control – motion – interface

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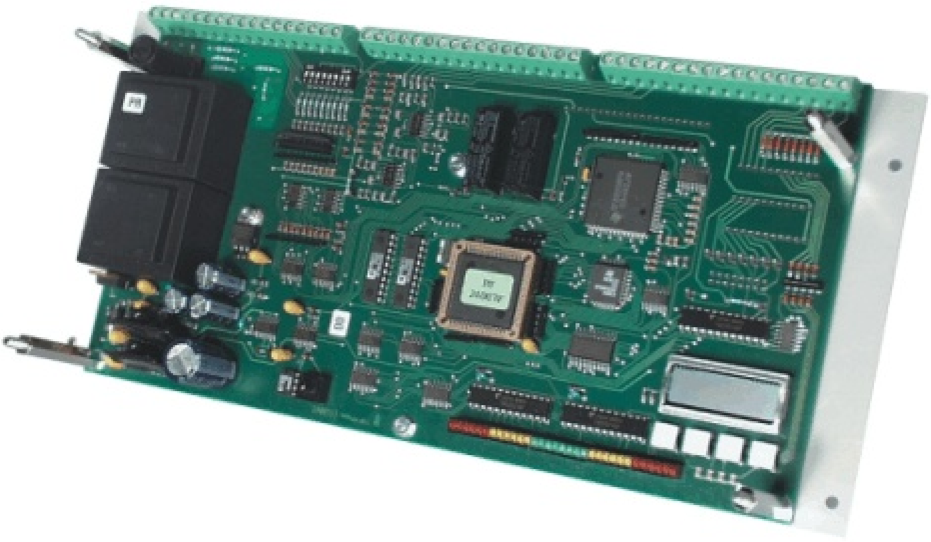
CE

BY 240 / BY 840

Synchro-Controllers Operating Instructions



- **Error-free angular synchronisation and adjustable speed ratios**
- **Highly dynamic, only 120µsec of cycle time**
- **80 KHz of encoder feedback frequency**
- **HTL encoder inputs for 10-30 Volts level**
- **Index and print mark registration facilities**
- **Speed transitions by S-shape speed profile**
- **Easy LCD display setting or PC setting by Windows software**
- **BY240: PCB construction for cabinet mounting**
  BY840: Standard mount-housing for front panel mounting

BY24003o.DOC / Mai 08 / 39 pages

Table of Contents:

1. Introduction

BY240 repesents an upgrade version of the former BY200 controller which tenthousendfold has been installed for many applications worldwide. The new models, with respect to dimensions and wiring, are almost *) compatible to the old version, but use updated processor technology providing extended functions and upgraded features.

These are the most important changes:

- Increased encoder feedback frequency of 80 KHz
- Setup by LCD and keypad instead of thumbwheel switches and potentiometers
- Optional RS232 serial interface for PC control and easy setup by the OS3.0 operator software
- Extended operation modes with index registration
- Analogue feed forward facility to be compatible with old version, but also fully digital feed forward mode for new application

*) Not compatible:
  a) Old BY200 units were able to operate with either single channel encoders or quadrature encoders. New BY240 model needs quadrature encoders at any time. A special single channel version is available on request.
  b) Units with parallel interface (old option PI200, new option PS240) have a different potential on pin 3 of the 25-pin Sub-D-connector. While pin 3 was GND with old units, Pin 3 is a “Store-to-EEprom“ input with BY240 units.

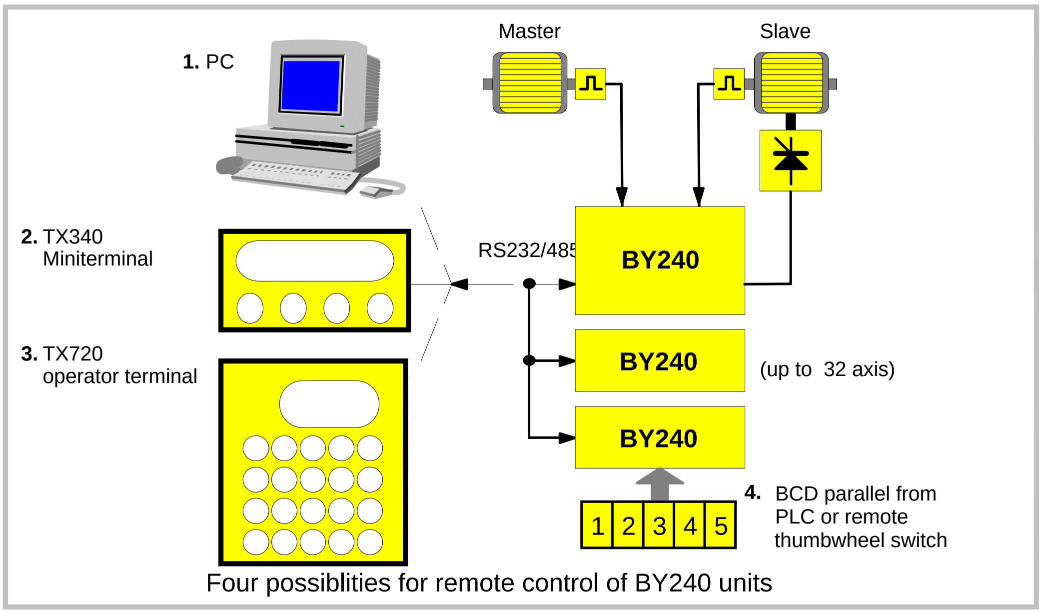
The standard set of functions allows setting and changing of speed ratios, preset and change of phase and relative position between the drives and full position control by index and print mark tracking.
All settings are fully digital and repeatable and no potentiometers or trimmers must be adjusted. With option PS240, a parallel and a serial interface is available providing remote settings of variables by simple BCD thumbwheel switches or PLC or PC.

BY240 is supplied as a PCB print construction with screw terminal connectors and a plexi glass cover. Normal power supply is 115/230 VAC (jumper selectable). Against special remark upon order, the unit is availbale with 18...30 VDC supply.

BY840 is similar to BY240, but the PCB is built into a DIN housing (288x72x170mm) for mounting in a front panel or an operator desk.

Ordering Information:

BY240 resp. BY840	:	Controller without communication interface
Option PS240	:	Supplement BCD parallel interface and serial RS232/RS485 interface for full remote control



Four possiblities for remote control of BY240 units

Fig.1

2. Principle of operation

All operation is based on setting an "analogue synchronisation" 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-synchronisation can match the two speeds within an error range of a few percent.

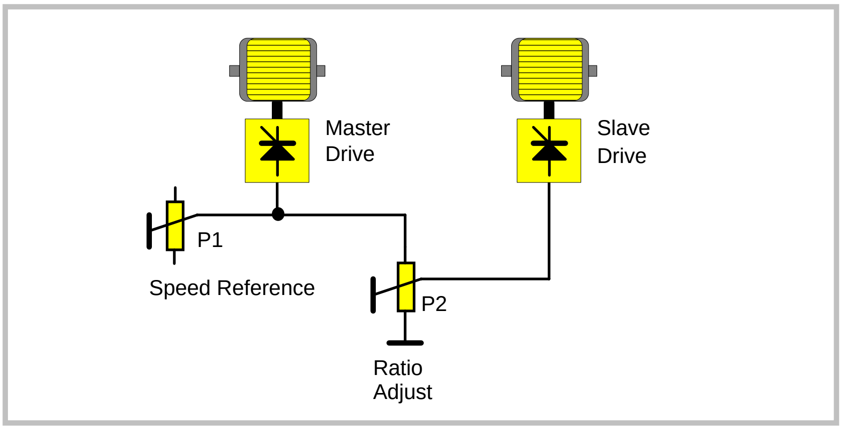


Fig. 2

The digital synchronisation now has to compensate for the analogue speed errors in order to get an **absolute**, **angular** and **positional** synchronisation with **no drift** and no cummulative 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. (i. e. encoder simulation from a resolver system) are used.

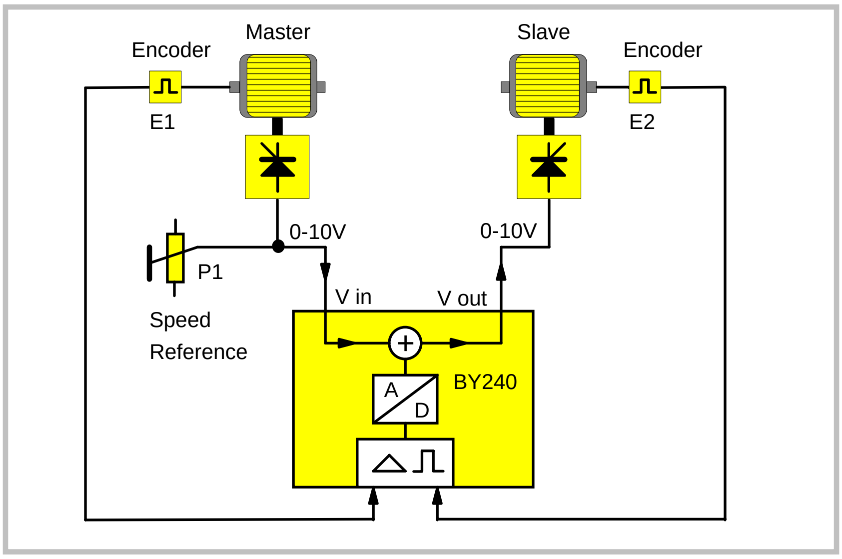


Fig. 3

The synchroniser 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 synchroniser responds within only microseconds to each individual encoder pulse, the slave will practically have no chance to drift away.

Fig. 3 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 two ways to generate Vin:

a) Use of the master speed reference voltage, like shown in Fig. 3. 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 BY200 units against a new BY240 version.**

b) Use of the ultra high speed frequency- to- voltage converter installed in the BY240 units. **This procedure can be used for most of all applications.**

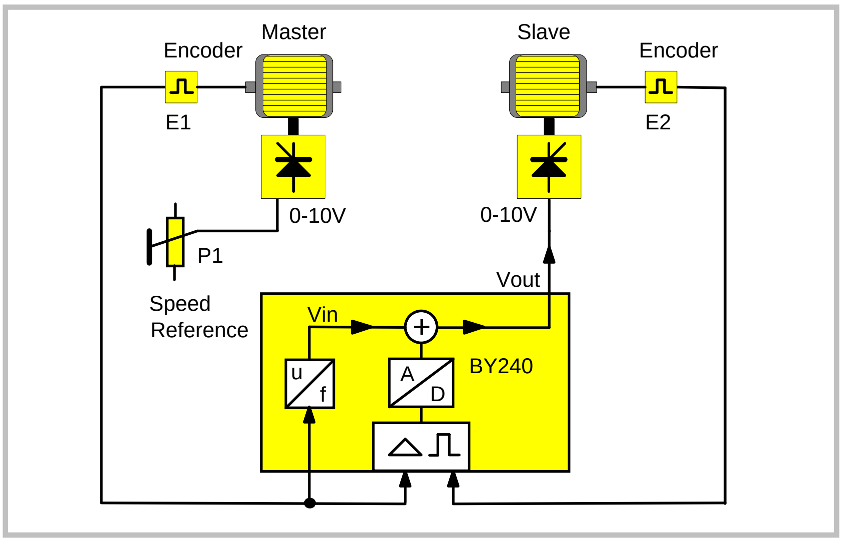


Fig. 4

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, instead of a real drive.

Where, due to poor resolution of the master encoder, the master frequency at <u>maximum speed</u> does not even reach values like 500 Hz, it may become necessary to apply an external frequency-to-voltage converter (ex. motrona Type FU202) to generate the feed-forward signal.

3. <u>Impulse Scaling</u>

For easy adaption of the synchroniser to operational and physical conditions (gear ratios, encoder resolution, roll diameters etc.), both, Master and Slave impulses can be scaled separately. 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 synchronisation. The factors can also be set remotely via parallel interface, using a simple BCD thumbwheel switch or a PLC parallel output. Of course, remote setting is also possible from a PC with RS232/RS485 communication.
Independent of the way of factor setting, the slave always changes it`s shaft position with respect to the master according to the following formula:

$$S_{Slave} = \frac{\text{Factor 1}}{\text{Factor 2}} \bullet S_{Master}$$

(Proportional operation)

$$S_{Slave} = \frac{1}{\text{Factor 1}} \bullet \frac{1}{\text{Factor 2}} \bullet S_{Master}$$

(Reciprocal operation)

Proportional or **reciprocal** operation can be selected by the parameter **"LV-Calc "** in the Setup menu.

Remarks to previous formulae:

When **positional** and **angular synchronisation** is required, we recommend to set S_{master} and S_{slave} to a number of encoder pulses received from the encoders when both drives move a defined step, pitch or machine cycle forward. When only **speed synchronisation** is needed (i.e. speed errors in a range of 10^{-5} 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 have Factor 1 directly in "User units". (Factor1 is the parameter that could be changed during production, and Factor2 is a "machine constant" that normally will never be changed).

