Synchronizing / Bypass option

for Emotron VFX 2.1 and FDU 2.1 AC drives

Instruction manual
English

emotron
DEDICATED DRIVE
A CG Product

Synchronizing / Bypass option

for Emotron VFX 2.1 and FDU 2.1 AC drives
valid from software version 5.12-11.07

Instruction manual — English

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Safety

Instruction manual

Read this instruction manual before starting installation.

This option is a supplementary part of the Emotron VFX/FDU AC drives and hereinafter in this manual referred to as the “main product” and the user must be acquainted with the original instruction manual of the main product. All safety instructions, warnings, etc. as mentioned in this instruction manual must be known to the user.

Safety instructions

Read the safety instructions in the instruction manual for the main product.

Installation

Installation, commissioning, dismounting, making measurements, etc. on the main product may only be carried out by personnel who are technically qualified for the task. Installation must also be carried out in accordance with the local standards. Ensure that all necessary safety measures are taken.

WARNING!
Take all necessary safety precautions during installation and commissioning to prevent personal injuries, e.g. by an uncontrolled load.

Opening the main product

WARNING!
Always switch off the mains supply before opening the main product.
For AC drives, wait at least 7 minutes to allow the buffer capacitors to discharge.

Always take adequate precautions before opening the main product, even though the connections for the control signals and jumpers are isolated from the mains voltage.

Contents

1. Introduction

The Synchronization and bypass option is a software for Emotron VFX 2.1 and FDU 2.1 making it possible to synchronize the inverter output to the actual grid voltage and frequency, and then bypassing the inverter. This software option requires measurement of the grid voltage by a voltage measurement unit (VMU). This option can be useful when the same drive is used for ramping up several motors. For example ramping up pumps to the grid speed.

NOTE: The Synchronization / Bypass option software requires an Emotron VFX/FDU AC drive with a connected voltage measurement unit.

2. System connections

The total system (according to Fig. 1) consists of:

- Emotron VFX/FDU with Sync/Bypass option software (V5.12-11.07).
- Voltage measurement unit (VMU)
- Standard output choke (not included in delivery).
- Bypass switch (not included in delivery).
- VSI switch (optional).

Wiring for Sync/Bypass option is shown in Fig. 5, page 13.

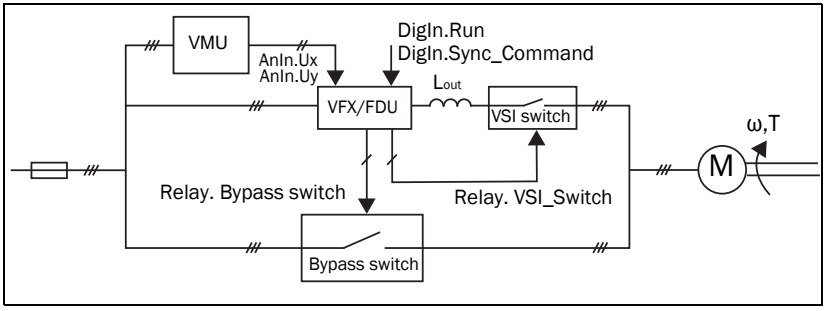


Fig. 1 System connections when using the Sync/Bypass option software.

The following default connections are used for digital inputs and relays. The VSI switch is optional and not configured per default.

Control board		Default setting
X1:9	Digital input 2	RunR
X1:16	Digital input 4	Sync Command
X3:51-52	Relay 3	Bypass switch

3. VMU installation

This section describes installation of the Emotron voltage measurement unit (VMU).

The VMU package includes:

- VMU
- Cable clamp for connection of control cable shield.
- This instruction manual

Fig. 2 Voltage measurement unit and clamp for shield connection.

Check for visible signs of damage. Do not install if damage is found. If damage is found or something is missing from the package, please contact your supplier.

Make sure that the AC drive has been switched off for **at least seven minutes** to ensure that the capacitor bank is discharged before continuing with installation! Also make sure that no external equipment connected to the drive's interface is powered on.

• Mount the VMU on a DIN-rail close to the main product.

3.1 Shielding

Connect the shield of control cable to the earthing clamp in the AC Drive close to the control board.

Connect the other side of the shield with the clamp (included in delivery) close to the VMU, see Fig. 2.

