Universal Serial Bus

Physical Interface Device Class
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Revision History

<table>
<thead>
<tr>
<th>Revision</th>
<th>Issue Date</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>August 25, 1998</td>
<td>Added Start Delay usage. Dropped all specific references to units in Usage definitions. And added a recommendation to check Units, Unit Exponent, Physical Minimum and Maximum to determine units. Added Device Operation Report and Device Gain usages.</td>
</tr>
<tr>
<td>0.8b</td>
<td>March 31, 1998</td>
<td>Fixed Usage ID assignment problem</td>
</tr>
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<td>October 24, 1997</td>
<td>Updated with input from 8.0</td>
</tr>
<tr>
<td>0.8</td>
<td>July 24, 1997</td>
<td>Initial Draft</td>
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USB PID Class
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1. Introduction

1.1 Scope

This Document describes the USB Physical Interface Device or PID Class. The PID Class is intended as an extension of the Human Interface Device (HID) Class for devices that require “real-time” physical feedback. The main focus for the definition is for the use of haptic devices and the implementation of force feedback systems. However there is no requirement that members of this class generate this type of effect. Examples of devices that are member of this class are force feedback joysticks, motion platforms, and force feedback exoskeletons.

1.2 Purpose

This document is intended to supplement to the USB specification and provide manufacturers of PID class devices with the information necessary to build USB compatible devices. Further, this specification specifies how the PID class driver should extract data from USB data streams. Since this device class is an extension of the HID class, the HID class specifications will be required to implement the device functionality.

1.3 Related Documents

Universal Serial Bus Specification
Device Class Definition for Human Interface Devices (HID)
Universal Serial Bus HID Usage Tables

1.4 Definitions

Set PB Report

This term is used to refer to any of the Set-Report commands. Where Set-Reports represents one of the following report types: Set Effect Report, Set Custom Force Report, Set Periodic Report, Set Constant Force Report, Set Ramp Force Report, Set Vendor Report, Set Envelope Report, and Set Condition Report.

INFINITE

Referrers to the maximum value of a range. i.e. if in an 8 bit unsigned field the value of 255 would indicate INFINITE.

Normalized

When a usage is declared as a Normalized value, then the device assumes that a range of values between %0 and %100 can be applied by the device where the actual applied value is a percentage p, where 

\[ p = \frac{\text{Usage Value}}{\text{Logical Maximum} - \text{Logical Minimum}} \times 100. \]
2. Functional Overview
The Functional connection model for the PID class is below.

![Diagram showing the functional connection model for the PID class.](image)

The data transfer mechanism for the PID class is based on the HID class Report Descriptors. Communication with a PID device is identical to that of a HID device.

<table>
<thead>
<tr>
<th>Report Type</th>
<th>Transfer for a GET_REPORT</th>
<th>Transfer for a SETREPORT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>HID Interrupt In pipe</td>
<td>Control pipe</td>
</tr>
<tr>
<td>Output</td>
<td>Control pipe</td>
<td>HID Interrupt Out pipe</td>
</tr>
<tr>
<td>Feature</td>
<td>Control pipe</td>
<td>Control pipe</td>
</tr>
</tbody>
</table>
3. Configurations

3.1 Configuration and Interface Structure

The PID class has a standard configuration and interface structure defined. The interface structure is designed to be an extension of the HID interface that will allow for the needed low latency output requirement. The first pipe is the default control pipe required for all devices. The second pipe in the interface is an interrupt IN pipe that will process reports as described by the HID specification. The third pipe is an interrupt OUT pipe. The intent of this pipe is to handle all output reports that are sent to the device. This will allow commands to be sent to the device with minimum latency.

