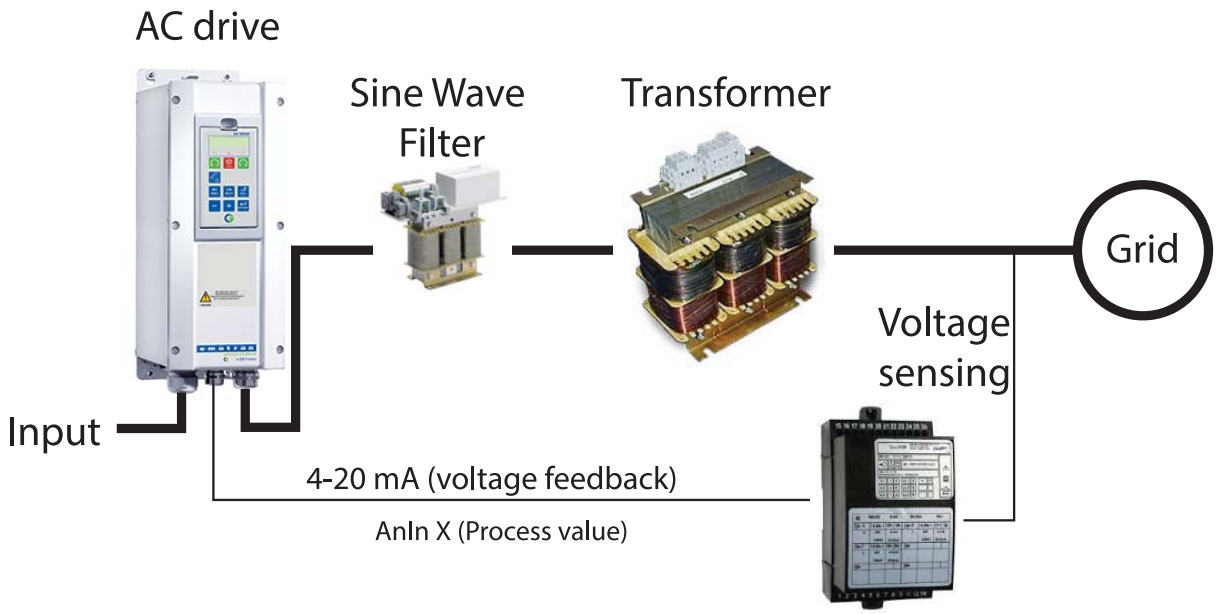
Emotron FDU Supply option

Software option for Emotron FDU2.0 AC drives
Valid from Software version **4.39-02.02**



Addendum to Instruction manual
English

emotron
DEDICATED DRIVE
A CG Product

Emotron FDU Supply option

Software option for Emotron FDU2.0 AC drives
Valid from Software version 4.39-02.02

Addendum to main Instruction manual

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Safety

This is an addendum to the main instruction manual for the AC drive. the user must be acquainted with the original instruction manual of the AC drive. All safety instructions, warnings, etc. as mentioned in the main instruction manual must be known to the user.

Handling the AC drive

Installation, commissioning, demounting, taking measurements, etc, of or on the AC drive may only be carried out by personnel technically qualified for the task.
A number of national, regional and local regulations govern handling, storage and installation of the equipment. Always observe current rules and legislation.

Opening the AC drive

WARNING!
If you need to open the product, 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 AC drive. Although the connections for the control signals and the switches are isolated from the main voltage, do not touch the control board when the AC drive is switched on.

Contents

1. Introduction

This manual is an addendum to the main instruction manual for Emotron FDU and describes the Emotron FDU Supply option. Using the Emotron FDU Supply option, user can create a supply (grid) with the desired voltage and frequency. It gives a possibility to control the output (grid) voltage and frequency levels independently as per need.

1.1 Operation principle

Standard AC drives usually handle voltage and frequency together so that they varies in relation to each other i.e. increasing frequency also results in increased output voltage and vice versa hence they cannot be used as a power supply. Therefore a special control principle is developed for “Emotron FDU Supply option” allowing independent control of output voltage and frequency so that they can be varied and controlled separately. Fig. 1 shows the working area of standard V/Hz based AC drive (dark grey) compared to the working area of special control principle of “Emotron FDU Supply option” (light grey). The dark grey zone designates the U/F line wherein the drives with the regular V/Hz control mode can work. In standard V/Hz control the speed (frequency) can be varied according to the necessities of the user but the output voltage is automatically adjusted in order to always deliver the optimal magnetic field. The special control principle of “Emotron FDU Supply option” allows the drive to run at any point of the graph area (dark grey and grey zone) by letting modify the output voltage without varying or affecting the frequency and vice versa, in other words both parameters can be set independently.

