

BY 125

Low Cost Synchronous-Controller

Operating Instructions for Operator Software OS3.x



- 80 kHz counting frequency
- Highly dynamic response (120 μ sec)
- Positional synchronization and ratio control
- Marker pulse and print mark registration
- Speed transitions by S-shape profile
- TTL encoder inputs (A, \bar{A} , B, \bar{B} , Z, \bar{Z})
- Easy PC setting via serial link, data loading on the fly
- Simple to mount (rack or DIN rail)
- Standard version suitable for all 4-quadrant type drives with +/-10 V speed input
- Option UP125 especially suitable for 1-quadrant type inverter drives with positive speed input only and digital direction select inputs

Operating Instructions



Safety Instructions

- This manual is an essential part of the unit and contains important hints about function, correct handling and commissioning. Non-observance can result in damage to the unit or the machine or even in injury to persons using the equipment!
- The unit must only be installed, connected and activated by a qualified electrician
- It is a must to observe all general and also all country-specific and application-specific safety standards
- When this unit is used with applications where failure or maloperation could cause damage to a machine or hazard to the operating staff, it is indispensable to meet effective precautions in order to avoid such consequences
- Regarding installation, wiring, environmental conditions, screening of cables and earthing, you must follow the general standards of industrial automation industry
- - Errors and omissions excepted –

Version:	Description:
BY12512P/ TJ/ Sept. 03/	Encoder input options HTLIN1 and HTLIN2 Page 12 Integrator must be switched off with index registration Page 18, 33 Only one LED on front side Page 23 Serial access codes in fig. 22+23 corrected Page 24 Serial access of control word and status word. Page 34 Encoder supply, input resistance, response time Page 36

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1. Introduction

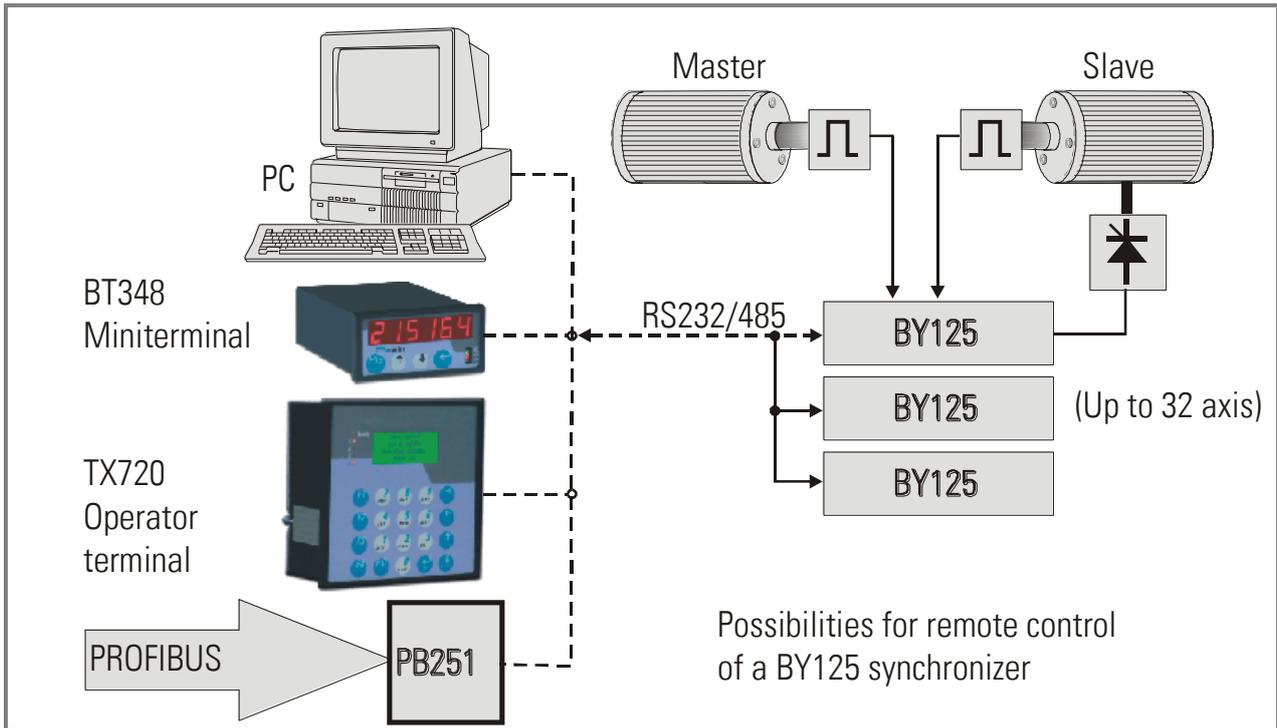
The BY 125 is a cost-effective synchronizer for high performance synchronization and registration applications between two independent drives, with a convincing value for price ratio. The units are suitable for any kind of drives (AC, DC, Servo etc.) that are variable in speed under control of a 0-10 volts speed reference. The 80 kHz counting frequency allows use of high-resolution encoders even with high operation speeds. Due to the very short response time of 120 μ sec only, the unit also provides a proper synchronization under highly dynamic conditions with servo drives.

When on the slave site you use a 1-quadrant-type drive (speed reference always with positive polarity 0...+10 volts), and your drive uses digital forward/reverse select inputs, please see "Option UP125" and observe the special hints given in section 18 of this manual.

As a matter of course, full ratio control and other functions like index pulse tracking, print mark registration and remote phase control are included in the wide set of standard functions. All settings are fully digital and no potentiometer adjustments are necessary. Programming of parameters is accomplished by PC/Laptop, using our **operator software OS3.x** (CD included in delivery). Remote control is possible by serial communication, e.g. with use of one of our operator terminals TX720 or BT348. PROFIBUS control is possible with use of the PB251 gateway (see "accessories")

The mechanical construction uses a closed 19" steel cassette with all connections on its front. Rack mounting of the cassette therefore does not require use of a swivel frame.

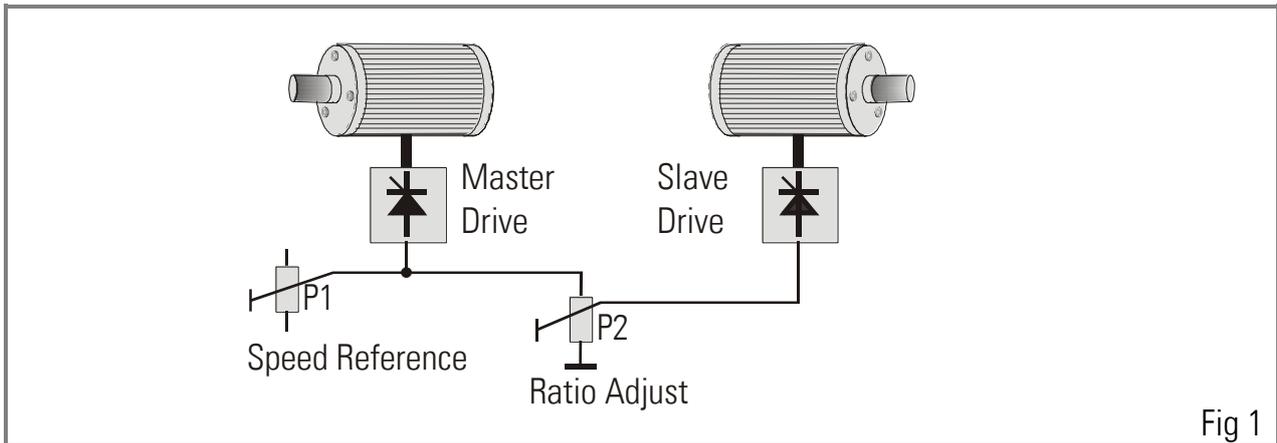
Use of our **SM 150 back plane** (option) also allows easy DIN rail mounting. The BY 125 operates from an unstabilized 24 VDC supply (18 V... 30V).



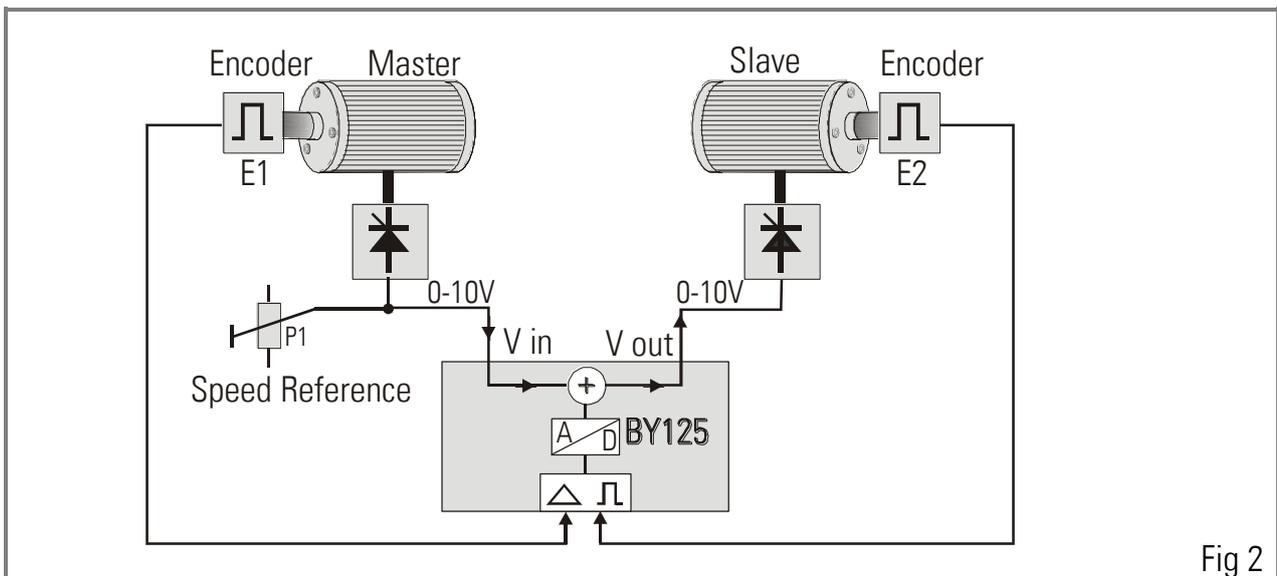
When on the slave site you intend to use a 1-quadrant-type drive (speed reference always with positive polarity 0...+10 volts and digital forward/reverse select inputs), please refer to "Option UP125" and observe the special hints given in section 17 of this manual.

2. Principle of operation

All operation is based on setting an "analogue synchronization" between the drives first. This can be achieved by feeding a common speed reference voltage to the drives and tuning the drive speeds in order to get them into an approximate synchronism. A ratio adaptation may be necessary for the Slave drive, as shown in figure 1. This analogue pre-synchronization can match the two speeds within an error range of approx. 1%.



The digital synchronization now has to compensate for the analogue speed errors in order to get an **absolute, angular and positional** synchronization with **no drift** and no cumulative displacement of the motor shafts. This needs a digital feedback of the angular shaft position of the drives. In general, incremental shaft encoders or equivalent signals (e. g. encoder simulation from a resolver system) are used.



The synchronizer continuously checks the two shaft positions and immediately responds by an analogue correction signal when an angular error starts to appear. This analogue correction, added to the slave's reference with the correct polarity, will keep the shaft positions of Master and Slave in line. As the synchronizer responds within only microseconds to each individual encoder pulse, the slave will practically have no chance to drift away.

Fig. 2 shows that a feed forward signal "Vin" is needed to run the drives, and a correction voltage is added to receive the total slave speed reference "Vout". It is easy to understand that the feed forward signal must be proportional to the master speed.

There are three ways to generate Vin:

- a) Use of the master speed reference voltage, like shown in Fig. 2. This presumes the master drive does not use any remarkable internal ramps, because otherwise Vin would not represent the real master speed upon acceleration or deceleration. As a result, procedure a) must only be used when the master speed reference already includes the ramp (generated by a PLC output etc.) and the drive's internal ramp is set to zero or it's minimum value. However, a real speed analogue signal from a tacho generator can be used at any time.

Analogue feed forward should only be used when replacing older existing BY125 units against a new one.

- b) Use of the frequency- to- voltage converter installed in the BY125 units.
This procedure can be used with most of all applications.

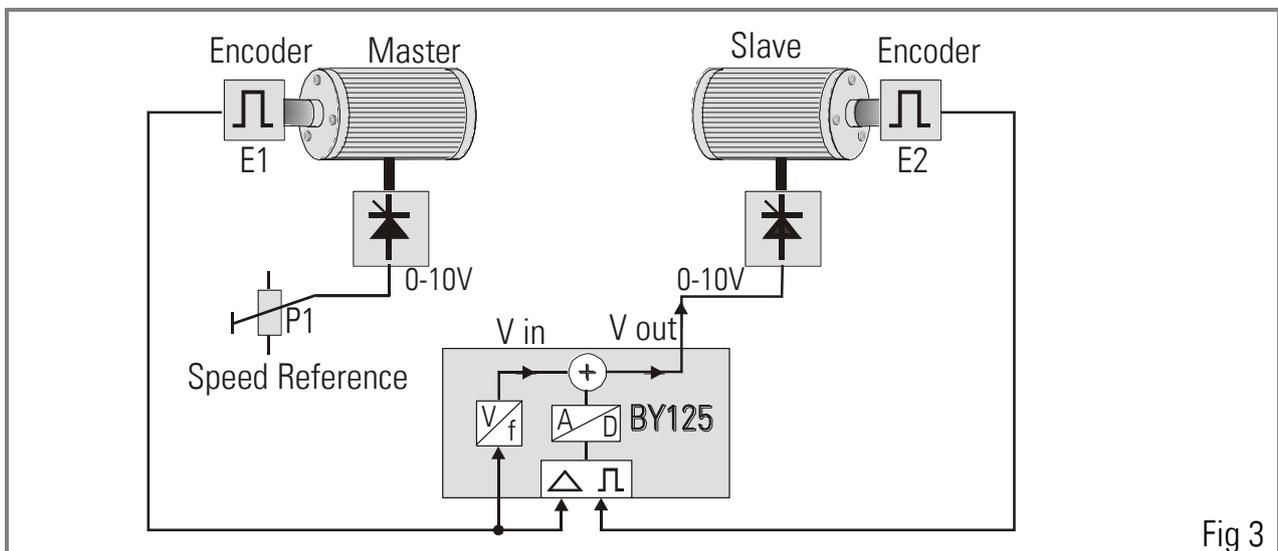


Fig 3

The feed forward signal now is generated internally from the frequency of the master encoder and no external voltage must be applied to the analogue input. This allows the master drive to use internal ramps, because the encoder frequency always represents the real actual speed of the master.

Also, procedure b) allows the "Master" to be just a measuring wheel with encoder, and not really a drive.

Digital feed forward like shown here requires encoder frequencies of at least 1 kHz at maximum speed of the master drive. Where we cannot reach this frequency at maximum speed, slight instability of the synchronization may be the result.

- c) Use of an external voltage- to- frequency converter
This procedure is used only exceptionally.

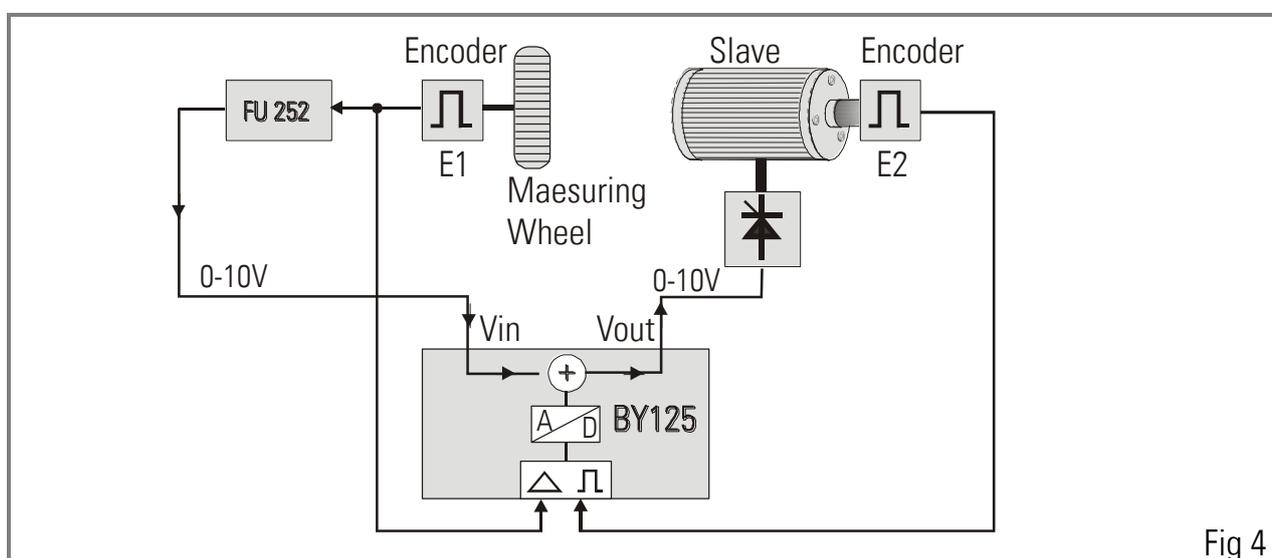


Fig 4

With use of our ultra fast precision converter type FU252, also extremely low master frequencies will be acceptable with no problem.



