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1. Safety Regulation

1.1.1. Approvals

1.1.2. Symbols

Symbols used in these Operating Instructions.

NB!
Indicates something to be noted by the reader.

Indicates a general warning.

Indicates a high-voltage warning.

* Indicates default setting

1.1.3. Disposal Instruction

Equipment containing electrical components may not be disposed of together with domestic waste.
It must be separately collected with Electrical and Electronic waste according to local and currently valid legislation.

The FC 300 AutomationDrive DC link capacitors remain charged after power has been disconnected. To avoid electrical shock hazard, disconnect the FC 300 from the mains before carrying out maintenance. When using a PM-motor, make sure it is disconnected. Before doing service on the frequency converter wait at least the amount of time indicated below:

1

FC 300	380 - 500 V	0.25 - 7.5 kW	4 minutes
		11 - 22 kW	15 minutes
		30 - 75 kW	15 minutes
		90 - 200 kW	20 minutes
		250 - 400 kW	40 minutes
	525 - 690 V	37 - 250 kW	20 minutes
		315 - 560 kW	30 minutes

MCO 350 Synchronising Controller for
VLT AutomationDrive FC 30x
Operating Instructions
Software version: 1.1x

These Operating Instructions can be used for all MCO 350 Synchronising Controller for VLT AutomationDrive FC 30x frequency converters with software version 1.1x.
The software version number can be seen from parameter 19-92.

1.1.4. High Voltage



The voltage of the frequency converter is dangerous whenever the frequency converter is connected to mains. Incorrect installation or operation of the motor or frequency converter may cause damage to the equipment, serious personal injury or death. The instructions in this manual must consequently be observed, as well as applicable local and national rules and safety regulations.



Installation in high altitudes
At altitudes above 2 km, please contact Danfoss Drives regarding PELV.

1.1.5. Safety Instructions

- Make sure the FC 300 is properly connected to earth.
- Do not remove mains plugs or motor plugs while the FC 300 is connected to mains.
- Protect users against supply voltage.
- Protect the motor against overloading according to national and local regulations.
- Motor overload protection is not included in the default settings. To add this function, set parameter 1-90 *Motor thermal protection* to value *ETR trip* or *ETR warning*. For the North American market: ETR functions provide class 20 motor overload protection, in accordance with NEC.
- The earth leakage current exceeds 3.5 mA.
- The [OFF] key is not a safety switch. It does not disconnect the FC 300 from mains.

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1.1.6. General Warning



Warning:
Touching the electrical parts may be fatal - even after the equipment has been disconnected from mains.
Also make sure that other voltage inputs have been disconnected, such as load-sharing (linkage of DC intermediate circuit), as well as the motor connection for kinetic back-up.
Using VLT® AutomationDrive FC 300: wait at least 15 minutes.
Shorter time is allowed only if indicated on the nameplate for the specific unit.



Leakage Current
The earth leakage current from the FC 300 exceeds 3.5 mA. To ensure that the earth cable has a good mechanical connection to the earth connection (terminal 95), the cable cross section must be at least 10 mm^2 or 2 times rated earth wires terminated separately.
Residual Current Device
This product can cause a D.C. current in the protective conductor. Where a residual current device (RCD) is used for extra protection, only an RCD of Type B (time delayed) shall be used on the supply side of this product. See also RCD Application Note MN.90.GX.02.
Protective earthing of the FC 300 and the use of RCD's must always follow national and local regulations.

1.1.7. Before Commencing Repair Work

1. Disconnect the frequency converter from mains
2. Wait for discharge of the DC-link. See period of time on the warning label.
3. Disconnect DC bus terminals 88 and 89
4. Remove motor cable

1.1.8. Avoid Unintended Start

While FC 300 is connected to mains, the motor can be started/stopped using digital commands, bus commands, references or via the Local Control Panel (LCP).

- Disconnect the FC 300 from mains whenever personal safety considerations make it necessary to avoid unintended start.
- To avoid unintended start, always activate the [OFF] key before changing parameters.
- An electronic fault, temporary overload, a fault in the mains supply, or lost motor connection may cause a stopped motor to start. FC 300 with Safe Stop (i.e. FC 301 in A1 enclosure and FC 302) provides protection against unintended start, if the Safe Stop Terminal 37 is on low voltage level or disconnected.

1.1.9. Safe Stop of FC 300

The FC 302, and also the FC301 in A1 enclosure, can perform the safety function *Safe Torque Off* (As defined by IEC 61800-5-2) or *Stop Category 0* (as defined in EN 60204-1).

FC 301 A1 enclosure: When Safe Stop is included in the drive, position 18 of Type Code must be either T or U. If position 18 is B or X, Safe Stop Terminal 37 is not included!
Example:
Type Code for FC 301 A1 with Safe Stop: FC-301PK75T4Z20H4TGCXXXSXXXXA0BXCXXXXD0

1

It is designed and approved suitable for the requirements of Safety Category 3 in EN 954-1. This functionality is called Safe Stop. Prior to integration and use of Safe Stop in an installation, a thorough risk analysis on the installation must be carried out in order to determine whether the Safe Stop functionality and safety category are appropriate and sufficient. In order to install and use the Safe Stop function in accordance with the requirements of Safety Category 3 in EN 954-1, the related information and instructions of the FC 300 Design Guide MG.33.BX.YY must be followed! The information and instructions of the Operating Instructions are not sufficient for a correct and safe use of the Safe Stop functionality!



Prüf- und Zertifizierungsstelle
im BG-PRÜFZERT

BGIA
Berufsgenossenschaftliches Institut für Arbeitsschutz
Hauptverband der gewerblichen Berufsgenossenschaften

130BA373.10

Translation
In any case, the German original shall prevail.

Type Test Certificate

05 06004
No. of certificate

Name and address of the holder of the certificate: (customer)	Danfoss Drives A/S, Ulnaes 1 DK-6300 Graasten, Dänemark
Name and address of the manufacturer:	Danfoss Drives A/S, Ulnaes 1 DK-6300 Graasten, Dänemark

Ref. of customer:	Ref. of Test and Certification Body: Apf/Köh VE-Nr. 2003 23220	Date of Issue: 13.04.2005

Product designation:	Frequency converter with integrated safety functions
Type:	VLT® Automation Drive FC 302
Intended purpose:	Implementation of safety function „Safe Stop"
Testing based on:	EN 954-1, 1997-03, DKE AK 226.03, 1998-06, EN ISO 13849-2; 2003-12, EN 61800-3, 2001-02, EN 61800-5-1, 2003-09,
Test certificate:	No.: 2003 23220 from 13.04.2005
Remarks:	The presented types of the frequency converter FC 302 meet the requirements laid down in the test bases. With correct wiring a category 3 according to DIN EN 954-1 is reached for the safety function.

The type tested complies with the provisions laid down in the directive 98/37/EC (Machinery).

Further conditions are laid down in the Rules of Procedure for Testing and Certification of April 2004.

Head of certification body
(Prof. Dr. rer. nat. Dietmar Reinert)

Certification officer
(Dipl.-Ing. R. Apfeld)

FZB10E
01.05

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Fax: 0 22 41/2 31-22 34

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1.1.10. Safe Stop Installation (FC302 and FC301 - A1 enclosure only)

To carry out an installation of a Category 0 Stop (EN60204) in conformance with Safety Category 3 (EN954-1), follow these instructions:

1. The bridge (jumper) between Terminal 37 and 24 V DC must be removed. Cutting or breaking the jumper is not sufficient. Remove it entirely to avoid short-circuiting. See jumper on illustration.
2. Connect terminal 37 to 24 V DC by a short-circuit protected cable. The 24 V DC voltage supply must be interruptible by an EN954-1 Category 3 circuit interrupt device. If the interrupt device and the frequency converter are placed in the same installation panel, you can use a regular cable instead of a protected one.
3. Unless the FC302 itself has protection class IP54 and higher, it must be placed in an IP 54 enclosure. Consequently, FC301 A1 must always be placed in an IP 54 enclosure.

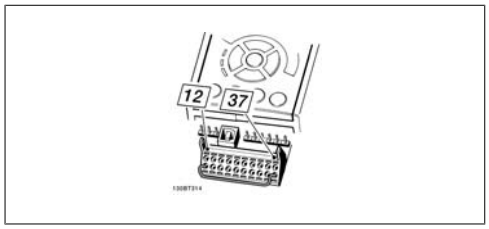


Illustration 1.1: Bridge jumper between terminal 37 and 24 VDC

The illustration below shows a Stopping Category 0 (EN 60204-1) with safety Category 3 (EN 954-1). The circuit interrupt is caused by an opening door contact. The illustration also shows how to connect a non-safety related hardware coast.

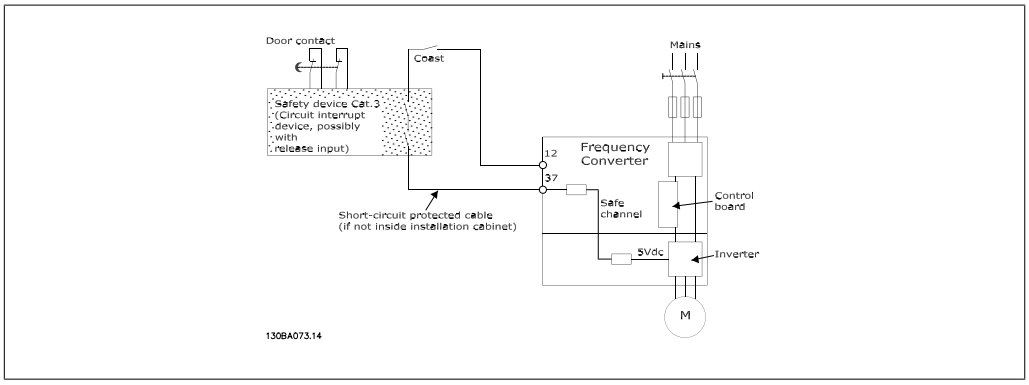


Illustration 1.2: Illustration of the essential aspects of an installation to achieve a Stopping Category 0 (EN 60204-1) with safety Category 3 (EN 954-1).

1.1.11. IT Mains

Par. 14-50 *RFI 1* can on FC 102/202/302 be used to disconnect the internal RFI capacitors from the RFI filter to ground. If this is done it will reduce the RFI performance to A2 level.

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2. Introduction

The synchronising Controller is an application option for VLT Automation Drive FC 301 and 302.

The application option consists of two parts:

- synchronising controller part
- Test Run part

2.2. Function Description

2.2.1. Introduction

The synchronising controller can be used in any application where a drive is to operate synchronously with a master drive. The synchronising controller acts as an electronic shaft. The gear ratio is freely selectable and can also be changed during operation. The speed or the position is automatically and accurately controlled based on encoder feedback signals from both the master drive and the slave drives.

For synchronous operation of two or more drives you can use:

- Speed synchronisation
- Position synchronisation or
- Marker synchronisation

2.2.2. Speed Synchronisation

This is the simplest type of synchronisation. It can be used to compensate for speed differences, where it is not necessary to compensate for position errors.

The speed synchronisation between master and slave is done at maximum acceleration. To obtain optimum control the slave drive should therefore be set for a quicker acceleration speed than that of the master drive.

2.2.3. Position Synchronisation (angle synchronisation)

This is the electronic shaft ensuring a constant angle position ratio between master and slave drives. In case of a position deviation the slave drive is automatically accelerated to a speed level that is sufficient for regaining its position to the master drive (I-control like).

2.2.4. Marker Synchronisation

Marker synchronisation is an extended position control. Apart from ensuring a constant angle position between master and slave drives, marker synchronisation provides the option of using either an additional sensor or the zero track of the incremental encoder to compensate for any deviations between master and slave that may occur during operation. Using marker synchronisation the slave is position synchronised until the markers is reached and then the control compensates for the position difference between master marker and slave marker. This type of control is used where precision cannot be achieved by using a motor mounted encoder. That could be because of gearbox slack or other disturbance like belt elongation etc. that are not directly measurable. Similarly, with marker synchronisation, the slave drive does not need to be brought into the start position of the master drive at initial start-up, as this is affected automatically by marker correction.

2

2.2.5. Mechanical Brake Control

The synchronising controller has a 24 V DC digital output (Output 4) and a relay output (Relay 1) to control an electromechanical brake; this is very useful in applications when a motor (shaft) must be kept in the same position for a longer time. This is usually the case in hoisting applications. The brake output will be active (low) in case of an error and when synchronisation is stopped, that means whenever motor control is switched off. The brake signal can be delayed when switched on and off in two individual parameters (par. 19-21 *Brake on Delay* and par. 19-22 *Brake off Delay*). Please note that the brake output is kept low in VLT mode (when input 8 is high). That means the brake must be opened for example by means of the VLT mechanical brake function in set-up 2.

2.3. Tips and Tricks for Synchronisation Tasks

2.3.1. Introduction

When configuring the drives to be synchronised please keep in mind that the ratios should be of integer size. When using gear it is also important to know the number of teeth of the various gear stages (ask the gear manufacturer) as gears are normally set up with infinite gear ratios. When calculating the ratios between master and slave you must either use the figure PI for both of them or not use PI at all.

2.3.2. Example

A master drive with a 4-pole motor and an incremental encoder of 1024 increments/revolution works on a 2-stage gear. i is specified to be 30.33. At the gear output, a belt ratio of 40:20 is placed, driving a conveyor belt on the drive side with a diameter of 102mm. Via a 3-stage gear (i is specified to be 46,54) the slave drive is connected to an 8-toothed chain conveyor with a tooth pitch of 200mm.

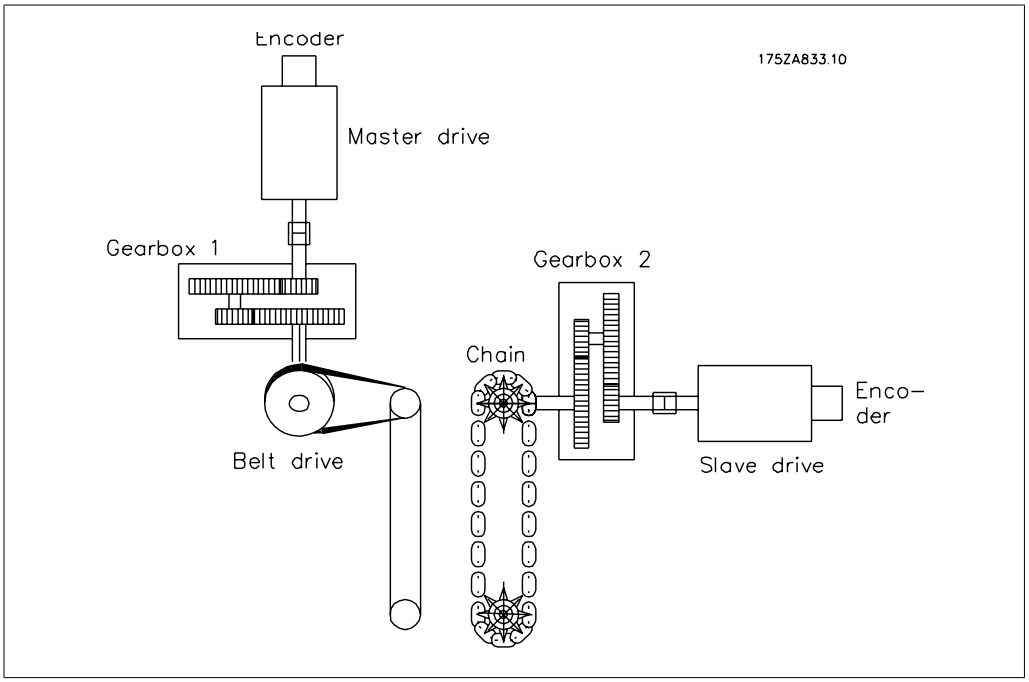


Illustration 2.1: Calculation Example

2.3.3. Calculation with Insufficient Numerical Values

The master/slave gear ratio (numerator to denominator) is now calculated as follows:

Master side = increments * i1 * i2 * power take off =

$$1024\ incr\ x\ 30.33\ x\ \frac{20}{40}\ x\ \frac{1}{102\ mm\ x\ \pi} = 48,460995$$

Slave side = increments * i1 * power take off =

$$1024\ incr\ x\ 46.54\ x\ \frac{1}{8\ x\ 200\ mm} = 29,7856$$

This gives a ratio of: $\frac{48,460995}{29,7856}$

That gives a numerical value of 48,460995 for the numerator and 29,7856 for the denominator. Note: It is only possible to enter integer values. The most serious error: The master expression contains the value Pi, an infinite number sequence. Even with small numerical values for master and slave, the effect would always be that the drives drifted apart, as the Numerator: Denominator expression can never be an integer.

Another error arises from the gear ratios given, as the master drive was specified with a value of i = 30.33. The correct ratio is easily found by recalculating the individual numbers of teeth. The gear is a 2-stage gear; the first stage is formed from two pinions, 126 to 27, and the second stage from two pinions, 117 to 18.

The ratio is calculated as: $\frac{126\ x\ 117}{27\ x\ 18} = 30,33$

The specified value of 30.33 thus deviates by 0.1 ‰.

This may appear small; if this error is related to the encoder resolution, however, it will be seen that even this error is serious.

From the example it can be seen that it is important to maintain the exact values of the gear stages and to ensure that the data include Pi either for both drives or for none of them.

2.3.4. Example with Corrected Numerical Values

Master side: Gear 1st stage 126/27 2nd stage 117/18; belt ratio 40/20; drive shaft 100 mm
Slave side: Gear 1st stage 97/10, 2nd stage 43/11, 3rd stage 27/22; effective diameter of the sprocket wheel 510mm

Master side: $\frac{1024\ Incr\ x\ 126\ x\ 117\ x\ 20}{27\ x\ 18\ x\ 40\ x\ 102\ x\ \pi}$

Slave side: $\frac{1024\ Incr\ x\ 97\ x\ 43\ x\ 27}{10\ x\ 11\ x\ 22\ x\ 510\ x\ \pi}$

To remove Pi from the equations, substitute both equations into the combined formula:

$$\frac{Masterside}{Slaveside} = \frac{1024\ Incr\ x\ 126\ x\ 117\ x\ 20}{27\ x\ 18\ x\ 40\ x\ 102\ x\ \pi} \div \frac{1024\ Incr\ x\ 97\ x\ 43\ x\ 27}{10\ x\ 11\ x\ 22\ x\ 510\ x\ \pi}$$

$$\frac{1024\ Incr\ x\ 126\ x\ 117\ x\ 20\ x\ 510\ x\ \pi\ x\ 10\ x\ 11\ x\ 22}{27\ x\ 18\ x\ 40\ x\ 1024\ Incr\ x\ 97\ x\ 43\ x\ 27\ x\ 102\ x\ \pi}$$

Reduce by Pi and 1024 incr.: $\frac{126\ x\ 117\ x\ 20\ x\ 510\ x\ 10\ x\ 11\ x\ 22}{27\ x\ 18\ x\ 40\ x\ 97\ x\ 43\ x\ 27\ x\ 102}$

Reduce further:

$$\frac{7\ x\ 5\ x\ 54\ x\ 11\ x\ 22\ x\ 117}{27\ x\ 97\ x\ 43\ x\ 27}$$

This gives a ratio of $\frac{4954950}{3040659}$

This is an absolute value, as it contains no infinite number sequences and no rounded values.

2.4. Hardware

2.4.1. VLT Control Card Terminals

The terminals on the control card are allocated for synchronising controller functions the following parameter settings should therefore not be changed in synchronising mode (set-up 1):

Digital inputs 18, 19, 27, 32 and 33
Parameters 510–515 are set to *No operation* (default setting), then the inputs are ignored by the control card but they are used as inputs for the synchronising controller.

Analogue inputs 53, 54
Parameters 315, 316 and 317 are set to *No function*, then the inputs are ignored by the control card but they are used as inputs to the synchronising controller.

Digital/analogue outputs 42
Parameters 650 are set to: *MCO 0 ... 20 mA [52] analogue output*

2.5. Technical Data

2.5.1. Introduction

Technical data on the control card terminals can be found in the VLT Automation Drive FC 300 Design Guide.

2.5.2. Option Card Terminals

There are two encoder interfaces, which coveers the following functions:

- Feedback encoder input
- Master encoder input / virtual master output

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Terminal X55	
Terminal Number	Descriptive Name Encoder 2 (Feed-back)
1	+ 24 V Supply
2	+ 8 V Supply
3	+ 5 V Supply
4	GND
5	A
6	A not
7	B
8	B not
9	Z / Clock
10	Z / Clock not
11	Data
12	Data not

Terminal X56	
Terminal Number	Descriptive Name Encoder (Master)
1	+ 24 V Supply
2	NC
3	+ 5 V Supply
4	GND
5	A
6	A not
7	B
8	B not
9	Z / Clock
10	Z / Clock not
11	Data
12	Data not

There are 2 digital input/output terminal blocks, 10 inputs and 8 outputs. (See figure below)

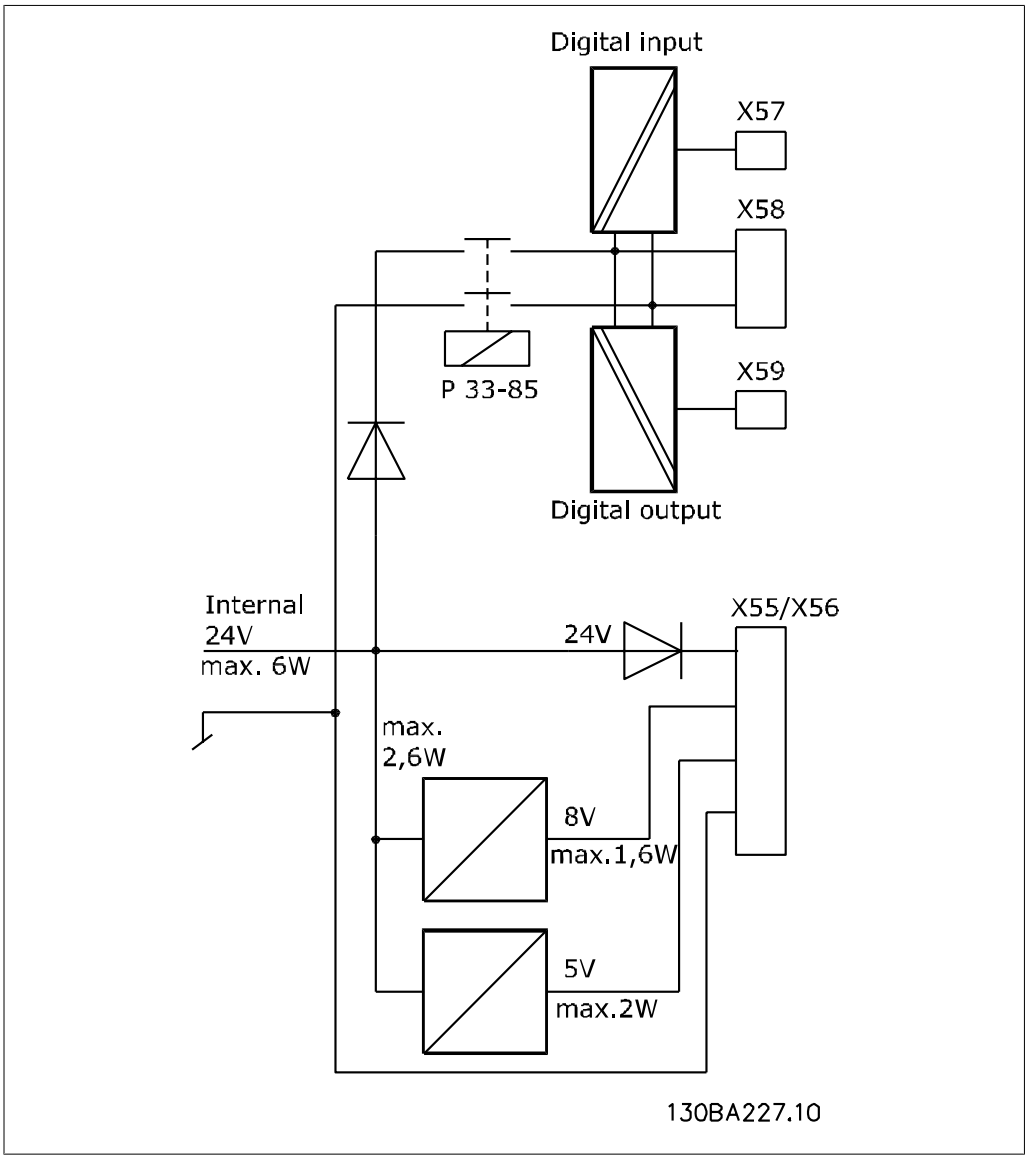
Terminal X57	
Terminal Number	Descriptive Name Digital Inputs
1	Digital Input
2	Digital Input
3	Digital Input
4	Digital Input
5	Digital Input
6	Digital Input
7	Digital Input
8	Digital Input
9	Digital Input
10	Digital Input

Terminal X59	
Terminal Number	Descriptive Name Digital Output
1	Digital Output
2	Digital Output
3	Digital Output
4	Digital Output
5	Digital Output
6	Digital Output
7	Digital Output
8	Digital Output

Terminal X58	
Terminal Number	Descriptive Name 24 V Supply
1	+ 24 V Supply
2	GND

There are 2 digital input/output terminal blocks, 10 inputs and 8 outputs. (See figure below)

2



2.5.3. Encoder Monitor

Both encoder interfaces are equipped with a monitoring circuit that can detect open circuit as well as short circuit of each encoder channel. Each encoder channel has a LED showing the status: Green light means OK, no light means fault. An encoder fault will result in an "Option error" 192 if encoder monitoring is activated via parameter 3239 (master) and 3209 (slave).

