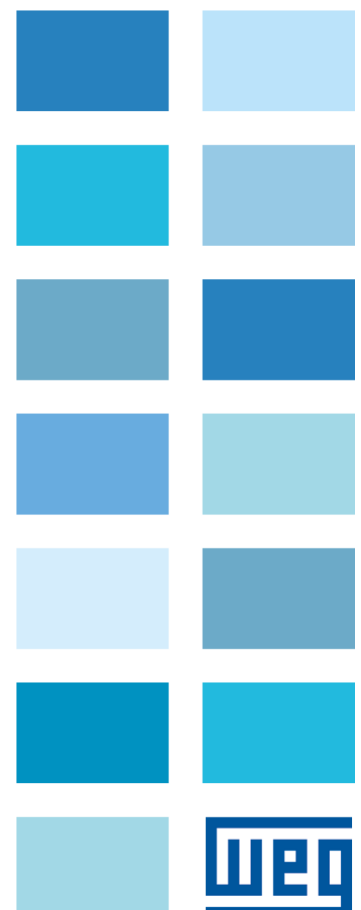


Field oriented vector AC Drive for synchronous/asynchronous motors

ADV200 - PID Application

Instruction manual

Language: English



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Before using the product, read the safety instruction section carefully.

Keep the manual in a safe place and available to engineering and installation personnel during the product functioning period.

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1. GENERAL INFORMATION

The PID function was developed for general uses, including the operation of drive rolls, winders and unwinders and pump and extruder pressure control.

A dancer or a load cell can be used as position/tension transducer.

The inputs (except those concerning transducers) and outputs can be configured and associated with various drive parameters. For example, the PID output can be sent to the ramp or torque regulators.

Analog inputs/outputs are sampled/updated every 2 msec.

Digital inputs/outputs are sampled/updated every 8 msec.

1.1. Compatibility Application version / Drive firmware

PID	Drive Firmware
2.0.1	5.X.X : 6.X.X ; 7.X.X and higher

3. PID menu tree

Refer to the following sections for a detailed description of each parameter.

The internal Type column is useful for configuring PDC (fieldbus) channels if programmed as “direct access”.

Menu	Ipa	Parameter Name	User type	Target type	Mu
MAIN		11002 PID Norm Value	Int16	Int16	Cnts
		11004 PID Out Sign	Enum	Boolean	
		11006 Enable PD	Enum	Boolean	
		11008 Enable PI	Enum	Boolean	
		11010 Fwd-Rev PID	Enum	Boolean	
		12000 PID Feed-fwd	Int16	Int16	norm
		12004 PI Output	Float	Int16	
		12006 Real Feed-fwd	Int16	Int16	norm
		12008 PD Output	Int16	Int16	norm
		12010 PID Output	Int16	Int16	norm
		12012 Drive Status	Enum	Int16	
		12014 PID Status	Uint16	Uint16	
PID SOURCE		11012 PID Source Gain	Float	Int16	
		11014 PID Source	Int16	Int16	norm
		11016 PID Src Acc Time	Float	Int32	sec
		11018 PID Src Dec Time	Float	Int32	sec
		11020 PID FstStop Dec	Float	Int32	sec
		11022 PID Src RampIn=0	Boolean	Boolean	
		11024 PID Fast Stop	Enum	Boolean	
PID REFERENCES		11026 PID Clamp	Int16	Int16	norm
		11028 PID Offset 0	Int16	Int16	norm
		11030 PID Offset 1	Int16	Int16	norm
		11032 PID Feed-back	Int16	Int16	norm
		11034 PID Offset0 Gain	Float	Int16	
		11036 PID Error Gain	Float	Int16	
		11038 PID Offs AccTime	Float	Int32	sec
		11040 PID Offs DecTime	Float	Int32	sec
		11042 PID Offset Sel	Enum	Boolean	
		12016 PID Error	Int16	Int16	norm
PI CONTROLS		11044 PI Steady Delay	Uint16	Uint16	msec
		11046 PI Steady Thr	Int16	Int16	norm
		11048 P Init Gain	Float	Int16	%
		11050 I Init Gain	Float	Int16	%
		11052 PI Top Limit	Float	Int16	
		11054 PI Bottom Limit	Float	Int16	
		11056 PI Central V1	Float	Int16	
		11058 PI Central V2	Float	Int16	
		11060 PI Central V3	Float	Int16	
		11062 PICentral V Sel	Uint16	Uint16	
		11064 PI Int Freeze	Enum	Boolean	
		12018 PI Input	Int16	Int16	norm

Menu	Ipa	Parameter Name	User type	Target type	Mu
	12020	PI P Gain In Use	Float	Int16	%
	12022	PI I Gain In Use	Float	Int16	%
PD CONTROLS					
	11066	PD D Filter	Int32	Int32	msec
	12024	PD D Gain In Use	Float	Int16	%
	12026	PD P Gain In Use	Float	Int16	%
GAINS ADAPTIVE					
REGIONS					
	11116	Region A End	Int16	Int16	norm
	11118	Region B Start	Int16	Int16	norm
	11120	Region B End	Int16	Int16	norm
	11122	Region C Start	Int16	Int16	norm
PI ADAPTIVE					
	11124	PI P Gain A	Float	Int16	%
	11126	PI I Gain A	Float	Int16	%
	11128	PI Adapt Ref Sel	Enum	UInt16	
	11130	PI Adapt Ref	Int16	Int16	norm
	11132	PI P Gain B	Float	Int16	%
	11134	PI I Gain B	Float	Int16	%
	11136	PI P Gain C	Float	Int16	%
	11138	PI I Gain C	Float	Int16	%
PD ADAPTIVE					
	11142	PD Adapt Ref Sel	Enum	UInt16	
	11144	PD Adapt Ref	Int16	Int16	norm
	11146	PD P Gain A	Float	Int16	%
	11148	PD D Gain A	Float	Int16	%
	11150	PD P Gain B	Float	Int16	%
	11152	PD D Gain B	Float	Int16	%
	11154	PD P Gain C	Float	Int16	%
	11156	PD D Gain C	Float	Int16	%
	11158	PD Adapt Enable	Enum	Boolean	
PID TARGET					
	11068	PID Output Scale	Float	Int16	
	11070	PID Target Sel	Enum	UInt16	
	12028	PID Target	Int16	Int16	
DIAMETER CALC					
	11072	Diam Calc SpdThr	Int16	Int16	%
	11074	Line Speed	Int16	Int16	norm
	11076	Line Speed Gain	Float	Int16	
	11078	Base Omega	Int16	Int16	rpm
	11080	Diam Calc FilTau	Float	Int32	s
	11082	Diameter Thr 1	Float	Float	mm/inches
	11084	Diameter Thr 2	Float	Float	mm/inches
	11086	Maximum Diameter	Float	Float	mm/inches
	11088	Unwind	Boolean	Boolean	
	11090	Diameter Calc	Enum	Boolean	
	11092	DiamIncDecEnable	Enum	Boolean	
	12030	LineSpeed Scaled	Int16	Int16	norm
	12032	Calc Diameter	Float	Float	mm/inches

Menu	Ipa	Parameter Name	User type	Target type	Mu
	12034	Estimated Diam	Float	Float	mm/inches
	12036	Over Diam Thr 1	Boolean	Boolean	
	12038	Over Diam Thr 2	Boolean	Boolean	
	12040	Diam Max Stat	Boolean	Boolean	
	12042	Diam Min Stat	Boolean	Boolean	
DIAMETER INIT					
	11094	Dancer Pitches	Uint16	Uint16	
	11096	Max Deviation	Int16	Int16	norm
	11098	Positioning Spd	Int16	Int16	rpm
	11100	Gear Box Ratio	Float	Float	
	11102	Minimum Diameter	Float	Float	mm/inches
	11104	DancerHalfTravel	Float	Float	mm/inches
	11106	Diameter Init	Enum	Boolean	
	12044	DiameterInitStatus	Enum	Int16	
	12046	Initial Diameter	Float	Float	mm/inches
	12048	DiamInitComplete	Boolean	Boolean	
	12050	DiamInit Aborted	Boolean	Boolean	
I/O					
DIGITAL INPUTS					
	11178	Fwd-Rev PID Sel	Enum	Int16	
	11180	Enable PD Sel	Enum	Int16	
	11182	Enable PI Sel	Enum	Int16	
	11184	PI C V Bit 0 Sel	Enum	Int16	
	11186	PI C V Bit 1 Sel	Enum	Int16	
	11188	PID Offset InSel	Enum	Int16	
	11190	PI Int Freez Sel	Enum	Int16	
	11192	Wind Unwind Sel	Enum	Int16	
	11194	Diam Init Sel	Enum	Int16	
	11196	PIDSrcRamp=0 Sel	Enum	Int16	
	11198	PID FastStop Sel	Enum	Int16	
DIGITAL OUTPUTS					
	11114	PID Status Dest	Enum	Int16	
	11200	Max Diam Dest	Enum	Int16	
	11202	Min Diam Dest	Enum	Int16	
	11204	Diam Thr 1 Dest	Enum	Int16	
	11206	Diam Thr 2 Dest	Enum	Int16	
	11208	DiamIniCompl Des	Enum	Int16	
	11210	DiamIniAbort Des	Enum	Int16	
ANALOG INPUTS					
	11212	PID Src Sel	Enum	Uint16	
	11214	FeedBack Sel	Enum	Uint16	
	11216	PIDOffs0 Sel	Enum	Uint16	
	11218	PICentralV3 Sel	Enum	Uint16	
	11220	LineSpeed Sel	Enum	Uint16	
ANALOG OUTPUTS					
	11222	PID Target Dest	Enum	Int16	
	11224	Calc Diam Dest	Enum	Int16	
	11226	PID Error Dest	Enum	Int16	

Menu	Ipa	Parameter Name	User type	Target type	Mu
FIELD BUS	11000	PID Rem Cnds Src	Enum	Uint16	
	11228	PID Remote Cnds	Uint16	Uint16	
SPEED	11110	MainEncSpeedBase	Uint32	Uint32	rpm
	12052	Actual Speed	Int16	Int16	norm
ABOUT	12056	APP Version	Float	Float	
	12058	MDPlc Version	Float	Float	
	12060	GF Version	Float	Float	

4. Machine control states

The PID machine control function states are shown below.

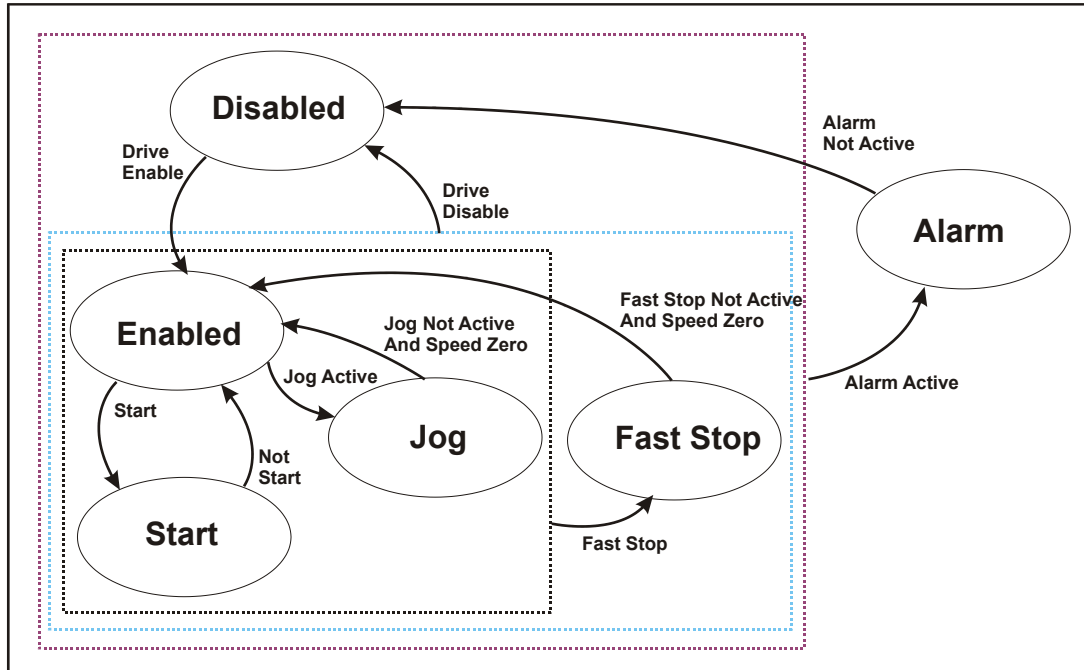


Fig. 1 - PID machine control states

There are 6 defined states:

Disabled	Initial state; the drive is disabled; the PID function is enabled. If PID Target Sel is set to a value other than Off, the integral part of the PI regulator and the ramp on PID Source are blocked. The state ceases if the Enable Cmd is sent.
Enabled	This state is activated when Enable Cmd is sent; the PID function is enabled. If PID Target Sel is set with Dig ramp ref 1, Dig speed ref 1 or Dig torque ref 1, the integral part of the PI regulator and the ramp on PID Source are blocked.
Jog	This state is started when the Jog commands are active; the drive is enabled, the PID function is enabled. If PID Target Sel is set to a value other than Off, the integral part of the PI regulator and the ramp on PID Source are blocked.
Start	This state is activated when Start cmd is sent. The drive is enabled, the PID function is enabled. Jog commands can no longer be sent. The state ceases when Start cmd is removed.
Fast Stop	In the Enabled, Jog and Start states, the drive can be stopped in the Fast Stop condition; the drive is enabled, the PID function is enabled. If PID Target Sel is set to a value other than Off, the integral part of the PI regulator and the ramp on PID Source are blocked.
Alarm	In each of the states described above, if an alarm occurs the drive enters Alarm mode; the drive is disabled, the PID function is enabled. If PID Target Sel is set to a value other than Off, the integral part of the PI regulator and the ramp on PID Source are blocked. The state ceases when none of the alarms are active any more and the user has sent an Alarm Reset command.

5. General parameters

Parameter	N.	Value			Standard configuration
		min	max	factory	
PID Norm Value	11002	0	16383	10000	
Drive Status	12012	See below			
PID Status	12014	0	FFFF Hex	0	

PID Norm Value This parameter indicates the full scale value at the PID analog inputs/outputs; this value is usually set to 10000, but it can be changed to suit particular requirements. The unit of measure for parameters normalised according to this value is the “**norm**”.

Drive Status Machine condition according to drive states (see “Machine control states”)

- 0 - Disabled
- 1 - Enabled
- 2 - Start Active
- 3 - JOG Active
- 4 - Fast Stop Active
- 5 - Alarm!

PID Status PID status bitwords.

- Bit 0 : Drive ready
- Bit 1 : Drive enabled status
- Bit 2 : Maximum diameter reached
- Bit 3 : Minimum diameter reached
- Bit 4 : Diameter threshold exceeded 1
- Bit 5 : Diameter threshold exceeded 2
- Bit 6 : Diameter initialisation complete
- Bit 7 : Diameter initialisation aborted
- Bit 8 : Zero speed status

6. Inputs/Outputs

6.1. Regulation inputs/outputs

PID Source	Feedforward input normally programmed on analog input.
PID Feed-back	Analog input for the position/tension transducer (dancer/load cell).
PID Offset 0	Offset from analog input added to PID Feed-back . It can be used to adjust the dancer position.
PI Central V3	Setting of the initial value of the integral component of the regulator (corresponding to the initial diameter). It can be programmed on an analog input connected, for example, to an ultrasonic transducer used to measure the diameter of a winder/unwinder.
Line Speed	Line speed used to measure the roll diameter.
PID Target	Parameter associated with the regulator output; it is normally programmed on the drive ramp reference.
PID Output	Analog output of the regulator. It can be used to perform reference cascades in multi-drive systems.
Calc Diameter	Output of the roll diameter calculation.

Input commands (programmable on digital inputs)

Enable PI	Enabling of the PI part (proportional – integral) of the regulator. Input L – H transition also requires the automatic acquisition of the power value of the integral component (corresponding to the initial diameter).
Enable PD	Enabling of the PD part (proportional – derivative) of the regulator.
PID Src RampIn=0	The PID Source ramp input is set to 0.
PID Fast Stop	PID Fast Stop acts on the PID Source ramp and differs from the general Fast Stop command. The PID Source ramp input is set to 0 and the deceleration time is selected on the basis of the PID FstStop Dec parameter.
PI Int Freeze	The current condition of the regulator integral component is frozen.
PID Offset Sel	Selection of the offset added to the PID Feed-back parameter: L = PID Offset 0 , H = PID Offset 1 .

PI C V Bit0 Sel	Initial PI block output selector. When the PI C V Bit0 parameter has been defined through binary selection, 4 different initial integral level settings can be selected (corresponding to the initial diameter).
PI C V Bit1 Sel	Initial PI block output selector. When the PI C V Bit1 parameter has been defined through binary selection, 4 different initial integral level settings can be selected (corresponding to the initial diameter).
Diameter Init	Enabling of the diameter initialisation function.
Unwind	Used to indicate to the diameter calculation procedure that the drive is in the unwinding phase.
Fwd-Rev PID	Used to invert the PID Output signal if the mechanical ratio is reversed.

