

# P01 Proportional, Integral and Derivative (PID) Executor User Manual

V1.0

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# **1 Overview**

Dynatrol DS-32 PID Executor Application resides in the DS-32 RTU can be used to provide Proportional, Integral and Derivative Control for industrial processes. Dynatrol DS-32 PID Executor Application consists of two pieces of software, namely PID Executor and PID GUI. PID Executor resides in the DS-32 RTU, which executes the PID control algorithm according to the PID configuration. PID GUI resides in the PC, which interfaces with the PID Executor for MMI functions.

## **1.1 PID Executor Features**

The following are the features of the Dynatrol DS-32 PID Executor Application:

- Direct or Reverse acting control: The direction of the PID output can be configured to response directly to the sign of the error or inversely to the sign of the error.
- Interactive or non-interactive PID equations: The tuning parameters of the PID can be independent of each other or the tuning parameters for the Integral and Derivative terms can be configured to depend on the tuning parameter of the Proportional term.
- Manual mode operation with bumpless transfer: The PID can be put to Manual mode. In Manual mode, the output of the PID can be set manually. When the PID is put to Auto mode, the Integral term is aligned with the output of the PID to produce the bumpless transfer operation. With this feature, the output of the PID does not produce a big step change when the PID is put to Auto mode operation.
- Output limiting with anti-reset windup: The output of the PID can be set with low and high limits other than 0% and 100% respectively. When the output limit is reached, the Integral term is aligned with the Output of the PID to prevent Integral Term saturation. With this feature, when the output of the PID reaches a limit for an extended period of time, the PID is still responsive with no time delay in the output if the control process changes.
- Feedforward output biasing: The output of the PID can be biased with a feedforward control term. Feedforward control can be easily employed with the PID control algorithm.
- Input scaling in engineering units: Input signals can be in engineering units for ease of presentation and fine tuning of the control.
- Deviation alarming: When the process variable deviates from the setpoint by a configurable range, deviation alarm is generated.
- Control deadbanding: For digital output PID controls, digital output pulses only when the process variable deviates from the setpoint by the configurable control deadbanding range. This prevents unnecessary oscillating outputs.
- Adjustable PID update rate: Depending on the applications, PID update rate can be adjusted for slower or faster control applications.
- Process Variable tracking or non-tracking in manual to automatic transition: The setpoint can be reset to be the same as the process variable on Manual to Auto

mode transition.

- Setpoint limiting: Setpoint can be limited by the predefined values in the configuration.
- Emergency shutdown with predefined output value for Analog Output type The PID is equipped with emergency shutdown feature for outputting the predefined output value. This feature is only available for analog output type of PID.
- Output types of Analog, Pulse Duration or Pulse Trains Output of the PID can be configured as analog output, pulse duration or pulse train types.
- Gain scheduling: The tuning parameters of the PID change according to the magnitude of the error. This feature enables faster control response with less overshoot.

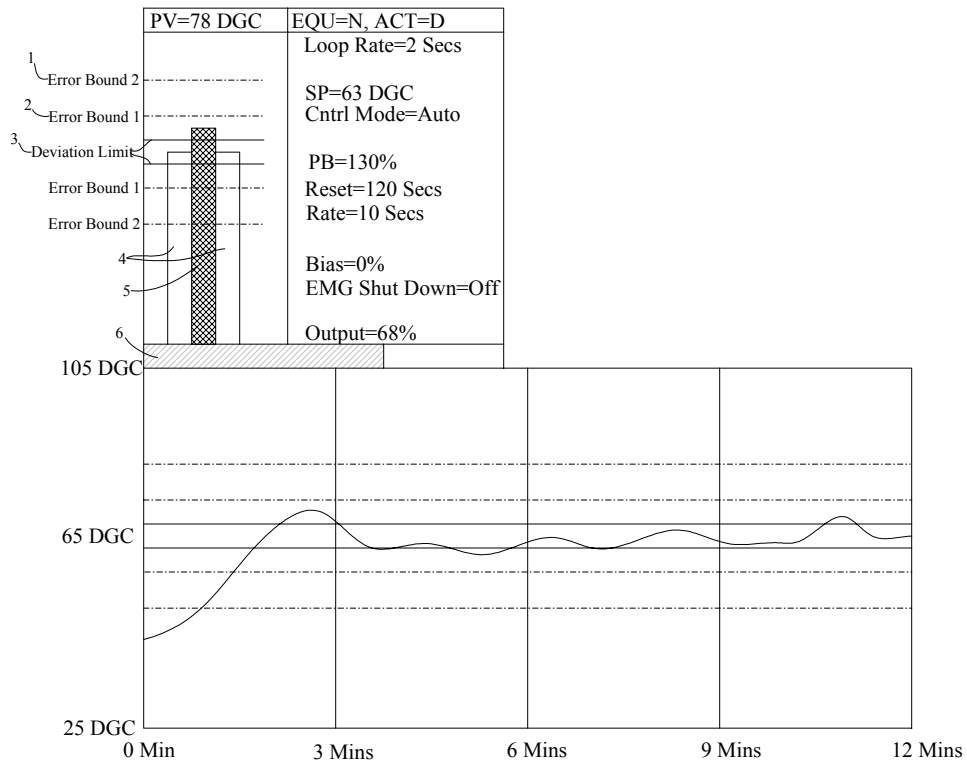
## **1.2 PID GUI Interface**

The PID GUI has not been implemented yet.

