OPEN DRIVE

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Regenerative AC-DC
A.F.E.

INDEX

The Regenerative AC-DC Converter (**A**ctive **F**ront **E**nd) acts as an AC-DC rectifier with line input voltages L1, L2, L3 and output being the V_{BUS} DC set by the user. The power exchanged with the mains can be in the two directions (absorption or power regeneration), according to the needs of the load.

The control is made by a voltage loop (V_{BUS} DC) and a current one, that provides sinusoidal current under any condition of load (the part of reactive power can be set by the user). In detail, when setting at zero the part of reactive power exchanged with the mains, only active power is exchanged with the mains (power factor equal to one).

1. Complete list of the control values

1.1. Parameters

The parameters are configuration values of the converter that assume a numeric value included in the range admitted. Their representation is very often in percentage and this is very useful if one must change the converter size, because one just needs to modify the only reference values and the rest shall automatically change. The parameters are divided in free, reserved and reserved TDE MACNO.
The following rules are valid:

- **Parameters free**: they can be modified also when running without opening any key
- **Reserved parameters (r)**: they can be modified only out of running, after opening the reserved parameters key in P60 or the reserved parameters key TDE MACNO in P99
- **Reserved parameters TDE MACNO (t)**: they can be modified only out of running, after opening the reserved parameters key TDE MACNO in P99. Until the related key is not open, these parameters are not shown in the display.

The complete list of parameters is indicated below.
Pay great attention to the referring values of the various parameters for their correct setting. In the last column it is indicated the internal representation of the parameters; this data is important if one wishes to read or to write the parameters via serial or field bus.

Example1: P62 = Rated voltage of mains

Normalization unit = Volt
Internal repr. = 10
Internal value = 3800 → real data = 3800/10 = 380.0 Volt

1.1.1. Parameters list

PAR.		DESCRIPTION	FIELD	DEFAULT	REPR
P r	01	Corrective factor analog ref. 1 (AN_INP_1) at 14 bits	±400.0	100.0	%
P r	02	Corrective offset analog ref. 1 (AN_INP_1) at 14 bits	±100.0	0.0	%
P r	03	Corrective factor analog ref. 2 (AN_INP_2) at 14 bits	±400.0	100.0	%
P r	04	Corrective offset analog ref. 2 (AN_INP_2) at 14 bits	±100.0	0.0	%
P	05	Corrective factor analog ref. 3 (AN_INP_3) at 14 bits	±400.0	100.0	%
P	06	Corrective offset analog ref. 3 (AN_INP_3) at 14 bits	±100.0	0.0	%
P r	07	Voltage reference V_{BUS} DC *(internal calculation)*	110.0÷200.0	115.0	%P62*rad(2)
P r	08	Voltage reference V_{BUS} DC	300.0÷110.0	650.0	[Volt]
P r	30	Feed Forward of current	5.0÷40.0	5.0	ms