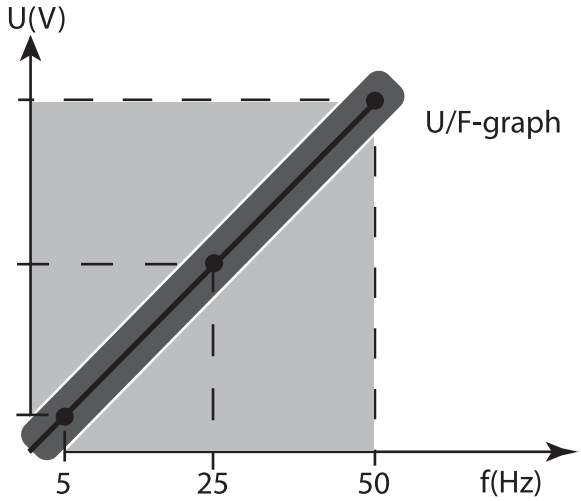


Fig. 1 Working area of the drive with V/Hz control (dark grey) and with the special control (dark grey and light grey)

1.2 Applications

Emotron FDU Supply option can be used in any application where the utility grid voltage or frequency do not match with the installed equipment or load. Following are typical applications of Emotron FDU Supply option.

- Shore connection for vessels: Different vessels have different rated equipment which makes it hard to make a shore connection when docked at the port. Emotron FDU Supply option helps to overcome this limitation.
- Testing: Some products are required to be tested at different combination of voltages and frequencies. Emotron FDU Supply option can be served as a test supply for such products.

1.3 Users

This instruction manual is intended for:

- Installation engineers
- Maintenance engineers
- Operators
- Service engineers

2. Mounting and installation

Mount and install the AC drive according to the main instruction manual for the AC drive.

3. Control connections

"Emotron FDU supply option" can be used either in

- Open loop applications or
- Closed loop applications.

For closed loop control, an external (drive output) voltage measurement device (transducer) is required. "Emotron FDU Supply option" functionality is activated via [321] Proc Source = "Option" which defines the "inverter output voltage" as the "process" and the "input reference".

3.1 Open loop voltage control

"Process value [711]" which is actually the inverter output voltage is calculated internally when used in open loop mode. No external, inverter output voltage measuring device is required to provide the feedback. Advantage of open loop control is that it is simple and easy to configure. On the drawback side, inverter is not able to compensate for the voltage drop that appears across the sinus filter and hence can't guarantee the fixed steady inverter output voltage. Fig. 2 shows the single line diagram of the system when configured in open loop voltage control.

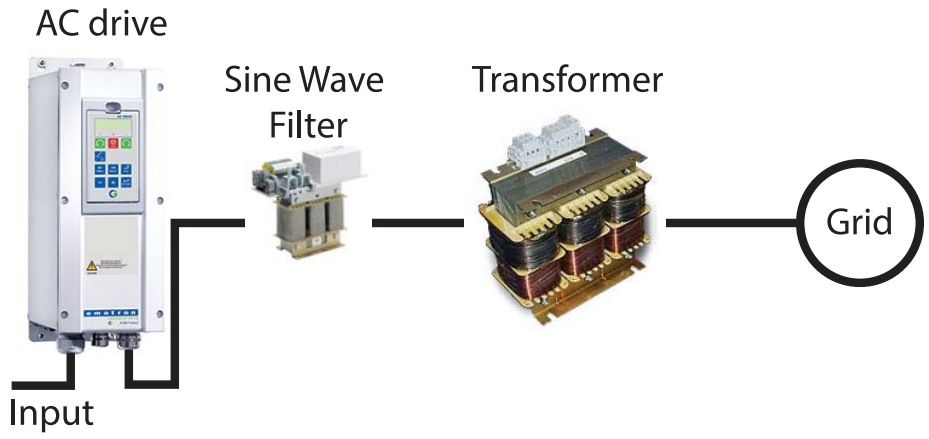


Fig. 2 Open loop voltage control.

3.2 Closed loop voltage control

An analogue input [51x] can be used to obtain the output voltage feedback for closed loop control. An external, drive output voltage measuring device (transducer) is required at first stage to get the signal to the analogue input (AnInx). Using the output voltage feedback and process PID controller [38x] (close-loop control), “Emotron FDU Supply option” can compensate for the voltage drop that appears across the sinus filter and thereby able to maintain a steady inverter output voltage (grid supply voltage) as per set reference level. However, it must be noted that “Emotron FDU Supply option” does not have the possibility of voltage boosting i.e. it cannot produce more than the input supply voltage. Practically instead there will be a drop of some % across the “Emotron FDU Supply option drive” itself and across the sinus filter. Therefore to have the output voltage equal to or higher than the input supply voltage, it is recommended to use a step-up transformer at the output of sinus filter. Fig. 3 below shows the connections when used in closed loop control mode.