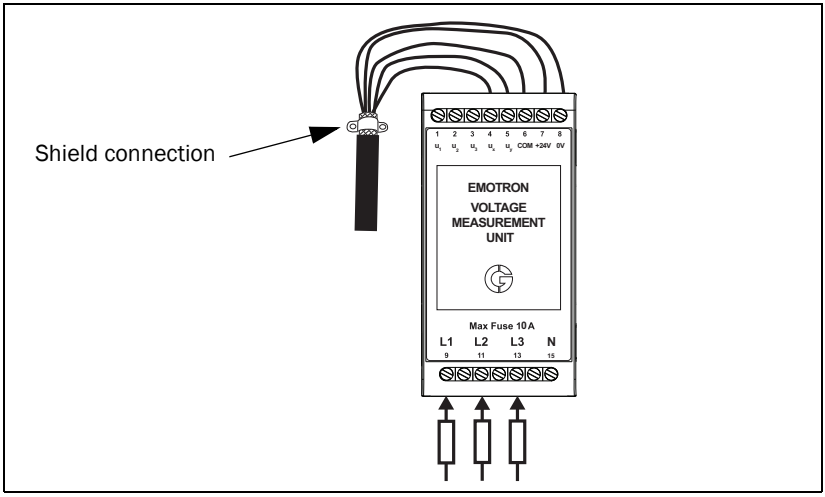


Fig. 3 Shield connection close to the VMU.

3.2 Installation

3.2.1 Terminals

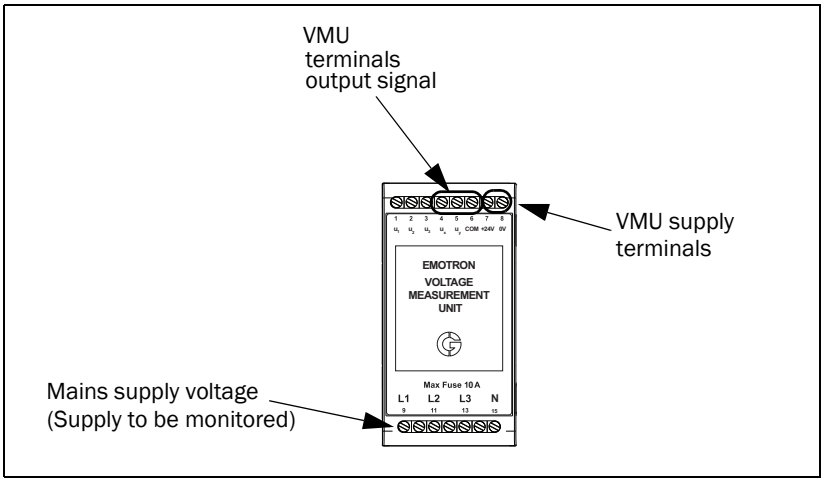


Fig. 4 Voltage measurement unit terminals.

Table 1 List of terminals and connections.

Terminal	Name	Function	Cable dimension
Terminals 1 - 8 for connections to 24 VDC, ground and measured analogue signals			
1	U_1	Not used	0.5 mm^2 Use screened cables
2	U_2	Not used	
3	U_3	Not used	
4	U_x	Connect to AnIn3 (X1.4)	
5	U_y	Connect to AnIn4 (X1.5)	
6	COM	Connect to X1.7	
7	+24 V	Connect to 24 V_{DC} supply X1.11)	
8	0 V	Connected to X1.7	
Terminals 9, 11, 13 and 15 connect mains supply to be monitored			
9	L1	Three phase supply, 380 - 690 V 50 - 60 Hz Install fuses of Max 10 A	1 mm^2
11	L2		
13	L3		
15	N	Optional	

Note that the VMU draws 50 mA (out of 100 mA) from the VFX/FDU control board.

NOTE: An external 24V_{DC} supply may instead be connected to terminals 7 and 8. Terminals 7 and 8 are galvanically isolated from terminals 1-6