The mode of generating the feed forward signal can be selected by register "LV- Calculation".

3. Impulse Scaling

Both, Master and Slave impulses can be scaled separately, for easy adaptation of the synchronizer to existing conditions (gear ratios, encoder resolution, roll diameters etc.). The scaling factor "**Factor 1**" provides impulse scaling for the Master channel and the scaling factor "**Factor 2**" does the same for the slave. Both factors are 5 decade and operate in a range from 0.0001 to 9.9999. Setting them both to 1.0000 will result in a 1:1 speed and phase synchronizations.

The factors can be set via serial link, using the **RS232** or the optional **RS485** interface (ordering number **SS124**).

Independent of the way of factor setting, the slave always changes its shaft position with respect to the master according to the following formula:

$S_{\text{Slave}} = \frac{\text{Factor 1}}{\text{Factor 2}} \cdot S_{\text{Master}}$	(Proportional - operation)
$S_{\text{Slave}} = \frac{1}{\text{Factor 2}} \cdot \frac{1}{\text{Factor 2}} \cdot S_{\text{Master}}$	(Reciprocal operation)

Proportional or reciprocal operation can be selected by the parameter "LV-Calc "

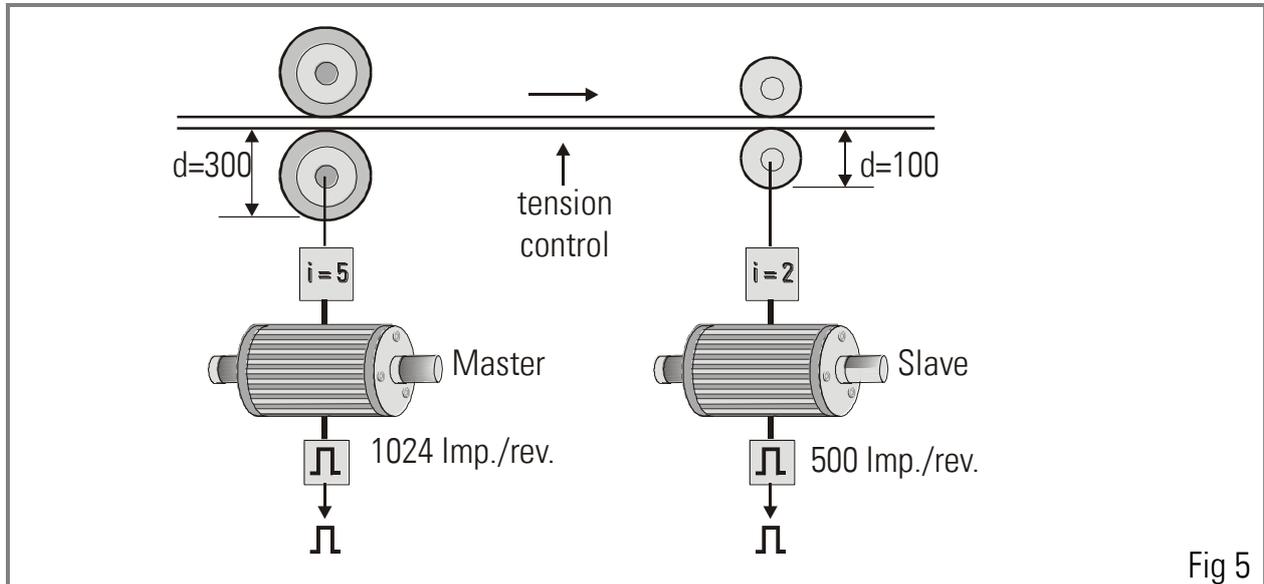
Remarks to previous formulae:

When **positional** and **angular synchronization** is required, we recommend to set S_{Master} and S_{Slave} to a number of encoder pulses as received from the encoders when both drives move a defined synchronous distance or one machine cycle forward.

When only **speed synchronization** is needed (i.e. speed errors in a range of 0.01% can be accepted), S_{Master} and S_{Slave} can also be set to the encoder frequencies at synchronous speed.

For a normal, proportional operation, under consideration of all geometrical machine data, one would try to fix up the value of Factor 2 in a way to receive a Fact1 scaling directly in "User units". (Factor 1 is the parameter that would be changed during production, and Factor 2 is a "machine constant" containing all mechanical gearings, which normally would never change).

The following example should explain the calculations for Factor 1 and Factor 2 with a feed roll system, where the tension of the material should be varied remotely by adapting the slave speed:



With one full revolution of the master must roll, we receive $5 \times 1024 = 5120$ impulses from the master encoder. If the material must pass the roll **without** any tension, the slave roll would exactly need three revolutions at the same time. So we will get $3 \times 2 \times 500 = 3000$ impulses from the slave encoder. This means, we need **3000 slave pulses for every 5120 master pulses** to operate synchronously.

We subsequently have to set up Factor 1 and Factor 2 so, that the relation

$$5120 \times \text{Faktor1} = 3000 \times \text{Faktor 2}$$

becomes true. The simplest way to do this is by setting the factors exactly to the digital value of the impulse numbers from the opposite side, i.e. Factor 1 = 0.3000 and Factor 2 = 0.5120. Then, the synchronous condition will absolutely match the formula, **but** there could be little comprehension from the operator, that he needs to set a value of 0.3000 on his terminal to have tension-free synchronism. He would understand more clearly, if the setting was 1.0000.

So, we need to use the formula with different figures:

$$5120 \times 1,0000 = 3000 \times \text{Faktor 2}$$

As a result we find that Factor 2 must be $5120 : 3000 = 1.7067$. This setting calibrates the Factor 1 to comprehensible "user units" (1.0000 = no tension, 1.0375 = 3,75% tension).

The same result can be achieved when using the parameter "F1-Scaling Factor" to scale the values transmitted from the operator terminal (see chapter 8.1).



Hint 1:

It is best, whenever possible, to have Factor 1 and Factor 2 in a numeric range of 0.1000 - 2.0000. This allows the BY to use the full 12 Bit resolution of all D/A converters. When, for example, the factor calculation results in figures like 4.5000 and 7.8000, it is better to set 0.4500 and 0.7800 (or 0.9000 and 1.5600 or any other proportional values within the recommended range) to ensure best operation.

Hint 2:

Whenever a positional synchronization is needed, cumulative errors must be avoided by proper factor setting (factors can only be set with 4 digits to the right of decimal point).

If, e.g. a ratio of 16 : 17 would be required, never use the decimal expression of 0.94117647...for Factor 1, because the non-entered digits will accumulate to give positional errors after a short time. This can be completely avoided when using factors like 1.6000 and 1.7000 (or also 0.8000 : 0.8500 etc.).

This hint needs not be observed with speed synchronization alone, because speed errors will remain undetectable small.

Hint 3:

It is best to choose the ppr number of the encoders to receive frequencies in approx. the same range on both sides. It can e.g. become difficult to synchronize 100 Hz on one side with 80 kHz on the other side.

4. Ratio Change during Operation

The speed ratio can be changed at any time by changing Factor 1 via serial link. Changing Factor 1 from 1.0000 to 2.0000 will result in double slave speed. The speed transition can be sudden or soft. The slave approaches its new speed via an adjustable \sin^2 ramp. See parameter "Ramp1".

When using operation **mode 4**, the speed ratio can also be changed via remote push buttons or PLC signals. In this mode, any activation of the „Index Master“ and „Index Slave“ hardware inputs will cause Factor 1 to continuously increment or decrement. Upon release of the Trim command, the latest scaling factor will be responsible for the speed ratio.

The speed of incrementing / decrementing can be set by the register "Trim Speed". At any time, the operative scaling factor can be stored to the EEPROM by hardware signal or software command. This facility ensures later use of the same speed ratio, also after power down.



To avoid wrong operator settings or exceeding of given limits, Factor 1 range can be limited by the parameters Factor 1 Minimum and Factor 1 Maximum.

5. Change of Phase and Relative Position

The relative phase situation between Master and Slave is normally set by the state upon power-up or with the last Reset signal (with index modes, the index edges and the programmed phase displacement define the relative position, see chapter 6.)



During all the operation, this initial phase condition is held without any errors, unless the operator uses one of the following facilities to change this condition

5.1. Timer Trimming (Modes 1 - 4 and 8)

This function, activated by the "Trim +" and "Trim -" inputs, provides a temporary higher or lower slave speed which results in a phase displacement between the motor shafts. When releasing the trim buttons, the drives will synchronize again in their new relative position. The differential trim speed is generated by an internal timer and is adjustable. It operates as a speed addition or a subtraction to the slave, without consideration of the actual absolute speed. This is why the trim function can also be used at standstill, to move the slave into a convenient start-up position.

5.2. Impulse Trimming (Modes 5 and 6)

The "Trim +" and "Trim -" inputs accept external pulses from a pulse generator, encoder or a PLC. Every pulse applied to one of the Trim inputs will shift the phase exactly one encoder increment forward or backward. This procedure provides repeatable changes and adjustments of the phase situation between the drives, e.g. under control of an external impulse counter or a PLC. Modes 5 and 6 can also be used to realize the function of a differential gearbox.

5.3. Phase Offset Operation (Mode3)

The unit provides an Offset register, which can be set to a desired number of encoder impulses. Every rising edge at the "Index Master" input will displace the actual phase forward by the number of offset impulses, and every rising edge at the "Index Slave" input will do the same to the other direction. By this function, the phase situation can be stepped forward or reverse by the pitch set to the offset register (e.g. in steps of one or several angular degrees).

6. Index Control (Modes 2, 6 and 8)

Index or marker pulses are used to automatically set the drives or the material into a correct relative position. It is possible to **either** use the zero pulse inputs on the encoder terminals (Z and /Z, 5 VTTL) **or** the index inputs on the screw terminals (10...30 V), and the parameter "Index Mode" selects which inputs are in use.

It is possible to enter the phase displacement between the marker pulses by PC or host computer, and to change it at any time, at standstill or on the fly (Register "Phase offset").

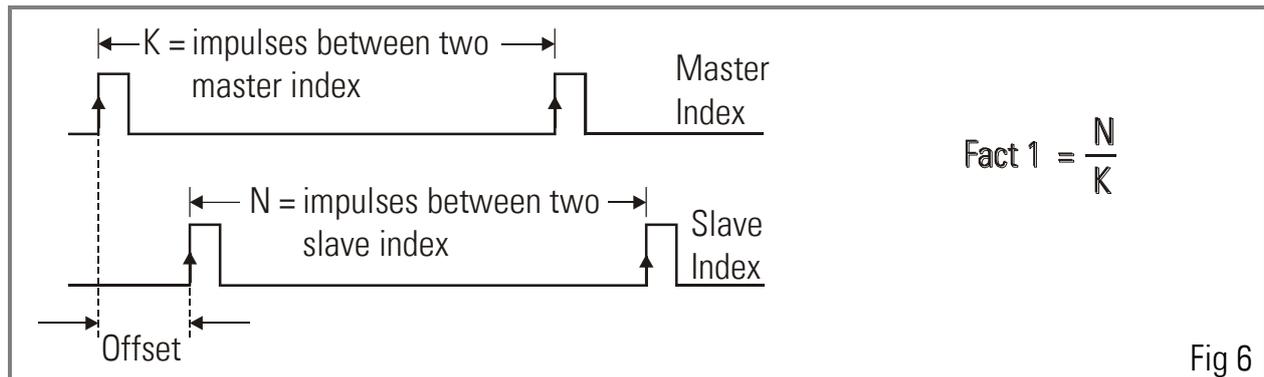


Fig 6

The parameter **Factor 1** is used to align different impulse numbers **K** and **N** on both encoders.

The number of slave impulses **N** must be set to register "**Impulse Index**".

The formula Fig. 6 shows how to calculate Factor 1. The offset needs to be set directly as "number of slave impulses" and has a setting range from $-N$ to $+N$ which means -360° to $+360^\circ$ of displacement.

Between two marker signals, the drives operate in a normal digital synchronism. The master impulses are scaled with **Factor 1**, but the slave impulses count with a **fixed factor of 1,0000** in all Index modes.

A positive edge on the slave index input starts a phase comparison with the previous master index and a correction, if not coincident to the offset M . **Additional phase adjustment**, as described under sections 5.1 and 5.2, is also possible in index mode. I. e., starting from an initial **phase** position, the final phase can be easily **tuned**, by pushbuttons or PLC, if applicable. The new phase can be restored to the phase offset register by a store command.

As a special, the BY 125 can even operate with **different number of marker pulses** on both sides. This is possible due to the following features:

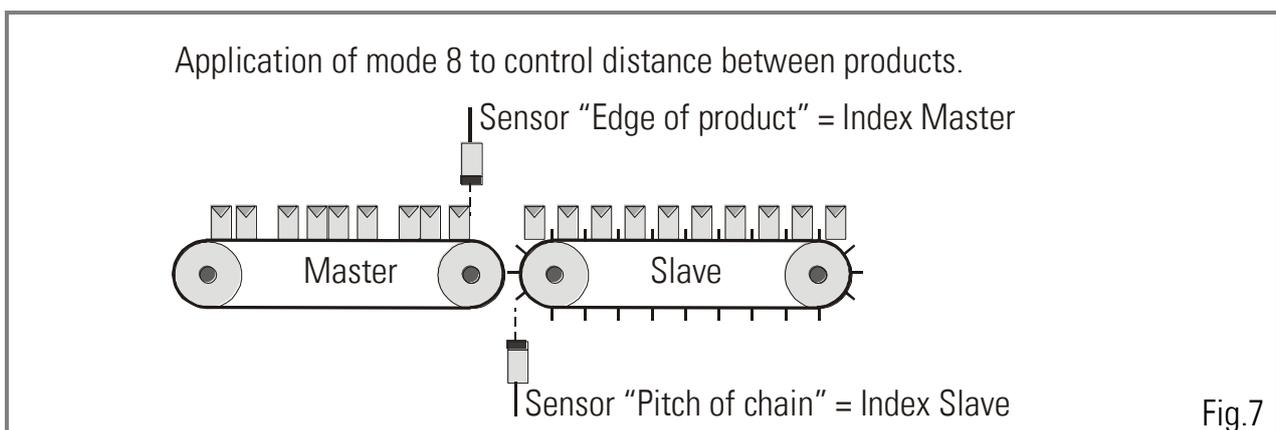
- a. The master index input is equipped with a programmable index divider, which, for example, allows sampling of only each fifth marker pulse.
- b. The slave index input is locked in a way that it becomes active only once after each valid master marker pulse.

This enables the user, in terms of one machine cycle, to have for example five master markers and three slave markers. Upon start up, the BY 125 checks for the nearest marker couple and sets them in line. Subsequently, each fifth master index will be checked with each third slave index.

Operation mode 8 provides a fully unlocked function of the index inputs and every couple of marker impulses will cause a correction, no matter if the master leads the slave index or vice-versa.

This mode needs setting of a "maximum index error" to the "Impulse Index" register (setting in slave encoder increments). Errors higher than the maximum index error setting will not be corrected with this mode. The differential speed to correct for the index error can be set by register "Trim speed".

Mode 8 is perfectly suitable for compensation of wheel slip with large cranes (reference marks on the rails) and to equalize different distance between products when passing from one conveyor to another.