Note: If an analogue input is defined to be a Process value then it will be taken as a voltage feedback (closed-loop) otherwise internally calculated voltage will be used (open-loop).

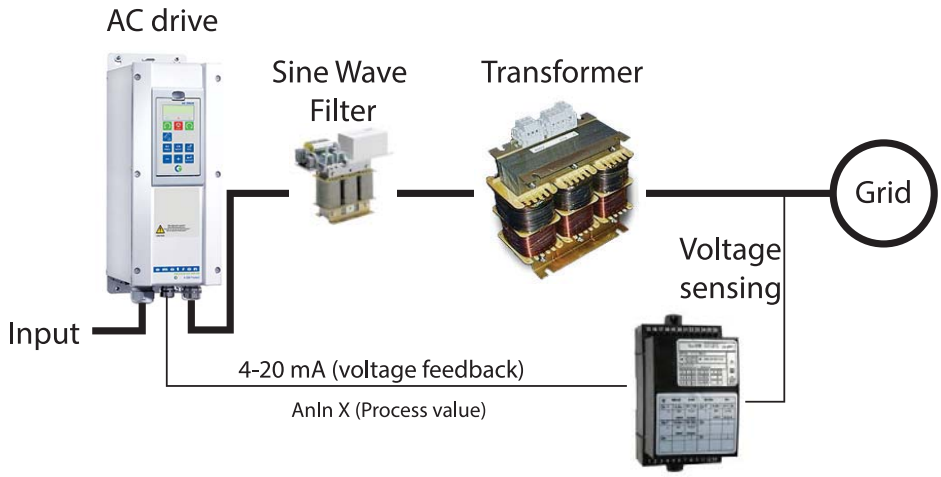


Fig. 3 Closed loop voltage control.

Here AnIn x represents the corresponding analogue input where x can be 1, 2, 3 or 4. Transducer used should be able to convert measured voltage into the analogue signal (voltage or current). Requirements on transducer can be found in section § 3.3, page 8.

3.3 Requirements on transducer or voltage measuring device

As mentioned earlier, an external, output voltage measuring device (transducer) is required for closed loop control of output voltage. In order to achieve optimum performance of the system, selected/used transducer should at least fulfil the following requirements.

1. Transducer should be able to convert measured voltage signal to analogue signal.
2. Analogue signal can either be voltage signal or current signal with any of the following specifications.
   Analogue signal ranging from 0 – 10 V where 10 volts should be enough to capture the voltage transients/spikes i.e. within 10 V feedback there should be room for over voltage and spikes if they appear in drive output voltage.
   - Analogue signal ranging from 2 – 10 V where 10 volts should be enough to capture the voltage transients/spikes i.e. within 10 V feedback there should be room for over voltage and spikes if they appear in drive output voltage.
   - Analogue signal ranging from 0 – 20 mA where 20 mA should be enough to capture the voltage transients/spikes i.e. within 20 mA feedback there should be room for over voltage and spikes if they appear in drive output voltage.
   - Analogue signal ranging from 4 – 20 mA where 20 mA should be enough to capture the voltage transients/spikes i.e. within 20 mA feedback there should be room for over voltage and spikes if they appear in drive output voltage..
3. Transducer should have galvanic isolation between the input and output terminals.

Although the voltage analogue signal can be used for feedback but still it is recommended to use a transducer that provides a 4-20 mA analogue signal. Current analogue output signal is preferred over voltage analogue signal because current eliminates errors due to wire resistance and also it is less affected by electrical noise. 4-20 mA signal is preferred over 0 to 20 mA signal as it indicates when there is an open wire or any transmission failure.

It is also recommended to use a shielded cable for feedback signal so that it is least affected by the noise.

Note: Analogue inputs [51x] on drive must be configured according to the type of feedback signal i.e. voltage or current signal. See further information in main instruction manual, chapter “Functional description”.

4. PID Process controller for closed loop application.

See main instruction manual chapter “PID Process control [380]”.

4.1 Tuning of PID controller

Tuning the PID controllers is a complex topic and it is hard to give a general tuning guide of PID controllers that can fit to all systems as every system has its own dynamics and response. Table 1 below gives an idea about the impact of different parameters on the performance of PID controller. Tuning PID D Time [385] is the most complicated task therefore it is recommended to not use PID D Time [385] i.e. set 0 in [385] as it is not required for most of the systems. Also the default (factory) values used in [383], [384] and [385] are good enough for most of the systems therefore it is recommended to first run/test the system with default (factory) values in [383], [384] and [385]. If system works OK then don’t change the values in [383], [384] and [385] otherwise tuning can be done.

Table 1 Effect on increasing a parameter independently.

