

Technical instruction

ACS250 micro drives, 110-480 V

PI closed loop feedback control applications



General

ACS250 has a built-in flexible PI controller that can be used for a variety of process control applications. Typical applications include pressure control, flow control, temperature control etc.

Application macros

Application macros are pre-programmed parameter sets that simplify drive setup. ACS250 drives have several different built-in application macros including a User PI mode macro. For 110–480 V ACS250 drives, select macro number 5 in parameter 1103 Primary command source mode for the User PI mode macro.

This technical instruction describes the setup procedure for each of the operating modes available.

PI overview

PI (Proportional & Integral) control is widely used in many applications. A PI system requires:

- Set point signal (reference)

This is the desired operating point of the system proportional to the feedback signal. An example the pressure level which the pump is required to maintain, for instance 1.5 bar.

- Feedback signal

This is the feedback signal proportional to the range of the feedback transducer. This could be a pressure transducer with a range of 0–10 bar for a 4–20 mA signal range.

The drive will continuously monitor the feedback signal and compare it to the set point, and then adjust the output speed automatically to try to maintain the correct set point level.

Configuration parameters

4011 PI set point (reference)

For a simple system with a fixed set point, the value for 4011 can be calculated from the transducer range.

If a system is required to hold a constant pressure of 1.5 bar, and uses a transducer for feedback with measurement range 0 to 10 bar, the value of 4011 can be calculated as:

$$(1.5 \text{ bar} / 10 \text{ bar}) \times 100 \% = 15 \%$$

4001 PI proportional gain

In simple terms, the PI gain parameter controls how great a variation in pump speed will be seen relative to a change in pressure. If the value used is too high, the pump will continuously change speed, and the pressure will be unstable. Typically on a pump system, the factory set value of 1 will provide good performance. If the pump speed is unstable, reduce the value.

4002 PI integral time

The ACS250 monitors the change of feedback over time to determine the average pressure and how rapidly it is changing. This time filter helps to provide smooth operation. In most cases, the factory set value of one second provides good operation, however the value may need to be increased on systems where the pressure changes relatively slowly in the system.

4005 PI controller operating mode selection

The PI controller mode is set using parameter 4005.

In all cases, the 4005 allows the user to select either direct PI control, where an increase in the speed of the motor increases the feedback value, or to select inverse mode, where an increase in the speed of the motor reduces the feedback value.

4005	Function	Typical application	Explanation
0	Direct mode	Pump pressure control compressor pressure control	An increase in the motor speed should result in an increase in the feedback signal, e.g. a pump rotates faster to create more pressure.
1	Inverse mode	Inverse mode condenser fan temperature control	An increase in the motor speed should result in a decrease in the feedback signal, e.g. a fan rotates faster to provide more cooling effect.

4016 PI feedback select

The PI feedback can be selected from three different sources.

Value	Feedback signal	Format of the feedback
0	Analog input 2 (T4)	1304
1	Analog input 1 (T6)	1300
2	Motor load current	Fixed

By default the feedback signal is set to analog input 2 on terminal 4.

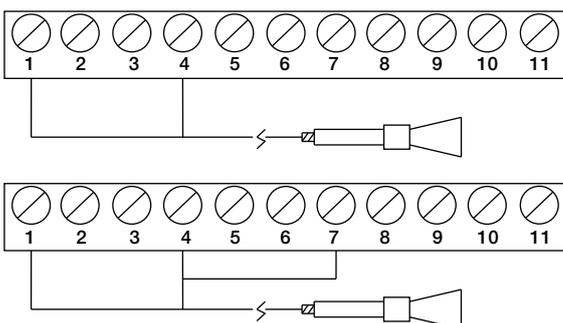
The format of the feedback signal can be configured by setting the format of the analog input in use as required. Most feedback transducers use the 4-20 mA format.

If analog input 1 is selected as a feedback signal, digital input 3 (2nd analog input) can then be used as an external trip input which enables the user to connect a PTC motor thermistor for motor protection purposes and by setting 9902=3.

This external trip function is not available if 2nd analog input is selected as PI feedback input.