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:

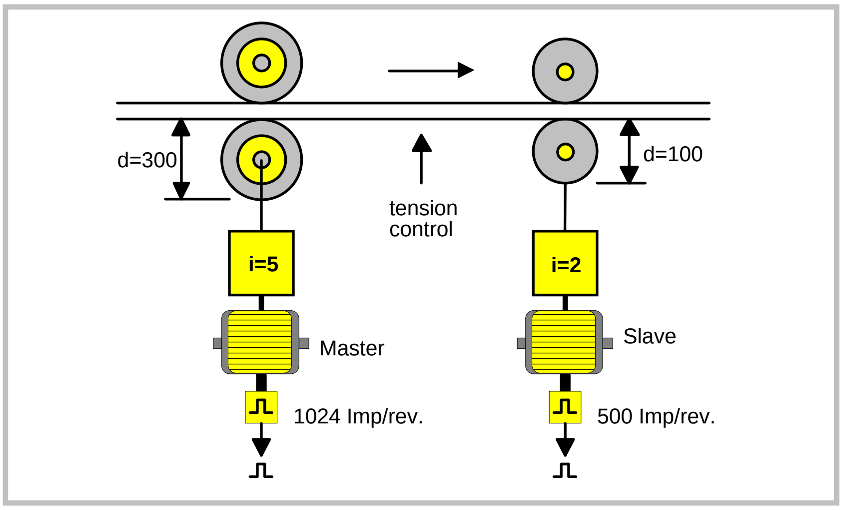


Fig. 5

With one full revolution of the master roll, we receive 5 x 1024 = 5120 impulses from the master encoder. If the material must pass the roll **without** any tension, the slave roll would exactly need 3 revolutions at the same time. So we will get 3 x 2 x 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 x Factor 1 = 3000 X Factor 2

becomes true. The simplest way to do this , is to set 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 formulae with different figures:

5120 x 1,0000 = 3000 X Factor 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.

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 synchronisation** is needed, cummulative errors must be avoided by proper factor setting (factors can only be set with 4 digits to the right of decimal point).
If, i.e., a ratio of 16 : 17 would be required, never use the decimal expression of 0.**9411**7647....as Factor 1, because the non-entered digits will accummulate 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 need not be observed with **speed synchronisation** alone, because speed errors will remain undetectably 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 i.e. become difficult to synchronise 100 Hz on one side with 80kHz on the other side.

4. Ratio Change during Operation

The speed ratio can be changed at any time by changing Fact1. Changing Fact1 from 1.0000 to 2.0000 will result in double slave speed.
The **speed transition** can be sudden or soft. The slave approaches it`s new speed via an adjustable **S-shape ramp**. See parameter "Ramp 1".

With some applications, the **numerical value** of the speed ratio is **unknown** and the operator has to find it out by his own observation and **feeling**. For these applications, the BY 240 provides a **"Factor-Tuning"** function. Starting from the programmed basic value, Fact1 can be incremented or decremented via external pushbuttons "+" and "-". While keeping the button down, Fact 1 will increase or decrease with an adjustable tuning speed. When releasing the button, the actual ratio will be active to keep the drive speeds with digital accuracy.
See „Mode 4“

To avoid wrong operator settings, the remotely accessible range of Fact1 can be limited by the parameters Fact1-min and Fact1-max.

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 (in index modes, the index edges and the programmed phase displacement define the relative position, see chapter 6.)

During all the operation, this inital phase condition is held without any errors, unless the operator uses one of three available phase adjustment facilities:

5.1. Phase Adjustment by Timer Trimming (Mode 1)

This function, activated by the "Trim +" and "Trim -" inputs, provides a temporary higher or lower slave speed which will result in a phase displacement between the motor shafts. When releasing the trim buttons, the drives will synchronise again in their new relative position.
The **differential trim speed** is adjustable and 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. Phase Adjustment by External Impulse Stepping (Mode 5)

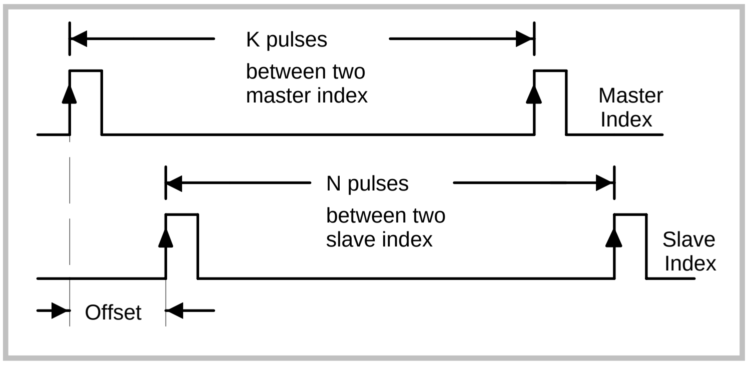
In this operation mode, the trim inputs operate as edge triggered impulse inputs and each negative transition will displace the slave shaft position exactly by one encoder impulse
(Trim+ = forward, Trim- = reverse). This function allows, for example, a PLC control to step the phase to different, **fully repeatable positions** during operation or standstill, in accordance with different product dimensions on a machine. Also is it possible to operate the BY 240 like a **differential gearbox**, because the slave can move according to the **sum** or **difference** of two other drive speeds.

5.3. Phase Adjustment by Digital Phase Offset (Mode 3)

The unit provides an Offset register which can be set to a desired number of encoder impulses. Every negative edge at the ”Index Master” input will displace the actual phase forward by the number of offset impulses, and every negative 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.

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

Index or marker pulses are used to automatically set the drives or the material into a correct relative position. Depending on the Mode setting, the “Trim” inputs have multiple functions and can also receive marker pulses from an encoder or proximity or photocell.
It is possible to enter the phase displacement between the marker pulses by keypad and remotely BCD parallel input or by PC or host computer, and to change it at any time, at standstill or on the fly (Register "Phase offset").



$$\boxed{\text{Fact 1} = \frac{N}{K}}$$

Fig. 7

The parameter **Factor 1** is used to adapt 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. 7 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° 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 Index mode, independant from your Factor 2 setting.

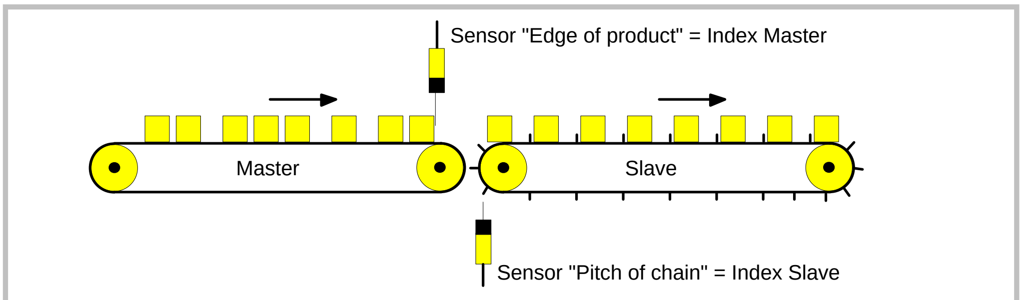
A falling edge on the slave index input starts a phase comparison with the previous master index and a correction, if not coincident to the offset setting.
As a special, the BY 240 can even operate with **different numbers of marker pulses** on both sides. This is possible due to the following features:

a. The master index input is equipped with a programmable index divider , which, for example, allows sampling of only each 5th marker pulse.

b. The slave index input is locked in a way, that it is active only once after each valid master marker pulse.

This enables the user, in terms of one machine cycle, to have for example 5 master markers and 3 slave markers. Upon start up, the BY 240 checks for the nearest marker couple and sets them in line. Subsequently, each 5th master index will be checked with each 3rd 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). The differential speed to correct for the index error can be set by register ”Trimm speed”.
Mode 8 is perfectly suitable for compensation of wheel slip with large cranes (reference marks on the rails, see special description ”Version B25”), to equalise different distance between products when passing from one conveyor to another and similar applications.



Application of mode 8 to control distance between products.

Fig. 8

7. Terminal Assignement and Setup

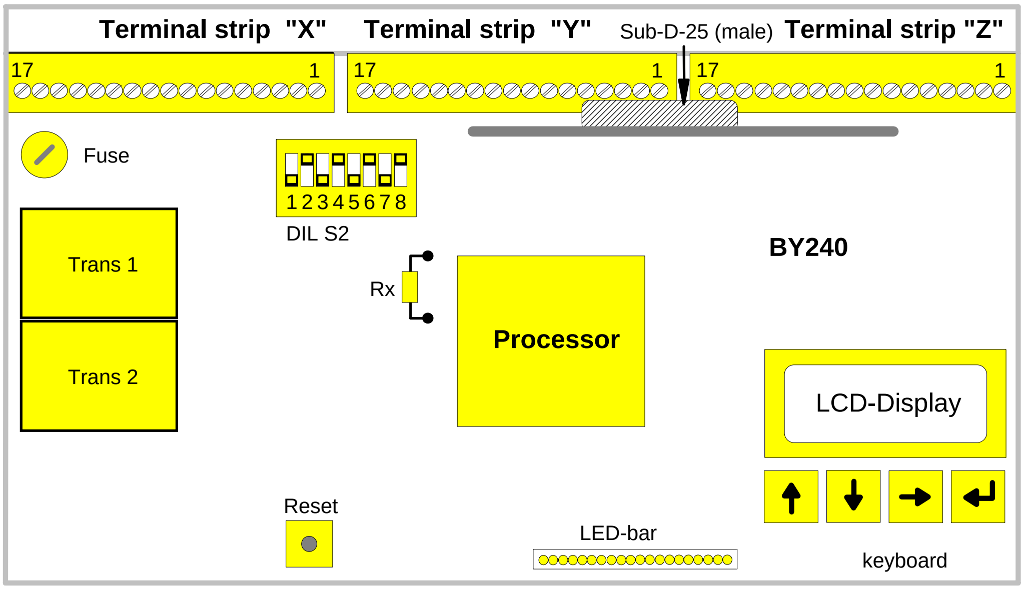


Fig. 9

Fig. 9 informs about the mechanical location of terminals and other components. Fig. 10 shows a block diagram with minimal peripheral configuration and Fig. 11 explains the functions of the screw terminal connectors.

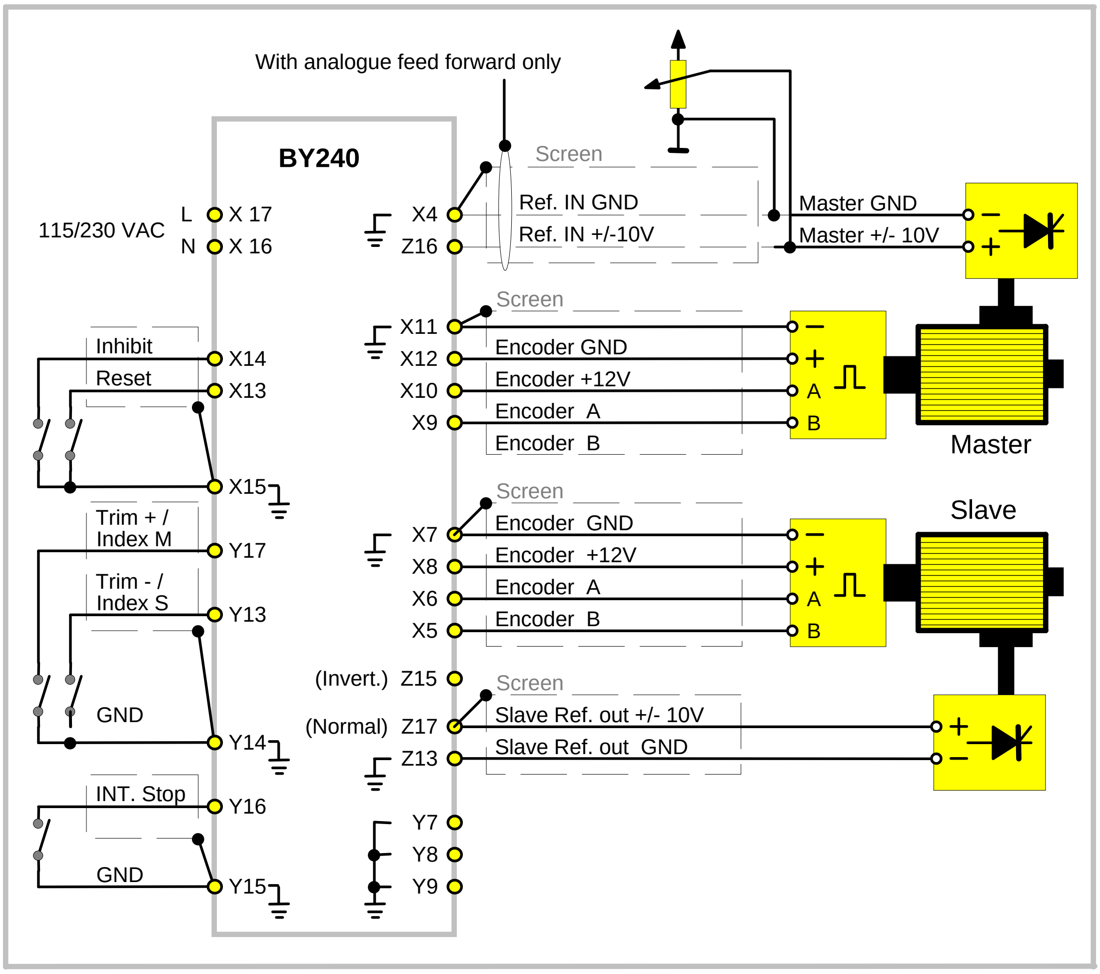
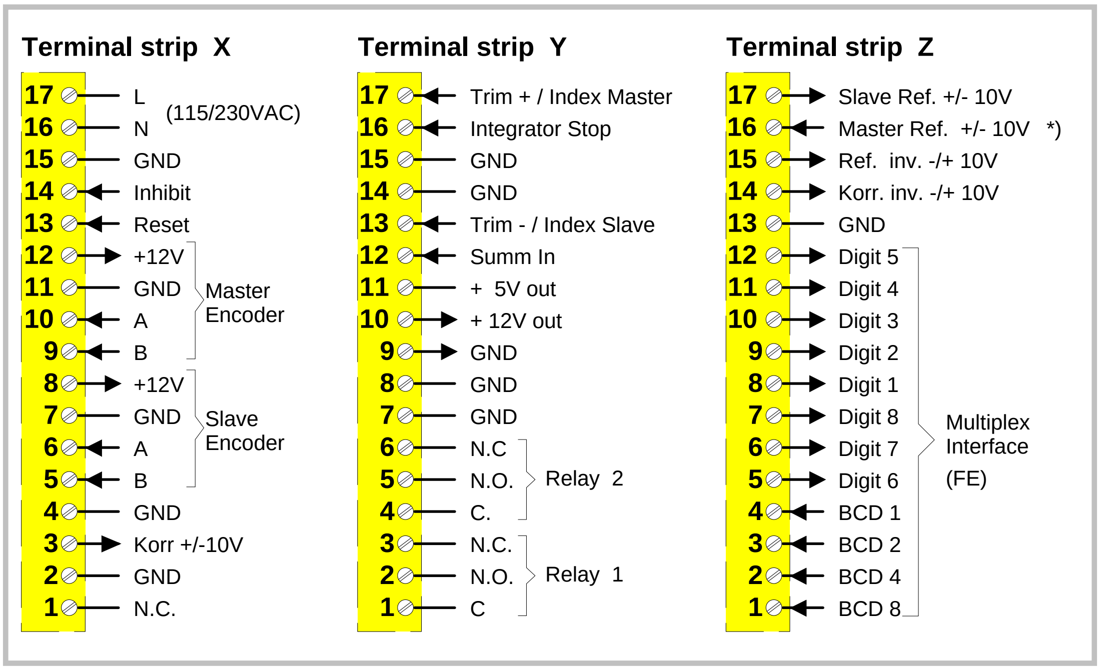