3.1.1 Configuration

3.1.2 Interface Definition

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Type</th>
<th>Description</th>
<th>Required?</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>ctrl</td>
<td>USB control &amp; class SET/GET commands</td>
<td>Y</td>
</tr>
<tr>
<td>a</td>
<td>interrupt in</td>
<td>HID data in from device</td>
<td>Y</td>
</tr>
<tr>
<td>b</td>
<td>interrupt out</td>
<td>PID command out to the device</td>
<td>N</td>
</tr>
</tbody>
</table>
4. Conventions

4.1 Actuators

An Actuator is a mechanism that can exert a force against an object. Typically the force applied by the actuator can defined in some combination of 6 dimensions; X, Y, Z, Rx, Ry and Rz. By definition in the HID specification these dimensions are defined in a coordinate system that is referenced to the direction that the user is facing. For simplicity the usages X, Y, Z, Rx, Ry and Rz from the Generic Desktop page are used by PID class devices to define a NORMALIZED force values. i.e. if the Logical Minimum and Logical Maximum values for an axis are defined to be -100 and +100 respectively, then -100 represents maximum force in the negative direction, 0 no force, and +100 maximum force in the positive direction. If a device requires the assertion of precise absolute force then the Vectors Vx, Vy, Vz, Vbrx, Vbry and Vbrz can be used from the Generic Desktop usage table with Units declaring the actual range of applied force.

In some cases the application of force does not have an easily identifiable set of dimensions that can be applied. An example is the force applied by a pressure suit in a flight simulator. In this document this type of “dimensionless” force will be referred to as a Normal force. For simplicity the PID:Normal usage is used to define a Normalized force that can vary between 0 and the maximum force that a device can assert. If the assertion of precise absolute force is required by a device then the vector Vno can be used from the Generic Desktop usage table with Units declaring the actual range of applied force.

Table 1: Actuator Usages

<table>
<thead>
<tr>
<th>Actuator Type</th>
<th>Normalized Usages</th>
<th>Absolute Usages</th>
<th>Orientation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensionless</td>
<td>PID: Normal</td>
<td>Vno</td>
<td>Perpendicular to the surface of an object.</td>
</tr>
<tr>
<td>Translation</td>
<td>Generic Desktop: X</td>
<td>Vx</td>
<td>Force in linear X direction</td>
</tr>
<tr>
<td>Translation</td>
<td>Generic Desktop: Y</td>
<td>Vy</td>
<td>Force in linear Y direction</td>
</tr>
<tr>
<td>Translation</td>
<td>Generic Desktop: Z</td>
<td>Vx</td>
<td>Force in linear Z direction</td>
</tr>
<tr>
<td>Rotation</td>
<td>Generic Desktop: Rx</td>
<td>Vbrx</td>
<td>Torque about X</td>
</tr>
<tr>
<td>Rotation</td>
<td>Generic Desktop: Ry</td>
<td>Vbry</td>
<td>Torque about Y</td>
</tr>
<tr>
<td>Rotation</td>
<td>Generic Desktop: Rz</td>
<td>Vbrz</td>
<td>Torque about Z</td>
</tr>
</tbody>
</table>

4.2 Joints

A Joint is a collection of actuators. PID devices can control multiple joints where each joint can have multiple degrees of freedom (axes). This document refers to Joint Collections, which are physical collections wrapped around fields (Main Items), associated with a joint, thus tying the axes together. The usage applied to a Joint collection identifies it in a report. i.e. in a joystick the input axes are contained in a physical collection with the Pointer usage attached. The matching output in a force feedback joystick is found in the Joint (physical) collection that has a Pointer usage attached to it. Vendor Defined or Ordinal usages can be applied to Joints when more appropriate usages cannot be found. When describing exoskeletons, ordinal usages are attached to the joint physical collections and the Physical Descriptor attached to the joint physical collection can be used to further qualify the specific joint.

4.3 Low Speed Devices

Because the use of the interrupt out pipe type is limited to high-speed devices, all PID class devices must be high-speed devices.
4.4 Units

Usages state specifically whether Units are required to define a time base or other reference. A Units requirement implies the definition of Units, Physical Maximum, Physical Minimum and Unit Exponent items.

Remember that Units are global items that persist from main item to main item. Units can be disabled by setting Units to “None”, and Physical Maximum, Physical Minimum and Unit Exponent equal to 0. Applications will typically ignore Units when it encounters a Usage that they are not appropriate for, but don’t count on it. Always make sure that the Units are correctly declared for every Usage.