Parameter	Rise Time	Overshoot	Setting time	Steady state error	Stability
PID P Gain [383]	Decrease	Increase	Small change	Decrease	Degrade
PID I Time [384]	Minor change	Increase	Increase	Decrease	Degrade
PID D Time [385]	Minor change	Decrease	Decrease	No effect in theory	Improve if PID D Time [385] small

5. Power connections

For proper functioning and control, it is desired to have a sinus filter and a breaker at the output of the VSI. Breaker gives the freedom to the operator to connect or disconnect the VSI at any time (for example in case if any fault appears at the grid and it is desired to isolate the VSI from the rest of the grid). Sinus filter is required to improve the quality of the voltage created by the VSI. Fig. 4 shows a single line diagram for power connections of "Emotron FDU Supply option". It is recommended to use step-up transformer at the output of sinus filter for following reasons:

1. Possible to achieve equal to or higher than input supply voltage as "Emotron FDU Supply option" does not offer boosting of voltage.
2. Transformer adds the possibility of neutral (star connected output winding, neutral point).

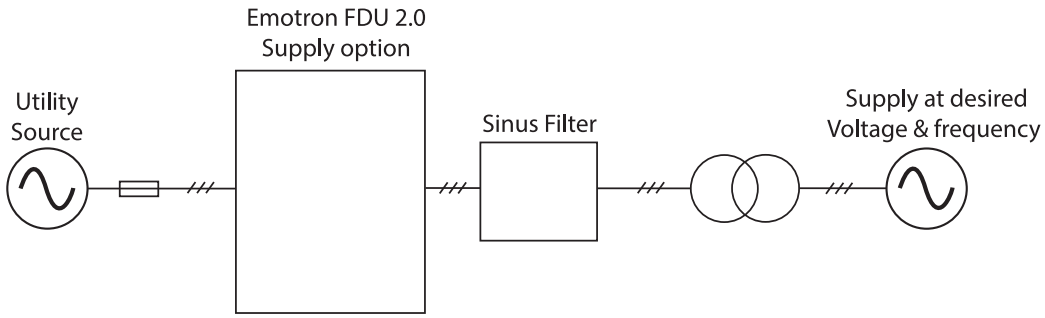


Fig. 4 Single line diagram of Emotron FDU Supply option system

6. Supply option functional description

6.1 Nominal values

Settings in following menus define the corresponding nominal values.

- [221 Motor Volts] Defines nominal inverter output voltage i.e. before transformer and sine filter.
- [222 Motor Freq] defines nominal maximum output frequency.
- [223 Motor Curr] defines current limit of CL controller if enabled via [O21].

6.2 Voltage control

Unlike standard FDU 2.0 drive, Emotron FDU Supply option has the possibility to produce desired inverter output voltage. The inverter output voltage can be produced from 0 up to the mains supply input voltage before transformer and sine filter. Inverter output voltage is considered as the process which Emotron FDU Supply option can control.

Emotron FDU Supply option has the possibility to control inverter output voltage either in open loop or in closed loop. For closed loop control inverter output voltage needs to be measured and feedback in via analogue input. Detail about configuring the closed or open loop voltage control can be found in chapter 7.4 page 16.

6.3 Frequency control

Emotron FDU Supply option can control inverter output voltage and frequency independently meaning that user can create a grid of its own desires. Unlike inverter output voltage, the inverter output frequency is not limited to the mains supply frequency. Emotron FDU Supply option can produce frequency greater or lower than the input supply frequency depending upon the user requirement.

With the existing “supply option‘’ software it is not possible to have a closed loop frequency control. “Supply option” can produce either a fixed output frequency or variable desired output frequency depending upon how the inverter is configured.

6.3.1 Fixed output frequency control

By default “Supply Option” produces a fixed output frequency that is a function of [222] “Motor Freq” i.e. drive produces output voltage at a frequency that is defined in window [222].

6.3.2 Variable output frequency control

Using the analogue input “Emotron FDU Supply option” can produce variable output frequency i.e. by varying the maximum allowed frequency through analogue input the drive can produce a voltage at variable frequency. For that one of the analogue inputs needs to be configured as a function of maximum speed (Max Speed).

[222] “Motor freq” defines the maximum frequency that supply option can produce at the inverter output when operated in variable frequency control mode i.e. output frequency can be controlled between 0 and value set in [222] via the corresponding AnIn that is set as “Max Speed”. Detail about configuring the variable output frequency control can be found in chapter 7.4 page 16.

6.4 Current controller

Grid created by the “Emotron FDU Supply option” is usually a weak grid especially if a sudden high load connection is made. This type of connections can cause an “over current trip” on the inverter. To avoid such unnecessary “over current trips” an internal current control (PI controller) is implemented in the software. Output of the current controller directly controls the inverter output voltage. Fig. 5 below shows the study case without current controller, with default current controller and with fast current controller. It should be noted that current controller controls the inverter output voltage to control/reduce the inverter current. Depending upon the load step inverter output voltage is reduced and then ramped slowly. User should analyze its application before using current control mode if this behaviour suits user application or not.

