OPEN DRIVE

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Standard closed loop application

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(references generation)

CONTENTS

The OPEN DRIVE standard application makes it possible to control the motor in speed or in current by inputting the references analogically and digitally. Management of digital input/output and Field-Bus references can also be carried out.

1. Application configuration

1.1. Application parameters

PAR	DESCRIPTION	Variation FIELD	Default VALUE	Normalisation UNIT	internal Repr.
P01	14 bit analog ref. correction factor 1 (AN_INP_1)	±400.0	100.0	%	10
P02	14 bit analog corrective offset ref. 1 (AN_INP_1)	±16383	0	16383=100%	1
P03	14 bit analog ref. correction factor 2 (AN_INP_2)	±400.0	100.0	%	10
P04	14 bit analog corrective offset ref. 2 (AN_INP_2)	±16383	0	16383=100%	1
P05	14 bit analog ref. correction factor 3 (AN_INP_3)	±400.0	100.0	%	10
P06	14 bit analog corrective offset ref. 3 (AN_INP_3)	±16383	0	16383=100%	1
P07	Digital speed reference (JOG1)	±100.00	0.00	% n_{MAX}	16383
P08	Digital motor potentiometer starting speed	±100.0	2.0	% n_{MAX}	16383
P09	Analog torque reference time filter constant	0.0÷20.0	0.0	ms	10
P10	Offset on high precision analog reference	±19999	0	/100 mV	1
P11	NUM – Frequency input slip ratio	±16383	100		1
P12	DEN – Frequency input slip ratio	0÷16383	100		1
P13	Correction factor for analog speed reference at 16 bit	±400.0	100.0	%	10
P14	Offset correction factor for analog speed reference at 16 bit	±16383	0	16383=100%	1
P16	Maximum motor potentiometer speed reference	±105.0	105.0	% n_{MAX}	16383
P17	Minimum motor potentiometer speed reference	±105.0	-105.0	% n_{MAX}	16383
P20	Digital potentiometer acceleration time	0.3÷1999.9	50.0	s	10
P48	Speed reference frequency input time filter constant	0.0÷20.0	1.6	ms	10
P49	Correction factor for Speed reference frequency input	0÷200.0	100.0	%	16383
P180	Torque Feed-forward: II order time filter constant on speed reference	0.0÷1000.0	0.0	ms	10
P181	Torque Feed-forward: Startup time	0÷19999	0	ms	1
P182	% Increment multiplicative factor on speed reference	100.0 ÷ 800.0	100.0	%	4095
P183	% Decrement multiplicative factor on speed reference	0.0 ÷ 100.0	0.0	%	4095
P184	Velocità massima di lavoro – SECOND BANK	50-30000	2000	Rpm	1
P185	KpV speed regulator – SECOND BANK	0.1÷400.0	4.0		10
P186	TiV speed regulator – SECOND BANK	0.1÷3000.0	80.0	ms	10
P187	TfV (filter) – SECOND BANK	0÷25	0.8	ms	10
P188	CW acceleration time – SECOND BANK	0.01÷199.99	10.00	s	100
P189	CW deceleration time – SECOND BANK	0.01÷199.99	10.00	s	100
P190	CCW acceleration time – SECOND BANK	0.01÷199.99	10.00	s	100
P191	CCW deceleration time – SECOND BANK	0.01÷199.99	10.00	s	100

1.2. Application connections

CON	DESCRIPTION	Variation FIELD	Default value	Meaning of default	Type
C01	Logic input 1 meaning	-1÷63	8	RESET ALL	r
C02	Logic input 2 meaning	-1÷63	2	CONSENT	r
C03	Logic input 3 meaning	-1÷63	3	ENABLE REF AI1	r
C04	Logic input 4 meaning	-1÷63	0	RUN	r
C05	Logic input 5 meaning	-1÷63	4	ENABLE REF AI2	r
C06	Logic input 6 meaning	-1÷63	12	CW/CCW	r
C07	Logic input 7 meaning	-1÷63	5	ENABLE JOG	r
C08	Logic input 8 meaning	-1÷63	22	ENABLE RAMPS	r
C09	Frequency input determination : 0=analog; 1=digital encoder; 2=digital frequency/sign; 3=digital frequency/sign 1 edge	0÷3	1	DIGITAL ENCODER	r
C10	Logic output 1 meaning	-32÷31	3	RUN	r
C11	Logic output 2 meaning	-32÷31	0	RESET READY	r
C12	Logic output 3 meaning	-32÷31	6	END OF RAMP	r
C13	Logic output 4 meaning	-32÷31	10	SWITCH ON POWER INPUT	r
C15	Meaning of programmable analog output 1	-63÷64	11	CURRENT	
C16	Meaning of programmable analog output 2	-63÷64	4	SPEED	
C17	Meaning of 14 bit analog input A .I.1	0÷2	0	SPEED REF	r
C18	Meaning of 14 bit analog input A .I.2	0÷2	1	TORQUE REF	r
C19	Meaning of 14 bit analog input A .I.3	0÷2	2	LIMIT REF	r
C20	Load last digital potentiometer frequency	0.1	0		
C22	Enable 14 bit analog reference A.I.1	0,1	0		
C23	Enable 14 bit analog reference A.I.2	0,1	0		
C24	Parallel bit at REF3 (jog)	0,1	0		
C25	Parallel bit at REF4 (digital motor potentiometer)	0,1	0		
C26	Ramp inclusion	0,1	x		
C31	Enable 14 bit analog reference A.I.3	0,1	0		
C36	Reference signal software reversal	0,1	0		
C39	Impulses/revolution selection FREQUENCY INPUT	0÷9	5	1024 ppr	
C40	Enable 16 bit analog speed reference	0,1	0		
C43	Enables speed reference in frequency	0,1	0		
C52	Enable FIELD-BUS references	0,1	0		r
C53	Enable locked RUN	0,1	0		r
C70	Enable Speed reference frequency input decoded in time	0,1	0		
C79	Enable digital inputs active low	0÷255	0		r
C90	Enable Torque feed-forward on speed reference 0=not enabled; 1=analog speed ref; 2=frequency speed reference	0÷2	0		
C91	Enable offset on overlap position loop reference	0,1	0		
C92	Enable overlap position loop memory clear when power is switched-off	0,1	0		r
C93	Analog input selection for multiplicative factor 0=none 2=AI2 3=AI3 4=AI16bit	0÷4	0		
C94	Speed reference selection with multiplicative factor 0=none 1=AI enabled 2=AI16bit 3=NUM electrical gear	0÷3	0		
C95	Active bank speed regulator gains	0,1	0		