P	31	KpV voltage regulator proportional gain	0.5÷100.0	6.0	
P	32	TiV voltage regulator lead time constant	4.0÷1000	30.0	ms
P	33	TfV voltage regulator filter time constant	0÷25	0.4	ms
P t	39	Minimum voltage V_{BUS} DC for end of soft-start	60.0÷95.0	80.0	% Vrete
P	40	Current limit	0 ÷ P103	P103	% $I_{NOM\ CONV}$
	42	Maximum regeneration current	0÷400	200	% $I_{NOMLine}$
P r	43	Maximum absorption current	–400÷0	-200	% $I_{NOMLine}$
P r	50	Alarm level for minimum mains voltage	65.0÷95.0	70.0	%P62
P r	51	Alarm level for maximum mains voltage	105.0÷135.0	130.0	%P62
P r	52	Corrective factor of mains voltage (d21)	25.0÷200.0	100.0	%
P	53	Rated current of converter (displaying)	0.0÷400.0	1	Ampere
P	54	Sampling period MONITOR	1÷19999	1	T_{PWM}
P	55	Points stored after the event of trigger MONITOR	1÷2000	1	
P	56	Level of trigger MONITOR	-200.0÷200.0	0.0	%
P	57	Val. % corresponding to the 10V for the analog outputA	100.0÷400.0	200.0	%
P	58	Val. % corresponding to the 10V for the analog outputB	100.0÷400.0	200.0	%
P	60	Access key to reserved parameters	0÷19999	P100	
P r	61	In Line (reactor)	10.0÷100.0	100.0	% $I_{NOM\ CONV}$
P r	62	Rated voltage of mains V_{NOM}	30.0÷500.0	400.0	Volt.
P r	63	Rated frequency of mains $f_{NOM\ MAINS}$	50.0÷60.0	50.0	Hertz
P r	64	Filter of Mains Voltage	0.0÷30.0	0.0	ms
P r	65	Time delay to switch on the Soft-start remote control	20÷2000	1000	ms
P r	68	Reactive reference current (Iq_rif)	-50÷50	0	%($I_{NOM\ Line}$)
Pr	71	Thermal constant of time, main reactance	30÷2400	600	S
P r	75	Initial position angle (internal reconstruction)	±180.0	4.7	Degrees
P r	76	ΔV_{RS} %	1.0÷25.0	1.0	% $V_{NOM\ CONV}$
P r	77	ΔV_{LS} %	5.0÷100.0	10.0	% $V_{NOM\ CONV}$
P r	78	Time constant (main inductance) τ_S	0.0÷50.0	50.0	ms
P r	83	Kpc current regulator proportional gain	0.5÷100.0	1.0	
P r	84	Tic current regulator lead time constant	0.0÷1000.0	50	ms
P r	85	Tfc current regulator (filter) time constant	0÷25	0.0	ms
P r	91	Reactor maximum temperature (if measured with PT100)	0.0÷150.0	130.0	Degrees C°
P r	92	Serial identification N.	0÷255	1	
P r	93	Baud rate	19.2, 38.4, 57.6	19.2	Kbit/s
P r	95	Reactor NTC or PTC value for alarm	0-19999	1500	Ω
P r	96	Intervention threshold of logic output 14 thermal of reactor	0.0÷200.0	100.0	%P70
P r	97	Minimum level of voltage for the forcing of the mains-off	100÷1200	425	Volt
P r	99	Access key to the TDE parameters	0÷19999	-------	

1.1.2. Other TDE MACNO reserved parameters

P t	100	Value of the access key to the reserved parameters	0÷9999	95	
P r	101	PWM Frequency	2500÷16000	5000	Hz
P t	102	Dead time compensation	0.0÷100.0	20.0	‰ V max
P t	103	I converter limit	0.0÷200.0	200.0	% $I_{NOM\ AZ}$
P t	104	Time constant of heatsink	10.0÷360.0	80.0	Secondi
P t	105	Corrective factor of Bus voltage	80.0÷200.0	100.0	%
P t	106	Minimum DC Bus Voltage	200.0÷500.0	400.0	Volt

P t	107	Maximum DC Bus Voltage	350.0÷1200.0	760.0	Volt
P t	110	Offset A/D 1	-100.0÷100.0	0.0	% Vmax
P t	111	Offset A/D 2	-100.0÷100.0	0.0	% Vmax
P t	112	Waiting time to return to display standby	3÷20	5	Secondi
P t	113	Converter maximum current	0÷2000.0	0	Ampere
P t	115	Multiplicative factor of analog reference PTC/NTC/PT100 of the reactance	0.0÷200.0	100.0	
P t	116	Junction time constant	0.1÷10.0	3.5	Secondi
P t	117	Multiplicative factor of analog reference PTC/NTC heatsink	-200.0÷200.0	100.0	
P t	118	Maximum temperature admitted by PTC/NTC heatsink	0.0÷150.0	100.0	°C
P t	119	Maximum heat-sink PTC/NTC temperature for start-up	0.0÷150.0	85.0	°C
P t	120	Temperature threshold for logic output o.15	0.0÷150.0	90.0	°C
P t	122	Index of maximum modulation	0.500÷0.994	0.98	
P t	126	KpI Corrective coeff. Kp estimated for current loop	0÷200.0	50.0	
P r	129	Test current for the determination of the ΔV_{LS}	0÷100.0	30%	% $I_{NOM\ MOT}$
P r	151	Xb = amplitude of the cubic junction zone	0÷50.0	0.0	% $I_{NOM\ AZ}$
P r	152	Yc = compensation to the nominal converter	0÷100.0	100.0	% P102
P r	153	Xoo = amplitude of dead zone	0÷50.0	0.0	% $I_{NOM\ AZ}$
P t	155	Room temperature of reference (overload)	0.0÷150.0	40.0	°C
P t	156	Converter characteristic PWM frequency	2500÷16000	5000	Hz
P t	157	Duration of dead times	3.0÷20.0	4.0	usec
P t	158	Corrective coeff. terms of decoupling	0.0÷800.0	50.0	
P t	160	Compensation of the delay of the PWM on the currents	-400.0÷400.0	40.0	%T_{PWM}
P t	161	Compensation of the delay of the PWM on the voltages	-400.0÷400.0	140.0	%T_{PWM}
P t	162	ID node CAN BUS	1÷127	1	
P t	163	Alarms enabling	-100.0÷100.0		
P t	174	Converter AC characteristic voltage	200.0÷690.0	400.0	Volt(rms)
P P	180 ÷ 199	----- Reserved to the application ----- see application enclosure			

1.2. Connections

The connections are configuration values of the converter that assume a numeric value to simulate a digital selector.
The connections are divided in free, reserved and reserved TDE MACNO; for their modification the same rules seen for the parameters are valid.
The internal representation is always in integer numbers.