The PID GUI can be activated via DynaView special application menu or independently. The PID GUI communicates with the RTU via the Maintenance Port.

Upon activating the PID GUI, a selection of PIDs is available for the user to choose from. For examples, if there are 3 PIDs configured in the RTU, the user can select any one of the PIDs for display. The following is the PID display, which consists of PID faceplate and the trending:

## PID Faceplate and Trending



The information presented in the Faceplate can be categorized into 3 areas. They are informative area, tuning and control area and bar graph display area.

The informative area consists of 3 fields. They are as follows:

- PV is the process variable, in this case the PV is 78 degree C. DGC is the engineering units.
- EQU is the equation, in this case EQU is N for Non-interacting. It can be I for Interacting.
- ACT is the acting direction; in this case ACT is D for Direct acting. It can be R for reverse acting.

The tuning and control area consists of 9 fields. These fields are for information displays and also they can be changed. They are as follows:

- Loop Rate is the frequency the PID activates; in this case the loop rate is 2 secs.
- SP is the Setpoint; in this case the SP is 63 DGC.
- Cntrl Mode is the Control Mode; in this case the Control Mode is Auto. It can be Man for Manual. Only under manual mode the Output can be changed.
- PB is the Proportional Band in %; in this case the PB is 130%.
- RESET is the Reset term in Secs; in this case the Reset is 120 secs.

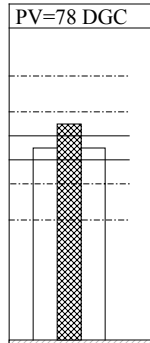
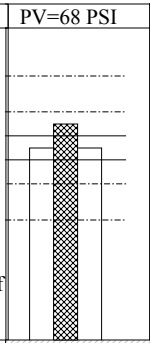
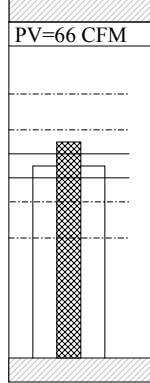
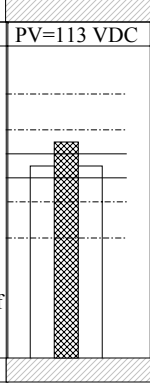
- RATE is the Rate term in Secs; in this case the Rate is 10 secs.
- Bias is the Bias of the output in %, in this case is 0%.
- EMG Shut Down is the Emergency Shut Down Mode; in this case it is Off.
- Output is the Output of the Controller, in this case it is 68%

The bar graph display area presents the information in Bar Graph format for ease of correlating the information. They are consists of 6 pieces of information as describe as follows:

- 1: Error Bound 2: These lines indicate the error bound 2 positions relative to the Setpoint. Beyond these 2 lines (one above the Set Point, one below the Set Point), the 3<sup>rd</sup> set of Gain parameters is used.
- 2: Error Bound 1: These lines indicate the error bound 1 positions relative to the Setpoint. Between the error bound 1 and 2, the 2<sup>nd</sup> set of Gain parameters is used. It should be noted that the area between the 2 error bound 1 lines, the 1<sup>st</sup> set of tuning parameters is used.
- 3: Deviation Limit: If the Process Variable is beyond these lines, the Deviation Alarm is detected.
- 4: Setpoint Bar Graph: The length of this bar graph is proportional to the Set Point value.
- 5: Process Variable Bar Graph: The length of this bar graph is proportional to the Process Variable value.
- 6: Control Output Bar Graph: The length of this bar graph is proportional to the Controller Output value.