Output states (programmable on digital outputs)

Max Diameter	The diameter calculation procedure has detected the maximum diameter.
Min Diameter	The diameter calculation procedure has detected the minimum diameter.
Over Diam Thr 1	The diameter calculation procedure has detected that the diameter exceeds the Diameter Thr 1 parameter.
Over Diam Thr 2	The diameter calculation procedure has detected that the diameter exceeds the Diameter Thr 2 parameter.
DiamInitComplete	The diameter initialisation procedure is complete.
DiamInit Aborted	The diameter initialisation procedure has been aborted

7. Feedforward

Parameter	N.	Value			Standard configuration
		min	max	factory	
PID Source	11014	-32767	+32767	0	1
PID Source Gain	11012	-100.000	+100.000	1	
PID Feed-fwd	12000	PID Norm Value	+PID Norm Value	0	
PID Src Acc Time	11016	0.01	200	0.1	
PID Src Dec Time	11018	0.01	200	0.1	
PID FstStop Dec	11020	0.01	200	2	
PID Src RampIn=0	11022	0- Off	1- On	0-Off	2
PID Fast Stop	11024	0 -Active	1-Not Active	Not Active	3

- 1 The **PID Source** value can be sampled from a list of selectable sources; refer to the **PID Src AnInpSel** parameter in the I/O\Analog Inputs menu.
- 2 **PID Src RampIn=0** can be sampled from a list of digital inputs; refer to the **PIDSrcRamp=0 Sel** parameter in the I/O\Digital Inputs menu
- 3 **PID Fast Stop** can be sampled from a list of digital inputs; refer to the **PID FastStop Sel** parameter in the I/O\Digital Inputs menu

When in use, the feedforward signal is the main reference of the regulator. Inside the regulator, the signal is reduced or amplified by the PID function and output as a reference signal for the drive.

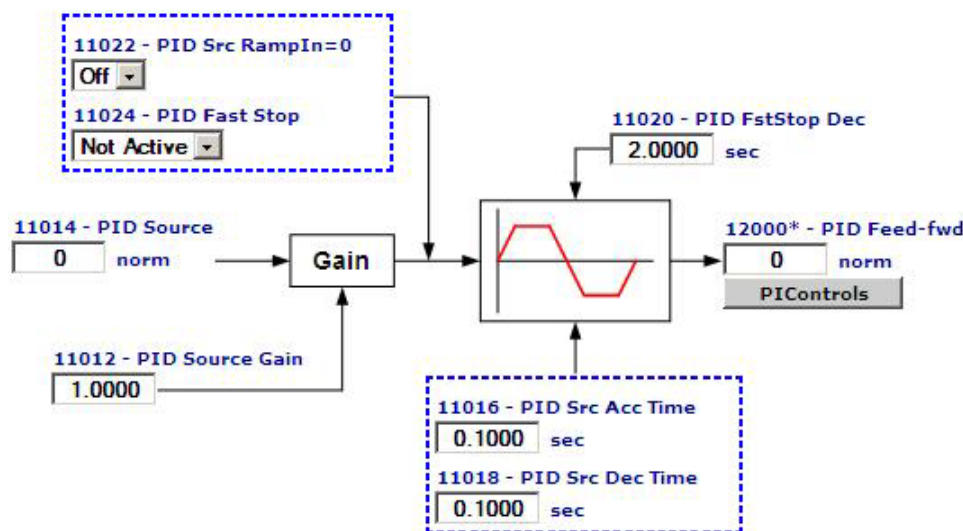


Fig. 2 – description of the feedforward block

PID Source	PID Source value.
PID Source Gain	Multiplication factor of the input value in relation to the PID Source parameter.
PID Feed-fwd	Feedforward value
PID Src Acc Time	Ramp acceleration time of the PID Source parameter; the value indicates the time required for the ramp output to go from zero to [PID Norm Value] (e.g. from 0 to 10000). The predefined value is low so that the ramp is not present.

PID Src Dec Time	Ramp deceleration time of the PID Source parameter; the value indicates the time required for the ramp output to go from [PID Norm Value] to zero (e.g. from 10000 to 0). The predefined value is low so that the ramp is not present.
PID Fst Stop Dec	Ramp deceleration time of the PID Source Fast Stop parameter; the value indicates the time required for the ramp output to go from [PID Norm Value] to zero (e.g. from 10000 to 0).
PID Src RampIn=0	Input of the PID Source Ramp parameter set to 0; if enabled, the ramp input is immediately set to 0 and the output reaches the zero value in the time set in the PID Src Dec Time parameter.
PID Fast Stop	PID Fast stop command; if activated, the ramp input is immediately set to 0 and the output reaches the zero value in the time set in the PID Fst Stop Dec parameter.
Nota!	If the regulator is used as "generic PID" without the feedforward function, the Feed - fwd parameter must be set to its maximum value. This must be done by setting the PID Source parameter using the same value as that set in PID Norm value

8. PID function

The PID function is divided into three blocks:

- Feedback input **"PID References"**
- Proportional - integral control block **"PI Controls"**
- Proportional - derivative control block **"PD Controls"**

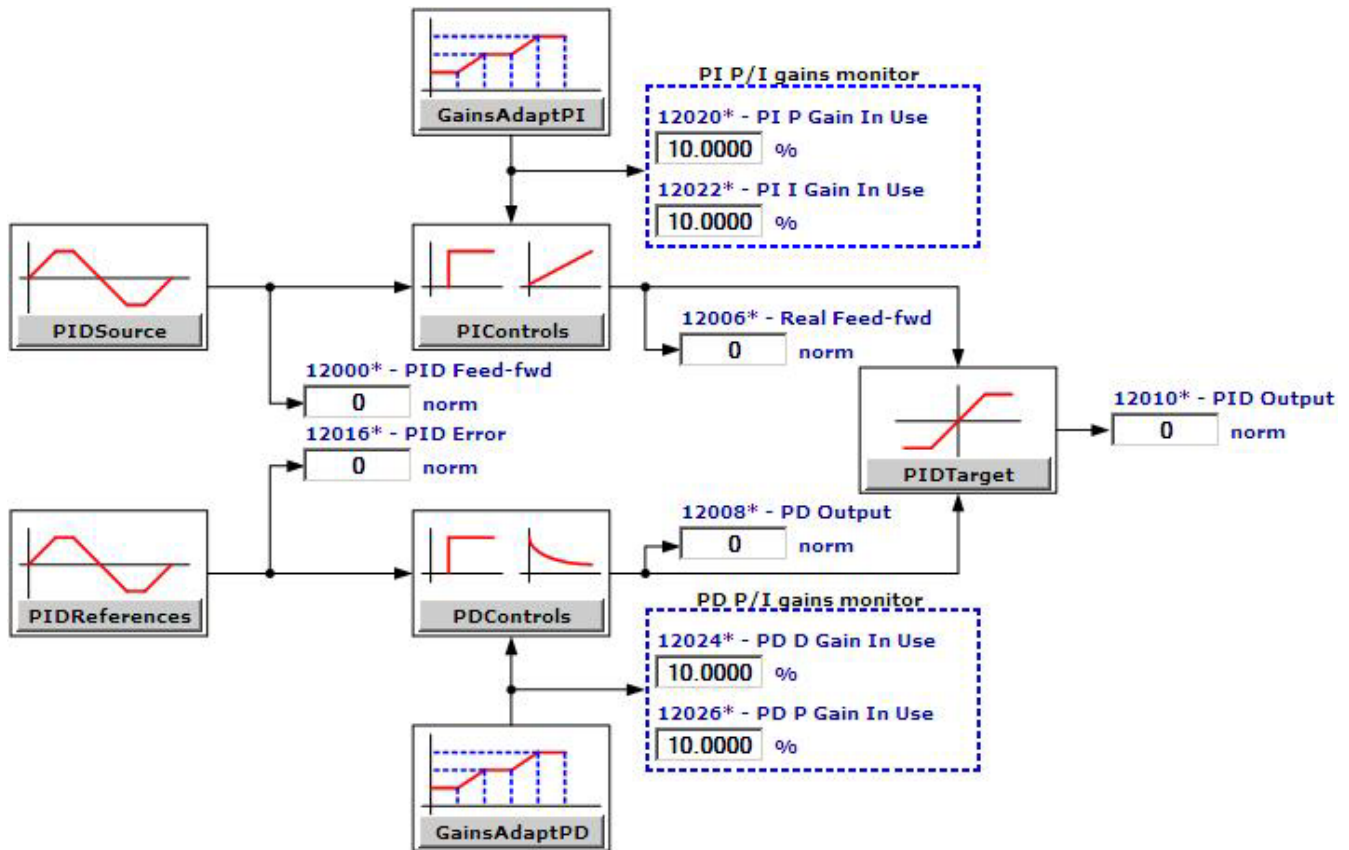


Fig. 2-A – Overview PID function

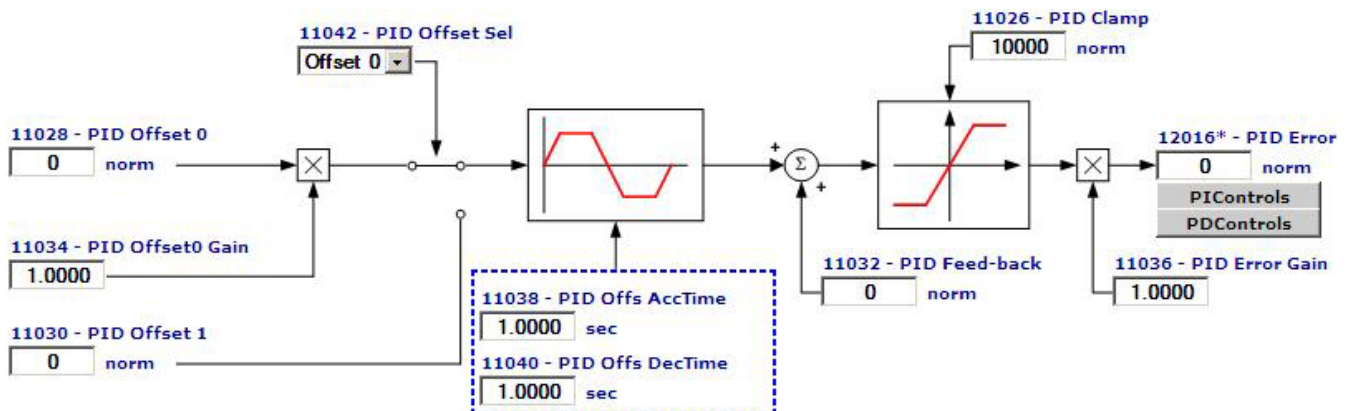


Fig. 3-B – description of the feedback block

Parameter	N.	Value			Standard configuration
		min	max	factory	
PID Error	12016	-PID Norm Value	+PID Norm Value	0	1
PID Feed-back	11032	-PID Norm Value	+PID Norm Value	0	2
PID Offset Sel	11042	0	1	0	3
PID Offset0 Gain	11034	-10.00	+10.00	1	
PID Offset 0	11028	-PID Norm Value	+PID Norm Value	0	4
PID Offset 1	11030	-PID Norm Value	+PID Norm Value	0	
PID Offs Acc time	11038	0.0	900.0	1.0	
PID Offs Dec time	11040	0.0	900.0	1.0	
PID Error Gain	11036	-10.00	+10.00	1	
PID Clamp	11026	-PID Norm Value	+PID Norm Value	10000	

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1 The PID Error value can be set on a programmable analog output; refer to the I/O\Analog Outputs menu.

2 The PID Feed-back value can be sampled from a list of selectable sources; refer to the FeedBack AnInpSel parameter in the I/O\Analog Inputs menu.

3 PID Offset Sel can be sampled from a list of digital inputs; refer to the PID Offset InSel parameter in the I/O\Digital Inputs menu

4 The PID Offset 0 value can be sampled from a list of selectable sources; refer to the PIDOffs0 AnInpSel parameter in the I/O\Analog Inputs menu.

PID Error Reading of the error input to the PID function (**PID Clamp** block output).

PID Feed-back Reading of the feedback value from the position (dancer) or tension (load cell) transducers.

PID Offset Sel Selection of the offset added to **PID Feed-back**. This parameter can be set from a programmable digital input.

0 = **PID Offset 0** 1 = **PID Offset 1**

PID Offset 0 Offset 0 added to **PID Feed-back**. This parameter can be set via an analog input, for example to set the tension when using a load cell as feedback.

PID Offset0 Gain Gain of **PID Offset 0**

PID Offset 1 Offset 1 added to **PID Feed-back**.

PID Offs AccTime Ramp acceleration time in seconds after the **PID Offset** parameter block.

PID Offs DecTime Ramp deceleration time in seconds after blocking the **PID Offset** parameter block.

PID Error Gain Gain of **PID error**

PID Clamp The clamp allows the controlled system, winder or unwinder, to be tensioned smoothly, when the “**Errore. L'origine riferimento non è stata trovata.**” function cannot be used. When the drive is enabled with the dancer at the minimum full scale, so that the **PID Error** is at its maximum value, the motor could accelerate suddenly to move the dancer to its central working position.

If **PID Clamp** is set to a sufficiently low value, for instance 1000, after enabling the drive and the **Enable PD** parameter, the **PID Error** value is limited to 1000 until the signal coming from the dancer (**PID Feed-back**) falls below the clamp value. The **PID Clamp** value is then automatically restored to the maximum value corresponding to the **PID Norm Value** parameter. The clamp is kept at this value until the drive or the **Enable PD** parameter is disabled again.

The feedback input is supplied to connect the analog transducers such as the dancer, to the relative potentiometer or load cell. However, the input block can be used as a point of comparison between two generic input signals of + / - 10V.

Connection to a dancer via potentiometer connected with an interval of between - 10 and + 10V.

The cursor of the potentiometer can be connected to one of the analog inputs of the drive.
The selected input must be programmed in **FeedBack AnInpSel** in the I/O\Analog Inputs menu.
The position of the dancer can be adjusted through the **PID Offset 0** or **PID Offset 1** parameters.

Connection to a load cell with maximum voltage + 10V.

The output of the load cell can be connected to one of the analog inputs of the drive.
The selected input must be programmed in **FeedBack AnInpSel** in the I/O\Analog Inputs menu.
The tension setting, with a value of 0...-10V, can be sent to one of the remaining programmable analog inputs and programmed using the **PIDOffs0 AnInpSel** parameter in the I/O\Analog Inputs menu.

9. Proportional - integral control block

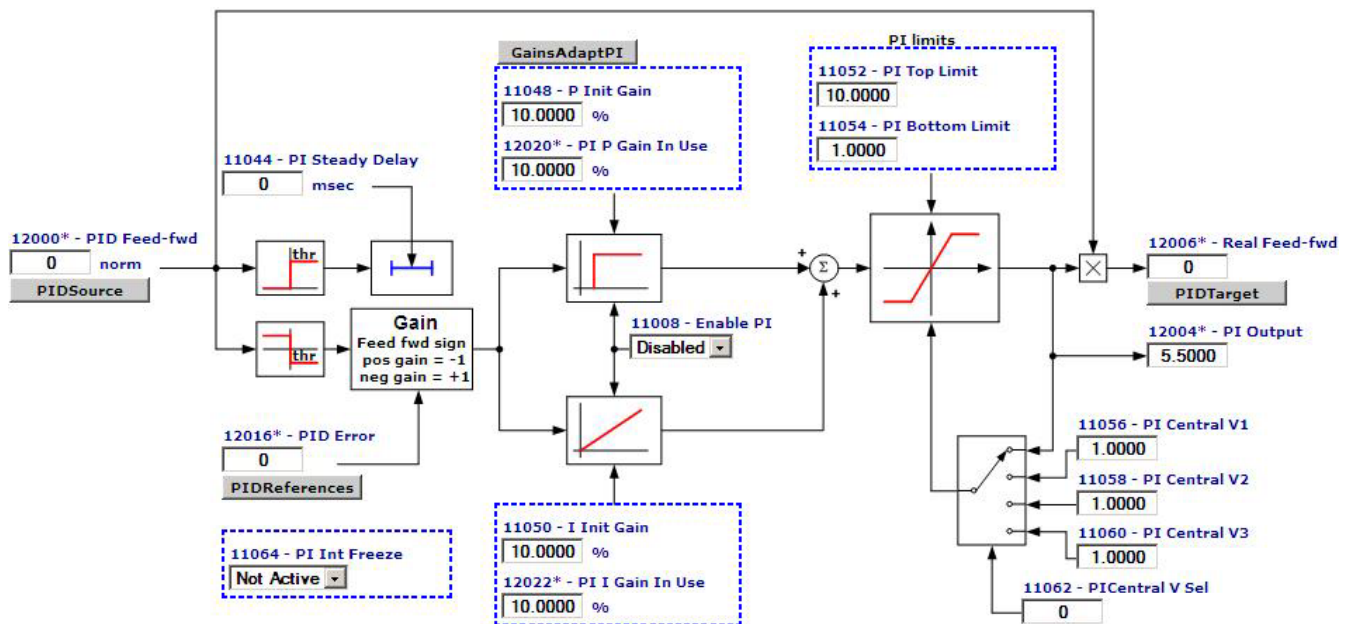


Fig. 4 – description of the PI block

The PI block receives the **PID Error** parameter as an input: this is the error to be processed by the regulator. The PI block performs a proportional - integral regulation; the output is identified by parameter **PI output**. After being suitably adapted according to the system to be controlled, it is used as the **PID Feed-fwd** multiplication factor in order to obtain the correct drive speed reference value (**Real Feed-fwd**).

The PI block is enabled by setting **Enable PI** = Enable. If the **Enable PI** parameter is programmed on a digital input, it must be set to a high logic level (+24V).

Parameter	N.	Value			Standard configuration
		min	max	factory	
Menu					
Enable PI	11008	0-Disabled	1-Enabled	Disabled	1

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¹ **Enable PI** can be sampled from a list of digital inputs; refer to the **Enable PI Sel** parameter in the I/O\Digital Inputs menu

Enable PI	Enabled	Enables the proportional - integral block
	Disabled	Disables the proportional - integral block.