Normalized Usages use Logical Minimum and Logical Maximum to define their range of values. These values are automatically scaled by an application to fit the range of values required for the target operation and do not require Units.
5. Physical Input Device Page (0x0F)

Force feedback devices use PID usages to describe their output and Usages from other Usage Pages to describe their input.

A Physical Input Device can use one of two methods to generate sensations to the user: Effects or Custom Effects. A device may support either or both methods. Effects generate force feedback based on the parameters stored in a variety of parameter blocks (structures) that are maintained in the device. The host loads the parameter blocks, then issues a Start Effect Command over an Interrupt Out pipe. Custom Effects are similar to playing an audio file, force information for each axis can be downloaded and “played” locally or sent to the device over an Isochronous Output pipe.

Effects are comprised of parameter blocks. There are 6 types of parameter blocks defined: Effect, Envelope, Condition, Periodic, Constant Force and Ramp Force. All Effects require an Effect Parameter Block. Depending on the effect one or more additional parameter blocks will be required. Parameter blocks are accessed by an handle. The size of a parameter block for a particular device is a function of the size of the associated report.

A default allocation of each type of parameter block is provided by the device, however the host driver can modify the resource allocation to best meet its needs.

<table>
<thead>
<tr>
<th>Usage ID</th>
<th>Usage Name</th>
<th>Usage ID</th>
<th>Usage Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Undefined</td>
<td>71</td>
<td>Phase</td>
</tr>
<tr>
<td>01</td>
<td>Physical Interface</td>
<td>72</td>
<td>Period</td>
</tr>
<tr>
<td>02-0F</td>
<td>Reserved</td>
<td>73</td>
<td>Set Constant Force</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Report</td>
</tr>
<tr>
<td>20</td>
<td>Normal</td>
<td>74</td>
<td>Set Ramp Force</td>
</tr>
<tr>
<td>21</td>
<td>Set Effect Report</td>
<td>75</td>
<td>Ramp Start</td>
</tr>
<tr>
<td>22</td>
<td>Effect Block Index</td>
<td>76</td>
<td>Ramp End</td>
</tr>
<tr>
<td>23</td>
<td>Parameter Block Off</td>
<td>77</td>
<td>Effect Operation</td>
</tr>
<tr>
<td>24</td>
<td>ROM Flag</td>
<td>78</td>
<td>Operation</td>
</tr>
<tr>
<td>25</td>
<td>Effect Type</td>
<td>79</td>
<td>Op Effect Start</td>
</tr>
<tr>
<td>26</td>
<td>ET Constant Force</td>
<td>7A</td>
<td>Op Effect Start Solo</td>
</tr>
<tr>
<td>27</td>
<td>ET Ramp</td>
<td>7B</td>
<td>Op Effect Stop</td>
</tr>
<tr>
<td>28</td>
<td>ET Custom Force Data</td>
<td>7C</td>
<td>Loop Count</td>
</tr>
<tr>
<td>29-0F</td>
<td>Reserved</td>
<td>7D</td>
<td>Device Operation</td>
</tr>
<tr>
<td>30</td>
<td>ET Square</td>
<td>7E</td>
<td>Device Gain</td>
</tr>
<tr>
<td>31</td>
<td>ET Sine</td>
<td>7F</td>
<td>PID Pool Report</td>
</tr>
<tr>
<td>32</td>
<td>ET Triangle</td>
<td>80</td>
<td>RAM Pool Size</td>
</tr>
<tr>
<td>33</td>
<td>ET Sawtooth Up</td>
<td>81</td>
<td>ROM Pool Size</td>
</tr>
<tr>
<td>34</td>
<td>ET Sawtooth Down</td>
<td>82</td>
<td>ROM Effect Block Count</td>
</tr>
<tr>
<td>35-0F</td>
<td>Reserved</td>
<td>83</td>
<td>Simultaneous Effects Max</td>
</tr>
<tr>
<td>40</td>
<td>ET Spring</td>
<td>84</td>
<td>Pool Alignment</td>
</tr>
<tr>
<td>41</td>
<td>ET Damper</td>
<td>85</td>
<td>PID Pool Move Report</td>
</tr>
<tr>
<td>42</td>