Fig. 10



Terminal strip X

17	L	(115/230VAC)
16	N	
15	GND	
14	Inhibit	
13	Reset	
12	+12V	Master Encoder
11	GND	
10	A	
9	B	
8	+12V	Slave Encoder
7	GND	
6	A	
5	B	
4	GND	
3	Korr +/-10V	
2	GND	
1	N.C.	

Terminal strip Y

17	Trim + / Index Master	
16	Integrator Stop	
15	GND	
14	GND	
13	Trim - / Index Slave	
12	Summ In	
11	+ 5V out	
10	+ 12V out	
9	GND	
8	GND	
7	GND	
6	N.C	Relay 2
5	N.O.	
4	C.	
3	N.C.	Relay 1
2	N.O.	
1	C	

Terminal strip Z

17	Slave Ref. +/- 10V	
16	Master Ref. +/- 10V *)	
15	Ref. inv. -/+ 10V	
14	Korr. inv. -/+ 10V	
13	GND	
12	Digit 5	Multiplex Interface (FE)
11	Digit 4	
10	Digit 3	
9	Digit 2	
8	Digit 1	
7	Digit 8	
6	Digit 7	
5	Digit 6	
4	BCD 1	
3	BCD 2	
2	BCD 4	
1	BCD 8	

Fig. 11

7.1 Power Supply

The unit needs a 115 resp. 230 Volts AC power (selectable by jumper on board) at 50 or 60 Hz. Against special ordering information, BY240 is also available for 18....30 VDC supply. Ex factory, without special ordering advice, the units are delivered with 230 VAC setting.

7.2 Encoders

Encoder inputs operate with HTL signals (10-30 V level). It is a must to use quadrature encoders with A and B outputs (90° phase). Marker pulses (Z) can be applied according to need. Against special order, a special hardware version is available for operation with single channel encoders only.

Where you find you must use TTL encoders with line driver signals (5V level at RS422 standard), you must use our PU204 level converter to translate the encoder signals to the HTL standard required.

For encoder supply, an auxiliary voltage of 13,2 Volts (400 mA max.) is available on terminals X8 and X12.

Fig. 12 shows the principle of input circuit. It is not important to wire A and B to produce a certain counting direction, because it is register settable.

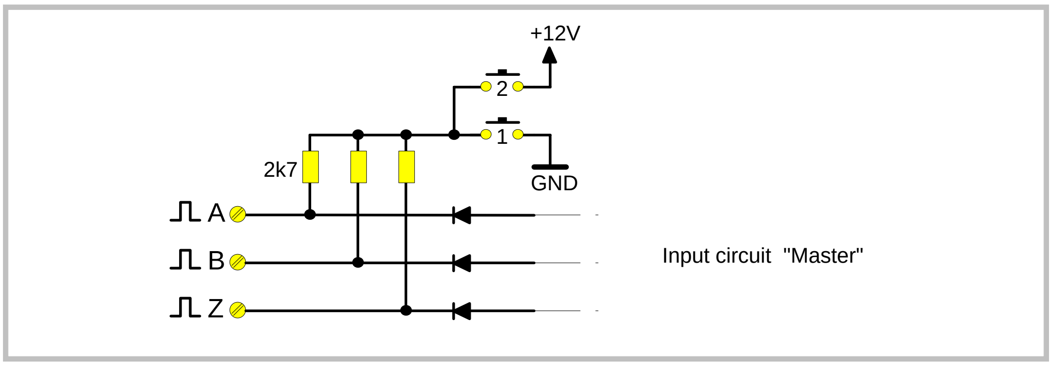


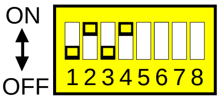
Fig 12

The 8-position DIL switch S2 selects the encoder inputs for NPN or PNP operation (switching to minus or to plus)

	Master	
NPN	1 OFF	2 ON
PNP	1 ON	2 OFF

	Slave	
NPN	3 OFF	4 ON
PNP	3 ON	4 OFF

Because, in general, almost all encoders provide NPN or push-pull outpus, you will mostly set S2 like shown.



Never you must set position 1 and position 2 to ON at the same time!

Never you must set position 3 and position 4 to ON at the same time!

For shielding or screening, observe section 12.3!

7.3 Analogue Inputs and Outputs

Terminal **Z16** provides a +/- 10 Volts analogue input for analogue feedforward according to section 2a) and 2c). This input must only be used, when

a) the BY240 unit should replace an existing BY200

b) the Master encoder frequency is extremely low and does not even reach 1 KHz at full speed

All other applications use digital feedforward and terminal Z16 remains unconnected.

Terminal **Z17** provides the +/- 10 Volts analogue output for the speed reference of the slave drive.

Terminal **Z15** supplies the inverted signal of Z17 and can be used with special applications.

At terminal **X3**, the pure correction signal can be found, representing the actual angular error between Master and Slave.

Terminal **Z14** is the inverted output of X3.

Terminal **Y12** provides a summing input for adding remote analogue signals to the total speed reference output.

When you intend to make reversals with your drives, there won't be a problem with 4-Q-drive types. However, special considerations are necessary with 1Q drives and contact reversals. In general, you must remove the summing register RX on the print and then add the correction with correct polarity by external relay, like shown in Fig. 13.

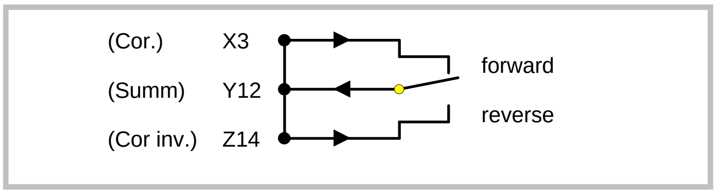


Fig 13

7.4 The serial port (option PS240)

Units equipped with option board PS240 provide a serial RS232/RS485 interface as well as a parallel interface. The serial link uses a Sub-D-9 connector (female on unit). Communication is possible with both the RS232 and the RS485 port, but the data must not overlap.

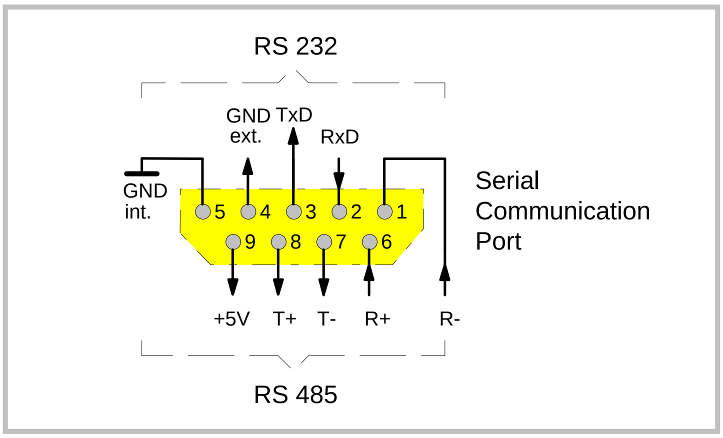


Fig 14

Serial communication can be used to set up and test the unit upon commissioning, using a PC and operator software OS 3.0. It can also be used for online transmissions of speed ratios etc from a host computer or PLC or one of our operator terminals (TX340 or TX720). All communication uses the „Drivecom“ protocol according to the ISO 1745 standard.

With RS485 operation, the following wiring versions are possible:

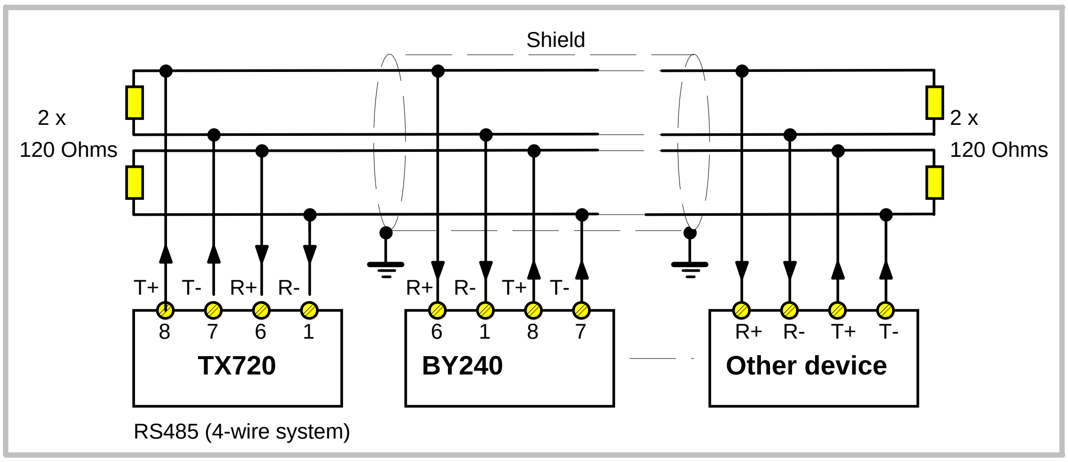


Fig 15

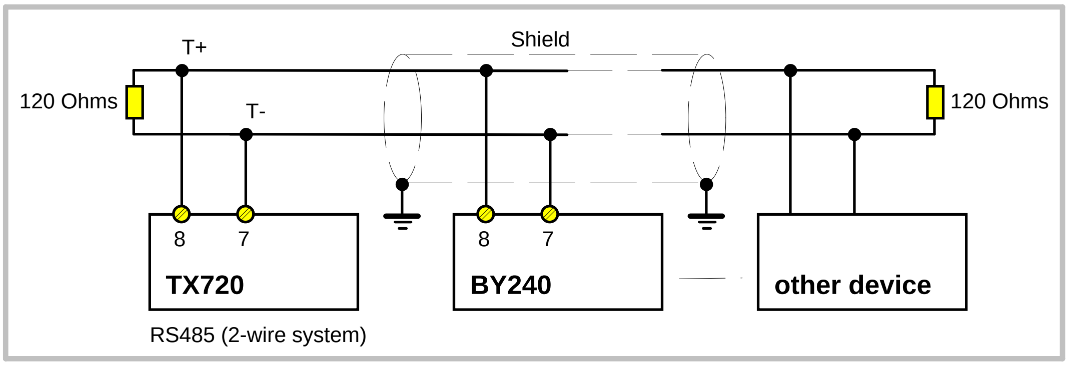


Fig 16

Please note that RS485 operation requires some delay times to change between „Receive“ and „Transmit“ actions, like shown in the table:

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

Fig 17

7.5 Control Inputs and Outputs

For remote control, the inputs “Reset“, “Inhibit“, “Trimm+“, “Trimm-“ and “Integrator Stop“ are available. All inputs are “activ Low“ and must be at zero to provide the corresponding function.

DIL switch S2 allows to select the Reset and the Inhibit inputs for either NPN or PNP operation. With setting NPN, the open input is internally pulled up to „High“ and the corresponding function is switched off. To activate the function, the input must be tied to GND.

With setting PNP, the open input is pulled down to zero and the commands are active. For normal synchronous operation, the inputs must be tied to High (+10V...+30V).