Parameter	N.	Value			Standard configuration
		min	max	factory	
PI Input	12018	-PID Norm Value	+PID Norm Value	0	
PI P Gain In Use	12020	0.00	100.00	10.00	
PI I Gain In Use	12022	0.00	100.00	10.00	
PI Steady Thr	11046	0	10000	500	
PI Steady Delay	11044	0	60000	0	
P Init Gain	11048	0.00	100.00	10.00	
I Init Gain	11050	0.00	100.00	10.00	
PI Central V Sel	11062	0	3	1	1
PI Central V 1	11056	PI Bottom Lim	PI Top Limit	1.00	
PI Central V 2	11058	PI Bottom Lim	PI Top Limit	1.00	
PI Central V 3	11060	PI Bottom Lim	PI Top Limit	1.00	2
PI Top Limit	11052	PI Bottom Lim	10.00	10.00	
PI Bottom Limit	11054	-10.00	PI Top Limit	0.00	
PI Int Freeze	11064	0	1	0	3
PI Output	12004	0	1000 x PI Top Limit	0.00	
Real Feed-fwd	12006	-10000	+10000	0	

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1 **PI Central V Sel** can be sampled from a list of digital inputs; refer to the **PI C V Bit 0 Sel** and **PI C V Bit 1 Sel** parameters in the I/O\Digital inputs menu

2 The **PI Central V 3** value can be sampled from a list of selectable sources; refer to the **PI Central V3AnInp** parameter in the I/O\Analog Inputs menu.

3 **PI Int Freeze** can be sampled from a list of digital inputs; refer to the **PI Int Freez Sel** parameter in the I/O\Digital inputs menu

PI Input PI input signal (PID Error after converting the sign)

PI P Gain In Use Proportional gain of the PI block; this value indicates the output of the PI Proportional Gain Adaptive parameter. If the adaptive function is disabled, this value corresponds to that of **PI P Gain A**.

PI I Gain In Use Integral gain of the PI block; this value indicates the output of the PI Proportional Gain Adaptive parameter. If the adaptive function is disabled, this value corresponds to that of **PI I Gain A**.

PI Steady Thr Threshold for feedforward measurement. If **PID Feed-fwd** is less than **PI Steady Thr**, integral regulation stops and the proportional gain assumes the value set in **P Init Gain**.
When **PID Feed-fwd** exceeds the limit, integral regulation is enabled with the gain set in **I Init Gain**. The PI block maintains the **P Init Gain** and **I Init Gain** parameters according to the time set in **PI Steady Delay**; at the end of this delay, they are automatically brought back to **PI P Gain In Use** and **PI I Gain In Use**.

PI Steady Delay The time required to maintain the gains in **P Init Gain** and **I Init Gain** operational after the feedforward limit set in **PI Steady Thr** has been exceeded.

The **PI Steady Delay** time and consequent functions in relation to the change in the initial gains, are also operational in the L – H transition of the **Enable PI** parameter.

P Init Gain Initial proportional gain. See the **PI Steady Thr** parameter for a detailed description.

I init gain PID Initial integral gain. See the **PI Steady Thr** parameter for a detailed description.

PI Central V Sel Selection of the output for PI block initialisation. **PI Central V Sel** (0...3) determines which of the 4 possible settings for the initial value of the integral component of the regulator (corresponding to the initial diameter) must be used.

The **PI Central V Sel** parameter can be set directly via keypad and serial line/bus or via two digital inputs (see **PI C V Bit 0 Sel** and **PI C V Bit 1 Sel** in the I/O\Digital inputs menu).

If **PI Central V Sel = 0** is selected with the PI block disabled (**Enable PI = Disable**), the last value of the integral portion that was calculated is stored (corresponding to the core diameter). The value in question is displayed in **PI Output**. Once the block has been re-enabled, the regulation re-starts from that value. The same function is also available if the drive is switched off. This type of operation can be used when, while controlling a winder, for example, the machine has to be stopped for any reason and the drive must be disabled or the control panel must be disconnected from the power supply.

When **PI Central V Sel = 1-2-3** is selected after disabling the PI block, the value of **PI Output** is set to the value programmed according to the corresponding central value (x1000).

When the drive is re-started after being switched off, the value of **PI Output** at the time of the last break is only automatically restored if, when the drive is switched on, the digital input programmed as **Enable PI** is already set to high.

PI Central V 1 Setting of the first initial value of the regulator's integral component (corresponding to initial diameter 1). The value of **PI Central V 1** must be within the set limits.

PI Top Limit and **PI Bottom Limit**.

PI Central V 1 is selected by setting the **PI Central V Sel** parameter to 1.

PI Central V 2 Setting of the second initial value for the regulator's integral component (corresponding to initial diameter 2). The value of **PI Central V 2** must be within the set limits.

PI Top Limit and **PI Bottom Limit**.

PI Central V 2 is selected by setting the **PI Central V Sel** parameter to 2.

PI Central V 3 Setting of the third initial value for the regulator's integral component (corresponding to initial diameter 3). The value of **PI Central V 3** must be within the set limits.

PI Top Limit and **PI Bottom Limit**.

PI Central V 3 is selected by setting the **PI Central V Sel** parameter to 3.

PI Top Limit Indicates the upper limit for the PI adjustment adaptive block.

PI Bottom Limit Indicates the lower limit for the PI adjustment adaptive block.

The PI block output is the feedforward multiplication factor. This value must be adjusted by the regulator according to the maximum limits between **+PID Norm Value** and **-PID Norm Value** and defined by **PI Top Limit** and **PI Bottom Limit**. The value of these parameters is defined on the basis of the the system to be controlled. Further details are provided in the "Examples of application" section.

PI Int Freeze The integral component of the regulator stops in the present condition.

PI Output PI block output, adapted to the values between the **PI Top Limit** and **PI Bottom Limit** parameters. When the drive is switched on, the **PI Output** parameter automatically acquires the value selected in **PI Central V Sel**.

Example: if **PI Central V 2** = 0.5 and **PI Central V Sel** = 2,
at start-up the **PI Output** parameter is set to = 500 (0.5x1000).

When **Enable PI** is activated, the **PI Output** parameter can, depending on the input error, integrate the value up to the limits set in **PI Top Limit** or **PI Bottom Limit** multiplied by 1000.

Example: **PI Top Limit** = 2, **PI Output** max = 2000.

The PI block output is also limited by saturation of the **Real Feed-fwd** parameter (see the corresponding parameter).

As described previously, the **PI Output** parameter acts as a feedforward multiplication factor to obtain the angular speed reference of the motor. For this reason, if the PID function is used to control a winder/unwinder, its value is inversely proportional to the core diameter.

Winding performed at a constant peripheral speed can satisfy the following equation:

$$\omega_0 \cdot \Phi_1 = \omega_1 \cdot \Phi_0$$

where:

ω_0 = angular speed at minimum diameter

Φ_0 = minimum diameter

ω_1 = angular speed at current diameter

Φ_1 = current diameter

$$\omega_1 = \omega_0 \times (\Phi_0 / \Phi_1)$$

When the drive is correctly adjusted ω is equal to the maximum feedforward value, so that the **PI Output** parameter depends on (Φ_0 / Φ_1) .

Considering the internal coefficients of the firmware, the following formula is obtained:

$$\text{PI Output} = (\Phi_0 / \Phi_1) \times 1000$$

This formula can be used to verify the accuracy of the setting while the system is working or the initial diameter calculation procedure.

Real Feed-fwd Indicates the feedforward value re-calculated according to the PI correction. This is calculated using the following formula:

$$\text{Real Feed-fwd} = (\text{PID Feed-fwd} / 1000) \times \text{PI Output}$$

The maximum value of the **Real Feed-fwd** parameter is equal to +/- **PID Norm Value**. If this limit is reached, any further increase in the value of **PI Output** is prevented, to avoid dangerous situations in connection with regulator saturation.

Example: **PID Feed-fwd** = + 8000, **PID Norm Value** = 10000, the positive limit for **PI Output** is automatically set to: $10000 / (8000 / 1000) = 1250$.

10. Blocco di controllo proporzionale – derivativo

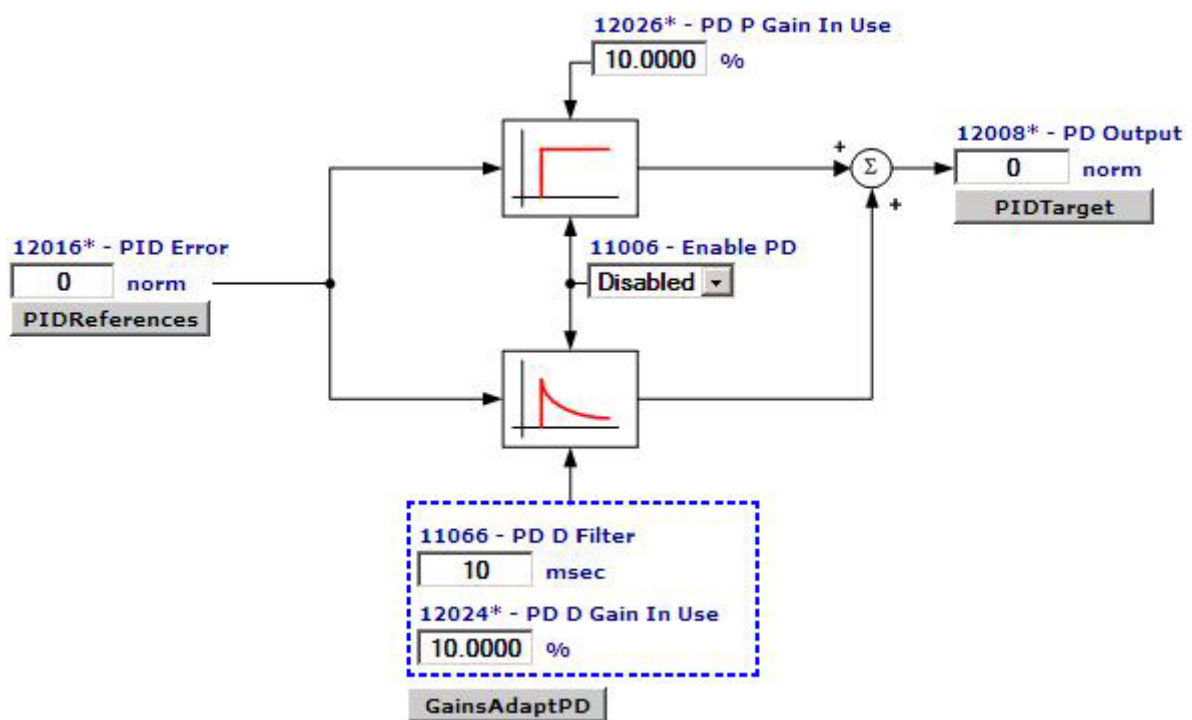


Fig. 5 – description of the PD block

The PD block receives the **PID Error** parameter as an input: this is the error to be processed by the regulator. The PD block performs a proportional - derivative regulation; its output identified by **PD Output** is added directly to the **Real Feed-fwd** parameter.

The PD block is enabled when **Enable PD** = Enable. If the **Enable PD** parameter is programmed on a digital input, it must be set to a high logic level.

Parameter	N.	Value			Standard configuration
		min	max	factory	
Menu					
Enable PD	11006	0- Disabled	1-Enabled	Disabled	1

1 Enable PD can be sampled from a list of digital inputs; refer to the Enable PD Sel parameter in the I/O\Digital Inputs menu

Enable PD PID	Enabled	Enables the proportional - derivative block
	Disabled	Disables the proportional - derivative block.

Parameter	N.	Value			Standard configuration
		min	max	factory	
PD P Gain In Use	12026	0.00	100.00	10.00	
PD D Gain In Use	12024	0.00	100.00	10.00	
PD D Filter	11066	0	1000	10	
PD Output	12008	-32767	+32767	0	

T6395g

PD P Gain In Use	Proportional gain of the PD block; this value indicates the output of the PD Proportional Gain Adaptive parameter. If the adaptive function is disabled, this value corresponds to that of PD P Gain A .
PD D Gain In Use	Derivative gain of the PD block; this value indicates the output of the PD Derivative Gain Adaptive parameter. If the adaptive function is disabled, this value corresponds to that of PD D Gain A .
PD D Filter	Time constant of the derivative filter expressed in milliseconds.
PD Output	PD block output.

11. Output reference

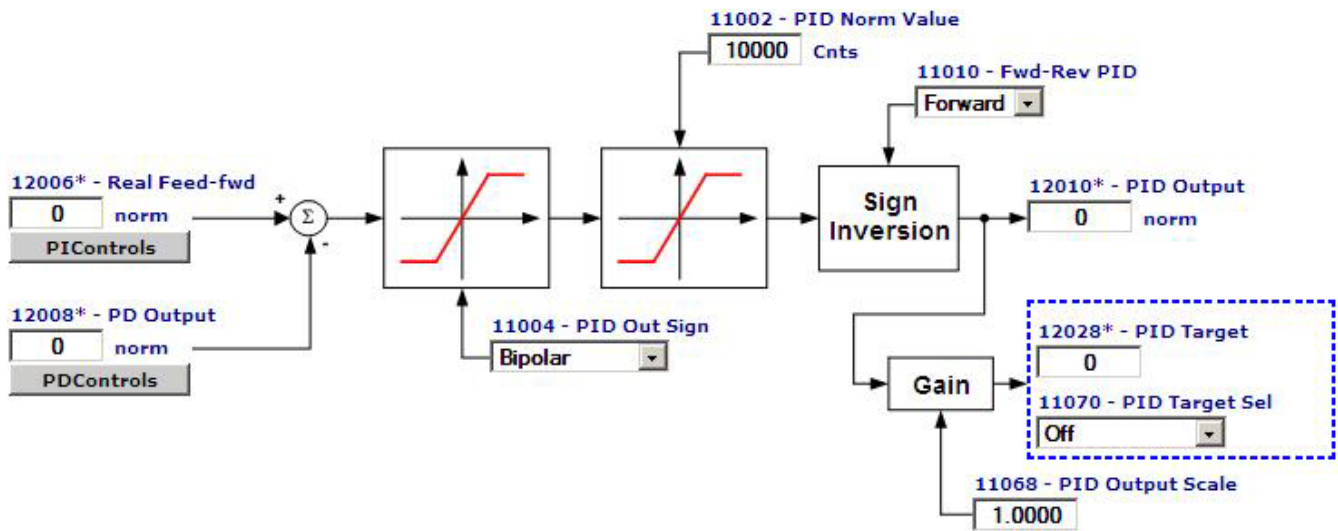


Fig. 6 – description of the output reference block

Parameter	N.	Value			Standard configuration
		min	max	factory	
PID Out Sign	11004	0-Only Positive	1-Bipolar	Bipolar	
Fwd-Rev PID	11010	0-Forward	1-Reverse	Forward	1
PID Output	12010	-PID Norm Value	+PID Norm Value	0	2

1 Fwd-Rev PID can be sampled from a list of digital inputs; refer to the **Fwd-Rev PID Sel** parameter in the I/O\Digital Inputs menu

2 This parameter can be set on a programmable analog output, refer to the I/O\Analog Outputs menu.

PID Out Sign This parameter can be used to set the type of regulator output as either bipolar or positive only (negative clamp values).

Fwd-Rev PID This parameter can be used to reverse the sign of the **PID Output** value, which is useful when the mechanical ratio is inverted.

PID Output The regulator output is displayed. This parameter can be programmed on an analog output in order to perform reference cascades in multi-drive systems.

Parameter	N.	Value			Standard configuration
		min	max	factory	
PID Target Sel	11070	0 – Off	7- Trq curr lim Neg	0-Off	
PID Output Scale	1005	-	-	1.000	
PID Target	7015	-32767	+32767	0	

PID Target Sel	Selection of the destination of the PID Target parameter; this value can be set as follows: 1. Off: Target not assigned 2. Dig ramp ref 1: the target is assigned to reference 1 of the drive's standard ramp generator. If the PID Output Scale parameter is set to 1, a PID Norm Value on PID Output corresponds to a value equal to Full scale speed on PID Target (ramp reference). 3. Dig ramp ref 2: the target is assigned to reference 2 of the drive's standard ramp generator. If the PID Output Scale parameter is set to 1, a PID Norm Value on PID Output corresponds to a value equal to Full scale speed on PID Target (ramp reference). 4. Dig speed ref 1: the target is assigned to reference 1 of the drive's speed regulator. If the PID Output Scale is set to 1, a PID Norm Value on PID Output corresponds to a value equal to Full scale speed on PID Target (reference speed). 5. Dig speed ref 2: the target is assigned to reference 2 of the drive's speed regulator. If the PID Output Scale is set to 1, a PID Norm Value on PID Output corresponds to a value equal to Full scale speed on PID Target (reference speed). 6. Dig torque ref 1: the target is assigned to the drive's current regulator reference. If the PID Output Scale parameter is set to 1, a PID Norm Value on PID Output corresponds to a value equal to Drive cont current on PID Target (current reference). 7. Trq curr lim Pos: the target is assigned to the positive limit of the drive's current regulator. If the PID Output Scale parameter is set to 1, a PID Norm Value on PID Output corresponds to a value equal to Drive cont current on PID Target (current limit). 8. Trq curr lim Neg: the target is assigned to the negative limit of the drive's current regulator. If the PID Output Scale parameter is set to 1, a PID Norm Value on PID Output corresponds to a value equal to Drive cont current on PID Target (current limit).
PID Output scale	PID Output and PID Target parameter adjustment factor. Increase or decrease this value to set a factor other than 1 in the speed and torque ratios described in PID Target Sel .
PID Target	Current PID target value after setting the PID Output Scale parameter.