2.5.4. Option Card Layout

MCO 350 control terminals are plug connectors with screw terminals; the terminal blocks are duplicated to enable use of the same MCO 350 in all frame sizes. See illustration to locate the terminal blocks:

(1) is used with frame sizes A2 and A
(2) is used with frame sizes A5, B1 and B2
X55 = Encoder 2
X56 = Encoder 1
X57 = Digital inputs
X58 = 24VDC supply
X59 = Digital outputs

2.5.5. General Technical Data

– All inputs, outputs and supply voltages are protected against short circuit.
– All inputs, outputs and supply voltages are galvanic isolated from high voltages such as mains supply and motor voltage (PELV).
– Encoder signals are monitored during operation and standstill.
– All MCO 350 parameters including user defined application parameters are accessible via the FC 300 Local Control Panel.
– MCO 350 can be combined with other FC 300 options, namely PROFIBUS and DeviceNet interface.
– All digital inputs and outputs are galvanic isolated from the internal electronics and can be sourced from an external 24V power supply.

Connection Terminals:	
Maximum cross section, rigid wire	1.5 mm^2/AWG 16
Maximum cross section, flexible wire	1.5 mm^2/AWG 16
Maximum cross section, wire with enclosed core	1.5 mm^2/AWG 16
Minimum cross section	0.08[2]/AWG 28

Digital inputs:	
Number of programmable digital inputs	10
Terminal block	X57
Terminal number	1[1)],2[1)],3,4,5,6,7,8,9,10
Logic	PNP or NPN[1)]
Voltage level	0 - 24 V DC
Voltage level	0 - 24 V DC
Voltage level, logic '0' PNP	< 5 DC
Voltage level, logic'1' PNP	> 10 V DC
Voltage level, logic '0' NPN[2)]	> 19 V DC
Voltage level, logic '1' NPN[2)]	< 14 V DC
Maximum voltage on input	28 V DC

1)) Selected in parameter 5-00 Digital I/O mode.
The digital inputs are galvanic isolated from the internal electronics and can be sourced by an external 24V power supply.

Digital outputs:	
Number of programmable digital outputs	8 (6)[1]
Terminal block	X59
Terminal number	1[1)], 2[1)],3,4,5,6,7,8
Driver type	push/pull
Logic	PNP or NPN[2)]
Voltage level	0 - 24 V DC
Max. output current (sink or source) with internal power supply (total Σ)	40 mA
Max. output current (sink or source) with external power supply (per output)	100 mA

Terminals X59-1 and X59-2 can be programmed as input, parameter 33-60.

2

Combined Digital Inputs/Outputs:	
Number of digital outputs which can be used as digital inputs	2[1)]
Terminal block	X59
Terminal number	1,2
Logic	PNP or NPN[2)]
Voltage level	0 - 24 V DC
Voltage level	0 - 24 V DC
Voltage level, logic '0' PNP	< 10 V DC
Voltage level, logic'1' PNP	> 17 V DC
Voltage level, logic '0' NPN	> 13 V DC
Voltage level, logic '1' NPN	< 6 V DC
Maximum voltage on input	28 V DC

1) Terminals X59-1 and X59-2 can be programmed as input, parameter 33-60.
2) Selected in parameter 5-00 Digital I/O mode.

24 V DC Supply Output	
Terminal block	X58
Terminal number	1,2
Maximum load	65 mA

The internal 24V power supply can be disconnected via parameter 33-85, an external 24V power supply must then be connected to X58-1 and X58-2.

Encoder Inputs	
Number of encoder inputs	2
Terminal block	X55 and X56
Terminal number	5,6,7,8,9,10,11,12
Input impedance	120Ω
Maximum voltage on inputs	5 V DC
Cable type	Screened cable with a twisted pair of wires for each encoder channel[1)]
Incremental encoder type	RS422/TTL
Maximum frequency	410 kHz
Phase displacement between A and B	90°±30°
Maximum cable length	300 m[1)]
Absolute encoder type	SSI
Data coding	Gray
Data length	12 - 37 bit
Clock frequency	78 kHz - 2 MHz[1)]
Absolute encoder type	SSI
Maximum cable length	150 m[1)]

1) Always observe specifications/limitations prescribed by the encoder supplier.
2) 150 m cable is possible up to 500 kHz clock frequency, above 500 kHz cable length must be limited further.

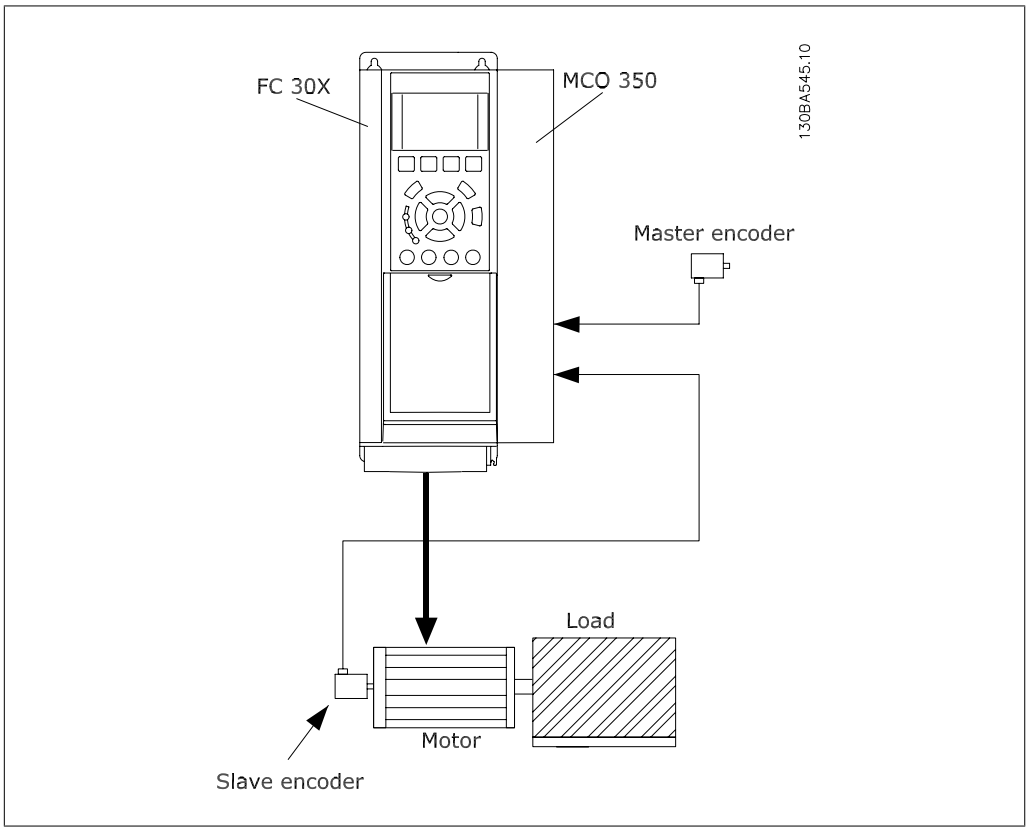
Encoder Output	
Number of encoder outputs	1
Terminal block	X56
Terminal number	5,6,7,8,9,10,11,12
Signal type	RS 422Ω
Maximum frequency	410 kHz
Maximum number of slaves	31 (more with repeater)
Maximum cable length	400 m

Encoder Output	
Number of supply voltages	3
Terminal block	X55 and X56
Terminal number	1,2,3,4

24 V, max load	250 mA[1)]
8 V, max load	250 mA[1) 2)]
5 V, max load	400 mA[1)]
Absolute encoder type	SSI
Maximum cable length	150 m[1)]

1) This is maximum load when only one supply voltage is used; when 2 or 3 supply voltages are used simultaneously the load must be reduced accordingly. The following must be observed: load24V + load8V + load5V ≤ 6W and load8V + load5V ≤ 2W.
2) 8 V is only available at terminal block X55.

2.6. Example of Encoder Interface connections



2.7. Description of Terminals

2

I/O Number	Designation	Description
12	24 V DC	24V power supply for switches etc.
13	24 V DC	24V power supply for switches etc.
18	Disable Resync	The Resync function (to be enabled by param 1924) can be temporarily disabled by setting this input to 1
19	Home run	Starts the homing.
20	GND	Ground for 24 V.
27	Reset/Enable	Error reset on rising edge. To enable operation, this input must be switched to "1". "0" = motor coast.
32	Test run reverse	Test run; Program 1: Test run reverse at the speed defined in Parameter 19-01
	Speed/Pos -	Synchronous operation; Program 2: In velocity synchronous mode (P. 1901 = 0, 3, 6 or 7) the gear ratio and thus the velocity of the slave can be changed by the value specified in parameter 1912. In position synchronous and marker synchronous operation (P. 1901 = 1, 2, 4 or 5), the position offset of the slave can be changed by the value specified in Parameter 1912. The sign of the value in parameter 1912 selects the offset type to be absolute or relative. Absolute offset means that the fixed offset of parameter 1912 is changed and this offset is executed when restarting synchronisation. Relative offset means that the actual slave position is displaced but the fixed offset of parameter 1912 is unchanged. This again means that the actual slave position is maintained when restarting synchronisation. Relative offset is useful when always changing the offset in the same direction as this would give a very high fixed offset when using absolute offset. This high fixed offset would then be executed when restarting synchronisation and the min. or max. limit of parameter 1912 would eventually be reached.

I/O Number	Designation	Description
33	Test run forward	Test run; Program 1: Test run forward at the speed defined in Parameter 1901
	Speed/Pos +	Synchronous operation; Program 2: In velocity synchronous mode (P. 1901 = 0, 3, 6 or 7) the gear ratio and thus the velocity of the slave can be changed by the value specified in parameter 19-12. In position synchronous and marker synchronous operation (par. 19-01 = 1, 2, 4 or 5), the position offset of the slave can be changed by the value specified in Parameter 1912. The sign of the value in parameter 1912 selects the offset type to be absolute or relative. Absolute offset means that the fixed offset of parameter 19-12 is changed and this offset is executed when restarting synchronisation. Relative offset means that the actual slave position is displaced but the fixed offset of parameter 19-12 is unchanged. This again means that the actual slave position is maintained when restarting synchronisation. Relative offset is useful when always changing the offset in the same direction as this would give a very high fixed offset when using absolute offset. This high fixed offset would then be executed when restarting synchronisation and the min. or max. limit of parameter 1912 would eventually be reached.
01	COM; 240V AC/2A	Relay output 1:
02	Electromechanical brake: NO	Relay 1 is open (brake activated) during power off, and start-up of the frequency converter. Afterwards the brake-control depends on the selected Sync mode.
03	NC	
04	COM; 50V AC/1A; 75V DC/1A	Relay output 2: Function can be configured by means of Parameter 540.
05	NO	
06	NC	
39	GND	Ground for analogue inputs/outputs.
42	Slave/Master velocity	The output value is scaled to maximum slave velocity (parameter 32-80); The output can be selected between slave or master velocity by means of parameter 19-25
50	10V DC 15mA	Power supply for reference value potentiometer
53	0 - 10V In	Serves as reference input for the virtual master if "0" is selected in Parameter 19-16.
54	0 - 10V In	Serves as numerator for the gear ratio if "6" or "7" is selected in parameter 19-01.

2

2.7.1. Standard RS 485-Interface

I/O Number	Designation	Description
61	Ground RS 485	Not used
68	RS 485-P	Not used
69	RS 485-N	Not used

2.7.2. MCO 350 Terminal X57

I/O Number	Designation	Description
1	I1 - Sync-Start	Start and stop of synchronisation. Input 1 must be toggled if synchronisation was interrupted by an error or by input 27 (motor coast). Behaviour at stop can be selected via parameter 1901.
2	I2 - Take over gear ratio	Activates the gear ratio selected at Terminals 9 and 10.
3	I3 - Start/Stop virtual master	Test run; Program 1: Start test run with virtual master. Synchronous operation; Program 2: The virtual master is accelerated up to the set pulse frequency, or stopped, with the set ramp time.
4	I4 - Hold	The drive is held at a programmable (parameter 1903) speed, or the current speed (parameter 1902 = 1). Synchronous control is not activated.
5	I5 - Master marker input	When using external marker signal for the master drive it must be connected to this input.
6	I6 - Slave marker input	When using external marker signal for the slave drive it must be connected to this input.
7	I7 - Measuring of the master marker interval	Test run; Program 1: Measuring of the master marker interval is started.
	Home switch	Synchronous operation; Program 2: If a home position is to be attained, the home switch must be connected here. The signal must show a rising edge
8	I8 - measuring of the slave marker interval	Test run; Program 1: Measurement of the slave marker interval is started.
	I8 - VLT mode selection	Synchronous operation; Program 2: Switches the VLT to normal frequency converter operation. The settings for this operating mode are to be made in Parameter set-up 2. Refer to the VLT Automation Drive Product Manual.
9	Gear ratio 2^0	Gear ratio least significant bit
10	Gear ratio 2^1	Gear ratio most significant bit

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2.7.3. MCO 350 Terminal X59

I/O Number	Designation	Description
1	O1 - READY	Ready, i.e. for the number of marker signals that were specified in Parameter 3325, the slave drive has run within the tolerance (Accuracy).
2	O2 - FAULT	Fault, i.e. for the number of marker signals that were specified in Parameter 3324, the slave drive has run outside the tolerance (Accuracy). OR when the number of marker signals have been missing when marker monitor is activated in parameter 1923.
3	O3 - ACCURACY	The drive runs within the tolerance specified in Parameter 3313.
4	O4 - Brake control	This output can be used to control a mechanical brake. "0" means that the brake must be closed (braking) "1" means that the brake must be open (not braking)
5	O5 - Saving	This output stays high while saving is in progress. The saving is initiated by Parameter 1900, Input 4 or fieldbus bit 4.
6	O6 - Drive running	Signal "1" when the drive is running.
7	O7 - Home reached	If the data value "1" was chosen in Parameter 3300, this output shows "1" when homing is completed.
8	O8 - Ready, no error	The synchronising controller is ready for operation.

2.8. Description of Fieldbus Interface



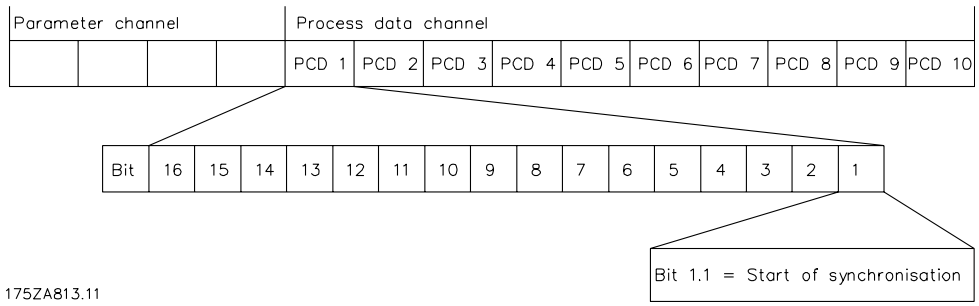
NB!
This section is only relevant if the VLT is equipped with a Field bus interface (option) as well as the synchronising controller.

The synchronising controller can be controlled via the digital/analogue inputs or via field bus. The control source can be selected individually for test-run and synchronising in the parameters 1919 (test-run) and 1920 (synchronising). There can only be one control source at a time meaning that the digital/analogue inputs are inactive when Field bus is selected as control source and visa versa. The only exception is input 27, which is always stop/enable also when Field bus is selected as control source. In synchronising mode three signals are only available as digital inputs even when Field bus is selected as control source that is the marker signals for marker synchronisation and the Home switch. This is because these signals are too time-critical for Field bus control. Status signals are always available on the digital/analogue outputs but they are only available via Field bus when Field bus is selected as control source.

2.8.1. Data Layout

Control and status signals are transferred via the so-called process data channel (PCD) of the various fieldbus interfaces. The telegram structure and the available number of data words depends on the Fieldbus used, please refer to the manual of the Fieldbus option in use for further details. The below example is based on the layout of a PROFIBUS telegram, the so-called PPO:

Example using PROFIBUS PPO type 5:



Fieldbus Control Signals			
Fieldbus [word.bit]	Test Run	synchronising	Corresponding Input
1.1	Not used	Start of synchronisation	1
1.2	Not used	Take over gear ratio	2
1.3	Start/stop virtual master	Start/stop virtual master	3
1.4	Not used	Save gear-settings (only possible when stopped!)	4
1.5	Not used	VLT-mode	8
1.6	Not used	Gear-ratio select LSB	9
1.7	Not used	Gear-ratio select MSB	10
1.8	Not used	Start homing	19
1.9	Reset/enable	Reset/enable	27
1.10	Not used	Hold	29
1.11	Not used	Speed/position -	32
1.12	Not used	Speed/position +	33
1.13	Measuring master marker distance	Not used	7
1.14	Measuring slave marker distance	Not used	8
1.15	Test-run left	Not used	32
1.16	Test-run right	Virtual master negative direction	33
2	Virtual master reference*	Virtual master reference*	53

*) Only when par. 19-16 = 2.

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Fieldbus Status Signals			
Fieldbus [word.bit]	Test Run	synchronising	Corresponding Output/ Parame-ter
1.1	Not used	Ready	1
1.2	Not used	Fault	2
1.3	Not used	Accuracy	3
1.5	Saving	Saving	5
1.6	Running	Running	6
1.7	Not used	Home reached	7
1.8	Ready, no error	Ready, no error	8
2	Track error	Track error	Par. 19-93 (testrun)/ Par. 19-96 (synchronising)
3	Not used	synchronising error	Par. 19-93
4	Not used	Status of synchronisation	Par. 34-60
5	Slave speed	Slave speed	Par. 19-94
6	Master speed	Master speed	Par. 19-95

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3. Programming

3.1. Description of Parameters

19-00 Store data		
Option:		Function: Here you can save the gear-ratio data permanently in the EE-PROM
[0]	no function	
[1]	Gear data is being saved	While saving, the value remains "1"; when saving is finished, the value automatically reverts to "0". At the same time, during saving, Output O5 "Saving" is set to "1". Saving is not possible during operation, but only in the stopped state.

19-01 Test run; Program 1	
Option:	Function: Test run speed: Specify here the speed at which the test runs are to be carried out. The speed is specified as a percentage of the maximum speed defined in par. 32-80.

19-01 Synchronous operation; Program 2	
Option:	Function: Type of operation: Select here the type of operation of the synchronising Controller
[0]	Speed synchronising
[1]	Position synchronising
[2]	Marker synchronising
[3]	Speed synchronising with motor coast after stop
[4]	Position synchronising with motor coast after stop
[5]	Marker synchronising with motor coast after stop
[6] .	Speed synchronising with motor coast after stop and setting of gear ratio via analogue input 54
[7]	Speed synchronising with setting of gear ratio via analogue input 54.

With the selections "0" - "2" and "7" the motor is always controlled keeping the actual position when stopping synchronisation (input 1 = "0").

3

19-02 Test run; Program 1	
Option:	Function:
	Test run acceleration: Specify here the acceleration for the test run as a percentage of the maximum acceleration. 100 % means that the drive accelerates with the minimum ramp specified in par. 32-81. 50 % means that the drive only proceeds with half the acceleration, i.e. the acceleration takes twice as long as with the minimum ramp specified in par. 32-81.
	Synchronous operation; Program 2: Hold function: If the contact at Terminal 29 is closed, the slave drive is disengaged, i.e. it no longer runs in synchrony with the master.
[0]	If "0" is set, the slave drive is brought to the speed set in par. 19-03.
[1]	If "1" is set, the actual speed is maintained. While these signals are present, the current Hold speed can be changed by means of Inputs 32 and 33.

19-03 Test run; Program 1	
Option:	Function:
	Test run distance: Specify the distance for the test run in quad counts.
	Synchronous operation; Program 2: Hold speed: If Hold function "0" was selected, enter here the speed as a percentage of the maximum speed (par. 32-80).

19-04 Test run, program 1: synchronising type (Sync type)		
Option:		Function:
		This parameter is used to specify the type of synchronisation used when optimising the PID controller for synchronisation by means of the virtual master.
[0]	Speed synchronising	Select "0" if speed synchronising should be used in synchronous mode
[1]	Position synchronising	Select "1" if position or marker synchronising should be used in synchronous mode.
		Synchronous operation; Program 2: Delta hold speed: Specify the percentage by which the hold speed is to change when Input 32 or 33 is activated during Hold mode.

19-05 Test run, program 1: Activate feed forward and PID calculation (FFVEL calc.)	
Option:	Function:
	This parameter is used to trigger automatic calculation of the optimal value for velocity feed forward (par. 32-65) as well as PID sample time (par. 32-69), proportional factor (par. 32-60) and derivative factor (par. 32-61).
[0] No action	

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[1]	Activate calculation of velocity feed forward (par. 3265)	The calculation is based on the following parameters that must be set before the calculation is started: Par. 32-00/32-02 "Slave encoder type", Par. 3201/3203 "Slave encoder resolution", Par. 32-80 "encoder velocity" Par. 32-69 "PID sample time".
[2]		Activate calculation of velocity feed forward (par. 32-65), PID sample time (par. 32-69), Proportional factor (par. 32-60) and derivative factor (par. 32-61). The calculations are based on the following parameters that must be set before the calculation is started: Par. 32-00/32-02 "Slave encoder type", Par. 32-01/32-03 "Slave encoder resolution", Par. 32-80 "Maximum velocity",

The parameter value is automatically reset to "0" when the calculation is done.

NB!
If any of the above mentioned parameters are changed the calculation must be repeated.

Synchronous operation; Program 2:
Gear ratio no.: Select the number of the gear ratio that you want to edit in parameters 19-06 to 19-10.

19-06 Gear ratio numerator

Option: Function:

Enter the numerator for the gear ratio selected in par. 19-05. Ensure that the gear ratio matches the marker ratio.

19-07 Gear ratio denominator

Option: Function:

Enter the denominator for the gear ratio selected in par. 19-05. Ensure that the gear ratio matches the marker ratio.

19-08 Slave marker quantity

Option: Function:

Enter the number of slave markers for the marker ratio. Ensure that the gear ratio matches the marker ratio.