	Reset	
NPN	7 OFF	8 ON
PNP	7 ON	8 OFF

	Inhibit	
NPN	5 OFF	6 ON
PNP	5 ON	6 OFF

Both „Trim“ inputs are also used as index inputs of encoders (if applicable). Therefore the NPN/PNP characteristics of Trim inputs is the same as the encoder setting. With NPN setting, open Trim inputs are high and the Trimm function is switched off. With PNP setting you must tie both Trim inputs to High (+10....+30V) to disable the Trim function.

Input „Integrator Stop“ is always NPN and must be tied to GND to switch the Integration off.

Inputs:

Reset (X13):
When low, all counting is disabled and the differential counter is forced to zero. The drives run in an analogue synchronisation only. Reset also reads and activates data from the BCD parallel interface.

Inhibit (X14):
When low, all counting is disabled, but the differential counter is kept on it’s last counting state. Inhibit also reads and activates data from the BCD parallel interface.

Trim + (Y17):
Trim – (Y13):
These inputs have multiple function, depending on the mode of operation:

a) Displacement of the angular phase by temporary higher or lower Slave speed.

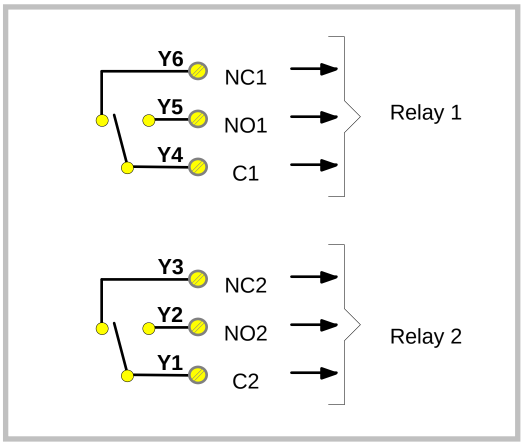
b) Reception of encoder marker pulses or other index signals.

c) Increasing or decreasing of the speed ratio by incrementing or decrementing Factor 1.

Integrator Stop (Y16):
This input sets the phase integrator to 0. This prevents the integrator from building up error when the drives are stopped, but not in a perfect synchronous position. This prevents any leap in speed on restart.

Outputs:

There are two relay outputs available (dry changeover each). In normal operation, the relays signal that the Slave moves outside the angular tolerance window set, in one or the other direction. With index operation, relay 2 signals that the phase – with respect to index impulses and offset preset – is correct or not.



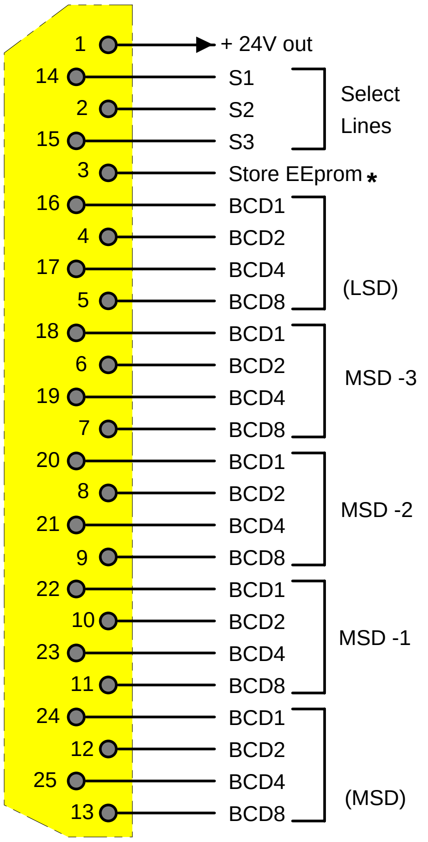
Register „Relay Mode“ selects if the relays energize or deenergize when the error gets outside the set window.

7.6 The parallel interface (Option PS240)

The interface provides remote setting of operational and configuration registers. It receives BCD or binary data (selectable) from a remote thumbwheel switch or a PLC control. There are 3 binary coded select lines which provide access to 8 addresses, via 20 data lines. Parallel data can be stored to the RAM by cycling either the RESET or the INHIBIT input.
Pin3 of the parallel interface allows to store all RAM data to the EEprom, so that remote changes of registers remain operative also after power down.

The parallel interface is accessible by a rear Sub-D-25-connector (male) and uses standard PLC levels with PNP characteristics:

Log. 0 (Low) = 0...+5V   Log. 1 (High) = 10...30V



S3	S2	S1		
0	0	0	Fact 1	(C 00)
0	0	1	Fact 2	(C 01)
0	1	0	Trim	(C 02)
0	1	1	I Zahl	(C 04)
1	0	0	Offset	(C 05)
1	0	1	Gain - Cor	(C 48)
1	1	0	Gain - Tot	(C 50)

* Pin 3 was a GND potential
with old BY200 units!

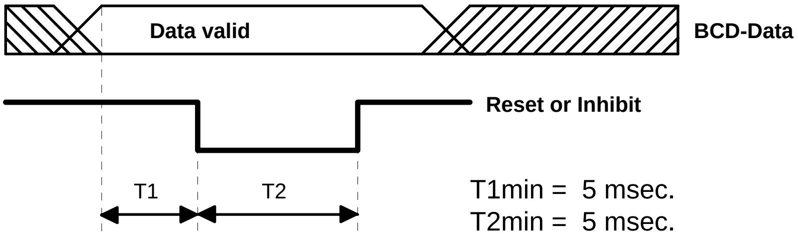
With sign-related inputs, pin 13 represents the sign (Low = +).

With binary code, pin 16 receives the lowest bit and Pin 13 the highest bit.

For BCD or binary code select, see register "PI-Form".

Fig 18

Parallel interface operations must keep the following timing conditions:



T1min = 5 msec.
T2min = 5 msec.

Fig 19

Data is stored with a negative (falling) edge on the Reset or Inhibit input. BCD data must be stable 5msec prior to the falling edge and the Low time of the Reset or Inhibit pulse must be at least 5 msec.

8. Register List and Clarification

All registers are held on an EEprom. Registers can be set by keypad with LCD control, or by serial communication with RS232/RS485 link. The OS 3.0 PC operator software is automatically included with all units using the PS240 option. This allows easy loading, editing and copying of settings and also features excellent testing and adjusting routines upon commissioning.

The subsequent table shows all accessible registers and indications like „C00,C01" etc. mark the serial access codes. The numeric setting range of each register is internally limited according to need. Registers marked with „* " are only relevant with index operation and need not to be set in other operation modes.

Data in		Setup	
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	Alert1	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		

Fig 20

8.1 Data In Registers

Fact 1:
Pulse multiplication for the master encoder. Range 0.0001 - 9.9999.

Fact 2:
Pulse multiplication for the slave encoder. Range 0.0001 - 9.9999. In modes 2 and 8, the setting is automatically replaced by a fixed 1.0000 scaling.

Trim:
Rate of change, to be entered as a number of software cycles (1 cycle = 100 µsec), for

a. phase trimming, when the +/- trim inputs are activated in modes 1, 6 and 7.

b. factor tuning, i.e. speed for incrementing/decrementing Fact1 (mode 4)

c. offset displacement, i.e. additional speed to change from previous to new phase position (mode 3).

Range of setting: 001 - 999 cycles per increment.

Example:
In mode 1, with Trim set to 001, each 100 µsec the phase will be displaced by one encoder increment (= 10.000 increments each second), and with Trim set to 050, the processor will take 50 cycles for one increment.

INT-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 msec) to compensate for one increment etc.
With all index modes, the integrator is automatically switched off because the index control eliminates positional errors.

Imp-Ind*:
For marker synchronisation only. Number N of pulses between slave markers (see 6.).
Range 1 – 999 999. In mode 8, the maximum occurring index error must be set here.

Offset*:
Number of slave encoder pulses that the slave should displace with respect to the master. With mode 2, this is equivalent to the phase displacement between the falling edges of the index signals, in mode 3 it defines the pitch of displacement upon external command. Range: +/- 999 999.

Alert 1:
Set tolerance window. Can be set between 0000 - 9999 bits of difference. Typical setting 30. Affects the Alarm relays when out of tolerance.

Ramp:
Ramp time for changes of speed ratio. Range 0 - 99,9 sec.. 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, independant of the difference between initial and final speed.

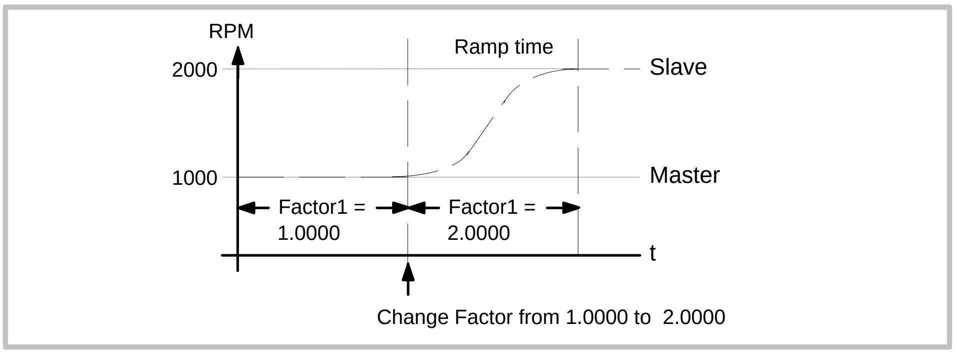


Fig 21

Stop-Ramp:
Ramps the slave drive down when you start a test program by PC or keypad. Range 0 - 99.9 sec. Setting Stop-Ramp to zero results in abrupt deceleration. All other settings provide a sin^2 - transition from operating speed to zero or vice versa within the preset time.

Cor-Divi:
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 (deadband or backlash) cannot respond. In such a case, it is not desirable to make corrections immediately. The "Cor-Divi" provides a window for the drive "backlash", within which the controller produces no correction.

Value 1 = No window, Reaction to 1 error increment.
Value 2 = Window +/- 1 Encoder increment.
Value 3 = Window +/- 2 Encoder increments.
Value 4 = Window +/- 4 Encoder increments.
Value 5 = Window +/- 8 Encoder increments. etc.

Phase Adj*:
Only for index operation. Digital attenuation of the response upon marker pulse errors.
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 33% of the residual error
4 = correction by several steps with 25% of the residual error
5 = correction by several steps with 20% of the residual error etc.

Clarification:
The setting depends on the dynamics of the drive and the maximum speed.
Example: If a marker pulse arrives every 20 msec but the drive cannot correct the largest error in 20msec, then it will lead to instability if the next correction is executed before the previous is completed. In such a case the phase correction percentage must be reduced.

Ind-Divi*:
Only for index operation. 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 10Hz..

F1-Scal:
This factor allows scaling of the remote Fact1 entry to **"user units"** resp. to adapt the numeric value of Fact1 to the application.
It is **essential**, for all steps of setup, to programm **F1-Scal** to **10000** first in order to avoid confusions with factor calculations.
(**Only with this value, the setting corresponds to the real operative Fact1)**!

Once the setup procedure is terminated, set F1-Scal to the numeric value that later should correspond to an operative value of 1.0000 for Fact1. Example: if the operator desires to set 3.5000 instead of 1.0000, set F1-Scal to 35000. For all factor calculations, please be aware if you operate with a proportional or a reciprocal characteristics of Fact1!

Fac1-min, Fac1-max:
These are limitations of the setting range of Fact1 and out of range settings will be overwritten by the appropriate min or max value. With Fac1-min set to 0.9500 and Fac1-max set to 1.0500, the operator is limited to a +/- 5% variation of the speed ratio. This may be especially useful when incrementing or decrementing the speed ratio with mode 4.

Ind-Wind:
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. Relay 2 will be signal when the slave index runs outside this window.

Relay Mode:
When set to „0“, the alarm relays are deenergized in normal operation and energized when the error exceeds the set window.
When set to „1“, all relay operation is inverted.

8.2 Setup- Register

Mode:
The mode setting determines the function of the Trimm resp. Index inputs. There are 8 modes available like shown in table.

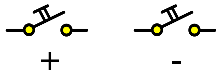
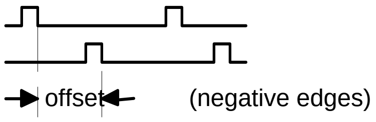
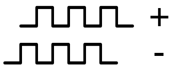
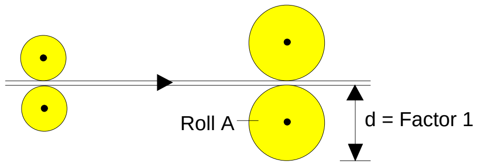
Mode	Inputs "Trim" resp. "Index" (Term. Y17 und Y13)	Scaling
1	Trim phase by supplementary speed. 	**Fact 1 : Fact 2**
2	Index operation with offset preset 	**Fact 1 : 1,0000**
3	Index Master ʅ = Displace phase forward by offset amount. Index Slave ʅ = d.o., but reverse	**Fact 1 : Fact 2**
4	Index Master Increment Fact 1 Index Slave  Decrement Fact 1	**Fact 1 : Fact 2**
5	Shift phase by external impulses 	**Fact 1 : Fact 2**
6	Like Mode 1	
7	Like Mode 1	
8	Unlocked Index operation for special applications	**Fact 1 : 1,0000**

Fig 23

LV-Calculation:
This parameter determines the relationship between the factor settings and the resulting slave speed. Also it selects analogue or digital feed forward operation.
With settings 1 - 4, an analogue signal proportional to the master speed must be applied to terminal Z16.
Settings 5 - 8 are similar to 1 - 4, but the feed forward signal is generated by the internal f/V converter and terminal Z16 remain unconnected.