3.2.1.1 Connections and wiring

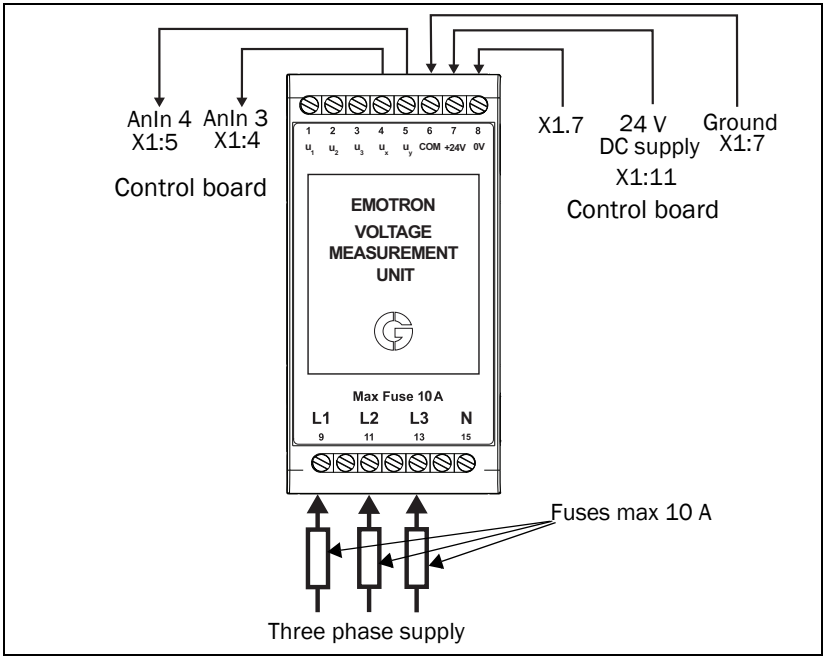


Fig. 5 Voltage measurement unit connection and wiring.

NOTE: Do not use X1:15 as ground.

NOTE: An external 24V_{DC} supply may instead be connected to terminals 7 and 8. Terminals 7 and 8 are galvanically isolated from terminals 1-6

VMU input supply voltage

The VMU requires +24 V_{DC} supply for its normal operation. VMU uses operational amplifiers for measuring the voltage, therefore it is important to have +24 V_{DC} supply input, otherwise the VMU can lead up to a wrong measurement.

Table 2 Input supply terminals

Connection terminal		Description
VMU terminals	**Control board terminals**	
7: +24 V	X1:11	+24 VDC supply. Control board of the main product can be used to supply +24 VDC to the VMU from X1:11 on the control board. For detailed information consult the instruction manual of the main product.
8: 0 V	X1:7	It is important for VMU to have proper reference signal. It can be obtained from Control board of the main product, terminals X1:7.

Input measuring signals

The voltage to be measured must be connected to L1, L2, L3 terminals. The voltage measurement unit measures three phase input supply up to 690V.

It is important to connect the three phases on the VMU in the same sequence as on the drive unit.

NOTE: An external 24V_{DC} supply may instead be connected to terminals 7 and 8. Terminals 7 and 8 are galvanically isolated from terminals 1-6

Outputs

The voltage measurement unit measures supply voltage and give two analogue outputs as a measurement i.e Ux and Uy.

Drive controller uses Ux and Uy for computing the grid supply voltage amplitude, frequency and phase sequence.

Output terminals

Table 3 Output terminals

Connection terminal		Description
Ux	1	Ux must be connected to analogue input 3 on the Control board
Uy	2	Uy must be connected to analogue input 4 on the Control board

NOTE: Control board selectors S3 and S4 must be set to U (voltage).

3.2.2 Earlier VMU revision

The earlier revision of the VMU is shown in Fig. 6. The main difference compared to the new VMU is that it does not provide the output signals U1, U2 and U3. These signals are not used by the Sync/Bypass option software.