12. Gains adaptive

The gains of the PI and PD blocks can be fixed or variable, depending on machine characteristics. For example, PD block gains can be dynamically modified according to the speed or a proportional analog input to a unit measured by the system. This unit therefore acts as an adaptive reference for the PD Adaptive.

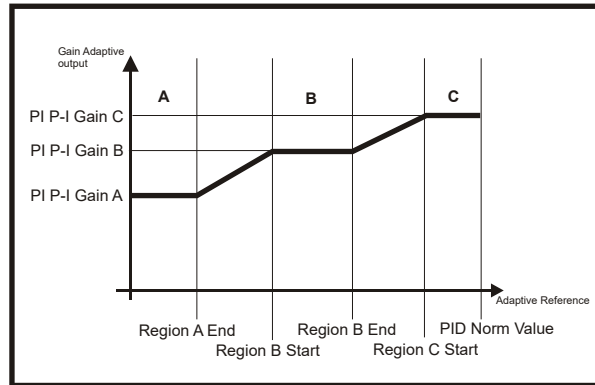


Fig. 7 – Adaptive gains

The regulator can be configured with the best settings, depending on the specific requirements, by defining 3 different sectors, in which the gains assume 3 different constant values. Linear interpolation is used to switch between sectors.

Parameter	N.	Value			Standard configuration
		min	max	factory	
Region A End	11116	0	PID Norm Value	0	
Region B Start	11118	0	PID Norm Value	0	
Region B End	11120	0	PID Norm Value	0	
Region C Start	11122	0	PID Norm Value	0	

Region A End End of the first sector with constant gains.

Region B Start Start of the second sector with constant gains.

Region B End End of the second sector with constant gains.

Region C Start Start of the third sector with constant gains.

The unit that is selected as the adaptive reference is first normalised according to the **PID Norm Value** parameter, which is also the Region C End value.

The normalisation procedure according to the selected reference is described below:

Analog Input(s) PID Norm Value corresponds to an analog input set to 10V (with input scale set to 1)

Main Encoder Speed PID Norm Value corresponds to a speed equal to that in **MainEncSpeedBase**

Motor Torque	PID Norm Value corresponds to the maximum torque that can be supplied by the drive
Calc Diameter	PID Norm Value corresponds to Maximum Diameter
PI Output	The PI Output parameter is already scaled to the PID Norm Value
Pads	Set the PID Norm Value as the full scale in the Pads
Fieldbus M->Sx	Set the PID Norm Value as the full scale in the processing channels

12.1. PI Adaptive

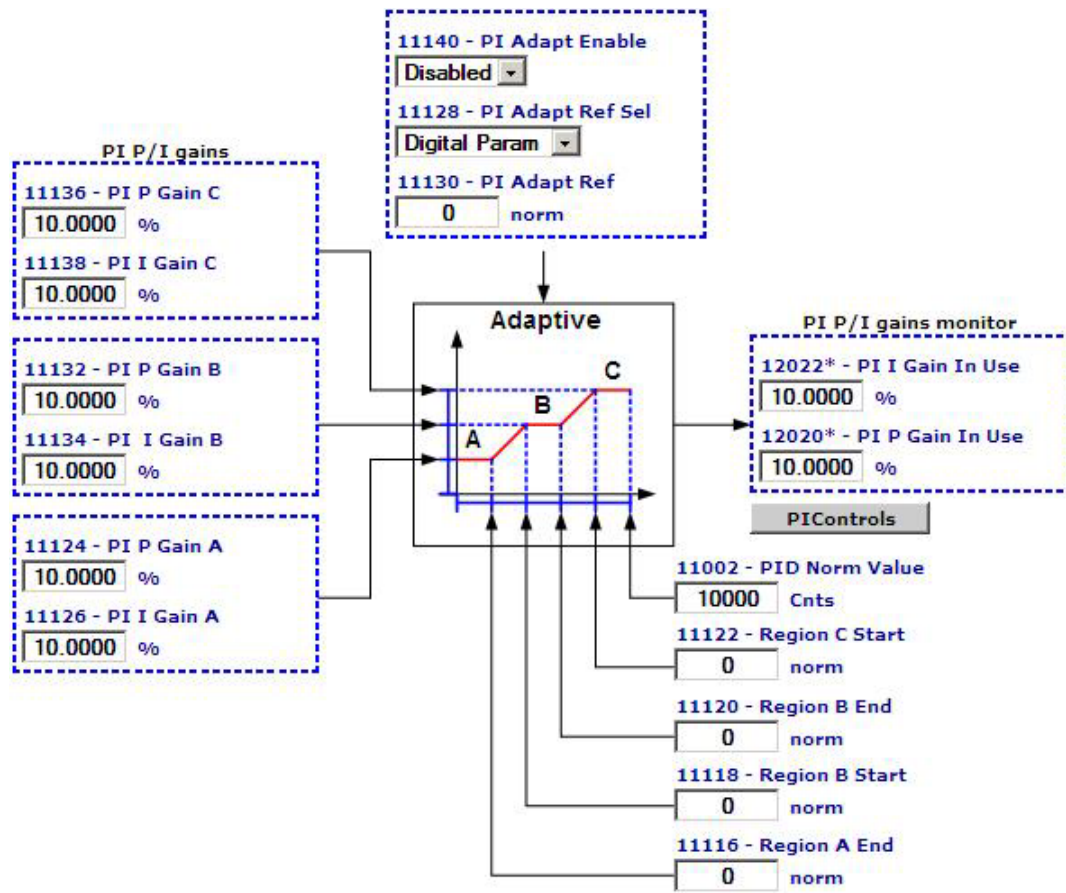


Fig. 8– PI Adaptive

Parameter	N.	Value			Standard configuration
		min	max	factory	
PI Adapt Enable	11140	0 – Disabled	1-Enabled	Disabled	
PI Adapt Ref Sel	11128	-	-	1.000	
PI Adapt Ref	11130	-PID Norm Value	+PID Norm Value	0	
PI P Gain A	11124	0	100%	10	
PI I Gain A	11126	0	100%	10	
PI P Gain B	11132	0	100%	10	
PI I Gain B	11134	0	100%	10	
PI P Gain C	11136	0	100%	10	
PI I Gain C	11138	0	100%	10	

PI Adapt Enable

Enabling of the PI regulator adaptive; if disabled, the PI Adaptive output gains stay fixed at the values of parameters **PI P Gain A** and **PI I Gain A**.

PI Adapt Ref Sel

Selection of the **PI Adapt Ref** source. If set to Digital Parameter, the PI Adaptive reference value can be set directly in **PI Adapt Ref**.

PI Adapt Ref	Current PI Adaptive reference value. If PI Adapt Ref Sel is set to Digital Parameter, the PI Adaptive reference value can be set directly in PI Adapt Ref .
PI P Gain A	Proportional gain in region A. This value is also set as the proportional gain output of the PI adaptive if the PI Adapt Enable parameter is disabled.
PI I Gain A	Integral gain in region A. This value is also set as the integral gain output of the PI adaptive if the PI Adapt Enable parameter is disabled.
PI P Gain B	Proportional gain of region B.
PI I Gain B	Integral gain of region B.
PI P Gain C	Proportional gain of region C.
PI I Gain C	Integral gain of region C.

The output values of the PI adaptive are stored in the **PI P Gain In Use** and **PI I Gain In Use** parameters, which are used as actual gains of the PI regulator.

12.2. PD Adaptive

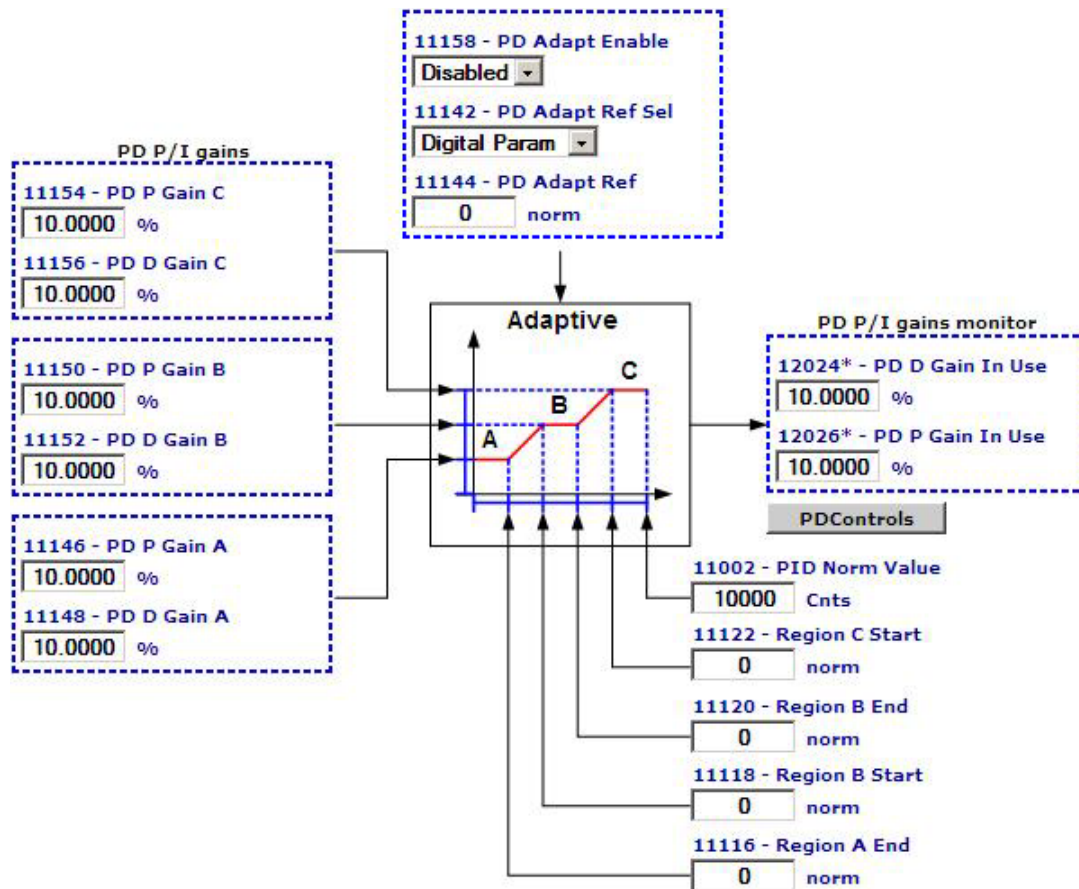


Fig. 9 – PD Adaptive

Parameter	N.	Value			Standard configuration
		min	max	factory	
PD Adapt Enable	11158	0 – Disabled	1-Enabled	Disabled	
PD Adapt Ref Sel	11142	-	-	1.000	
PD Adapt Ref	11144	-PID Norm Value	+PID Norm Value	0	
PD P Gain A	11146	0	100%	10	
PD D Gain A	11148	0	100%	10	
PD P Gain B	11150	0	100%	10	
PD D Gain B	11152	0	100%	10	
PD P Gain C	11154	0	100%	10	
PD D Gain C	11156	0	100%	10	

PD Adapt Enable Enabling of the PD Adaptive; if disabled, the PD Adaptive output gains stay fixed at the values of the **PD P Gain A** and **PD I Gain A** parameters.

PD Adapt Ref Sel Selection of the **PD Adapt Ref** source. If set to Digital Parameter, the PD Adaptive reference value can be set directly in **PD Adapt Ref**.

PD Adapt Ref Current PD Adaptive reference value. If **PD Adapt Ref Sel** is set to Digital Parameter, the PD Adaptive reference value can be set directly in **PD Adapt Ref**.

PD P Gain A	Proportional gain of region A. This value is also set as the proportional gain output of the PD adaptive if the PD Adapt Enable parameter is disabled.
PD D Gain A	Derivative gain of region A. This value is also set as the integral gain output of the PD adaptive if the PD Adapt Enable parameter is disabled.
PD P Gain B	Proportional gain of region B.
PD D Gain B	Derivative gain of region B.
PD P Gain C	Proportional gain of region C.
PD D Gain C	Derivative gain of region C.

The output values of the PD adaptive are stored in the **PD P Gain In Use** and **PD D Gain In Use** parameters, which are used as actual gains of the PD regulator.

13. Initial diameter calculation

This function performs a preliminary calculation of the diameter of a winder/unwinder before starting the line. This ensures better control, preventing any undesirable deviations of the dancer.

The calculation is based on the measurement of the movement of the dancer from the maximum deviation to the central working position, and the measurement of the angular movement of the drum during the initial phase.

NB: The initial diameter can only be calculated if the winder/unwinder is controlled by a dancer (not by a load cell).

The result of the calculation is assigned to the **PI Output** parameter and indicates the feedforward multiplication factor, to obtain the angular speed reference of the motor.

Its value is inversely proportional to the core diameter.

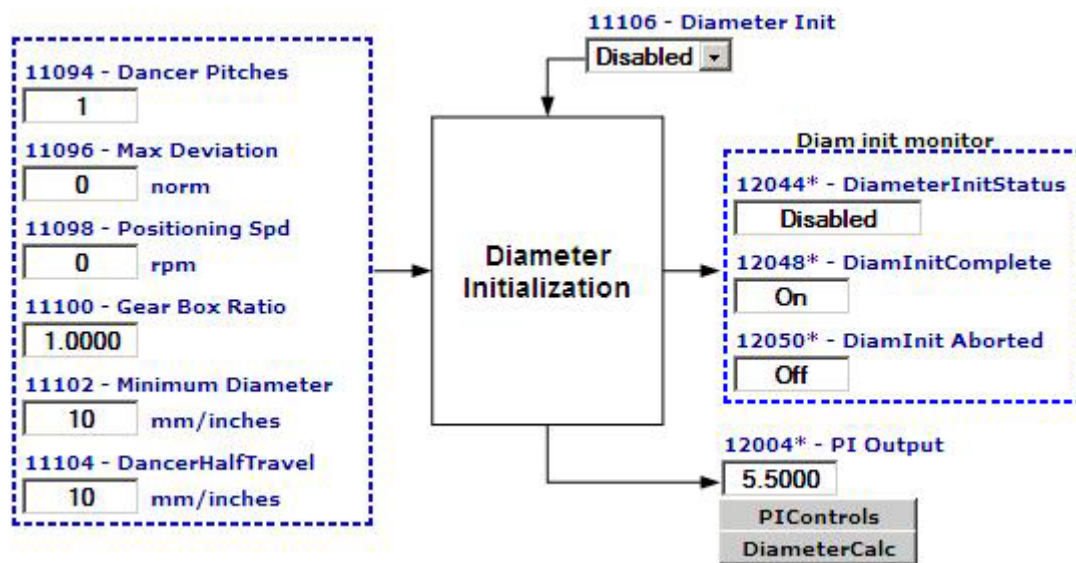


Fig. 10 – description of the diameter initialisation block

Parameter	N.	Value			Standard configuration
		min	max	factory	
Diameter Init	11106	0 – Disabled	1 – Enabled	Disabled	1
Positioning Spd	11098	-100	+100	0	
Max Deviation	11096	-PID Norm Value	+PID Norm Value	0	
Gear Box Ratio	11100	0.001	1.000	1.000	
Dancer Pitches	11094	1	100	1	
DancerHalfTravel	11104	0.001	-	10	
Minimum Diameter	11102	0.001	-	10	
Initial Diameter	12046	0.001	-	0	
DiameterInitStatus	12044	0 - Disabled	-	Disabled	
DiamInitComplete	12048	0 – Off	1 – On	0 – Off	2
DiamInit Aborted	12050	0 – Off	1 – On	0 – Off	3

1. **Diameter Init** can be sampled from a list of digital inputs; refer to the **Diam Int Sel** parameter in the I/O\Digital inputs menu
2. **DiamInitComplete** can be set on a programmable digital output; refer to the I/O\Digital Outputs menu
3. **DiamInit Aborted** can be set on a programmable digital output; refer to the I/O\Digital Outputs menu

Diameter Init Enabling of the initial diameter calculation. The calculation is performed by setting **Diameter Init** = Enabled. If the **Diameter Init** parameter is programmed on a digital input, it must be set to a high logic level.

Positioning Spd Indicates the speed of the motor according to whether the dancer is to be placed in the central working position during the initial diameter calculation phase. This value is expressed in rpm.

Max Deviation Value of the **PID Feed-back** parameter, corresponding to the maximum deviation position of the dancer. The initial measurement of the dancer movement during the initial diameter calculation is associated with this value.

During the preliminary start-up phase, the analog inputs must be set so that the maximum deviation corresponds to the **PID Norm Value**. To guarantee accurate calculation of the movement, the **Max Deviation** parameter must be set to a slightly lower value. (**Max Deviation** standard = 8000 if **PID Norm Value** is 10000).

Gear Box Ratio Reduction ratio between motor and core (≤ 1).

DancerHalfTravel Expresses the measurement in millimeters corresponding to half the total quantity of material in the dancer.

Dancer Pitches Indicates the number of dancer pitches.

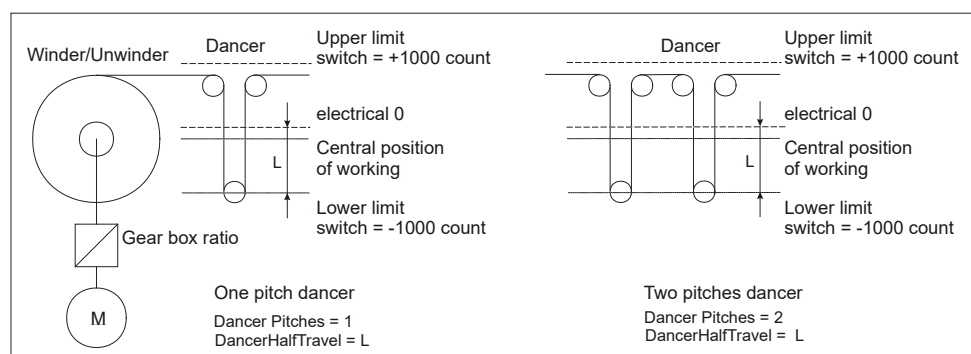


Fig. 11 – diameter initialisation

Measuring DancerHalfTravel:

With the dancer at the lowest deviation, set the analog input programmed as **PID Feed-back** to obtain **-PID Norm Value**.