7. Connections and Hardware Settings

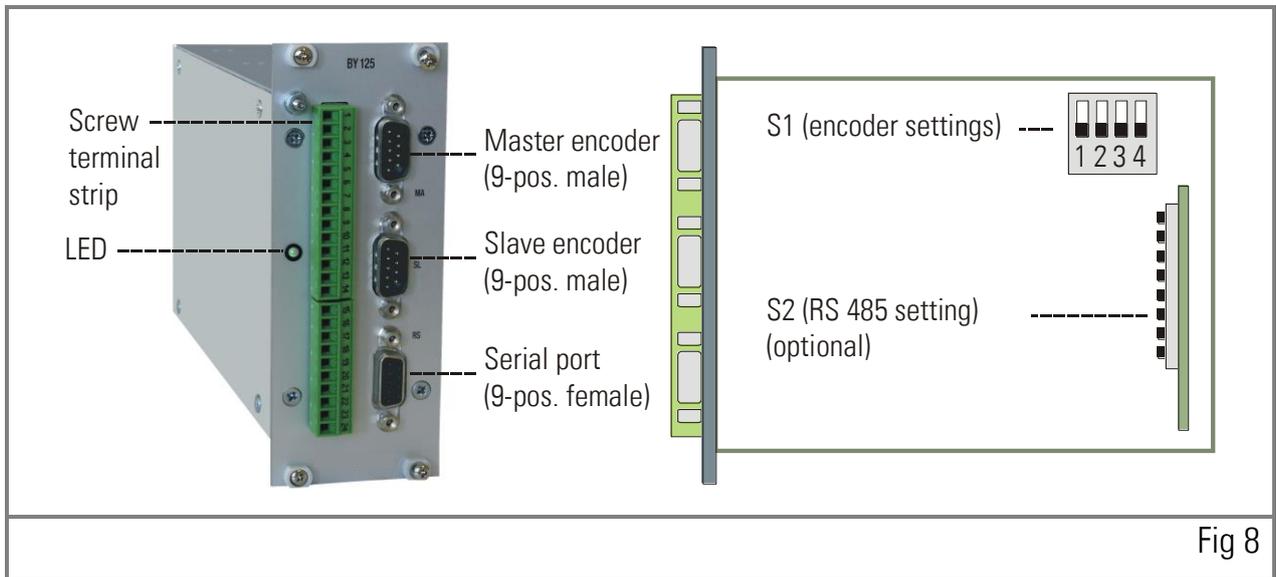


Fig 8

Fig. 8 shows the connectors available on the front plate, Fig. 9 shows the block diagram of the unit with its minimum peripheral configuration and Fig. 10 shows the screw terminal assignment.

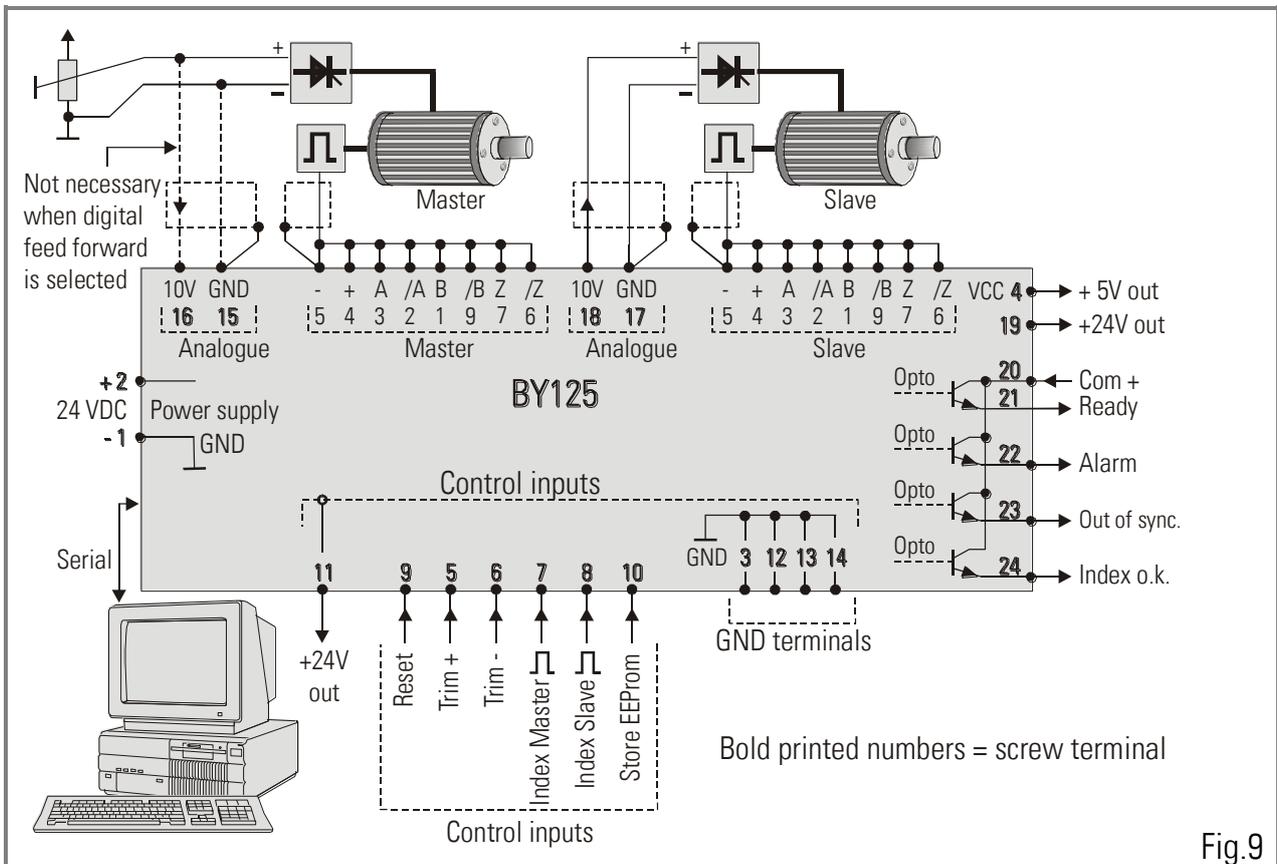


Fig.9

7.1. Power Supply

The BY 125 operates from an unstabilized 24 VDC supply (+/- 25%); however, the voltage including ripple should not exceed the following limits (18 V...30 V). The supply of the BY 125 is electrically protected against wrong polarity misconnection by protection diodes.

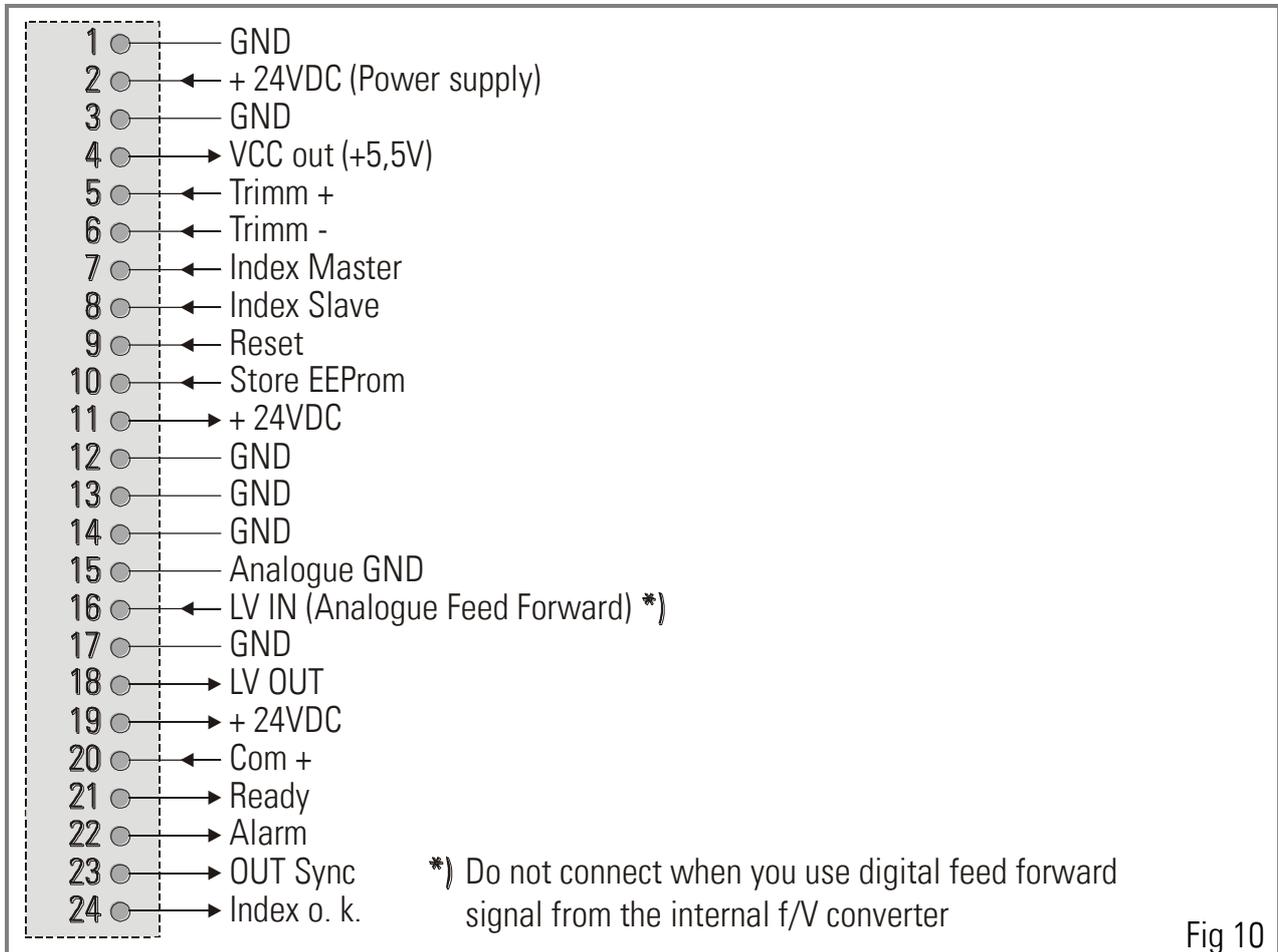


Fig 10

7.2. Encoders

The unit only accepts 5V differential TTL signals or similar signals from an encoder simulation of a drive. It is essential to connect the channels A, /A, B, /B at any time. The zero input channels Z and /Z can be omitted, if not needed.

An auxiliary voltage of **5.5 V (max. 500 mA totally)** is available on the connector plugs "**Master**" and "**Slave**", for easy supply of the encoders. Both connectors on the unit are Sub-D-9 pin, male.

Where you find you are working with existing 10-30 Volt encoder signals that feature only A, B and Z signals, the PU 202 converter should be used to gain full complementary signals in line with RS422 standards. Against special order designation, BY125 units can also be delivered with HTL encoder inputs: Option HTLIN1 provides inputs A, B, Z with 24V level (inverted channels not connected) and option HTLIN2 provides all six channels including the inverted ones with 24V level. With these options, the 24V power supply of the unit is connected to master and slave encoder connectors to supply the encoders.

Fig. 10 and Fig. 11 show the encoder connections and the principle of the input circuit. When connecting the encoders it is not important to wire the A and B signals to produce the correct counting direction. The direction can be determined in the setup menu.

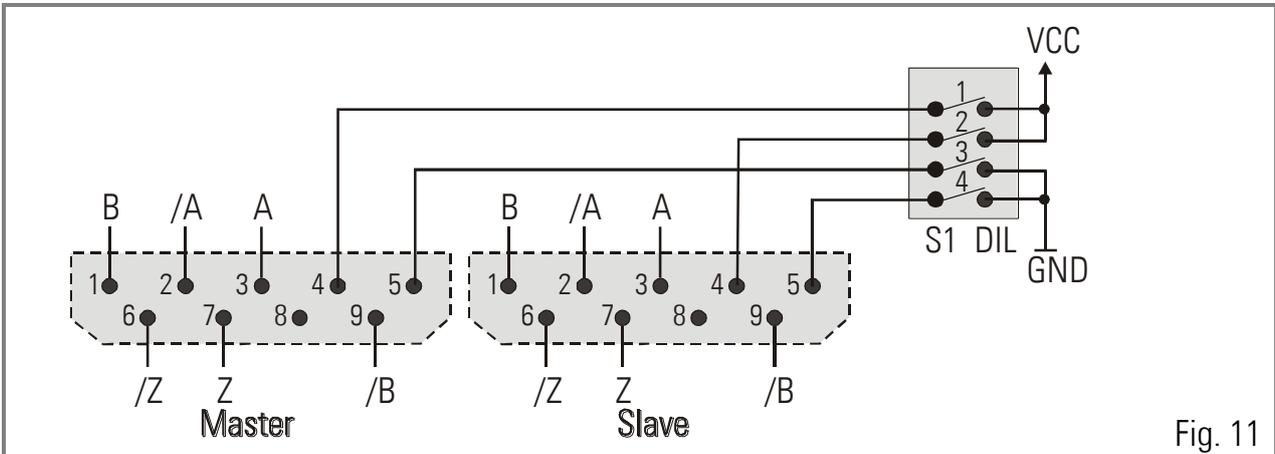


Fig. 11

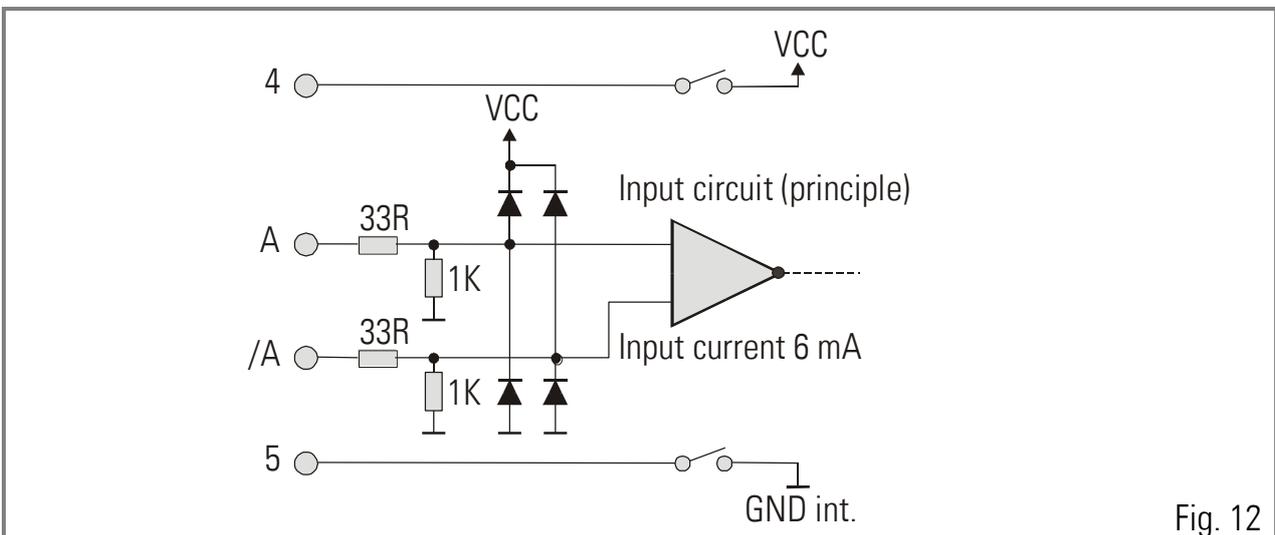


Fig. 12

For screening, please refer to section 12.3



The 4-position DIL switch S1 allows the desired encoder voltages to be set. Correct switch settings are essential for proper function. See Fig. 8.

- **With encoders, supplied by the BY 125:**
 Set positions 1 and 3 to "ON" (Master)
 Set positions 2 and 4 to "ON" (Slave)
 Connector pins 4 and 5 provide the encoder supply.
- **With encoders supplied by external source, or with encoder simulation from the drive:**
 Set position 1 to "OFF" and position 3 to "ON" (Master)
 Set position 2 to "OFF" and position 4 to "ON" (Slave)
 Use connector pin 5 as common GND potential.

- For fully differential operation (RS422):
Set positions 1 and 3 OFF (Master)
Set positions 2 and 4 OFF (Slave)

The inputs then operate in differential mode, which is best in terms of noise immunity. However, the impulse source must be of line driver type with external supply, when this input mode is used.



When switch positions 1 and 2 are "ON", you must ensure that no supply is applied to pins 4 and 5, as this will cause serious damage within the unit.

7.3. Analogue Input and Output

The analogue input and output signals can be found on screw terminals 16 and 18. The Analogue common GND is internally connected to the minus of the 24 VDC supply. All analogue levels are in range +/- 10 Volts.

LVin (Terminal 16)	: Receives a voltage proportional to the master speed e.g. master reference voltage or line tacho signal (+/- 10 V range), when you use analogue feed forward. Remains unconnected when you select digital feed forward
LVout (Terminal 18)	: This output supplies the slave with its speed output reference voltage. When the " Gain Corr " is set to any value except 0, the digital correction voltage is superimposed to this output.

7.4. The Serial Ports

Delivery always includes a RS232 interface. Also an additional RS485 interface is available (option SS 124). Both serial links use the same connector for wiring. Serial communication is possible with both interfaces at a time in an alternating sequence (dialogues must not overlap).