The user can choose to display the PID faceplate only, in this way, several PID faceplates can be displayed on the same screen. Up to 4 PID faceplate can be displayed on the same screen as shown as follows:

**PID Faceplate Display**

|   |  |   |  |
|---|--|---|--|
|  | <p>PV=78 DGC EQU=N, ACT=D<br/>                     Loop Rate=2 Secs<br/>                     SP=73 DGC<br/>                     Cntrl Mode=Auto<br/>                     PB=130%<br/>                     Reset=120 Secs<br/>                     Rate=10 Secs<br/>                     Bias=0%<br/>                     EMG Shut Down=Off<br/>                     Output=68%</p> |  | <p>PV=68 PSI EQU=N, ACT=D<br/>                     Loop Rate=3 Secs<br/>                     SP=63 PSI<br/>                     Cntrl Mode=Auto<br/>                     PB=200%<br/>                     Reset=180 Secs<br/>                     Rate=20 Secs<br/>                     Bias=0%<br/>                     EMG Shut Down=Off<br/>                     Output=88%</p>   |
|  | <p>PV=66 CFM EQU=N, ACT=D<br/>                     Loop Rate=10 Secs<br/>                     SP=63 CFM<br/>                     Cntrl Mode=Auto<br/>                     PB=300%<br/>                     Reset=200 Secs<br/>                     Rate=0 Secs<br/>                     Bias=0%<br/>                     EMG Shut Down=Off<br/>                     Output=78%</p> |  | <p>PV=113 VDC EQU=N, ACT=D<br/>                     Loop Rate=30 Secs<br/>                     SP=115VDC<br/>                     Cntrl Mode=Auto<br/>                     PB=100%<br/>                     Reset=300 Secs<br/>                     Rate=30 Secs<br/>                     Bias=0%<br/>                     EMG Shut Down=Off<br/>                     Output=86%</p> |

**2 Functional Specification**

The Dynatrol DS-32 PID Executor Application resides in the DS-32 RTU can be use to provide Proportional, Integral and Derivative control for industrial processes. The formula implemented is as follow:

$$Output(N) = P(N) + I(N) + D(N) + B(N)$$

$P(N)$  = Proportional Term

$I(N)$  = Integral Term

$D(N)$  = Derivative Term

$B(N)$  = Bias Term

$N$  = at PID  $N^{th}$  update

For Interactive:

1. Proportional Term

$$P(N) = (100 / PB) \times E(N)$$

$PB$  = Proportional inverted gain: Proportional Band in %

For Direct acting:  $E(N) = SP(N) - PV(N)$

For Reverse acting:  $E(N) = PV(N) - SP(N)$

$SP$  = Setpoint in Engineering Units

$PV$  = Process Variable in Engineering Units

$N$  = at PID  $N^{th}$  update

## 2. Integral Term

$$I(N) = (100 / PB) \times (PIDRate / Re\ set) \times \sum_0^N E(n)$$

$PIDRate$  = PID update Rate in Seconds

$Re\ set$  = Integral inverted gain: Reset in seconds

$E(n)$  = Error at  $n^{th}$  PID update

## 3. Derivative Term

$$D(N) = (100 / PB) \times (Rate / PIDRate) \times [E(N) - E(N - 1)]$$

$Rate$  = Derivative gain: Rate in Seconds

## For Non-interactive:

### 1. Proportional Term

$$P(N) = (100 / PB) \times E(N)$$

### 2. Integral Term

$$I(N) = (PIDRate / Re\ set) \times \sum_0^N E(n)$$

### 3. Derivative Term

$$D(N) = (Rate / PIDRate) \times [E(N) - E(N - 1)]$$

The following describes the functions of the DS-32 PID Executor applications:

- The PID can be put to Manual mode either via the mapped DI point or the PID owned control point. The last action dictates the PID mode of operation. In Manual mode, the output of the PID can be set manually. When the PID is put back to Auto mode, the Integral term is aligned with the output of the PID to produce the bumpless transfer operation. With this feature, the output of the PID does not produce a big step change when the PID is put to Auto mode operation.
- Output limiting with anti-reset windup: The output of the PID can be set with low and high limits other than 0% and 100% respectively. When the output limit is reached, the Integral term is aligned with the Output of the PID to prevent Integral Term saturation. With this feature, when the output of the PID reaches a limit for an extended period of time, the PID is still responsive with no time delay in the output if the control process changes.
- Feedforward output biasing: The output of the PID can be biased with a

feedforward control term. Feedforward control can be easily employed with the PID control algorithm. The biasing term is a PID owned Analog Output point, therefore, other applications can provide the biasing. The other application can be some special applications that provide the feedforward calculations.

- Input scaling in engineering units: Input signals can be in engineering units for ease of presentation and fine tuning of the control.
- Deviation alarming: When the process variable deviates from the setpoint by a configurable range, deviation alarm is generated. The deviation alarm can be high or low deviation alarms.
- Control deadbanding: For digital output PID controls, digital output pulses only when the process variable deviates from the setpoint by the configurable control deadbanding range. This prevents unnecessary oscillating outputs.
- Adjustable PID update rate: Depending on the applications, PID update rate can be adjusted for slower or faster control applications.
- Process Variable tracking or non-tracking in manual to automatic transition: The setpoint can be reset to be the same as the process variable on Manual to Auto mode transition.
- Setpoint limiting: Setpoint can be limited by the predefined values in the configuration.
- The PID can be set for Emergency shutdown either via the mapped DI or a PID owned control point. The last action dictates the emergency mode of operation. The PID is equipped with emergency shutdown feature for outputting the predefined output value for Analog Output type. For Output types that are Digital outputs, the Emergency Shut will force the Digital Output to pulse for shut off limits. For Direct Acting Controller, the pulse will force the controlled device to 0%. For Reverse Acting Controller, the pulse will force the controlled device to 100%.