Set the dancer so that the **PID Feed-back** displays the value 0 (electrical 0 position); measure the distance in millimeters between the lowest deviation and the current dancer position. Enter the distance in the **DancerHalfTravel** parameter.

Minimum diameter Minimum diameter of the core (nucleus) expressed in millimeters or inches.

Initial Diameter Initial diameter calculated in millimeters or inches. This value is the result of the diameter initialisation function.

DiameterInitStatus Status of the diameter initialisation procedure, which can assume the following values:

Disabled: Function not enabled

Wait Drive Enab: The **Diameter init** command has been sent; the drive is waiting for the **Enable cmd** and **Start cmd** commands.

Wait Max Deviat: Start of operations; the motor starts turning to allow the dancer to reach the value in **Max Deviation**

Wait Pos A: Max Deviation value reached; the motor starts turning in the opposite direction to allow the dancer to reach a value equal to 90% of **Max Deviation** (Pos A).

Wait Pos B: Pos A detected; the motor continues to turn until the dancer reaches a value of 5% of **Max Deviation** (Pos B).

Completed: Pos B detected; the **Initial Diameter** calculation has been performed correctly and the **PI Output** value has been set. The drive waits for the **Diameter Init** command to be removed to set the state to Disabled again, in order to perform a new diameter initialisation.

Aborted: Diameter initialisation has been aborted because the **Enable cmd**, **Start cmd** or **Diameter Init** command was removed during the procedure. To reset the state to Disabled, remove the **Diameter Init** command.

DiamInitComplete	Set to On when the diameter initialisation procedure is complete. The status can be monitored via a digital output. Important note: check the DiamInit Aborted value to establish whether the procedure failed.
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DiamInit Aborted	This is set to On when diameter initialisation is aborted because the Enable cmd , Start cmd or Diameter init command was removed during the procedure. To reset this signal, remove the Diameter init command. The status can be monitored via a digital output.
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13.1. Description of the initial diameter calculation

This calculation is based on the measurement of the movement of the dancer from the maximum deviation to the central working position, and the measurement of the angular movement of the drum during tensioning; it is therefore important to make sure that, during this procedure, the material is blocked by the roll downstream of the unwinder or upstream of the winder. The roll drive adjustment must therefore be enabled with speed reference = 0.

If the line rolls are also controlled by dancers or load cells, first the diameter must be calculated and the winders/unwinders tensioned, and then the rolls must be tensioned.

The **PI Central V Sel** parameter must be set to 0 to prevent the **PI Output** value from being automatically set to a predefined level.

When a high logic level (+24V) is assigned to the digital input programmed as **Diameter Init**, the procedure can be activated, provided the drive is enabled and the **Start cmd** command is active; in this phase the **Enable PI** and **Enable PD** parameters are automatically disabled.

The adjustment process checks the signal coming from the dancer potentiometer; if this is too high compared that set in the **Max Deviation** parameter, the motor starts with a speed reference equal to that set in **Positioning Spd** in order to wind the material on the drum and move the dancer to the central working position. If the adjustment process detects that the signal coming from the dancer potentiometer is lower than that set in the **Max Deviation** parameter, the motor starts with a speed reference equal to that set in **Positioning Spd** in order to unwind the material and move the dancer to the point set in **Max Deviation**. The reference is then inverted to move the dancer to the central working position.

When the dancer has reached the central position, the **PI Output** parameter is set to a value that is inversely proportional to the diameter and the **DiamInitComplete** digital output, which indicates the end of the diameter calculation phase, is set to a high logic level.

At this stage, if **Enable PI** and/or **Enable PD** are enabled, the system automatically proceeds to the adjustment phase; the digital inputs programmed as **Diameter Init**, **Enable PI** and/or **Enable PD** are therefore usually set simultaneously to a high logic level.

The **DiamInitComplete** output signal can be used to reset the **Diameter Init** command. This is active on the positive edge of the digital input, and so must be set to a high logic level after starting the drive and then reset when the initial diameter calculation phase is complete.

The **PI Output** value is calculated according to the following formula:

$$\text{PI Output} = (\text{Min Diameter} \times \text{PI Top Limit}) / \text{Initial Diameter}$$

The **PI Top Limit** and **PI Bottom Limit** parameters in the **PI Controls** menu must be set according to the maximum and minimum drum diameter; for further information, refer to the **Errore. L'origine riferimento non è stata trovata. - Errore. L'origine riferimento non è stata trovata.** section.

14. Run-time diameter calculation

This function uses the Line Speed, Motor Speed and Maximum Diameter data to calculate the roll diameter. If enabled, the calculation is performed when the line speed exceeds a given threshold, in order to measure the current diameter accurately.

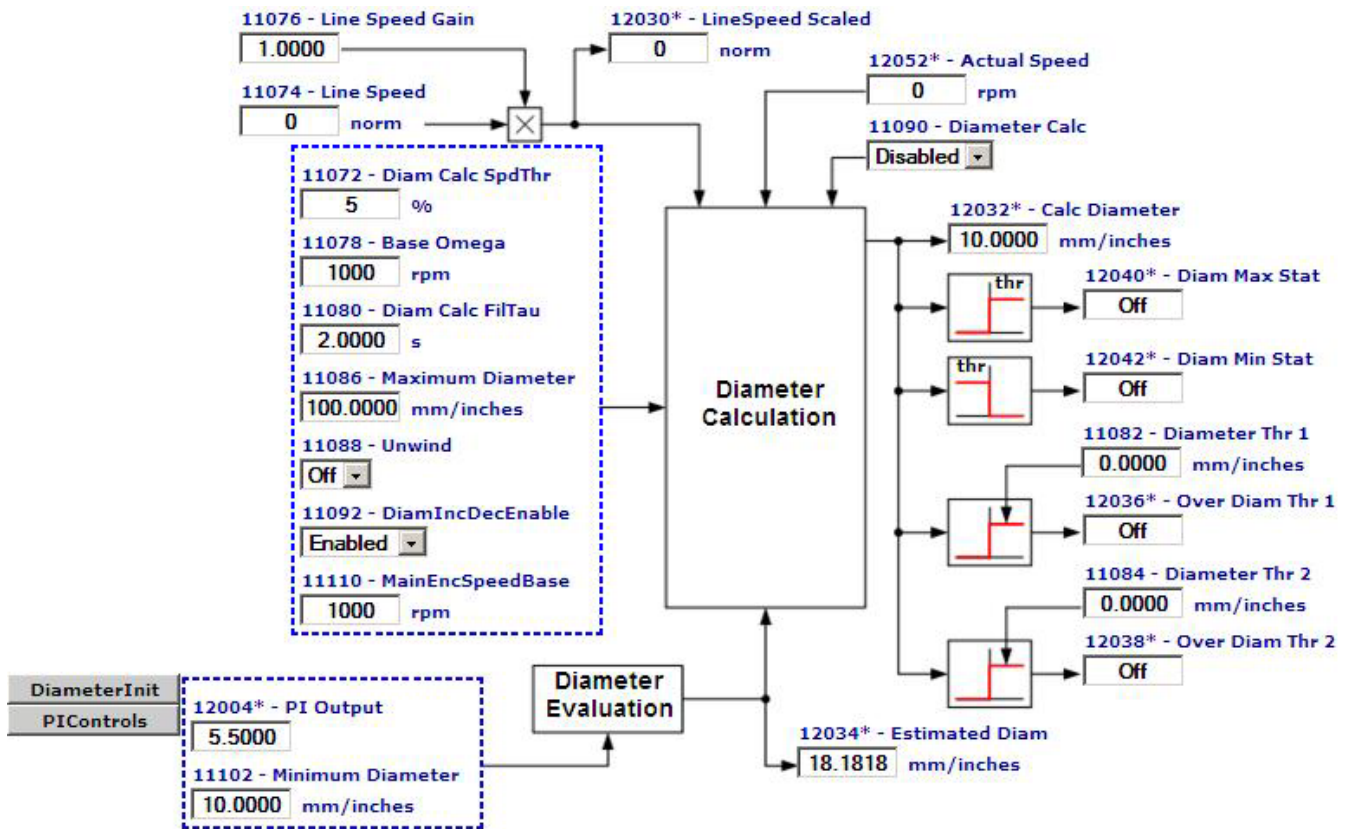


Fig. 12 – description of the diameter calculation block

Parameter	N.	Value			Standard configuration
		min	max	factory	
Diameter Calc	11090	0 – Disabled	1 – Enabled	Disabled	
Maximum Diameter	11086	0.001	-	100	
Line Speed	11074	-PID Norm Value	+PID Norm Value	0	1
Line Speed Gain	11076	-100	+100	1	
LineSpeed Scaled	12030	-PID Norm Value	+PID Norm Value	0	
Base Omega	11078	1	30000	1000	
Diam Calc SpdThr	11072	1%	100%	5	
Diam Calc FilTau	11080	0	100	2	
Unwind	11088	0-Off	1-On	Off	2
DiamIncDecEnable	11092	0-Disabled	1-Enabled	Disabled	
Diameter Thr 1	11082	0	-	0	
Diameter Thr 2	11084	0	-	0	
Calc Diameter	12032	0	-	0	3
Estimated Diameter	12034	0	-	0	
Diam Max Stat	12040	0-Off	1-On	0-Off	4
Diam Min Stat	12042	0-Off	1-On	0-Off	4
Over Diam Thr 1	12036	0-Off	1-On	0-Off	4
Over Diam Thr 2	12038	0-Off	1-On	0-Off	4

Parameter	N.	Value			Standard configuration
		min	max	factory	

1. **Line Speed** can be sampled from a list of sources; refer to the **LineSpeedAnInSel** parameter in the I/O\Analog Inputs menu
2. **Unwind** can be sampled from a list of digital inputs; refer to the **Wind Unwind Sel** parameter in the I/O\Analog Inputs menu
3. **Calc Diameter** can be set on a programmable analog output, refer to the I/O\Analog Outputs menu
4. **Diam Max Stat**, **Diam Min Stat**, **Over Diam Thr 1** and **Over Diam Thr 2** can be set on a programmable digital output, refer to the I/O\Digital Outputs menu

DiameterCalc	Enabling of the run-time diameter calculation. The calculation is performed by setting Diameter Calc= Enabled .
Maximum Diameter	Indicates the maximum roll diameter, expressed in millimeters or inches. This value and that of the Minimum Diameter parameter, in the Diameter Init menu, and of the PI Top Limit and PI Bottom Limit in the PI Controls menu must be known in order to calculate the current diameter.
Line Speed	Measurement of the line speed normalised according to the PID Norm Value parameter (=maximum line speed).
Line Speed Gain	Gain relating to the line speed measurement. The setting depends on the line speed sampling source; this parameter is used to obtain the maximum value for LineSpeed Scaled = PID Norm Value .
LineSpeed Scaled	Line Speed multiplied by Line Speed Gain .
Base Omega	Motor speed corresponding to Minimum Diameter at maximum Line Speed .
Diam Calc SpdThr	Line speed threshold above which diameter calculation is activated. The value is expressed as a percentage and refers to the full scale value.
Diam Calc FilTau	Time constant of the filter of the Diameter Calculation output value (Calc Diameter).
Unwind	Input signal indicating to the diameter calculation procedure whether the system is in the winding or unwinding phase; in the latter case, the signal must be set to On (high level).
DiamIncDecEnable	Enabling of the increase/reduction in the calculated diameter. During the winding phase the diameter can usually only increase, and the procedure therefore ignores reductions in the calculated diameter. In the unwinding phase the process is reversed. The controls are disabled when this parameter is enabled, allowing the calculated diameter to be increased or reduced freely.
Diameter Thr 1	Calculated diameter threshold, above which the Over Diam Thr 1 output signal is set to high.
Diameter Thr 2	Calculated diameter threshold, above which the Over Diam Thr 2 output signal is set to high.
Calc Diameter	Value output by the Diameter Calculation parameter, expressed in millimeters or inches. If programmed on an analog output, 10V corresponds to Maximum Diameter .

Estimated Diam	Estimated diameter based on the current PI Output value, which is used to initialise the Calc Diameter value when PICentral V Sel changes and the “ Errore. L'origine riferimento non è stata trovata. ” procedure is active. This allows the diameter to be calculated starting from a more accurate value. In order to calculate the Estimated Diam value, the PI Top Limit and PI Bottom Limit parameters must coincide, with a certain degree of precision, respectively with the minimum and maximum diameter.
Diam Max Stat	Output signal indicating that the Calc Diameter value has reached that set in Maximum Diameter . This signal can be sent to the digital outputs.
Diam Min Stat	Output signal indicating that the Calc Diameter value has reached that set in Minimum Diameter . This signal can be sent to the digital outputs.
Over Diam Thr 1	Output signal indicating that the Calc Diameter value has exceeded that set in Diameter Thr 1 . This signal can be sent to the digital outputs.
Over Diam Thr 2	Output signal indicating that the Calc Diameter value has exceeded that set in Diameter Thr 2 . This signal can be sent to the digital outputs.

14.1. Description of the diameter calculation procedure

As described previously, the diameter calculation is based on the Line Speed parameter reading and the angular speed of the drive roll (Motor Speed).

These two units are first of all normalised to the **PID Norm Value**. For the Line Speed parameter, this depends on the source that is selected (see **LineSpeedAnInSel** in 16.3 -

). For the Motor Speed parameter, **PID Norm Value** corresponds to **Base Omega** (motor speed corresponding to **Minimum Diameter** at maximum **Line Speed**).

If the **Diameter Calc** parameter is enabled, when the normalised **Line Speed** value is greater than the **Diam Calc SpdThr** percentage with reference to the full scale value, the diameter calculation is activated. This check is performed to prevent inaccurate calculation at low speeds. If the speed in question is less than the predefined threshold, the Calc Diameter value remains unchanged.

The system calculates the current diameter according to the following formula:

Calc Diameter = Norm Line Speed / Norm Motor Speed * Minimum Diameter

The **Calc Diameter** value is filtered by means of a low-pass filter with tau = **Diam Calc FilTau**.

As described previously, if the **DiamIncDecEnable** parameter is enabled, the calculated diameter can be increased or reduced freely. If it is disabled, the system runs a check on the Unwind signal: if set to Off (winder) the calculated diameter cannot be reduced; if set to On (unwinder), the diameter cannot be increased.

The Calc Diameter value is initialised according to the **Estimated Diam** parameter (conversion of the **PI Output** value) when **PI Central V Sel** changes (the user selects a different preset diameter). It is thus possible to select the initial diameter calculated according to the **PI Central V Sel** value.

Therefore, to obtain a correct **Estimated Diam** value, **PI Top Limit** and **PI Bottom Limit** must coincide, with a certain degree of precision, respectively with the minimum and maximum diameter.

The **Estimated Diam** value is also updated after the “**Errore. L'origine riferimento non è stata trovata.**” procedure, so that at the end the value is stored in **Calc Diameter**.

The initialisation of **Calc Diameter** with **Estimated Diameter**, as described above, is only performed if Line Speed is less than the **Diam Calc SpdThr** percentage.

15. Speed parameters

Speed parameters cover a series of functions:

Setting of Full scale speed, Zero Speed measurement, ramp settings, Jog mode operation, setting of Encoder Base Speed.

Parameter	N.	Value			Standard configuration
		min	max	factory	
Actual Speed	12052	-	-	0	
MainEncSpeedBase	11110	1	30000	1000	

1. **Actual Speed** can be set on a programmable analog output; refer to the I/O\Analog Outputs menu
2. **Speed Zero State** can be set on a programmable digital output; refer to the I/O\Digital Outputs menu
3. **Speed Reached** can be set on a programmable digital output; refer to the I/O\Digital Outputs menu

Actual Speed Actual speed of the motor normalised according to the PID Norm value (corresponding to Full scale speed).

MainEncSpeedBase Parameter used to indicate the correspondence between **PID Norm Value** and the maximum speed of the main encoder. This value is expressed in rpm.

16. I/O programming

A set of specific parameters can be used to program the drive's inputs and outputs.

16.1. Digital inputs

Parameter	N.	Value			Standard configuration
		min	max	factory	
Enable PD Sel	11180	See below		Digital Param	
Enable PI Sel	11182	See below		Digital Param	
PI C V Bit 0 Sel	11184	See below		Digital Param	
PI C V Bit 1 Sel	11186	See below		Digital Param	
PID Offset InSel	11188	See below		Digital Param	
PI Int Freez Sel	11190	See below		Digital Param	
Wind Unwind Sel	11192	See below		Digital Param	
Diam Init Sel	11194	See below		Digital Param	
PIDSrcRamp=0 Sel	11196	See below		Digital Param	
PID FastStop Sel	11198	See below		Digital Param	
Fwd-Rev PD Sel	11178	See below		Digital Param	

Enable PD Sel Selection of the source relating to the **Enable PD** command:

-2 - **Remote Command**: See relative bit in the **PID Remote Cmds** parameter

-1 - **Digital Param**: The source is the actual digital command; it can be set using the keypad and serial line.