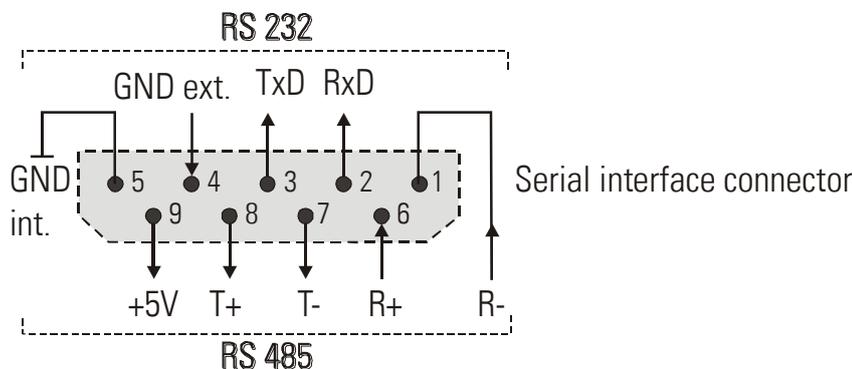
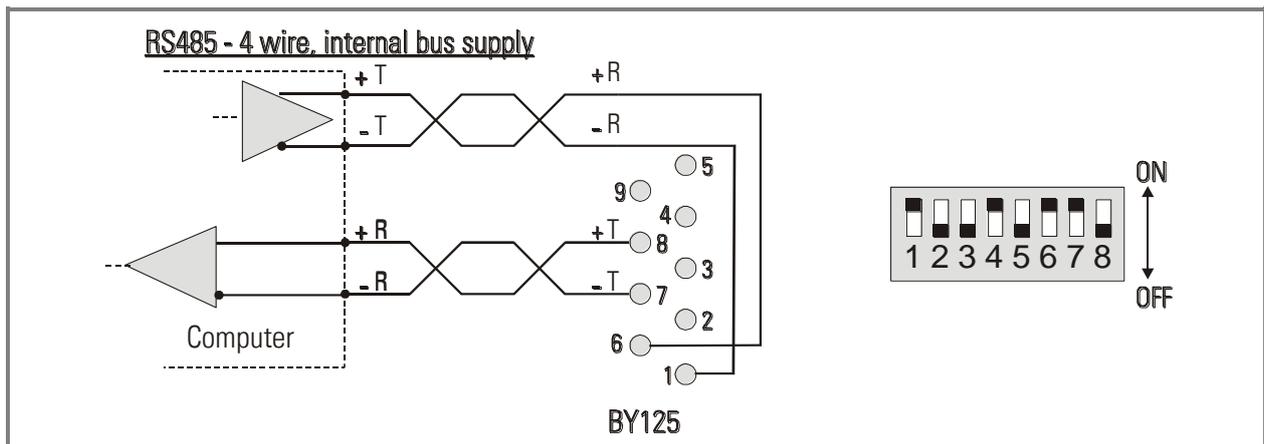
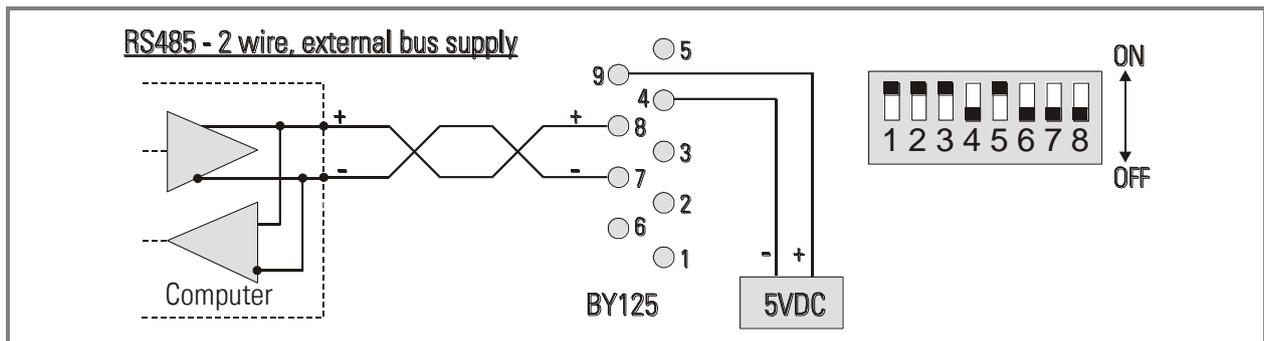
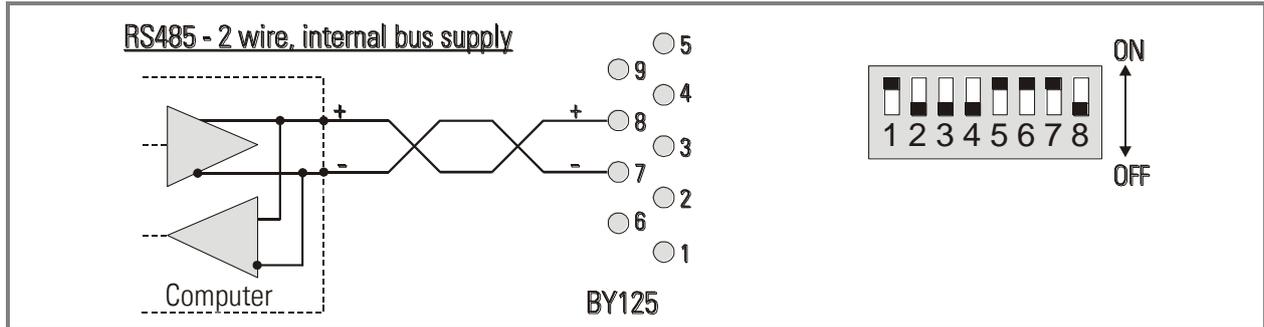


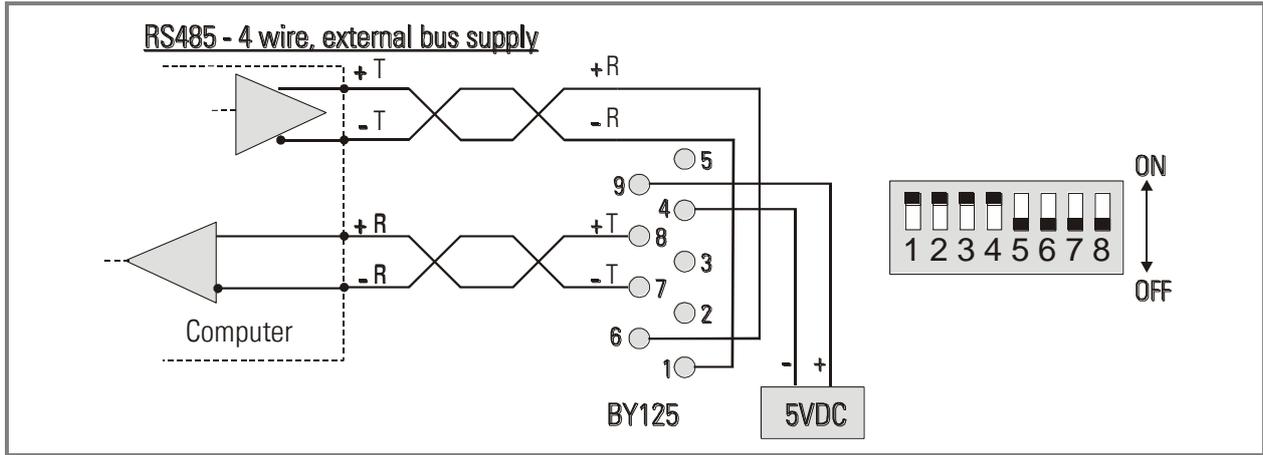
Fig. 13

The serial link must be used for PC set-up of the registers upon commissioning, with use of the operator software OS3.x

It can be used for on-line operation with a master computer, a PLC or an operator terminal (e.g. BT348 or TX720 or other), accessing all registers and control functions. The serial communication protocol uses the Drivcom standard (ISO 1745), which is widespread in drive industry.

Before running the BY125 with an **RS 485 bus**, some adjustments are necessary. Open the right hand side plate. The optional RS 485 interface card with the 8-position DIL switch S2 is located at the right-hand side of the main board (see Fig. 8). The desired bus type and potentials can be set there.





- When using RS485 transmission, the BY 125 needs time to switch from "transmit" to "receive" and the computer must provide a delay like shown in table 14 prior to the next serial access.
- With internal RS 485 bus supply, never an external voltage must be applied to pins 4 and 9 of the connector!

Delay Times:	
Baud Rate:	Time in msec:
600	32
1200	16
2400	8
4800	4
9600	2

Fig. 14

7.5. Control Inputs and Outputs

There are 6 control input lines and 4 control output lines available on the screw terminals. All inputs are PLC compatible. All signals refer to GND and the minus potential of the supply. All the outputs are opto-isolated transistor outputs that are also PLC compatible.

Logical 0 (low) = 0....5 Volts
 Logical 1 (high) = 18...30 Volts

To avoid command latch errors, the command signal must stay in a stable state for at least 1 msec.

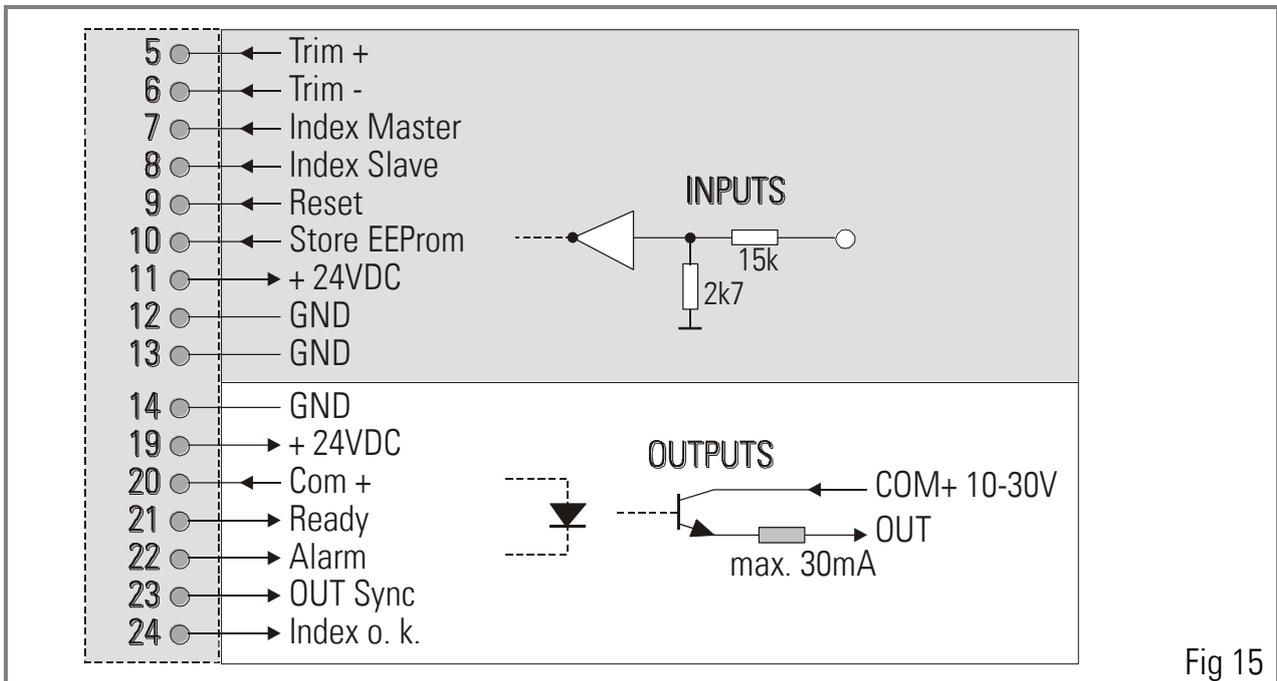


Fig 15

Inputs:

Trimm + (terminal 5)	Adjusts the angular position of the slave to lead the master, in the chosen direction, like described in section 5.1 and 5.2.
Trimm - (terminal 6)	As above but adjusts the slave to lag the master.
Index Master (terminal 7)	These 10-30 V inputs allow the use of marker pulses from proximity switches or photocells, when the encoder index pulses are not suitable.
Index Slave (terminal 8)	The inputs are edge-triggered (positive transition) and must be enabled by the "Index Mode" register. With mode 4, the index inputs are used to increment or decrement Factor 1.
Reset (terminal 9)	Sets the internal differential counter and the analogue correction signal to zero. Both drives run solely in analogue synchronization whilst held
Store data to EEPROM (terminal 10)	A rising edge on this input will store all actual operating data to the EEPROM and upon next power-up the data set will be available again. The BY 125 is out of operation for a time of 30 ms after activation of the store command and the Ready output will be low while storage is in progress.

Control Outputs:

Ready
(terminal 21)

This announces that the unit is ready to run. On power up, this output is "Low" for about one second to allow the power supply to settle, and then switches to "High". The output goes low also for the duration of parameter storage to the EEPROM.



When "High", the unit could not detect a system fault itself, but this is not a guarantee for fault-free operation!

Alarm
(terminal 22)

The alarm output signals that the preset tolerance band has been exceeded in one direction or the other, as specified by the parameter "Alert".

Out Sync
(terminal 23)

This output goes high when, despite of full analogue correction, the synchronization can no more be maintained. Mechanical or electrical problems can cause this situation (e. g. current limit of the drive).

Index o.k.
(terminal 24)

When High the slave index pulses are inside the window set by parameter "Index Window", with respect to the position of the Master index pulse and the phase displacement set to register "Phase Offset".

8. Register List and Clarification

The register set is held on an EEPROM. The registers can only be programmed via serial link, using the RS232 or RS485 interface.

The Software OS3.2 (included with delivery) allows easy downloading of complete register sets, reading, copying and editing the parameters.

It includes also an adjust program and a test program for easy setup and commissioning.

The subsequent table shows all operational registers. Remarks "C00", "C01" etc. indicate the appropriate serial access codes. All parameters, with respect to their numeric values, are internally limited to their permitted range. Register marked with * are only operative when you select one of the index modes.

Parameter List			
Operations Parameters		Setup Parameters	
C00	Factor 1	C40	Mode
C01	Factor 2	C41	LV Calculation
C02	Trim Time	C90	Unit NR.
C03	Integration Time	C91	Baud Rate
C04*	Impulse Index	C92	Serial Form
C05*	Offset	C45	Master Direction
C06	Alert	C46	Slave Direction
C07	Ramp	C47	Offset Correction
C08	Stop Ramp	C48	Gain Correction
C09	Correction Divider	C50	Gain Total
C10	Phase Adjust		
C11	Index Divider		
C12	F1 Scaling Factor		
C13	Factor 1 Minimum		
C14	Factor 1 Maximum		
C15*	Index Window		
C16	Sampling Time		
C17*	Index Mode		

Fig. 16

8.1. General Parameters

Menu	Description
Factor 1	Impulse scaling factor for the master encoder. Range 0.0001 - 9.9999
Factor 2	Impulse scaling factor for the slave encoder. Range 0.0001 - 9.9999. In modes 2, 6 and 8, this setting is automatically replaced by a fixed 1.0000 scaling
Trim Time	Rate of change of phase trimming, entered as number of software cycles (1 cycle = 100 µsec), when the +/- trim inputs are activated, or for Factor 1 inc. / dec. in mode 4. Range of setting: 001 (fast) - 999 (slow) cycles per increment. Example: With Trim Time set to 001, each 100 µsec the phase will be displaced by one encoder increment (= 10 000 increments each second), and with Trim Time set to 050, the processor will take 50 cycles = 5 ms. for one increment.
Integration Time	Time constant for the phase integrator, which avoids positional errors, is also to be entered as a number of software cycles. Range 000 - 999 Setting 000: No integration, proportional control only Setting 020: Integrator needs 20 cycles (= 2 ms) to compensate for one increment etc. With all index modes, the integrator should be switched off (set Integration Time = 0), because the index corrections will eliminate positional errors.
Impulse Index *	Number N of pulses between slave markers (see 6.). Range 1-999 999
Offset *	Number of slave encoder pulses that the slave should displace with respect to the master. With index modes, this is the offset between the rising edge of the master index and the rising edge of the slave index. With mode 3, this is the pitch of phase displacement with each rising edge.
Alert	Set tolerance window. Can be set between 0000 - 9999 bits of difference. Typical setting 30. Affects the Alarm output when out of tolerance. Please observe that the alarm count considers the error bits <u>after</u> the correction divider (see setting of register "Correction Divider").