## **2.1 PID Output Types**

PID Output types can be configured as Analog Output, Pulse Duration or Pulse Trains Output.

- **ANALOG OUTPUT:**  
The PID is updated every PID update Rate. The PID output value is outputted to the Analog Output.
- **PULSE DURATION and PULSE TRAINS:**  
The Output can be configured as Pulse Duration, which is the Raise/Lower output type. The PID keeps track of the Output variable and output the difference with the corresponding Raise or Lower output to align the output device to the Output variable.

For example, if the Output variable is 80% and the last Output variable was 70%, the

difference is 10% in the Raise direction. If the device requires 200 seconds to travel from fully close to fully open, the PID pulses the Raise output for 20 seconds (10% of the total span for the device to travel from fully close to fully open).

The Output can be configured as Pulse Trans type, which consists of 2 Latch/Pulse Digital Output type. The first L/P control is for the Raise direction and the 2<sup>nd</sup> L/P is for the Lower direction. Similar to the Pulse Duration control, The PID keeps track of the Output variable and output the difference with the corresponding Raise or Lower output to align the output device to the Output variable.

For example, if the Output variable is 68% and the last Output variable was 88%, the difference is 20% in the Lower direction. If the device requires 200 pulses to travel from fully close to fully open, the PID pulses the 2<sup>nd</sup> L/P Digital Output for 40 pulses (20% of the total span for the device to travel from fully close to fully open).

The Output of the Pulse Duration or Pulse Trains may extended beyond the next PID update time, therefore for these types of outputs, the PID waits for the completion of the controls and one PID update rate period for the Process to settle before next update.

For PID with actual output position Analog Input, the PID uses this input as the initial internal PID output position. It is recommended that always configures the span of the control beyond the actual span, i.e. the 0% to 100% of the PID output is beyond the actual controlled variable span. If output low or high limit is reached, the PID Executor will cancel the on going controls and realign the Integral Term to prevent the Reset windup. The actual output position Analog Input is the actual position measurement of the device the PID is controlling. For example, if the device the PID is controlling is a valve, the actual output position Analog Input is the measurement of the actual opening position of the valve. The low and high limits are switches mounted on the device to indicate to the PID that the limits are reached or not. For the same example, the low limit switch likely is mounted on the valve closing position. As soon as the valve is fully closed, the low limit switch is activated. The high limit switch likely is mounted on the valve opening position. As soon as the valve is fully open, the high limit switch is activated.

To prevent the Reset term from saturation, for PID with output low and high limit Digital Input switches, if output low or high limit is reached, the PID Executor will cancel the on going controls and realign the Integral Term to prevent the Reset windup.

For PID without actual output position Analog Input, and output low and high limit Digital Input switches, the PID Executor uses the Process Variable as the initial internal PID output, the PID Executor controls the outputs even when the limits are reached. However, the PID Executor always realigns the Integral Term to prevent Reset windup when limit is reached. That is for this type of setup the PID Executor relies on the external end switches to stop the control from controlling beyond the

limits.

If no actual output position is available, using process variable as the initial internal PID output is in attempt to provide some reasonable initial position for the controller. It is in no way perfect. It simply assumed that Process Variable is directly proportional to Controlled Variable.

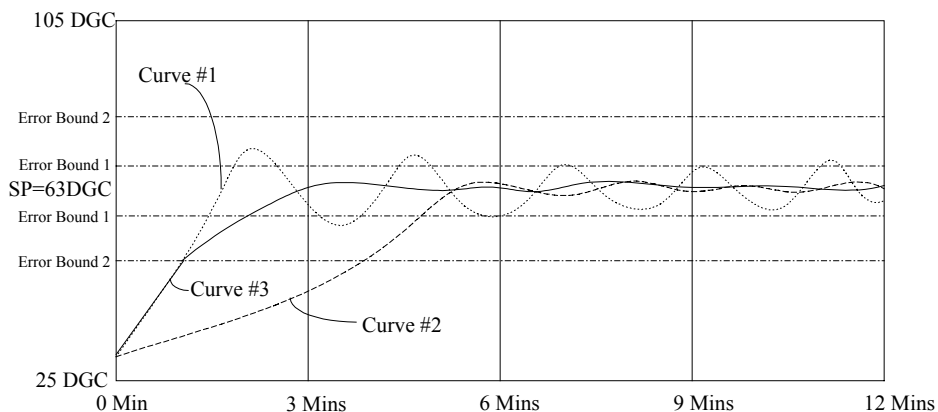
For Pulse Output types of control, the controller Output is only for reference between each update, it is not true indication of the position of the controlled variable.