0 - **Dig inp 1**: Standard digital input 1

1 - **Dig inp 2**: Standard digital input 2

2 - **Dig inp 3**: Standard digital input 3

3 - **Dig inp 4**: Standard digital input 4

4 - **Dig inp 5**: Standard digital input 5

5 - **Dig inp 6**: Standard digital input 6

8 - **Dig inp 1X**: Expansion card, digital input 1

9 - **Dig inp 2X**: Expansion card, digital input 2

10 - **Dig inp 3X**: Expansion card, digital input 3

11 - **Dig inp 4X**: Expansion card, digital input 4

12 - **Dig inp 5X**: Expansion card, digital input 5

13 - **Dig inp 6X**: Expansion card, digital input 6

14 - **Dig inp 7X**: Expansion card, digital input 7

15 - **Dig inp 8X**: Expansion card, digital input 8

30 - **Pad 1**: parameter Pad 1

31 - **Pad 2**: parameter Pad 2

32 - **Pad 3**: parameter Pad 3

33 - **Pad 4**: parameter Pad 4

34 - **Pad 5**: parameter Pad 5

35 - **Pad 6**: parameter Pad 6

36 - **Pad 7**: parameter Pad 7

37 – Pad 8: parameter Pad 8
38 – Pad 9: parameter Pad 9
39 – Pad 10: parameter Pad 10
40 – Pad 11: parameter Pad 11
41 – Pad 12: parameter Pad 12
42 – Pad 13: parameter Pad 13
43 – Pad 14: parameter Pad 14
44 – Pad 15: parameter Pad 15
45 – Pad 16: parameter Pad 16
50 – Fieldbus M->S1: processing channel Master-Slave 1
51 – Fieldbus M->S2: processing channel Master-Slave 1
52 – Fieldbus M->S3: processing channel Master-Slave 1
53 – Fieldbus M->S4: processing channel Master-Slave 1
54 – Fieldbus M->S5: processing channel Master-Slave 1
55 – Fieldbus M->S6: processing channel Master-Slave 1
56 – Fieldbus M->S7: processing channel Master-Slave 1
57 – Fieldbus M->S8: processing channel Master-Slave 1
58 – Fieldbus M->S9: processing channel Master-Slave 1
59 – Fieldbus M->S10: processing channel Master-Slave 10
50 – Fieldbus M->S11: processing channel Master-Slave 11
51 – Fieldbus M->S12: processing channel Master-Slave 12
52 – Fieldbus M->S13: processing channel Master-Slave 13
53 – Fieldbus M->S14: processing channel Master-Slave 14
54 – Fieldbus M->S15: processing channel Master-Slave 15
55 – Fieldbus M->S16: processing channel Master-Slave 1
70 – Bit0 decomp mon: bit 0 Word decomp
71 – Bit1 decomp mon: bit 1 Word decomp
72 – Bit2 decomp mon: bit 2 Word decomp
73 – Bit3 decomp mon: bit 3 Word decomp
74 – Bit4 decomp mon: bit 4 Word decomp
75 – Bit5 decomp mon: bit 5 Word decomp
76 – Bit6 decomp mon: bit 6 Word decomp
77 – Bit7 decomp mon: bit 7 Word decomp
78 – Bit8 decomp mon: bit 8 Word decomp
79 – Bit9 decomp mon: bit 9 Word decomp
70 – Bit10 decomp mon: bit 10 Word decomp
71 – Bit11 decomp mon: bit 11 Word decomp
72 – Bit12 decomp mon: bit 12 Word decomp
73 – Bit13 decomp mon: bit 13 Word decomp
74 – Bit14 decomp mon: bit 14 Word decomp
75 – Bit15 decomp mon: bit 15 Word decomp

Enable PI Sel	Selection of the source of the Enable PI command (see above for the list of possible selections).
PI C V Bit 0 Sel	Selection of the source of the PICentral V Sel bit 0 command (see above for the list of possible selections).
PI C V Bit 1 Sel	Selection of the source of the PICentral V Sel bit 1 command (see above for the list of possible selections).
PID Offset InSel	Selection of the source of the PID Offset Sel command (see above for the list of possible selections).
PI Int Freez Sel	Selection of the source of the PI Int Freeze command (see above for the list of possible selections). NB: Remote Command cannot be selected for the current version.
Wind Unwind Sel	Selection of the source of the Unwind command (see above for the list of possible selections).
PIDSrcRamp=0 Sel	Selection of the source of the PID Src RampIn=0 command (see above for the list of possible selections).
PID FastStop Sel	Selection of the source of the PID Fast Stop command (see above for the list of possible selections).
Fwd-Rev PID Sel	Selection of the source of the Fwd-Rev PID command (see above for the list of possible selections).

16.2. Digital outputs

Parameter	N.	Value			Standard configuration
		min	max	factory	
PID Status Dest	11114	See below		Off	
Max Diam Dest	11200	See below		Pad 4	
Min Diam Dest	11202	See below		Pad 5	
Diam Thr 1 Dest	11204	See below		Pad 6	
Diam Thr 2 Dest	11206	See below		Pad 7	
DiamIniCompl Des	11208	See below		Pad 8	
DiamIniAbort Des	11210	See below		Pad 9	

PID Status Dest	Destination of the PID Status parameter:	
	0	Off
	1	Pad 1
	2	Pad 2
	3	Pad 3
	4	Pad 4
	5	Pad 5
	6	Pad 6

7	Pad 7
8	Pad 8
9	Pad 9
10	Pad 10
11	Pad 11
12	Pad 12
13	Pad 13
14	Pad 14
15	Pad 15
16	Pad 16
20	Dig FB S->M1
21	Dig FB S->M2
22	Dig FB S->M3
23	Dig FB S->M4
24	Dig FB S->M5
25	Dig FB S->M6
26	Dig FB S->M7
27	Dig FB S->M8
28	Dig FB S->M9
29	Dig FB S->M10
30	Dig FB S->M11
31	Dig FB S->M12
32	Dig FB S->M13
33	Dig FB S->M14
34	Dig FB S->M15
35	Dig FB S->M16

Max Diam Dest	Destination of the Diam Max Stat signal (see above for list)
Min Diam Dest	Destination of the Diam Min Stat signal (see above for list)
Diam Thr 1 Dest	Destination of the Over Diam Thr 1 signal (see above for list)
Diam Thr 2 Dest	Destination of the Over Diam Thr 2 signal (see above for list)
DiamIniCompl Des	Destination of the DiamInitComplete signal (see above for list)
DiamIniAbort Des	Destination of the DiamInitAborted signal (see above for list)

16.3. Analog Inputs

Parameter	N.	Value			Standard configuration
		min	max	factory	
PID Src Sel	11212	See below		Digital Param	
FeedBack Sel	11214	See below		Digital Param	
PIDOffs0 Sel	11216	See below		Digital Param	
PICentralV3 Sel	11218	See below		Digital Param	
LineSpeed Sel	11220	See below		Digital Param	

PID Src AnInpSel

Selection of the source of the **PID Source** parameter; see below for the list of possible selections:

0 - Digital Param: The value of the parameter corresponding to that being used; it can be set using the keypad, serial line and fieldbus.

1 - Analog input 1: The parameter value derives from analog input 0; the value in **PID Norm Value** corresponds to the analog input set to 10V.

2 - Analog input 2: The parameter value derives from analog input 1.

3 - Analog inp 1X: The parameter value derives from Analog input 1 on the expansion card.

4 - Analog inp 2X: The parameter value derives from Analog input 2 on the expansion card.

5 - Encoder 1: The parameter value derives from the speed of the encoder 1; the value of **PID Norm Value** corresponds to a speed equal to **MainEncSpeedBase**.

6 - Encoder 2: The parameter value derives from the speed of the encoder 2; the value of **PID Norm Value** corresponds to a speed equal to **MainEncSpeedBase**.

7 - Motor Torque: The value of the parameter derives from the actual motor torque; the value of **PID Norm Value** corresponds to a torque equal to the **maximum torque supplied by the drive**.

9 - Calc Diameter: The parameter value derives from the current value of **Calc Diameter**; the value of **PID Norm Value** corresponds to **Maximum Diameter**.

10 - PI Output: The parameter value derives from the current value of **PI Output**; **PI Output** is already set to **PID Norm Value**.

30 - Pad 1: the parameter value corresponds to that of Pad 1.

31 - Pad 2

32 - Pad 3

33 - Pad 4

34 - Pad 5

35 - Pad 6

36 - Pad 7

37 - Pad 8

38 - Pad 9

39 - Pad 10

40 - Pad 11

41 - Pad 12

42 - Pad 13

43 - Pad 14

44 - Pad 15

45 - Pad 16

50 - Fieldbus M->S1: The parameter value corresponds to that sent to processing channel 1.

51 - Fieldbus M->S2

52 - Fieldbus M->S3

53 - Fieldbus M->S4

54 - Fieldbus M->S5

55 - Fieldbus M->S6

56 - Fieldbus M->S7

57 - Fieldbus M->S8

58 - Fieldbus M->S9

59 - Fieldbus M->S10

60 - Fieldbus M->S11

61 - Fieldbus M->S12

62 - Fieldbus M->S13

63 - Fieldbus M->S14

64 - Fieldbus M->S15

FeedBackAnInpSel	Selection of the source of the PID Feed-back parameter (see above for the list of possible selections).
PIDOffs0 AnInSel	Selection of the source of the PID Offset 0 parameter (see above for the list of possible selections).
PICentralV3AnInp	Selection of the source of the PI Central V3 parameter (see above for the list of possible selections); the ratio between the normalised analog input value (0...PID Norm value) and PI Central V3 is: $\text{PI Central V 3} = \text{PI Bottom Limit} * \text{PID Norm Value} / \text{Analog Input Normalised Value}$
LineSpeedAnInSel	Selection of the source of the Line Speed parameter (see above for the list of possible selections).

16.4. Analog Outputs

Parameter	N.	Value			Standard configuration
		min	max	factory	
PID Target Dest	11222	See below		Pad 1	
Calc Diam Dest	11224	See below		Pad 2	
PID Error Dest	11226	See below		Pad 3	

PID Target Dest

Selection of the destination of the **PID Target** value:

- 0 Off
- 1 Pad 1
- 2 Pad 2
- 3 Pad 3
- 4 Pad 4
- 5 Pad 5
- 6 Pad 6
- 7 Pad 7
- 8 Pad 8
- 9 Pad 9
- 10 Pad 10
- 11 Pad 11
- 12 Pad 12
- 13 Pad 13
- 14 Pad 14
- 15 Pad 15
- 16 Pad 16
- 20 Dig FB S->M1
- 21 Dig FB S->M2
- 22 Dig FB S->M3
- 23 Dig FB S->M4
- 24 Dig FB S->M5
- 25 Dig FB S->M6
- 26 Dig FB S->M7
- 27 Dig FB S->M8
- 28 Dig FB S->M9
- 29 Dig FB S->M10
- 30 Dig FB S->M11
- 31 Dig FB S->M12
- 32 Dig FB S->M13
- 33 Dig FB S->M14
- 34 Dig FB S->M15
- 35 Dig FB S->M16

Calc Diam Dest	Selection of the destination of the Calc Diameter value, see above for the list of possible selections.
PID Error Dest	Selection of the destination of the PID Error value , see above for the list of possible selections.

16.5. Fieldbus

Some commands can be programmed to be sent via fieldbus; also refer to the **Errore. L'origine riferimento non è stata trovata.** - **Errore. L'origine riferimento non è stata trovata.** section for programming the command source.

Parameter	N.	Value			Standard configuration
		min	max	factory	
PID Remote Cmds	1017	0	FFFF Hex	9001 Hex	

PID Remote Cmds Remote command bitwords; the meaning of each bit is shown below:

- Bit 0 : Not used
- Bit 1 : Not used
- Bit 2 : PD Enable
- Bit 3 : PI Enable
- Bit 4 : Fwd-Rev PID
- Bit 5 : Diameter Init
- Bit 6 : Unwind
- Bit 7 : PI Central V Sel Bit 0
- Bit 8 : PI Central V Sel Bit 1
- Bit 9 : PID Offset Sel
- Bit 10 : Not used
- Bit 11 : Not used
- Bit 12 : Not used
- Bit 13 : Not used
- Bit 14 : PID Src RampIn=0
- Bit 15 : PID Fast Stop

17. Examples of application

All of the following examples refer to a **PID Norm Value** parameter setting of **10000**.

17.1. Control using dancer

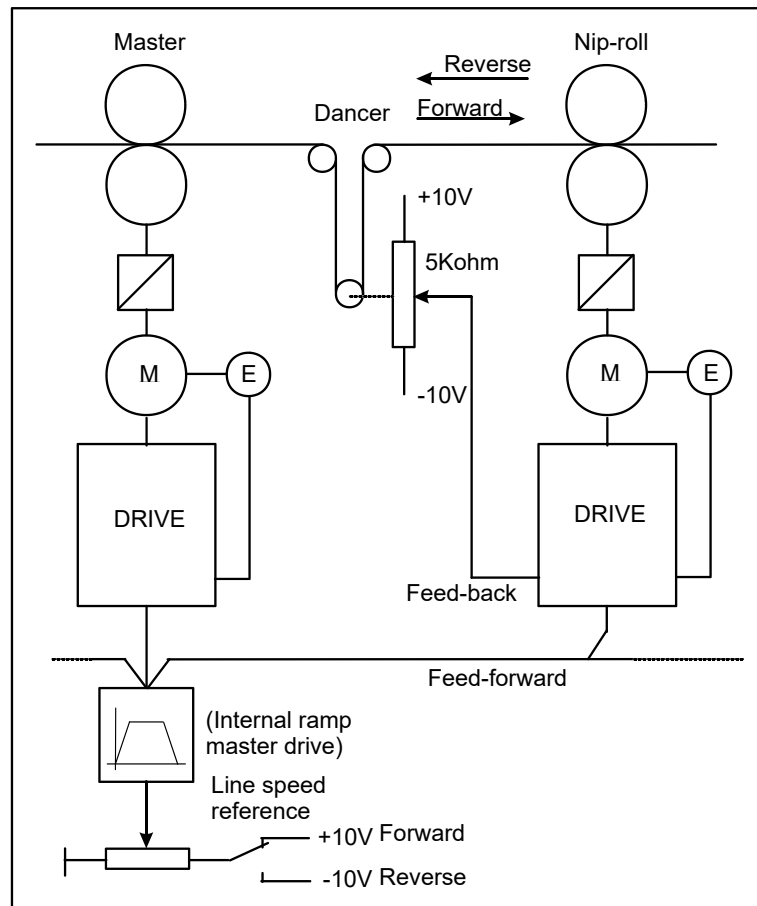


Fig. 13 – control using dancer

Machine data:

Rated speed of the slave motor in $V_n = 3000$ rpm

Slave motor speed corresponding to maximum line speed = $85\% V_n = 2550$ rpm

Maximum dancer adjustment = $\pm 15\%$ of line speed = ± 382.5 rpm

Connect the line speed and dancer position analog signals (with potentiometer supplied via terminals with a voltage of between -10V... +10V) and the digital commands to enable PID control to the roll drive. The output of the regulator is sent to the **Dig speed ref 1 (PID Target Sel)** parameter.

Drive settings: (only those relating to the PID function are described below)

Inputs/outputs

Set **Analog input 1** as the input for the dancer cursor.

FeedBackAnInpSel = Analog input 1

Set **Analog input 2** as the feedforward input:

PID Src AnInpSel = Analog input 2

Set **Digital Input 2** as the input enabling the PI block of the PID
Enable PI Sel = Dig inp 2

Set **Digital Input 3** as the input enabling the PD block of the PID
Enable PD Sel = Dig inp 3

Parameters

Set **Full scale speed** with a value equal to the rated speed of the motor.
Full scale speed = 3000 rpm

Set **PID Source Gain** so that, in correspondence with the maximum analog value of Analog input 2, **PID Feed-fwd** reaches 85% of the maximum value = 10000 x 85%.
PID Source Gain = 0.85

Set **PID Target Sel** as **Ramp Reference**.

Set **PID Output Scale** to 1 so that, in correspondence with the maximum analog value of **Analog input 2 (PID Feed-fwd = 8500)** and **Enable PI** and **Enable PD** = Disable, the **Ramp Reference** parameter is equal to 2550 rpm.

Set **PI Central V Sel** = 1
Set **PI Central V1** = 1

If no corrections are performed by the PI block of the regulator, the line speed reference (feedforward) must be multiplied by 1 and sent directly to the drive speed regulator.

In this type of application, the regulator usually only performs proportional control. The correction is indicated as a percentage of the line speed, from 0 to the maximum.

Program **PI Top Limit** and **PI Bottom Limit** so that, with maximum dancer deviation (maximum value of analog input 0 = Feed-back), when the proportional gain of the PI block is set to 15%, there is an equal proportional correction of the feedforward. To do this, set:

PI Top Limit = 10
PI Bottom Limit = 0.1

Set **PI P Gain In Use** = 15%
Set **PI I Gain In Use** = 0%

With this type of configuration, in case of a proportional correction of the line speed, the PI block is unable to position the dancer at speed=0. The PD block must be used for tensioning in a stop condition.

Set a value for **PD P Gain In Use** that allows the dancer to be positioned without large dynamic variations. For example:
PD P Gain In Use = 1%

If necessary, use the derivative component to dampen the response of the system during changes in speed, by running a programming procedure as described in the example below.

PD D Gain In Use = 5%
PD D Filter = 20 ms

If this is not necessary, keep these parameters = 0.

If cascade references are necessary for another drive, set **PID Target** on an analog output, for example:

PID Target Dest= Pad 1
Analog out 1 src = Pad 1
(with **Real Feed-fwd** = 10000 counts, **Analog output 1** = 10V).