LV-Calc = 1 or 5:
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 synchronising applications.

LV-Calc = 2 or 6:
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 recipocal to the motor speed.

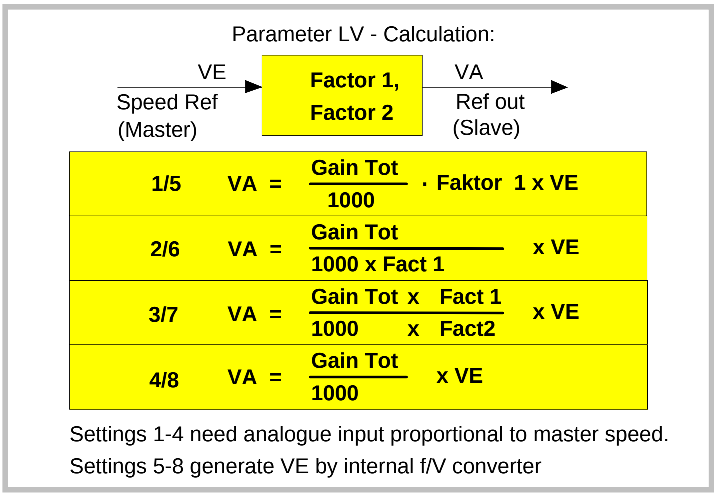


When increasing diameter of roll A, rotational speed must decrease for same line speed.

Fig 24

LV-Calc = 3 or 7:
The slave speed changes **proportionally to Factor 1** and **reciprocally to Factor 2.** Suitable for various applications which need remote setting of both scaling factors.

LV-Calc = 4 or 8:
The slave reference voltage remains constant, independent of Factor 1 and Factor 2 settings.



1/5	**VA =** $\frac{\text{Gain Tot}}{1000} \cdot \text{Faktor 1} \times \text{VE}$
2/6	**VA =** $\frac{\text{Gain Tot}}{1000 \times \text{Fact 1}} \times \text{VE}$
3/7	**VA =** $\frac{\text{Gain Tot} \times \text{Fact 1}}{1000 \times \text{Fact2}} \times \text{VE}$
4/8	**VA =** $\frac{\text{Gain Tot}}{1000} \times \text{VE}$

Settings 1-4 need analogue input proportional to master speed.
Settings 5-8 generate VE by internal f/V converter

Fig 25

Clarification 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.

Unit-Nr:
For serial operation only. Allows entry of a 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. Factory setting: 11

Baud-Rate:
For serial operation only. The following transmission rates can be selected:

0	9600	Baud
1	4800	Baud
2	2400	Baud
3	1200	Baud
4	600	Baud

Fig 26

Factory setting: 0

Ser-Form:
For serial operation only. The following formats of serial data can be selected:

Ser-Form	Databits	Parity	Stopbits
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	2
8	8	None	1
9	8	None	2

Fig 27

Factory setting: 0

Mast Dir:
Direction of phase of the master encoder. Settings can be changed from "0" to "1". See „Commissioning“

Slav Dir:
Direction of phase of the slave encoder. See „Commissioning“

Off-Cor:
Digital setting of analogue offset on correction signal. Setting range +/- 99. Normal setting "0" *****

BY 240 uses precision instrumental amplifiers which 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 settings different from zero may be used to compensate for deadbands which some inverter drives have with very low speed reference voltage.

Gain-Cor:
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. 2 mV....20 mV per error bit).

PI-Form:
Selects parallel input data to BCD-code when „0“ and to binary code when set to „1“.

Gain-Tot:
Digital setting of multiplication of analogue voltage signal. Range 0-9999.

With analogue feedforward (LV-Calc = 1...4) we get

$$\boxed{V\text{out} = \frac{\text{Gain Total}}{1000} \text{ x Factor 1 x Vin} \quad \text{(Volt)}}$$

With digital feed forward (LV-Calc = 5...8) we get:

$$\boxed{V\text{out} = \frac{\text{f master}}{7600} \text{ x Gain Total x Factor 1} \quad \text{(Volt)}}$$

Where fmaster is the Master encoder frequency in kHz.

9. The LED bar graph

The strip with 32 LED’s mounted on the board indicates the instantaneous angular difference between the two drives. The display provides information for commissioning and fault monitoring, in a very simple form.

When both green LED’s in the center are lit, the phase error is absolutely zero. With all other error states, only one LED is on.

When the LED’s move to the right, this indicates the Slave drive tries to go slower and recieves a positive correction to keep the synchronous speed.

When the LED’s move to the left, this indicates the slave drive tries to go faster and receives a negative correction to keep the synchronous speed.

This is valid for positive speed reference signals. With negative speed reference, the directions are vice-versa. It is possible to read the phase error from the LED’s. Every LED we are out of the green zero position means an error of 4 encoder increments. With totally 16 LED’s to each direction we can oberve a range of +/- 64 error increments. With higher errors, the extreme left or right LED (red) remains lit.

Please note: Even with the LED’s in the red range, we do not have a speed error but only an angular error between the motor shafts. This is valid until the correction signal reaches its saturation at + or – 1024 error increments.

10. Analogue Signal Guide

The following block diagram shows the treatment of analogue signals and the registers involved.

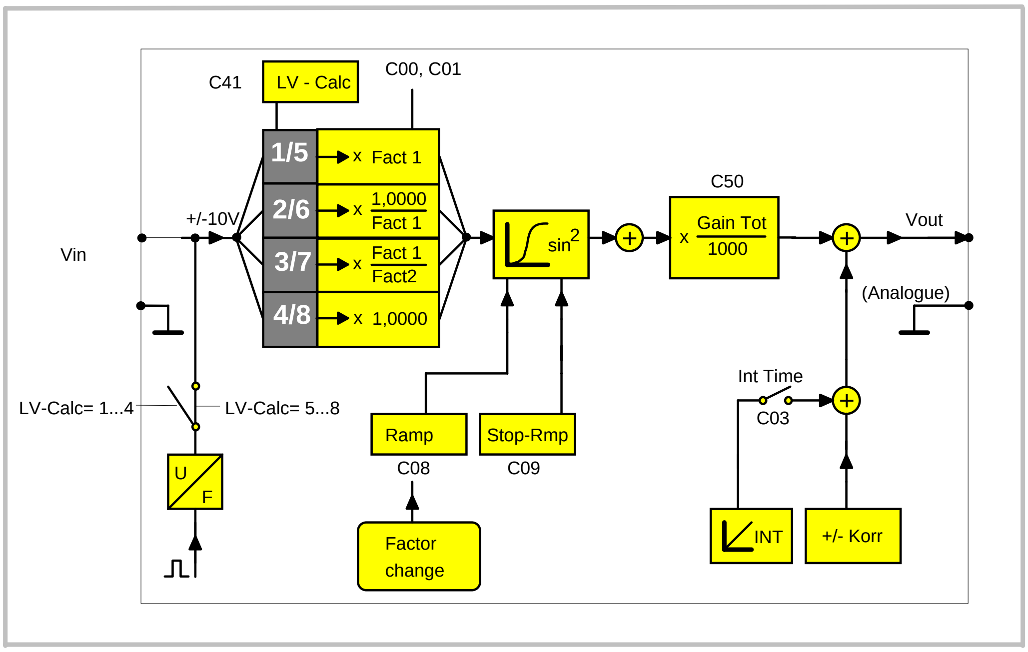


Fig. 28

11. Digital Signal Guide

The following block diagram refers to all essential impulse processing necessary to generate the analogue correction signal. For easier comprehension, unimportant details have been omitted.

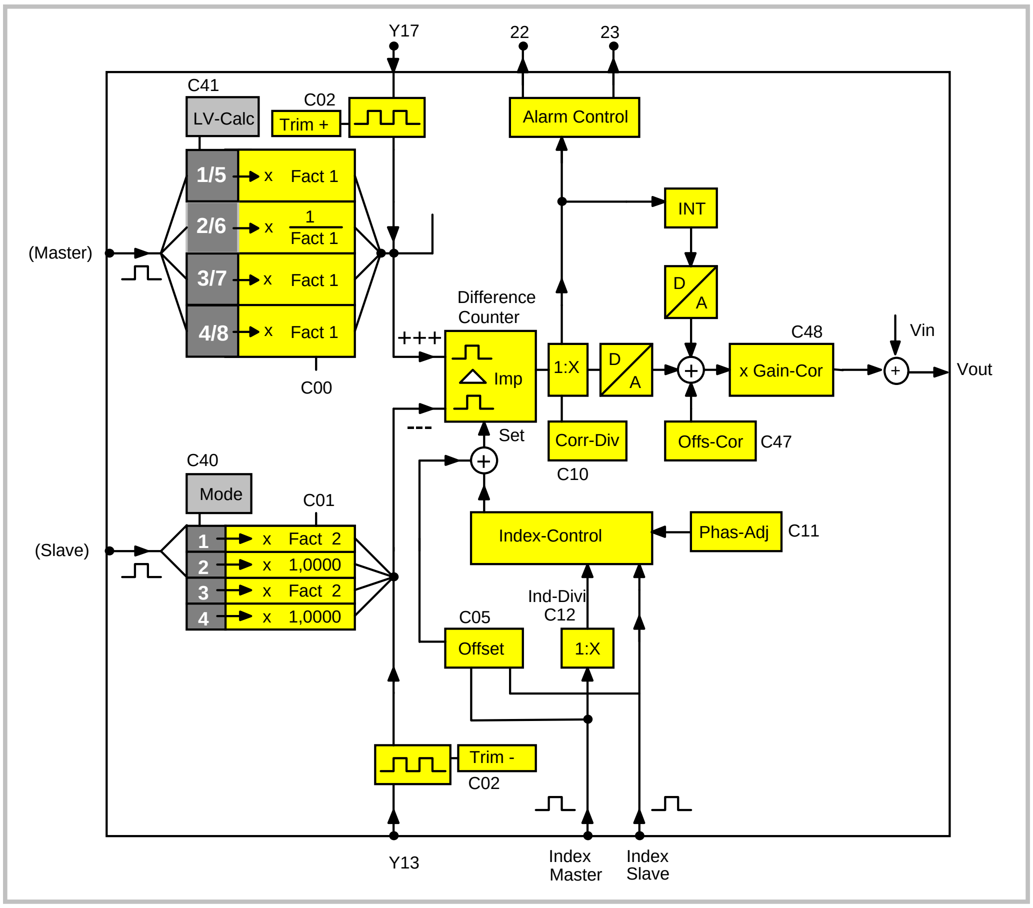


Fig 29

The total analogue correction output can be calculated as follows:

$$\text{Korr} = \frac{\triangle\ \text{Imp}}{\text{Corr- Div}} \quad \text{x} \quad \frac{\text{Gain-Cor x 10 mV}}{1024} \quad (\text{ m V })$$

An analogue saturation comes up with 1024 error bits, but the counter itself will memorize and compensate for up to 32000 error bits.

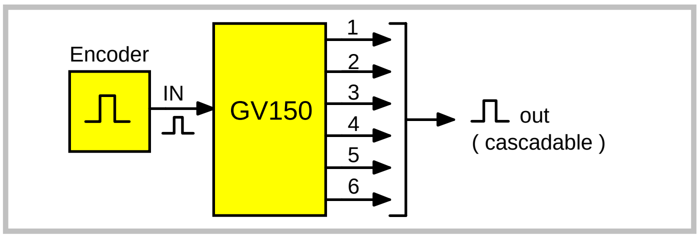
12. Remarks about Drives, Encoders, Cables, Installation

12.1 The **drives** in use must be dimensioned correctly with respect to power and dynamics required. **The BY 240 can never provide synchronisation outside the physical limits of the drives**. Prior to connecting the master and the slave to the synchroniser, 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 slave must be set to a maximum dynamic operation. You must set all internal ramps to zero or minimum. Where your slave drive allows to adjust the proportional gain, use the highest settings possible with regard to a stable operation.

Avoid ground loops, i. e. between the power supply source and the minus potential of the speed reference input which might be grounded also.

12.2 The resolution of the TTL-**encoders**, in principle, should be as high as possible (with consideration of the maximum frequency), in order to keep the mechanical phase error as small as possible when the synchroniser "plays" a few encoder increments around the zero error position. However it would be nonsense to choose the number of ppr much higher than needed or reasonable. If, for example, a gear box 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. PPR numbers of encoders should be chosen in a way that both, master and slave frequency are approximately in the same range.

BY240 units charge every encoder channel with a current of 6 mA. It is permissable to use one common encoder in parallel with several controllers. However, the total charge of encoder channels must never exceed the maximum current specified by the encoder manufacturer, If so, it is a „must“ to use our impulse splitter type GV150/HTL.



12.3 **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.