Using process variable as the initial internal PID output should take into account of direct or reverse acting controls. For Direct acting, the initial internal PID output position is directly proportional to the Process Variable, for reverse acting, the initial internal PID output is inversely proportional to the Process Variable.

## 2.2 PID Gain Scheduling

The tuning parameters of the PID can be changed according to the magnitude of the error. This feature is called Gain scheduling, which enables faster control response with less over shoot. The following diagram illustrates the difference between PID without Gain Scheduling feature and the PID with Gain Scheduling feature:

### PID Gain Scheduling



The Curve #1 is without Gain Scheduling, which corresponds to PID Executor with high gains. It approaches the setpoint very fast, but it oscillates. The Curve #2 is also without Gain Scheduling, which corresponds to PID Executor with low gains. It approaches the setpoint very slowly. It does not oscillates but lack of response to process variable changes. Both controllers are undesirable for practical applications. One is responsive but it oscillates, the other is stable but slow in response. It is preferred to approach the setpoint very rapidly when the Process Variable is far away from the Setpoint and slower response when it is closer to the Setpoint for stability. The Curve #3 is with Gain Scheduling. When it is outside the Error Bound #2, the

Gains are fast. When it is between Error Bound #2 and #1, the Gains are slower. When it is within the Error Bound #1, Gains are slowest. With the Gain Scheduling feature, the PID can provide fast response and stability at the same time.

If gain scheduling is enabled, the PID uses all 3 sets of gains according to the magnitude of the error. Therefore tuning in the PID faceplate display in the PID GUI is disallowed. If user wants to tune the control loop, the PID gain scheduling should be disabled first. After tuning, the user should reconfigure all 3 sets of gains according to the experiments performed in tuning exercise and enable the gain scheduling. If gain scheduling is disabled, the first set of the gains is used.

### **3 PID Configuration**

PID Configuration is part of DynaConfig Configuration. There are 8 tables for the PID Configuration.

#### **3.1 RIA Table**

The RIA Table is P01\_RIA. The parameters in this table determine the corresponding number of owned points of the PID Executor task. It should be noted, all the input points are indication points (DI, AI) for external applications. All the control points (LP, AO) can be used by external application to influence or control the PID Executor. There is only one record in this table. This Table is read only. For every PID Executor configured, there are 5 DI, 1 AI, 2 LP and 13 AO.

The following describes each parameter:

1. NumDI: Data Type is unsigned integer. This parameter is the number of owned DIs for this application. The number is always 5 per PID loop. These points indicate the status of the PID Executor. The following is the indication of each DI:
  - 1<sup>st</sup> Point: Automatic/Manual Indication: 0=Automatic, 1=Manual.
  - 2<sup>nd</sup> Point: Emergency Shut Down Indication: 0=Normal Operation, 1=Shut Down.
  - 3<sup>rd</sup> Point: Output High Limit Reached Indication: 0=Normal, 1=High Limit Alarm.
  - 4<sup>th</sup> Point: Output Low Limit Reached Indication: 0=Normal, 1=Low Limit Alarm.
  - 5<sup>th</sup> Point: Deviation Alarm: 0=Normal, 1=Deviation Alarm.
2. NumACC: Data Type is unsigned integer. This parameter is the number of owned Accumulators for this application. The number is always zero.
3. NumBCD: Data Type is unsigned integer. This parameter is the number of owned BCDs for this application. The number is always zero.
4. NumLP: Data Type is unsigned integer. This parameter is the number of owned LPs for this application. The number is always 2 per PID loop. These points are used by other application to influence the operation of the PID. The following is the function of each LP:
  - 1<sup>st</sup> Point: Automatic/Manual Control: 0=Automatic, 1=Manual.