NB!
This parameter is only used in marker synchronising mode (par. 19-01 = 2 or 5).

3

19-09 Master marker quantity

Option:

Function:

Enter the number of master markers for the marker ratio. Ensure that the marker ratio matches the gear ratio.



NB!
This parameter is only used in marker synchronising mode (par. 1901 = 2 or 5).

19-10 Fixed offset

Option:

Function:

Enter the position offset. This makes it possible to compensate for differences in the placing of the encoder or markers. Input is in quad counts.



NB!
Offset is related to the master position. Offset related to the slave position can be calculated as follows:

$$Offset_slave: \frac{Offest\ x\ Parameter\ 19-06}{Parameter\ 19-07}$$

19-11 Step time

Option:

Function:

Enter the time after which

- with the Hold function activated and the presence of one of the signals at Terminal 32 or 33, a change in speed takes place;
- in the engaged state, without Hold, the next change of the slave position takes place.

Input is in milliseconds.

19-12 Step Length

Option:

Function:

Enter the step value for changing the position offset in quad counts. Par. 19-10 is changed accordingly. The sign of this parameter selects the offset type when changing the offset via the position + and - inputs:

A positive value selects absolute offset (see Input 32/33).
A negative value selects relative offset (see Input 32/33).

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19-13 Slave speed factor

Option:

Function:

Enter here the factor by which the slave speed must be scaled, so that the desired value is displayed. The following formula applies for calculation of the factor:

$$Factor = \frac{N_{Set} \ x \ 400 \ x \ Slaveencoder_resolution}{60 \ x \ Display_value}$$

Example: Resolution 1024 PPR, desired display 100 at 15001/ min

$$Factor = \frac{1500\frac{1}{min} \ x \ 400 \ x \ 1024 \ \frac{Incr.}{Rev.}}{60 \ x \ 100} = 102400$$

19-14 Master speed factor

Option:

Function:

Enter here the factor by which the master speed must be scaled, so that desired value is displayed. The formula for calculation of the factor is:

$$Factor = \frac{N_{Set} \ x \ 400 \ x \ Slaveencoder_resolution}{60 \ x \ Display_value}$$

19-15 synchronising error display factor

Option:

Function:

Enter the factor by which the error must be scaled, so that the desired value is displayed. The formula for calculation of the factor is:

Speed synchronisation: The factor should be 100, the synchronising error is then displayed in RPM related to the slave.

Position synchronisation:

$$Factor = \frac{N_{Set} \ x \ 400 \ x \ Slaveencoder_resolution}{User \ unit}$$

Example: Resolution 1024 PPR, user unit is 100 mm/revolution

$$Factor = \frac{N_{Set} \ x \ 400 \ x \ 1024}{100} = 4096$$

19-16 Virtual master reference value

Option:

Function:

Select the type of reference value for the virtual master.

[0]	reference value signal 0.. *10V via Terminal 53,
[1]	reference value can be set via par. 310 subindex 1.
[2]	reference value is set via Field bus (PCD 2). +/- 1000 corresponds to maximum virtual master velocity (par. 1918).

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19-17 Virtual master acceleration

Option:

Function:

Enter here the acceleration for the virtual master in Hz/s.
Virtual master acceleration =

$$\frac{Pulsfrequenz\ [Hz]}{t[s]}$$

Example: The virtual master must correspond to an encoder with 1024 inc/rotation. The maximum speed of 25 encoder rotations per second must be attained in 1 second.
Virtual master acceleration =

$$\frac{25\frac{1}{s}\ x\ 1024\ \frac{Incr.}{Rev.}}{1s} = 25600\ Hz \Big/ s$$

19-18 Virtual master maximum speed

Option:

Function:

Enter here the maximum speed of the virtual master in Hz.
Virtual master maximum speed =

$$\frac{Increments}{Rev.}\ x\ \frac{Rev.}{s}$$

Example: The maximum virtual master signal must correspond to an incremental encoder with 1024 inc/rotation at a rotational speed of 50 rotations/s.
Virtual master maximum speed =

$$\frac{1024}{1}\ x\ \frac{50}{s} = 51200\ 1 \Big/ s$$

19-19 Control source test run (Contr. testrun)

Option:

Function:

This parameter is used to select the control source in test run mode (par. 33-80 = "1"). There can only be one control source at a time: Digital inputs or field bus control word. Only exception is input 27 which is always stop also with field-bus control.

When digital control is selected status signals are updated on the digital outputs, when field bus control is selected status signals are updated on digital outputs as well as field bus.

[0]	Digital Inputs	"0" means that all control commands are activated via the digital inputs according to the description of the terminals.
[1]	Fieldbus	"1" means that all control commands are activated via the field bus control word according to the description of field bus control.

NB!
The new control source selected in this parameter is not active before next power up (power cycle).

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19-20 Control source synchronising (Contr. synchron)		
Option:		Function:
		This parameter is used to select the control source in synchronising mode (par. 33-80 = "2"). There can only be one control source at a time: Digital inputs or field bus control word. Only exception is input 27 which is always stop also with field-bus control. When digital control is selected status signals are updated on the digital outputs, when field bus control is selected status signals are updated on digital outputs as well as field bus.
[0]	Digital Inputs	means that all control commands are activated via the digital inputs according to the description of the terminals.
[1]	Fieldbus	means that all control commands are activated via the field bus control word according to the description of field bus control.

NB!
The new control source selected in this parameter is not active before next power up (power cycle).

19-21 Brake on delay (Brake on delay)		
Range:		Function:
		This parameter is used to specify the delay time between closing the mechanical brake (output 4) and disabling motor control (motor coast). This is necessary to avoid loosing the load because of the reaction time of the mechanical brake.
	[0...5000 msec.]	The value must be set according to the reaction time of the mechanical brake.

19-22 Brake off delay (Brake off delay)		
Range:		Function:
		This parameter is used to specify the delay time between activating motor control and opening the mechanical brake (output 4). This is necessary to avoid loosing the load because of the reaction time of the mechanical brake.
	[0...5000 msec.]	The value must be set according to the reaction time of the mechanical brake.

19-23 Marker monitor		
Option:		Function:
		This parameter specifies the behaviour when markers are missing in Marker synchronising mode (par. 1901 = 2 or 5)
[0]	Output 2	Fault is set when "not accuracy" for x number of markers (x = par. 33-24).
[1]	Output 2	Fault is set when "not accuracy" for x number of markers (x = par. 33-24) OR when x number of markers are missing.

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[2]	Output 2	Fault is set when "not accuracy" for x number of markers (x = par. 33-24) and Output 2, fault is set and the error handler is called when x number of markers are missing.

NB!
This function can only be used if marker windows are used (par. 33-22 and 33-21).

19-24 Resync.

Option: Function:

With resync active synchronisation will remain active while the slave is stopped (Input 1 and/or Input 27 = 0). The actual synchronising error will be corrected with the set velocity and acceleration when restarting synchronisation.

[0] Inactive
[1] Active

19-25 Select Analogue output 42

Option: Function:

[0] Slave speed
[1] Master speed

19-92 Software version number

Option: Function:

The software version of the synchronising controller is displayed here.

19-93 Test run; Program 1

Option: Function:

Track error": The track error is displayed in quad counts.

Synchronous operation; Program 2: "Sync-error": The synchronisation error is displayed with the value calculated in par. 19-15.

19-94 Slave speed (read only)

Option: Function:

The slave speed is displayed with the value calculated in par. 19-13.

19-95 Master speed (read only)

Option: Function:

The master speed is displayed with the value calculated in par. 19-14.

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19-96 Track error (read only)		
Option:		Function:
		"Track-error": The synchronisation error is displayed with the value calculated in par. 19-15.

32-00 Incremental Signal Type (Slave)		
Option:		Function:
[0]	None	Choose if an absolute encoder is used
[1]	RS422 (TTL/Line driver)	
[2]	Sinusoidal 1 Vpp	Choose if 1 V peak to peak analog incremental encoder is used.

32-01 Incremental Resolution (Slave)	
Option:	Function:
	Enter the pulses per revolution

32-02 Absolute Protocol (Slave)		
Option:		Function:
[0]	None	choose if an incremental encoder is used.
[1]	SSI.	
[2]	SSI with filter	choose if the encoder signal is unstable.

32-03 Absolute Resolution (Slave)	
Option:	Function:
	Enter the positions per revolution.

32-05 Absolute Encoder Data Length (Slave)	
Option:	Function:
	Enter the number of data bits of the connected absolute encoder.

32-06 Absolute Encoder Clock Frequency (Slave)	
Option:	Function:
	Enter the clock frequency according to the encoder manufacturer specifications.

32-07 Absolute Encoder Clock Generation (Slave)		
Option:		Function:
	Off	Clock signal is not generated.
	On	Clock signal is generated, this is most commonly used.

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32-08 Absolute Encoder Cable Length (Slave)	
Option:	Function:
	Enter the cable length of the encoder, please note that 300 meters is the maximum.

32-09 Encoder Monitoring (Slave)	
Option:	Function:
Off	No monitoring of encoder hardware.
On	Monitoring of encoder hardware, open- or short-curcuit will generate error 192.

32-10 Direction of rotation	
Option:	Function:
[1]	standard, position is counting positive when the drive is running forward.
[3]	position is counting negative when the drive is running forward.
[2]	as "1", but with opposite sign of the reference to the drive. This can be used as alternative to swapping two motor phases if direction of motor rotation is wrong.
[4]	as "3", but with opposite sign of the reference to the drive. This can be used as alternative to swapping two motor phases if direction of motor rotation is wrong.

32-30 Incremental Signal Type (Master)		
Option:		Function:
[0]	None	choose if an absolute encoder is used
[1]	RS422 (TTL/Line driver).	
[2]	Sinusoidal 1 Vpp	choose if 1 V peak to peak analog incremental encoder is used.

32-31 Incremental Resolution (Master)	
Option:	Function:
	Enter the pulses per revolution.

32-32 Absolute Protocol (Master)		
Option:		Function:
[0]	None	choose if an incremental encoder is used.
[1]	SSI.	
[2]	SSI with filter	choose if the encoder signal is unstable.

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32-33 Absolute Resolution (Master)

Option:	Function:
	Enter the positions per revolution.

32-35 Absolute Encoder Data Length (Master)

Option:	Function:
	Enter the number of data bits of the connected absolute encoder.

32-36 Absolute Encoder Clock Frequency (Master)

Option:	Function:
	Enter the clock frequency according to the encoder manufacturer specifications.

32-37 Absolute Encoder Clock Generation (Master)

Option:	Function:
Off	Clock signal is not generated.
On	Clock signal is generated, this is most commonly used.

32-38 Absolute Encoder Cable Length (Master)

Option:	Function:
	Enter the cable length of the encoder, please note that 300 meters is the maximum.

32-39 Encoder Monitoring (Master)

Option:	Function:
Off	No monitoring of encoder hardware.
On	Monitoring of encoder harware, open- or short-curcuit will generate O.ERR_192.

32-40 Encoder Termination (Master)

Option:	Function:
	If only one encoder is connected then select "ON", for all other configurations select "OFF"

32-60 P-portion of the synchronising controller

Option:	Function:
	Setting: see Examples.

32-61 D-portion of the synchronising controller

Option:	Function:
	Setting: see Examples.

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32-62 I-portion of the synchronising controller

Option:

Function:

Setting: see Examples.

32-63 Limitation for I-portion

Option:

Function:

Setting: see Examples.

32-64 Band width for PID controller

Option:

Function:

32-65 Velocity feed forward

Option:

Function:

Setting: see Examples.

32-66 Acceleration feed forward

Option:

Function:

Setting: see Examples.

32-67 Maximum track error

Option:

Function:

Enter here the maximum track error. This is the permitted error between the calculated position and the feedback position. If the value is exceeded, the drive stops and displays the error message: O.ERR_108 "Position error". The value should be set higher than the permitted tolerance range ACCURACY in par. 33-13. Input in quad counts.

32-68 Reversing behaviour

Option:	Function:
[0]	means that the slave drive may always reverse, e.g. after over-shooting the target position.
[1]	the slave drive may only reverse when the master is reversing.
[2]	the slave drive may never reverse.

32-69 PID-sample time

Option:

Function:

The parameter is setting the sample time of the control algorithm. The value should be increased if:

- The pulse frequency is very low, e.g. 1 to 2 quad counts per sample time (you need at least 10 to 20 quad counts per sample time).

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- The system is very slow and heavy (high inertia). Controlling systems with 1 ms can make big motors vibrate.

The correct value can be calculated automatically, see test run par. 19-05.



NB!
The parameter setting has direct influence on the PID loop; if for example the Sample time is doubled, the P-portion (par. 32-60) also has the double effect.

32-80 Maximum speed

Option:

Function:

Enter here the maximum speed of the slave drive, measured at the slave encoder in revolutions per minute.

32-81 Minimum ramp

Option:

Function:

Enter here the minimum possible ramp in which the slave drive can accelerate from 0 to the speed specified in par. 3280. This is input in milliseconds.

33-00 Home_Force

Option:

Function:

If this param is set to 1, a home has to be carried out before sync can start

33-02 Home acceleration

Option:

Function:

Specify here the acceleration for the homing as a percentage of the maximum acceleration. 100% means that the drive accelerates with the minimum ramp specified in par. 32-81. 50% means that the drive only proceeds with half the acceleration, i.e. the acceleration takes twice as long as the minimum ramp specified in par. 32-81.

33-03 Velocity of Home Motion

Option:

Function:

In % of the Maximum Velocity 3280

33-04 Synchronous operation; Program 2

Option:

Function:

[0]

The homing only has to be carried out after power up

3

[1-3]	The homing has to be carried out before every sync start.

33-13 Synchronous operation; Program 2

Option:

Function:

Accuracy: This parameter specifies that maximum master – slave position deviance, this is used to control the accuracy output (O 3). The accuracy output will only be "1" if the actual master – slave position deviance is within this value. In velocity synchronisation (par. 19-01 = 0, 3, 6 or 7) the value must be set in RPM (Rounds Per Minute) in all other modes it must be set in quad counts. With a negative value in this parameter the synchronising error (par. 19-93) is shown with a sign otherwise the synchronising error is unsigned.

33-14 Synchronous operation; Program 2

Option:

Function:

M-S tolerance speed: Specify here the tolerated speed deviation between master and slave while synchronising. The following apply here:

Slave must catch up: The slave can travel at the maximum permitted speed or at the speed: master speed + master speed * M-S tolerance speed / 100, whichever of the two is lowest.

Slave must slow down: The slave travels at the minimum speed: master speed - master speed * M-S tolerance speed / 100. If the M-S tolerance speed value is set to 50, the slave will not travel more slowly than half the master speed.

33-17 Marker interval at the master

Option:

Function:

Enter here the interval between two markers at the master drive in quad counts. If this value is not known, it can be determined during the test run. For procedure, see as described in the section "Testing the incremental encoders" in the Loading belt, Marker synchronisation, application example.



NB!
This parameter is only used in marker synchronising mode (par. 19-01 = 2 or 5).

33-18 Marker interval at the slave

Option:

Function:

Enter here the interval between two markers at the slave drive in quad counts. If this value is not known, it can be determined during the test run. For procedure, see description in the section "Testing the incremental encoders" in the packaging application example.

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NB!
This parameter is only used in marker synchronising mode (par. 19-01 = 2 or 5).

33-19 Master marker type

Option:		Function:
[0]	rising edge of the zero track	Select here the type of marker signal for the master drive
[1]	falling edge of the zero track	
[2]	rising edge at I5	
[1]	falling edge of the zero track	
[3]	falling edge at I5	



NB!
This parameter is only used in marker synchronising mode (par. 19-01 = 2 or 5).

33-20 Slave marker type

Option:		Function:
[0]	rising edge of the zero track	Select here the type of marker signal for the slave drive
[1]	falling edge of the zero track	
[2]	rising edge at I6	
[1]	falling edge of the zero track	
[3]	falling edge at I6	



NB!
This parameter is only used in marker synchronising mode (par. 19-01 = 2 or 5).

33-21 Marker window master

Option:

Function:

Enter how large the permitted tolerance for the occurrence of the marker is. The factory setting "0" means all markers are used. At every other setting only those markers are accepted which are within the window. Example: Marker interval = 30000 and marker window = 1000. Only markers with an interval of 29000 to 31000 is accepted.



NB!
This parameter is only used in marker synchronising mode (par. 19-01 = 2 or 5).

3

33-22 Marker window slave

Option: Function:

Enter how large the permitted tolerance for the occurrence of the marker is. The factory setting "0" means all markers are used. At every other setting only those markers are accepted which are within the window. Example: Marker interval = 30000 and marker window = 1000. Only markers with an interval of 29000 to 31000 is accepted.



NB!
This parameter is only used in marker synchronising mode (par. 1901 = 2 or 5).

33-23 Marker synchronous operation

Option:	Function:
[0]	last marker pulse, i.e. the slave synchronises to the last detected marker pulse. This is achieved by accelerating to this position.
[1]	next marker pulse: The slave waits for the next marker pulse and synchronises to it.
[2]	once the master speed is reached marker correction to next following markers take place(may catch up slow down).
[3]	same as "0" but after master speed is reached.
[4]	same as "1" but after master speed is reached.
[5]	once the master speed is reached marker correction to closest marker take place.

If 1000 is added to the previous choices the fixed offset is not executed before the marker correction has taken place.



NB!
This parameter is only used in marker synchronising mode (par. 19-01 = 2 or 5).

33-24 Marker quantity FAULT

Option: Function:

Enter when a FAULT signal (O2) must be set. Input the number of marker pulses, i.e. a setting of 10 means that ACCURACY must be low for 10 marker pulses before the FAULT signal is set.

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In position synchronisation (par. 19-01 = 1 or 4) only the slave marker is used; in marker synchronisation (par. 19-01 = 2 or 5) both slave and master marker must be detected before counting.

33-25 Marker quantity READY

Option:

Function:

Enter when a READY signal (O1) must be set. Enter the number of marker pulses, i.e. a setting of 10 means that ACCURACY must be present for 10 marker pulses before the READY signal is set.

In position synchronisation (par. 19-01 = 1 or 4) only the slave marker is used; in marker synchronisation (par. 19-01 = 2 or 5) both slave and master marker must be detected before counting.

33-26 Velocity filter

Option:

Function:

In speed synchronisation it is recommended to set a filter time based on resolution. This is to avoid speed fluctuation at low speed or when using low resolution of encoders. Please see following table:

Encoder Resolution	Filter Time Value
250	39500
500	19500
1000	9500
2000	4500
2500	3500
4096	1900
5000	1400

For all other types of synchronisation: Changing the sign of the filter value enables the use of filtering the other types of synchronisation. This means that unstable position or marker synchronisation can be smoothened.

33-80 Selection of the Operation Mode

Option:

Function:

[1] Test run
[2] synchronisation

34-40 Input status (read only)

Option:

Function:

This parameter is showing the actual status of the 10 digital inputs (I1 - I10) on X 57 as a binary code.

Input 3, 7 and 8 high
Par 3440 = 11000100
Input 1 and 3 high
Par 3440 = 101

Table 3.1: Example:

3

34-50 Slave position (read only)

Option:

Function:

The slave position is displayed in quad counts.

34-52 Master position (read only)

Option:

Function:

The master position is displayed in quad counts.

34-56 Track error (read only)

Option:

Function:

This parameter indicates the actual PID error during synchronisation

34-60 Status of synchronisation

Option:

Function:

The following status flags are defined for position and marker synchronisation. The flags are not updated when using speed synchronisation:

Flag:	Decimal value	Bit
SYNCREADY	1	0
SYNCFAULT	2	1
SYNCACCURACY	4	2
Only marker synchronisation:		
Master marker HIT	8	3
Slave marker HIT	16	4
Master marker Error	32	5
Slave marker Error	64	6

The flags are reset when restarting synchronisation (SyncStart).

SYNCACCURACY
Each millisecond it is checked if the actual position deviance between master and slave is smaller than par. 33-13(accuracy), if this is true the SYNCACCURACY flag is set (1), otherwise the flag is reset. (0).

SYNCFAULT / SYNCREADY
For every marker pulse it is checked whether the SYNCACCURACY flag is present or not. If it is not present the fault counter

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is increased and the ready counter set to 0, if it is present the ready counter is increased and the fault counter set to 0.

If the ready counter is higher than the value set in par. 33-25 (marker quantity ready) then the flag SYNCREADY is set, if not the flag is reset.

If the fault counter is higher than the value in par. 33-24 (marker quantity fault) the flag SYNCFAULT is set (1), if not the flag is reset (0).

Marker HIT flags:
The marker HIT flags are set (1) after detecting n marker pulses (n = par. 19-08 and 19-09).

Marker error flags:
It is checked at each n marker pulse (n = par. 19-08 or 19-09) whether the distance between the actual marker position and the last registered marker position is lower than 1.8 times the value of par. 33-18 or 33-17. If this is not true, then the associated flag is set. (1). When using marker windows (par. 33-22 and 33-21) it is checked whether a marker is detected within the window. If no marker is detected the error flag is set (1).

4

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4. Synchronisation

4.1. Speed Synchronisation

4.1.1. SyncStart

When closing the SyncStart contact (Terminal I1), the slave drive accelerates with minimum ramp time to the speed of the master drive, taking the gear ratio into account. When I1 is opened, the slave drive ramp or coast to stop. Stop behaviour is selected in par. 19-01.

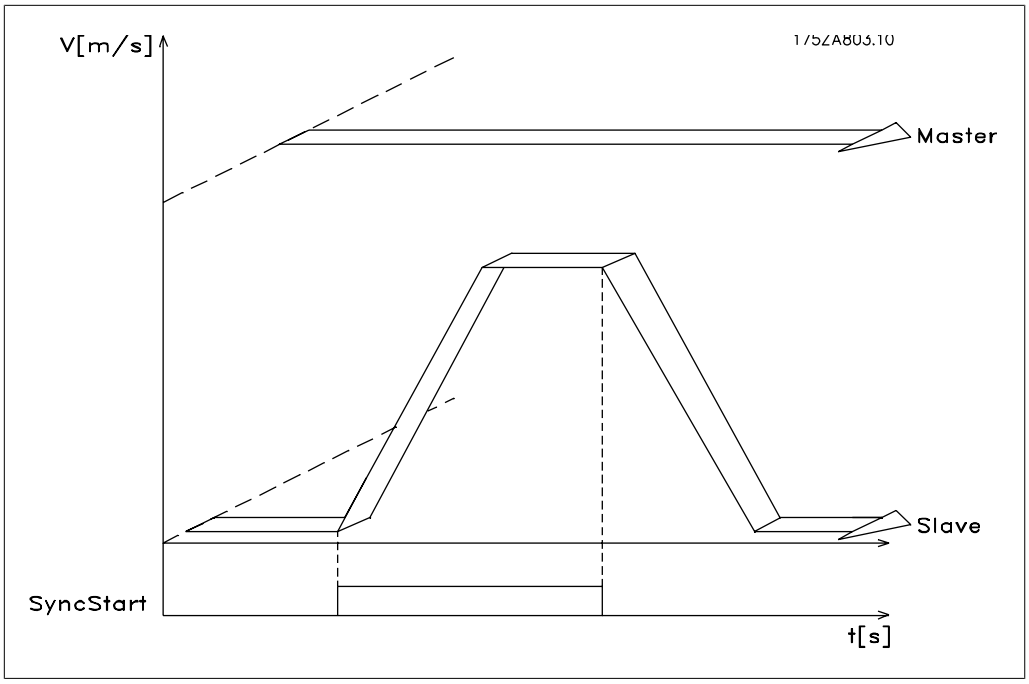


Illustration 4.1: Figure 10: SyncStart with speed synchronisation

4.2. Function Diagrams for Speed Synchronisation

4.2.1. SyncStart

When closing the SyncStart contact (Terminal I1), the slave drive accelerates with minimum ramp time to the speed of the master drive, taking the gear ratio into account. When I1 is opened, the slave drive ramp or coast to stop. Stop behaviour is selected in par. 19-01.