1.2.1. Connections list

WITH.		DESCRIPTION	FIELD	DEFAULT	
C	00	Automatic vision of internal values	0÷63	24 V_{BUS}	
C	01	Meaning of logic input 1	0÷28	8 RESET ALL	r
C	02	Meaning of logic input 2	0÷28	2 CONSENT	r
C	03	Meaning of logic input 3	0÷28		r
C	04	Meaning of logic input 4	0÷28	0 RUN	r
C	05	Meaning of logic input 5	0÷28		r
C	06	Meaning of logic input 6	0÷28		r
C	07	Meaning of logic input 7	0÷28		r
C	08	Meaning of logic input 8	0÷28		r
C	10	Meaning of logic output 1	-32÷31	3 RUN	r
C	11	Meaning of logic output 2	-32÷31	0 Conv. READY	r
C	12	Meaning of logic output 3	-32÷31	12 Mains fault	r
C	13	Meaning of logic output 4	-32÷31	10 IP	r
C	14	Choice of typology of TRIGGER 0 ≤ inputs 1 = 1° alarm 2...63= analog values	-31÷63	0	
C	15	Meaning of programmable analog output 1	-63÷63	11 CURRENT	
C	16	Meaning of programmable analog output 2	-63÷63	24 V_{BUS}	
C	21	Software power enable	0,1	1	
C	28	Enabling ff of voltage	0,1	0	
C	29	Converter software consent	0,1	1	
C	30	Alarms reset	0,1	0	
C	32	Line thermal → Converter Block ?	0,1	0	
C	33	Choice of the Thermal Curve	0÷1	0	
C	35	Automatic reset of the alarms at the return of the mains	0,1	0	
C	37	Enabling the Soft-start Insertion	0,1	1	
C	44	Reset of alarms counter	0,1	0	t
C	46	Enable the management of the thermal probe in the line (PT100/PTC/NTC)	0÷3	2	
C	48	Configuration BAUD RATE CAN Bus 0=1M 1=800K 2=500K 3 =250K 4=125K 5=50K 6=20K 7=10K	0÷7	0	r
C	52	Enabling of the references from field-bus	0,1	0	r
C	53	Enabling RUN with retention	0,1	0	r
C	55	Choice on the size used in the current Relay $0 = \lvert I \rvert / I_{NOM\ MOT}$ $1 = I\tau / I\ \tau_{NOM}$ $2 = P / P_{NOM}$	0÷2	0	
C	56	Typology of overload 0=120%×45″ 1=150%× 45 2=200%× 45″ 3=200%× 3″+155%×50″	0÷3	3	
C	57	Enable the management of the thermal probe of the heatsink (PTC/NTC) 0=120%×45″ 1=150%× 45″ 2=200%× 45″ 3=200%× 3″+155%×50″	0,4	1	
C	58	Reset CAPTURE MONITOR	0,1	0	
C	59	Disable the dynamic decoupling + feedforward	0,1	0	
C	60	Active bench of parameters	0,1	0	
C	61	Parameters reading by default	0,1	0	N
C	62	Parameters reading from EEPROM	0,1	0	N
C	63	Save parameters on EEPROM	0,1	0	N
C	64	Enable control of current	0,1	0	
C	66	Front of intervention monitor TRIGGER 0 = up ; 1 = down			
C C	90 ÷ 99	----- Reserved to the application ----- see application enclosure			

1.3. Logic functions of input

The logic functions of input are commands that may come from the logic inputs of the terminal board (with suitable configuration), from the serial and from the Field bus.