Feedback transducers

There are generally two types of transducers, and an example of how to connect each of these to the drive is shown below. When connecting a 2-wire feedback transducer (e.g. 4-20 mA type), check that the transducer is suitable for 24 V operation, then connect the transducer supply to pin 1 and the transducer output to pin 4.



4010 PI reference select

The PI controller reference can be given by an external analog input signal or by digital preset value depending on application requirements. This is set up using 4010.

4010	Description
0	PI control using the digital preset value for the reference input. The digital preset reference value is defined in parameter 4011, this is proportional to 0 to 100 % of the full range of the feedback value.
1	PI control using analog input 1 (T6) for the reference input.

Note that the user has to adjust the PI control parameters (P-gain, I-gain) in 4001 and 4002 respectively to get the best control performance. The values will vary depending on system inertia and the time constant (rate of change) of the system being controlled.

Standby function

The ACS250 has a built-in standby function, which allows the pump to automatically switch off completely when the motor is not required i.e. running at set point level. This function should only be used on systems where the set point can be maintained even when the motor is stopped.

In order to use this function, the speed reference on the drive must be at 0.0 Hz for 20 seconds after which the ACS250 will switch off the motor, and the display will show "Stndby".

For applications where a minimum operating frequency is required to protect the motor from overheating. The use of skip frequencies is possible to avoid operation below the minimum operating point frequency which is typically between 20-30 Hz.

Standby function with skip frequencies

Parameter description

Parameter	Function	Explanation
2500	Skip frequency hysteresis band	Set 9907 before adjusting. Speed reference held at upper or lower skip frequency limit until input signal reaches the opposite skip frequency limit. Speed ramps through the skip frequency band at a rate set by 2202 and 2203.
2501	Skip frequency	Set 9907 before adjusting. Skip frequency center point.

Example values

Minimum speed to be 24 Hz then ramp down to 0 Hz before entering "Stndby" after 20 seconds "stndby".

$$2500=24 \text{ Hz}$$

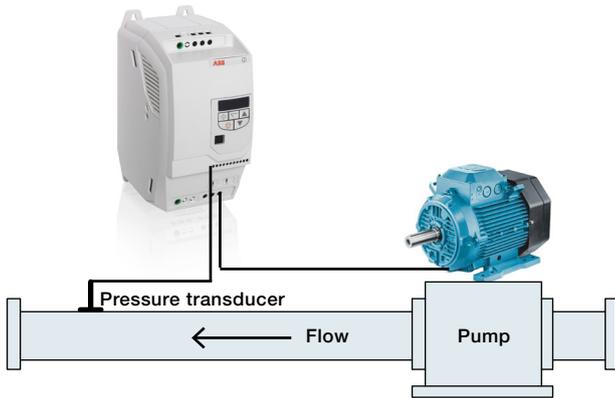
$$2501=2500/2=24 \text{ Hz}/2=12 \text{ Hz}$$

Application examples

Pressure control

Simple fixed PI set point

Picture no. 1



See picture no. 1

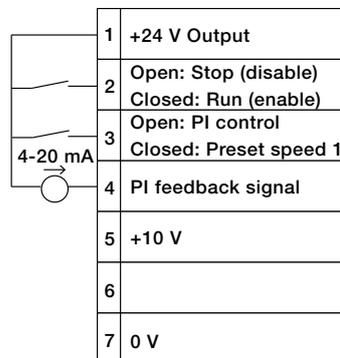
Par	Function	Example setting	Explanation
2202	Acceleration ramp time	10–30 s	Allows for smooth starting and stopping of the system.
2203	Deceleration ramp time	10–30 s	
2601	Energy optimizer	1	Energy optimizer enabled.
9905	Motor rated voltage	-	Enter the values from the motor nameplate, to avoid damaging the motor.
9906	Motor rated current	-	
9907	Motor rated frequency	-	
1103	Control selection	5	Enables PI control.
1304	2nd analog input format	4–20 mA	Set to match the transducer signal type
4001	PI proportional gain	0.5–2	System dependant.
4002	PI integral time	1–5 s	System dependant.
4005	PI mode select	0	Direct operation – increase in motor speed signal for an increase in feedback signal.
4010	PI set point selection	0	Digital set point with level set in 4011.
4011	PI set point (reference)	-	Set to desired operating level.

