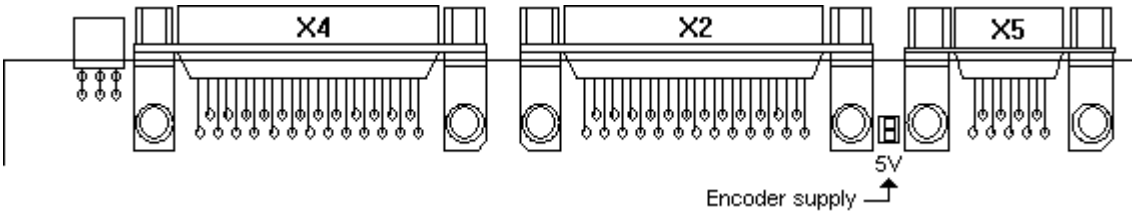
Check the amplifier standard configuration as described in Chapter 6 of the standard SMT-BD1 manual.

Check for the presence of the SMT-I3 daughter board between both logic and power boards (see chapter 8.0.0).

Check that the E and S jumpers are open on the logic board (see chapter 8.0.0)

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, as shown below.:



6.2.0 Applying power

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

6.3.0 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 **PI^2** 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, 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 the limitation).

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

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

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:

Slave motor max speed (rpm) = Master motor max speed (rpm) x Maximum speed ratio

- Select the **Tension control** parameters submenu in the **Advanced function** menu of BPCW software.
- Select **Pulse input mode** in the **Tension control** module.
- Adjust **Speed ratio scaling** parameter to obtain the desired master/slave speed ratio:

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

- Set **Maximum ratio variation** parameter at 0 % to disable the tension controller and to test first the master/slave system with a fixed ratio.
- Activate 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 **Analog input** module.
- Adjust **Speed following error** parameter at its minimum value in order to avoid the **VIT** output to be activated during the normal duty cycle.

6.4.0 Tension control adjustment

It is advisable to limit the motor torque (**Maximum current** parameter) during the commissioning phase in order to avoid a materiel braking in case the tension regulator becomes unstable.

- Engage the materiel in the machine and fasten it to the downstream traction system
- Select **Tension control parameters** submenu accessible via the **Advanced functions** menu of the **BPCW** software.
- Set the **Maximum ratio** variation parameter to 1%.
- The material tension is manually adjusted by using the JOG+ and JOG- inputs to move only the slave axis.
- When the optimum tension is reached, read the load cell voltage by means of the **Tension acquisition** function.
- Set the **Tension set point** parameter equal to the **Tension acquisition** parameter value which corresponds to the actual optimum material tension.
- Set 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.
- 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.

- Set the **Tension error scaling** parameter to its maximum value (100 %).
- Set the **Integral tension gain** and the **Derivative tension gain** parameters to 0.
- Set **Proportional tension gain** parameter to its minimum value.
- Disable the **TDI** input to enable the tension controller, and activate the Enable input.
- If the system is unstable (slave motor running or torque saturated), select **the Reverse error sign** function and change the sign of the **Tension set point** parameter.
- 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** 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 control 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 done, select **Save parameters to EEPROM** function to store all parameters into the amplifier EEPROM.

7.0.0 FAULT FINDING

7.1.0 "Speed following error" default

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 Function menu.

Check that the slave motor speed does not reach the maximum speed defined by **the Maximum Speed** parameter of the Analog 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 of the master motor.

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 input meet the requirements in Chapter 4.0.0
Check that the wiring of the load cell device 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 elasticity's in the gearbox and coupling).
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 the highest position resolution on the slave motor (Encoder resolution) according to the maximum rotation speed (see chapter 5.2.0). 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 Function** menu to filter the tension measurement if necessary.

8.0.0 APPENDIX

LOCATION DIAGRAM OF THE HARDWARE OPTIONS