1.3. Input logic functions

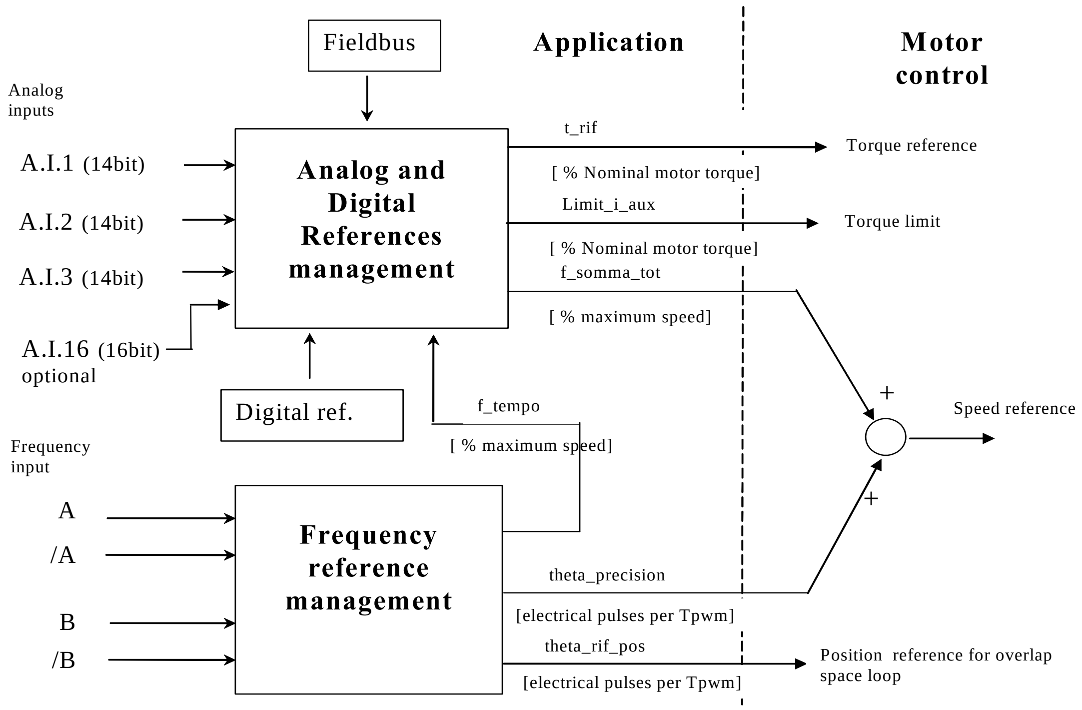
INP	LOGIC FUNCTION ASSIGNED
I00	Run
I01	Torque control
I03	Enable 14 bit analog reference A.I.1.
I04	Enable 14 bit analog reference A.I.2.
I05	Enable speed jog
I06	Enable digital potentiometer speed reference
I07	Enable 14 bit analog reference A.I.3.
I09	DP UP digital potentiometer up
I10	DP DOWN digital potentiometer down
I11	Load last digital potentiometer value
I12	Reference reversal
I14	Enable FIELD-BUS references
I18	Enable speed reference in frequency decoded in time
I19	Enable speed reference in frequency
I20	Enable 16 bit speed reference (if present)
I21	STOP command (run with retention)
I22	Enable line ramps
I24	Freeze PI speed regulator integral memory
I25	Enable offset on overlap position loop reference
I26	Enable second bank speed regulator gains

1.4. Application internal quantities

INT	INTERNAL ASSIGNED VARIABLE	Normalisation unit	Internal repr.
d06	16 bit analog speed reference	% n_{MAX}	16383
d10	Reference for torque generated by the application	% $C_{NOM\ MOT}$	4095
d12	14 bit analog speed reference	% n_{MAX}	16383
d14	Reference for speed in frequency generated by the application	% n_{MAX}	16383
d32	Reference for torque limit generated by the application	% $C_{NOM\ MOT}$	4095
d33	Reference for speed percentage generated by the application	% n_{MAX}	16383

2. References management

The standard application regards the configuration and management of various digital inputs for the generation of speed, torque and torque limit references for the actual control of the motor.