Connection no. 1

PI mode 1103=5,
9902=0

Remote control (PI):
Control set by pressure level.

Local control: None



Pressure control

Variable PI set point with local/remote operation

See picture no. 1

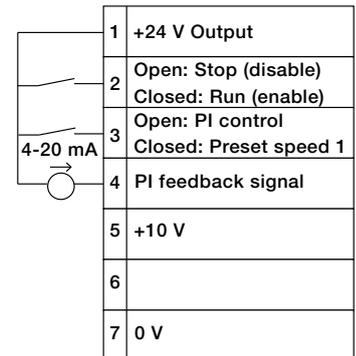
Par	Function	Example setting	Explanation
2202, 2203, 2601, 9905, 9906, 9907, 1103, 1304, 4001, 4002, 4005			See table no. 1.
9902	Terminal configuration		See below.
4010	PI set point selection	0	Analog set point with level set from external signal e.g. potentiometer.

Connection no. 2

PI mode 1103=5,
9902=0

Remote control (PI):
Control set by pressure level.

Local control: Speed set by preset speed 1 (1202).

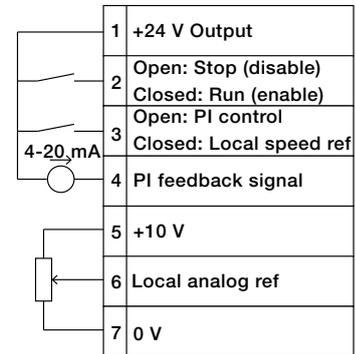


Connection no. 3

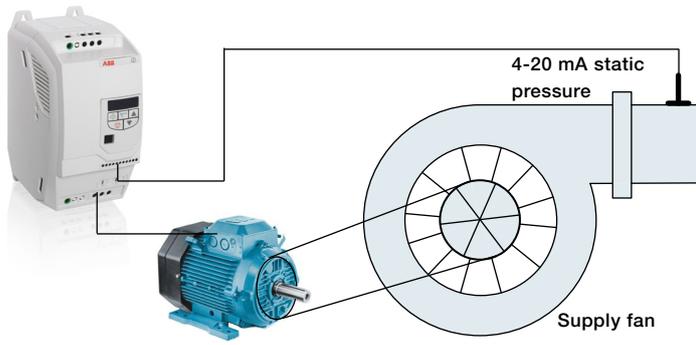
PI mode 1103=5,
9902=1

Remote control (PI):
Control set by pressure level.

Local control: Speed set by potentiometer.



Blower/compressor control using pressure feedback
Picture no. 2



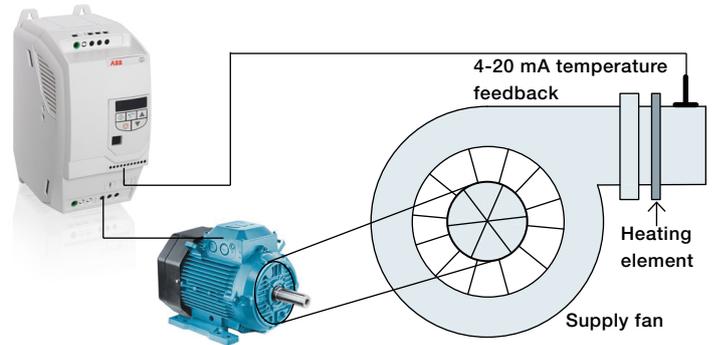
See picture no. 2

Table no. 3

Par	Function	Example setting	Explanation
2202, 2203, 2601, 9905, 9906, 9907, 1103, 9902, 1304, 4001, 4002, 4005, 4010			See table no. 2.

See connections no. 2 and no. 3.

Temperature control using temperature feedback
Picture no. 3



See picture no. 3

Table no. 4

Par	Function	Example setting	Explanation
2202, 2203, 2601, 9905, 9906, 9907, 1103, 9902, 1304, 4001, 4002, 4010			See table no. 2.
4005			Inverse operation – increase in motor speed signal for a decrease in feedback signal.

See connections no. 2 and no. 3.

3AJUA0000156951 REV A EN 6.5.2015

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