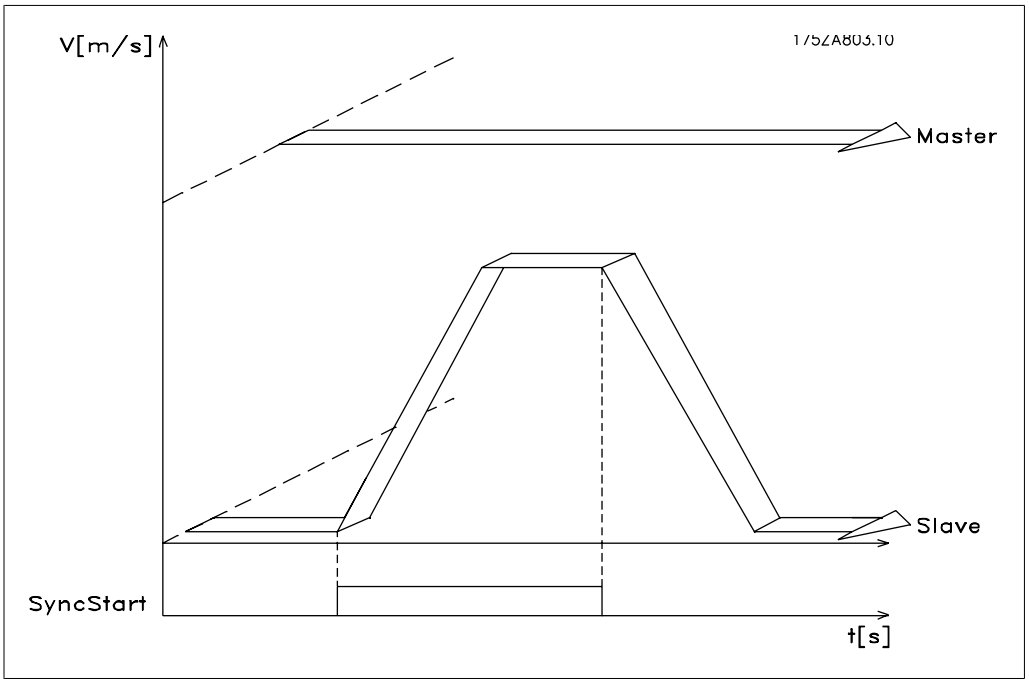


Illustration 4.2: Figure 10: SyncStart with speed synchronisation

4.2.2. Up/ Down Factor

After the slave has been synchronised to the speed of the master by means of SyncStart (Terminal I1), the gear ratio can be changed during operation. By means of Inputs 33 Speed+ / Up-factor, or 32 Speed- / Down-factor, the gear ratio can be changed by the value set in par. 19-12 *step width* . This change affects only the slave factor. For more sensitive adjustment of the gear ratio, the gear ratio digits should be extended and a small step width should be selected. If one of the two inputs is on longer than the time defined in par. 19-11*step time*, a further step will be executed. Example: Gear ratio i = 22:43 If the step width is equal to 1, the first upward step will result in i = 22:44, which represents almost 3 %. It would be better to set the ratio as i = 2200:4300. Then the upward step will result in i = 2200:4301, which represents a change of approx. 0.03 %.

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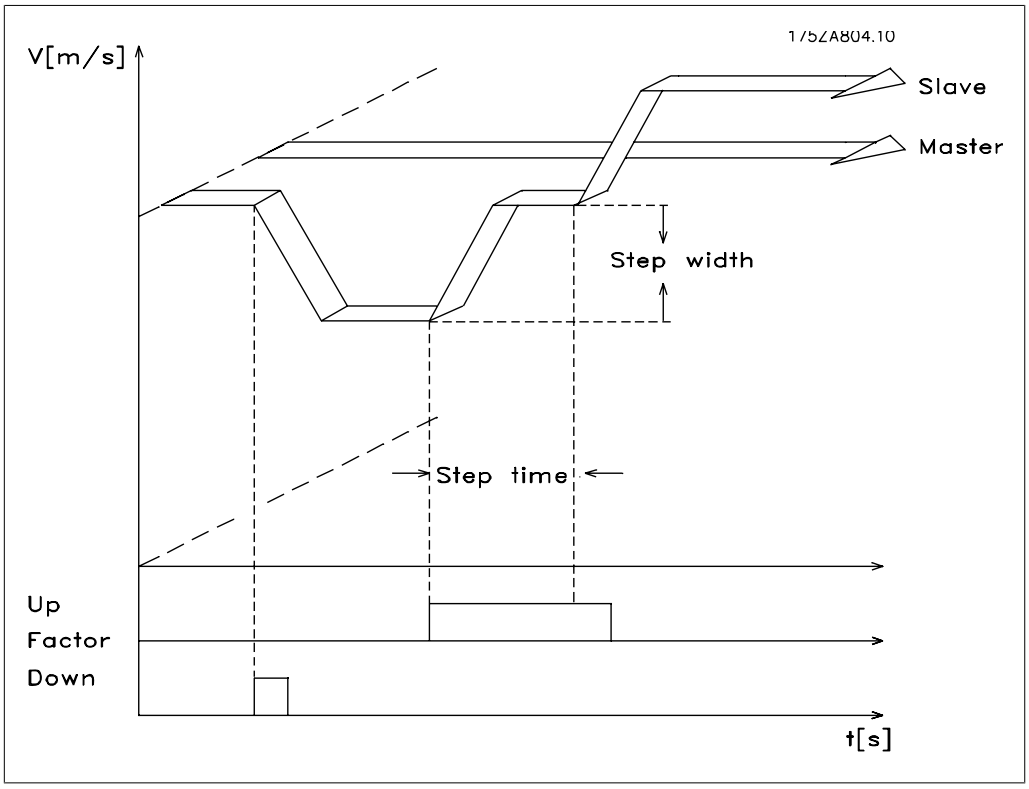


Illustration 4.3: Up/down factor with speed synchronisation

4.2.3. Hold Function

The Hold function operates the slave drive in closed loop speed control at a speed independent of the master. With par. 19-02 *Hold function* you can choose whether the slave is to run at a fixed speed set in par. 19-03 or whether it is to maintain current speed. For the duration of the Hold signal, the speed of the master is no longer taken into account; the master can even stop without this having any effect on the slave drive. While the Hold function is activated you can change the speed with inputs 32 and 33. The speed is changing according to the settings in par. 19-04 *Delta hold speed* and par. 19-12 *Step width*.

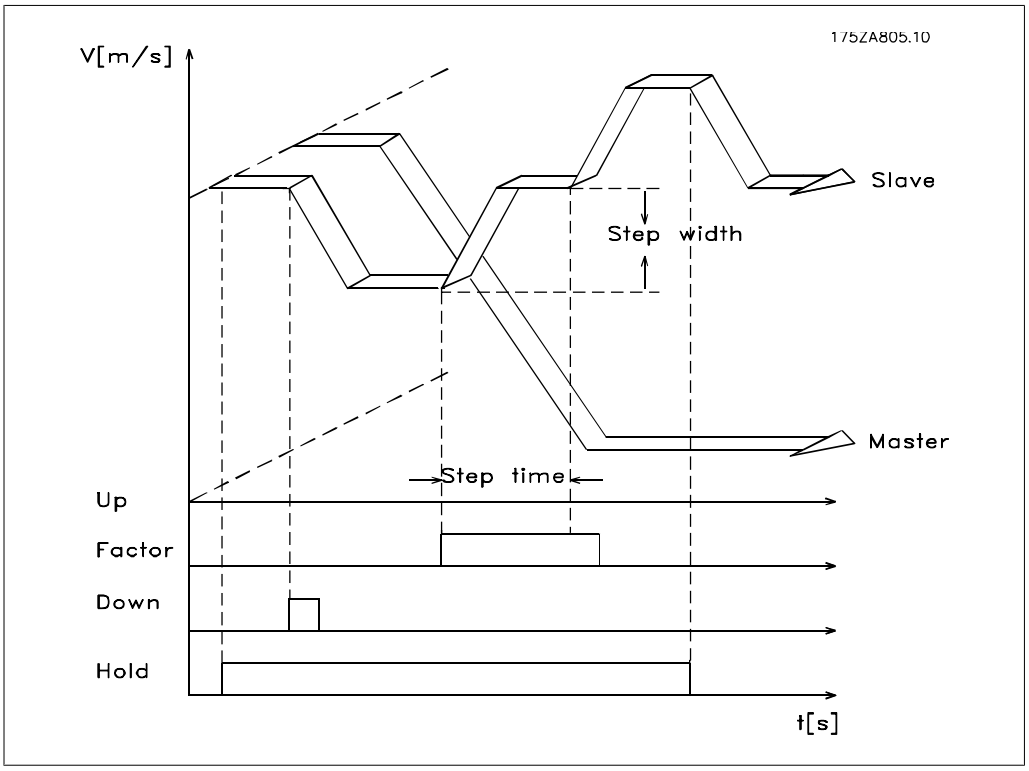


Illustration 4.4: Hold speed

4.2.4. Gear Changing

During synchronous operation, it is possible to switch between 4 fixed gear ratios, set in par. 19-05 to 19-07. The fixed gear ratios are selected at terminals 9 and 10:

Input 9	Input 10	Gear Ratio no.
0	0	0
0	1	1
1	0	2
1	1	3

To activate the new ratio you must activate input I2. The newly set gear ratio is attained with the minimum possible ramp.

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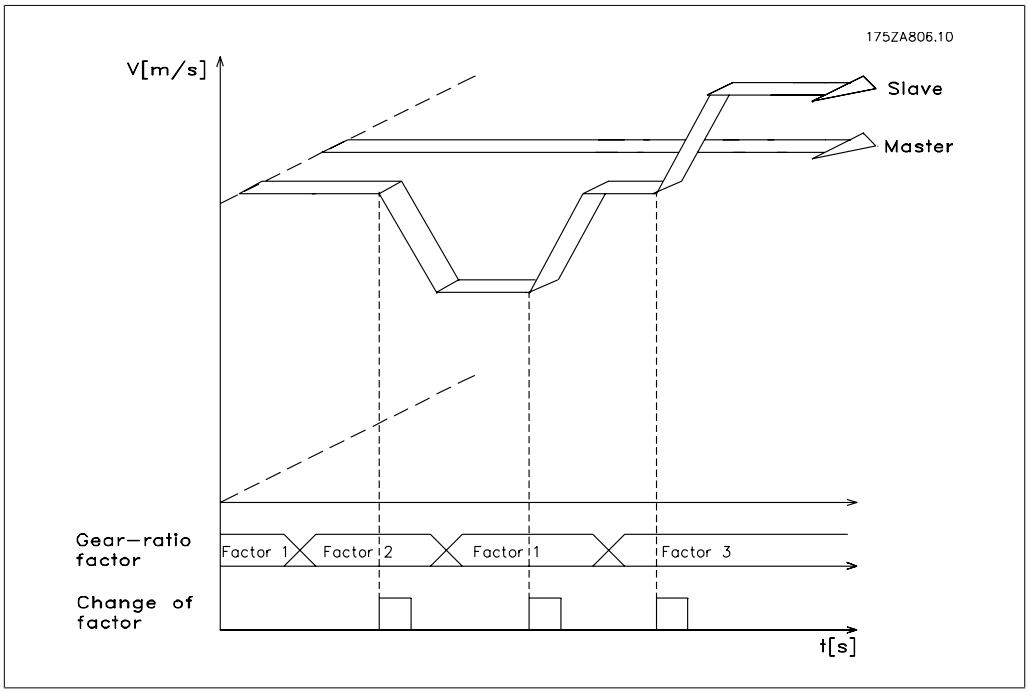


Illustration 4.5: Changing the gear ratio in speed synchronisation

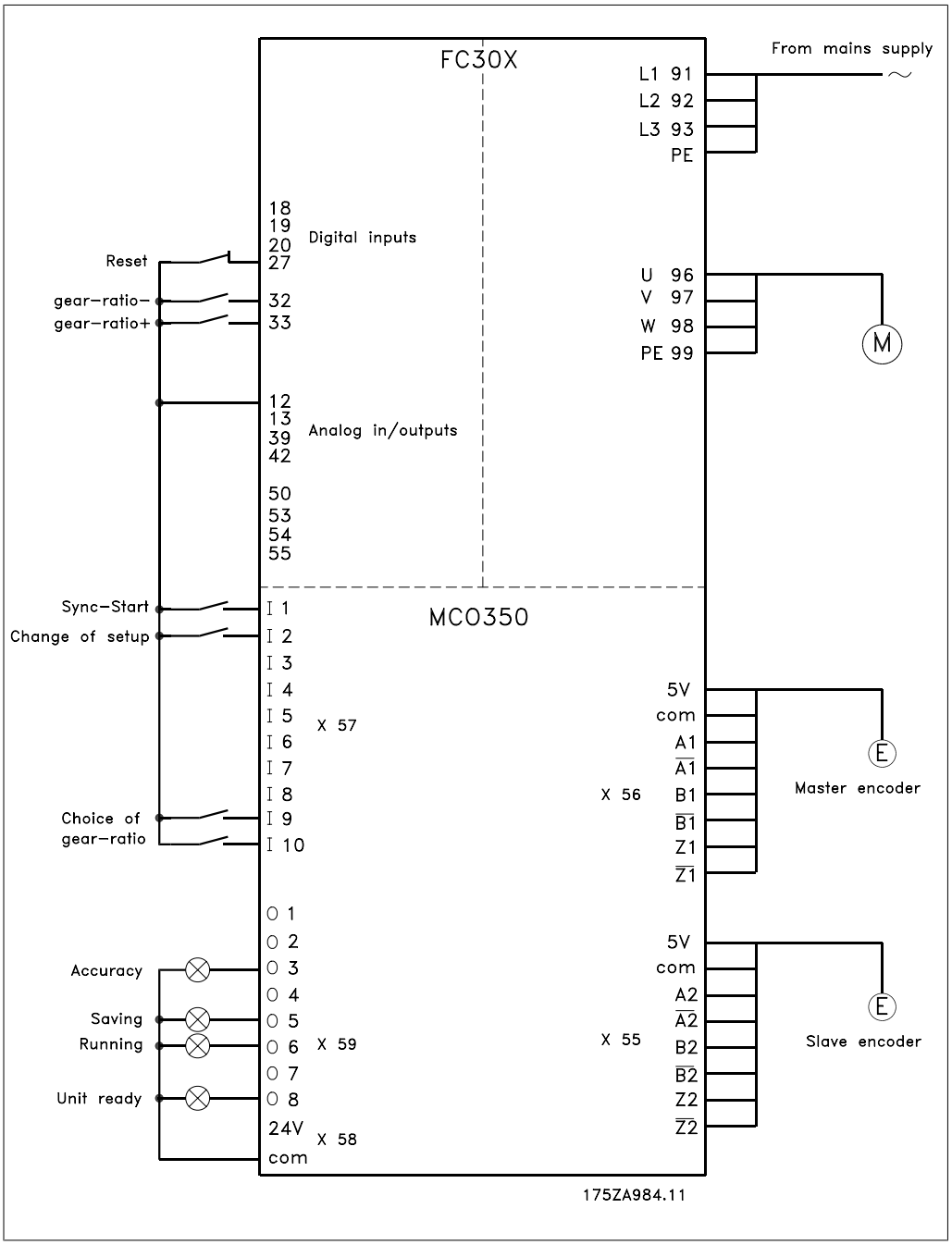
4.2.5. Changing the Gear Ratio with an Analogue Value

As an alternative the gear ratio can be set via analogue input 54 with a +/- 10V signal, this function is active when synchronising type 6 or 7 is selected in parameter 1901. The gear ratio denominator is taken from the setting in gear 0. The gear ratio numerator is set by input 54, 5V corresponds to 500. If you e.g. have set up 500 for masterfactor in gear 0, this would give a gear ratio of 1:1.

4.3. Application Examples - Admixture

A feed screw conveyor pump leads substance 1 to a nozzle adding substance 2. For different end products it must be possible to select different mixing ratios (ratio 1 = 1:1; ratio 2 = 1:1.12; ratio 3 = 1:1.2; ratio 4 = 1:1.21). During operation it must be possible manually to make slight adjustments of the selected mixing ratio.

Description of terminals and terminal configuration



4.3.1. Setting the Parameters

For this work it is recommended to have the description of parameters at hand. See the *VLT AutomationDrive Programming Guide.*

NB!
It is very important that the frequency converter is optimised for the motor before optimising the synchronising controller:

1. Record the motor data and perform an AMA (Automatic Motor Adaptation) if possible.
2. Start programming the synchronisation functions.

Parameter No. 303
Maximum reference: Set the frequency for a value that is about 10% higher than the maximum value of par. 32-80.
Example:

Motor 7.5 *kW*, 1460 1/*min at* 50 *Hz*, 62 *Hz maximum ref. value speed of the application approx.* 1800 1/*min*

$$\frac{f_{Nom} \; x \; N_{Application}}{N_{Nom}} x1.1 \; = \; \frac{50 \; Hz \; x \; 1800\frac{1}{min}}{1460\frac{1}{min}} =$$

Parameter No. 416
Torque limit for motor mode: Set for maximum. – Choose a lower value, if special safety precautions are necessary.

Parameter No. 417
Torque limit for regenerative operation: Set for maximum. – Choose a lower value, if special safety precautions are necessary.

Parameter No. 33-80
Record "1" to start the test program.

Parameter No. 33-26
This parameter configures the velocity filter for speed synchronisation. Since speed synchronisation is based on speed a small fluctuation in master speed, when running at low speed, can have an effect on the pid loop control. Hence this filter will even out the effect.

Cmdvel = Old_Cmdvel + (Actvel – Old_Cmdvel) * ms/tau_filt

Cmdvel = set velocity

Old_Cmdvel = last set velocity

Actvel = actual velocity of master

ms = sample time (parameter 32-69)

tau_filt = filter time constant

For standard encoders the following table can be used:

Encoder Resolution	Tau_filt (ms)
250	39500
256	38600
500	19500
512	19000
1000	9500
1024	9300
2000	4500
2048	4400
2500	3500
4096	1900
5000	1400

Parameter No. 32-00/ 32-02
Record the type of slave encoder. Factory default is incremental encoder.

Parameter No. 32-01/ 32-03
Record the resolution of the slave encoder.

Parameter No. 32-30/ 32-32
Record the type of master encoder. Factory default is incremental encoder.

Parameter No. 32-31/ 32-33
Record the resolution of the master encoder.

Parameter No. 32-10
Record "No action" for clockwise rotation of both master and slave. Record "User units reversed" if the slave is to run in the opposite direction.

Parameter No. 32-80
Record maximum RPM measured at the slave encoder.

Parameter No. 32-81
Minimum ramp: Set the time in Ms for the slave drive to accelerate from standstill to maximum speed (par 3280). This value is important as this setting highly affects the control accuracy!

Parameter No. 32-82
Ramp type: Record "0" for linear ramp and "1" for s-ramp. NOTE: S-ramp requires higher acceleration torque.

Parameter No. 32-68
Reversing behaviour: Record "0" if reversing is allowed, "1" if the slave must always follow the direction of the master or "2" if reversion is not allowed.

4.3.2. How to Check the Motor Connection

When the above parameters have been programmed, check the motor connection as follows:

1. Remove all signals to terminals 18-33 and I1-I10.
2. Press [Hand On] button on the LCP
3. Set the reference to a low value with the arrow keys (25 to 50 rpm). Please note that the motor may now turn!
4. Press the [Off] button on the LCP to stop again. If the motor rotates in the wrong direction then exchange the motor phases.

4.3.3. How to Test the Incremental Encoders

When you have tested the motor speed direction you test the incremental encoder connection as follows: 1. 2. 3.

1. Remove all signals to terminals 18-33 and I1-I10.
2. Select parameter 34-50. The current actual position is then displayed.
3. Rotate the slave drive motor shaft manually in the forward direction. Now the display shows an ascending count of the slave position. If the count is descending, exchange the slave encoder track A by B and A/ by B/. If there is no counting in the display then check the wiring of the encoder.

Follow the same procedure when testing the master encoder but use par. 34-52 for read-out of the master position. Remember to push [Auto On] to return to normal control.

4.3.4. How to Optimise the Controller

synchronisation is obtained via two main elements of the controller: Velocity feed forward and the PID controller.

> NB!
> Before starting the optimising procedures it is important to select the right type of synchronisation in parameter 1904, in this example it must be "0" for velocity synchronisation. Please always have the necessary degree of accuracy in mind, you could go on optimising for a long time, but it might not be necessary to have a 100% accuracy in the application you are dealing with.

First step is to optimise velocity feed forward this can be done via the automatic calculation function:
Velocity feed forward calculation is activated by setting parameter 19-05 to "1", remember to make the required parameter settings according to the description of par. 19-05 before starting the calculation. The calculation is done when the value of par. 19-05 returns to "0".

Velocity feed forward can also be optimised manually by the following procedure:

1. Set par. 32-64 PID bandwidth to "0".
2. Set par. 32-67 maximum track error to a high value (e.g. 1,000,000).
3. Set par. 32-65 velocity feed forward to 100.
4. Start test-run with virtual master with a known velocity via input 3 = 1.
5. Increase parameter 3265 while watching master and slave velocity (press [Status] to get the velocity readouts). You have found the optimal velocity feed forward when slave velocity is approximately equal to the master velocity.
6. Stop test-run by input 3 = 0.
7. Reset parameter 3267 to the original value.
8. Reset parameter 3264 to 1000.

Second step is to optimise the PID controller, a good starting point can be found be means of the automatic calculation function:
By setting par. 19-05 to "2" velocity feed forward calculation is activated as well as calculation of PID sample time and P/D factors, remember to make the required parameter settings according to the description of par. 19-05 before starting the calculation. The calculation is done when the value of par. 19-05 returns to "0".

Using the test run functions can optimise the PID factors further:
There is two types of test run available: Positioning where the slave drive moves a specific distance and synchronising with virtual master where the slave follows the virtual master in position or speed. Generally it is better to use test run with virtual master as that comes closer to the operating conditions in synchronising mode (program 2).

For test run with positioning the following parameters must be set:

Parameter No. 19-01
Test run speed: Record the speed as a percentage of the maximum speed of parameter 3280.

Parameter No. 19-02
Test run acceleration: record the acceleration time in per cent. 100% is minimum acceleration. 50% is half as fast as minimum acceleration, the ramp time will thus be twice as long.

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Parameter No. 19-03
Test run distance: Record the distance (quad counts) for the drive to run during optimisation.

Then use the following procedure:

1. Close the contacts at terminal 32 (clockwise/forward direction) or terminal 33 (counter-clockwise/reverse). During the test the last value of the first display line will indicate the track error (PID error). After the test run is completed you can see the maximum track error (PID error) in the display.
2. Increase the P-portion (par. 3260). After each change you should make a test run to find the right setting. If the drive becomes unsteady or if a message is given about over-voltage or over-current, then reduce the value in parameter 3260 to about 70-80% of the set value.
3. Now set the D-portion (parameter 3261) to 5 times the value of parameter 3260.
4. If a lower synchronising error is required the I-portion (parameter 3262) can be set to a low value e.g. 10 but be careful a too high value will course overshoot and instability.

For test run with virtual master the following parameters must be set:

Parameter No. 19-16
Virtual master reference: Select the reference source for setting the velocity of the virtual master. "0" is analogue input 53, "1" is parameter 310 sub-index 0 and "2" is Fieldbus PCD 2.

Parameter No. 19-17
Virtual master acceleration: Set the acceleration of the virtual master in encoder pulses per second^2.

Parameter No. 19-18
Virtual master maximum speed: Set the maximum velocity of the virtual master in encoder pulses per second.