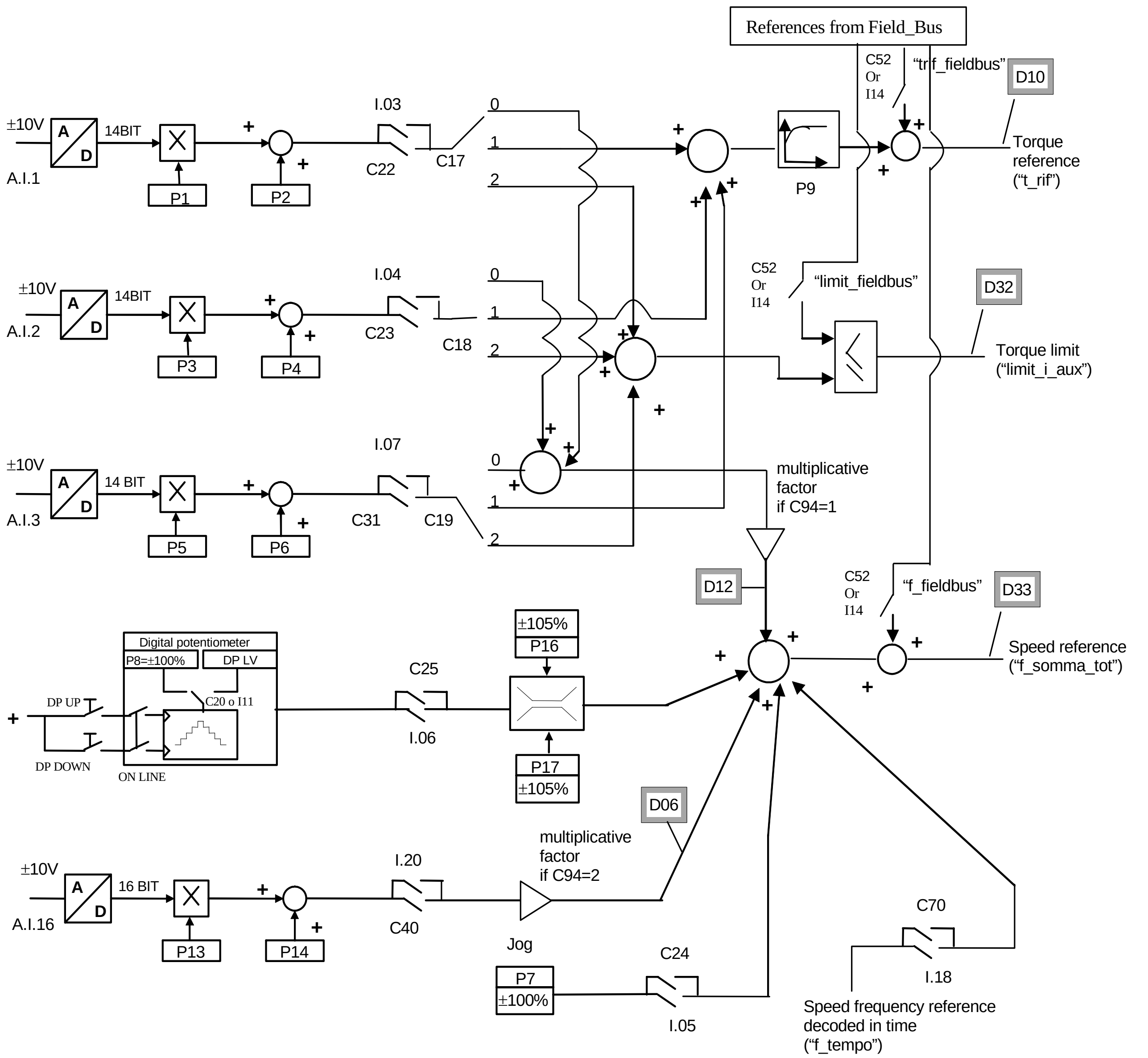


5 references for the motor control are generated by this block:

1. a torque reference ("t_rif") as percentage of the motor's nominal torque
2. a torque limit reference ("limit_i_aux") as percentage of the motor's nominal torque.
3. a speed reference ("f_somma_tot") as percentage of the maximum speed (set in parameter P65)
4. another speed reference ("theta_precision") in electrical pulses for the period of PWM. This particular reference is to ensure no pulse is lost if frequency input is used. Internal normalisation requires there to be 65536 pulses per mechanical revolution and these are considered the pulses multiplied by the motor's number of polar pairs: this so as not to lose sensor resolution.
5. a incremental position reference ("theta_rif_pos") in electrical pulses for the period of PWM, that will be the reference for the overlap space loop.

Inside the motor control, the two speed references are added up after they have been suitably adapted.

2.1. Digital and analog references management



It's possible to enable separately all references using connections or logic input functions.
For speed and torque references the active reference is the sum of all enabled references, for torque limit prevails the more constrain active reference, between the sum of analog and the Fieldbus references.

2.1.1. 14 bit analog references

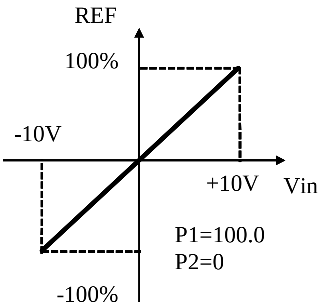
There can be up to 3 differential analog inputs (A.I.1 ÷ A.I.3) ± 10V which, after being digitally converted with a resolution of 14 bits, can be:

- conditioned by digital offset and a multiplicative coefficient
- enabled independently through configurable logic inputs or connections
- configured as meaning through the corresponding connection (**C17** ÷ **C19**)
- added together for the references with the same configuration

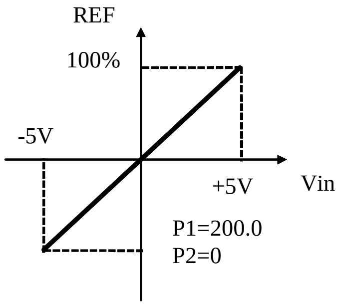
For example in the case of A.I.1, the result of the conditioning is given by the following equation:

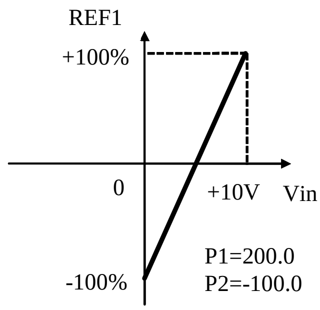
REF1= ((A.I.1/10)*P1) + P2

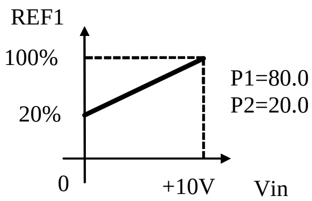
By selecting a suitable correction factor and offset the most varied linear relationships can be obtained between the input signal and the reference generated, as exemplified below.

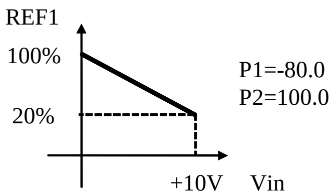


Default setting









Note: for the offset parameters (P02, P04 and P06) an integer representation has been used on the basis of 16383, in order to obtain maximum possible resolution for their settings.
For example if P02=100 ⟹ offset = 100/16383 = 0.61%

As said above, the enabling of each analog input is independent and can be set permanently by using the corresponding connection or can be controlled by a logic input after it has been suitably configured.
For example to enable input **A.I.1** the connection **C22** or the input logic function **I03** can be used, with the default allocated to logic input 3.

The connections C17 ÷and C19 are used to separately configure the three analog inputs available:

C17 – C19	Meaning
0	Speed reference
1	Torque reference
2	Torque limit reference

Several inputs can be configured to the same meaning so that the corresponding references, if enabled, will be added together.

Note: using the appropriate multiplicative coefficient for each reference it is therefore possible to execute the subtraction of two signals.

In the case of the torque limit, if there is no analog input configured to the given meaning and enabled, the reference is automatically put at the maximum that can be represented, i.e. 400%. In internal quantities **d32** it is possible to view the torque limit imposed by the application.

In the case of the torque reference there is a first order filter with time constant that can be set in milliseconds in parameter **P9**. In the internal quantity **d10** the torque reference can be viewed as set by the application

2.1.2. Digital speed reference (Jog)

The value programmed in parameter **P7** can be used as digital speed reference either by activating the logic function “Enable Jog” I.05 assigned to an input (default input L.I.5) or with the connection **C24**=1. The resolution is 1/10000 of the maximum working speed.

2.1.3. Digital Potentiometer speed reference

A function that makes it possible to obtain a terminal board adjustable speed reference through the use of two logic inputs to which are assigned the input functions digital potentiometer up **I09**” (DP.UP) and “Digital potentiometer down **I10**” (DP.DOWN) .
The reference is obtained by increasing or decreasing an internal counter with the DP.UP and DP.DOWN functions respectively.
The speed of increase or decrease set by parameter **P20** (acceleration time of the digital potentiometer) which sets how many seconds the reference takes to go from 0 to 100%, keeping the DP.UP active (this times is the same as to go from 100.0% to 0.0% by holding DP.DN active). If DU.UP are DP.DOWN are activated at the same time the reference remains still.
The movement of the reference is only enabled when the converter is in RUN.
The initial reference value at the time of start up of the converter, is set by the value programmed by the parameter **P8** (P8=2.0% default) if neither the function “last digital potentiometer value I20” (DP.LV not active by default), nor connection **C20** (C20=0 default) is active, while the initial reference value remains the same as that when the converter was stopped, even if power has been removed in the meantime, when the DP.LV function is active or connection C20 is active. Thanks to this permanent memory, even if the power supply is lost, the digital potentiometer can be used as if it were a physical potentiometer.