- 2<sup>nd</sup> Point: Emergency Shut Down Control: 0=Normal Operation, 1=Emergency Shut Down.
5. NumRL: Data Type is unsigned integer. This parameter is the number of owned RL s for this application. The number is always zero.
  6. NumPAT: Data Type is unsigned integer. This parameter is the number of owned PATs for this application. The number is always zero.
  7. NumDPS: Data Type is unsigned integer. This parameter is the number of owned DPSs for this application. The number is always zero.
  8. NumTC: Data Type is unsigned integer. This parameter is the number of owned TCs for this application. The number is always zero.  
NumAI: Data Type is unsigned integer. This parameter is the number of owned AIs for this application. The number is always 1 per PID loop. This point indicates the Output value of the PID Executor.
  9. NumAO: Data Type is unsigned integer. This parameter is the number of owned AOs for this application. The number is always 13 per PID loop. These points are used by other application to influence the operation of the PID. The following is the function of each AO:
    - 1<sup>st</sup> Point: PID Update Rate: every count represents 0.01 Second.
    - 2<sup>nd</sup> Point: Setpoint Change in EGU: in Decimal-2 Format. Decimal-2 Format means that every count represents a decimal value of 0.01.
    - 3<sup>rd</sup> Point: Gain set 1: Proportional Band Change in 0.01%: in Decimal-2 Format.
    - 2<sup>nd</sup> Point: Setpoint Change in EGU: in Decimal-2 Format. Decimal-2 Format means that every count represents a decimal value of 0.01.
    - 4<sup>th</sup> Point: Gain set 1: Reset Change in 0.01 Second: in Decimal-2 Format.
    - 5<sup>th</sup> Point: Gain set 1: Rate Change in 0.01 Second: in Decimal-2 Format.
    - 6<sup>th</sup> Point: Gain set 2: Proportional Band Change in 0.01%: in Decimal-2 Format.
    - 7<sup>th</sup> Point: Gain set 2: Reset Change in 0.01 Second: in Decimal-2 Format.
    - 8<sup>th</sup> Point: Gain set 2: Rate Change in 0.01 Second: in Decimal-2 Format.
    - 9<sup>th</sup> Point: Gain set 3: Proportional Band Change in 0.01%: in Decimal-2 Format.
    - 10<sup>th</sup> Point: Gain set 3: Reset Change in 0.01 Second: in Decimal-2 Format.
    - 11<sup>th</sup> Point: Gain set 3: Rate Change in 0.01 Second: in Decimal-2 Format.
    - 12<sup>th</sup> Point: Output Bias Change in 0.01%: in Decimal-2 Format.
    - 13<sup>th</sup> Point: PID Output Manual Control in 0.01%: in Decimal-2 Format.
  10. NumDEV: Data Type is unsigned integer. This parameter is the number of owned DEVs for this application. The number is always zero.

## **3.2 VRU Table**

The VRU Table is P01\_VRU. The parameters in this table determine the VRU ownership of the mapped points. For this application, there is only one VRU. That is there is only one record in this table.

The following describes each parameter:

1. NumDI: Data Type is unsigned integer. This parameter is the number of system DIs used for this application. The number is always 4 per PID loop. These points are External DI control points or external indication points for the PID Executor. The following is the control function or indication status of each DI:
  - 1<sup>st</sup> Point: Automatic/Manual Input: 0=Automatic, 1=Manual.
  - 2<sup>nd</sup> Point: Emergency Shut Down: 0=Normal Operation, 1=Emergency Shut Down.
  - 3<sup>rd</sup> Point: High Limit Switch Input: 0=Normal, 1=High Limit On.
  - 4<sup>th</sup> Point: High Limit Switch Input: 0=Normal, 1=High Limit On.
2. pDI: Pointer to the DI Mapping table.
3. NumACC: Data Type is unsigned integer. This parameter is the number of system ACCs used for this application. The number is always zero.
4. pACC: Pointer to the ACC Mapping table.
5. NumBCD: Data Type is unsigned integer. This parameter is the number of system BCDs used for this application. The number is always zero.
6. pBCD: Pointer to the BCD Mapping table.
7. NumLP: Data Type is unsigned integer. This parameter is the number of system LPs used for this application. The number is always 2 per PID loop. These points are used by the PID Executor to control the external device. The following is the function of each LP:
  - 1<sup>st</sup> Point: Raise Control Point for Pulse Train.
  - 2<sup>nd</sup> Point: Lower Control Point for Pulse Train.
8. pLP: Pointer to the LP Mapping table.
9. NumRL: Data Type is unsigned integer. This parameter is the number of system RLs used for this application. The number is always 1 per PID loop. This Raise/Lower Control is used by the PID Executor to control the external device for Pulse Duration control.
10. pRL: Pointer to the RL Mapping table.
11. NumPAT: Data Type is unsigned integer. This parameter is the number of system PATs used for this application. The number is always zero.
12. pPAT: Pointer to the PAT Mapping table.
13. NumDPS: Data Type is unsigned integer. This parameter is the number of system DPSs used for this application. The number is always zero.
14. pDPS: Pointer to the DPS Mapping table.
15. NumTC: Data Type is unsigned integer. This parameter is the number of system TCs used for this application. The number is always zero.
16. pTC: Pointer to the TC Mapping table.
17. NumAI: Data Type is unsigned integer. This parameter is the number of system AIs used for this application. The number is always 2 per PID loop. These points are External AI points for the PID Executor. The following is the function of each AI:
  - 1<sup>st</sup> Point: Process Variable.
  - 2<sup>nd</sup> Point: Actual Output Position.
18. pAI: Pointer to the AI Mapping table.