		LOGIC FUNCTIONS OF INPUT	STATUS (H=ON L=OFF)
I	00	Run	L-H
I	02	External consent	L-H
I	08	Alarms reset	L-H
I	13	Enabling soft-start insertion	L-H
I	14	Enabling references from FIELD-BUS	L-H
I	16	Activation of second bench of parameters	L-H
I	21	STOP command (running with retention)	L-H

		LOGIC INPUTS FROM THE POWER	STATUS (H=ON L=OFF)
I	29	/ PTM	H = OK; L = active alarm
I	30	/ MAXV	H = OK; L = active alarm
I	31	/ MAINS OFF	H = OK; L = active alarm

1.4. Internal values

The internal values are internal variables to the converter that can be shown on the display or via serial on the supervisor and are available also from the field bus.
Pay great attention to the internal representation of the values, this data is important when reading via serial or field bus.

		INTERNAL VALUES	REPRESENTATION
D	00	Software version	
D	07	Request of current Iq rif (axis in squaring)	% $I_{NOM\ CONV}$
D	08	Request of current Id rif (direct axis)	% $I_{NOM\ CONV}$
D	11	Module of the Current	A rms
D	15	Iq (current read on axis in squaring)	% $I_{NOM\ CONV}$
D	16	Id (current read on direct axis)	% $I_{NOM\ CONV}$
D	18	Module of the reference voltage	% E_{NOM}
D	19	Index of modulation	Absolute
D	20	Vq rif	% E_{NOM}
D	21	Voltage AC of mains read	[V rms]
D	22	Vd rif	% E_{NOM}
D	24	Voltage DC Bus	Volt
D	25	Temperature of the heat sink measured	Degrees C°
D	26	Temperature of the reactor measured (if PT100 is present)	Degrees C°
D	28	Thermal current of the reactor	% intervention threshold A6
D	29	Current limit	% $I_{NOM\ CONV}$
D	48	Serial number OPEN	
D	49	Alarm code	
D d	50 ÷ 60	----- Reserved to the application ----- see application enclosure	
D	61	Code of present application	
D	62	Sensor code managed by the firmware	
D	63	Sensor code managed by the hardware	

1.5. Logic functions of output

The logic functions signal the status of the converter and can be assigned to one of the 4 logic outputs. Please see the chapter concerning the application for the explanation of their configuration.

		LOGIC OUTPUTS	STATUS (H=ON L=OFF)
o	00	Converter ready	L-H
o	01	Reactance thermal alarm	L-H
o	03	Converter running	L-H
o	05	Output of the current relay	L-H
o	07	Converter in current limit	L-H
o	10	Insertion of the active soft-start	L-H
o	12	Mains fault	L-H
o	14	Thermal current greater than the threshold (P96)	L-H
o	15	Excessive temperature of the heat sink (greater than the threshold P120)	L-H
o	21	Recovery of energy in mains (generation)	L-H
o o	21 31	----- Reserved to the application -----	L-H

1.6. Alarms list

All the alarms that are managed are listed below. The description of the specific alarms of an AFE system is shown in the Par.5.

		ALARMS	
A	0	Alarm in writing EEPROM	
A	1	Alarm in reading EEPROM	
A	2	Alarm for mains fault/ sequence of phases L1,L2,L3 not correct	
A	3	Power fault	
A	4	Heat-sink Thermal Pellet	
A	5	Reactor Thermal Pellet	
A	6	Reactor thermal	
A	7	Mains over-voltage (Vmains)	
A	8	External alarm	
A	10	Minimum voltage of power circuit	
A	11	Over-voltage of power circuit	
A	12	Internal alarm	
A	13	Missing soft-start insertion	
A	14	Missing loading of the Bus during the soft-start	

1.7. List of internal values for monitor and analog outputs

Internal values that can be monitored through the analog outputs or through the monitor of the Supervisor are listed below

INTERNAL VALUES		REPRESENTATION
00	Angle read	100% = 180°
01	Delta m	100% = 180°
06	-- internal size : ***status*** (for MONITOR)	
07	Iq rif	% $I_{NOM\ CONV}$
08	Id rif	% $I_{NOM\ CONV}$
10	-- internal size : ***alarms*** (for MONITOR)	
11	Module of the Current	% $I_{NOM\ CONV}$
13	Current phase U	% $I_{MAX\ CONV}$
14	-- internal size : ***inputs*** (for MONITOR)	
15	Component Iq of the current read (quad. axis)	% $I_{;MAX\ CONV}$
16	Component Id of the current read (direct axis)	% $I_{MAX\ CONV}$
17	Tu	
18	Module of the reference voltage	% $V_{NOM\ CONV}$
19	Index of modulation	%
20	Vq_rif	% V_{NOM}
21		
22	Vd_rif	% V_{NOM}
23	F_fi	
24	Voltage of Bus	f.s. 1800 V
25	Temperature of the heat-sink measured	% 37.6°
26	Temperature of the reactance measured	% 80°
28	Reactance thermal current	% threshold of intervention A6
29	Current limit	% $I_{MAX\ CONV}$
32	-- internal size : ***outputs*** (for MONITOR)	
33	-- internal size : ***inputs_hw*** (for MONITOR)	
34	Current phase V	% I MAX CONV
35	Current phase W	% I MAX CONV
36	(alfa_fi)	100%=180°
37	Analog input A.I.1	100%=16384
38	Analog input A.I.2	100%=16384
39	Analog input A.I.3	100%=16384
57	Mains voltage V_{MAINS}	100%=4096