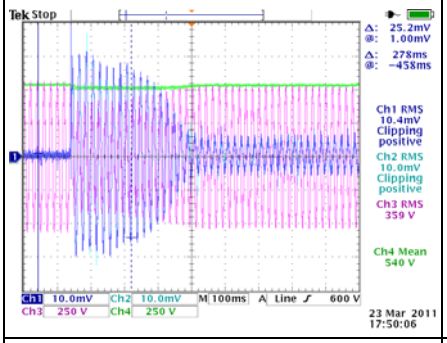
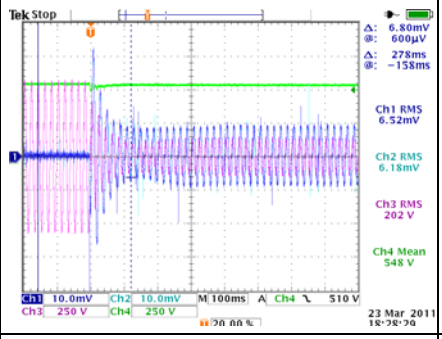
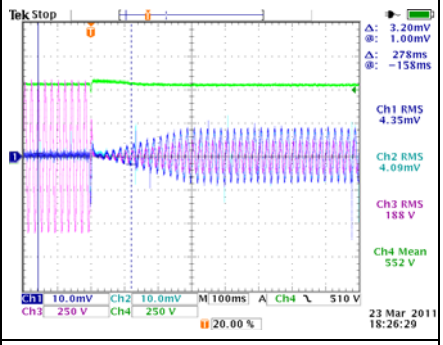
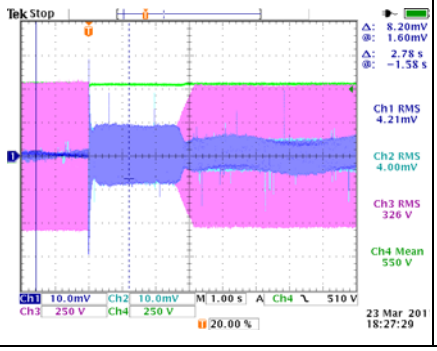
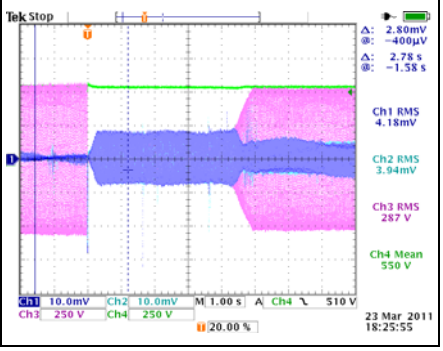
1) No CL control 011=1s 021=0ff	2) CL control (default) 011=1s 021=0n 022=0.01 023=0.1s	3) CL control (Fast) 011=1s 021=0n 022=0.1 023=0.1s
		
Ch1: Iw,Lsin [1mV/A] Ch2: Iw,motor[1mV/A] Ch3: Uuv [1V] Ch4: Udc [1V]		

Fig. 5 Demo setup FDU48-019, 4kVA sine filter (10mH,3uF), load breaker and a 2.2kW induction motor.

Dynamic measurements where the 2.2kW motor was directly started by activating the load breaker for
1) No CL controller,
2) Default CL controller and
3) Fast CL controller.

6.5 Sinus filter

Output of the inverter voltage along with the fundamental frequency component contains undesired high frequency components (around inverter switching frequency) which should be removed. To remove the high frequency components it is required to use a sinus filter at the output of the inverter.

Please see in the Technical catalogue for filter Information.

6.6 Software protections

Following standard FDU software protections, limits or controllers are disabled in Emotron FDU Supply option.

- Torque limit controller
- Current limit controller
- Over voltage controller
- Low voltage override controller.
- Over current control limit is defined via [224] Motor current.
- Motor ID run is disabled if [321] = “Option”.

7. Getting started

7.1 Supply option parameters

Table 2 Supply option parameters and factory default settings, adjustable according to requirement.

Window	Default	Range	Modbus nr	Modbus format	Description
000 Supply opt					
010 Voltage pars					
011 U Ramp	1.00 s	0.01 - 10.0s	48001	EInt	Defines voltage ramp time. Defined as time from 0 to Unom.
020 Current Pars					
021 CL PI Ctrl	On	0= Off 1= On	48011		Enables Current Lmit PI-controller.
022 CL PI Gain	0.010	0.000 - 1.00	48012	EInt	Defines Current Lmit PI controller P gain.
023 CL PI Time	0.100s	0.01 - 10.0s	48013	EInt	Defines Current Lmit PI controller I time.