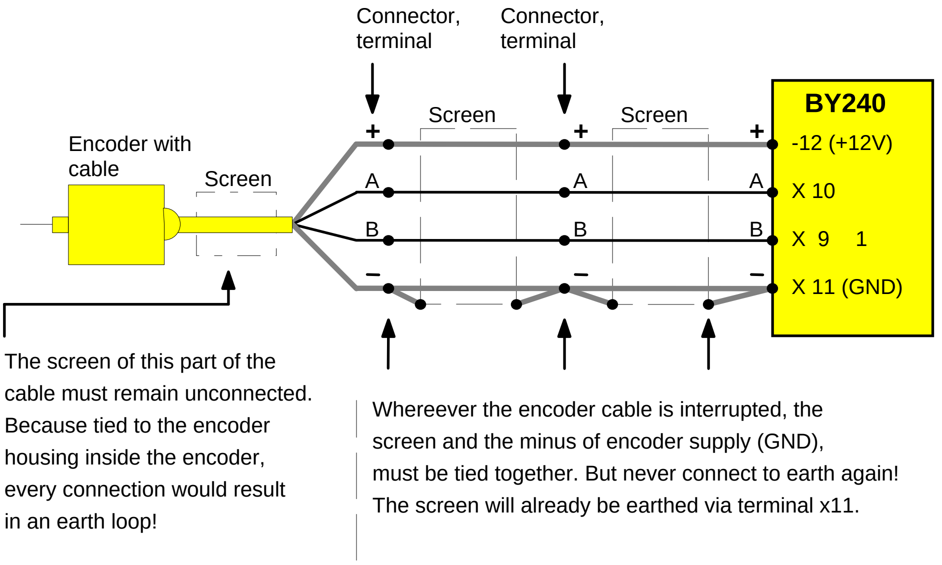
The following basic screening rules must be observed:

a. With impulse cables (encoders), the screen must be connected at both ends.

b. Analogue signals and control lines need screens connected only on one end.

c. The screen potential must be the internal GND of the BY240 unit (not earth potential! See GND terminals on terminal strip). It is advisable to tie one of the GND terminals to earth potential right on the controller site, which ensures that also the screens are earthed. But never connect screens just to earth!

d. At it’s peripheral end, the screen **must never** be tied to earth nor touch metallic parts which are earthed! Where you use an encoder with plug connection, the screen must absolutely not touch the metallic housing of this connector! (Whith the encoder mounted at the machine, this would be an illegal earth loop).

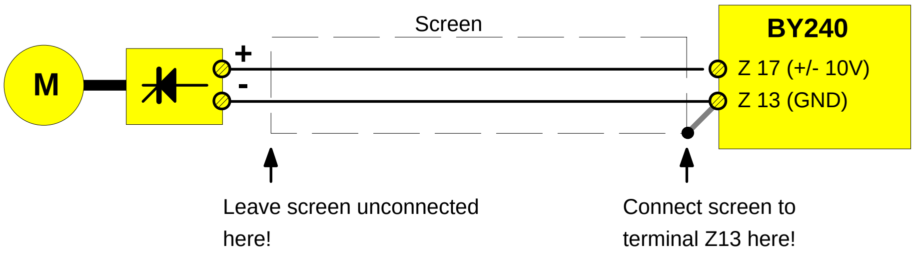


The screen of this part of the cable must remain unconnected. Because tied to the encoder housing inside the encoder, every connection would result in an earth loop!

Whereever the encoder cable is interrupted, the screen and the minus of encoder supply (GND), must be tied together. But never connect to earth again! The screen will already be earthed via terminal x11.

Example: Correct connection of screens with an encoder cable interrupted by terminals or connector plugs.

Fig 30



Leave screen unconnected here!

Connect screen to terminal Z13 here!

Example: Correct screening of analogue speed reference cable.

Fig 31

Please note, that **not all types of cables** are suited to transmit frequencies as high as **100 kHz**! However, with proper installation and screening, perfect transmission even over long distances is possible.
The **cross section** of encoder cables must be chosen with consideration of voltage drop on the line. The BY 240 provides a 13,2 V encoder supply and at the other end the encoder must at least receive it`s minimum supply voltage! (See encoder specifications).

12.4 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 synchroniser (i. e. RC filters for AC contactors and diodes for DC inductive circuits). Take all precautions with respect to wiring and environment conditions that are usual for industrial electronic equipment.

12.5 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 or analogue switching, we recommend the use of our electronic matrix switch type GV 155.

13. How to operate the keypad

The PCB comprises 4 keys and a LCD display for setup of the unit.

When you use a PC and the operator software OS 3.0 for setup, the following hints are irrelevant. For PC operation, your unit needs option PS240 to be installed.

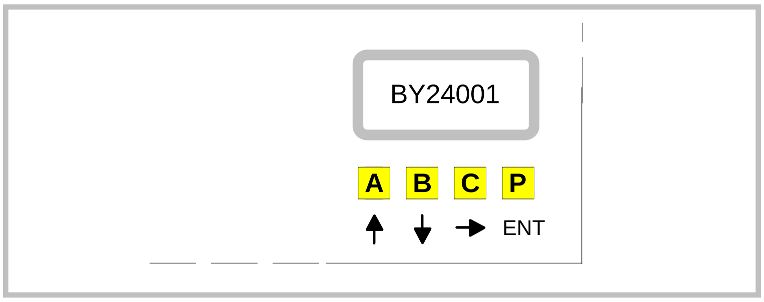


Fig 32

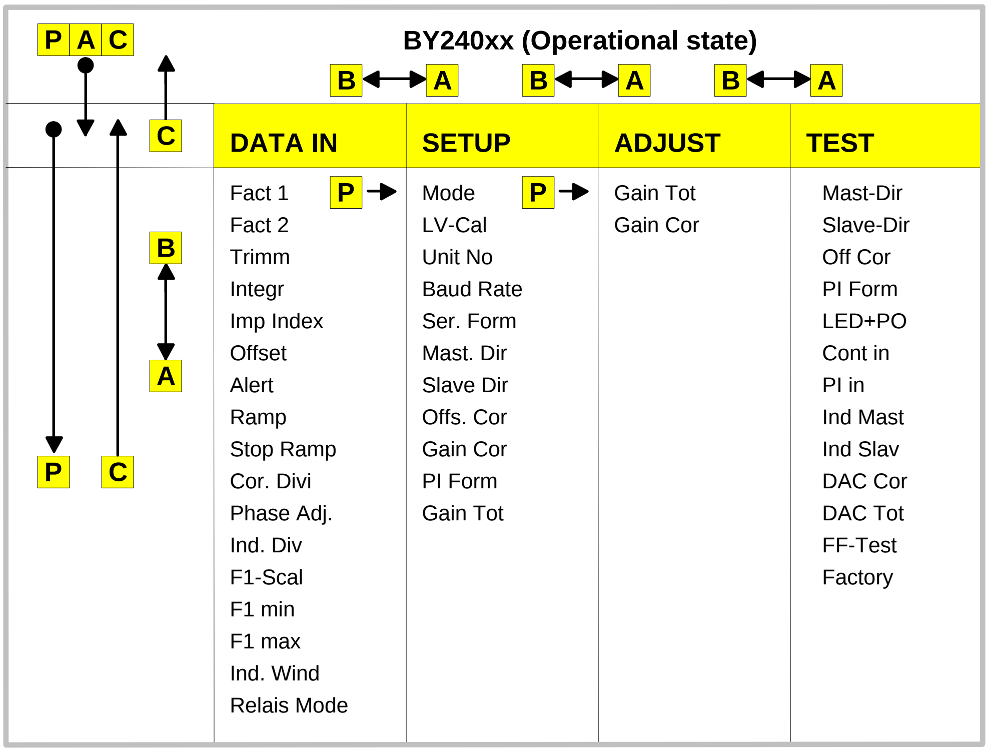
LCD and keys can be found right side down on the PCB. With normal operation, the LCD displays the software version of the controller and the keys are code protected to avoid unauthorised or inadvertently operation. To activate the entry mode, within a 5 seconds time window you must press the key sequence

P – **A** – **C**

After this, the LCD display will change to „DATA IN“ and the keys are ready to operate like shown:

A (↑)	Scrolls the menu dialogue forward or increments the digit high-lighted by the cursor.
B (↓)	Scrolls the menu dialogue back or decrements the digit high-lighted by the cursor.
C (→)	Returns from register to menu titles or increments highlighted digits to the right (or from full right to full left).
P (ENT)	Enters from menu to registers. Changes register from text to value and back to text again. Stores actual data to the EEProm.

This is the structure of the menu and the operation of the keys:



DATA IN	SETUP	ADJUST	TEST
Fact 1	Mode	Gain Tot	Mast-Dir
Fact 2	LV-Cal	Gain Cor	Slave-Dir
Trimm	Unit No		Off Cor
Integr	Baud Rate		PI Form
Imp Index	Ser. Form		LED+PO
Offset	Mast. Dir		Cont in
Alert	Slave Dir		PI in
Ramp	Offs. Cor		Ind Mast
Stop Ramp	Gain Cor		Ind Slav
Cor. Divi	PI Form		DAC Cor
Phase Adj.	Gain Tot		DAC Tot
Ind. Div			FF-Test
F1-Scal			Factory
F1 min			
F1 max			
Ind. Wind			
Relais Mode			

Fig 33

The subsequent example shows how to change the value of Factor2 from 1.0000 to 1.5000

Action	Result
● **P A C**	**DATA IN**
● **P**	**Fact 1**
● **A**	**Fact 2**
● **P**	LCD shows actual value of Fact2 **1. 0000**
● **C**	Cursor shifts to right **1. 0000**
● **A** (x5)	Digit increments **1. 5000**
● **P**	New value 1.5000 stored. LCD shows next text **Trimm**
● **C**	Back to main menu **DATA IN**
● **C**	Concludes entry mode **BY24001**

14. Steps for commissioning

The drives must be adjusted properly to run the speeds required without oscillation. Where you use the Master speed reference voltage as a feed forward signal, make sure all acceleration and deceleration ramps of the Master and the Slave are set to zero or minimum. Where you use a real speed signal or with digital feed forward mode, the Master may have ramps, but the Slave must again be set to maximum dynamic operation with all internal ramps set to zero.

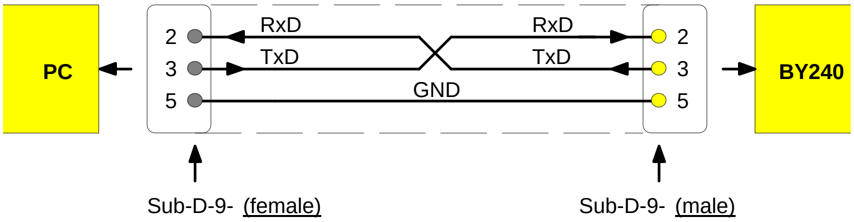
Please oberserve all hints given in this manual and the manual of the drives and observe all general safety standards. In case of any problems, a digital Voltmeter and an oscilloscope are helpful.

14.1 Set DIL switch S2 as shown in section 7.

14.2 Check again for correct and proper wiring. Then power the unit up. After a short delay you must see both green LED’s in the center of the bar graph lit.

Where you use a PC for setup, follow steps 14.3 to 14.12.
Where you use LCD key setting, proceed to step 14.13 now.

14.3 Connect your PC to the BY240 unit. Your cable must have 3 leads only and must be wired like shown.

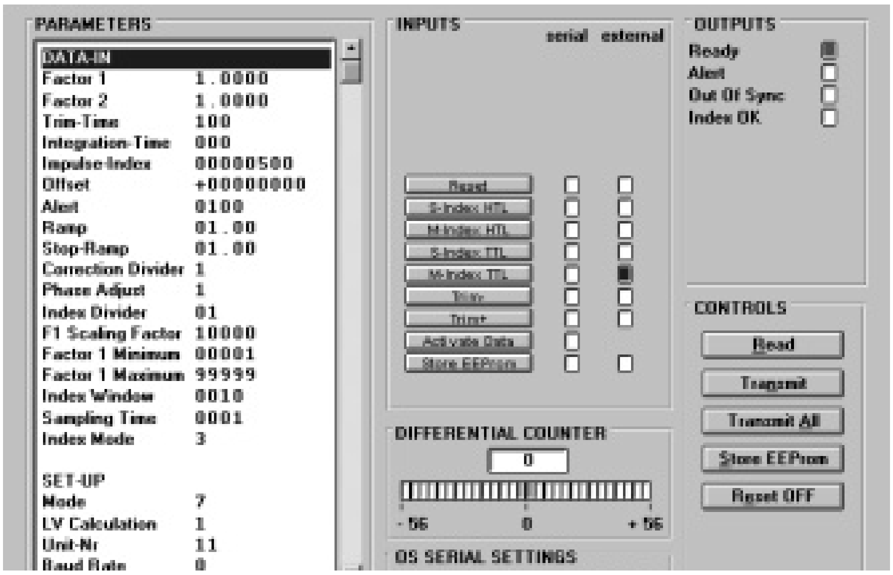


Only pins 2,3 and 5 used, 2 and 3 crossed.

Connection of more pins results in failure of communication!