19. NumAO: Data Type is unsigned integer. This parameter is the number of system AOs used for this application. The number is always 1 per PID loop. This point is the Controlled Variable for Analog Output Type.
20. pAO: Pointer to the AO Mapping table.

### **3.3 Digital Input Mapping Table**

The Digital Input Mapping Table is P01\_DI. The parameters in this table determine which DI system points are used in this application. These points that belong to other RIA applications are input points to the PID executor. The number of records is the number of system DI points used in this application. The number is always 4 per PID loop.

The following describes each parameter:

1. RIAIndex: Data Type is unsigned integer. This is the RIA application Index. This index determines which RIA application the point belongs to.
2. DIPoint: Data Type is unsigned integer. This is the DI point index of the RIA.

### **3.4 Latch/Pulse Mapping Table**

The Latch/Pulse Mapping Table is P01\_LP. The parameters in this table determine which LP system points are used in this application. It should be noted, the points that belong to other RIA applications are output points of the PID Executor. The number of records is the number of system LP points used in this application. The number is always 2 per PID loop.

The following describes each parameter:

1. RIAIndex: Data Type is unsigned integer. This is the RIA application Index. This index determines which RIA application the point belongs to.
2. LPPoint: Data Type is unsigned integer. This is the LP point index of the RIA.

### **3.5 Raise/Lower Mapping Table**

The Raise/Lower Mapping Table is P01\_RL. The parameters in this table determine which RL system points are used in this application. It should be noted, the points that belong to other RIA applications are output points of the PID Executor. The number of records is the number of system RL points used in this application. The number is always 1 per PID loop.

The following describes each parameter:

1. RIAIndex: Data Type is unsigned integer. This is the RIA application Index. This index determines which RIA application the point belongs to.
2. RLPoint: Data Type is unsigned integer. This is the RL point index of the RIA.

### **3.6 Analog Input Mapping Table**

The Analog Input Mapping Table is P01\_AI. The parameters in this table determine which AI system points are used in this application. It should be noted, the points that belong to other RIA applications are input points to the PID Executor. The number of records is the number of system AI points used in this application. The number is always 2 per PID loop.

The following describes each parameter:

1. RIAIndex: Data Type is unsigned integer. This is the RIA application Index. This index determines which RIA application the point belongs to.
2. AIPoint: Data Type is unsigned integer. This is the AI point index of the RIA.

### **3.7 Analog Output Mapping Table**

The Analog Output Mapping Table is P01\_AO. The parameters in this table determine which AO system points are used in this application. It should be noted, the points that belong to other RIA applications are output points of the PID Executor. The number of records is the number of system AO points used in this application. The number is always 2 per PID loop.

The following describes each parameter:

1. RIAIndex: Data Type is unsigned integer. This is the RIA application Index. This index determines which RIA application the point belongs to.
2. AOPoint: Data Type is unsigned integer. This is the AO point index of the RIA.

### **3.8 Configuration Table**

The CFG Table is P01\_CFG. The parameters in this table control the operation characteristics of PID. The user can edit this table.

The following describes each parameter:

1. DirRev: Data Type is unsigned char. This parameter determines the direction of the control: 0=Direct Acting, 1=Reverse Acting.
2. Interactive: Data Type is unsigned char. This parameter determines the type of equation: 0=Non-interactive Equation, 1=Interactive Equation.
3. SP\_EGU\_Full: Data Type is a long. This parameter is Setpoint Full Scale Engineering Unit in Decimal-2 format. . Decimal-2 Format means that every count represents a decimal value of 0.01. Valid range is -21474836 to 21474736. This parameter corresponds to the Engineering Unit at full scale of the input. In this case, the value of AI full scale of 32767 corresponds to the setting of this parameter.
4. SP\_EGU\_Zero: Data Type is a long. This parameter is Setpoint Zero Scale Engineering Unit in Decimal-2 format. Valid range is -21474836 to 21474736. This

parameter corresponds to the Engineering Unit at zero scale of the input. In this case, the value of AI zero scale of 0 corresponds to the setting of this parameter.