7.2 Factory default settings for standard parameters

The following standard user/service parameters have factory default settings which are compatible with Emotron FDU Supply option software functionality. During commissioning it must be verified that all of the below given menus are configured as per below given default settings.

Table 3

Window	Default	Comment (via [243])
212 Select Motor	M4	M4 dedicated to Emotron FDU Supply option functionality
213 Drive Mode	V/Hz	
22A Motor Sound	Advanced	
22E2 PWM Mode	Sine Filt	Sine filter operation
321 Proc Source	Option	Option to enable Emotron FDU Supply option functionality
339 Start Mode	Fast	
33B Stop Mode	Coast	Coast to avoid frequency ramp when stopping
421 Low Volt OR	Off	Off to avoid frequency decrease by LVO operation

Table 4

Window	Default	Comment (only via [243] = “Factory default”)
E477 OvComp igno	On	On to disable compensation for over-modulation
E47B Uboost igno	On	On to disable over-modulation
E47C PEBB igno	On	On to disable current sharing protection

7.3 Motor data [220]

Settings in motor data [220] define the nominal maximum inverter output voltage and frequency therefore it is important to set these parameters as per desired requirements. Table 5 gives an explanation regarding the impact of settings in motor parameters on the inverter output.

Table 5

Window	Default	Comment (via [243])
221 Motor Volts	400 V	Defines nominal maximum inverter output voltage i.e. before transformer and sine filter. Note: Physically inverter maximum output voltage is limited by the input supply voltage i.e. inverter cannot produce output voltage higher than the input supply voltage.
222 Motor Freq	50 Hz	Defines nominal maximum inverter output frequency.
224 Motor Curr	I_{MOT}	Defines current limit of current limit (CL) controller if enabled via [021].

For configuring variable frequency/Voltage setting, proceed according to Chapter 7.4 page 16.

NOTE: M4 is automatically selected when [321] is configured to 'Option' and similarly motor set 1 (M1) is selected if [321] is configured to something else than 'Option'.

NOTE: [229] Motor ID-run disabled if [321]='Option'.

7.4 Connection examples

Default settings in “Emotron FDU Supply option” software is for open loop control i.e. without feedback. It is very easy to configure for closed loop control as it requires only altering a couple of menus.

7.4.1 Open loop with variable output voltage and fixed frequency

“Emotron FDU supply option” can produce variable inverter output voltage depending upon the provided voltage reference. Voltage reference can be given from remote, local (keyboard) or through communication mode. Table 6 and Fig. 6 gives an idea about how to configure for an open loop variable inverter output voltage and fixed frequency installation/application.

Table 6 Menu settings.

Menu	Default	Comment
214 Ref Control	Remote	Use default value
221 Motor Voltage	400	Set maximum desired output voltage
222 Motor Freq	50.0 Hz	Set maximum desired output frequency
224 Motor Current	I_{MOT}	Set maximum desired output current
511 AnIn1 Fc	Process Ref	Reference can vary from 0 to value set in menu [221]
512 AnIn1 Setup	4 - 20 mA	Note: Current signal is used in this example but voltage signal can be used if required.

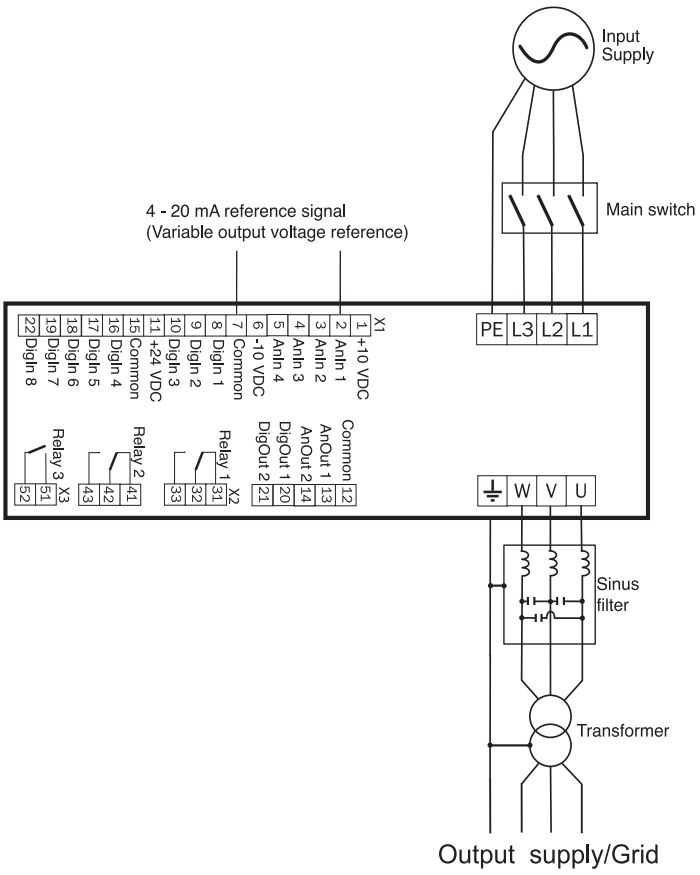


Fig. 6 Connection example, Open loop - variable voltage - fixed frequency.