2. *Fundamental parameters setting*

For the correct operation of the converter it is important to set some fundamental parameter. These parameters are:

P61	Rated current of the line reactance in % of the rated current of the converter
P62	Rated voltage of the line in Volts
P63	Rated frequency of line in Hz
P71	Time of thermal constant of the reactance in seconds

P61 is calculated as follows:

P61 = (Inom_line *100.0))/(Inom_converter)

Remark: *in general if the inductor is sized for the thermal current of the converter P61=100(%).*

2.1. Parameters for the calibration of the Current Loop

P76	ΔV_{RS} Voltage drop on the line Resistance and on the IGBT to the rated current of the reactance in % of the rated voltage of mains
P77	ΔV_{LS} % Voltage drop on the total line reactance to the rated line current in % of the rated line voltage
P78	Time constant τ_S in milliseconds

These parameters are very important in order to correctly model the system. To obtain these parameters it is necessary to start from the nameplate data of the line reactance:

Rs = Resistance of the line reactor in Ohms
Ls = inductance of the line reactor in mHenry
$I_{NOM\ LINE}$ = Rated current of the reactor in Amperes
V_{NOM} = Line voltage in Volts

It is possible then to calculate:

$$P76 = \frac{Rs \cdot I_{NOM\ LINE} \cdot \sqrt{3}}{V_{NOM}} \qquad P77 = \frac{2\pi \cdot f_{NOM} \cdot Ls \cdot I_{NOM\ LINE} \cdot \sqrt{3}}{V_{NOM}} \qquad P78 = \frac{Ls}{Rs}\ [ms]$$

Example

$I_{NOMLINE} = 60$ A,
$V_{NOM} = 380V$ $f_{NOM} = 50Hz$
$Rs = 0{,}05\ \Omega$ $Ls= 1{,}4mH$

Performing the calculations yields:

P76=1,3% P77=11,4% P78=28ms

2.2. Reference of DC voltage

P8	DC voltage reference V_{BUS} DC. (Volt)

P.8 represents the reference of the DC voltage of the Bus (Volt) that is set by the user. It is necessary to remember that in order to have a correct system operation, the value to be set in P.8 must be greater than the rectified value of the mains voltage (ex. $380 \cdot \sqrt{2}$), in this way it is avoided that the Bus is loaded by the free wheeling diodes in anti-parallel to the IGBTs.

Remark: *the parameter P7 (that is calculated by the control) expresses the reference of DC voltage in internal representation. Thus, it must not be set by the user.*

2.3. Parameters for the calibration of the DC voltage loop

The task of the voltage regulator is to produce the correct current demand thus to keep the voltage of the BUS at the value required by the user (set on P.8).

The constants of the voltage regulator are fixed in engineering units by the parameters **P31**, proportional gain Kp , **P32**, lead time constant [ms], Ta equal to the time constant of the integral regulator multiplied by the gain (Ta = Ti*Kp) , **P33**, constant of filter Tf of the I^{st} order in ms on the error.
The total transfer function of the voltage regulator is:

$$I\_rif(s) = \left[Vrif(s) - Vbus(s)\right] \cdot Kp \cdot \left[\frac{1}{1+sTf} + \frac{1}{sTa}\right]$$

Vrif(s)= voltage reference (normalized to the rated voltage)
Vbus(s)=voltage of the bus read (normalized to the rated voltage)
I_rif(s)=request of current (normalized to the rated current of line)
Kp = Proportional gain (**P31**)
Ta = Lead time constant (**P32** in ms)
Tf = Filter time constant (**P33** in ms)

The default values of these constants are calculated to ensure the stability in almost all the conditions but, if the converter is a little disturbed, just operate on the P31, reducing the gain up to the stability, otherwise increase the gain if the regulator is too slow.

