



[www.imoticondrives.co.uk](http://www.imoticondrives.co.uk)

<b>Document number</b>	Imoticon-ID700-023
<b>Revision</b>	0.0
<b>Author</b>	Gareth Lloyd
<b>Product</b>	Imoticon ID700

<b>Title</b>	Imoticon ID700 PID Loop Set-up for use with a milking parlour vacuum pump
--------------	---

<b>Summary</b>	This document gives information on how to set up the Imoticon ID700 PID Loop for PID control for use with a milking parlour vacuum pump
----------------	---

**NOTE: Please read this document in conjunction with the Imoticon ID700 Easy Start Guide and Imoticon ID700 Advanced User Manual.**

### Overview

The Imoticon ID700 has a built in PID (proportional-integral-derivative) controller that can be used for a variety of process control applications. Some typical applications will include - temperature control, flow control, pressure & vacuum control etc.

This document describes the principles of PID control and the procedure for setting up the Imoticon ID700.

### Principles of PID Control

Industrial processes can often require a constant process value (such as temperature, pressure, fluid level, vacuum or flow rate etc.) to be maintained regardless of any variation in system operating parameters.

### Example:

The level of liquid in a tank is to be maintained regardless of the number of output valves opened. This can be achieved by using a variable speed drive with PID control to vary the speed of the inlet pump and thus inlet flow to maintain a set level within the tank regardless of how many outlet valves are opened.

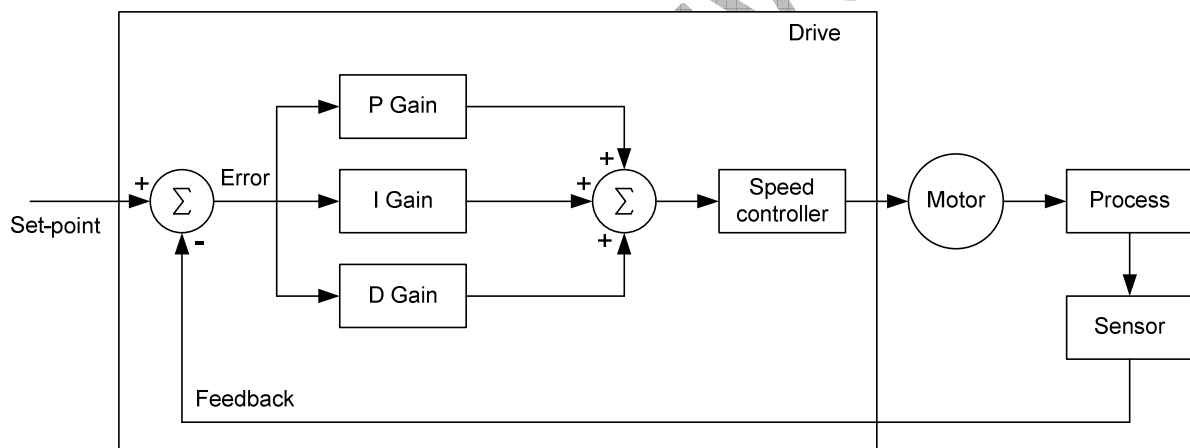
The PID control loop would need feedback from a sensor that represented the variable to be controlled and a set-point that represented the process level that was required to be maintained.

So for the example of the tank, a level sensor would be required to be placed in the tank to feedback the level of liquid to the ID700. A set-point would be programmed into the ID700 which would be the level to be maintained. The PID control loop would then modify the speed of the inlet pump depending on the outlet flow (number of outlet valves opened). If only one outlet valve was opened then the inlet pump would run at a slower speed to maintain the set-point level. If 3 outlet valves were opened then the inlet pump would run at a higher speed to maintain the set-point level.

The PID controller operates on the 'error value' or the difference between the measured process value and the programmed set-point. The PID control loop will attempt to eliminate the error (maintain the set-point) by adjusting the drives output speed and thus adjusting the flow, level, pressure, temperature within the system.

The PID controller will react to this error value and how the PID controller reacts depends on the size of the error and the time the error has existed. The PID controller corrects the error and for best performance corrects the error in the shortest possible time although this does depend on the type of application being controlled by the PID controller.