7.4.2 Open loop with variable output voltage and variable frequency

"Emotron FDU supply option" has the possibility to produce variable inverter output voltage at variable (desired) frequency. Analogue input can be used for controlling the frequency of the output voltage. Table 7 and Fig. 7 gives an idea about how to configure for an open loop variable inverter output voltage and variable (desired) frequency installation/application.

Table 7 Menu settings.

Menu	Default	Comment
214 Ref Control	Remote	Use default value
221 Motor Voltage	400	Set maximum desired output voltage
222 Motor Freq	50.0 Hz	Set maximum desired output frequency
224 Motor Current	I_{MOT}	Set maximum desired output current
511 AnIn1 Fc	Process Ref	Reference can vary from 0 to value set in menu [221]
512 AnIn1 Setup	4 - 20 mA	Use default value. Note: Current signal is used in this example but voltage signal can be used if required.
514 AnIn2 Fc	Off	Set to "Max speed" for use as variable output frequency reference (if 50 and 60 Hz output to be selectable)
515 AnIn2 Setup	4 - 20 mA	Use default value. Note: Current signal is used in this example but voltage signal can be used if required.

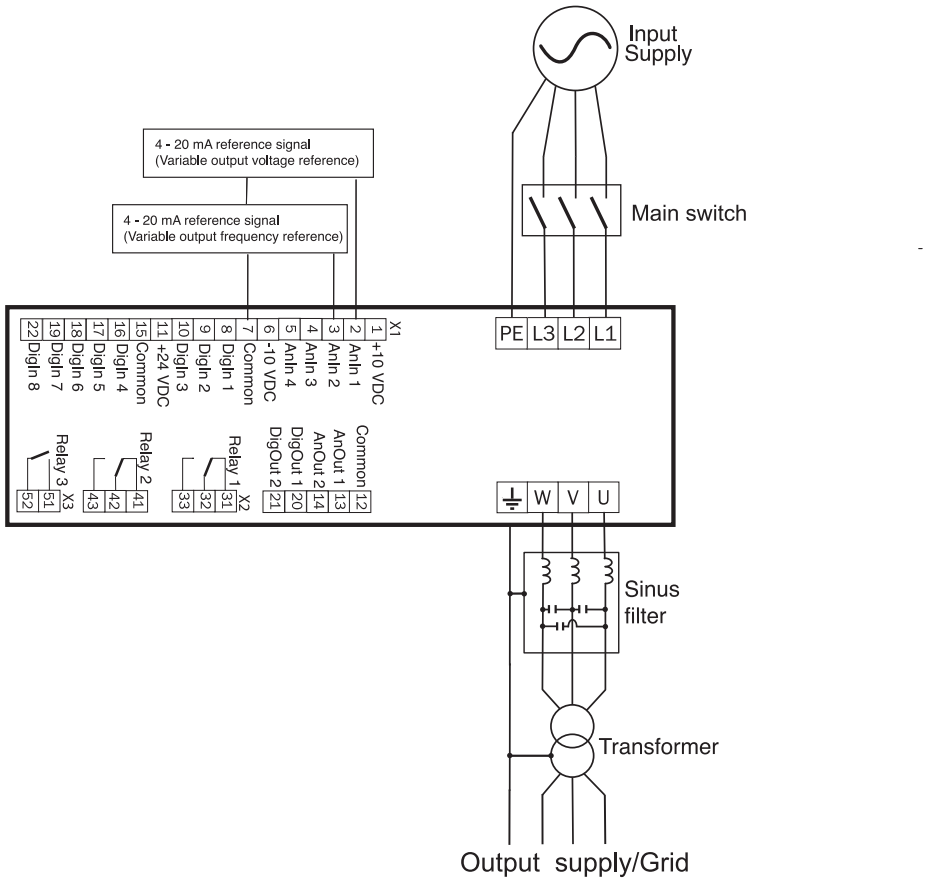


Fig. 7 Connection example, Open loop - variable voltage - variable frequency.

7.4.3 Closed loop with variable output voltage and variable frequency

For more precise control of inverter output voltage, “Emotron FDU supply option” can be configured in closed loop control where inverter output voltage feedback must be provided to the drive. Table 8 and Fig. 8 gives an idea about how to configure for closed loop variable inverter output voltage and variable (desired) frequency installation/application

Table 8 Menu settings.