Menu	Description
Ramp	<p>Ramp time for changes of speed ratio. Range 0 – 99.99 s. Setting Ramp to zero results in abrupt change of the slave speed. All other settings provide a \sin^2 transition from one ratio to next within the preset time, independent of the difference between initial and final speed.</p>
Stop Ramp	<p>When during full operation the Test- Program is activated by serial command, the slave drive will use this ramp to slow down prior to executing the test functions. Range 0 – 99.99 s.</p>
Correction Divider	<p>This setting function is active in all operation modes. Setting range 1-9. This provides a digital attenuation of the phase correction signal that is produced, when the drive on mechanical grounds (dead band or backlash) cannot respond. In such a case, it is not desirable to make corrections immediately. The "Correction Divider" provides a window for the drive "backlash", within which the controller produces no correction and a division of the differential error count.</p> <p>Value 1 = No window, Reaction to 1 error increment, no division Value 2 = Window +/- 1 Encoder increment and error division by 2. Value 3 = Window +/- 3 Encoder increments and error division by 4. Value 4 = Window +/- 7 Encoder increments and error division by 8. Value 5 = Window +/- 15 Encoder increments and error division by 16 etc.</p>
Phase Adjust*	<p>Digital attenuation of the response upon marker pulse errors.</p> <p>1 = full correction with each index check, i.e. 100% 2 = correction by several steps with 50% of the residual error 3 = correction by several steps with 25% of the residual error 4 = correction by several steps with 12.5% of the residual error 5 = correction by several steps with 6.25% of the residual error etc.</p>

Menu	Description
Phase Adjust*	<p><u>Clarification:</u> The setting depends on the dynamics of the drive and the maximum speed. If a marker pulse arrives every 20 ms but the drive cannot correct the largest error in 20msec, then it will lead to instability, if the next correction is performed before the previous is completed. In such a case the phase correction percentage must be reduced.</p>
Index Divider*	<p>This is a programmable index divider for the master marker pulses, permitting different numbers of marker pulses from the master and the slave. See Section 6. Range 1 - 99. For the same reason as clarified above, we also recommend to use the divider with marker pulse frequencies higher than 10 Hz.</p>
F1 Scaling Factor	<p>This factor allows scaling of the remote Factor 1 entry to "user units" or to adapt the numeric value of Factor 1 to the application. It is essential, for all steps of set-up, to program F1-Scaling Factor to 10000 first in order to avoid confusions with factor calculations. Only with this value, the setting corresponds to the real operative Factor 1! Once the set-up is terminated, set F1-Scaling Factor to the numeric value that later should correspond to an operative value of 1.0000 for Factor 1.</p>
	<p> <u>Example:</u> If the operator desires to set 3.5000 instead of 1.0000, set F1-Scaling Factor to 35000. For all factor calculations, please be aware if you operate with a proportional or a reciprocal characteristic of Fact1!</p>
Factor 1- Minimum Factor 1- Maximum	<p>These are limitations of the setting range of Factor 1 and out of range settings will be overwritten by the appropriate min or max value. With Factor 1 Minimum set to 0.9500 and Factor 1 Maximum set to 1.0500, the operator is limited to a +/- 5% variation of the speed ratio. In mode 4 the inc. / dec. range of Fact 1 is limited to this window.</p>
Index Window*	<p>This parameter sets a window, where the master and slave index pulses should be within during operation. It is possible to set the value in a range from 1 to 9999 encoder increments. It affects the output "Index o.k." when master and slave index pulse are out of range.</p>

Menu	Description															
Sampling Time	<p>Sets the internal f/V converter (digital feed forward control) with respect to dynamics and resolution.</p> <p>Setting is uncritical. Lower set values result in faster response, but less accuracy of the feed forward signal. Higher set values result in better accuracy, but slower response with sudden speed changes.</p> <p><u>Please note:</u> Feed forward signals with lower accuracy do not at all affect speed accuracy of the synchronizing process, but only might cause slight angular errors.</p> <p>Depending of the maximum master encoder frequency, the subsequent setting can be recommended:</p>															
	<table border="1"> <thead> <tr> <th>fmax</th> <th>Sampling-Time (recommended)</th> </tr> </thead> <tbody> <tr> <td>1 kHz</td> <td>100 msec</td> </tr> <tr> <td>3 kHz</td> <td>33 msec</td> </tr> <tr> <td>10 kHz</td> <td>10 msec</td> </tr> <tr> <td>30 kHz</td> <td>3 msec</td> </tr> <tr> <td>100 kHz</td> <td>1 msec</td> </tr> </tbody> </table>	fmax	Sampling-Time (recommended)	1 kHz	100 msec	3 kHz	33 msec	10 kHz	10 msec	30 kHz	3 msec	100 kHz	1 msec			
fmax	Sampling-Time (recommended)															
1 kHz	100 msec															
3 kHz	33 msec															
10 kHz	10 msec															
30 kHz	3 msec															
100 kHz	1 msec															
Index Mode*	<p>Selects the source of the index pulse individually for the Master and Slave side, where HTL means a Z signal with 18...30 volts level on screw terminal input and TTL means a Z and /Z signal with TTL level at the Sub-D-encoder input plugs.</p>															
	<table border="1"> <thead> <tr> <th>Index Mode</th> <th>Active input (Slave)</th> <th>Active input (Master)</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>HTL, terminal 8 on screw terminal strip</td> <td>HTL, terminal 7 on screw terminal strip</td> </tr> <tr> <td>1</td> <td>TTL, Index-pins 6 und 7 at Slave input</td> <td>HTL, terminal 7 on screw terminal strip</td> </tr> <tr> <td>2</td> <td>HTL, terminal 8 on screw terminal strip</td> <td>TTL, Index-pins 6 and 7 at Master input</td> </tr> <tr> <td>3</td> <td>TTL, Index-pins 6 und 7 at Slave input</td> <td>TTL, Index-pins 6 und 7 at Master input</td> </tr> </tbody> </table>	Index Mode	Active input (Slave)	Active input (Master)	0	HTL, terminal 8 on screw terminal strip	HTL, terminal 7 on screw terminal strip	1	TTL, Index-pins 6 und 7 at Slave input	HTL, terminal 7 on screw terminal strip	2	HTL, terminal 8 on screw terminal strip	TTL, Index-pins 6 and 7 at Master input	3	TTL, Index-pins 6 und 7 at Slave input	TTL, Index-pins 6 und 7 at Master input
	Index Mode	Active input (Slave)	Active input (Master)													
	0	HTL, terminal 8 on screw terminal strip	HTL, terminal 7 on screw terminal strip													
	1	TTL, Index-pins 6 und 7 at Slave input	HTL, terminal 7 on screw terminal strip													
2	HTL, terminal 8 on screw terminal strip	TTL, Index-pins 6 and 7 at Master input														
3	TTL, Index-pins 6 und 7 at Slave input	TTL, Index-pins 6 und 7 at Master input														

8.2. Setup Registers

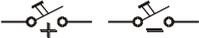
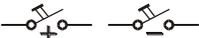
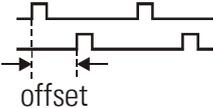
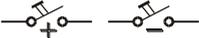
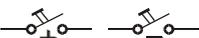
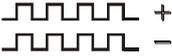
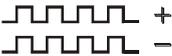
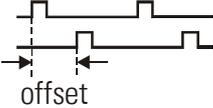
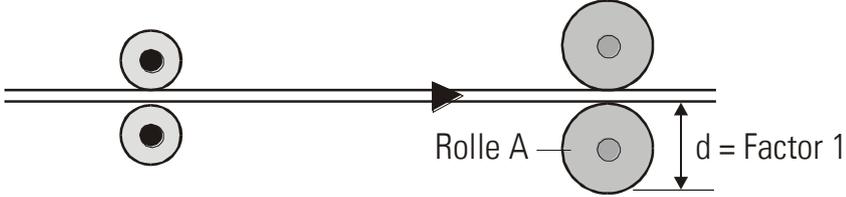
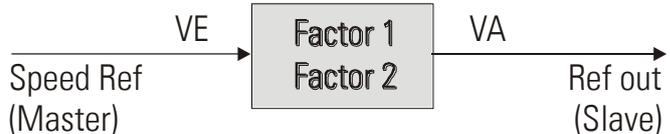
Menu	Description		
Mode	The mode setting determines the function of the Trim inputs and the Index inputs. There are 8 modes available like shown in the table below.		
Mode	Trim inputs	Index inputs	Impulse scaling
1	Phase trim by internal timer (additional speed) 	No Function	Fact 1 : Fact 2
2	Phase trim by internal timer (additional speed) 	Index-control with phase offset 	Fact 1 : 1,0000
3	Phase trim by internal timer 	Index Master $\text{J} =$ Forward offset displacement Index Slave $\text{J} =$ Reverse offset displacement	Fact 1 : Fact 2
4	Phase trim by internal timer (additional speed) 	Index Master  Increment Fact 1 Index Slave  Decrement Fact 1	Fact 1 : Fact 2
5	Phase trim by external pulse source 	No function	Fact 1 : Fact 2
6	Phase trim by external pulse source 	Index-control with phase offset 	Fact 1 : 1,0000
7	Similar to Mode 1	Similar to Mode 1	Similar to Mode 1
8	Phase trim by internal timer (additional speed) 	Unlocked index registration for special applications	Fact 1 : 1,0000

Fig. 17

Menu	Description
LV- Calculation	<p>This parameter determines the relationship between the factor settings and the resulting slave speed. Also it selects analogue or digital feed forward operation.</p> <p>With settings 1 - 4, an analogue signal proportional to the master speed must be applied to terminal 16.</p> <p>Settings 5 - 8 are similar to 1 - 4, but the feed forward signal is generated by the internal f/V converter and terminal 16 must remain unconnected.</p>
LV-Calc = 1 or 5	<p>The slave speed changes proportionally to the Factor 1 setting, i.e. doubles motor speed when changing Factor 1 from 1.0000 to 2.0000. This setting is suitable for the majority of all synchronizing applications.</p>
LV-Calc = 2 or 6	<p>The slave speed is reciprocal to the Factor 1 setting, i.e. halves the motor speed when changing Factor 1 from 1.0000 to 2.0000. This setting is suitable for rotating cutter applications (Factor 1 represents the length preset) and all other applications where the engineering units are reciprocal to the motor speed.</p>
<div style="text-align: center;">  <p>When <u>increasing</u> diameter of roll A, rotational speed must <u>decrease</u> for same line speed.</p> </div>	
LV-Calc = 3 or 7	<p>The slave speed changes proportionally to Factor 1 and reciprocally to Factor 2. Suitable for various applications that need remote setting of both scaling factors.</p>
LV-Calc = 4 or 8	<p>The slave reference voltage remains constant, independent of Factor 1 and Factor 2 settings.</p>

Menu	Description												
	<p style="text-align: center;">Parameter LV-Calculation:</p> <div style="text-align: center;">  <pre> graph LR A[Speed Ref (Master)] -- VE --> B[Factor 1 Factor 2] B -- VA --> C[Ref out (Slave)] </pre> </div> <table border="1" style="margin: 10px auto; border-collapse: collapse;"> <tbody> <tr> <td style="padding: 5px;">1/5 : VA =</td> <td style="padding: 5px; text-align: center;">$\frac{\text{Gain Tot}}{1000}$</td> <td style="padding: 5px;">Faktor 1 x VE</td> </tr> <tr> <td style="padding: 5px;">2/6 : VA =</td> <td style="padding: 5px; text-align: center;">$\frac{\text{Gain Tot}}{1000 \times \text{Fact 1}}$</td> <td style="padding: 5px;">x VE</td> </tr> <tr> <td style="padding: 5px;">3/7 : VA =</td> <td style="padding: 5px; text-align: center;">$\frac{\text{Gain Tot} \cdot \text{Fact 1}}{1000 \cdot \text{Fact 2}}$</td> <td style="padding: 5px;">x VE</td> </tr> <tr> <td style="padding: 5px;">4/8 : VA =</td> <td style="padding: 5px; text-align: center;">$\frac{\text{Gain Tot}}{1000}$</td> <td style="padding: 5px;">x VE</td> </tr> </tbody> </table> <p style="text-align: center;">Setting 1-4 need analogue input proportional to master speed. Setting 5-8 generate VE by internal f/V converter</p> <p><u>Clarification:</u> When LV - Calc is set to 1, the output voltage will be equal to the input voltage with Fact 1 = 1.0000 and Gain Tot = 1000.</p>	1/5 : VA =	$\frac{\text{Gain Tot}}{1000}$	Faktor 1 x VE	2/6 : VA =	$\frac{\text{Gain Tot}}{1000 \times \text{Fact 1}}$	x VE	3/7 : VA =	$\frac{\text{Gain Tot} \cdot \text{Fact 1}}{1000 \cdot \text{Fact 2}}$	x VE	4/8 : VA =	$\frac{\text{Gain Tot}}{1000}$	x VE
1/5 : VA =	$\frac{\text{Gain Tot}}{1000}$	Faktor 1 x VE											
2/6 : VA =	$\frac{\text{Gain Tot}}{1000 \times \text{Fact 1}}$	x VE											
3/7 : VA =	$\frac{\text{Gain Tot} \cdot \text{Fact 1}}{1000 \cdot \text{Fact 2}}$	x VE											
4/8 : VA =	$\frac{\text{Gain Tot}}{1000}$	x VE											

Unit - Nr.	<p>Allows entry of a serial device address between 11 and 99. It is not allowed to use addresses containing a "0" (i.e. 20, 30, 40 etc.) as these are reserved for collective addressing of several units.</p> <p>Factory setting: 11.</p>														
Baud Rate	<p>The following transmission rates can be selected:</p> <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 50%;">Setting</th> <th style="width: 50%;">Baud</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>9600</td> </tr> <tr> <td>1</td> <td>4800</td> </tr> <tr> <td>2</td> <td>2400</td> </tr> <tr> <td>3</td> <td>1200</td> </tr> <tr> <td>4</td> <td>600</td> </tr> <tr> <td colspan="2" style="text-align: center;">Factory setting: = 0</td> </tr> </tbody> </table>	Setting	Baud	0	9600	1	4800	2	2400	3	1200	4	600	Factory setting: = 0	
Setting	Baud														
0	9600														
1	4800														
2	2400														
3	1200														
4	600														
Factory setting: = 0															

Fig 20

Menu	Description																																																
Ser- Form	The following formats of serial data can be selected:																																																
	<table border="1"> <thead> <tr> <th>Ser-Form</th> <th>Data bits</th> <th>Parity</th> <th>Stop bits</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>7</td> <td>even</td> <td>1</td> </tr> <tr> <td>1</td> <td>7</td> <td>even</td> <td>2</td> </tr> <tr> <td>2</td> <td>7</td> <td>odd</td> <td>1</td> </tr> <tr> <td>3</td> <td>7</td> <td>odd</td> <td>2</td> </tr> <tr> <td>4</td> <td>7</td> <td>None</td> <td>1</td> </tr> <tr> <td>5</td> <td>7</td> <td>None</td> <td>2</td> </tr> <tr> <td>6</td> <td>8</td> <td>Even</td> <td>1</td> </tr> <tr> <td>7</td> <td>8</td> <td>Odd</td> <td>1</td> </tr> <tr> <td>8</td> <td>8</td> <td>None</td> <td>1</td> </tr> <tr> <td>9</td> <td>8</td> <td>none</td> <td>2</td> </tr> <tr> <td colspan="4" style="text-align: center;">Factory setting: = 0</td> </tr> </tbody> </table>	Ser-Form	Data bits	Parity	Stop bits	0	7	even	1	1	7	even	2	2	7	odd	1	3	7	odd	2	4	7	None	1	5	7	None	2	6	8	Even	1	7	8	Odd	1	8	8	None	1	9	8	none	2	Factory setting: = 0			
Ser-Form	Data bits	Parity	Stop bits																																														
0	7	even	1																																														
1	7	even	2																																														
2	7	odd	1																																														
3	7	odd	2																																														
4	7	None	1																																														
5	7	None	2																																														
6	8	Even	1																																														
7	8	Odd	1																																														
8	8	None	1																																														
9	8	none	2																																														
Factory setting: = 0																																																	
	Fig. 21																																																
Mast Dir	Direction of phase A/B of the master encoder. Setting 0 or 1. See commissioning.																																																
Slave Dir	Direction of phase A/B of the slave encoder. Setting 0 or 1. See commissioning.																																																
Offset Correction	Digital setting of analogue offset on correction signal. Setting range +/-99. Normal setting "0". <u>Remark:</u> BY125 uses precision instrumental amplifiers that do not need an offset adjustment. In larger drive plants however, by balance currents between several devices, an external offset can build up, which can be compensated by the offset adjust. Also, offset setting can be used to compensate for dead band with AC inverter drives.																																																
Gain Correction	Digital setting of gain control (proportional control) Range 0 - 9999. Setting to 9999 results in a response of 100 mV per error bit. Recommended setting: 200...2000 (i.e. 2mV...20mV per error bit).																																																

Menu	Description
Offset Total	Not used. Set to 00 at any time.
Gain Total	<p>Digital setting of multiplication of analogue voltage signal. Range 0 - 99999. With analogue feed forward, the output voltage is</p> $V_{out} = \frac{\text{Gain Total}}{1000} \times \text{Factor 1} \times V_{in} \text{ (Volt)}$ <p>With digital feed forward, the output voltage is approximately</p> $V_{out} = \frac{f_{\text{master}}}{5400} \times \text{Gain Total} \times \text{Factor 1 (Volt)}$ <p>where f_{master} is the frequency of the master encoder in kHz. Please note the output voltage swing is limited to +/-10 Volts max.</p>

9. The Front LED

The LED on the BY125 front side indicates the operating condition of the unit. When all operation is o.k. the LED is flashing slowly. With any other kind of LED state, the unit indicates hardware or software fault.