Fig 34

14.4 Start the OS3.0 operator software. You will see the following screen:



DATA-IN	
Factor 1	1.0000
Factor 2	1.0000
Trim-Time	100
Integration-Time	000
Impulse-Index	00000500
Offset	+00000000
Alert	0100
Ramp	01.00
Stop-Ramp	01.00
Correction Divider	1
Phase Adjust	1
Index Divider	01
F1 Scaling Factor	10000
Factor 1 Minimum	00001
Factor 1 Maximum	99999
Index Window	0010
Sampling Time	0001
Index Mode	3
SET-UP	
Mode	7
LV Calculation	1
Unit-Nr	11
Baud Rate	0

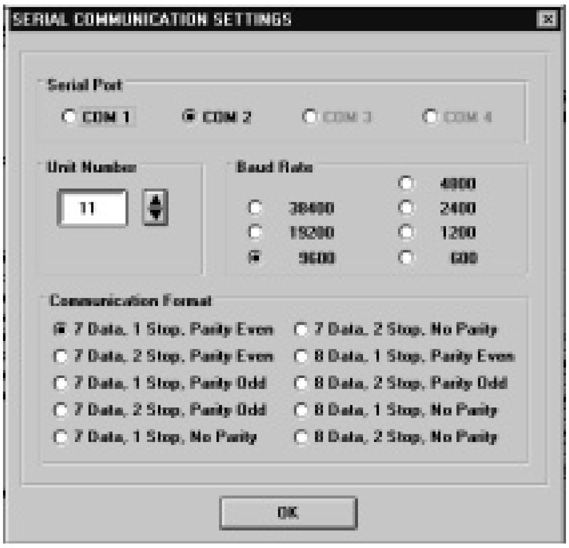
	serial	external
Reset	☐	☐
S-Index HTL	☐	☐
M-Index HTL	☐	☐
S-Index TTL	☐	☐
M-Index TTL	☐	☒
Trim-	☐	☐
Trim+	☐	☐
Activate Data	☐	
Store EEProm	☐	☐

Ready	☒
Alert	☐
Out Of Sync	☐
Index OK	☐

DIFFERENTIAL COUNTER: 0

Fig 35

If instead, you see an empty screen mask with the remark „OFFLINE“, you must check the serial settings. Select the Comms menu. Ex factory, the BY240 controller is configuered like shown.



SERIAL COMMUNICATION SETTINGS

Serial Port

○ COM 1 ● COM 2 ○ COM 3 ○ COM 4

Unit Number: 11

Baud Rate

○ 38400 ○ 4800
○ 19200 ○ 2400
● 9600 ○ 1200
○ 600

Communication Format

● 7 Data, 1 Stop, Parity Even ○ 7 Data, 2 Stop, No Parity
○ 7 Data, 2 Stop, Parity Even ○ 8 Data, 1 Stop, Parity Even
○ 7 Data, 1 Stop, Parity Odd ○ 8 Data, 2 Stop, Parity Odd
○ 7 Data, 2 Stop, Parity Odd ○ 8 Data, 1 Stop, No Parity
○ 7 Data, 1 Stop, No Parity ○ 8 Data, 2 Stop, No Parity

Fig 36

It is important that you have selected the correct port (COM1 or COM2) where your serial cable is connected.
When serial settings of the BY240 controller are fully unknown, you can find them out by using the SCAN function of the Tools -menu.

14.5 When the serial communication works fine, we can set all parameters (variables according to the application. For the first steps, you must set the following registers to the values shown in table. Only when commissioning has been completed, you can change to other values.

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 with digital feed forward

Gain Correction : 100

Gain Total : a) 1000 with analogue feed forward
b) see table with digital feed forward

Fig 37

With digital feed forward mode, the inital setting of „Gain Total“ depends on the ouput frequency of the Master encoder at maximum Master speed.

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

Fig 38

Values shown are „approximate“ and values between can be interpolated.

Some settings like „Master direction“ are still unknown at this time and will be found out later.

After completion of entries, click Transmit All to transmit and then Store EEprom to store the settings.

Remark: Where you find underlined characters with the softkeys, you can get the same function by pressing the corresponding key with the ALT - key kept down.
Example: ALT + S = Store EEprom.

14.6 We recommend to check for proper function of the control inputs you use. You can see the logical state on the indicator boxes of your screen (Inputs, external).

14.7 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.

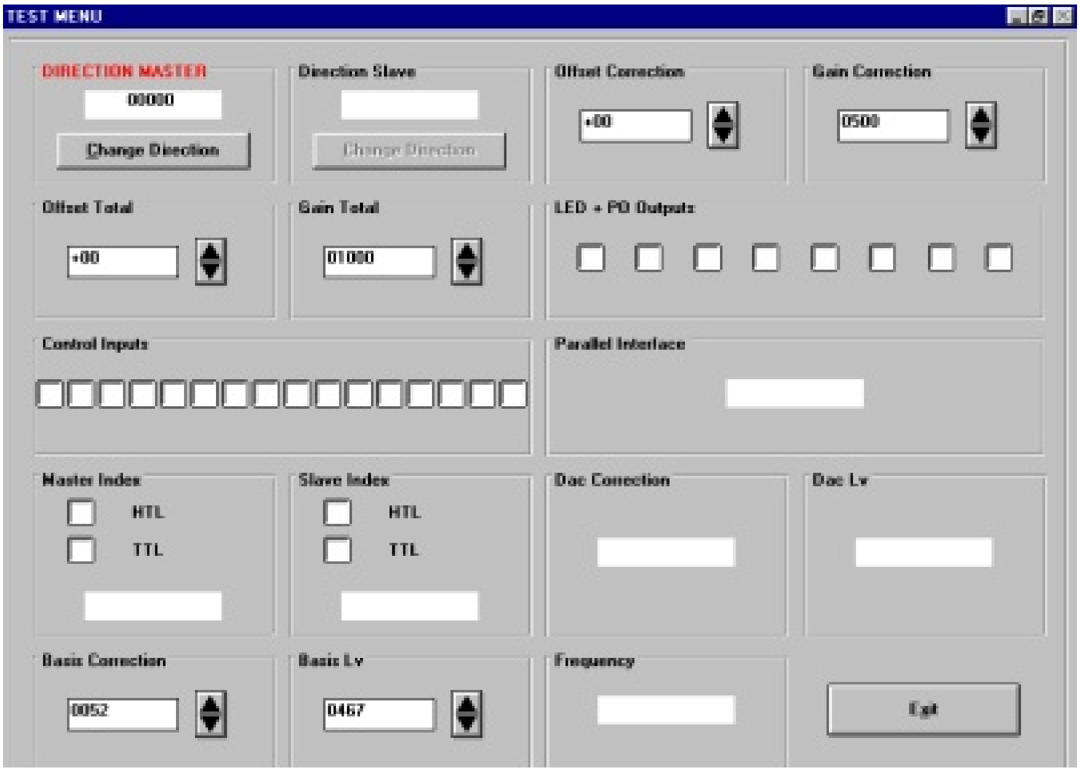
a) Where we use analogue feed forward system
(LV-Calcualtion = 1...4), the **forward** direction for both, Master and Slave, is the direction which the drives take when **positive speed reference** (o...+10V) is applied.

b) Where we 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).

The subsequent steps will fail upon non-observance!

Select the **Test** function of the Tools menue



DIRECTION MASTER: 00000
Direction Slave:
Offset Correction: +00
Gain Correction: 0500
Offset Total: +00
Gain Total: 01000
Basis Correction: 0052
Basis Lv: 0467

- Click to the **”Direction Master”** 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**. If it counts down, click ”Change direction” to reverse the counting sense. If it counts 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. If it counts 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.

Hint: 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.

14.8 When you use the parallel interface (PI), click to the Parallel Interface box and verify that your parallel data appear correctly on the screen. You can easily detect wiring faults or transmission problems when the figures shown in the indicator box do not match the data transmit.

14.9 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!).

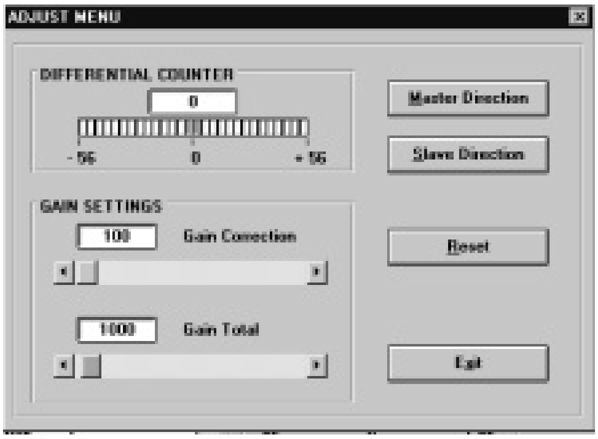
- When we move slow enough, we can also see the index pulses blinking in the corresponding indicator boxes.

- When we rotate to reverse direction, the display will not show our impulse number, but it’s 16 bit complement which is ”65536 - impulse number”.

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

14.10 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.



DIFFERENTIAL COUNTER: 0

100 Gain Correction

1000 Gain Total

Fig 39

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 Colour bar graph to the green center by switching Reset to ON.
- Watch the colour 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 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 colour bar around the green center zone.
- For rough adjusting, use the slide button in the Gain Total field. For fine tuning, use the ◀ ▶ keys.

14.11 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.

14.12 Change the speed between standstill and maximum speed, observe the differential counter and the colour bar and **optimise** 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 BY240 synchroniser.

This concludes the general setup procedure which needs to be done with every application. At this time your drives operate in a closed loop digital synchronisation and the next section will show you some hints how you could still improve performance with some applications. Please continue with section 15 now.

14.13 The subsequent sections describe commissioning without a PC, by use of LCD setting. These steps are not to be used with PC setup.

14.14 Enter all variables by keypad, like shown in section 13. For some of the settings it is a must to use the initial values like shown.

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 with digital feed forward

Gain Correction : 100

Gain Total : a) 1000 with analogue feed forward
b) see table with digital feed forward

Fig 40

With digital feed forward mode, the initial „Gain Total“ setting depends on the output frequency of the Master encoder at maximum master speed.

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

Fig 41

The setting can be „approximate“ and values between can be interpolated.

Some settings like “Master Direction“ are unimportant at this time and found out later.

14.15 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-Calcualtion = 1...4), the **forward** direction for both, Master and Slave, is the direction which the drives take when **positive speed reference** (o...+10V) is applied.

b) Where we 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).

Select the “Testprog“ menu and press **P** .

The LCD shows “Mast-Dir“ now. Press **P** again.

Die LCD display now operates as an up/down counter for the master encoder. Rotate the Master forward. The counter must count up (increment). When we count down, press **A** to change the direction. Key **B** resets your counter to zero at any time. When we count up, press **P** to store the Master direction bit.

The LCD will now show „Slave-Dir“. Press P to activate the Slave counter. With forward rotation of the Slave we must again count up. If not, press B to change direction. When we count up, press P to also store the Slave direction bit.

14.16 Select now the „Adjust“ menu and Gain-Tot. When you press P , the display will show the actual Gain-Tot setting. Run the Master drive now and see how the slave follows. Observe the LED bar graph. When we deviate to the right, our Gain-Tot setting is too low and must be increased. When we deviate to the left, our Gain-Tot is too high and must be decreased.

To increase Gain-Tot, keep A down. The value will increment slowly first, and after 5 seconds at 10 times the speed.

To decrease Gain- Total:, keep B down.

While you keep A or B down, the LCD display will not be updated and you will see the new value only after you release the button again.

You must set Gain-Tot in a way that the LED's always remain around the green center position. While adjusting Gain-Tot, you can always use the Reset button on print to get the LED bar to the initial center position again.

14.17 Next step is to set „Gain-Cor“.

Select Gain-Cor in the Adjust menu and presst P to see the actual setting.
The rule is to use settings as high as possible and practical values are in a range 300 .....2000.

Depending on gearings, inertias and dynamic conditions, too high settings of Gain-Cor can, however, cause stability problems like oscillation or rough motion. Then you must reduce the setting again correspondingly.

To increase or decrease Gain-Cor, use again keys A and B like shown in previous section.

When you have set Gain-Cor correctly, your drives must operate synchronous with the speed ratio set, over the full speed range, and the LED bar graph should always move around the green/yellow center zone. This concludes the steps for commissioning.

15. Hints for Final Operation

15.1 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. colour bar deviates to left at low speed, stays in center at medium speed and deviates to right at maximum, speed).

* Please note that a deviation of the colour 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”” 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 is automatically switched off, because the marker pulses will compensate for phase errors.

15.2 Correction Divider

Where you find your colour 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.

15.3 Offset voltage

Some low cost AC inverter drives have a deadband around zero. e.g. they would not respond to small speed references like 50mV. 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 +50mV at standstill and the drive is kept at the threshold of it’s deadband from where it can break off immediately.

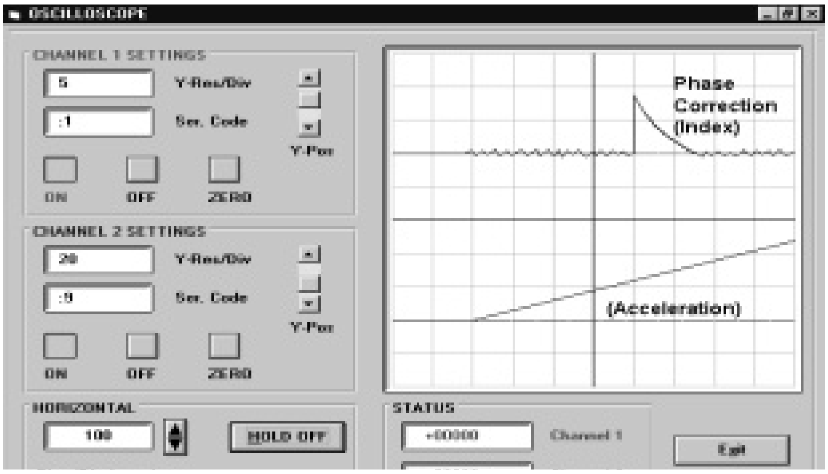
15.4 Other settings

Up to now, we have operated 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.