Then use the following procedure:

1. Disconnect the master encoder from the synchronising controller (X56). Start test run with virtual master by activating input 3. During test run you can read the track error in the last value of the first display line. At stop the maximum track error during the test run is read out. Because velocity synchronisation is selected (parameter 1904 = 0) the track error is velocity deviance between master and slave.
2. If more accurate and dynamic control is required the P-portion (parameter 3260) must be increased. If the slave becomes unstable the value must be reduced to by approximately 25%.
3. Now set the D-portion (parameter 3261) to 5 times the value of parameter 3260
4. If a lower synchronising error is required the I-portion (parameter 3262) can be set to a low value e.g. 10 but be careful a too high value will course overshoot and instability.

The optimised values are automatically saved.

4.3.5. How to Programme Synchronisation

Change the value of parameter 33-80 to "2". This will start the synchronisation application program. To do the synchronisation programming use the following parameters:

Parameter No. 19-01
Type of operation: Record "0" or "3" for speed synchronisation.

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Parameter No. 19-02
Hold function: Specify how the drive is to react when Input 29 is activated . "Hold" switches the drive from master synchronisation to a fixed frequency. Choose "0" to use the frequency set in par. 1903 and "1" to use the current frequency.

Parameter No. 19-03
Hold speed: Set here, as a percentage of the maximum speed, the speed at which the drive should move when you activate Hold and the value "0" was selected in Parameter 1902.

Parameter No. 19-04
Delta hold speed: Set here the step width by which the hold speed is to be changed upwards or downwards by activating Terminals 32 + 33.

Parameter No. 19-05
Gear ratio No.: Record the number of the gear ratio that is to be displayed in Parameters 1906 to 1907. Then you set the values required in Parameters 1906 to 1908. Follow the same procedure for the next gear ratio(s).

Parameter No. 19-06
Gear ratio numerator: Record the numerator value of the gear ratio. That is the encoder pulses of the slave drive. To make fine adjustment possible by means of inputs 32 and 33 a ratio of for example 7:16 must be programmed as 7000:16000.

Parameter No. 19-07
Gear ratio denominator: Enter here the denominator value of the gear ratio. This value corresponds to the master pulses.

Parameter No. 19-11
Step time: In Hold mode, the next frequency change and, in synchronisation mode, the next change of the counter factor of the gear ratio, is carried out after this time, on the presence of one of the signals at terminal 32 or 33. The time input is in milliseconds.

Parameter No. 19-12
Step width: In speed synchronisation, the gear ratio numerator is changed by this amount, if one of the terminals 32 or 33 is closed.

Parameter No. 19-13
Slave speed factor: Record the factor by which the slave speed must be multiplied, so that it can be displayed. Use the following formula:

$$Factor = \frac{N_{set} \ x \ 400 \ x \ Slaveencoder_resolution}{60 \ x \ Display_value}$$

Example:

Resolution 1024 *increments*, *desired display* 100 *at* 1500 1

$$Factor = \frac{1500\frac{1}{min} \ x \ 400 \ x \ 1024 \ \frac{Incr.}{Rev.}}{60 \ x \ 100} = 102400$$

Parameter No. 19-14
Master speed factor: Record the factor by which the master speed must be multiplied, so that it can be displayed. Use the following formula:

$$Factor = \frac{N_{set} \ x \ 400 \ x \ Masterencoder_resolution}{60 \ x \ Display_value}$$

Parameter No. 19-15
Synchronising error display factor: This factor must be 100, the synchronising error is then displayed in RPM related to the slave.
The settings are automatically saved.

4.4.1. Starting Synchronisation

Synchronisation with the master is achieved by closing the SyncStart contact (I1); the drive accelerates the maximum permitted acceleration to the speed of the master (calculated by means of the gear ratio).

4.4.2. Stopping Synchronisation

When the SyncStart contact (I1) is opened, the slave is stopped at the permitted acceleration.

4.4.3. Fine Setting of the Gear Ratio

Fine setting of the gear ratio can now be undertaken by means of Inputs 32 + 33. This setting is only temporary, i.e. the fine setting data will be lost as soon as the VLT is disconnected from the mains. If the setting is to be saved, a Store operation must be carried out by closing the Store contact (I4) or by means of Parameters 1900 before the VLT is switched off.

4.4.4. Switching to Another Gear Ratio

During synchronisation, a new gear ratio can be selected at Inputs 9 and 10. The gear ratio is then activated by means of the Switching Input (I2). The slave will then proceed at the permitted acceleration to this new gear ratio.

4.4.5. Error Procedure

Errors of tracking, over current etc. make the drive stop and the Ready output (O8) is reset. Reset is done with Input 27 or fieldbus bit 1.9. Reset is also possible with the [Reset] key of the local control panel of the drive.



In case the drive has stopped because of earth fault or short-circuit, please cycle the power to the drive from the mains before you reset!

4.5. Position Synchronisation

4.5.1. Position Synchronisation (angle synchronisation)

The position controller adjusts the slave drive position or angle to the master.

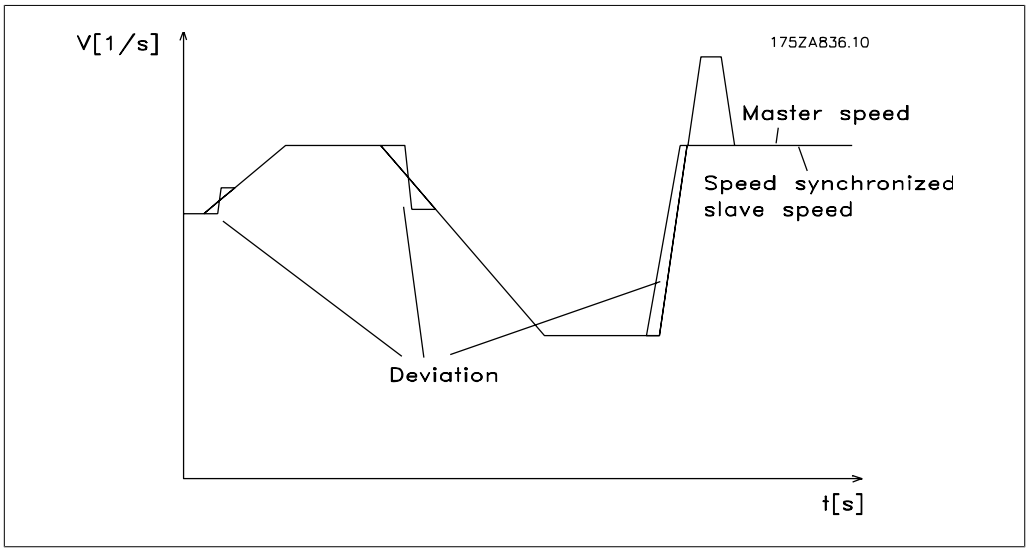
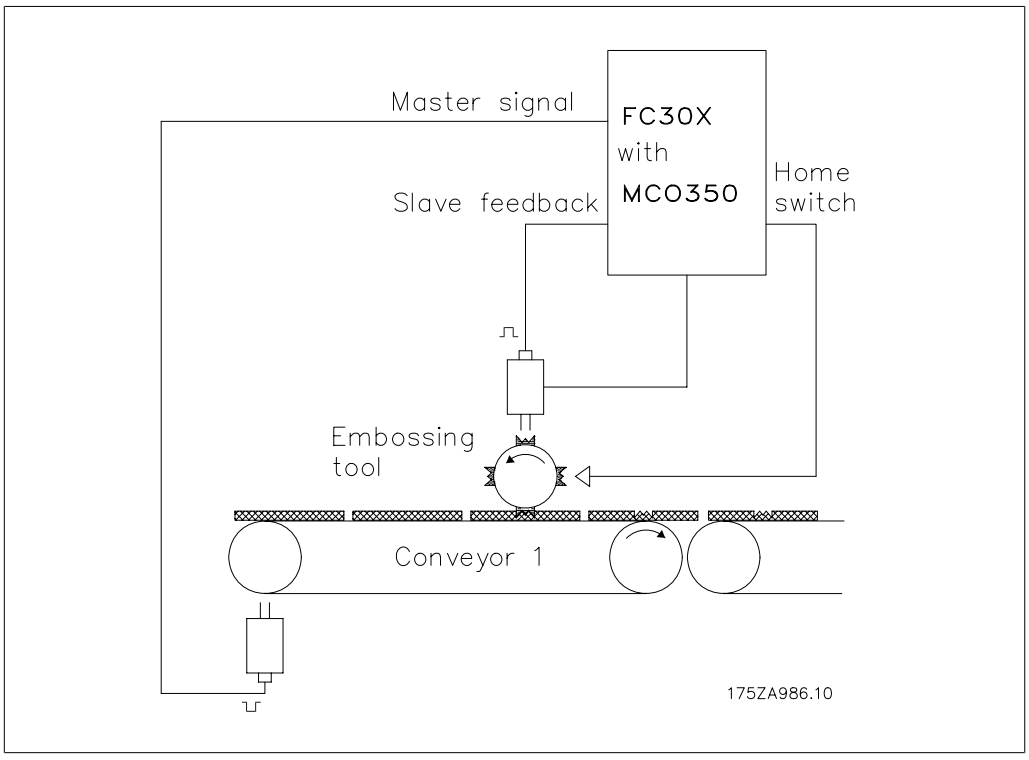


Illustration 4.6: Control behaviour with position synchronisation

It appears from the diagram that the control accuracy depends on the master acceleration and on the speed deviation between slave and master. A typical application for this type of synchronising could be the replacement of a mechanical shaft. Or mixing controls where a mixing rate is required.

The following example shows how embossing patterns on moulds is controlled. This application requires accurate position control.



4.6. Function Diagrams for Position Synchronisation

4.6.1. SyncStart to a Stationary Master

If the slave is synchronised to a stationary master drive, the slave will remain stationary. However, if a fixed offset is defined for the activated gear ratio, the slave travels to the extent of this offset during synchronisation.

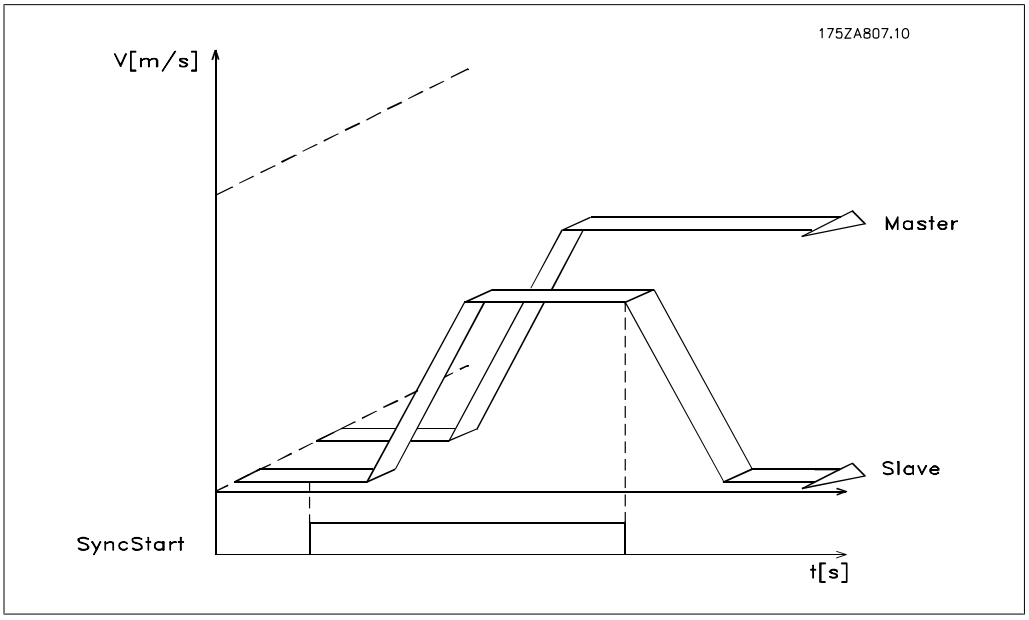


Illustration 4.7: synchronising to a stationary master

4.6.2. SyncStart to a Running Master

If synchronisation is effected to a running master, the slave drive first makes up the deviation of distance then it proceeds synchronously with the master. Any Offset setting is taken into account.

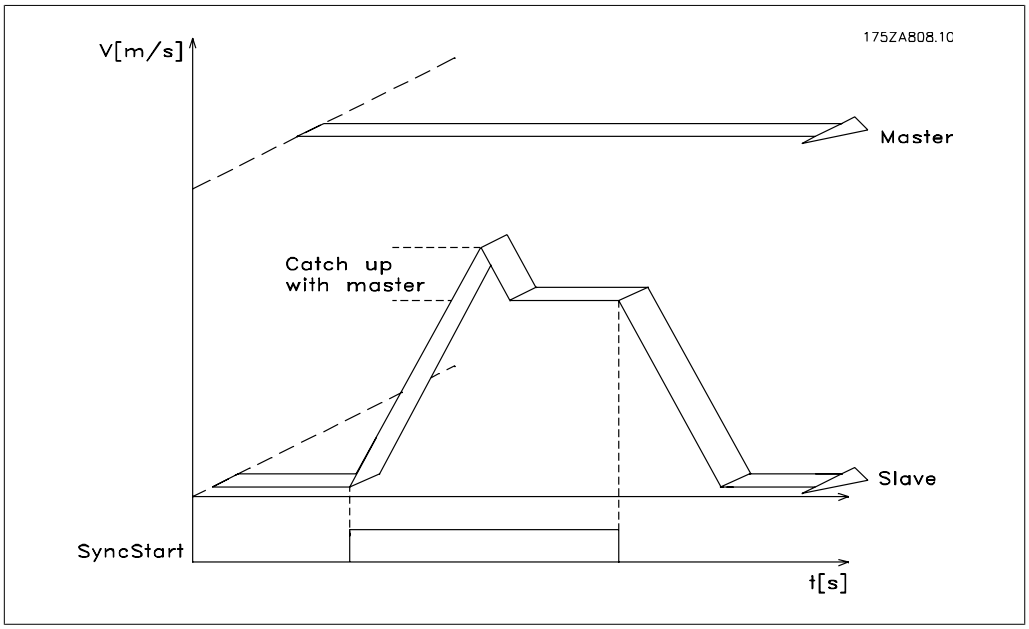


Illustration 4.8: synchronising to a running master

4.6.3. Position Displacement with a Running Master

If one of the Inputs 32 or 33 is activated during synchronous travel, the actual position in relation to the master is displaced by the value set in Parameter 1910. If the displacement is positive, the slave accelerates in order to travel the necessary distance in order then again to travel synchronously to the master at the speed determined via the gear ratio. If the displacement is negative, the slave decelerates in order to attain the necessary distance to then again travel synchronously with the master at the speed determined via the gear ratio.

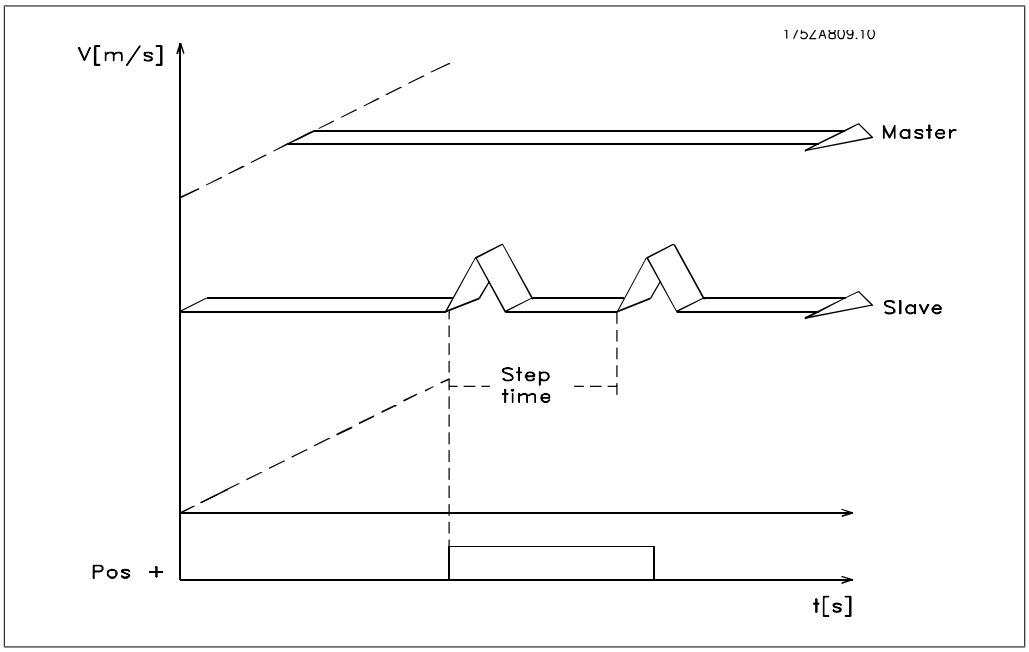
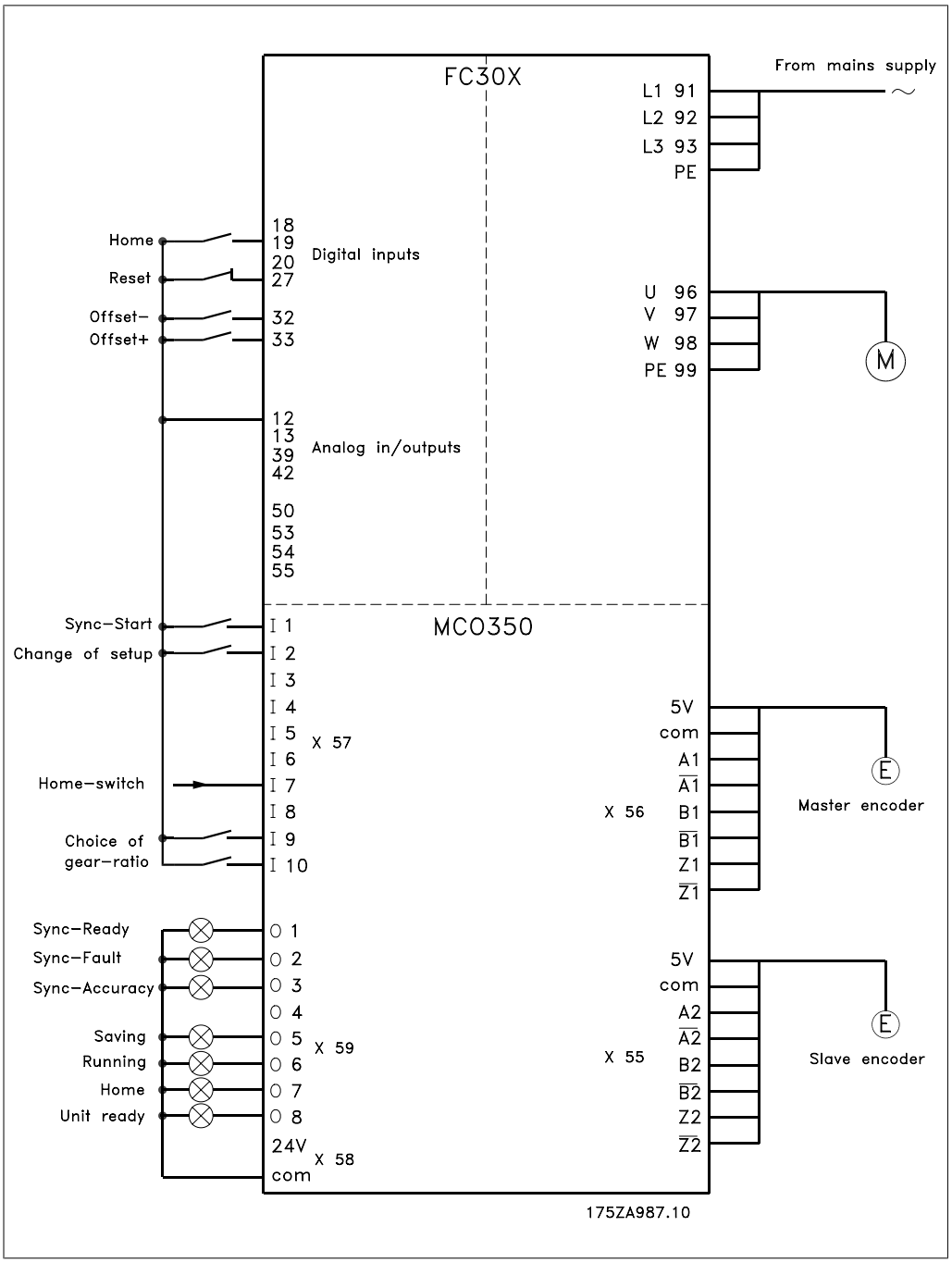


Illustration 4.9: Position displacement

4.7.1. Application Example - Embossing Patterns on Mould

Moulds of two different kinds and lengths are embossed with a pattern. The conveyor belt operator changes the position of the pattern by means of two buttons. Each of the two incremental encoders has a zero track for marker synchronisation.

4.7.2. Description of Terminals and Terminal Configuration



4.7.3. Setting the Parameters

For this work it is recommended to have the description of parameters at hand. See the *VLT Automation Drive Operating Instructions.*

NB!

It is very important that the VLT is optimised for the motor before optimising the synchronising controller:

1. Record the motor data and perform an AMA (Automatic Motor Adaptation) if possible.
2. Start programming the synchronisation functions.

Parameter No. 303
Maximum reference: Set the frequency for a value that is about 10% higher than the maximum value of par.32-80.
Example: Motor 7.5 kW, 1460 1/min at 50 Hz, speed of the application approx. 1800 1/min

$$\frac{f_{Nom} \; x \; N_{Application}}{N_{Nom}} \; x \; 1,1 \; = \; \frac{50 \; Hz \; x \; 1800 \frac{1}{min}}{1460 \frac{1}{min}} \; x \; 1,1$$

$$= \; 62 \; Hz \; Maximum \; ref. \; value$$

Parameter No. 416
Torque limit for motor mode: Set for maximum. – Choose a lower value, if special safety precautions are necessary.

Parameter No. 417
Torque limit for regenerative operation: Set for maximum. – Choose a lower value, if special safety precautions are necessary.

Parameter No. 33-80
Record "1" to start the test program.

Parameter No. 33-26
When performing position synchronisation this parameter is used to insert a filter to compensate for an oscillating master signal. If, for example, the master is experiencing shock loads the pid loop of the synchronising controller will have a tendency to oscillate as well. A negative value must be entered.
Example: If a filter factor of –100000 (100 ms) is used the correction is balanced within: 1000/ (filter factor *10)= 1 second.

Parameter No. 32-00/ 32-02
Record the slave encoder type. "0" represents the incremental encoder.

Parameter No. 32-01/ 32-03
Record the resolution of the slave encoder.

Parameter No. 32-30/ 32-32
Record the master encoder type. "0" represents the incremental encoder.

Parameter No. 32-31/ 32-33
Record the resolution of the master encoder.

Parameter No. 32-10
Record "No action" for clockwise rotation of both master and slave. Record "User units reversed" if the slave is to run in the opposite direction.

Parameter No. 32-80
Record maximum RPM measured at the slave encoder.

Parameter No. 32-81
Minimum ramp: Set the time in ms for the slave drive to accelerate from standstill to maximum speed (par 3280). The value is important, as this setting highly affects the control accuracy!

Parameter No. 32-82
Ramp type: Record "0" for linear ramp and "1" for s-ramp. Note: S-ramp requires higher acceleration torque

Parameter No. 32-67
Maximum track error: Record the value that is to generate "Track error" indication in the display, if exceeded. Input is in quad counts.

Parameter No. 32-68
Reversing behaviour: Record "0" if reversing is allowed, "1" if the slave must always follow the direction of the master or "2" if reversing is not allowed.

The settings are automatically saved.

4.7.4. How to Check the Motor Connection

When the above parameters have been programmed, check the motor connection as follows:

Remove all signals to terminals 18-33 and I1-I10

Press [Hand On] button on the LCP.