The functioning is summarised in the following table :

Converter running on-line	DP.UP	DP.DOWN	DP.LV	C20	REF
H	H	L	x	x	increases
H	L	H	x	x	decreases
H	L	L	x	x	stopped
H	H	H	x	x	stopped
L	x	x	x	x	stopped
L -> H	x	x	L	L	P8
L -> H	x	x	H	L	REF4 L.v.
L -> H	x	x	L	H	REF4 L.v.
L -> H	x	x	H	H	REF4 L.v.

H = active x = does not matter L = not active L -> H = From Off-line to On-line

The digital potentiometer reference requires, to be enabled, activation of function **I06** after allocating an input or activating connection **C25** (C25=1) .
In the parameters **P16** and **P17** the maximum and the minimum admitted reference values can be marked for the digital potentiometer reference.

2.1.4. 16 bit analog speed reference (optional)

When very precise speed sensors such as Sin/Cos Encoders, Endat can have an analog speed reference ± 10V converted into 16 bit digital so also to have an excellent resolution reference.
For correct wiring of this 16 bit speed reference see the speed sensor appendix to the installation manual.

Also for this speed reference it possible to condition with offset and multiplicative coefficient:

REF16= ((A.I.16/10)*P13) + P14

The 16 bit analog speed reference requires activation of function **I20** after assigning an input or activation of connection **C40** (C40=1) .
In internal quantity **d6** this reference can be viewed as a percentage of the maximum working speed.

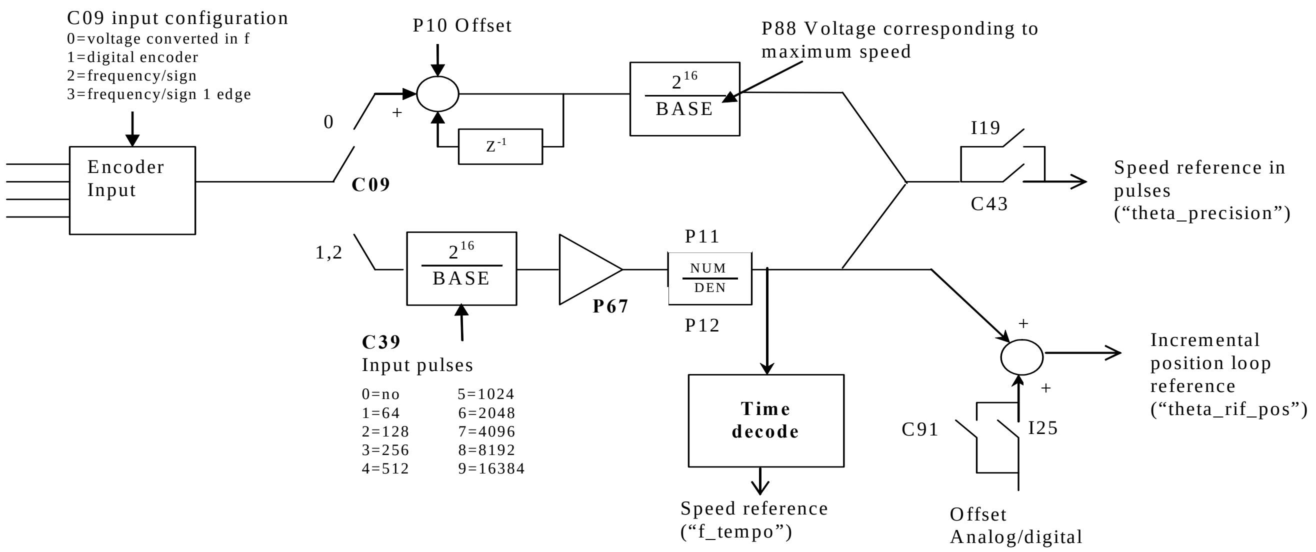
2.1.5. Speed frequency reference decoded in time

The speed frequency reference decoded in time can be used as digital speed reference either by activating the logic function **I.18** assigned to an input or with the connection **C70=1**.
View in paragraph 2.2.3 for more detailed explanation.

2.2. Speed frequency reference management

This speed reference in pulses (“theta_precision”) can be provided in 3 different ways (alternatives to each other), that can be selected by means of connection C09.

C 09	Mode of working
0	Analog reference ±10V (optional)
1	4 track frequency reference (default)
2	Frequency reference (freq. and up/down) counting all edges
3	Frequency reference (freq. and up/down) counting one edge

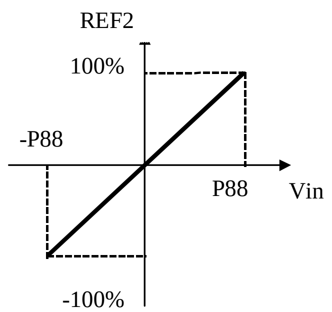


To be used Speed reference in pulses must be enabled either by activating the function “ Enable reference in frequency **I19** “assigned an input or by means of connection **C43**=1 .
The incremental position reference is always enabled and it’s possible to add an offset depending on analog and digital speed reference enable (“f_somma_tot”).

2.2.1. High resolution analog reference (optional)

Putting **C09 = 0** (with the optional hardware) an analog signal can be provided ±of 10V that will be converted into frequency while impulse counting will be taken from the high precision speed reference. Parameter **P10** permits compensation of any offset present in the analog input and is expressed in units of 10μV;

Parameter **P88** permits setting of the voltage to which maximum speed will correspond (default value of 10000mV or 10V).



2.2.2. Frequency reference

Two working modes can be selected with C09 :

- Setting **C09 = 1** a reference can be provided with an encoder signal with 4 tracks of a maximum range varying between 5V and 24V and a maximum frequency of 300KHz.
- Setting **C09 = 2** a speed reference can be provided with an frequency signal with a maximum range varying between 5V and 24V and a maximum frequency of 300KHz.
  (setting **C09 =3** will be manage the same input, but internally will be count only rising edge, this option is useful only if it is used the time decode, see par. 2.2.3)

The number N of impulses/revolution for the reference is set by connection **C39**:

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
N° of impulses/revolution	disable	64	128	256	512	1024	2048	4096	8192	16384

There are the parameters **P11** and **P12** that permit specification of the ratio between the reference speed and input frequency as a Numerator/Denominator ratio.