### Basic PID controller diagram

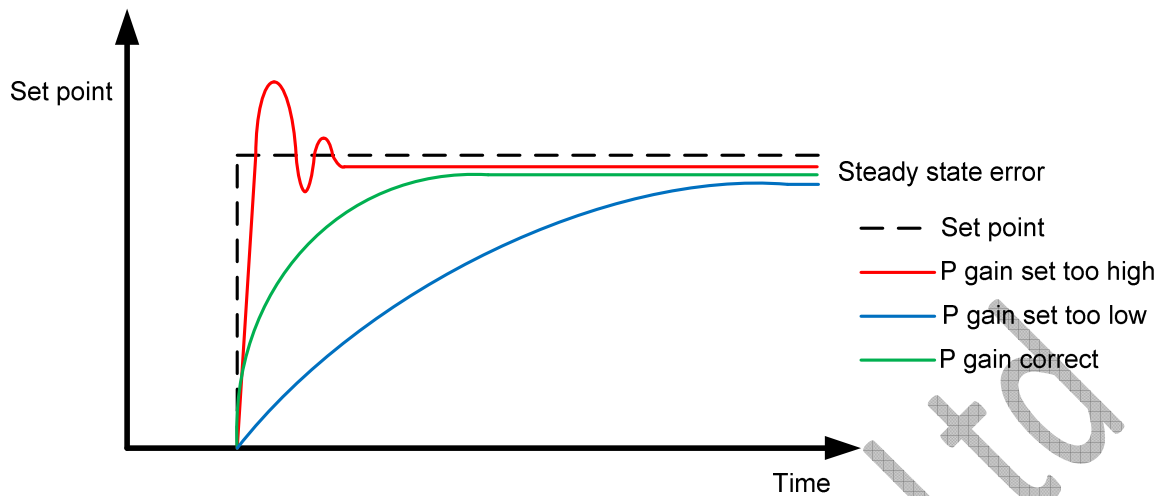


### Proportional – P-Gain

The (P) proportional term in a PID function is simply a multiplier for the error signal. The P term directly affects the size of the error value seen by the PID controller and how quickly the Imoticon ID700 output responds. If the P gain value is set too low then the ID700 will take more time to modify its output and correct the error. If the P gain is set too high then the ID700 may respond too quickly and cause the system (and feedback) to overshoot the required set-point. This results in what are called 'oscillations' where the PID controller has to compensate for the overshoot. If the P gain is set significantly too high then the system can become 'unstable'.

When only a 'P' term is applied to the PID controller (no 'I' or 'D' term) then there will always be error in existence between the set-point and the feedback level. This error exists because the P term is a multiplier value and with no error to multiply, the output will start to decrease (in turn creating an error). The system will eventually balance out with a steady state error always present.

The following graph shows the affects of tuning the Proportional term:



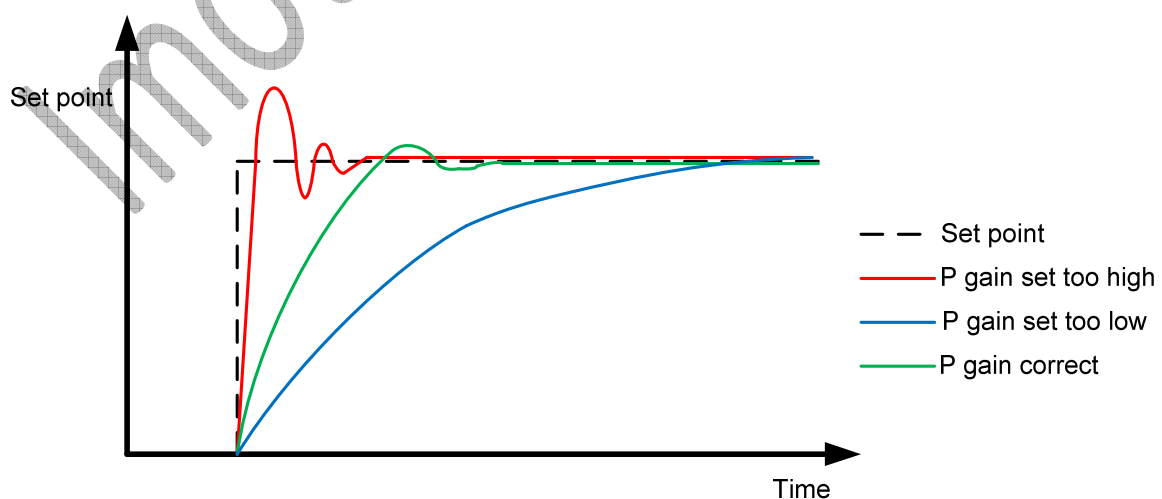
### Integral – I-Gain

The (I) Integral term in a PID function samples the error present over a given time and takes an average of those values, hence the affect on the system is based on the accumulation of recent errors rather than the current or existing error. The I term is used to eliminate the steady state error (caused by only applying P term) and it adds longer term precision. The I term should always be used in conjunction with the P term.