Set the reference tor a low value with the arrow kkeys (25 to 50 rpm).
Please note that the motor may now turn

Press the [Off] button on the LCP to stop again. If the motor rotates in the wrong direction then exchange the motor phases.

4.7.5. How to Test the Incremental Encoders

After testing the motor speed direction, test the incremental encoder connection as follows:

1. Remove all signals to terminals 18-33 and I1-I10.
2. Select parameter 3450. The current actual position is then displayed.
3. Rotate the slave drive motor shaft manually in the forward direction. Now the display shows an ascending count of the slave position.
4. If the count is descending, exchange the slave encoder track A by B and A/ by B/.
5. If there is no counting in the display then check the wiring of the encoder.

Follow the same procedure when testing the master encoder but use parameter 34-52 for read-out of the master position. Remember to push [Auto On] to return to normal control.

4.7.6. How to Optimise the Controller

Synchronisation is obtained via two main elements of the controller: Velocity feed forward and the PID controller.

NB!
Before starting the optimising procedures it is important to select the right type of synchronisation in parameter 1904, in this example it must be "1" for position synchronisation. Please always have the necessary degree of accuracy in mind, you could go on optimising for a long time, but it might not be necessary to have a 100% accuracy in the application you are dealing with.

First step is to optimise velocity feed forward this can be done via the automatic calculation function: Velocity feed forward calculation is activated by setting parameter 1905 to "1", remember to make the required parameter settings according to the description of par. 1905 before starting the calculation. The calculation is done when the value of par. 1905 returns to "0".

Velocity feed forward can also be optimised manually by the following procedure:

Set parameter 3264 PID bandwidth to "0".

Set parameter 3267 maximum track error to a high value (e.g. 1.000.000).

Set parameter 3265 velocity feed forward to 100.

Start test-run with virtual master with a known velocity via input 3 = 1.

Increase parameter 3265 while watching master and slave velocity (press [DISPLAY/ STATUS] to get the velocity readouts). The optimal velocity feed forward has been identified when the slave velocity is approximately equal to the master velocity.

Stop test-run by input 3 = 0.

Reset parameter 3267 to the original value.

Reset parameter 3264 to 1000.

Second step is to optimise the PID controller, a good starting point can be found be means of the automatic calculation function: By setting parameter 1905 to "2" velocity feed forward calculation is activated as well as calculation of PID sample time and P/D factors, remember to make the required parameter settings according to the description of par. 1905 before starting the calculation. The calculation is done when the value of par. 1905 returns to "0".

Using the test run functions optimises the PID factors further:
Two types of test runs are available: Positioning where the slave drive moves a specific distance and synchronising with virtual master where the slave follows the virtual master in position or speed. Generally it is better to use test run with virtual master as that comes closer to the operating conditions in synchronising mode (program 2).

For test run with positioning the following parameters must be set:

Parameter No. 1901
Test run speed: Record the speed as a percentage of the maximum speed of parameter 3280.

Parameter No. 1902
Test run acceleration: record the acceleration time in per cent. 100% is minimum acceleration. 50% is half as fast as minimum acceleration, the ramp time will thus be twice as long.

Parameter No. 1903
Test run distance: Record the distance (quad counts) for the drive to run during optimisation.

4

Then use the following procedure:

1. Close the contacts at terminal 32 (clockwise direction) or terminal 33 (counter-clockwise). During the test the last value of the first display line will indicate the track error (PID error). After the test run is completed you can see the maximum track error (PID error).
2. Increase the P-portion (par. 3260). After each change you should make a test run to find the right setting. If the drive becomes unsteady or if a message is given about over-voltage or over-current, then reduce the value in parameter 3260 to about 70-80% of the set value.
3. Now set the D-portion (parameter 3261) to 5 times the value of parameter 3260.
4. If a lower synchronising error is required the I-portion (parameter 3262) can be set to a low value e.g. 10 but be careful a too high value will course overshoot and instability

For test run with virtual master the following parameters must be set:

Parameter No. 19-16
Virtual master reference: Select the reference source for setting the velocity of the virtual master. "0" is analogue input 53, "1" is parameter 310 sub-index 0, "2" is Fieldbus PCD 2.

Parameter No. 19-17
Virtual master acceleration: Set the acceleration of the virtual master in encoder pulses per second^2.

Parameter No. 19-18
Virtual master maximum speed: Set the maximum velocity of the virtual master in encoder pulses per second.

Then use the following procedure:

1. Start test run with virtual master by activating input 3. During test run you can read the track error in the last value of the first display line. At stop the maximum track error during the test run is read out.
2. If more accurate and dynamic control is required the P-portion (parameter 3260) must be increased. If the slave becomes unstable the value must be reduced to by approximately 25%.
3. Now set the D-portion (parameter 3261) to 5 times the value of parameter 3260
4. If a lower synchronising error is required the I-portion (parameter 3262) can be set to a low value e.g. 10 but be careful a too high value will course overshoot and instability.

The settings are automatically saved.

4.7.7. How to Programme Synchronisation

Change the value of parameter 33-80 to "2". This will start the synchronisation program of VLT. To do the synchronisation programming you use the following parameters:

Parameter No. 19-01
Type of operation: Record "1" or "4" for position synchronisation.

Parameter No. 33-00
Home function, used together with par 30-04: Specify the start function of the drive: "0" Home-run not forced "1" Home run must be carried out before the first start of synchronisation

Parameter No. 33-02
Home acceleration: Set the acceleration (% of minimum acceleration) for homing.

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Parameter No. 30-03
Home speed: Set the speed (% of maximum speed) at which Homing is to be made. Positive values for clockwise rotation, negative values for counter-clockwise rotation.

Parameter No. 30-04
Home force function:
0 = The homing only has to be carried out after power up
1-3 = The homing has to be carried out before every sync start

Parameter No. 33-13
Accuracy: Record a value (quad counts) for a tolerance within which the slave position may deviate from the position of the master. With a negative value the synchronising error (parameter 1993) show the error with a sign.

Parameter No. 33-24
Marker quantity Fault: Inaccuracy: Record the number of marker signals to generate a Fault signal.

Parameter No. 33-25
Marker quantity Ready: Accuracy: Record the number of marker signals to generate a Ready signal.

Parameter No. 19-05
Gear ratio No.: Record the number of the gear ratio that is to be displayed in Parameters 1906 to 1907. First set the number of the gear ratio, then the necessary values for this gear ratio can be set in Parameters 1906 and 1907. The next gear ratio is then selected in Parameter 1905 and the same procedure is repeated.

Parameter No. 19-06
Gear ratio numerator: Enter here the numerator value of the gear ratio. The value corresponds to the encoder pulses of the slave drive. To make fine adjustment possible by means of inputs 32 and 33 a ratio of for example 7:16 must be programmed as 7000:16000.

Parameter No. 19-07
Gear ratio denominator: Record the denominator value of the gear ratio. This value corresponds to the master pulses.

Parameter No. 19-10
Fixed Offset: Record a fixed position offset for the selected gear ratio (quad counts). You use this value to specify the position deviation between slave and master. During operation you can change the value by means of inputs 32 and 33. Note: Offset is related to the master position. Offset related to the slave position can be calculated as follows:

$$Offset_slave = \frac{Offset \times Par.\ 738}{Par.\ 739}$$

Parameter No. 19-11
Step time: Record the delay in ms from one frequency change to another (hold mode) and from one gear ratio numerator factor change to another (synchronisation mode) when there is a signal on terminal 32 or 33.

Parameter No. 19-12
Step width: Record a value to specify the position displacement between slave and master.

Parameter No. 19-13

Slave speed factor: Record the factor by which the slave speed must be multiplied, so that the desired value is displayed. To calculate the value use the following formula:

$$Factor = \frac{N_{Set} \ x \ 400 \ x \ Slaveencoder_resolution}{60 \ x \ Display_value}$$

Example:
Resolution 1024 increments, desired display 100 at 15001/min

$$Factor = \frac{1500 \ \frac{1}{min} \ x \ 400 \ x \ 1024 \ \frac{Incr.}{Rev.}}{60 \ x \ 100} = 102400$$

Parameter No. 19-14
Master speed factor: Record the factor by which the master speed must be multiplied, so that the desired value is displayed. To calculate the value use the following formula:

$$Factor = \frac{N_{Set} \ x \ 400 \ x \ Slaveencoder_resolution}{60 \ x \ Display_value}$$

Parameter No. 19-15
Synchronisation error display factor: Record the factor by which the error must be multiplied, so that the desired value is displayed. To calculate the value use the following formula:

$$Factor = \frac{N_{Set} \ x \ 400 \ x \ Slaveencoder_resolution}{60 \ x \ Display_value}$$

The settings are automatically saved.

4.7.8. Operation and Operating Functions

After all values have been set as described and the controller has been optimised for the application, Parameter 3004 Home function is set to the value of "2". The drive can now be operated normally.

Home run
As parameter 33-00 is set to "1" and parameter 33-04 is set to "2" homing must be carried out before each start. To start homing the contact at Terminal 19 is closed. The slave drive then travels to the home switch and stops there. If the reversing procedure is set to "0", the slave travels back to the start of the home switch; otherwise, the offset arising from disabling reversing is added to the fixed offset.

Starting synchronisation
Preferably, the master is first similarly brought into its start position and the slave activated by means of I1 (SyncStart), then the master is started. This produces optimum synchronisation. The slave can, of course, also be started by, e.g. a start signal from the master, although in that case it should be noted that the delay of the start signal can be prolonged by the scan time of e.g. the PLC. Attention should be paid to the accuracy of the start signal. Hence, it is better to start the slave drive when the master is in position. The position of the master, plus the value of the fixed offset, is the synchronisation position to which the slave drive will travel at the maximum permitted acceleration when started. It may happen here that the slave drive travels faster than the master, as the slave drive needs to catch up with the master position.

Stopping synchronisation
On opening the SyncStart contact (I1), the slave is stopped at the permitted acceleration. Because Home force function is set at "2", a new start is only possible after a renewed Home run.

Fine setting of the position

As soon as the slave drive is in position synchronisation to the master, a displacement of this position can be effected by means of Inputs 32 + 33. Offset is related to the master position. Offset related to the slave position can be calculated as follows:

$$Offset_slave = \frac{Offset \ x \ Par.\ 19-06}{Par.\ 19-07}$$

Switching to another gear ratio

During synchronisation, a new gear ratio can be selected at Inputs 9 and 10. The gear ratio is then activated by means of Input (I2). The slave will then proceed at the permitted acceleration to this new gear ratio. The offset is related to the first gear ratio after SyncStart. Therefore a stop and then start must be performed if the offset must relate to the latest gear ratio it the gear ratio has been changed.

Error procedure

Errors of tracking, over current etc. make the drive stop. The Ready output (O8) is set low. Reset is done with Input 27 or fieldbus bit 1.9. Reset is also possible with of the [Reset] button on the local control panel of the drive.



In case the drive has stopped because of earth fault or short-circuit, disconnect the drive from the mains before resetting!

4.8. Marker Synchronisation - Function Diagrams for Marker Synchronisation

4.8.1. Marker Synchronising

Using Marker synchronising the start position is not predefined. The Marker will alter the position during operation, as required. Marker synchronising is for example used to compensate for any undesired slip.

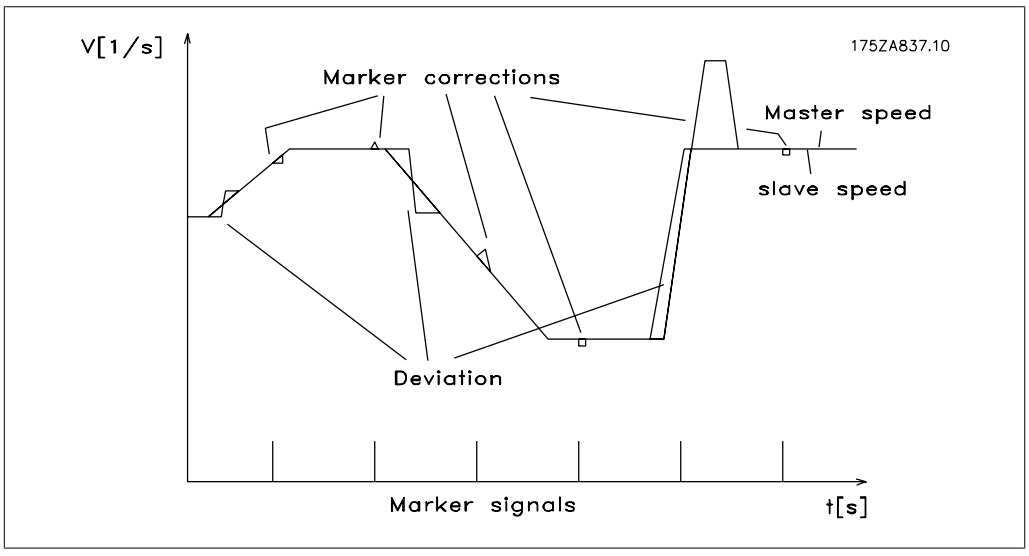


Illustration 4.10: Control behaviour with marker synchronisation

It appears from the diagram that the control accuracy depends on the master acceleration and on the speed deviation between slave and master.

4

The following example shows the use of marker synchronisation to compensate for friction slip that can arise from dropping a box onto Conveyor belt 1. By means of marker correction in the form of object recognition, the slave belt is controlled so that the product will always be placed right in the middle of the box, even if the box itself is not centrally positioned in its conveyor compartment.

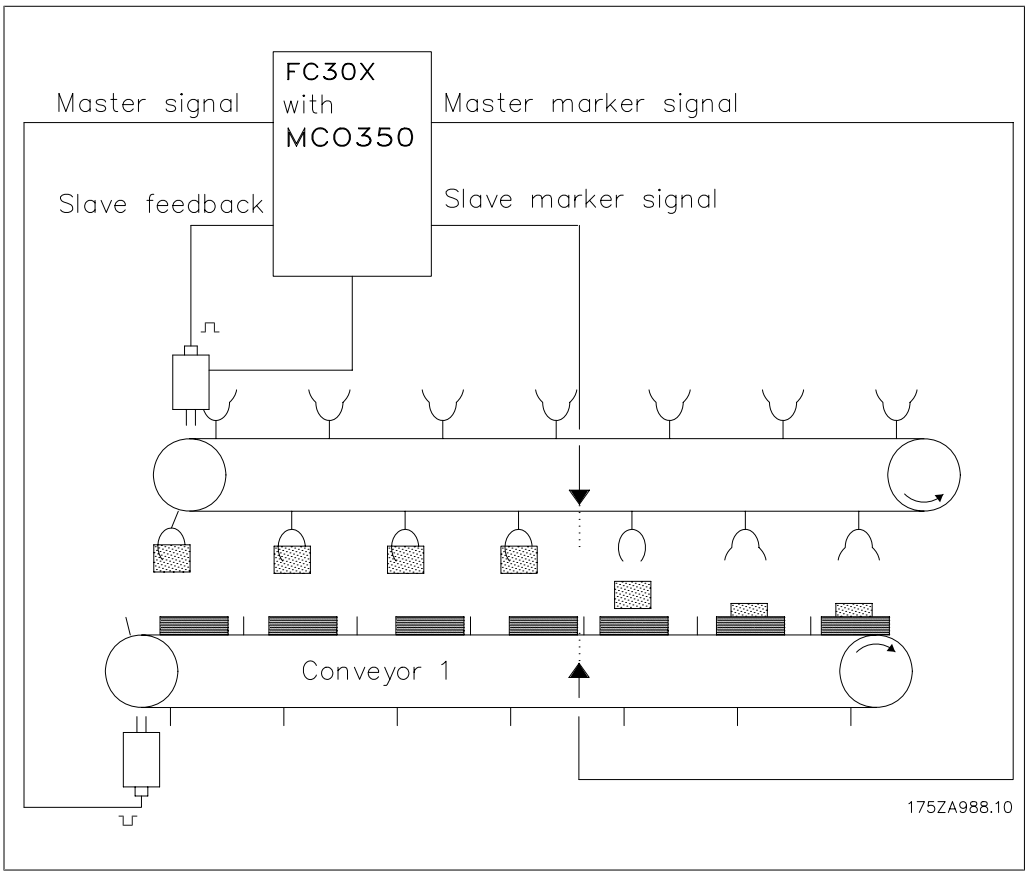


Illustration 4.11: Conveyor belt with marker synchronisation

4.8.2. SyncStart to a Running Master after Power ON

If the slave is synchronised to a running master drive, the slave automatically synchronises its position to the master. After at least one slave marker and one master marker have been detected, the marker compensation comes into effect.

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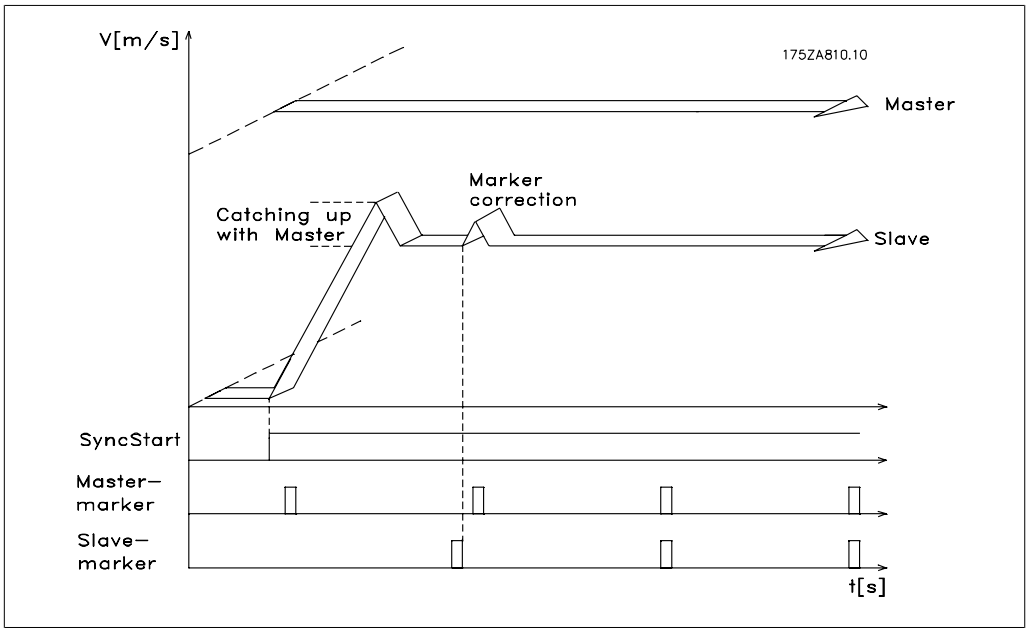


Illustration 4.12: Initial start-up with marker synchronisation

4.8.3. Marker Correction during Operation

During operation, marker correction is always carried out when the markers is detected. This ensures optimum synchronisation, no matter whether the gear ratios are not accurate or there is a slip.

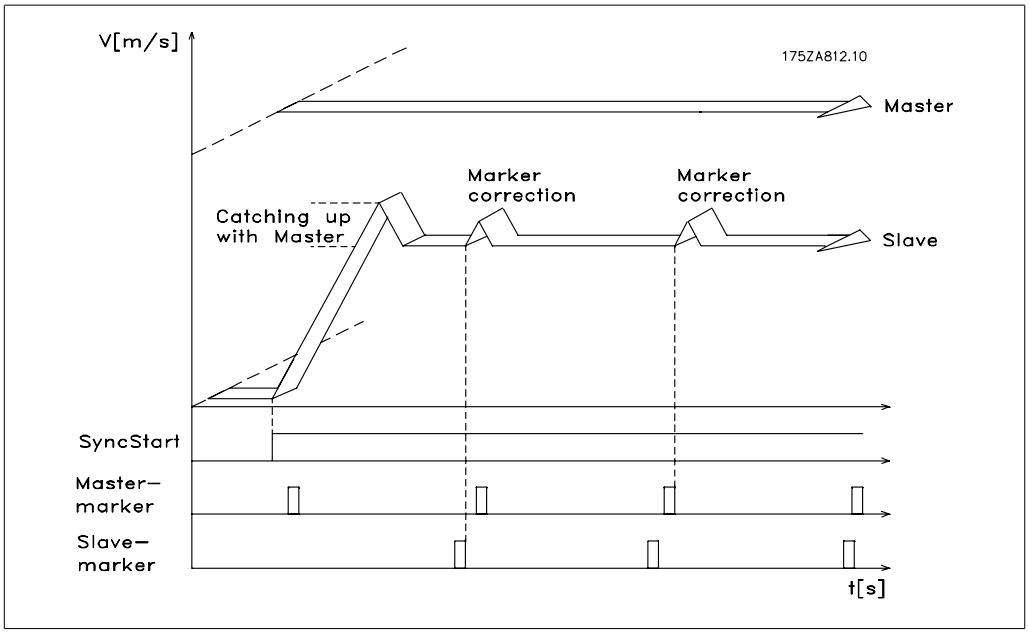


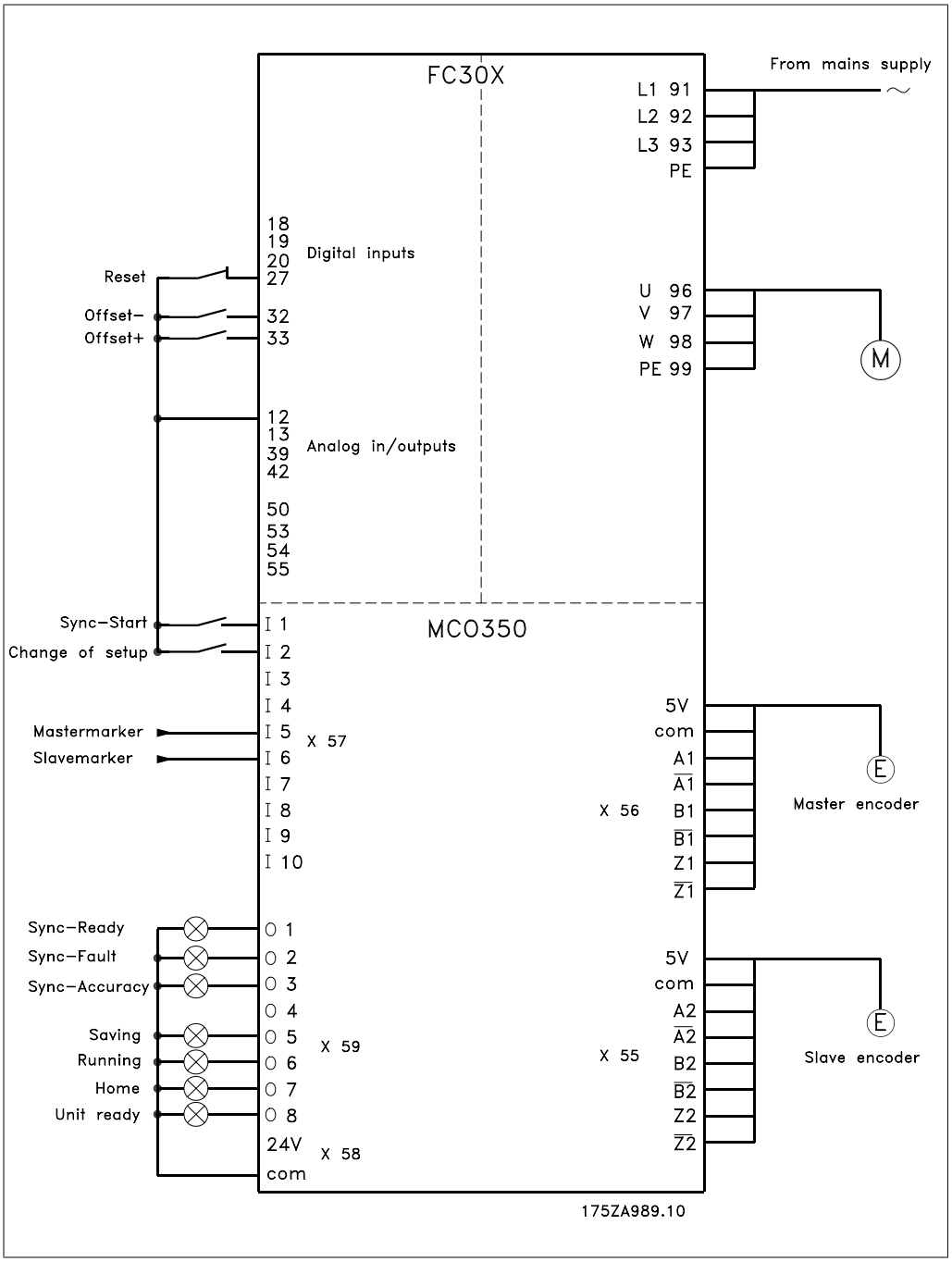
Illustration 4.13: Marker correction during operation

4.9. Application Example - Packaging

This example is a conveyor belt with cardboard boxes of low weight and different lengths. To ensure that the components to be packed are placed right in the middle of the boxes you must use synchronisation with marker correction. The grab belt is controlled by position synchronisation

and as soon as one of the two markers is recognised, the grab belt is either moved forward to the conveyor belt position or slowed down. It is also possible for the operator to change the position by means of two push buttons.