<td>ET Inertia</td>
<td>86</td>
<td>Move Source</td>
</tr>
<tr>
<td>Usage ID</td>
<td>Usage Name</td>
<td>Usage ID</td>
<td>Usage Name</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------</td>
<td>---------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>43</td>
<td>ET Friction</td>
<td>87</td>
<td>Move Destination</td>
</tr>
<tr>
<td>44-4F</td>
<td>Reserved</td>
<td>88</td>
<td>Move Length</td>
</tr>
<tr>
<td>50</td>
<td>Duration</td>
<td>89</td>
<td><strong>PID Block Load Report</strong></td>
</tr>
<tr>
<td>51</td>
<td>Sample Period</td>
<td>8A</td>
<td>Handshake Key</td>
</tr>
<tr>
<td>52</td>
<td>Gain</td>
<td>8B</td>
<td><strong>Block Load Status</strong></td>
</tr>
<tr>
<td>53</td>
<td>Trigger Button</td>
<td>8C</td>
<td>Block Load Success</td>
</tr>
<tr>
<td>54</td>
<td>Trigger Repeat Interval</td>
<td>8D</td>
<td>Block Load Full</td>
</tr>
<tr>
<td>55</td>
<td>Axes Enable</td>
<td>8E</td>
<td>Block Load Error</td>
</tr>
<tr>
<td>56</td>
<td>Direction</td>
<td>8F</td>
<td>Block Handle</td>
</tr>
<tr>
<td>57</td>
<td><strong>Direction</strong></td>
<td>90</td>
<td><strong>PID Block Free Report</strong></td>
</tr>
<tr>
<td>58</td>
<td>Type Specific Block Offset</td>
<td>91</td>
<td>Type Specific Block Handle</td>
</tr>
<tr>
<td>59</td>
<td>Block Type</td>
<td>92</td>
<td><strong>PID State Report</strong></td>
</tr>
<tr>
<td>5A</td>
<td>Set Envelope Report</td>
<td>93</td>
<td><strong>PID Effect State</strong></td>
</tr>
<tr>
<td>5B</td>
<td>Attack Level</td>
<td>94</td>
<td>ES Playing</td>
</tr>
<tr>
<td>5C</td>
<td>Attack Time</td>
<td>95</td>
<td>ES Stopped</td>
</tr>
<tr>
<td>5D</td>
<td>Fade Level</td>
<td>96</td>
<td><strong>PID Device Control</strong></td>
</tr>
<tr>
<td>5E</td>
<td>Fade Time</td>
<td>97</td>
<td>DC Enable Actuators</td>
</tr>
<tr>
<td>5F</td>
<td><strong>Set Condition Report</strong></td>
<td>98</td>
<td>DC Disable Actuators</td>
</tr>
<tr>
<td>60</td>
<td>CP Offset</td>
<td>99</td>
<td>DC Stop All Effects</td>
</tr>
<tr>
<td>61</td>
<td>Positive Coefficient</td>
<td>9A</td>
<td>DC Device Reset</td>
</tr>
<tr>
<td>62</td>
<td>Negative Coefficient</td>
<td>9B</td>
<td>DC Device Pause</td>
</tr>
<tr>
<td>63</td>
<td>Positive Saturation</td>
<td>9C</td>
<td>DC Device Continue</td>
</tr>
<tr>
<td>64</td>
<td>Negative Saturation</td>
<td>9D</td>
<td>Reserved</td>
</tr>
<tr>
<td>65</td>
<td>Dead Band</td>
<td>9E</td>
<td>Reserved</td>
</tr>
<tr>
<td>66</td>
<td><strong>Download Force Sample</strong></td>
<td>9F</td>
<td>Device Paused</td>
</tr>
<tr>
<td>67</td>
<td>Isoch Custom Force Enable</td>
<td>A0</td>
<td>Actuators Enabled</td>
</tr>
<tr>
<td>68</td>
<td><strong>Custom Force Data Report</strong></td>
<td>A1</td>
<td>Reserved</td>
</tr>
<tr>
<td>69</td>
<td>Custom Force Data</td>
<td>A2</td>
<td>Reserved</td>
</tr>
<tr>
<td>6A</td>
<td>Custom Force Data Offset</td>
<td>A3</td>
<td>Reserved</td>
</tr>
<tr>
<td>6B</td>
<td><strong>Set Custom Force Report</strong></td>
<td>A4</td>
<td>Safety Switch</td>
</tr>
<tr>
<td>6C</td>
<td>Custom Force Data Offset</td>
<td>A5</td>
<td>Actuator Override Switch</td>
</tr>
<tr>
<td>6D</td>
<td>Sample Count</td>
<td>A6</td>
<td>Actuator Power</td>
</tr>
<tr>
<td>6E</td>
<td><strong>Set Periodic Report</strong></td>
<td>A7</td>
<td>Start Delay</td>
</tr>
<tr>
<td>6F</td>
<td>Offset</td>
<td>A8</td>
<td><strong>Parameter Block Size</strong></td>
</tr>
<tr>
<td>70</td>
<td>Magnitude</td>
<td>A9-FFFF</td>
<td>Reserved</td>
</tr>
</tbody>
</table>