17.2. Control using load cell

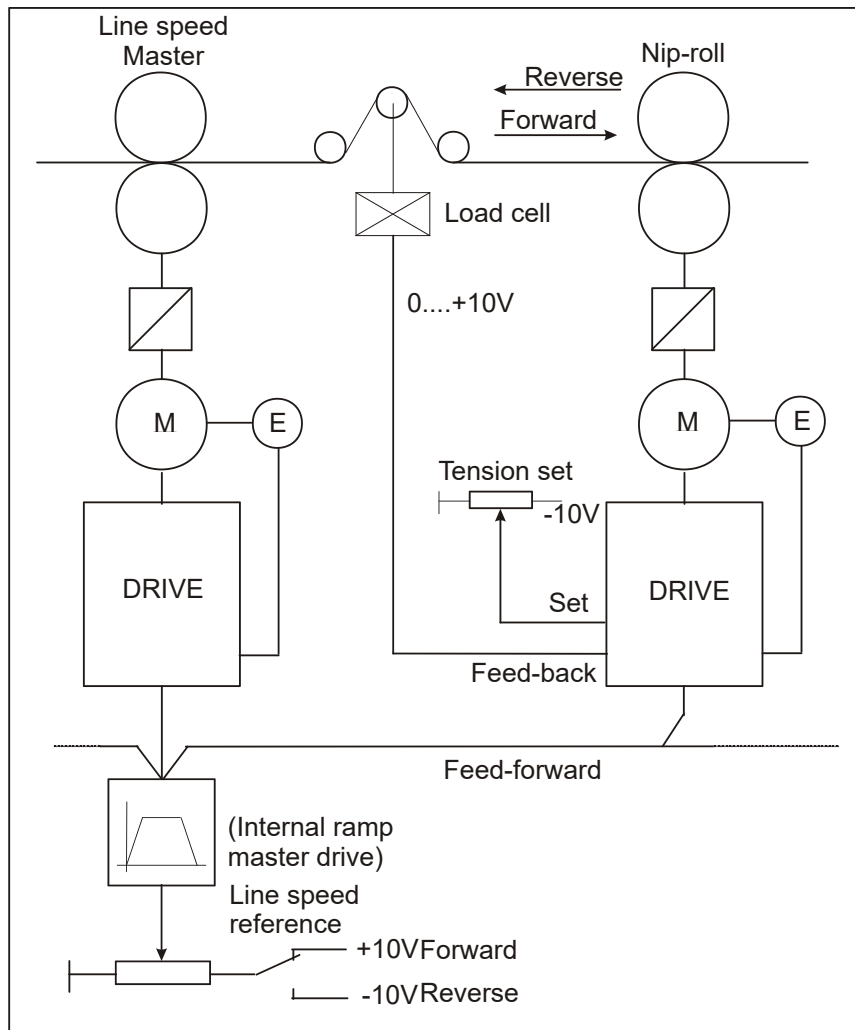


Fig. 14 – control using load cell

Machine data:

Rated speed of the slave motor in $V_n = 3000$ rpm

Slave motor speed corresponding to maximum line speed = 85% V_n = 2550 rpm

Maximum dancer adjustment = $\pm 20\%$ of line speed = ± 510 rpm

Connect the line speed and load cell analog signals (with potentiometer supplied with a voltage of between 0....+10V) to the slave drive and the digital commands to enable PID control.

The output of the regulator is sent to the **Dig speed ref 1 (PID Target Sel)** parameter.

Drive settings: (only those relating to the PID function are described below)

Inputs/outputs

Set **Analog input 1** as the load cell input:

FeedBackAnInpSel = Analog input 1

Set **Analog input 2** as the feedforward input:

PID Src AnInpSel = Analog input 2

Set the expansion card (optional **Analog input 1**) as the input for the tension setting (**PID Offset 0**):

PIDOff0AnInSel = Analog inp 1X

Set **Digital Input 2** as the input enabling the PI block of the PID

Enable PI Sel = Dig inp 2

Set **Digital Input 3** as the input enabling the PD block of the PID

Enable PD Sel = Dig inp 3

Parameters

Set **Full scale speed** with a value equal to the rated speed of the motor.

Full scale speed = 3000 rpm

Set **PID Source Gain** so that, in correspondence with the maximum analog value of Analog input 2, **PID Feed-fwd** reaches 85% of the maximum value = $10000 \times 85\%$.

PID Source Gain = 0.85

Set **PID Target Sel** as **Ramp Reference**.

Set **PID Output Scale** to **1** so that, in correspondence with the maximum analog value of **Analog input 2 (PID Feed-fwd = 8500)** and **Enable PI** and **Enable PD** = Disable, the **Ramp Reference** parameter is equal to 2550 rpm.

Set **PICentral V Sel** = 1

Set **PI Central V1** = 1

If no corrections are performed by the PI block of the regulator, the line speed reference (feedforward) must be multiplied by 1 and sent directly to the drive speed regulator.

In this type of application, the regulator usually performs a proportional-integral control.

The correction is indicated as a percentage of the line speed, from 0 to the maximum.

Program **PI Top Limit** and **PI Bottom Limit** so that the maximum correction of the PI block corresponds to 20% of the line speed.

The **PI Top Limit** and **PI Bottom Limit** parameters are the maximum and minimum feedforward value multiplication factor.

At maximum line speed they correspond to 2550 rpm of the motor (maximum feedforward).

Maximum correction = $2550 \times 20\% = 510$ rpm

$2550 + 510 = 3060$ rpm → **PI Top Limit** = $3060 / 2550 = 1.2$

$2550 - 510 = 2040$ rpm → **PI Bottom Limit** = $2040 / 2550 = 0.80$

which means multiplying the value of **PI Central V1** (= 1) by + 20% (1.2) and - 20% (0.80).

With this type of configuration, in case of a proportional correction of the line speed, the PI block is unable to apply a tension at speed=0. The PD block must be used for tensioning in a stop condition.

The gains of the single components must be set with the machine loaded; tests can start using the values shown below (predefined values):

Set **PI P Gain In Use** = 10%

Set **PI I Gain In Use** = 10%

Set **PD P Gain In Use** = 10%

If necessary, use the derivative component to dampen the response of the system during changes in speed, by running a programming procedure as described in the example below:

PD D Gain In Use = 5%

PD D Filter = 20 ms

If this is not necessary, keep these parameters = 0.

If cascade references are necessary for another drive, set **PID Target** on an analog output, for example:

PID Target Dest= Pad 1

Analog out 1 src = Pad 1

(with **Real Feed-fwd** = 10000 counts, **Analog output 1** = 10V).

NB: To implement a system with integral regulation enabled and feedforward = 0, capable of achieving a zero tensioning error with the machine stopped, refer to the "Generic PID" section.

17.3. Winder/unwinder control using dancer

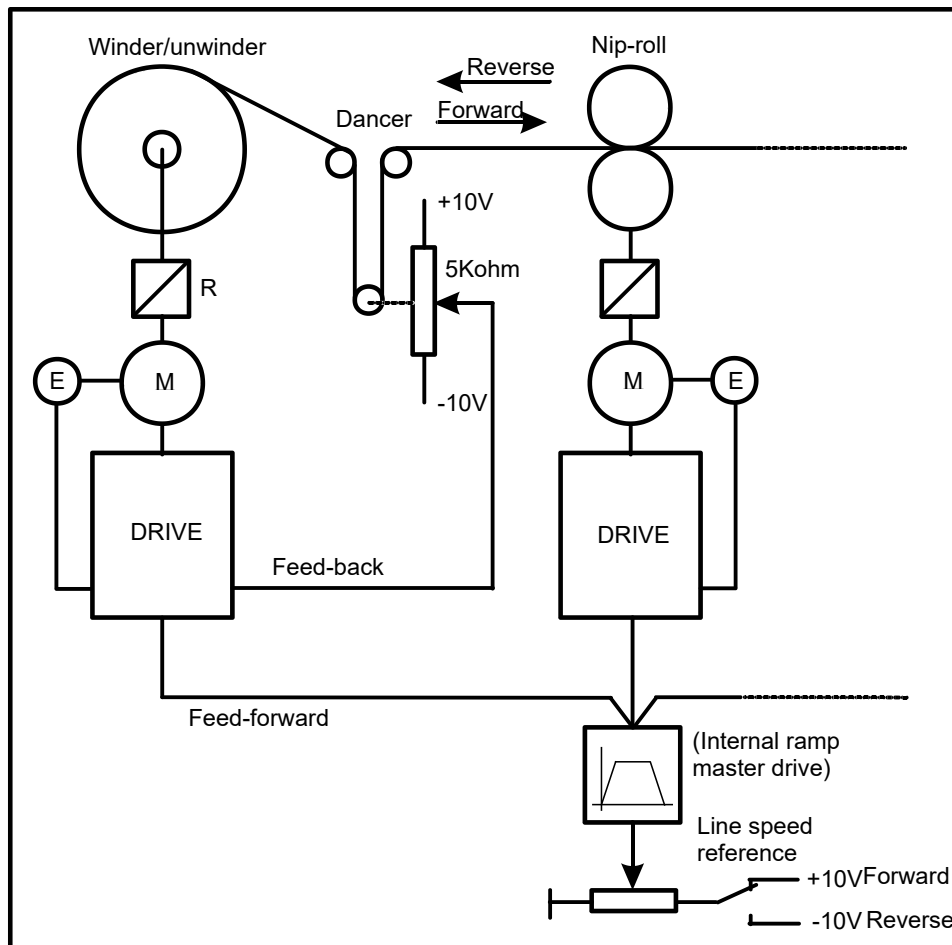


Fig. 15 - winder/unwinder control using dancer

Machine data:

Maximum line speed = 400 m/min

Rated speed of the drum motor in $V_n = 3000$ rpm

Maximum drum diameter = 700 mm

Minimum drum diameter = 100 mm

Motor-core reduction ratio = 0.5

One-pitch dancer

Dancer travel from lower limit switch to the electrical zero position = 160 mm.

Connect the line speed and dancer position analog signals (with potentiometer supplied via terminals with a voltage of between -10V... +10V) and the digital commands to enable PID control to the winder/unwinder drive. The output of the regulator is sent to the **Ramp Reference (PID Target Sel)** parameter.

Drive settings: (only those relating to the PID function are described below)

Inputs/outputs

Set **Analog input 1** as the input for the dancer cursor.

FeedBackAnInpSel = Analog input 1

Set **Analog input 2** as the feedforward input:

PID Src AnInpSel = Analog input 2

Set **Digital Input 2** as the input enabling the PI block of the PID

Enable PI Sel = Dig inp 2

Set **Digital Input 3** as the input enabling the PD block of the PID

Enable PD Sel = Dig inp 3

Set **Digital Input 4** as the input enabling the initial diameter calculation function.

Diam Init Sel = Dig inp 4

Digital Output 1 signals the end of the initial diameter calculation.

DiameterInitCompl Des = Pad 8

Digital output 1 src = Pad 8

Parameters

Set **Full scale speed** with a value equal to the rated speed of the motor.

Full scale speed = 3000 rpm

Set **PID Source Gain** and **PID Output Scale** so that, in correspondence with the maximum analog value of **Analog input 2** and when there is no PID correction (**Enable PI** and **Enable PD** = Disable), the peripheral speed of the core with the minimum diameter (core) is the same as the maximum line speed.

Calculation of motor speed in the conditions described above:

$$V_p = \pi \times \Phi_{\min} \times \omega \times R$$

where:

V_p = core peripheral speed = line speed

$\Phi_{\min}$ = minimum core diameter [m]

ω = angular speed of the motor [rpm]

R = motor - core reduction ratio

$$\omega = V_p / \pi \times \Phi_{\min} \times R = 400 / (\pi \times 0.1 \times 0.5) = 2546 \text{ rpm} = \text{approx } 2550 \text{ rpm}$$

Maintaining a margin of 15% as the regulator saturation limit (10000 counts), set **PID Source Gain** so that **PID Feed-fwd** reaches, in conjunction with the maximum analog value of **Analog input 2**, 85% of its maximum value.

PID Source Gain = 0.85

When **PID Output** assumes the value of 8500 (10000 * 0.85), **Ramp Reference** must assume the value of 2550 (motor speed corresponding to the maximum line speed with the minimum diameter); given that **Full scale speed** is 3000 rpm (corresponding to 10000 in **PID Target**), **PID Output Scale** must be set as follows:

$$\text{PID Output Scale} = (2550/3000) \times (10000 / 8500) = 1$$

Set **PID Target Sel** as **Ramp Reference**.

Set **PICentral V Sel** = 0

With this configuration and using the appropriate procedure, the initial diameter can be calculated. The last diameter that was calculated is stored in case the machine stops or the electric panel is switched off.

As described previously, the procedure determines the theoretical feedforward multiplication factor (**PI Output**) in relation to the calculated diameter, in order to send the correct angular speed value to the drive.

NB: When **PICentral V Sel** = 0 is selected and the PI block is disabled, the system stores (or, if switched off, automatically resets) the last PI Output value that was calculated. If this parameter value has to be set in order to obtain an incorrect reference output that is equal to the feedforward value, a digital input can be configured as a corrective reset.

Configure as follows:

PI C V Bit0 Sel= Dig inp 4
PI Central V1 = 1.00

When a high logic level is assigned to the digital input, **PI Output** is reset.

Set **PI Top Limit** and **PI Bottom Limit** according to the core diameter ratio.

The **PI Top Limit** and **PI Bottom Limit** parameters can be considered, respectively, as the maximum and minimum feedforward multiplication factor.

Bearing in mind that the angular speed of the motor and the corresponding reference change inversely in relation to the diameter of the winder/unwinder, set:

PI Top Limit = 1

PI Bottom Limit = $\Phi_{\min} / \Phi_{\max} = 100 / 700 = 0.14$

The above settings are explained below.

Calculation of the angular speed of the motor:

$\omega_{\max.} = VI / (\pi \times \Phi_{\min} \times R)$ and $\omega_{\min} = VI / (\pi \times \Phi_{\max.} \times R)$

where:

$\omega_{\max.}$ = angular speed of the motor with minimum diameter [rpm]

$\omega_{\min}$ = angular speed of the motor with maximum diameter [rpm]

VI = line speed

$\Phi_{\min}$ = minimum core diameter [m]

$\Phi_{\max.}$ = maximum core diameter [m]

R = motor - core reduction ratio

Therefore:

$\omega_{\max.} / \omega_{\min} = \Phi_{\max.} / \Phi_{\min}$ thus $\omega_{\min} = (\Phi_{\min} / \Phi_{\max}) \times \omega_{\max.}$

Bearing in mind that the **PI Top Limit** and **PI Bottom Limit** parameters can be considered, respectively, as the maximum and minimum feedforward multiplication factor.

By multiplying the feedforward by **PI Top Limit** = 1, the maximum speed reference in relation to the minimum diameter is obtained.

By multiplying the feedforward by **PI Bottom Limit** = 0.14, the minimum speed reference in relation to the maximum diameter is obtained.

This application requires the system to perform a proportional-integral control.

The gains of the various components are set experimentally with the machine loaded. Tests can start using the following values:

Set **PI P Gain In Use** = 15%

Set **PI I Gain In Use** = 8%

Set **PD P Gain In Use** = 5%

If necessary, use the derivative component to dampen the response of the system during changes in speed, by running a programming procedure as described in the example below:

PD D Gain In Use = 20%

PD D Filter = 20 ms

If cascade references are necessary for another drive, set **PID Output** on an analog output, for example:

An Output 0 Sel = PID Output

(with **Real Feed-fwd** = 10000 counts, **Analog output 0** = 10V).

Parameters for calculating the initial diameter

This function is always necessary when controlling an unwinder or if the starting diameter is not known. Set the rpm value of **Positioning Spd** with which to perform initial dancer positioning. For example:

Positioning Spd = 15 rpm

Set **Max Deviation** to a value slightly lower than that corresponding to the maximum acceptable mechanical deviation of the dancer.

The drive's analog inputs must always be set during commissioning; in particular, set analog input 0 so that, with the dancer at the lowest edge of the interval, PID Feed-back is equal to -10000. Thus, to guarantee accurate calculation, set:

Max Deviation = 8000 (predefined value)

Set **Gear Box Ratio** with a value equal to that of the reduction ratio between the motor and core.

Gear Box Ratio = 0.5

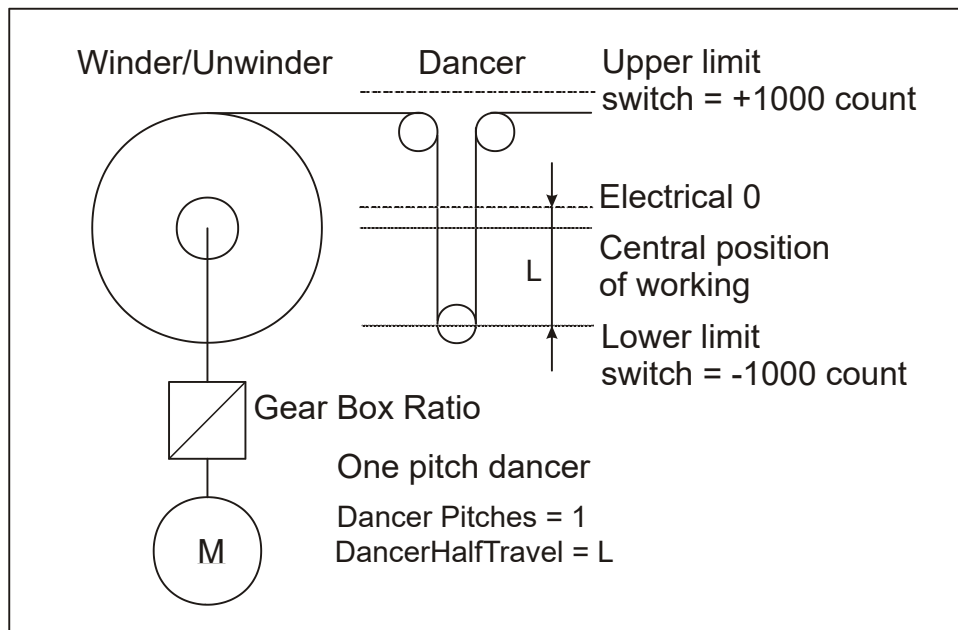


Fig. 16 - diameter calculation

Measurement of DancerHalfTravel:

With the dancer at the lowest deviation, set the analog input programmed as PID Feed-back to obtain -10000. Set the dancer so that the PID Feed-back displays the value of 0 (0 electrical position); measure the distance in millimeters between the lowest deviation and the dancer's current position.