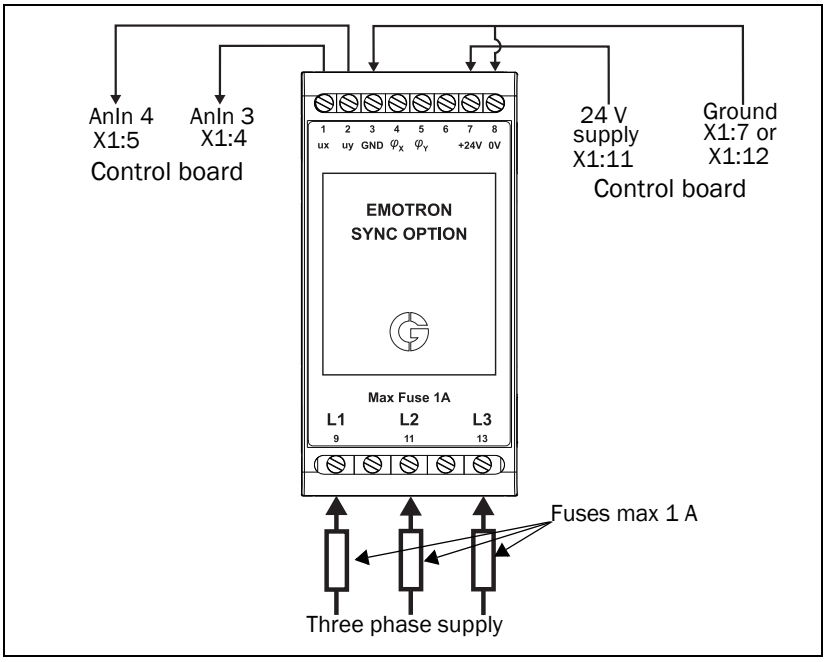


Fig. 6 Earlier VMU connection and wiring.

Table 4 List of terminals and connections.

Terminal	Name	Function	Cable dimension
Terminals 1 - 8 for connections to 24 VDC, ground and measured analogue signals			
1	Ux	Connect to AnIn3	0.5 mm^2 Use screened cables
2	Uy	Connect to AnIn4	
3	GND	Connect to Ground	
4	φ_x	Not used	
5	φ_y	Not used	
6		Not used	
7	+24 V	Connect to 24 V_{DC} supply	
8	0 V	Connect to Ground	
Terminals 9, 11 and 13 connect mains supply to be monitored			
9	L1	Three phase supply, 380 - 690 V, 50 - 60 Hz Install fuses of Max 1 A.	1 mm^2
11	L2		
13	L3		

4. Software configuration

This chapter describes how to set parameters on main product (VFX/FDU).

4.1 I/O configuration

Menus/switches described in this section needs to be set during commissioning of the product.

Table 5 Required setting with voltage measurement unit.

Menu		Default	Required Setting
518	AnIn 3 setup	4 - 20 mA	User Bipolar V
51B	AnIn 4 setup	4 - 20 mA	User Bipolar V

NOTE: To be able to use AnIn3 and AnIn4 for voltage measurement, set selectors S3 and S4 to "voltage" position, see Table 6.

Table 6 Settings for S3 and S4

Input	Signal type	Selector configuration
AnIn3	Voltage	S3 
	Current (default)	S3 
AnIn4	Voltage	S4 
	Current (default)	S4 

4.2 Option parameters

Following option menus/parameters are available for user settings when using the voltage measurement unit with Emotron VFX/FDU AC drives.

Table 7 Menus for voltage measurement unit.

Menu		Default value	Range/ Setting	Description	Modbus number
000	Sync option				
010	Sync pars				
011	Sync Enable	Off	Off External Internal Pump	Off - Syncing disabled Ext - Syncing from outside Int - Syncing controlled by Control board Pump - Syncing controlled by control board pump functionality See further information in Chapter 5.2 page 28.	48001
012	Sync Time	1 s	0 - 32 s	Maximum time for bypass switch detection, i.e. parallel operation **Note: Should be setup to maximum closing time of bypass switch.**	48002
013	Sync ΔCurr %	50 %	0 - 200 %	Bypass switch detection level based on margin on actual motor current. Detection to a fast current increase compared to mean measured current level in % above the mean value.	48003
014	Sync Curr A	Inv Imax	0 - 3000 A	Bypass switch detection level based on motor current. **Note: Should be set higher than maximum motor current and should not be more than inverters maximum current.**	48004

Table 7 Menus for voltage measurement unit.

Menu		Default value	Range/ Setting	Description	Modbus number
015	Sync ΔVolt %	20 %	0 - 200 %	Bypass switch detection level based on actual DC-link voltage. Detection to a fast DC-link change compared to mean measured DC-link voltage level in % above the mean value.	48005
016	Sync Volt V	Inv Umax	0 - 3000 V	Bypass switch detection level based on actual DC-link voltage. **Note: Should not be more than inverter maximum voltage.**	48006
020	Sync Status			Tells the state of the inverter.	
021	Status	0000		Syncing process, status register: - - - X = State - - x - = Syncing flag - x - - = Bypass detect flag See further in Table 8.	48011
030	Sync Sup Chk			Supply check when the motor is running. Detects supply deviations compared to motor voltage and frequency. See further information in Chapter 5.3 page 29.	
031	Check_ Enable	Trip	Off Trip Warning	A deviation results in a “Sync Sup Err” warning if a check is enabled and: - Drive trips is a synch command is given (Trip selected) - Drive blocks synch command (Warning selected)	48007
032	Sup V Lim	25%	0-50%	Allowed supply voltage deviation from nominal motor voltage.	48008

Table 7 Menus for voltage measurement unit.