10. Remarks about Drives, Encoders, Cables etc.

10.1. Drives

The **drives** in use must be dimensioned correctly with respect to power and dynamics required. **The BY 125 can never provide synchronization outside the physical limits of the drives.** Prior to connecting the master and the slave to the synchronizer, they must be adjusted for a proper stand-alone operation with no oscillation, by means of a remote speed reference voltage. The reference inputs must be potential free. The Minus input may be tied to protection earth. In this case, avoid ground loops, i.e. by the power supply source that might be grounded also. The reference inputs must never be at mains potential!

10.2. Encoders

The resolution of the **TTL-encoders**, in principle, should be as high as possible (observe maximum frequency!), in order to keep the mechanical phase error as small as possible when the synchronizer "plays" a few encoder increments around the zero error position. Normal phase errors are in a range of five encoder increments and the encoder resolution determines what the mechanical result is. However it would be nonsense to choose the number of ppr much higher than needed or reasonable. If, for example, a gearbox with several 0.1 mm of clearance is installed, a 0.01 mm resolution of the encoder could cause stability problems, which needed to be removed by the "Corr-Div" error divider again.

Please choose ppr numbers of master and slave encoders in a way that encoder frequencies are approximately in the same range. This ensures that the unit can use full analogue resolution.

The BY 125 loads each encoder channel with a current of 6 mA. Though some encoder types are able to supply the impulse inputs of several synchronizers at a time, we recommend using an appropriate impulse splitter (e.g. GV210 or GV470) as soon as one encoder is used with several target units.

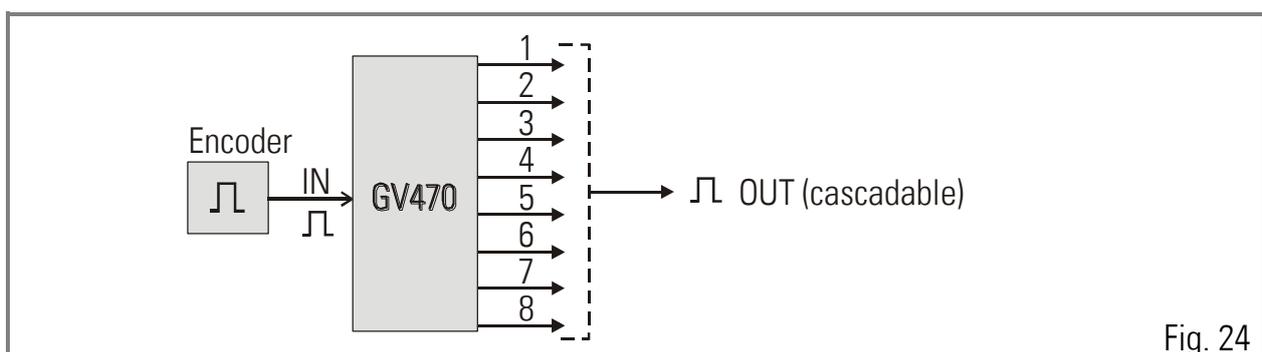
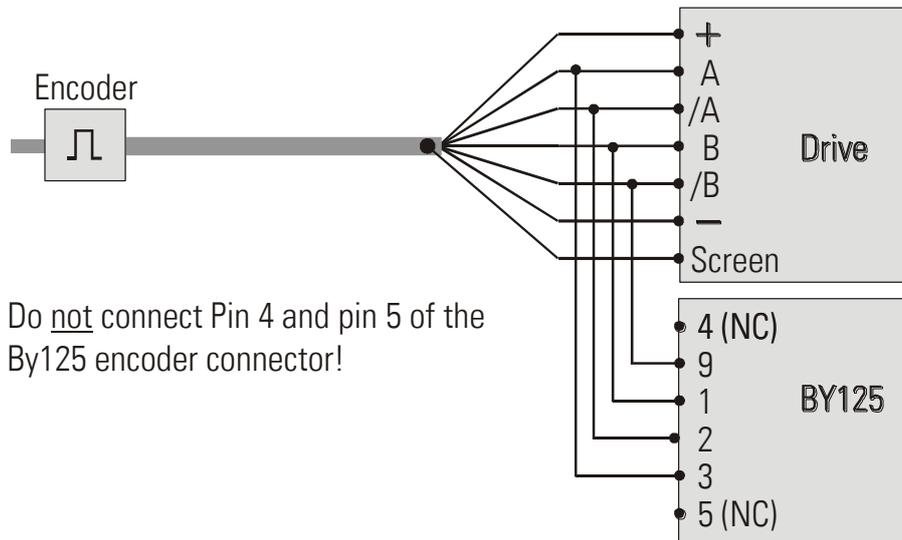


Fig. 24



Where you use **one common encoder** for feedback of the drive and feedback for the BY125 at the same time, there may come up interference problems. You can use an impulse splitter to eliminate any kind of problems. In some applications, the common encoder would also work fine when it is supplied by the drive and the BY125 operates in fully differential mode like shown.



10.3. Screening

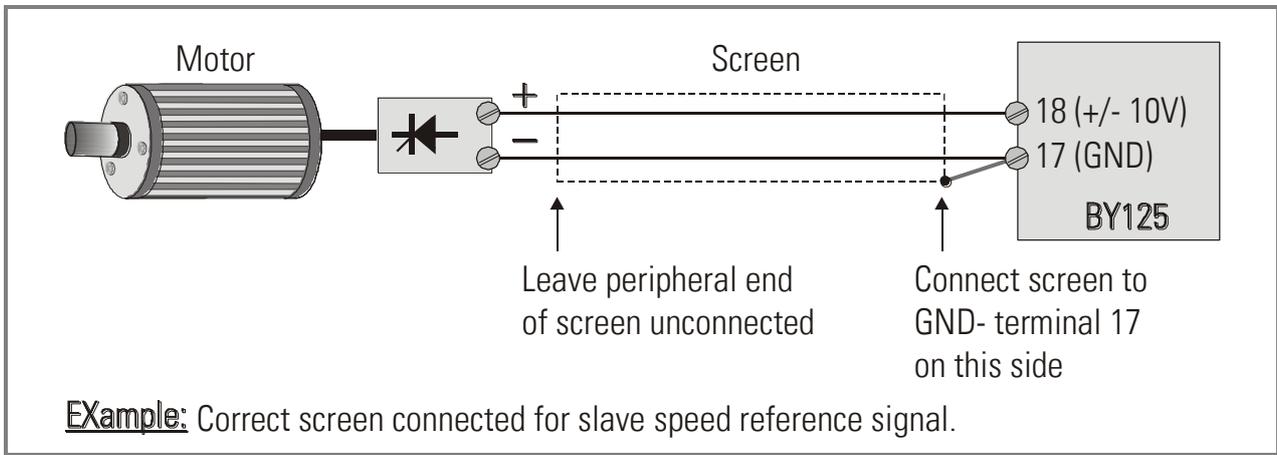
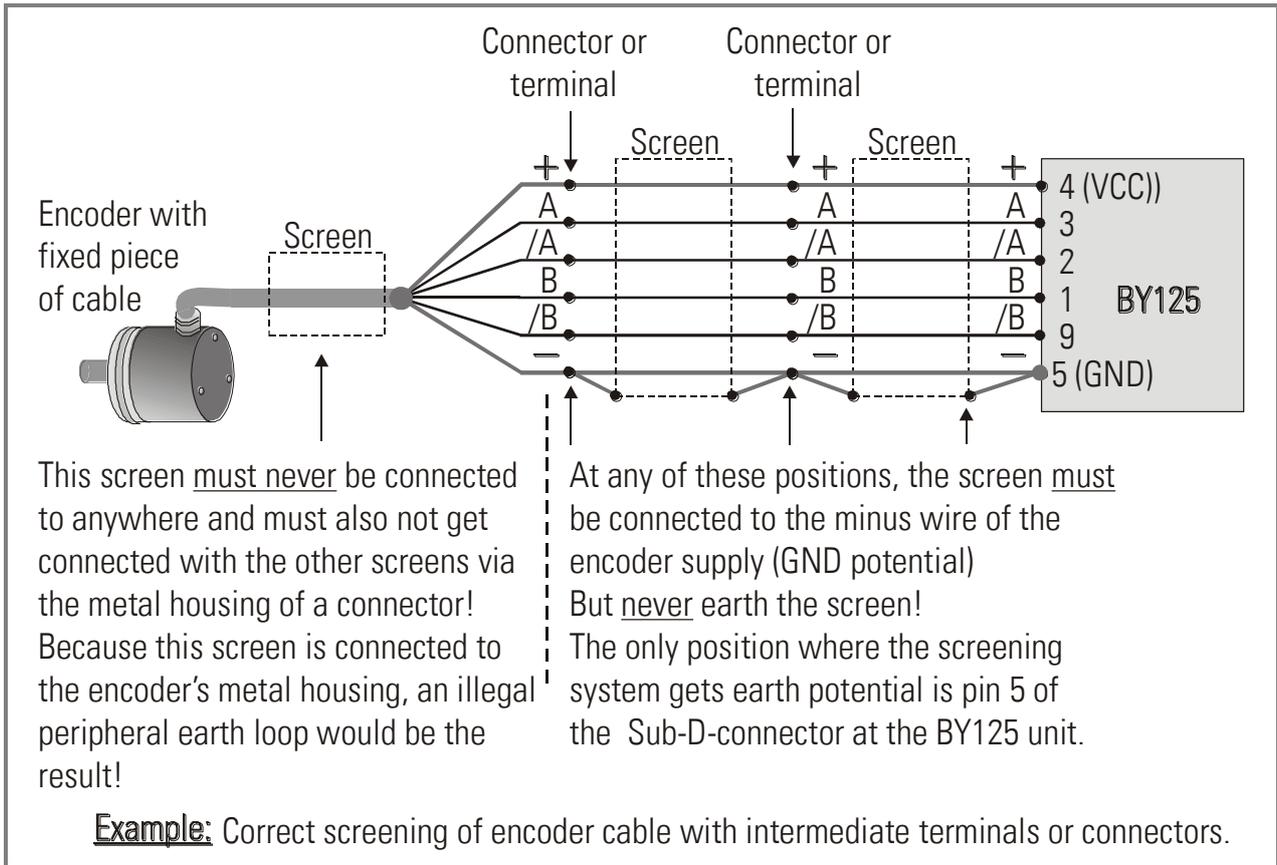
It is mandatory to use screened cables for encoders and analogue signals. Correct connection of the screens is **essential** for trouble-free function.

Control inputs like Reset, Trim etc. can be unscreened, provided the cable length does not exceed 5 meters. Use screened cables for longer length also.



The following basic screening rules must be observed:

- With impulse cables (encoders), the screen must be connected at both ends.
- Analogue signals and control lines need screens connected only on one end.
- The screen potential must be the internal GND of the BY125 unit (not earth potential! See GND terminals on terminal strip). Since, in general, the minus wire of the 24V power supply will be earthed anyway, the screens will automatically receive earth potential when connected to GND.
- At its peripheral end, the screen **should not** be tied to earth nor touch metallic parts that are earthed. Where you use an encoder with plug connection, the screen should not touch the metallic housing of this connector! (With the encoder mounted at the machine, this would be an illegal earth loop).



Please note, that **not all types of cables** are suited to transmit frequencies as high as **80 kHz!** However, with proper installation and screening, the RS 422 lines provide perfect transmission even over long distances.

The **cross section** of encoder cables must be chosen with consideration of voltage drop on the line. The BY 125 provides a 5.5 V encoder supply and at the other end the encoder must at least receive its minimum supply voltage! (See encoder specifications).

10.4. Cables

All cables should be installed separately from motor cables and other power lines. Use normal filtering methods for all inductive equipment installed close to the synchronizer (i.e. RC filters for AC contactors and diodes for DC inductive circuits). Take all standard precautions with respect to wiring and environment conditions that are usual for industrial electronic equipment.

10.5. Remote Signal Commutation

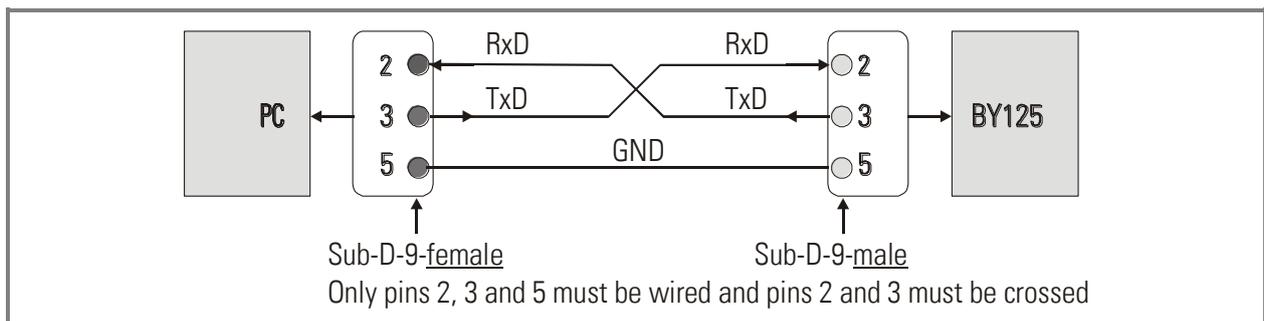
If you need to switch electronic signals by relay contacts, it is necessary to use relays with gold contacts (low voltage and micro- currents). For impulse switching we recommend the use of our electronic cross switcher GV210. For impulse and analogue switching, we recommend the use of our electronic matrix switch GV 155.

11. Steps for Commissioning

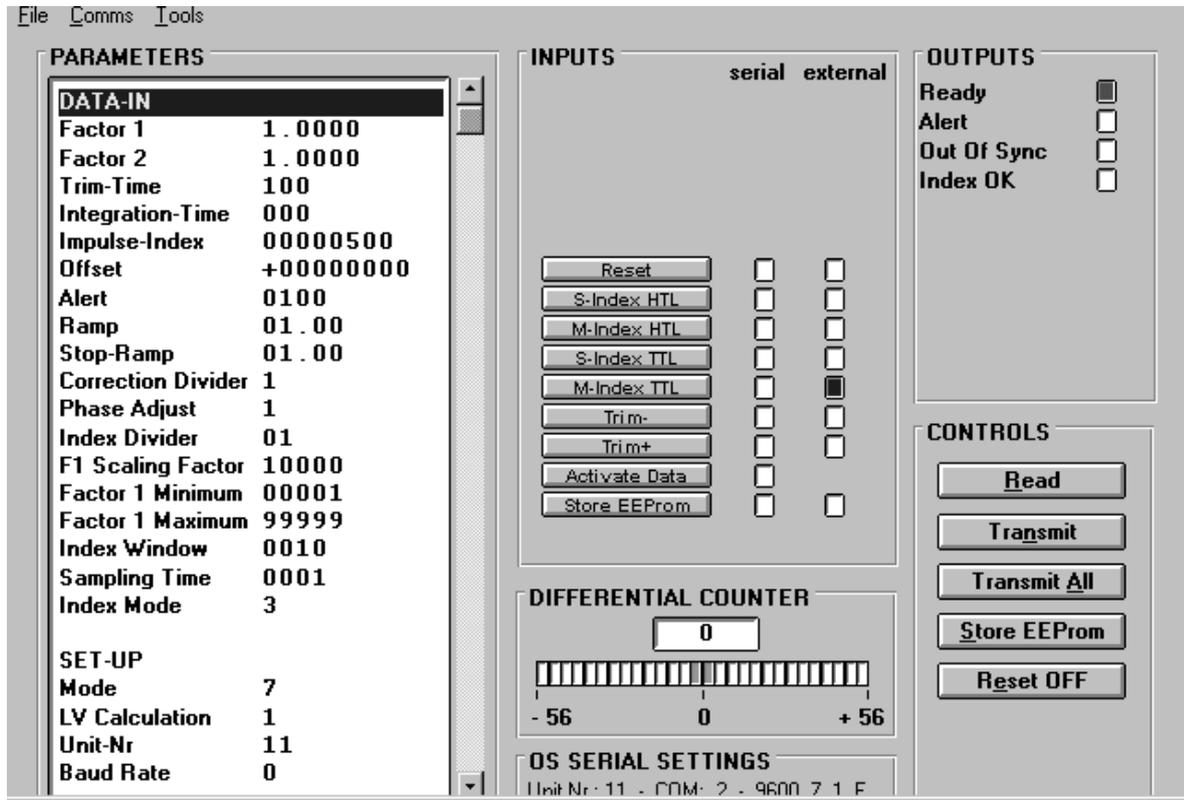
Make sure that the drives are properly adjusted to run the speeds needed for later synchronization. When using analogue feed forward, the internal acceleration ramps of Master and Slave must be set to minimum. With digital feed forward, the Master may use internal ramps, but the Slave ramps must be set to zero or minimum.