In general terms, therefore, if you want the speed of rotation of the rotor to be **x** rpm, the relationship to use to determine the input frequency is the following:

$$f = \frac{x \times N_{pulses/revolution} \times P12}{60 \times P11} \quad \text{and vice versa} \quad x = \frac{f \times 60 \times P11}{N_{pulses/revolution} \times P12}$$

Let us now look at a few examples of cascade activation (MASTER SLAVE) with frequency input according to a standard encoder.
By a MASTER drive the simulated encoder signals A,/A,B,/B are picked up to be taken to the frequency input of the SLAVE. By means of parameters P11 and P12 the slipping between the two is programmed.

MASTER	**SLAVE**
N° of pulses/revolution = 512	N° of pulses/revolution = 512
P65 = 2500 rpm	P65 = 2500 rpm
	P11=P12=100
The SLAVE goes at the same speed as the MASTER	

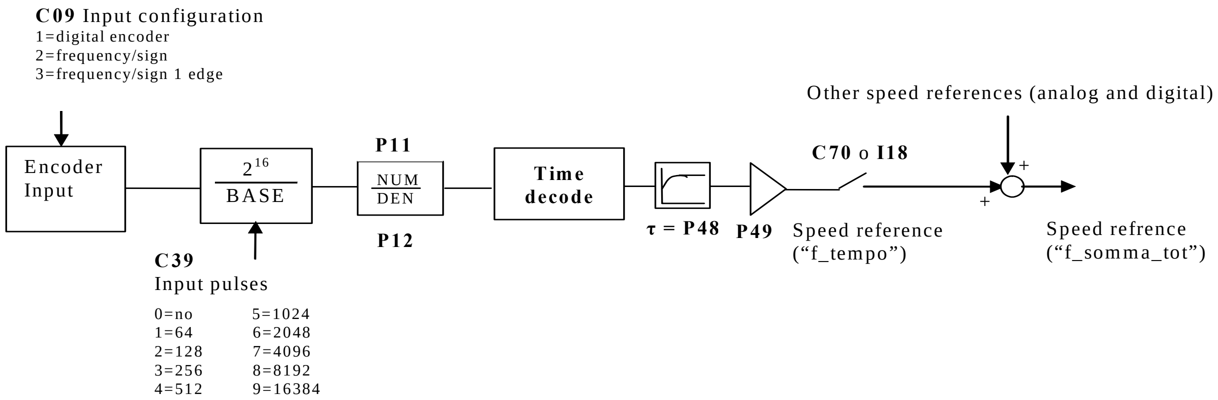
MASTER	**SLAVE**
N° of pulses/revolution = 512	N° of pulses/revolution = 512
P65 = 2500 rpm	P65 = 2500 rpm
	P11=50 P12=100
The SLAVE goes at half the speed of the MASTER	

MASTER	**SLAVE**
N° of pulses/revolution = 512	N° of pulses/revolution = 512
P65 = 2500 rpm	P65 = 2500 rpm
	P11 =100 P12=50
The SLAVE goes at double the speed of the MASTER	

To obtain good performance at low
Speed it is necessary to select an encoder resolution
for the MASTER that is sufficiently high.

2.2.3. Time decode of frequency input

The speed reference in pulses is very accurate (no pulses is lost) but for its nature it has an irregular shape because are counted the edges every sampling period (TPWM) and this produce a speed reference with many noise. Also if the frequency input is constant, between a PWM period and another could be counted a variable number of pulses, ± one pulse. This produce a low resolution reference, expecially when the frequency input decreases.
For not use a big filter with frequency reference it's possible to use its time decode that has a good resolution. It is measured the time between various edges of frequency input with resolution of 25ns, reaching a percentage resolution not less than 1/8000 (13 bit) working to 5KHz of PWM (increasing PWM resolution decreases linearly).
It is produced the speed reference as percentage of maximum speed, knowing the pulses per revolution in input and the transformation ratio P11 over P12.
Following the time decode there is a first order filter with time constant set in milliseconds into parameter **P48** and a proportional gain imposed with parameter **P49** as percentage.



If the input is a frequency/sign reference it's very important to set **C09=3** because only counting the rising edge it will be possibile to measure the time between one pulse and the other, and not the pulse width.

The speed reference obtained could be used as in sum with the other analog and digital references. (see par. 2.1).

In the follow paragraph it is explain how to use frequency input decoded in time within the pulses reference in a electric axis.

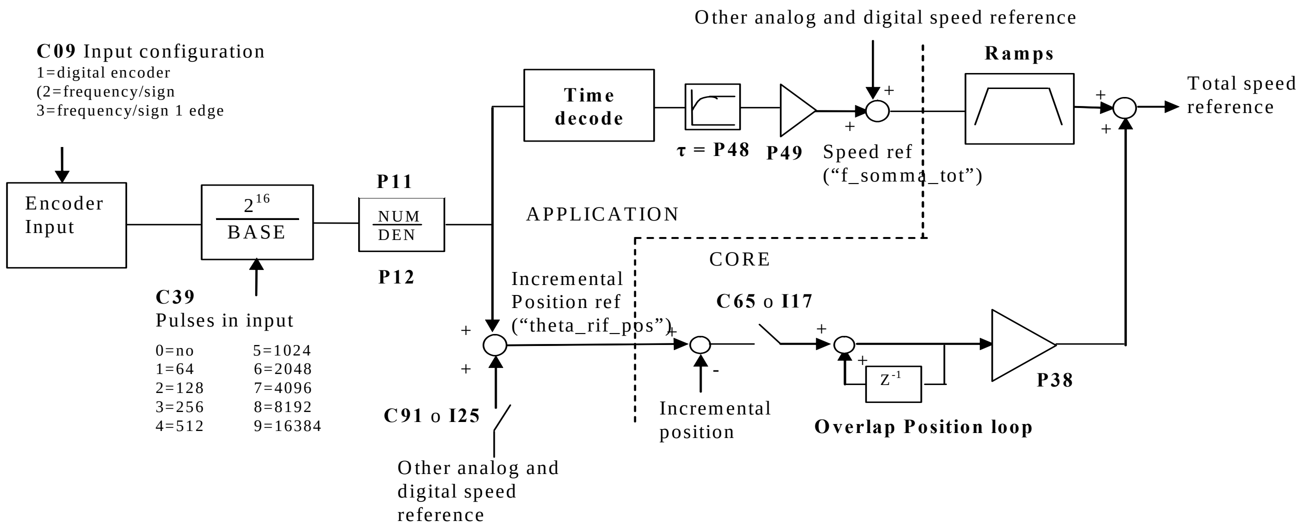
2.2.3.1. Electric axis with frequency reference decoded in time

Manage a frequency position reference meaning ensure every time the correct phase between master and slave. For obtain this result can be used the time decode of frequency input for giving the speed reference in feed-forward, enabling the overlap position loop to ensure the synchronization in phase between master and slave.