Menu		Default value	Range/ Setting	Description	Modbus number
033	Sup F Lim	10%	0-50%	Allowed supply frequency deviation from nominal motor frequency.	48009
040	Sync Spd-PI			Speed PI parameters during synchronization. See further information in Chapter 5.4 page 29.	
041	Enable		Off On		48012
042	Spd Gain	5.0	0.1-60.0		48013
043	Spd I-time	0.10	0.05-100.0s		48014

Explanation of menu 021 Status

Table 8 Menu 021 status explanation

State "- - - X"	Syncing flag "- - X -"	Bypass detect flag "- X - -":
0=Stopped 1=Running normally 2=Syncing frequency 3=Syncing amplitude 4=Syncing angle 5=Bypassing 6=Mains	1 = Syncing active, trying to sync to supply frequency 3 = Frequency synced, trying to sync to supply amplitude 7 = Frequency and amplitude synced, trying to sync to supply angle F = Synced	1 = Timeout (depends on setting in [012]) 2 = Sync on current 4 = Sync on DC voltage 8 = Trip

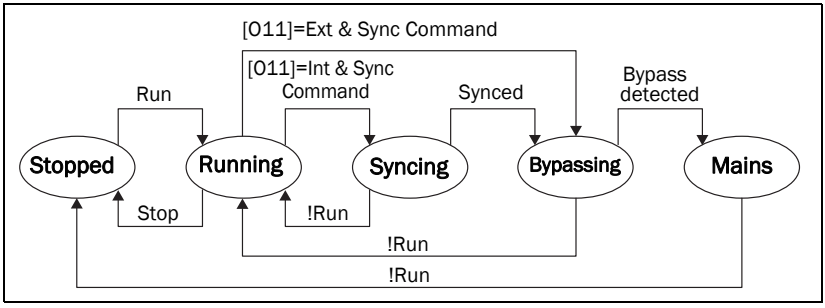
Added selections in standard menus

Table 9 Added selections in standard menus.

Menu		Selection	Comment
3941	Change Condition	... 3: Sync ...	
511	AnIn1 Function	... 6: Ux 7: Uy	Analog input selections for the voltage measurement board.
514	AnIn2 Function		
517	AnIn3 Function		
51A	AnIn4 Function		
52x	Digin x	... 38: Sync Command ...	Digital input selection for synchronization command.
56x	VIO # Dest		
54x	Dig Out x	... 90: Bypass switch ...	Digital output selection for bypass switch command.
55x	Relay x		
56x	VIO x Source		
54x	Dig Out x	... 111: VSI switch ...	Digital output selection of VSI switch (optional). This output is active until one second after reaching the mains state.
55x	Relay x		
56x	VIO x Source		

5. Functional description

5.1 State machine



Bypass switch=0	Bypass switch=0	Bypass switch=0	Bypass switch=1	Bypass switch=1
IGBTs=Off	IGBTs=Active	IGBTs=Active	IGBTs=Active	IGBTs=Off
VSI Switch=1	VSI Switch=1	VSI Switch=1	VSI Switch=1	VSI Switch=0 after 1 second

Fig. 7 Synchronization software option State machine.

5.1.1 Stopped

The AC drive is stopped.

5.1.2 Running

The AC drive is running normally with reference value from setup source.

5.1.3 Syncing

The AC drive is synchronizing to supply, i.e. reference value from internal control. When synchronizing is completed, i.e. in sync, then the bypassing state is entered.

The synchronizing consists of following three steps.

1. Ramp drive speed/frequency to supply speed/frequency.
2. Synchronizing drive speed/frequency and amplitude to supply frequency and amplitude.
3. Synchronizing drive phase angle to supply phase angle.

5.1.4 Bypassing

The digital output function "Bypass switch" becomes high in this state. This output should be used to activate the bypass switch. The AC drive is trying to detect actual closing of the Bypass switch. After detection the mains state is entered.

NOTE: The digital output function “Bypass switch” is in high state. This output should be used to activate the bypass switch.

The detection of closed bypass switch is triggered either from:

1. Time-out according to set time in menu [O12].
2. Current peak detected according to menus [O13] and [O14].
3. DC voltage increase, detected according to menus [O15] and [O16].