A low value of I term results in a low sample time, making the drive output more responsive but more prone to instability. A high value of I term results in a high sample time that might make the drive output unresponsive or not fully eliminate the steady state error.

Small changes of Integral time can have a large affect on the system response and can very quickly lead to instability. Care should be taken in adjusting this value to ensure no instability is introduced into the system, especially resulting from a large change in error or set-point value resulting in a large error occurring.

The following graph shows the affects of tuning the Integral term (having tuned the P term):



## Differential- D-Gain

The (D) Derivative term (sometimes referred to as the Differential term) in a PID function looks at the rate of change of error and attempts to respond proactively based on this behaviour. The D term effectively predicts where the drive is likely to be after a given time and adapts the output to create a more dynamic response. One of the issues associated with the D term is that it can cause high frequency oscillations and instability in the system if set incorrectly. The D term should always be used in conjunction with both the P and I terms.

A low value of D term results in a low sample time, and makes the drive output more responsive but more susceptible to instabilities. A high value of D term results in a high sample time that might make the drive output unresponsive.

**Note: The majority of Standard Motor Control Applications do not require adjustment of the D term. By default the D term is set to '0' in the Imoticon ID700 which disables the function. Care should always be taken in adjusting this value and it is recommended only for experienced drive commissioning engineers with good practical experience of tuning the D term in PID control applications.**

## Drive Configuration and Commissioning

The following section will explain how to configure the Imoticon ID700 in PID mode for a basic application. The configuration has been broken down into smaller steps set out in the sequence that they should be followed during commissioning.

The following steps assume that the Imoticon ID700 is in the default state – if parameters have been modified from their default state, this could affect the operation of the drive.

### Motor data

The first step is to enter the motor nameplate data into the drive as follows:

**P00.01** = Motor Rated Voltage (230V/400V default) – Set to motor nameplate voltage

**P00.02** = Motor Rated Current – Set to motor nameplate current

**P00.03** = Motor Rated Frequency (50Hz default) – Set to motor nameplate frequency

### Control mode

**P00.04** = Control mode – Set to 1 - terminal control

### Reference source select

**P00.05** = Reference source select – Set to 8 - User programmed

### Minimum and Maximum speeds

**P00.06** = Minimum speed – Set to the required minimum speed (if required)

**P00.07** = Maximum speed – Set to the required maximum speed (if required)

### Acceleration & deceleration ramps

Usually for Fan and pump applications, the default acceleration ramp of 10s and deceleration ramp of 20s are acceptable as fast response is not usually required although for bigger fans, these values may need increasing.

**P00.08** = Acceleration ramp (10s default) – Set to the required acceleration ramp time

**P00.09** = Deceleration ramp (20s default) – Set to the required deceleration ramp time

### **PID Controller Enable**

**P15.07** – Set to 1 to enable PID controller

### **PID Reference Set-point Source**

The PID reference set-point can either be from an analogue signal, digital reference or keypad. In this set up, the digital reference.

### **PID Feedback Source**

The PID feedback source is from an analogue signal and is fed into analogue input 1 (AI 1)

**P15-02** = 8.17 - Analogue input 1 level as feedback source

The form of analogue input 1 can be changed using parameter P00.11.

AI 1 signal can be voltage or current:

**0: 0mA-20mA**

**1: 20mA-0mA**

**2: 4mA-20mA** (With F013 current loss trip if input current falls below 3mA)

**3: 20mA-4mA** (With F013 current loss trip if input current falls below 3mA)

**4: 4 mA-20mA** (Without trip)

**5: 20mA-4mA** (Without trip)

**6: 0V-10V**

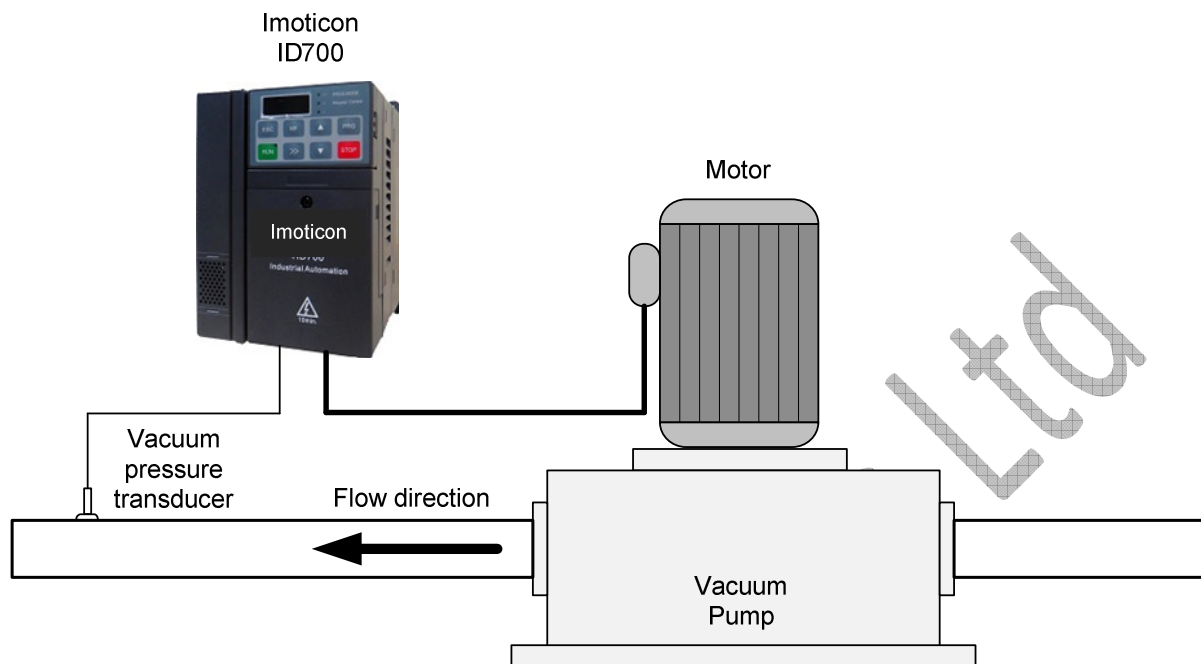
### **PID Output**

**P15.15** = 1.27 - PID output destination to User programmed main aux reference

Imoticon Drives Ltd

## Application Example 1

### Vacuum pump control with a fixed PID set-point



Consider a pumping application  
Feedback transducer = 4-20mA / -1 – 0 bar  
Pressure target level = -0.5 bar

We can calculate the digital set point for as follows:  
Set-point =  $-0.5 \text{ bar} / -1 \text{ bar} \times 100.0\% = 50.0\%$   
Set 15.01 = 17.42  
P17.42 = 0 to 300.0% Therefore 50% of 300 = 150.0  
Set **P17.42 = 150.0**

With this set up, fast reaction times are required for the vacuum pump.  
Also with this set up, there are 2 different acceleration ramps. Ramp one (slow acceleration) for initial accelerating on the run command, ramp two (fast acceleration) for accelerating during normal running.

**Parameter changes required from default**

Par	Function	Example Setting	Explanation
P00.01	Motor rated voltage	-	Enter the values from the motor nameplate
P00.02	Motor rated current	-	
P00.03	Motor rated frequency	-	
P00.04	Control mode	1	Terminal control
P00.05	Reference source selector	8	Ref source to user programmable
P00.06	Minimum reference	-	System dependant
P00.08	Acceleration 1 ramp time	1 to 5s	System dependant: Initial acceleration ramp
P00.09	Deceleration 1 ramp time	1s	System dependant
P00.11	Analogue input 1 format	2: 4 to 20mA with trip	Set to match the transducer signal type
P00.23	Extended parameter access	1	Allows extended parameter access
P02.06	Acceleration 2 ramp time	2 to 0.5s	System dependant: Normal running acceleration ramp
P03.01	Allow reverse	1	Disabled running reverse
P09.02	Digital input 1 function	2	DI 1 function as 'Run/Stop'
P15.01	PID reference source	17.42	PID ref source from P17.42
P15.02	PID feedback source	8.17	PID feedback from AI 1 level
P15.04	PID reference invert	1	Inverts PID reference
P15.05	PID feedback invert	1	Inverts PID feedback
P15.07	PID enable	1	Enabled PID controller
P15.09	PID P gain	4.000	System dependant: Values of 4.000 give fast response
P15.10	PID I gain	4.000	
P15.14	PID output scaling	4.000	
P15.15	PID output destination	1.27	PID output to user programmed reference
P16.01	Programmable logic 1 source 1	9.40	From DI 1 state
P16.03	Programmable logic 1 source 2	9.40	From DI 1 state
P16.06	Programmable logic block 1 delay	10s	System dependant: Time delay between acceleration ramp 1 and 2
P16.07	Programmable output destination	2.14	Acceleration ramp bit 0
P17.42	User defined word variable 1	150.0	Sets PID set point to 50%