Set:

CON	DESCRIPTION	VALUE to set	MEANING
C43 e I19	Enable speed reference in frequency	**0**	Not enable
C52 e I14	Enable references from Fieldbus	**0**	Not enable
C70 o I18	Enable Speed reference frequency input decoded in time	**1**	Enable

With this configuration there is the follow control scheme:



The speed reference in time ("f_somma_tot") has a good resolution also for low frequency in input, allowing to have high gains in speed regulator.

The overlap position loop has to be enabled setting **C65=1** or **I17=H**, after that no pulse will be lost and it will be ensure the correct phase between master and slave.
When the overlap position loop works it's useless enable the ramps in speed reference decoded in time.
It's possible to add an offset to the position reference, setting **C91=1** or **I25=H**. The offset is equal to the sum of the other analog and digital speed reference enabled.

2.3. Multiplicative factor on speed reference

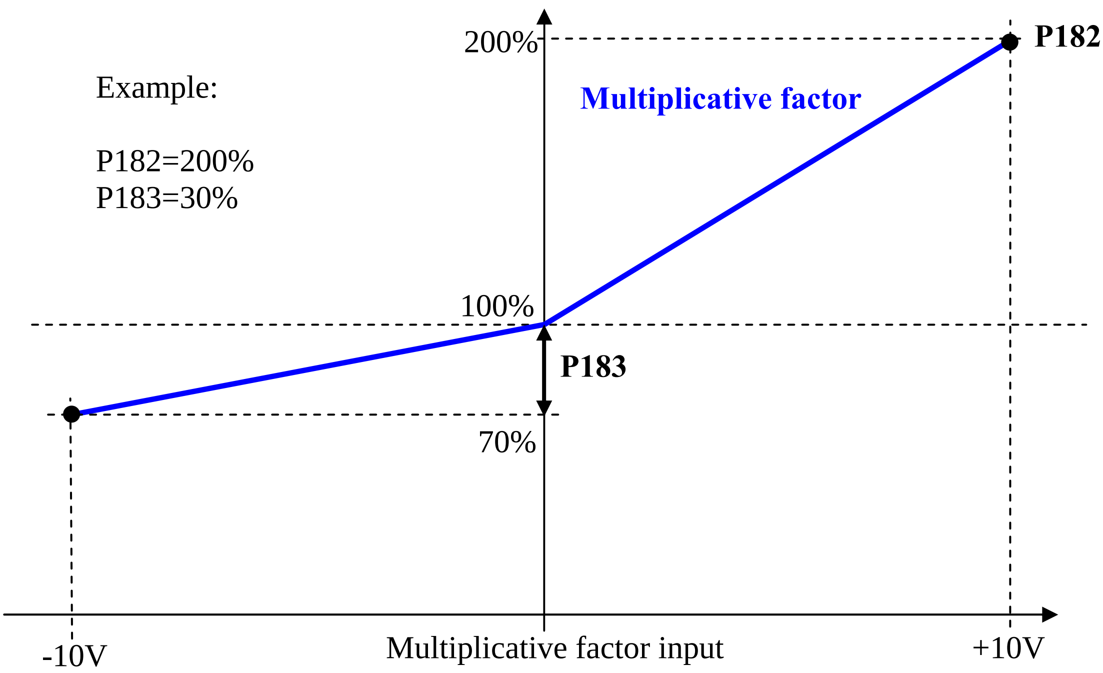
This function enables a multiplicative factor, depending on analog input, on speed reference.
It's possible to choose the input for the multiplicative factor using **C93** connection:

C93	Multiplicative factor input
0	None
1	AI1
2	AI2
3	AI3
4	AI16

With **C94** connection, it's possible to choose the speed reference that will be multiply by the factor:

C94	Speed ref. multiplied
0	None
1	AI1+AI2+AI3 (if configurated)
2	AI16
3	NUM electrical gear

With parameters **P182** e **P183** it's possible to choose the percentage variation of the speed reference corresponding to ± 10V of multiplicative factor input.

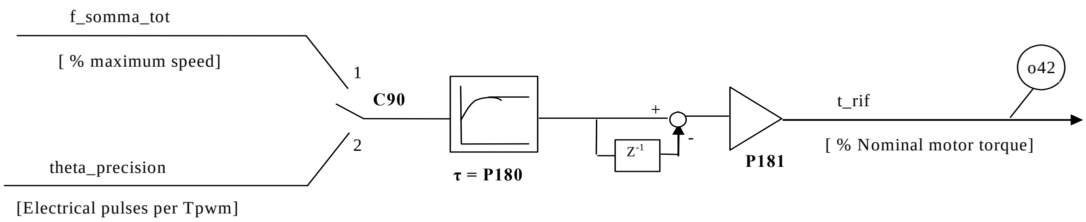


2.4. Torque feed-forward on speed reference

It's possible to enable the Torque feed-forward on speed reference using **C90** connection:

C90	Mode of working
0	Not enabled
1	"f_somma_tot" speed reference derivative (analog a/o Fieldbus)
2	"theta_precision" speed reference derivative (analog to frequency, frequency or from Fieldbus)

It' possible to estimate the torque reference needing for the speed variation requested with the speed reference derivative using a II° order filter (time constant in **P180** in ms) and taking account of total inertia (setting parameter P181 Startup time).



The Startup time is the time necessary for motor and load to reach the maximum speed (set in P65) with the nominal motor torque. This data has to be set in milliseconds in parameter P181.
It's useful to set some milliseconds of filter (P180) on order to avoid too much noise on torque reference for the time derivative.
When it's enabled this function the torque reference "t_rif" cannot be impose using the analog and digital references see before.

The torque feed-forward can be very useful in the servo-drive application when the target is to follow very promptly the speed reference, because it increases the bandwidth without using high gains on speed regulator.

Note 1: for understand if the torque compensation is correct it's useful to compare it with the total torque reference from speed regulator. The internal monitoring variables are o42 for feed-forward term and o5 for the final torque reference.

Note2: torque feed-forward isn't appropriate in load variable inertia applications.

2.5. Speed regulator second parameters bank

This function is used to change on-line the speed regulator parameters (P31÷P33), the maximum speed (P65) and the linear ramps acceleration times (P21÷P24), to achieve a good reference resolution, working at low speed.