2.4. Maximum current limiting

The converter is fitted with a maximum current limiting circuit that cuts in if exceeded, restricting the maximum current delivered to the lowest value from among parameter **P40,** the value calculated by the converter thermal image circuit, and the line thermal protection circuit.
P40 is used to program the maximum current limit delivered by the converter from 0% to the maximum value allowed, which depends on the type of overload chosen with the connection **C56**.
It is also possible to limit the active current in different ways using the parameters:

P42: Maximum limit for active current regeneration.
P43: Maximum limit for active current absorption.

2.5. Converter thermal image

Four types of converter overload can be set on **C56**:

C56	Overload type for rated converter current (P53)
0	120% for 30 seconds
1	150% for 30 seconds
2	200% for 30 seconds
3	200% for 3 seconds and 155% for 30 seconds

NB: the choice also changes the rated converter current as shown by the tables in the installation file and the correct value is always displayed in ampere rms in **P53**.

The delivered current is also used to calculate the operating temperature reached by the power component junctions. The converter is supposed to be working with standard ventilation at the maximum ambient temperature allowed.
If this temperature reaches the maximum value allowed for the junction, the delivered power limit is restricted to a value that is just over the rated converter current, i.e. the system's effective thermal current (see following table).
Now the converter will only overload if the temperature drops below the rated value, which will only occur after a period of operation at currents below the rated current.

C56	Max. converter current	converter thermal current	Limit below 2.5 Hz
0	120% $I_{NOM\ CONV}$ for 30 seconds	103% $I_{NOM\ AZ}$	84% $I_{NOM\ AZ}$
1	150% $I_{NOM\ CONV}$ for 30 seconds	108% $I_{NOM\ AZ}$	105% $I_{NOM\ AZ}$
2	200% $I_{NOM\ CONV}$ for 30 seconds	120% $I_{NOM\ AZ}$	140% $I_{NOM\ AZ}$
3*	200% $I_{NOM\ CONV}$ for 3 seconds 155% $I_{NOM\ CONV}$ for 30 seconds	110% $I_{NOM\ AZ}$	140% $I_{NOM\ AZ}$

Note = the overload time illustrated is calculated with the converter running steady at the rated line reactor current. If the average delivered current is lower than the rated line reactor current, then the overload time will increase. Thus the overload will be available for a longer or identical time to the ones shown.

Note 3* = the 200% overload is available until junction temperatures are estimated to be 95% of the rated value; at the rated value the maximum limit becomes 180%. For repeated work cycles, TDE MACNO is available to estimate the converter's actual overload capacity.

Note = automatic current derating is also provided due to the line Voltage (P62) compared with the characteristic converter voltage (P174) and due to PWM frequency (P101) compared with the characyteristic converter frequency (P156). For more details please contact TDEMacno.

2.6. Thermal protection

Line reactor nominal current, parameter **P71** (reactor thermal constant in seconds) and the current delivered by the converter are used to extimate operating the line reactor temperature considering maximum ambient temperature; the losses are evaluated with the square of the absorbed current and filtered with the line reactor thermal constant. When this value exceeds the maximum thermal current, the thermal protection cuts in, enabling logic output **o.L.1** and alarm A06. The action taken may be programmed via connection **C32** and by enabling alarm **A06**:

If A06 is disabled, no action will be taken.

If A06 is enabled, action will depend on C32:

- C32 = 0 (default value) the thermal alarm will cut in and reduce the current limit to match the line reactor thermal current.
- C32 = 1 the thermal alarm cuts in and stops the converter immediately.

Internal value d28 and analog output 28 display a second-by-second reading of the line reactor thermal current as a percentage of the rated line reactor current. When 100% is reached, the line reactor thermal switch cuts in.

P96 can be set with an alarm threshold which, when breached, commutes logic output **o.L.14** to a high level indicating the approximation to the reactor thermal limit.

3. Soft-start (external)

The regenerative AC DC unit needs a circuit of soft-start (external) to limit the currents of charge of the Bus capacitors at the insertion of the mains. To favor the performance of this circuit, a contact-relay (**X1_2** ; **X1_3**) is made available to the customer ; it is closed at the end of the soft-start, i.e. when the Bus voltage has exceeded the threshold $V_{BUS} \geq V_{NOM} \cdot \sqrt{2} \cdot P(39)$ where V_{NOM} is the rated voltage of the mains (P62) and after a time of 3 RC time constant is elapsed.

P(39) indicates (%) the minimum level of charge of the Bus voltage (referred to the rectified mains voltage).