15.5 It can be useful to observe the performance of synchronising 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	Synchronising error (Differential Counter)
:4	Integration register
:9	actual Master speed (1Bit = 19 Hz of master encoder frequency)

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



CHANNEL 1 SETTINGS
5 Y-Res/Div
:1 Ser. Code

CHANNEL 2 SETTINGS
20 Y-Res/Div
:9 Ser. Code

HORIZONTAL
100

STATUS
+00000 Channel 1

Fig 42

16. 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:

Code	Function	Type
60	Reset	S
61	Index Slave	S
62	Index Master	S
65	Trim -	S
66	Trim +	S
67	Activate Data	D
68	Store EEprom	D

S = Static Command, must be set to 1 or 0
D = Dynamic Command, must be set to 1 and resets to 0 automatically after execution.

Fig 43

For more details, refer to the manual of the Drivecom protocol which is available on request. Please note that serial commands are ”logical OR” to hardware commands and that a command is ON whenever set by serial or hardware input or both at a time.

17. General Master Reset and Erase of EEProm

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

- push the Reset button on the board.

  or

- power down the unit and power up again after a few seconds.

  Both measures 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 we must take the **Erase procedure for the EEprom:**

- switch off the unit

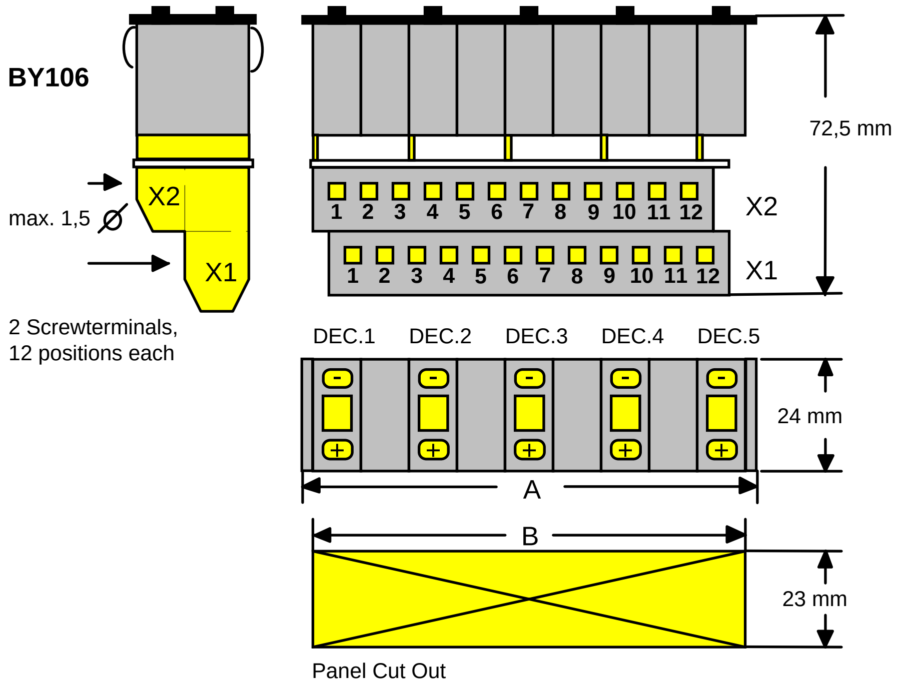
- keep key **A** and **C** down at the same time while powering on the unit and keep keys down for at least another 5 sec.

This will clear up all the EEProm to it`s minimum values, and all registers need to be setup once more or reloaded from a disc.

Above steps represent an emergency procedure that you will never have to apply under regular conditions. In an extreme case however (i. e. lightening-strike in the factory etc.) they could help to get the unit working again.

Please note that <u>you must always</u> use the Eeprom Erase Procedure when you have changed the processor for reasons of firmware upgrade !

18. The BY 106-X Remote Thumbwheel Switch



Switch Type	**No. Decades**	**A (mm)**	**B (mm)**
BY 106-3	3	59.5	57
BY 106-4	4	59.5	57
By 106-5	5	74.5	72

Fig 44

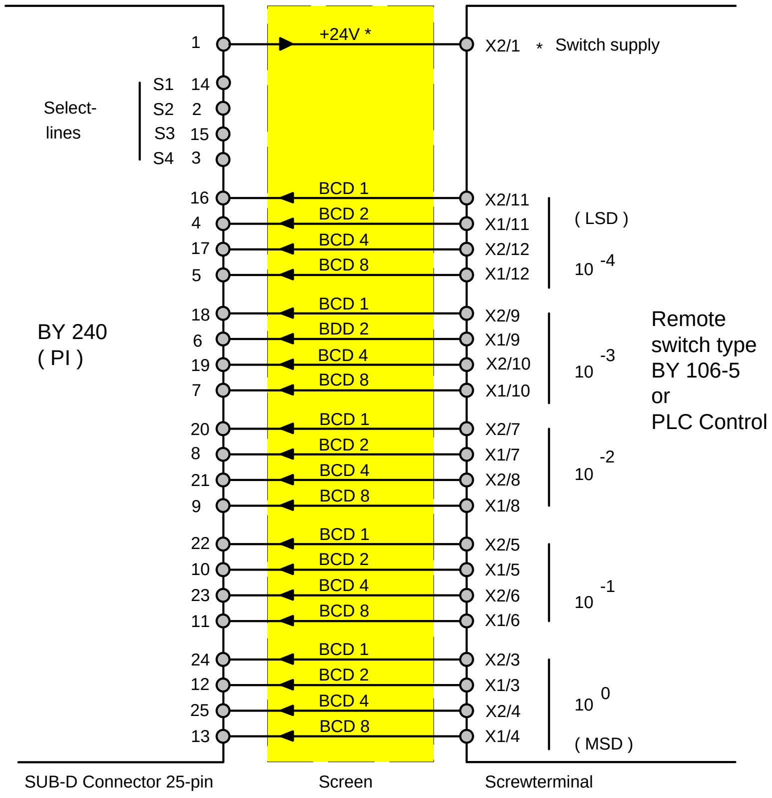


Fig 45

19. Register table

The subsequent table shows the setting range and the default values of all registers. Use the free column to write down your own settings.

Parameter	Einstellbereich / Default	Wert
FACT.1	0,0000 – 9,9999 / **1,0000**	
FACT.2	0,0000 – 9,9999 / **1,0000**	
TRIMM	001 – 999 / **001**	
INT.TIME	000 – 999 / **100**	
IMP.IND	00000001 – 99999999 / **00002000**	
OFFSET	-9999999 – +9999999 / **0**	
ALERT	0001 – 9999 / **0010**	
RAMP	0000 – 9999 / **0000**	
STOP-RMP	0000 – 9999 / **0000**	
COR.DIVI	1 – 9 / **1**	
PHAS.ADJ	1 – 9 / **1**	
IND.DIVI	01 – 99 / **01**	
F1 SCAL	00001 – 99999 / **10000**	
F1 MIN	00000 – 99999 / **00001**	
F1 MAX	00001 – 99999 / **99999**	
IND.WIN	0001 – 9999 / **0010**	
REL.MODE	0 – 1 / **0**	
MODE	1 –8 / **1**	
LV CALC	1 – 8 / **1**	
UNIT-NR	11 – 99 / **11**	
BAUD RAT	0 – 4 / **0**	
SER.FORM	0 – 9 / **0**	
MAST.DIR	0 – 1 / **0**	
SLAV.DIR	0 – 1 / **0**	
OFFS.COR	-99 - +99 / **0**	
GAIN COR	0000 – 9999 / **0100**	
PI-FORM	0 – 1 / **0**	
GAIN TOT	00000 – 99999 / **10000**	

20. Dimensions and technical specifications

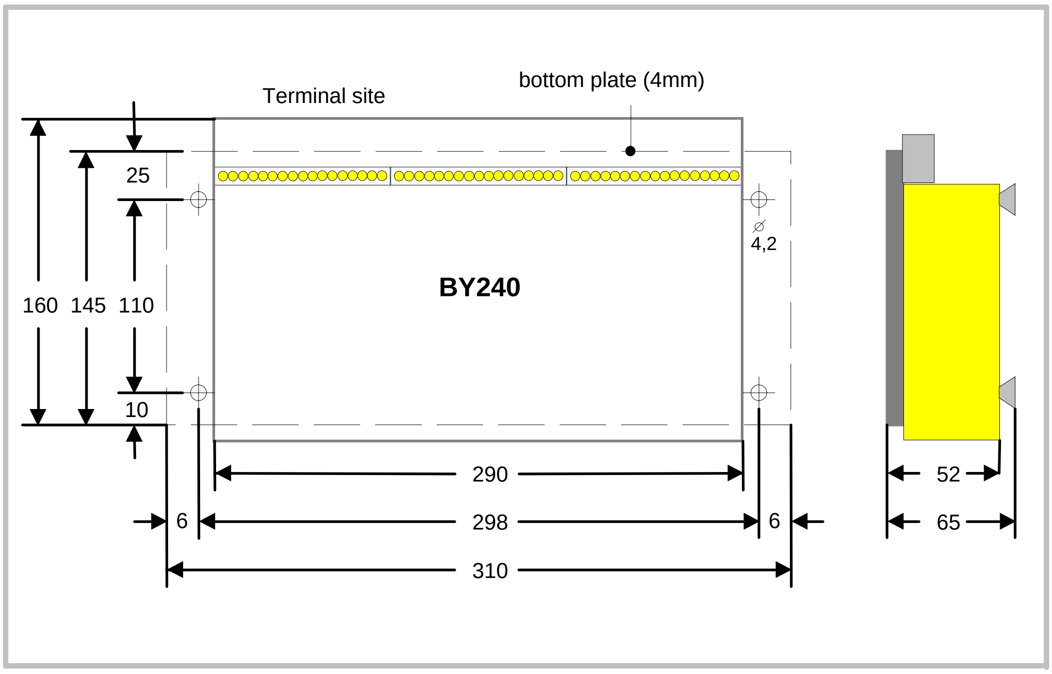
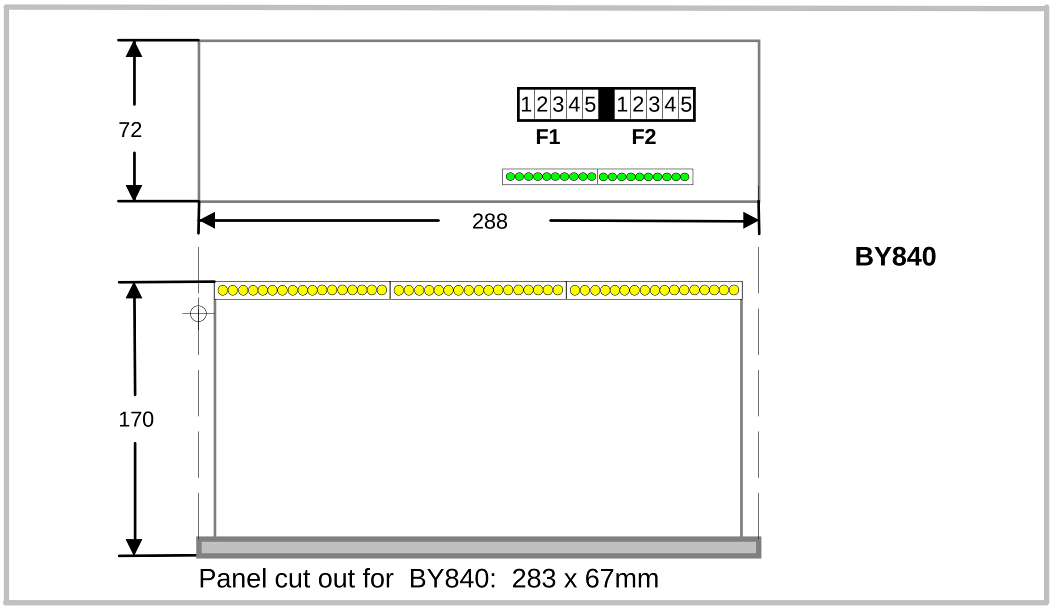


Fig 46



Panel cut out for BY840: 283 x 67mm

Fig 47

Supply	:	115/230VAC (Jumper), optional 24VDC
Consumption	:	approx. 15VA
Aux. encoder supply	:	13,2V / 400mA installed
Processor	:	H8 / 325 at 20 MHz
Construction	:	SMT, Multilayer, high speed Logic 74 HCT
Encoder Inputs	:	2 x A, B, Z (10- 30V- HTL-level)
Control Inputs	:	5, all „active Low“
Interfaces	:	Optional Parallel and RS232 / RS485
Max. feedback frequency	:	80 kHz
Response time	:	approx. 120 µsec
Analogue	:	2 IN +/- 10 V (Ri = 100k) 4 OUT +/- 10 V (I max = 5 mA) Resolution 12 Bit (4096 steps)
Analogue saturation	:	10 Bits = 1024 error increments
Error memory	:	32000 error counts
Control outputs	:	2 Relays (dry changeover), 230V/100VA
Speed error Master / Slave	:	+/- 0,00 (error free)
Dimensions	:	see drawing
weight	:	approx. 1100 g