Enter the distance in the **DancerHalfTravel** parameter.

Since the dancer has one pitch, set **Dancer Pitches** to 1.

Set **Minimum Diameter** to a value equal to the minimum core diameter [mm]:

Minimum diameter = 100 mm

17.4. Use of the diameter sensor

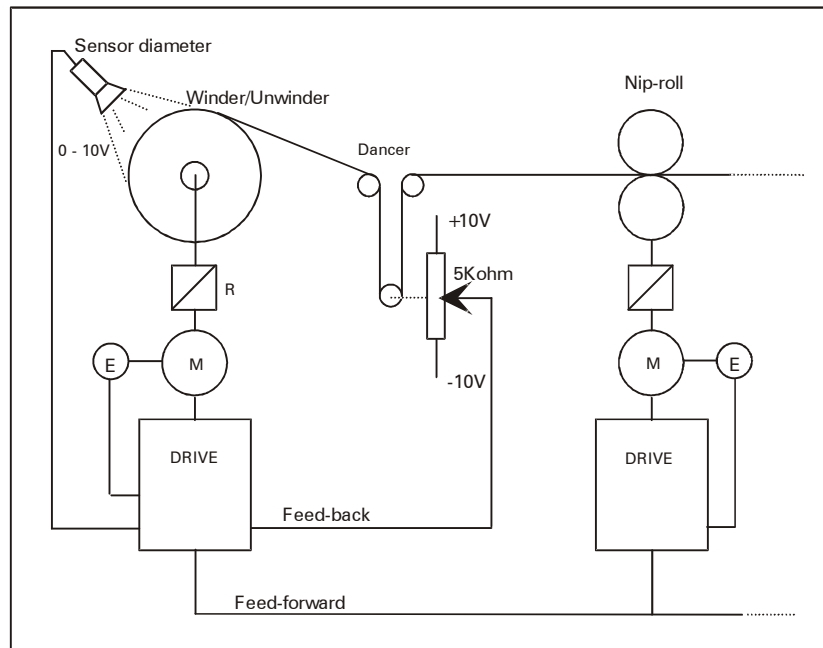


Fig. 17 – winder/unwinder control with diameter sensor

The diameter sensor is particularly useful when using unwinding systems with automatic change. In these systems, the initial diameter must be known, in order to calculate the angular speed reference of the motor before inserting the new spool. The transducer must be set to send a tension signal proportional to the core Diameter.

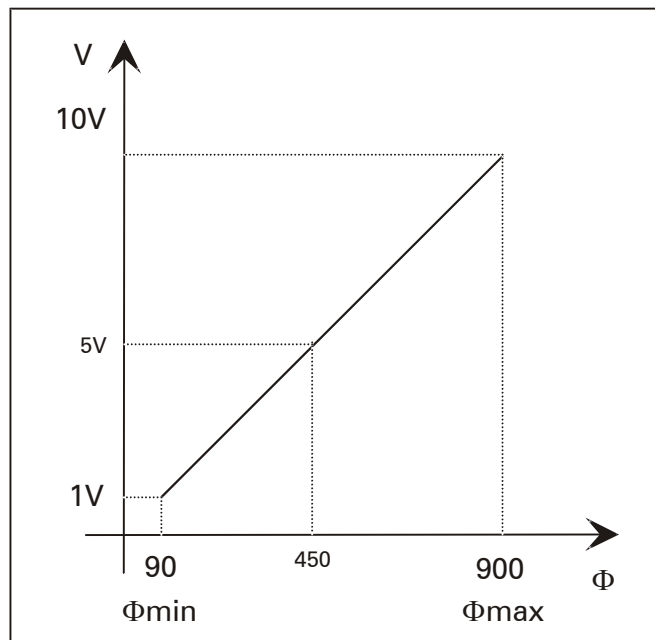


Fig. 18 – ratio between transducer signal and core signal

Example:

$\Phi_{\min}$	= 90 mm	transducer output = 1V
$\Phi_{\max}$	= 900 mm	transducer output = 10V
Φ	= 450 mm	transducer output = 5V

PI Central V3 must be programmed for the analog input to which the sensor is connected.

Set **PICentralV3AnInp** by selecting this input.

The value of **PICentral V Sel** must be = 3.

When **Enable PI** = disable, the value of **PI Central V3** is shown in **PI Output** and used as the feedforward multiplication factor.

As described previously in this manual, the value of **PI Output** depends on the ratio of the diameters, and the tension signal proportional to the diameter is automatically recalculated using the following formula:

$$\text{PI Central V3} = (\Phi_0 / \Phi_1)$$

Where: Φ_0 = minimum winder diameter

Φ_1 = current diameter

NB: During commissioning, check that the signal from the sensor really is proportional to the diameter and that its maximum value is 10V (if necessary set the analog input).

Also make sure that the PI Top Limit and PI Bottom Limit parameters have been programmed.

17.5. Pump and extruder pressure control

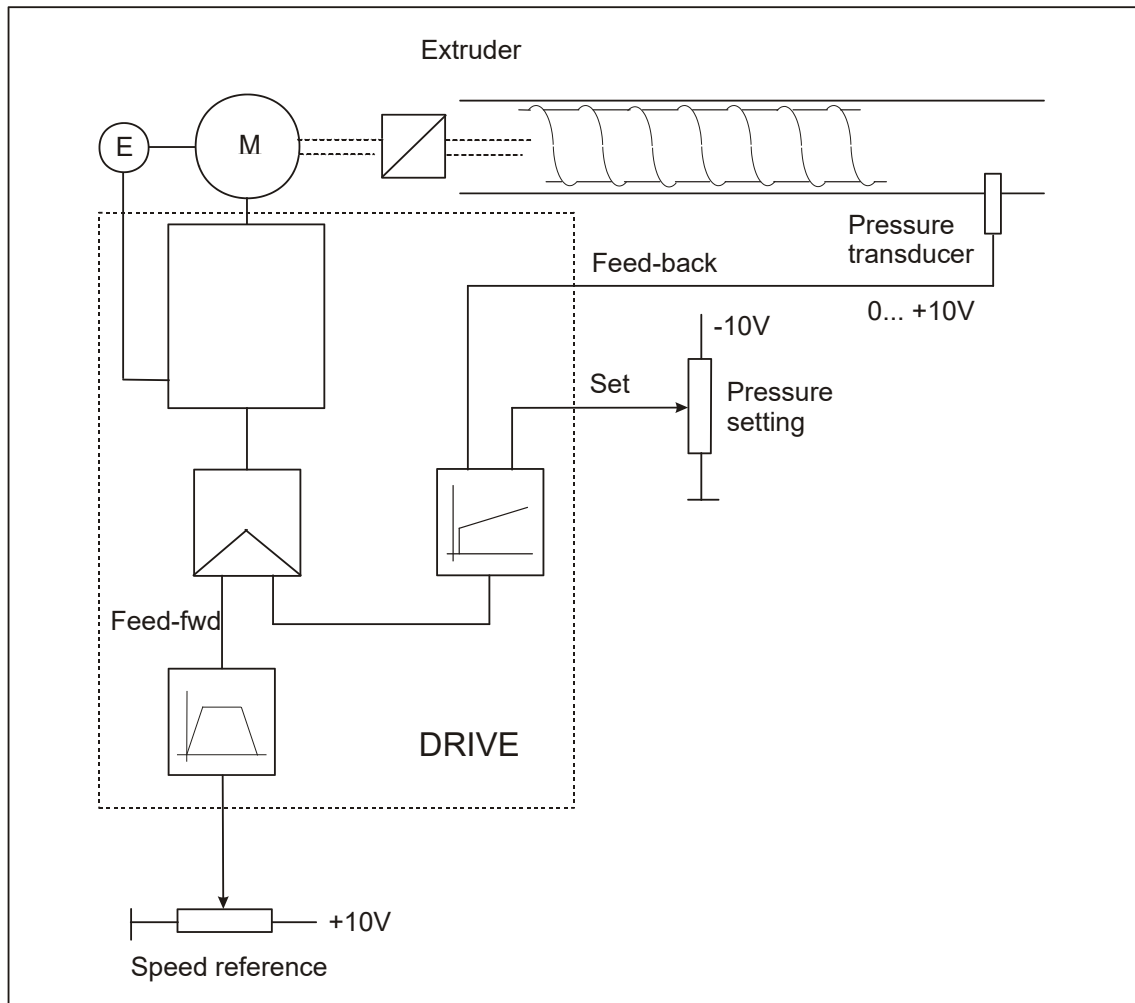


Fig. 19 – pump and extruder pressure control

Machine data:

Rated speed of the extruder motor in Vn = 3000 rpm

Transducer pressure 0... +10V

Send the following to the extruder slave drive: the analog signals relating to the speed reference, transducer pressure, pressure-setting potentiometer (supplied with a voltage of between 0V... -10V) and the digital commands to enable PID control.

The output of the regulator is sent to the **Dig speed ref 1 (PID Target Sel)** parameter.

Drive settings: (only those relating to the PID function are described below)

Inputs/outputs

Set **Analog input 1** as the transducer pressure input.

FeedBackAnInpSel = Analog input 1

Set **Analog input 2** as the feedforward input:

PID Src AnInpSel = Analog input 2

Set **Analog input 1** of the expansion card (optional) as the tension reference input (**PID Offset 0**):

PIDOff0AnInSel = Analog input 1X

Set **Digital Input 2** as the input enabling the PI block of the PID
Enable PI Sel = Dig inp 2

Set **Digital Input 3** as the input enabling the PD block of the PID
Enable PD Sel = Dig inp 3

Set **Digital Input 4** as PID Src Rampln = 0
PISSrcRamp=0 Sel = Dig inp 4

The **Start cmd** command must be set to On.

Parameters

Set **Full scale speed** with a value equal to the rated speed of the motor.
Full scale speed = 3000 rpm

Set **PID Src Acc Time** and **PID Src Dec Time** to the time required for the feedforward to pass from 0 to 10000 and from 10000 to 0.

Set **PID Source Gain** to 1.

Set **PID Target Sel** as **Ramp Reference**.

Set **PICentral V Sel** = 1
Set **PI Central V1** = 1

If no corrections are performed by the PI block of the regulator, the line speed reference (feedforward) must be multiplied by 1 and sent directly to the drive speed regulator.
In this type of application, the regulator usually performs a proportional-integral control.

Program **PI Top Limit** and **PI Bottom Limit** so that the maximum correction of the PI block corresponds to 100% of the speed reference.

The **PI Top Limit** and **PI Bottom Limit** parameters can be considered, respectively, as the maximum and minimum feedforward multiplication factor.

PI Top Limit = 1
PI Bottom Limit = 0

The gains of the various Tests can start using the following values (predefined values):

Set **PI P Gain In Use** = 10%
Set **PI I Gain In Use** = 20%
Set **PD P Gain In Use** = 10%

If necessary, use the derivative component to dampen the response of the system during changes in speed, by implementing the settings as described in the example below:

PD D Gain In Use = 5%
PD D Filter = 20 ms

If this is not necessary, keep these parameters = 0.

17.6. Generic PID

Drive settings: (only those relating to the PID function are described below)

Inputs/outputs

Program **Analog input 1** as the input of the variable to be regulated (feedback).

FeedBackAnInpSel = Analog input 1

Set **Analog input 2** as the setpoint input signal (**PID Offset 0**).

PIDOff0AnInSel = Analog input 2

Set **Digital Input 2** as the input enabling the PI block of the PID

Enable PI Sel = Dig inp 2

Set **Digital Input 3** as the input enabling the PD block of the PID

Enable PD Sel = Dig inp 3

Parameters

If using the regulator as "generic PID", thus not dependant on the feedforward function, set **PID Feed-fwd** to the maximum value. To do this, set **PID Source** = 10000.

Set **PID Source Gain** = 1.

Set **PID Target Sel** with the parameter with which the regulator output is associated (Ramp Reference or Torque reference).

NB: The firmware of the drive does not control the polarity of the value that is sent; if the regulator output is positive only, set **PID Out Sign** = Only positive

Set PICentral V Sel = 1

Set PI Central V1 = 0

In this configuration, when switching the parameters enabling the PID function from Off/On, the regulator output starts from 0.

To store the last value that was calculated even with the machine disabled, use a digital input programmed as bit 0 selection of the PI Central value.

PI C V Bit0 Sel =Dig inp xx

PI Central V1 = 0

When the digital input has a low logic level (L), the last value of **PI Output** that was calculated is stored, while this value is reset if a high logic level is set (H).

Program **PI Top Limit** and **PI Bottom Limit** to obtain a PID block correction equal to 100% of its maximum value.

PI Top Limit = 1

PI Bottom Limit = -1

In this configuration, the output of the PID block is both positive and negative.

Set **PI Top Limit** = 0, to block the positive part.

Set **PI Bottom Limit**= 0, to block the negative part.

The gains of the various components must be set experimentally with the machine loaded.

Tests can start using the following values:

Set **PI P Gain In Use** = 10%

Set **PI I Gain In Use** = 4%

Set **PD P Gain In Use** = 10%

If necessary, use the derivative component to dampen the system, by implementing the settings in the example below:

PD D Gain In Use = 5%

PD D Filter = 20 ms

If this is not necessary, keep these parameters = 0.

17.7. Application notes

Dynamic modification of PI block integral gain

The PID integral gain is usually set so that the lower its value the higher the diameter ratio of the core being controlled. A value that is too high would enable good control with small diameters but lead to significant swinging at larger core diameters.

On the contrary, excessively reduced integral gain values with the minimum diameter could cause the dancer to move from the electrical zero position, the value of which would increase the greater the line speed. This phenomenon is due to the fact that the integral component is loaded and unloaded more quickly than the time in which the diameter varies.

With a high diameter ratio, the value of the **PI I Gain In Use** parameter may have to be dynamically modified according to the current diameter.

This can be done by using the adaptive gains of the **PI regulator (PI Adaptive)**, see paragraph 12)

Suppose, for example, a winder with a diameter ratio of 1/10 is being controlled.

The integral component of the regulator must function in an inversely proportional manner in relation to the diameter.

The value of the **PI Output** parameter already acts in this way, as it changes according to the ratio Φ_0 / Φ_{act} .

Where: Φ_0 = minimum core diameter

Φ_{act} = current core diameter

To perform the desired operation, set the following parameters:

PI Top Limit = 1

PI Bottom Limit = 0.1

Region A End = 1000

Region B Start = 6000

Region B Start = 6000

Region C Start = 10000

PI I Gain A = 4%

PI I Gain B = 15%

PI Gain C = 40%

With a similar configuration, the minimum diameter corresponds to an integral gain = 40%, while the maximum diameter corresponds to an integral gain = 4%; between the two setpoints the gain changes according to the following curve:

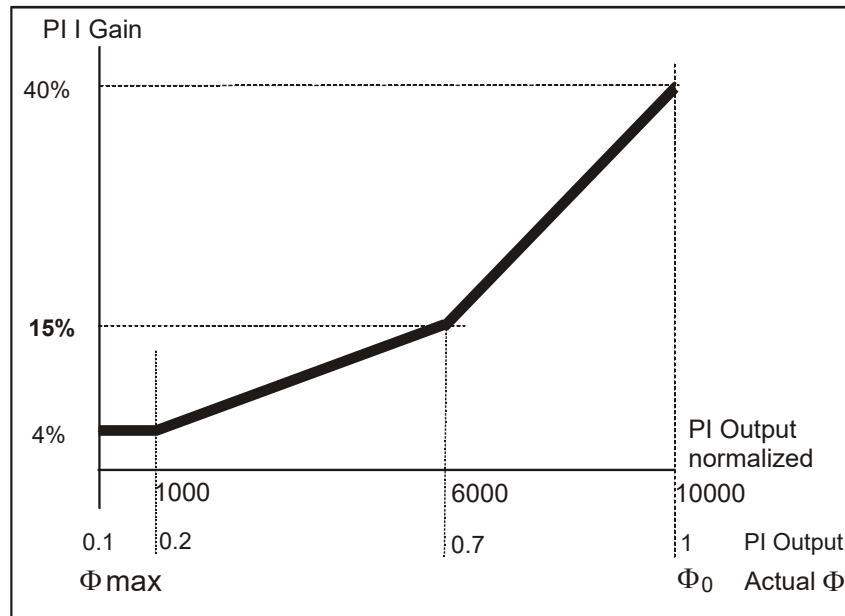


Fig. 20 – PI I Gain In Use e PI Output

As shown in paragraph. 12, the PI Output value is normalised to the PID Norm Value, which corresponds to PI Top Limit (in this case 1).

The value of **PI I Gain In Use** is displayed in the relative parameter in the **PI Controls** submenu.

The same procedure can also be used to change **PI P Gain In Use**.

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WEG Automation Europe S.r.l.

Via Giosuè Carducci, 24

21040 Gerenzano (VA) · Italy