5. EGU: Data Type is a 4-byte Engineering Unit. Valid entry is a 4-byte ASCII String.
6. SP: Data Type is a long. This parameter is the initial Setpoint in EGU and Decimal-2 format. Valid range is -21474836 to 21474736.
7. SP\_High: Data Type is a long. This parameter is the High Limit for Setpoint in EGU and Decimal-2 format. Valid range is -21474836 to 21474736. This parameter limits the highest Setpoint value one can set.
8. SP\_Low: Data Type is a long. This parameter is the Low Limit for Setpoint in EGU and Decimal-2 format. Valid range is -21474836 to 21474736. This parameter limits the lowest Setpoint value one can set.
9. Deviation: Data Type is a long. This parameter is the Deviation Alarm in EGU and Decimal-2 format. Valid range is -21474836 to 21474736. Under Automatic control, if the Process Variable deviates from the Setpoint more than this value, deviation alarm is generated.
10. Deadband: Data Type is a long. This parameter is the Control Deadband in EGU and Decimal-2 format. Valid range is -21474836 to 21474736. For Digital Output controls, PID only issues the control if the Process Variable deviates from the Setpoint more than this value.
11. UpdateRate: Data Type is a long. This parameter is PID Update Rate in 0.01 Second and Decimal-2 format. Valid range is -21474836 to 21474736. For example, a value of 3 represents 0.03 Second.
12. EmergencyOut: Data Type is a long. This parameter is Emergency shut down Output for Analog Output Type in % and Decimal-2 format. Valid range is 0 to 10000.
13. ProcessTracking: Data Type is unsigned char. This parameter determines the variable tracking is enabled or not. If the tracking is enabled, when the PID is put to Automatic Control, the Process Variable is copied to the Setpoint: 0=Process Variable Tracking Disable, 1=Enable.
14. GainScheduling: Data Type is unsigned char. This parameter determines the Gain Scheduling is enabled or not: 0=Disable, 1=Enable.
15. ErrorBound1: Data Type is a long. This parameter determines the Error Bound 1 in EGU and Decimal-2 format for Gain Scheduling. Valid range is -21474836 to 21474736.
16. ErrorBound2: Data Type is a long. This parameter determines the Error Bound 2 in EGU and Decimal-2 format for Gain Scheduling. Valid range is -21474836 to 21474736.
17. PB1: Data Type is a long. This parameter is the Proportional Band 1 in % and Decimal-2 format. Valid range is -21474836 to 21474736.
18. Reset1: Data Type is a long. This parameter is the Reset 1 in Second and Decimal-2 format. Valid range is -21474836 to 21474736.
19. Rate1: Data Type is a long. This parameter is the Rate 1 in Second and Decimal-2 format. Valid range is -21474836 to 21474736.
20. PB2: Data Type is a long. This parameter is the Proportional Band 2 in % and Decimal-2 format. Valid range is -21474836 to 21474736.
21. Reset2: Data Type is a long. This parameter is the Reset 2 in Second and Decimal-2 format. Valid range is -21474836 to 21474736.

22. Rate2: Data Type is a long. This parameter is the Rate 2 in Second and Decimal-2 format. Valid range is -21474836 to 21474736.
23. PB3: Data Type is a long. This parameter is the Proportional Band 3 in % and Decimal-2 format. Valid range is -21474836 to 21474736.
24. Reset3: Data Type is a long. This parameter is the Reset 3 in Second and Decimal-2 format. Valid range is -21474836 to 21474736.
25. Rate3: Data Type is a long. This parameter is the Rate 3 in Second and Decimal-2 format. Valid range is -21474836 to 21474736.
26. OutHigh: Data Type is a long. This parameter determines the High Limit of the PID Output in % and Decimal-2 format. Valid range is 0 to 10000.
27. OutLow: Data Type is a long. This parameter determines the Low Limit of the PID Output in % and Decimal-2 format. Valid range is 0 to 10000.
28. OutputType: Data Type is unsigned char. This parameter determines PID output type: 0=Pulse Duration, 1=Pulse Train, 2=Analog.
29. OutBias: Data Type is long. This parameter determines initial Output Bias in % and Decimal-2 format. Valid range is 0 to 10000.
30. MinOut: Data Type is long. This parameter determines Minimum PID output in % and Decimal-2 format. Valid range is 0 to 10000.
31. MaxOut: Data Type is long. This parameter determines Maximum PID output in % and Decimal-2 format. Valid range is 0 to 10000.
32. MaxPulseDuration: Data Type is unsigned long. This parameter determines Maximum Pulse Duration for Pulse Duration Output type in Millisecond. This value is the time for the output to travel from 0% to 100%. Valid range is 0 to 4294967295.
33. ONPulse: Data Type is unsigned long. This parameter determines Pulse ON for Pulse Train Output type in Millisecond. Valid range is 0 to 4294967295.
34. MultiPulseON: Data Type is unsigned int. This parameter determines Pulse OFF for Pulse Train Output type in terms of Multiple of the ON time. Valid range is 0 to 65535.
35. MaxPulseCnts: Data Type is unsigned int. This parameter determines Maximum number of Pulses for Pulse Train Output. This value is the number of pulses for the output to travel from 0% to 100%. Valid range is 0 to 65535.
36. InitialAutoMan: Data Type is unsigned char. This parameter determines the initial Automatic or Manual mode of the PID: 0=Auto, 1=Man.
37. InitialEmergency: Data Type is unsigned char. This parameter determines the initial Emergency Shut Down Mode: 0=Normal Operation, 1=Shut Down.