4.9.1. Terminals and Terminal Configuration



Wiring diagram - conveyor belt regulation

4.9.2. Setting the Parameters

For this purpose it is recommended to have the parameter descriptions at hand. See the *VLT Automation Drive FC 300 Operating Instructions.*



NB!
It is very important that the VLT is optimised for the motor before optimising the synchronising controller. First, record the motor data and perform an AMA (Automatic Motor Adaptation) if possible. Then start programming the synchronisation functions

Parameter No. 303
Maximum reference: Set the frequency for a value that is about 10% higher than the maximum value of parameter 32-80.
Example: Motor 7.5kW, 1460 1/min at 50Hz, speed of the application approx. 1800 1/min

$$\frac{f_{Nom} \; x \; N_{Application}}{N_{Nom}} \; x \; 1.1 \; = \; \frac{50 \; Hz \; x \; 1800 \; \frac{1}{min}}{1460 \; \frac{1}{min}} \; x \; 1.1$$

$$= \; 62 \; Hz \; maximum \; ref. \; value$$

Parameter No. 33-80
Record "1" to start the test program.

Parameter No. 33-26
When performing position synchronisation this parameter is used to insert a filter to compensate for an oscillating master signal. If, for example, the master is experiencing shock loads the pid loop of the synchronising controller will have a tendency to oscillate as well. A negative value must be entered.
Example: If a filter factor of –100000 (100 ms) is used the correction is balanced within: 1000/ (filter factor *10)= 1 second.

Parameter No. 32-00/ 32-02
Record the slave encoder type. "0" represents an incremental encoder.

Parameter No. 32-01/ 32-03
Record the resolution of the slave encoder.

Parameter No. 32-30/ 32-32
Record the master encoder type. "0" represents an incremental encoder.

Parameter No. 32-31/ 32-33
Record the resolution of the master encoder.

Parameter No. 32-10
Direction of rotation: Record "1" for clockwise rotation of the slave. Record "-1" if the slave is to run in the opposite direction.

Parameter No. 32-80
Record maximum RPM measured at the slave encoder.

Parameter No. 32-81
Minimum ramp: Set the time in ms for the slave drive to accelerate from standstill to maximum speed (par. 3280). Consider the value carefully as this setting will highly affect the control accuracy!

Parameter No. 32-82
Ramp type: Record "0" for linear ramp and "1" for s-ramp. NOTE: S-ramp requires higher acceleration torque.

Parameter No. 32-67
Maximum track error: Record the value that is to generate "Track error" indication in the display, if exceeded.

Parameter No. 32-68
Reversing procedure: Record "0" if reversing is allowed, "1" if the slave must always follow the direction of the master or "2" if reversing is not allowed.

Parameter No. 33-20
Slave marker type: As external marker signals are used, you can set the type of edge triggering of the external marker signal; "2" for a positive edge, "3" for a negative edge.

Parameter No. 33-18
Slave marker interval: Record the interval between two marker signals of the slave. Input of the interval is in quad counts. If the interval is not known, it can also be determined during the test run.

Parameter No. 33-19
Master marker type: As external marker signals are used, you can set the type of edge triggering of the external marker signal here; "2" for a positive edge, "3" for a negative edge.

Parameter No. 33-17
Master marker interval: Record the interval between two marker signals of the master. Input of the interval is in quad counts. If the interval is not known, it can also be determined during the test run.

Parameter No. 19-01
Test run speed: Record the speed at which you want to carry out the optimisation run. Record the speed as a percentage of the speed in Parameter 3280.

Parameter No. 19-02
Test run acceleration: Record the acceleration for the test run in percent of the minimum acceleration time. 100% represents the minimum acceleration, 50% is half as fast as minimum acceleration; the ramp time is thus twice as long.

Parameter No. 19-03
Test run distance: Record the distance (quad counts) for the drive to travel during optimisation.

4.9.3. How to Check the Motor Connection

After programming the above parameters, check the motor connection as follows:

1. Remove all signals to terminals 18-33 and I1-I10.
2. Press [Hand On] button on the LCP.
3. Set the reference to a low value with the arrow keys (25 to 50 rpm).
4. Press the [Off] button on the LCP to stop again. If the motor rotates in the wrong direction then exchange the motor phases.

How to test the incremental encoders When you have tested the motor speed direction you test the incremental encoder connection as follows: 1. Remove all signals to terminals 18-33 and I1-I10. 2. Select parameter 3450. The current actual position is then displayed, 3. Rotate the slave drive motor shaft manually in the forward direction. Now the display shows an ascending count of the slave position. If the count is descending, exchange the slave encoder track A by B and A/ by B/. If there is no counting in the display then check the wiring of the encoder. Follow the same

procedure when you test the master encoder but use parameter 3452 for read-out of the master position. Remember to push [Auto On] to return to normal control.

4.9.4. How to Test the Incremental Encoders

After testing the motor speed direction, test the incremental encoder connection as follows:

1. Remove all signals to terminals 18-33 and I1-I10.
2. Select parameter 34-50. The current actual position is then displayed
3. Rotate the slave drive motor shaft manually in the forward direction. Now the display shows an ascending count of the slave position. If the count is descending, exchange the slave encoder track A by B and A/ by B/. If there is no counting in the display then check the wiring of the encoder.

Follow the same procedure when testing the master encoder but use parameter 34-52 for read-out of the master position. Remember to push [Auto On] to return to normal control.

4.9.5. How to Optimise the Controller

Synchronisation is obtained via two main elements of the controller: Velocity feed forward and the PID controller.



NB!
Before starting the optimising procedures it is important to select the right type of synchronisation in parameter 1904, in this example it must be "1" for position synchronisation. Please always have the necessary degree of accuracy in mind, you could go on optimising for a long time, but it might not be necessary to have a 100% accuracy in the application you are dealing with.

First step is to optimise velocity feed forward this can be done via the automatic calculation function:
Velocity feed forward calculation is activated by setting parameter 1905 to "1", remember to make the required parameter settings according to the description of par. 1905 before starting the calculation. The calculation is done when the value of par. 1905 returns to "0".

Velocity feed forward can also be optimised manually by the following procedure:

1. Set parameter 3264 PID bandwidth to "0".
2. Set parameter 3267 maximum track error to a high value (e.g. 1.000.000).
3. Set parameter 3265 velocity feed forward to 100.
4. Start test-run with virtual master with a known velocity via input 3 = 1.
5. Increase parameter 3265 while watching master and slave velocity (press [DISPLAY/ STATUS] to get the velocity readouts). You have found the optimal velocity feed forward when slave velocity is approximately equal to the master velocity.
6. Stop test-run by input 3 = 0.
7. Reset parameter 3267 to the original value.
8. Reset parameter 3264 to 1000.

Second step is to optimise the PID controller, a good starting point can be found be means of the automatic calculation function:
By setting parameter 1905 to "2" velocity feed forward calculation is activated as well as calculation of PID sample time and P/D factors, remember to make the required parameter settings according to the description of par. 1905 before starting the calculation. The calculation is done when the value of par. 1905 returns to "0".

Using the test run functions can optimise the PID factors further:
There is two types of test run available: Positioning where the slave drive moves a specific distance and synchronising with virtual master where the slave follows the virtual master in position or speed. Generally it is better to use test run with virtual master as that comes closer to the operating conditions in synchronising mode (program 2).

For test run with positioning the following parameters must be set:

Parameter No. 19-01
Test run speed: Record the speed as a percentage of the maximum speed of parameter 3280.

Parameter No. 19-02
Test run acceleration: record the acceleration time in per cent. 100% is minimum acceleration. 50% is half as fast as minimum acceleration, the ramp time will thus be twice as long.

Parameter No. 19-03
Test run distance: Record the distance (quad counts) for the drive to run during optimisation.

Then use the following procedure:

1. Close the contacts at terminal 32 (clockwise direction) or terminal 33 (counter-clockwise). During the test the last value of the first display line will indicate the track error (PID error). After the test run is completed you can see the maximum track error (PID error).
2. Increase the P-portion (par. 3260). After each change you should make a test run to find the right setting. If the drive becomes unsteady or if a message is given about over-voltage or over-current, then reduce the value in parameter 3260 to about 70-80% of the set value.
3. Now set the D-portion (parameter 3261) to 5 times the value of parameter 3260.
4. If a lower synchronising error is required the I-portion (parameter 3262) can be set to a low value e.g. 10 but be careful a too high value will course overshoot and instability

For test run with virtual master the following parameters must be set:

Parameter No. 19-16
Virtual master reference: Select the reference source for setting the velocity of the virtual master. "0" is analogue input 53, "1" is parameter 310 sub-index, "2" is Fieldbus PCD 2.

Parameter No. 19-17
Virtual master acceleration: Set the acceleration of the virtual master in encoder pulses per second^2.

Parameter No. 19-18
Virtual master maximum speed: Set the maximum velocity of the virtual master in encoder pulses per second.

Then use the following procedure:

1. Start test run with virtual master by activating input 3. During test run you can read the track error in the last value of the first display line. At stop the maximum track error during the test run is read out.
2. If more accurate and dynamic control is required the P-portion (parameter 3260) must be increased. If the slave becomes unstable the value must be reduced to by approximately 25%.
3. Now set the D-portion (parameter 3261) to 5 times the value of parameter 3260.
4. If a lower synchronising error is required the I-portion (parameter 3262) can be set to a low value e.g. 10 but be careful a too high value will course overshoot and instability.

If the interval between two marker signals at the slave is not known, this interval can now be measured. To do this, the contact at the Slave marker search input (I8) is closed. The slave drive now rotates at the set test run speed. With each master signal, the interval can be read off in Parameter 3318. If the marker search is stopped by opening the Slave marker search contact (I8), an average of all the marker intervals is taken, and this is entered as the value in Parameter 3318. Similarly, the intervals between the marker signals of the master drive are measured by means of the Master marker search input (I7). To do this, it is necessary to start the master. The intervals are continuously displayed in Parameter 3317. After opening the Master marker search contact (I7), the calculated average of all the measurements is again entered as the final result in Parameter 3317.

The settings are automatically saved.

4.9.6. How to Programme Synchronisation

Change the value of parameter 33-80 to "2". This will start the synchronisation application program.

Use the following parameters to programme the synchronisation:

Parameter No. 19-01
Type of operation: Record "2" or "5" for marker synchronisation.

Parameter No. 33-23
Marker synchronisation behaviour: Specify here how the slave drive is to react while synchronising to the master marker. "0" means the last marker pulse of the master - the slave synchronises to the last master marker pulse already registered - it catches up. "1" means the next master marker pulse - the slave waits for the next master marker and synchronises to it - the slave slows down. "2" means that the slave uses the nearest master marker - it decides for itself whether to catch up or slow down.

Parameter No. 33-13
Accuracy: Record a value (quadcounts) for a tolerance within which the slave position may deviate from the position of the master.

Parameter No. 33-24
Marker quantity Fault: Inaccuracy: Record the number of market signals to generate a Fault signal.

Parameter No. 33-25
Marker quantity Ready: Accuracy: Record the number of marker signals to generate a Ready signal.

Parameter No. 19-05
Gear ratio No.: Record the number of the gear ratio that is to be displayed in Parameters 1906 to 1910. First set the number of the gear ratio, then in Parameters 1906 to 1910 the necessary values for this gear ratio. The next gear ratio is then selected in Parameter 1905 and the same procedure is repeated.

Parameter No. 19-06
Gear ratio numerator: Record the numerator value for the gear ratio. That is the encoder pulses of the slave drive. To make fine adjustment possible by means of inputs 32 and 33 a ratio of for example 7:16 must be programmed as 7000:16000.

4

Parameter No. 19-07
Gear ratio denominator: Record the denominator value of the gear ratio. This value corresponds to the master pulses.

Parameter No. 19-08
Slave markers: Record the number of slave markers for the marker ratio. Ensure that the gear ratio and the marker ratio match each other.

Parameter No. 19-09
Master markers: Record the number of master markers for the marker ratio. Ensure that the gear ratio and the marker ratio match each other.

Parameter No. 19-10
Fixed Offset: Record a fixed position offset for the selected gear ratio (quad counts). This value specifies the position deviation between the slave marker and the master marker. During operation the offset can be changed by means of inputs 32 and 33. Note: Offset is related to the master position.
Offset related to the slave position can be calculated as follows:

$$Offset_slave = \frac{Offset \ x \ Par.\ 19-06}{Par.\ 19-07}$$

Parameter No. 19-11
Step time: Record the delay in ms from one frequency change to another (hold mode) and from one gear ratio numerator factor change to another (synchronisation mode) when there is a signal on terminal 32 or 33.

Parameter No. 19-12
Step width: In marker synchronisation mode, Offset Parameter 1908 is changed by this value when Terminal 32 or Terminal 33 is activated.

Parameter No. 19-13
Slave speed factor: Record the factor by which the slave speed must be multiplied, so that the desired value is displayed. To calculate the value use the following formula:

$$Factor = \frac{N_{Set} \ x \ 400 \ x \ Slaveencoder_resolution}{60 \ x \ Display_value}$$

Example:
resolution 1024 increments, desired display 100 at 15001/min

$$Factor = \frac{1500 \ \frac{1}{min} \ x \ 400 \ x \ 1024 \ \frac{Inkr}{U mdr}}{60 \ x \ 100} = 102400$$

Parameter No. 19-14
Master speed factor: Record the factor by which the master speed must be multiplied, so that the desired value is displayed.
To calculate the value use the following formula:

$$Factor = \frac{N_{Set} \ x \ 400 \ x \ Slaveencoder_resolution}{60 \ x \ Display_value}$$

Parameter No. 19-15
Synchronising error display factor: Record the factor by which the error must be multiplied, so that the desired value is displayed.
To calculate the value, use the following formula:

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$$Factor = \frac{N_{Set} \ x \ 400 \ x \ Slaveencoder_resolution}{60 \ x \ Display_value}$$

The settings are automatically saved.

4.9.7. Operation and Operating Functions

After all the values have been set as described, the drive can now be operated normally.

Starting synchronisation

Synchronisation of the slave is started by means of SyncStart (I1), then the master is started. This ensures optimum synchronisation. The slave drive travels in position synchronisation to the master until both slave and master marker has been detected. The slave accelerates or slows down, according to the setting of Parameter 3323, in order to attain the marker position plus the set offset. It may happen that the slave drive travels faster than the master does, if the slave drive needs to catch up with the position.

Stopping synchronisation

On opening contact I1 (SyncStart), the slave is stopped at the permitted acceleration.

Fine setting of the position

As soon as the slave drive is in position synchronisation to the master, an adjustment of this position can be made by means of Inputs 32 + 33. Note: Offset is related to the master position. Offset related to the slave position can be calculated as follows:

$$Offset_slave = \frac{Offset \ x \ Par.\ 19-06}{Par.\ 19-07}$$

Switching to another gear ratio

During synchronisation, a new gear ratio can be selected at Inputs 9 and 10. The gear ratio is then activated by means of the Switching Input (I2). The slave will then proceed at the permitted acceleration to this new gear ratio. The offset is related to the first gear ratio after SyncStart. Therefore a stop and then start must be performed if the offset must relate to the latest gear ratio it the gear ratio has been changed.

Error procedure

Errors of tracking, over current etc. make the drive stop and the Ready output (O8) is set low. Reset is done with Input 27 or fieldbus bit 1.9. Reset is also possible with of the [Reset] button on the local control panel of the drive.



In case the drive has stopped because of earth fault or short-circuit, disconnect the drive from the mains before resetting!

5

5. Appendix

5.1. Messages and Error Reference

5.1.1. Warnings and Error Messages

All messages are shown in the LCP display of the FC 300 in short and in the APOSS software in plain text. You can find brief information on the error messages in the table or detailed information in the following section. The tables contain the messages in numerical order. Letters following a % sign represent variables which can be used in plain text at the corresponding locations.

Error No.	Error text	Description
103	Illegal axis num.	Axes not in system.
105	Error not reset	Error not cleared.
106	Home not done	Failed to move to HOME position.
107	Home vel. zero	Home was executed with Home Velocity set to zero.
108	Position error	Position error.
109	Index not found	Index pulse (encoder) not found.
110	Unknown cmd.	Unknown command.
111	SW end limit	Software end limit activated.
112	Unknown param.	Illegal parameter number.
113	FC not enabled	FC 300 is not ready but the PID controller is active.
114	Too many loops	Too many nested loops.
115	Par. save failed	Parameters save failed.
116	Param. memory	Parameters in memory are corrupted.
117	Progr. Memory	Programs in memory are corrupted.
118	Reset by CPU	Reset by CPU.
119	User abort	User abort.
125	HW end limit	HW end limit activated.
149	Too many inter.	Too many interrupt functions.
150	No ext. 24V	External supply is missing.
151	Too many gosub	Too many nested GOSUB commands
152	Too many return	Too many RETURN commands.
154	D. out overload	Digital Output overloaded.
155	LINK failed	LINKGPAR command failed.
162	Memory error	Error in verifying; EEPROM: address % defect.
170	Array sise (DIM)	Error in DIM command.
171	Array too small	Attempt was made to cross array bounds
179	Waitndx timeout	Timeout while waiting for index.
184	Too many ontime	Too many time interrupts.
187	Out of memory	No more room for variables.
190	Memory locked	The program memory is write-protected.
191	Illegal cam array	Curve array wrong.
192	Encoder error	Encoder error
199	Internal MCO fault	Encoder error

5.1.2. Errors

Error 103
Illegal axis num.
An attempt has been made to find an axis which does not exist in the controller. Check to see if the program axis command has an invalid number or a general axis command (...X(*)).

Error 105
Error not reset
An attempt has been made to execute a motion command, although a momentary error message has not been cleared.

Error 106
Home not done
Failed to move to HOME position. According to the axis par. 33-00 Force HOME, a forced move to the machine zero-point is demanded, before other motion commands can be executed. This move to the machine zero-point has not been executed.

Error 107
Home vel. zero
An attempt was made to execute the HOME command but the motor is set to 0 in par. 33-03 *Velocity of Home Motion.*

Error 108
Position error
The distance between the set and the real position was greater than the Maximum Tolerated Position Error defined in par. 32-67.
Causes:

- Mechanically blocked or overloaded drive
- Par. 32-67 *Max. Tolerated Position Error* too small
- Commanded speed greater than FC 300 parameters 4-13 *Motor Speed High Limit* and 3-03 *Maximum Reference*
- Commanded acceleration too great
- Par. 32-60 *Proportional Factor* too small, or
- FC 300 not enabled.

Error 109
Index not found
At reference or index search, the encoder index pulse could not be found within a motor rotation.
Causes:

- An encoder without an index pulse has been used
- Index pulse not connected
- Index pulse incorrect (all three channels must have a simultaneous low), or
- The par. 32-01 *Incremental Resolution* (ENCODER) is set too low.

Error 110
Unknown comm
Cause: A communication or program error. The program must be re-compiled and re-loaded.

Error 111
SW end limit
A motion command will cause or has caused the software end limit to be activated.
Identification of attainment of software limit at a motion in the speed mode will only be made after the current position is identical to the software limit switch.
The control unit will be switched off and the drive must be manually moved back to within the admissible area, or the monitoring of the software limit switch must be temporarily deactivated via the Negative and Positive Software End Limit in parameters 33-43 and 33-44. Only then is it possible to clear the error.
In positioning mode, it will be known before motion start that the target position lies outside the path. In this case, the movement will not be executed and the error message can be cleared.

Error 112
Unknown param.
An attempt has been made to change a parameter (SET or SETVLT command), which does not exist.

Error 113
FC not enabled
FC 300 is not ready but the PID controller is active. The FC status word (Bit 09 and Bit 11) is monitored every 20 ms when the PID con-

troller is active. The FC 300 is in the "Not ready" state when:

- It has an alarm
- It is in local mode
- Local LCP stop is activated

Error 114
Too many loops
Too many nested loops exist in the executed program.

Error 115
Par. Save failed
Saving of the option parameter failed.

Error 116
Param. memory
The parameters in EEPROM are no longer correct because of

- EEPROM defective or
- Power outage while saving



NB!
You have to re-initialise the parameter with a 14-22 Reset and then overwrite these parameters again with your own application parameters.

Otherwise motion programs which require application parameters will no longer function correctly.

Error 117
Progr. Memory
The program data stored in EEPROM cannot be found or are no longer correct because of

- EEPROM defective or
- Power outage while saving

You have to do a 3-finger reset to reset all parameters to their defaults (ex factory) and to delete all user programs, arrays, and application parameters.
Afterwards re-load the programs and parameters.
This corresponds to the → *Erase Option EEPROM* or a → *Reset complete* in the APOSS menu.

Error 118
Reset by CPU
The processor has been stopped and a re-set has automatically been executed (watchdog). Causes could be:

- Short term voltage drop
- Voltage peak, or
- Short circuit

Error 119
User abort
The *Autostart* program has been aborted by the user.
Or the [CANCEL] key was pressed during switching on and a Master Reset triggered.

Error 125
HW end limit
A motion command has caused an axis limit switch to be activated.
Through activation of an end limit switch, the controller (depending on the par. 33-40 *behaviour at End Limit Switch*) is automatically switched off and the drive must be manually moved out of this position, before the error message can be cleared.

Error 149
Too many inter.
More interrupt functions than the maximum possible number were used. Permitted are:

32	ON INT
32	ON STATBIT
32	ON COMBIT
10	ON PARAM
20	ON APOS, ON MAPOS, ON MCPOS

Error 150
No ext. 24V
External supply is missing.

Error 151
Too many gosub
In the program exists too many calls from one subroutine to another subroutine.
The error usually occurs when there is a recurrent reference to one of the subprograms in a subprogram.
Avoid too many (10 is maximum) opposing subroutine calls, and avoid subroutines which call themselves (re-cursive subroutine procedures).

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Error 152
Too many return
There are either more RETURN than corresponding GOSUB commands in the program, or there is a direct jump from a subroutine with a GOTO command.
Only one RETURN is allowed per subprogram. It is always better to jump to the beginning of a subprogram and then to jump with IF... to a previously defined label.

Error 154
D. out overload
Digital output overloaded.

Error 155
LINK failed
LINKGPAR command failed.

Error 162
Memory error
After saving something in the EEPROM (a program or parameters) an error was detected during verification.
Delete the EEPROM with a 3-finger reset and try to save the program or parameters again. If this is not successful please call the technical service department.

Error 170
Array sise (DIM)
The definition of an array in a DIM command does not correspond to an already existing array in the MCO 350.
Cause might be that the fields are from older SYNCPOS/APOSS programs. The current program has other definitions.
Either adapt the APOSS program to the correct array sise or delete the old arrays.



NB!
Remember to follow the recommendations concerning saving programs and parameters before deleting the EEPROM.