For enable the second parameters bank (P184÷P187) it's necessary to set the connection **C95=1**, otherwise to bring at high level the logical function **I26** using one of the 8 logical inputs.
When the function is activated the standard data (P31÷P33, P65 and P21÷P24) are automatically exchanged with the second bank (P184÷P191) and the connection C95 is set to 1.

I26 L → H

Speed regulator

Speed regulator		
Maximum speed	P65	P184
Proportional gain Kp	P31	P185
Lead time constant Ta	P32	P186
Filter time constant Tf	P33	P187
CW acceleration time CW	P21	P188
CW deceleration time CW	P22	P189
CW acceleration time CCW	P23	P190
CW deceleration time CCW	P24	P191

I26 H → L

The exchange will be executed only if the working speed is lower than the new maximum speed, this is useful to avoid the over speed alarm A09.
If the speed is greater than new maximum speed, the activation command is ignored.

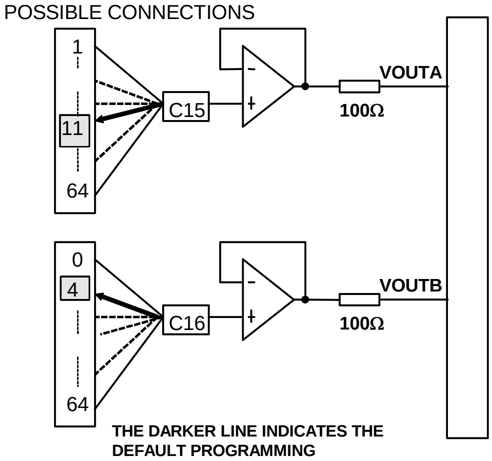
If the speed ramps are active your value will be automatically calculated to avoid sharp transitory.

The connection C95 keep memory of second parameters bank activation. When the drive is switched on, the connection C95 and the logical input I26 are tested: if there is coherence no action is taken, otherwise the connection C95 is automatically changed to line up with logical input I26 and the data are exchanged.

When the function is disabled, bringing I26 to low level or clearing C95=0, data are automatically exchanged, with initial value restore.

3. *Analog outputs management*

There can be a maximum of two analog outputs, VOUTA and VOUTB ± 10 V, 2mA.
To each of the two outputs can be associated an internally regulated variables selected from the list here below; the allocation is made by programming the connection corresponding to the output concerned, **C15** for VOUTA and **C16** for VOUTB, with the number given in the table below corresponding to the relative quantities. By means of the parameters **P57** (for VOUTA) and **P58** (for VOUTB) it is also possible to set the percentage of the variables selected to correspond to the maximum output voltage (default values are P57=P58=200% so 10V in output correspond to 200% of variable selected). The default for VOUTA is a signal proportional to the current supplied by converter (C15=11), in VOUTB the signal is proportional to the working speed (C16=4).
It is also possible to have the absolute internal variable value desired: to do this it is simply necessary to program the connection corresponding to the denied desired number: for example taking C15=-21 there will be an analog output signal proportional to the absolute value of the working frequency.
It is also possible to have a analog output fixed to +10V: to do this it is simply necessary to program the connection corresponding to 64.



NORMALISED BASE INTERNAL VARIABLES FOR ANALOG OUTPUTS			
O 00	Actual mechanical position read by the sensor (if the sensor has more than 2 poles it regards the current revolutio sector)	100%=180° (with 2 poles) 100% = semi-sector (+ poles)	32767
O 01	Actual electrical position read by the sensor (delta m)	100%=180°	32767
O 02	Reference speed after the ramp	% n_{MAX}	16383
O 03	Output reference speed from the torque regulator	% n_{MAX}	16383
O 04	Speed of rotation (filtered $T_f= 8 \times T_{PWM}$, 1,6ms at 5KHz)	% n_{MAX}	16383
O 05	Torque requirement	% $C_{NOM\ MOT}$	4095
O 07	Torque current requirement at current loop	% $I_{NOM\ AZ}$	4095
O 08	Flow current requirement at current loop	% $I_{NOM\ AZ}$	4095
O 09	Voltage requirement at maximum revolutions	% $V_{NOM\ MOT}$	4095
O 11	Current module	% $I_{NOM\ AZ}$	4095
O 12	Zero top	100%=180°	32767

O 13	U phase current measured	% $I_{MAX\ AZ}$	4095
O 15	Torque component of measured current	% $I_{NOM\ AZ}$	4095
O 16	Magnetising component of current measured	% $I_{NOM\ AZ}$	4095
O 17	Duty-cycle U phase voltage		32767
O18	Reference stator ground voltage module	% $V_{NOM\ MOT}$	4095
O19	Modulation index	$0 \Leftrightarrow 1$	4095
O20	Q axis voltage requirement (Vq_rif)	% V_{NOM}	4095
O21	Power supplied	% P_{NOM}	4095
O22	D axis voltage requirement (Vd_rif)	% V_{NOM}	4095
O24	Bus voltage	100%=900V	4095
O25	Measured radiator temperature	% 37.6°	4095
O26	Measure motor temperature	% 80°	4095
O27	Rotor flux	% ϕ_{NOM}	4095
O28	Motor thermal current	% A6 action threshold	4095
O29	Current limit	% $I_{MAX\ AZ}$	4095
O30	CW maximum torque	% $C_{NOM\ MOT}$	4095
O31	CCW maximum torque	% $C_{NOM\ MOT}$	4095
O34	Measured phase V current	% $I_{MAX\ AZ}$	4095
O35	Measured phase W current	% $I_{MAX\ AZ}$	4095
O36	Actual electrical position (alfa_fi)	100%=180°	32767
O37	Analog input A.I.1	100%=16383	16383
O38	Analog input A.I.2	100%=16383	16383
O39	Analog input A.I.3	100%=16383	16383
O40	Analog input A.I.16	100%=16383	16383
O41	Total speed reference (f_somma_tot)	% n_{MAX}	16383
O42	Total torque reference (t_rif) for the application	% $C_{NOM\ MOT}$	4095
O43	Total torque limit reference (limit_i_aux)	% $C_{NOM\ MOT}$	4095
O44	Total speed reference (theta_precision)	Pulses per Tpwm	1
O45	Reference for overlapping position loop (theta_rif_pos)	Pulses per Tpwm	1
O46	Amplitude at square of sine and cosine feedback signals	1=100%	32767
O47	Sen_theta (Direct resolver and Sin/Cos Encoder)	Max amplitude = 200%	16383
O48	Cos_ theta (Direct resolver and Sin/Cos Encoder)	Max amplitude = 200%	16383
O49	Unfiltered speed of rotation	% n_{MAX}	16383
O50	Delta pulses on PWM period from frequency input	Pulses per Tpwm	1
O51	Lsw memory space error (overlapped position loop)	Electrical pulses	1
O52	Msw memory space error (overlapped position loop)	Electrical turns	1
o53 ÷ o63	----- Reserved for special applications ----- see special application enclosure		
o64	Output fixed to +10V		