Menu	Default	Comment
214 Ref Control	Remote	Use default value
221 Motor Voltage	400	Set maximum desired output voltage
222 Motor Freq	50.0 Hz	Set maximum desired output frequency
224 Motor Current	I_{MOT}	Set maximum desired output current
511 AnIn1 Fc	Process Ref	Reference can vary from 0 to value set in menu [221]
512 AnIn1 Setup	4 - 20 mA	Use default value. Note: Current signal is used in this example but voltage signal can be used if required.
514 AnIn2 Fc	Off	Set to "Max speed" for use as variable output frequency reference (if 50 and 60 Hz output to be selectable)
515 AnIn2 Setup	4 - 20 mA	Use default value. Note: Current signal is used in this example but voltage signal can be used if required.
517 AnIn3 Fc	Off	Set to “Process value”
518 AnIn3 Setup	4 - 20 mA	Use default value. Note: Current signal is used in this example but voltage signal can be used if required.

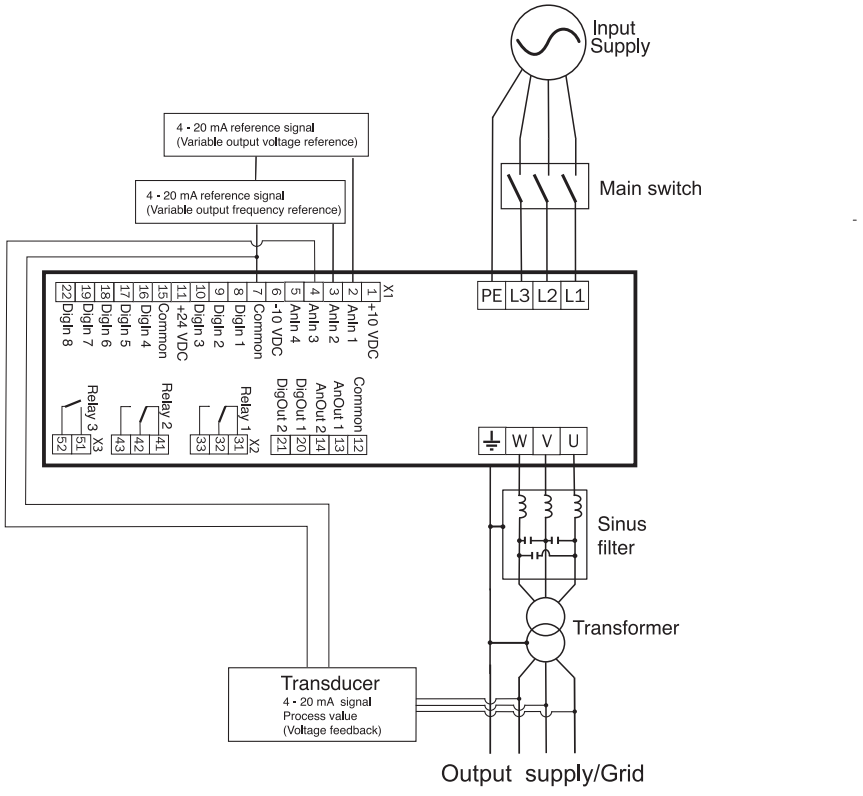


Fig. 8 Connection example, Closed loop - variable voltage - variable frequency

8. Specifications

See main instruction manual for Emotron FDU chapter Technical specifications.

9. Commissioning steps

1. Verify that drive is configured in FDU mode, see menu [921].
2. Verify that the supplied drive is provided with the corresponding “Emotron FDU Supply option” software in menu [923]. “Emotron FDU Supply option ” has software designation number 4.xx-02.xx. 02 here indicates that it is “Emotron FDU Supply option” software.
3. Connect the drive and sinus filter as shown in Fig. 3. Connect the feedback signal after sinus filter if closed-loop control is used.
4. Verify that the option parameters [Oxx] and standard parameters are configured as given in given in Table 2 to Table 4.
5. Verify that menu [321] is configured as “option”.
6. Verify that M4 is configured in menu [212].
7. For closed-loop control, configure one of the corresponding analogue input to “Process Value”.
8. For closed-loop control, configure process PID controller menu [381] to “ON”.
9. Configure the drive to be operational for testing from local control i.e. configure run/stop in menu[215], reference in menu [216]and reset to Keyboard mode in menu[214].
10. Set output voltage reference in menu[310].
11. Start the drive and verify that drive produces the desired voltage and frequency at the output.
12. Set desired ramp time in menu [O11].
13. Check if tuning is required for current in menu [O20].
14. If closed loop, also check if tuning is required in menu group [380].
15. Finally set run/stop control (menus [214], [214], [215]) according to customers requirement.

CG Drives & Automation Sweden AB
Mörsaregatan 12
Box 222 25
SE-250 24 Helsingborg
Sweden
T +46 42 16 99 00
F +46 42 16 99 49
www.emotron.com/www.cgglobal.com

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