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 is 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.

<table>
<thead>
<tr>
<th>Function</th>
<th>Typical application</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct</td>
<td>Pump pressure control compressor pressure control</td>
<td>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.</td>
</tr>
<tr>
<td>Inverse</td>
<td>Inverse mode condenser fan temperature control</td>
<td>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.</td>
</tr>
</tbody>
</table>

4016 PI feedback select
The PI feedback can be selected from three different sources.

<table>
<thead>
<tr>
<th>Value</th>
<th>Feedback signal</th>
<th>Format of the feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Analog input 2 (T4)</td>
<td>1304</td>
</tr>
<tr>
<td>1</td>
<td>Analog input 1 (T6)</td>
<td>1300</td>
</tr>
<tr>
<td>2</td>
<td>Motor load current</td>
<td>Fixed</td>
</tr>
</tbody>
</table>

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.

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Function</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2500</td>
<td>Skip frequency hysteresis band</td>
<td>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.</td>
</tr>
<tr>
<td>2501</td>
<td>Skip frequency</td>
<td>Set 9907 before adjusting. Skip frequency center point.</td>
</tr>
</tbody>
</table>

Example values
Minimum speed to be 24 Hz then ramp down to 0 Hz before entering “Stndby” after 20 seconds “stndby”.

2500=24 Hz
2501=2500/2=12 Hz
Application examples
Pressure control
Simple fixed PI set point

Picture no. 1

See picture no. 1

Table no. 1

Table no. 2

Pressure control
Variable PI set point with local/remote operation
See picture no. 1

Connection no. 1
PI mode 1103=5, 9902=0
Remote control (PI): Control set by pressure level.
Local control: None

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.

Connection no. 2

Connection no. 3

PI proportional gain 0.5–2 System dependant.
PI integral time 1–5 s System dependant.
PI mode select 0 Direct operation – increase in motor speed signal for an increase in feedback signal.
PI set point selection 0 Digital set point with level set in 4011.
PI set point (reference) - Set to desired operating level.

PI proportional gain
PI integral time
PI mode select
PI set point selection
PI set point (reference)
Table no. 3

<table>
<thead>
<tr>
<th>Par</th>
<th>Function</th>
<th>Example setting</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2202, 2203, 2601, 9905, 9906, 9907, 1103, 9902, 1304, 4001, 4002, 4005, 4010</td>
<td>See table no. 2.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

See connections no. 2 and no. 3.

Table no. 4

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

See connections no. 2 and no. 3.

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