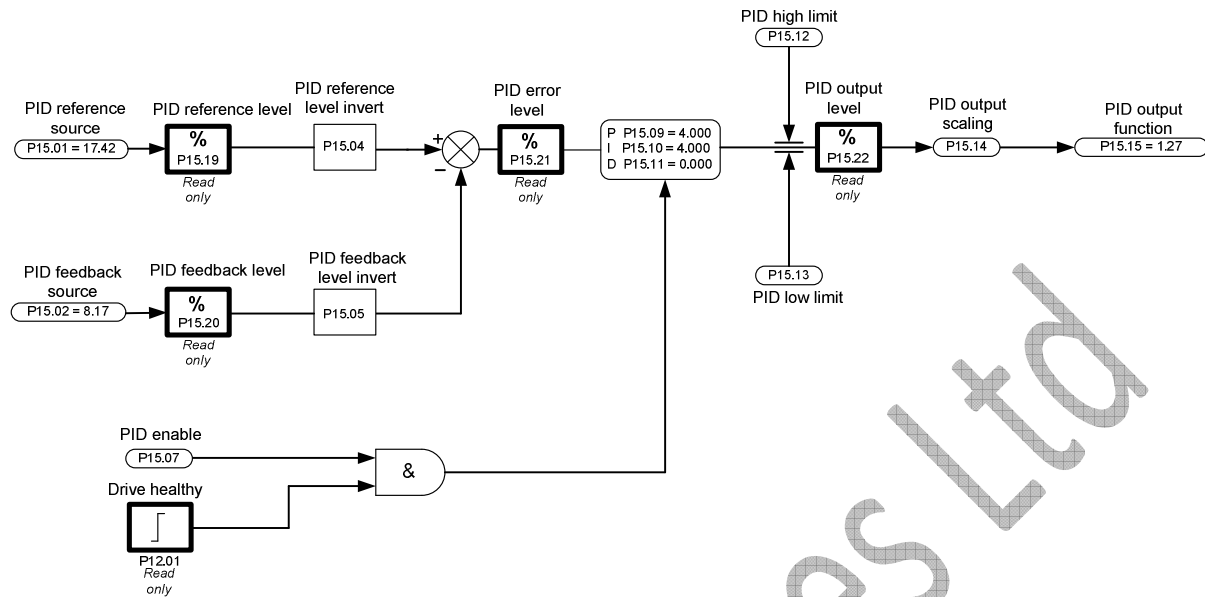
**Digital set-point**

P15.01 = 17.42 – User defined word variable as set-point

**NOTE:** P17.42 has a range of -300 to 300 which when programmed to P15.01 = 0 to 100% which can be read in P15.19.

Therefore, if P17.42 is set to 150, P15.19 = 50.0%

## PID diagram for above set-up



## Operation

Close the enable signal on DI 6 which will allow the drive to run when the Run signal is given on DI 1.

When the Run signal is given on terminal DI 1, the drive will enable and the motor will start to run and accelerate because the system feedback is high.

The acceleration ramp for the first 10s (time set by P16.06) will be set in P00.08 (acceleration ramp 1). This allows the initial acceleration ramp to be fairly slow.

After 10s, the drive will select P02.06 (acceleration ramp 2). The running acceleration and deceleration ramps can be fast to react to system changes. Also because the PID P gain, I gain and output scaling are set to maximum values, the PID output will react quickly.

As the motor accelerates the pressure in the system will start to increase so therefore the feedback will decrease. Therefore the motor will slow down.

The system will now regulate the pressure around -0.5 bar by speeding up and slowing down the vacuum pump as the pressure increases and decreases.

**NOTE:** If the system is required to work so that when the feedback is low, the speed is high and vice-versa, change parameters P15.04 and P15.05 = 0.