Error 171
Array too small
An attempt was made to describe an array element that is located outside of the defined array limits.
Cause might be an error in the APOSS program. Array sising does not agree with the space required (e.g. due to an incorrectly programmed loop).
Or the array is too small for the number of test drives triggered by TESTSTART.
Check loop variables.

Error 179
Waitndx timeout
The command WAITNDX was executed and the timeout listed was exceeded.
The timeout is probably too short or the index impulse could not found (see also Error 109).

Error 184
Too many ontime
Too many interrupts (ON TIME or ON PERIOD commands) were used within the program.
A maximum of 12 of these ON TIME and/or ON PERIOD commands are allowed within one program.

Error 187
Out of memory
No more space for variables.
When the APOSS program is started the space for the necessary variables is reserved dynamically. This space is now no longer available.
You may have selected a maximum number of variables which is too high. Reduce the maximum number in *Settings → Compiler* (Standard = 92).
Or the memory available is occupied with programs or arrays. Delete the programs or delete both the programs and arrays, i.e. by deleting the entire memory.



NB!
Remember to follow the recommendations concerning saving programs and parameters before deleting the EEPROM.

Error 190
Memory locked
The program memory is write-protected and cannot be altered.
This means that auto recognition can neither be set nor deleted and programs can neither be saved nor deleted. Equally, → *RAM* save and → *EEPROM delete* will not be executed.

Error 191
Illegal cam array
An incorrect or old array is defined in the DIM instruction for SETCURVE.

An old array may exist if the CNF file with all parameters and arrays has not been loaded into the *CAM-Editor.*
An incorrect array could be caused by the following:

- It was not created by the curve editor
- Previous version of a curve editor. Such an array must first be converted by the current CAM-Editor (→ *load* and *save*)
- Or the order of the arrays in the DIM instruction does not match the order in the cnf file. Refer to the number of the array in the title bar of the *CAM-Editor* in this respect.

Error 192
Encoder error
Error from encoder monitoring: open or short circuit in accordance with the displayed LED.



NB!
An error will be indicated even if no encoder is connected.

Error 199
Internal MCO fault
If such an error should occur, please contact your dealer and report the error number displayed to the technical service department.

5.2. Parameter Overview

5.2.1. Parameter Overview: 1900

Parameter Number	Description
1900	Store Data Factory setting: 0 Setting range from 0 - 1 User setting:
1901	*Test run: Program 1:* Test Run Speed Factory setting: 10% Setting range from 1 - 100% User setting (%): *Synchronous Operation: Program 2:* Type of Operation Factory setting: 0 Setting range from 0 - 7 User setting:
1902	*Test run: Program 1:* Test Run Acceleration Factory setting: 10% Setting range from 1 - 200% User setting (%): *Synchronous Operation: Program 2:* Hold Function Factory setting: 0 Setting range from 0 - 1 User setting:
1903	*Test run: Program 1:* Test Run Distance Factory setting: 4096 quad counts Setting range from 1 - 2147483647 quad counts User setting: *Synchronous Operation: Program 2:* Hold Speed Factory setting: 10% Setting range from 0 - 100 % User setting (%):

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Parameter Number	Description
1904	*Test run: Program 1:* Synchronising Type (Sync Type) Factory setting: 0 Setting range from 0 - 1 User setting: *Synchronous Operation: Program 2:* Delta Hold Speed Factory setting: 5% Setting range from 1 - 100 % User setting (%):
1905	*Test run: Program 1:* Activate Feed Forward and PID Calculation (FFVEL calc.) Factory setting: 0 Setting range from 0 - 2 User setting: Gear Ratio No. Factory setting: 0 Setting range from 0 - 3
1906	Gear Ratio Numerator Factory setting: 1000 Setting range from - MLONG - MLONG
1907	Gear Ratio Denominator Factory setting: 1000 Setting range from - MLONG - MLONG
1908	Slave Marker Quantity Factory setting: 1 Setting range from 1 - 2147483647
1909	Master Marker Quantity Factory setting: 1 Setting range from 1 - 2147483647
1910	Fixed Offset Factory setting: 1 Setting range from -2147483647 - 2147483647

1905	Gear Ratio No.	1	2	3	4
1906	Numerator				
1907	Denominator				
1908	Slave Markers				
1909	Master Markers				
1910	Fixed Offset				

Parameter Number	Description
1911	Step Time Factory setting: 100 ms Setting range from 10 - 2147483647 ms User setting (ms):
1912	Step Width Factory setting: 1 Setting range from -2147483647 - 2147483647 User setting:
1913	Slave Speed Factor Factory setting: 400 Setting range from 1 - 2147483647 User setting:
1914	Master Speed Factor Factory setting: 400 Setting range from 1 - 2147483647 User setting:
1915	Synchronising Error Display Factor Factory setting: 400 Setting range from 1 - 2147483647 User setting:
1916	Virtual Master Reference Value Factory setting: 0 Setting range from 0 - 3 User setting:
1917	Virtual Master Acceleration Factory setting: 25600 $^{Hz}/_{s}$ Setting range from 1 - 2147483647$^{Hz}/_{s}$ User setting ($^{Hz}/_{s}$):
1918	Virtual Master Maximum Speed Factory setting: 25600 $^{1}/_{s}$ Setting range from 1 - 2147483647$^{1}/_{s}$ User setting ($^{Hz}/_{s}$):
1919	Control Source Test Run (Contr. testrun) Factory setting: 0 Setting range from 0 - 1 User setting:

Parameter Number	Description
1920	Control Source Synchronising (Contr. synchron) Factory setting: 0 Setting range from 0 - 1 User setting:
1921	Brake on Delay (Brake on delay) Factory setting: 0 Setting range from 0 - 5000 msec. User setting (msec.):
1922	Brake Off Delay (Brake off delay) Factory setting: 0 Setting range from 0 - 5000 msec. User setting (msec.):
1923	Marker Monitor (Marker monitor) Factory setting: 0 Setting range from 0 - 2 User setting (msec.):
1924	Resync. (Resync.) Factory setting: 0 Setting range from 0 - 1 User setting:

5.2.2. Parameter Overview: 3200

Parameter Number	Description
3200	Slave Incremental Encoder Type Factory setting: 1 Setting range from 0 - 2 User setting:
3201	Slave Incremental Encoder Resoulution Factory setting: 1024 Setting range from 1 - MLONG User setting:
3202	Slave Encoder Absolute Protocol Factory setting: 0 Setting range from 0 - 5 User setting:
3203	Slave Encoder Absolute Resolution Factory setting: 8192 Setting range from 1 - MLONG User setting:
3205	Slave Encoder Absolute Data Length Factory setting: 25 Setting range from 8 - 37 User setting:
3206	Slave Encoder Absolute Clock Frequency Factory setting: 262000 Setting range from 78125 - 2000000 User setting:
3207	Slave Encoder Absolute Clock Generation Factory setting: On Setting range from Off - On User setting:
3208	Slave Encoder Absolute Cable Length Factory setting: 0 Setting range from 0 - 300 User setting:
3209	Slave Encoder Hardware Monitor Factory setting: Off Setting range from Off - On User setting:

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Parameter Number	Description
3210	Direction of Rotation Factory setting: 1 Setting range from -2 - 2 User setting:
3230	Master Incremental Encoder Type Factory setting: 1 Setting range from 0 - 1 User setting:
3231	Master Incremental Encoder Resolution Factory setting: 1024 Setting range from 1 - MLONG User setting:
3232	Master Encoder Absolute Protocol Factory setting: 0 Setting range from 0 - 5 User setting:
3233	Master Encoder Absolute Resolution Factory setting: 8192 Setting range from 1 - MLONG User setting:
3235	Master Encoder Absolute Data Length Factory setting: 25 Setting range from 8 - 37 User setting:
3236	Master Encoder Absolute Clock Frequency Factory setting: 262000 Setting range from 78125 - 2000000 User setting:
3237	Master Encoder Absolute Clock Generation Factory setting: On Setting range from Off - On User setting:
3238	Master Encoder Absolute Cable Length Factory setting: 0 Setting range from 0 - 300 User setting:

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Parameter Number	Description
3239	Master Encoder Hardware Monitor Factory setting: Off Setting range from Off - On User setting:
3240	Master Encoder Hardware Termination Factory setting: On Setting range from Off - On User setting:
3260	P-Portion Factory setting: 10 Setting range from 0 - 65000 User setting:
3261	D-Portion Factory setting: 0 Setting range from 0 - 65000 User setting:
3262	I-Portion Factory setting: 0 Setting range from 0 - 65000 User setting:
3263	Limitation for I-Portion Factory setting: 1000 Setting range from 0 - 65000 User setting:
3264	Band Width PID Controller Factory setting: 1000 Setting range from 0 - 65000 User setting:
3265	Velocity Feed Forward Factory setting: 0 Setting range from 0 - 65000 User setting:
3266	Acceleration Feed Forward Factory setting: 0 Setting range from 0 - 65000 User setting:

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Parameter Number	Description
3267	Maximum Track Error Factory setting: 10000 quad counts Setting range from 1 - 2147483647 User setting (quad counts):
3268	Reversing Behaviour Factory setting: 0 Setting range from 0 - 2 User setting:
3269	PID-Sample Time Factory setting: 1 ms Setting range from 1 - 1000 ms User setting (ms):
3280	Maximum Speed Factory setting: 1500 $^1/_{min}$ Setting range from 1 - 65535 $^1/_{min}$ User setting ($^1/_{min}$):
3281	Minimum Ramp Factory setting: 100 ms Setting range from 50 - 2147483647 ms User setting (ms):
3282	Ramp Type Factory setting: 0 Setting range from 0 - 1 User setting:

5.2.3. Parameter Overview: 3300

Parameter Number	Description
3300	Home Force Factory setting: 0 Setting range from 0 - 1 User setting:
3302	Home Acceleration Factory setting: 10 % Setting range from 1 - 200 % User setting (%):
3303	Home Velocity Factory setting: 10 % Setting range from 0 - 100 User setting:
3304	Home Force Function Factory setting: 0 Setting range from 0 - 4 User setting:
3313	Accuracy Factory setting: 1000 quad counts Setting range from -2147483647 - 2147483647 quad counts User setting (quad counts):
3314	M-S Tolerance Speed Factory setting: 0 % Setting range from 0 - 100 % User setting (%):
3317	Marker Interval at the Master Factory setting: 4096 quad counts Setting range from 0 - 2147483647 quad counts User setting (quad counts):
3319	Master Marker Type Factory setting: 0 Setting range from 0 - 3 User setting:
3320	Slave Marker Type Factory setting: 0 Setting range from 0 - 3 User setting:

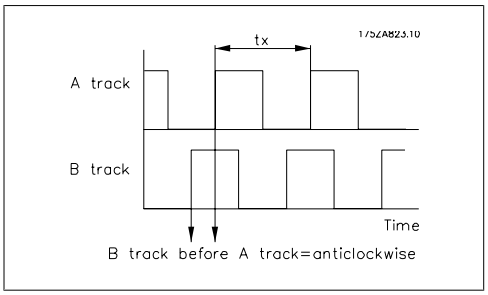
Parameter Number	Description
3321	Marker Window Master Factory setting: 0 Setting range from 1 - 2147483647 User setting:
3322	Marker Window Slave Factory setting: 0 Setting range from 1 - 2147483647 User setting:
3323	Master Synchronising Mode Factory setting: 0 Setting range from 0 - 1005 User setting:
3324	Marker Quantity FAULT Factory setting: 5 markers Setting range from 1 - 10000 markers User setting (markers):
3325	Marker Quantity READY Factory setting: 10 markers Setting range from 1 - 10000 markers User setting (markers):
3326	Velocity Filter Factory setting: 0 Setting range from 0 - 65000 User setting:

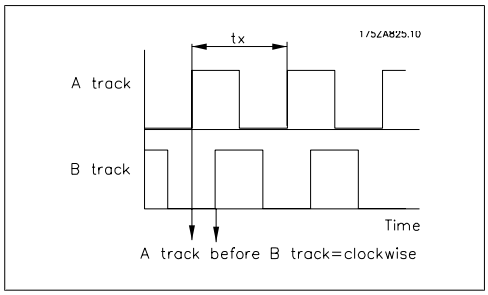
5.3. Glossary of Key Terms

Master-Slave
It means that a signal is taken from a master drive. The signal is then used to control a second "slave" drive that follows the master. The master drive does not have to be a drive; it can be any given part of a power transmission system.

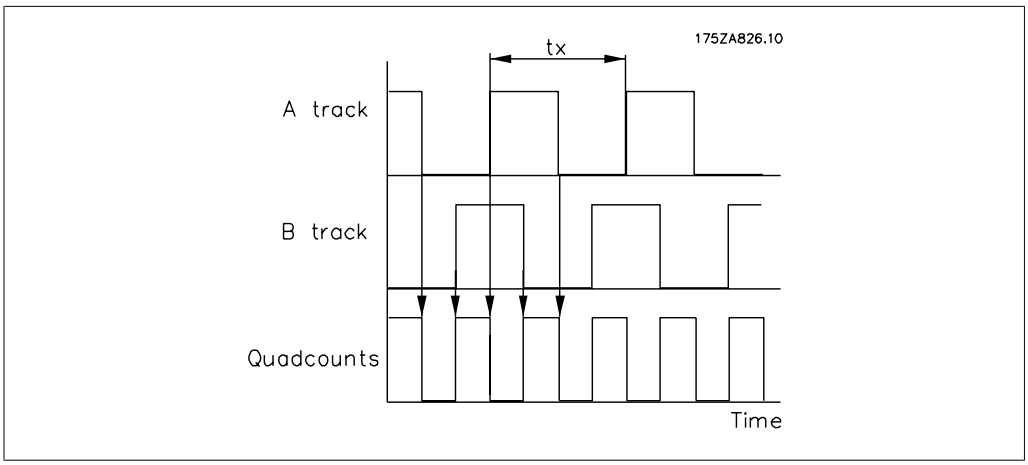
Incremental Encoder
This is an encoder system that picks up the speed and the direction of rotation and transmits on the appropriate configuration. The number of tracks, and thus the number of signals, indicate the properties of the encoder system. There are single-track systems that deliver a pulse signal dependent on the speed as well as a fixed direction signal. Dual-track systems deliver two pulse signals that are offset 90 degrees. By evaluating the two tracks, the direction signal is also obtained. Three-track encoders deliver, as well as the two tracks of the dual-track encoder, an additional "zero-track". This emits a signal when the zero transit is passed through.

Incremental Encoder Signals





Quad Counts
Through edge detection, a quadrupling of the increments is produced by both tracks (A/B) of the incremental encoder. This improves the resolution.



Absolute Encoder
This is a special form of encoder, as it indicates the absolute physical position. This is communicated via transfer of the position in parallel form or in the form of a telegram in serial form. Absolute encoders also come in two versions: Single-Turn encoders supply an absolute position on a shaft rotation; Multi-Turn encoders can report the absolute position via a specific quantity, or via a freely definable number of rotations.

Track Error
The synchronising controller of the slave drive uses the master drive signal and the gear ratio to calculate a reference position value for the slave drive. The deviation of the feedback position from the calculated position is known as the track error. This is specified in quad counts. The maximum track error is also a threshold value that defines the permitted operating area of the synchronising controller.

Accuracy
This value specifies the permitted deviation between the master and slave at which synchronisation is still present.

PPR
Pulses per revolution.

Virtual master
If several axes are to travel in synchrony, or if the synchronisation error is so to be kept as small as possible, it is often more advantageous not to take the reference position from a drive, but to have a master that simulates the reference position. This has the advantage that the cycle times of the individual drives are not added. These differences are illustrated below for the synchronous control of three conveyor belts. First, we show the classic synchronisation procedure where the reference value signal is taken from the preceding drive in each case.

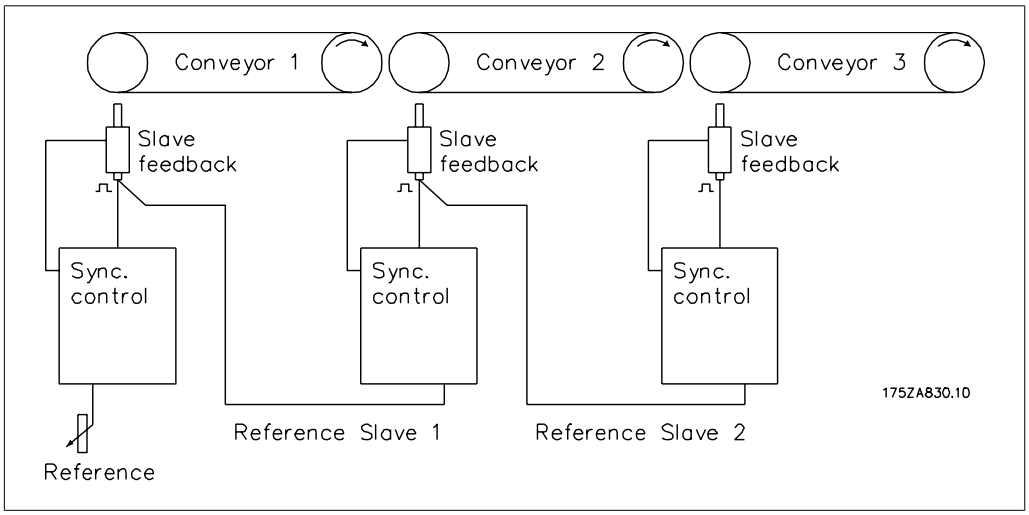


Illustration 5.1: Synchronisation without Virtual Master

As can be seen from the diagram below, at Start, as well as with every change in speed of the master drive, the cycle times are added. They are then compensated for again based on the control characteristics of the controller in question.

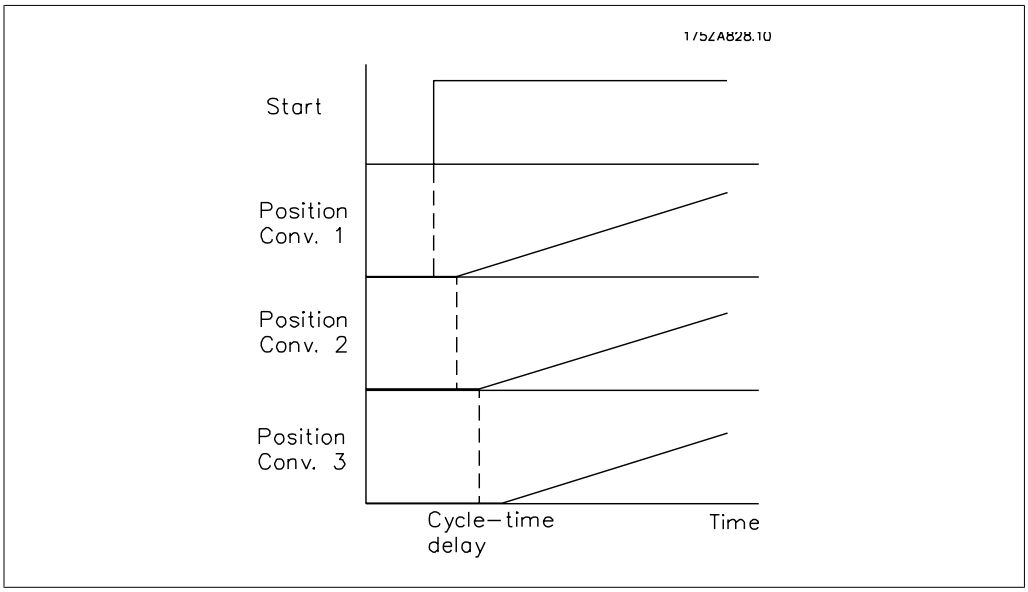


Illustration 5.2: Addition of the Cycle Times

In this case, the same application is realised by means of incorporating a virtual master. Although the way that the reference value is introduced at the first belt is analogous, the value is used to set the virtual master signals.

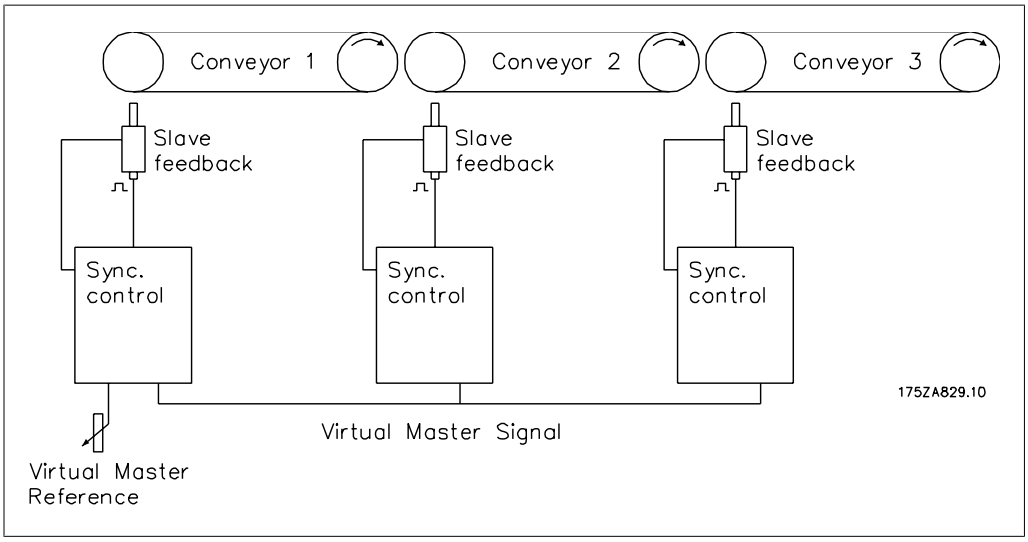


Illustration 5.3: Synchronisation with Virtual Master

It can be seen from the diagram below that the cycle time error is not added; instead, one cycle time applies for all the drives. The advantage of this is that the control has fewer errors to correct.

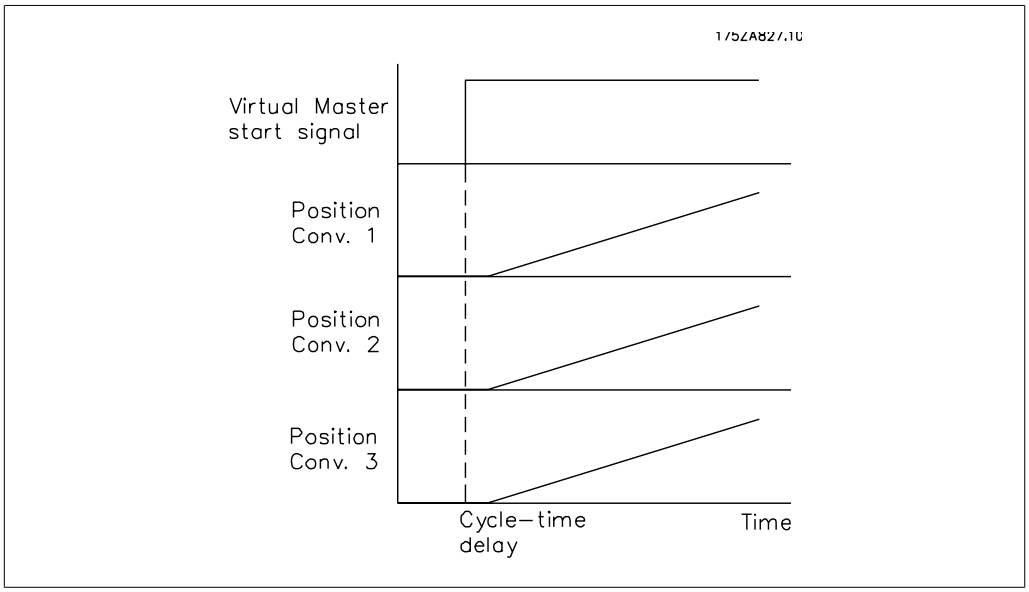


Illustration 5.4: No Addition of the Cycle Times

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