Status menu [O21] shows the current state of the sync/bypass functionality. It also shows the last detected bypass activation criteria.

NOTE: If menu “[O12] Sync time” = 0 s, the AC drive will be stopped when bypass switch is commanded.

NOTE: If menu “[O12] Sync time” = 32 s, then time-out is disabled, i.e. AC drive runs until current or DC voltage is detected. This is useful during commissioning to verify actual phase sequence if bypass switch operation is prohibited.

Fig. 8 explains how the current peak detection level is generated from menus [O13] and [O14] depending on the actual motor current.

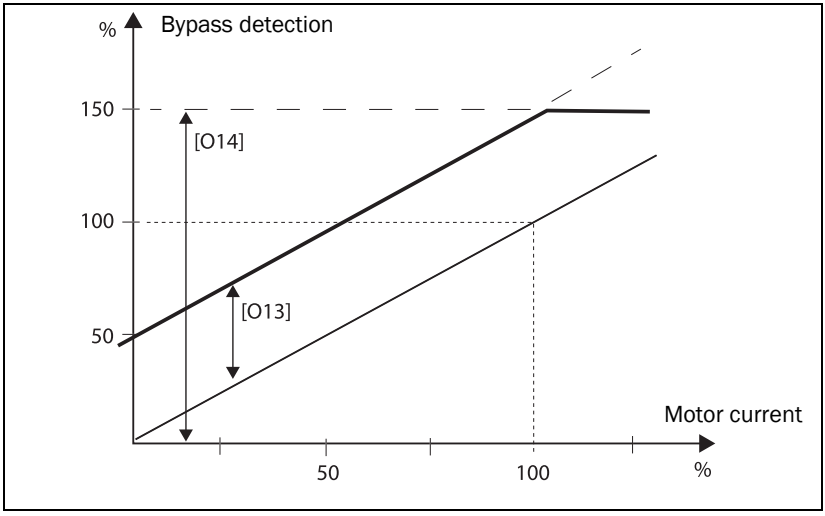


Fig. 8 Detection of bypass current as function of actual motor current.

5.1.5 Mains

The AC drive operation is blocked, i.e. not active.

Note that the digital output function "Bypass switch" remains high in this state.

Note that if the AC drive run command is removed, then the inverter state will turn to Stopped state and thereby the digital output function “Bypass switch” will turn low. If this is the case, external hold circuit for the bypass switch will be needed.

Note that the normally high digital output “VSI Switch” becomes low after 1 (one) second in the Mains state. This output can be used to control a drive output contactor. Deactivating the drive output contactor blocks mains voltage from being fed back to the IGBTs and DC-link.

5.2 Explanations of selections in menu [O11]

5.2.1 Internal

The typical usage of the Sync option is with internal synchronization. The synchronization sequence in this case is as follows.

- Power-up inverter -> Stopped

  * Inverter is stopped.

- Start inverter (Run from I/O, Fieldbus) -> Normal run

  * Inverter starts and ramps to [310].

- Activate Synchronization (Sync Command) -> Syncing

  * Inverter ramps to nominal speed

  * Inverter synchronizes frequency and amplitude

  * Inverter synchronizes phase-angle

- Inverter activates bypass switch (Sync Command) -> Bypassing

  * Inverter starts detecting actual closing of bypass switch via time, current or voltage.

- Inverter detects actual closing of bypass switch -> Mains

  * Inverter blocks operation.

- Stop inverter (removal of Run) -> Stopped

  * Inverter is stopped and state of bypass switch depends on hold circuitry.

5.2.2 External

If external synchronization is used, [O11] = External, then the syncing state is skipped. This means that the Bypass switch is activated directly, without synchronization, when a synchronization command is given.

5.2.3 Pump

The Sync option can be used for smooth transfer of pumps to mains, instead of throwing in slave pumps direct on line. This function is enabled if [394 Change Condition] = Sync. This setting forces [O11] = Pump. Disabling Sync as change condition forces [O11] = Off.

5.3 Supply check during synchronization [O3x]

The amplitude and frequency can be checked during synchronization. If the amplitude or frequency deviates, more from the nominal values than configured in [O32] and [O33], then a warning or trip “Sync Sup Err” is generated depending on the setting in [O31].

5.4 Speed PI parameters during synchronization [O4x]

Dedicated Speed PI parameter settings can be used during synchronization. Faster PI-control during synchronization can reduce the time needed for synchronization.

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