Observe all remarks and hints given in this manual and the drives manual. In case of any problems, a digital multi-meter and an oscilloscope should be available.

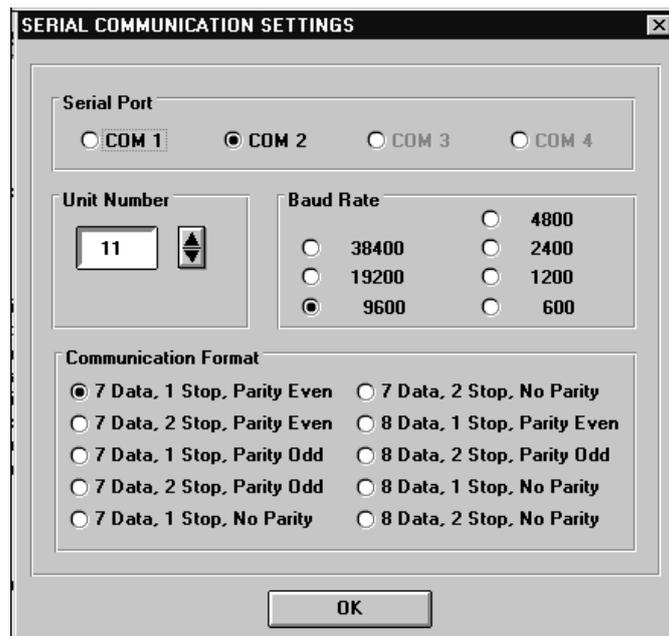
- Remove the right hand side plate and adjust carefully DIL switch S1, as shown in section 7.2. If a RS485 interface is used, also adjust S2, as shown in section 7.4.
- Verify that all connections are correct. Disconnect first all connectors from the front, except the power supply connector. Switch power on. After a short delay, the LED on the front will begin to flash slowly.
- Connect your PC to the BY125 unit. The cable you use must be wired like shown.



- Start the OS3.0 operator software.
You must see the following main screen now.



Where you find an empty mask with the indication "OFFLINE". click to the **Comms** menu and verify the serial settings. Ex factory, the BY125 is set like shown below and you must set the COM number of your PC which you use for communication.



Where you do not know the actual settings of your BY125 unit, you can use the **SCAN** function in the **Tools** menu to find out.

- When serial communication is o.k., **enter all variables** according to your application. The following registers must be set to fixed values for the first steps of commissioning, like shown in table. (You can change these settings later when the first steps have been completed successfully.)

Integration Time	:	000
Correction Divider	:	1
F1 Scaling Factor	:	10000
Factor 1 Minimum	:	00001
Factor 1 Maximum	:	99999
Mode	:	1
LV-Calculation	:	a. 1 with analogue feed forward b. 5 when you use the internal f/V converter (digital feed forward)
Gain Correction	:	100
Gain Total	:	a. 1000 with analogue feed forward b. See table for digital feed forward

With digital feed forward, the initial "Gain Total" setting depends on the master encoder frequency at maximum master speed:

fmax	Gain Total
1 kHz	54000
3 kHz	18000
10 kHz	5400
30 kHz	1800
100 kHz	540

Settings shown are approximate and values between can be interpolated.

Some other settings are unknown and not important at time this (e.g. Master direction)

When you have entered all variables, click the **Transmit All** button and then the **Store EEprom** key to transmit and store data to the BY125 synchronizer.

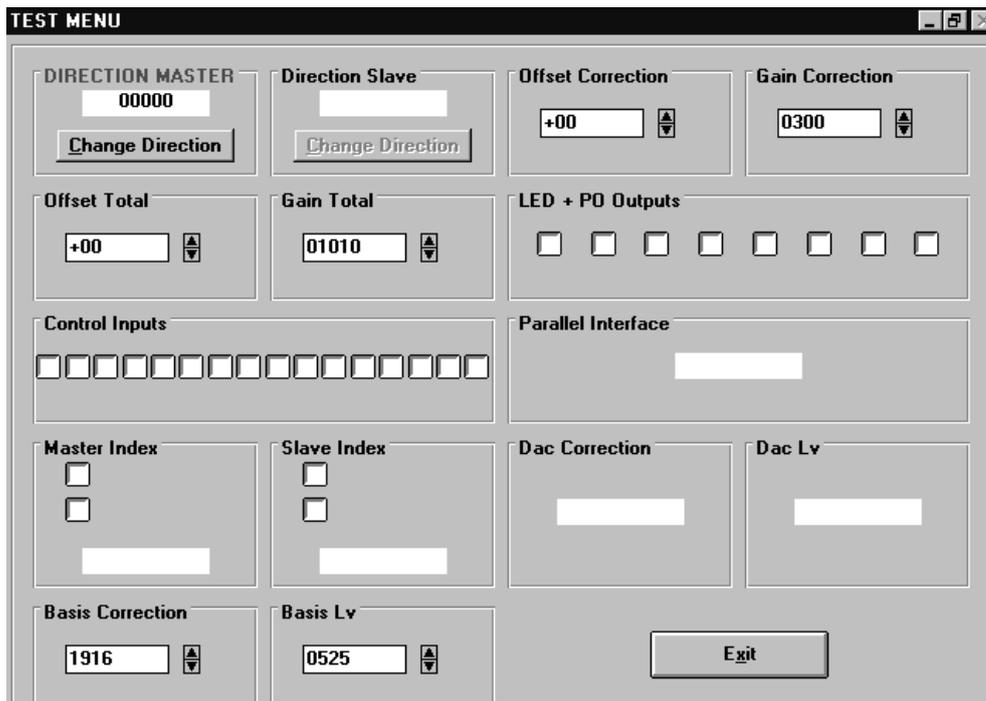


Where you find letters undersigned, you can get the same function also by keypad, pressing **Alt** and the corresponding key
(ex. **Alt** + **S** = **Store EEprom**)

- It is recommendable to check the correct function of the external control signals you have connected to the unit. When you switch ON and OFF the remote signals, you can see the input state in the corresponding indicator box of the "external" column of the INPUTS field on your screen.
- With the next step we need to find out the **direction bits** of Master and Slave. At this time we must be absolutely sure about the direction of rotation and our forward/reverse definition.
 - a) Where we use analogue feed forward system (LV-Calculation = 1...4), the **forward** direction for both, Master and Slave, is the direction which the drives take when **positive speed reference** (0...+10V) is applied.
 - b) Where use digital feed forward system (LV-Calculation = 5...8), the polarity assignment is not important for the Master. But at any time, the **forward** definition for the Slave is again the direction it moves **with positive speed reference**.
 - c) When in later operation no reversals are planned, set up your drives in a way that you **always use positive speed reference**. Where you later need to operate the drives in both directions, make sure you use always the "forward" direction for the following steps (like defined by a) and b).

Non-observance of above hints will result in failure of the commissioning procedure!

Select the **Test** function of the **Tools** menu



- Click to the "Master Direction" box and you will find an up/down counter for the master encoder. This counter must **count up** (increment) when you rotate the master encoder **forward**. When we count down, click "Change direction" to reverse the counting sense. When we count up, change over to the "Direction Slave" box.
- The "Direction Slave" counter again must **count up** when you rotate the Slave encoder **forward**. If necessary, change direction. When we count up, click to any other box to exit the direction settings.

This procedure has automatically set our Master and Slave direction bits to either 0 or 1 according to need.



You can use the previous procedure also to check the proper function of your encoders and wiring. While you rotate the encoder forward by exactly one or several turns, we must find the ppr number (or multiple) in our display window. When we rotate back by the same amount, our counter must again have reached zero. Any other result would indicate a problem like wrong wiring of encoder channels or slip of the coupling or interference due to bad screening etc.

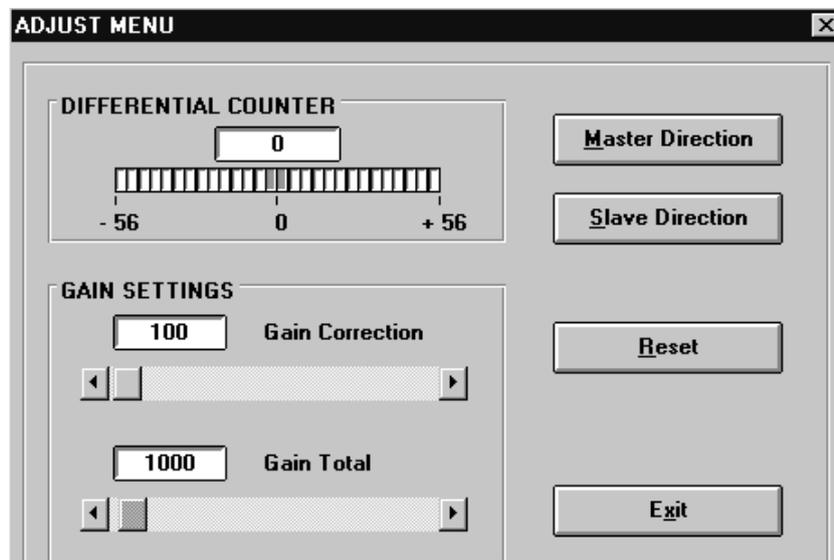
When, in final operation, we do not use one of the Index operation modes, we can exit the Test Menu now. Where **Index functions** will be needed later, click to the "Master Index" and the "Slave Index" boxes to execute the following tests:

- When you move the corresponding axis forward, you will find the number of encoder pulses between two index pulses in the display window. Where the index comes from the encoder itself, this is the ppr number of the encoder. Many times, when using external index pulses from a proximity, the accurate number of pulses between two markers is not exactly known and you can find it out by this test (see "N", "K" and "Factor1" in section 6. which is important for successful index operation!).
- When we move slowly enough, we can also see the index pulses blinking in one of the indicator boxes (Upper = HTL-index, Lower = TTL-index).
- When we rotate to reverse direction, the display will not show our impulse number, but its 16 bit complement which is "65536 - impulse number".

After performing the index tests, exit the test menu and get back to the main screen.

We must now adjust our **Gain Total** setting. This is to ensure the Slave drive receives the correct speed reference voltage for the speeds it should run.

Select the **Adjust** function of the **Tools** menu.



The subsequent procedure assumes our Gain Correction is set to 100 and you do not touch Gain correction before we have set Gain Total.

- Enable both, Master and Slave drive and run the Master forward at slow speed (e.g. 10-20% of max. speed). The Slave will follow the Master.
- Set the DIFFERENTIAL COUNTER to zero and the Color bar graph to the green centre by switching Reset to ON.
- Watch the color bar while you switch Reset OFF. It will deviate to right or left while the DIFFERENTIAL COUNTER counts to positive or negative. Please note, with very wrong initial setting we can swap over from any side to the opposite side after some time. Then please observe only to where we deviate immediately after releasing RESET.
- When we deviate to right (positive), our Gain Total setting is too low and must be increased.
- When we deviate to left (negative), our Gain Total setting is too high and must be reduced.
- Find the Gain Total setting that keeps the DIFFERENTIAL COUNTER around zero and the color bar around the green centre zone.
- For rough adjusting, use the slide button in the Gain Total field.
For fine tuning, use the ◀ ▶ keys.
- When Gain Total is set to keep the bar around zero, we adjust Gain Correction now. The general rule is to increase the setting to values as high as possible, but still ensure stable operation. Typical settings are between 300 and 2000. Depending on drive, inertia and gearing you can get stability problems when Gain-Correction is too high (rough or noisy motion of the drive and visible oscillation of the bar graph and the differential counter). If so, reduce Gain Correction until we are stable again. When you have observed stability problems, you should also try to suddenly stop and restart the master and ensure the slave does not tend to oscillate after this action also.
- To change the Gain Correction settings use again the slide button and the ◀ ▶ keys like with Gain-Total.
- Change the speed between standstill and maximum speed, observe the differential counter and the color bar and **optimize** the Gain settings if necessary. Exit the ADJUST MENU when you feel your settings are o.k. This will automatically store your settings to the EEPROM of the BY125 synchronizer.

This concludes the general set-up procedure which needs to be done with every application. At this time your drives operate in a closed loop digital synchronization and the next section will show you some hints how you could still improve performance with some applications.

12. Hints for Final Operation

12.1. Integrator

When, for stability reasons, you needed to keep your "Gain Correction" value low, any important non linearity in your drive system could cause changing phase errors* with changing speed (e.g. color bar deviates to right at low speed, stays in centre at medium speed and deviates to left at maximum, speed).



* Please note that a deviation of the color bar does not indicate a speed error at all, unless the differential counter shows figures outside a +/- 1024 error increment range. Inside this range, the speed always is error-free and deviations only refer to the constant number of encoder increments that the Master leads or lags the Slave position.

Where your differential counter remains in an acceptable range around zero (e.g. -5....0....+5) at any speed, there is no need to use the Integrator and you can leave the "Integration Time" setting at 000.

Where you feel your phase accuracy should be better, set Integration Time to 50....40....30 20....10 or even lower. The Integrator will move the phase error always into a +/-6 increments error window and the lower the setting, the faster the speed of compensation. Too low settings (= too high integration speeds) can result in oscillation, depending on individual inertia/friction/dynamic conditions of your system.

With Index operation, the Integrator should be switched off, because the marker pulses will compensate phase errors.

12.2. Correction Divider

Where you find your color bar oscillates quickly around zero over several fields, this indicates your encoder resolution is high with respect to mechanical clearance and backlash. Set the correction divider to 2 or 3 to get more stable operation.

12.3. Offset voltage

Some low cost AC inverter drives would have a dead band around zero, i.e. they would not respond to small speed references like 50 mV. This can cause the slave to lag the Master with very low speed. You are free to use the Offset Correction register and set it to a negative value like "-50". This will result in a small positive output voltage like +50 mV at standstill and the drive is kept at the threshold of its dead band from where it can break off immediately.

12.4. Other settings

Up to now we have been operating in mode 1 with a couple of initial settings, in order to make commissioning easier. You are free now to set all variables to their final values, like required for your application.

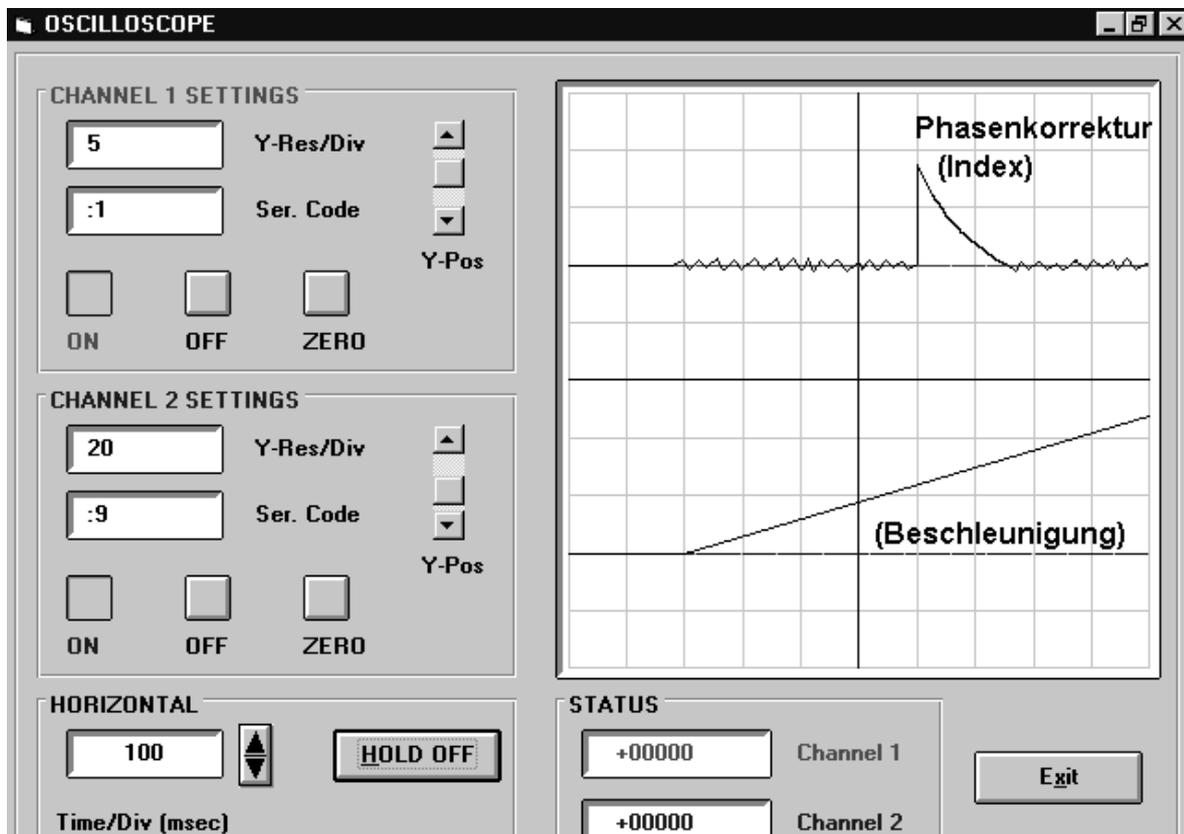
12.5. Oscilloscope Function

It can be useful to observe the performance of synchronizing by the oscilloscope function, which you can find in the **Tools** menu. You can record all the variables and registers by entering their serial access codes.