4. Input logic management

The control requires up to 8 optically insulated digital inputs (L.I.1 … L.I.8.) whose logic functions can be configured by means of connection **C1** ÷ **C8**.
The following table shows the logic functions managed by standard application:

		INPUT LOGIC FUNCTIONS	DEFAULT INPUT	DEFAULT STATUS
I	00	Run command	L.I.4	L
I	01	Torque control		L
I	02	External consent	L.I.2	H
I	03	Enable 14 bit analog reference A.I.1.	L.I.3	L
I	04	Enable 14 bit analog reference A.I.2.	L.I.5	L
I	05	Enable speed jog	L.I.7	L
I	06	Enable digital potentiometer speed reference		L
I	07	Enable 14 bit analog reference A.I.3.		L
I	08	Alarms reset	L.I.1	L
I	09	UP digital potentiometer		L
I	10	DOWN digital potentiometer		L
I	11	Load last digital potentiometer value		L
I	12	Reversal reference	L.I.6	L
I	13	Enable power soft-start		H
I	14	Enable FIELD-BUS references		L
I	15	Enable Φ external flux (only in the DVET)		L
I	16	Activation second bank of parameters		L
I	17	Enable space loop for electrical axis		L
I	18	Enable time decode speed reference in frequency		
I	19	Enable speed references in frequency		L
I	20	Enable 16 bit speed reference (if present)		L
I	21	STOP command (locked run)		L
I	22	Enable line ramps	L.I.8	L
I	23	Motor termo-switch		L
I	24	Freeze PI speed regulator integral memory		L
I	25	Enable offset on overlap position loop reference		L
I	26	Enable second bank speed regulator gains		L
I	29	--- Reserved for special applications ----		
I	63	see special application enclosure		

NB: pay particular attention to the fact that it is absolutely not possible to assign the same logic function to two different logic inputs: after changing the connection value that sets a determined input, check that the value has been accepted, if not check that another has not already been allocated to that input. In order to disable a logic input it's necessary to assign to it the logic function -1 : this is the only value that can be assigned to more than one inputs.

For example, to assign a specific logic function to logic input 1 you must first write the desired logic number for connection C01 :

C01 = 14 → logic input 1 can be used to enable Fieldbus references

The logic functions that have been configured become active (H) when the input level is at high status (20V < V < 28V), and there is a 2.2ms hardware filter. With the connection **C79** it's possible to enable the active logic low state for a particular digital input, it's necessary to sum 2 to the power of ordinal input number:

For example to set digital inputs I0 and I3 to active low state, set: $C79 = 2^0 + 2^3 = 9$

The functions that have not been assigned assume default value ; for example, if the function "external enable" is not assigned it becomes, as default, "active (H)" so the converter is as if there were no assent from the field.

4.1.1. Input logic functions set in other ways

In reality the input logic functions can also be set by serial connection and by fieldbus, with the following logic:

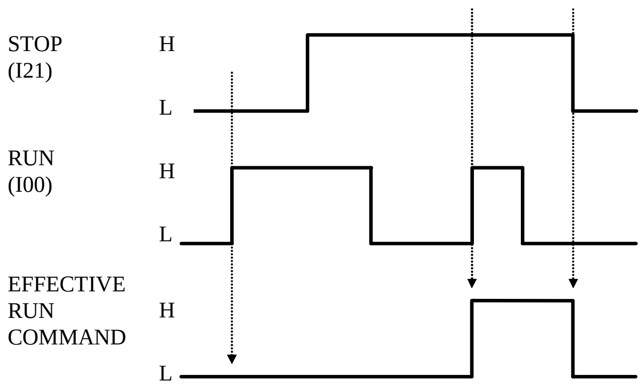
- I00 Run = stands alone, it has to be confirmed by terminal board inputs, by the serial and by the fieldbus, though in the case of the latter the default is active and so, if unaltered, controls only the terminal board input.
- I01÷ I28 = is the parallel of the corresponding functions that can be set at the terminal board, the serial or the fieldbus.
- I29 ÷ I63 = only the functions reserved for special applications, they can certainly be changed by suitably configuring the terminal board inputs, and other possibilities can be attributed by the application itself.

4.1.2. Locked Run from terminal board

It may be a matter of interest that the RUN command can be given by the commutation edge from a low to high signal: to enable this function set **C53=1**.
In this operational mode the STOP command is also used (I21, after having configured one of the logic inputs) which is level sensitive:

- low level: converter in STOP, power disabled
- high level: the converter can be at RUN

The diagram below shows the working logic:



- The RUN command is only given if there is a risign edge L->H on I00 with I21 high.
- Once RUN has been give to logic input I00 can return to low level
- As soon as the STOP signal (I21) goes to low the RUN command is switched off
- If the converter goes into an alarm state the run command will be switched off and so it will be necessary to repeat the start up procedure as soon as the converter is ready again.

5. Logic outputs management

The control can have up to 4 optically insulated digital outputs (L.O.1 … L.O.4) whose logic functions can be configured as active high (H) by means of connection **C10** ÷ **C13**.
The following table shows the logic functions managed by standard application:

		OUTPUT LOGIC FUNCTIONS	DEFAULT OUTPUT
O	00	Drive ready	L.O.2
O	01	Thermal motor alarm	
O	02	Speed above minimum	L.O.4
O	03	Run drive	L.O.1
O	04	CW / CCW	
O	05	Current/torque relay	
O	06	End of ramp	L.O.3
O	07	Current limit drive	
O	08	Torque limit drive	
O	09	Incremental position error > threshold (P37 ane P39)	
O	10	Switch on power soft-start	
O	11	Braking active	
O	12	No supply mains	
O	13	Bus regeneration activated (Support 1)	
O	14	Motor thermal current above threshold (P96)	
O	15	Radiator temperature too high (above threshold P120)	
O	16	Speed reached (above absolute value at P47)	
O	17	No supply main to Power electronic card	
O	19	Regulation card supplied and DSP not in reset state	
O	20	DC Bus above threshold (P177)	
O o	21 31	----- Reserved for special application ----- see special application enclosure	

If you wish to have the logic outputs active at the low level (L) you need just configure the connection corresponding to the chosen logic function but with the value denied: for example, if you want to associate the function " end of ramp " to logic output 1 active low, you have to program connection 10 with the number -6 (C10=-6).

Note: if you want to configure Output logic 0 to active low you have to set the desired connection to value -32