At the end of the soft-start phase, if there are no alarms, the control enables the logic output Dr Ready at a high level and the converter is ready to run. The time between the end of the soft-start (contact **X1_2** ; **X1_3** closed) and the enabling Dr Ready can be set in P65 [ms] and must be set according to the switch on time of the remote contactor (80-300ms).

Caution!: AFE unit is provided by three-phase IGBT bridge (with anti-parallel diodes). DC Bus can be charged also with the converter in ‘stop’ and the voltage at DC Bus equals the AC input voltage rectified by the diodes.

4. Compensation of reactive currents

The control of the current by the AFE, allows to compensate external reactive powers (ex. Filters or other reactive loads) whether they are of inductive or capacitive nature. This functionality is obtained by using the parameter **P.68** that expresses (in % of the rated current of line) the reactive part of the reference current (Iq_rif). Once the value of these reactive currents has been estimated (ex. The value of the capacitive currents on the line filters), it is possible to compensate them by inserting a reactive current request in P.68, equal and opposite in sign. Considering that the sign of the currents is positive if the current outcomes from the converter, a positive value written in P.68 means an absorption of capacitive current, a negative value indicates on the contrary an absorption of inductive current.
Setting P.68=0 (default), the power exchanged with the mains is only active (unity power factor).

5. AFE Alarms

ALARM		DESCRIPTION	CORRECTIVE ACTION
A0	FLASH writing	When data is being written in the FLASH the required values are always shown afterwards: an alarm triggers if differences are detected.	Try rewriting the values in the FLASH. The information may have been disturbed in some way. If the problem continues contact TDE as there must be a memory malfunction.
A1	FLASH reading	A Check Sum error occurred while the FLASH was reading the values. Default values loaded automatically.	Try rereading the values with the FLASH. The reading may have been disturbed in some way. If the problem continues contact TDE as there must a memory malfunction.
A2	Mains fault	This alarm indicates that the mains	Verify the connections ofr the mains and the

		fault. The missing mains is detected when the mains voltage goes under the threshold defined in P50 (in % of P62).	synchronisation signals. Verify the voltage read by d21.
A3	Power circuit	The converter output current has reached a level that has set off an alarm; this may be caused by an overcurrent due to leakage in the wires. There may also be a regulation fault or a problem in the sinchronisation wires.	Check the connection wires on the line side, in particular on the terminals, in order to prevent leakages or short circuits. Check the connections of the sincrhonisation circuit is correct according to the Installation file.
A4	Radiator thermal switch	**d49=0** The heatsink temperature (**d25**) is higher than the maximum (**P118**).	Check the temperature reading on d25 and then check the radiator. If -273.15 is displayed, the electrical connection towards the radiator heat probe has been interrupted. If the reading is correct and the line reactor is overheating, check that the converter cooling circuit is intact. Check the fan, its power unit, the vents, and the air inlet filters on the cabinet. Replace or clean as necessary. Ensure that the ambient temperature around the converter is within the limits permitted by its technical characteristics. Check parameter P118 is set correctly.
A5	line reactor thermal line reactor	This alarm is usually not managed in the AFE converter. Connection C46 runs a range of line heat probes. If C46=1, a PT100 is being used: the temperature reading (**d26**) must be higher than the maximum temperature (**P91**). If C46=2 or 3, a PTC/NTC is being used and its Ohm value (**d26**) has breached the safety threshold (**P95**).	If the line reactor thermal pellet is not managed, set c46=0 or exclude the Alarm A5. Check the temperature reading in d26 and then check the line reactor. With a PT100, if -273.15 appears the electrical connection towards the line reactor heat probe has been interrupted.
A6	Line reactor heat overload	The line electronic overload safety switch has cut in due to excessive current absorption for an extensive period.	Check the current from the line is comparable with the line reactor current. Check that the heat constant value is long enough (P71).
A7	Mains supply overvoltage	Mains voltage overcome the threshold in P51.	Check the line voltage set in P62. Check the mains voltage.
A8	External alarm triggered	The control input can no longer detect the high level of the signal from the field that enables converter operation.	The external safety switch has cut in disabling converter enable. Restore and reset. The connection has been broken. Check and eliminate the fault. Input function has been assigned, but enable has not been given. Authorise or do not assign the function.
A10	DC power circuit voltage at minimum	Intermediate converter circuit voltage (DC Bus see **d24**) has dropped below the minimum value (**P106**).	Mains fault. Voltage loop control is not properly set for the application (set parameter P31, P32, P33). Converter undersised compered to the DC loads.
A11	Overvoltage on DC power circuit	Intermediate converter circuit voltage (DC Bus see **d24**) has exceeded the maximum value (**P107**).	Voltage loop control is not properly set for the application (set parameter P31, P32, P33). Converter undersised compered to the DC loads.
A12	Internal alarm	**d49=0** Software Enable C29	Check and enable connection **C29** “converter software enable”
		d49=2 RUN with Trad>P119	Check the radiator temperature (d25)
A13	Soft start alarm	DC bus did not charged at soft start (P39).	Check the voltage of the three input phases. Try switching off and then back on, measuring the DC Bus level (with the monitor or tester).