The following supplementary codes are available for readout and record:

:1	Synchronizing error (Differential Counter)
:4	Integration register
:9	Actual Master speed, scaled as „number of master increments per sampling time“

The following example shows the error register (channel 1) and the line speed (channel 2) while we accelerate the drives, and the peak shows how the unit corrected the position after an index check.



13. Serial Codes

Beside the serial access codes shown in this manual, the subsequent codes are available to execute the same commands that can be activated by the hardware inputs also:

Ser. Code	Bit of control word(C86)	Function	Type
60	7	Reset	S
61	6	Index Slave	S
62	5	Index Master	S
65	2	Trim -	S
66	1	Trim +	S
67	12	Activate Data	D
68	0	Store EEPROM	D
S =	Static command. Must be set to 1 to activate command and must be reset to 0 deactivate command		
D =	Dynamic command. Must be set to 1 to activate command. Is automatically reset to 0 after execution.		

All commands can be activated either by their specific serial access code or by setting the corresponding bit of the **control word (Ser. Access code 86)**.

Please note that all serial commands are "logical OR" to the hardware commands (control inputs) and hence a command is ON whenever set by serial command or hardware input or both at a time.

The state of the control outputs can be read out by the **status word (Ser. Access code 85)** via serial interface. Bit 0, 1, 2 and 3 of the status word correspond to control outputs terminal 21, 22, 23 and 24.

For more details about all serial communication please refer to the SERCOM manual which is available on our homepage.

14. Master Reset and EEPROM Erasure

The unit carefully checks all entry data for validity and correctness within their permitted numeric range. If, as an extreme exception, invalid data should intrude into the register range, bad function or even a full hang-up could be the result. If this should ever happen

- Switch the unit off and on again

This will result in a complete reconfiguration of all ports and registers.

RAM and buffer data will be **lost** and the unit restores all data from the EEPROM.

If, however, invalid data should have penetrated to the EEPROM, even the previous steps will not help. In this case:

- Switch off the unit
- Set all control inputs to HIGH at the same time, i.e. connect all terminals from 5 to 10 to +24 volts (terminal 11).
- Switch power on again while all control inputs are HIGH at the same time.

This will clear up all the EEPROM to its default values, and all registers need to be set up once more.

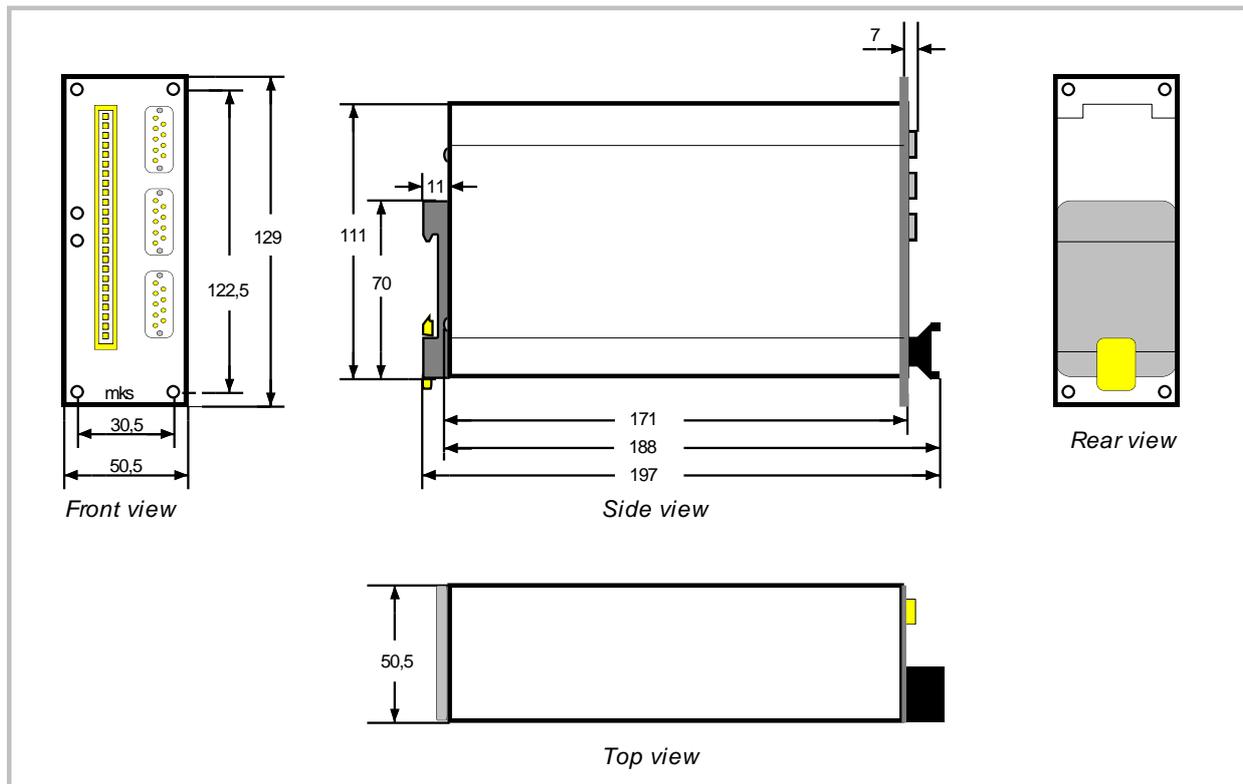


Above steps represent an emergency procedure that you will never have to apply under regular conditions.

In an extreme case however (i.e. lightning-strike in the factory etc.) they could help to get the unit working again.

Please note it is a must to clear up the EEPROM whenever you have changed the processor chip for upgrade or modification of the firmware!

15. Dimensions and Specifications



Power supply	:	18...30 V unstabilized
Consumption	:	approx. 200 mA (plus 25 % of the encoder supply currents, if internal encoder supply used)
Encoder Supply	:	Aux. voltage 5,5 V, max. 500 mA, <u>not</u> short-circuit proof
Processor	:	H8 / 325 with 20 MHz clock frequency
PBC and Technology	:	SMD, Multiplayer PCBs, high-speed logic 74 HCT
Encoder Inputs	:	Two A, \bar{A} , B, \bar{B} , Z, \bar{Z} (5 V TTL / RS 422), $R_i = 1\text{ k}\Omega$
Other Inputs	:	6 control lines, all PNP with 18 - 30 V level, $R_i = 15\text{ k}\Omega$
Serial link	:	RS 232 with DTR output and (optional) RS 485
Maximum frequency	:	80 kHz on each channel
Response time	:	approx. 160 μs
Analogue IN / OUT	:	1 input + / - 10 V ($R_i = 100\text{ k}\Omega$) 1 output + / - 10 V ($I_{\text{max}} = 5\text{ mA}$) Resolution: 12 Bit (= 4096 steps)
Analogue Correction	:	10 Bit = 1024 error increments
Saturation of error memory	:	32 000 error increments
Control Outputs	:	4 transistor outputs (opto-coupler 50 V / 30 mA max)
Speed error	:	+ / - 0.00 (absolute)
Operating temperature	:	0...45° C
Dimensions	:	see drawing
Weight	:	approx. 850 g

16. Appendix: Option UP125

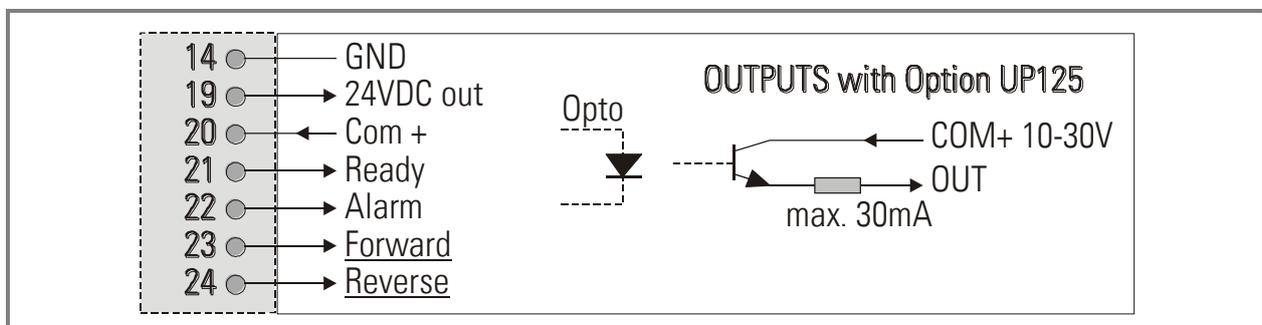
All previous remarks and hints are valid for drives accepting a +/- 10 volts speed input signal, where the direction of rotation depends on the polarity of the input voltage.

However, many of the standard AC inverter drives offer only a positive input range, and the direction of rotation is selected by means of two digital inputs ("Forward enable" and "Reverse enable"). The standard BY125 firmware will have a couple of problems to handle this type of drives under certain conditions. Therefore we offer a special firmware that takes into consideration the special features of 1-quadrant inverter drives. Where you intend to use such a drive as a Slave, please order

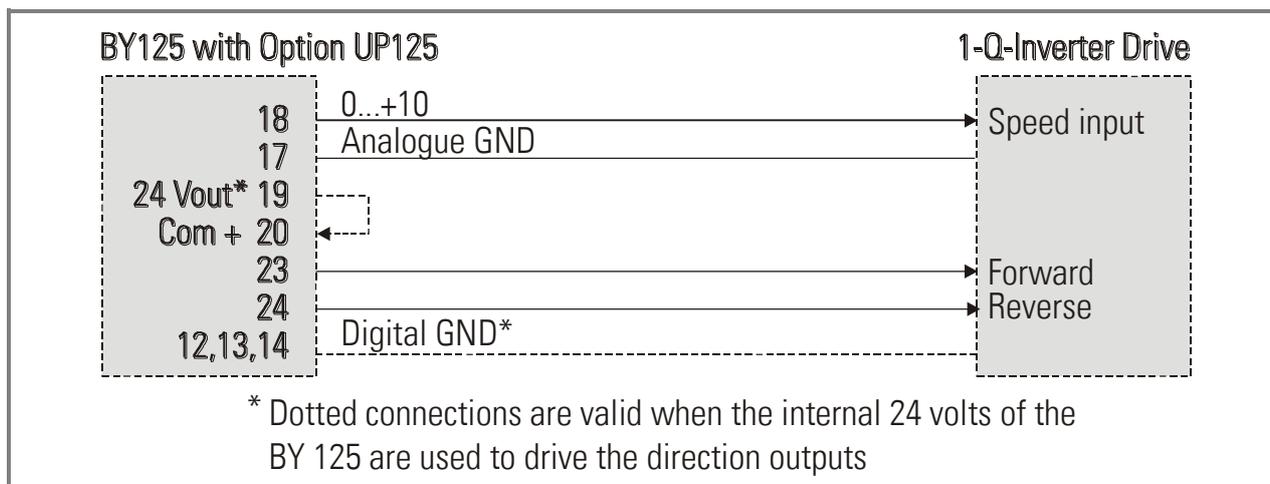
BY125 with Option UP125

and you will receive the same hardware, but with the special firmware (no difference in price). The subsequent comments describe the difference:

- You must set register "LV-Calculation" to 5 (or to 6 where reciprocal characteristics should be required). With digital feed forward, the unit will generate only positive voltages at the analogue output, no matter if we move forward or reverse.
- Output terminal 23 provides a "Forward" output and terminal 24 provides a "Reverse" output. The outputs switch to "HIGH" to select the corresponding direction. The outputs "Out of Sync" and "Index o.k." are not available with this version.



Please connect your Slave drive to the BY125 as shown:



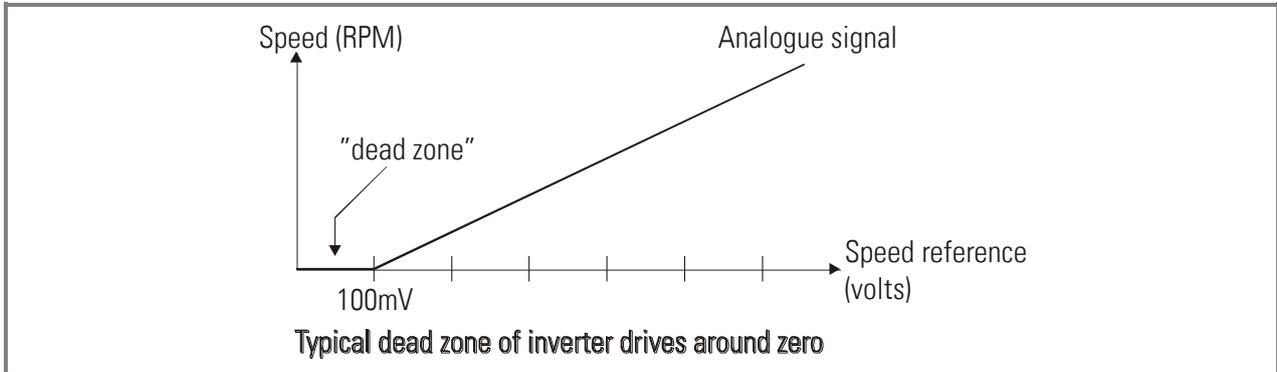
In the menu, instead of register "Index Window" you will find the register **"Dead Band"**. This register provides proper control of the Forward and Reverse direction outputs as follows:

- When the Master is moving into forward direction, the "Forward" output will be HIGH and the "Reverse" output will be LOW
- When the Master is moving into reverse direction, the "Reverse" output will be HIGH and the "Forward" output will be LOW
- When the Master is at Standstill, there are three options:
 - a. The relative position of the Slave is behind the Master (underswing situation). Then the "Forward" signal will remain on with a small voltage at the analogue output, so the Slave can crawl forward into the correct position
 - b. The relative position of the Slave is ahead of the Master (overswing situation). Then the "Reverse" signal will remain on with a small voltage at the analogue output, so the Slave can crawl reverse into the correct position
 - c. The relative position is inside the set window. Then both direction outputs will be off and the analogue output will be zero.
- With inverter drives, you must leave a +/- tolerance window where in standstill the relative Slave position is allowed to be without further actions of the controller. This window is set by the register "Dead Band". The scaling is in "analogue increments" where each increment corresponds to 5 mV. A typical register setting would be 15 meaning that both direction outputs remain OFF (drive disabled) as soon as the speed reference voltage gets lower than 75 mV.



Hint:

Most of the inverter drives would have an analogue dead zone near zero. This means they would not start to move with small voltage, but only break off when we overpass a certain minimum threshold (e.g. 100 mV)



It is easy to understand that this kind of behavior makes it difficult to have accurate control over the full speed range. For better performance we should therefore set an analogue offset of 100 mV (example), which, in standstill, keeps the drive already close to the break-off threshold and makes it move immediately with a small change of the analogue signal.

To do this, you can use register "Offset Correction" (C47). Every increment there corresponds to a voltage of 5 mV. Please note you must set the register to negative values to get positive voltage! Example: setting to -20 will result in a +100 mV output instead of zero.

Recommended procedure: (must be done before you run the Adjust menu to set the Gains)

- Make sure the master is in standstill. Click "Reset" to ON state, so our differential counter is held to zero. Enable the Slave drive by an external signal (both BY125 direction outputs will be OFF at this time).
- Change register "Offset Correction" to values like -10, -11, -12 etc. until you observe that the drive breaks off to move. Then reduce the setting by one digit and store the new setting.