			If the problem repeats, contact TDE as there must be a soft start circuit malfunction.
A14	DC Bus has not finished the charging	During soft start, the DC Bus has not finished the charging.	Check the voltage of the three input phases. Try switching off and then back on, measuring the DC Bus level (with the monitor or tester). If the problem repeats, contact TDE as there must be a soft start circuit malfunction.

6. AFE Calibrations

The following parameters

P r	01	Corrective factor analog ref. 1 (AN_INP_1) at 14 bits	±400.0	100.0	%
P r	02	Corrective offset analog ref. 1 (AN_INP_1) at 14 bits	±100.0	0.0	%
P r	03	Corrective factor analog ref. 2 (AN_INP_2) at 14 bits	±400.0	100.0	%
P r	04	Corrective offset analog ref. 2 (AN_INP_2) at 14 bits	±100.0	0.0	%
P r	52	Corrective factor mains voltage (d21)	80.0÷120.0	100.0	%
P r	75	Angle of starting position (internal reconstruction)	±180.0	0.0	Degrees

They are related to specific calibrations for the AFE system. They are already pre-set by TDEMACNO and must not be modified by the user.

7. A.F.E. control scheme

• For the unit A.F.E. the 24VDR and the 24VREG must always be managed altogether (a single 24V of auxiliary power supply must be managed).

• The converter runs if there are no alarms and it is closed the switch L.I.4.

• The inputs A.I.1 (**A.I.1** , **/A.I.1**) and A.I.2 (**A.I.2** , **/A.I.2**) are reserved and must be connected by TDEMACNO during the product test. The connections must not be removed by the user.

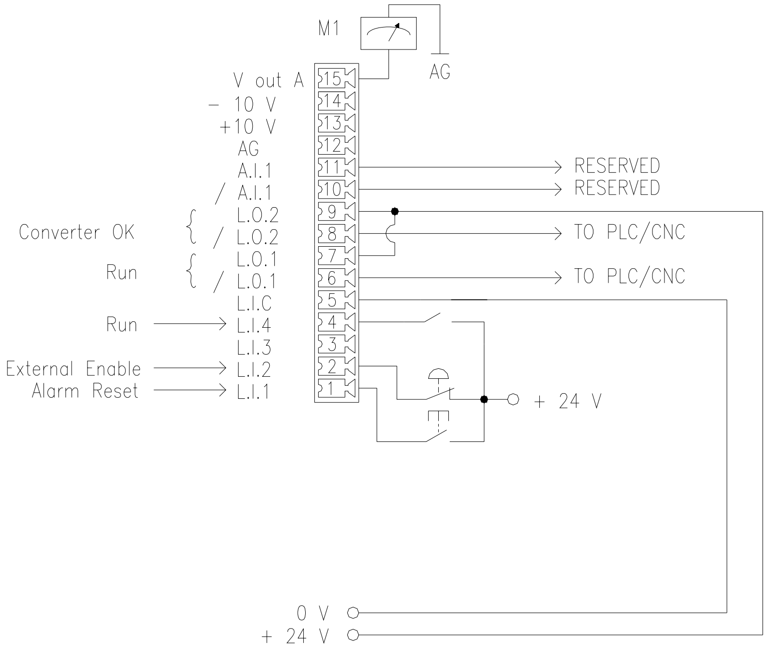

Figure 1: control scheme of A.F.E. unit

In this manual

The content of this manual responds to the software version **AFE 40.2**

If there is any question concerning the installation and operation of the equipment described in this manual, do not hesitate to contact the following address:

TDE MACNO
s.p.a. tecnologie digitali elettroniche
Via dell'Oreficeria, 41 36100 Vicenza - Italy tel. +39 0444/343555
Warehouse Via dell'Oreficeria, 27/B
Internet.address: http://www.tdemacno.it
Internet E-Mail: info @ tdemacno.it
fiscal and VAT code 00516300241 telefax +39 0444/343509

TDE MACNO reserves the right to perform in any moment technical modifications to this manual, with no special notices.