The following controls support force feedback devices.

**Physical Interface Device**

- **CA** - A collection of PID usages.
- **Normal**
- **DV** – A force applied perpendicular to the surface of an object.
5.1 Effect Block Parameters

The minimal Effect parameter block must contain (Effect) Parameter Block Index, Effect Type, Duration, Sample Period, Gain, Trigger Button, Trigger Repeat Interval, Axis Direction, and Type Specific Block Handle values.

**Set Effect Report**

CL – This usage applies the logical collection that identifies the report associated with setting the effect parameters of a PID.

**Effect Block Index**

DV - Effect Block Index varies from 0 to the maximum number of effects - 1 stored in the device. See Parameter Block Management for more information.

**Parameter Block Offset**

DV – The byte offset into the Parameter block pool where the Parameter Block is stored.

**ROM Flag**

DF – This flag used to distinguish between RAM and ROM based Effect Block Indices and Offsets.

### 5.1.1 Effect Types

Individual effects are identified by the contents of the Effect Type (ET) field. The declared ET usages enumerate the effects that a device supports. See Table 3 for required Type Specific Block Offsets.

**Effect Type**

NArY – This collection identifies the Type of Effect this command defines. See Table 3 for list of applicable Effect Type selectors. Vendor defined effect type selectors can also be included in this collection.

ET Constant Force

Sel – The current effect parameters define a Constant waveform.

ET Ramp

Sel - The current effect parameters define a Ramp waveform.

ET Custom Force Data

Sel - The current effect parameters define a downloaded Custom Force waveform.

ET Square

Sel - The current effect parameters define a Square waveform.

ET Sine

Sel - The current effect parameters define a Sine waveform.

ET Triangle

Sel - The current effect parameters define a Triangle waveform.

ET Sawtooth Up

Sel - The current effect parameters define a Sawtooth Up waveform.

ET Sawtooth Down

Sel - The current effect parameters define a Sawtooth Down waveform.

ET Spring

Sel - The current effect parameters creates a compliant restoring force that causes the device to return to a specified point in the device's range of motion.

ET Damper

Sel - The current effect parameters define a Damper effect.

ET Inertia

Sel - The current effect parameters define an Inertia effect

ET Friction

Sel - The current effect parameters define a Friction effect.

**Duration**

DV - The total duration of the effect. To sustain an effect until explicitly stopped with the Stop method, set Duration to INFINITE (Null). If an envelope has been applied to the effect, then the attack will be applied, followed by an infinite sustain. Units are used to define the time base.
Sample Period

DV - The period at which the device should play back the effect. A value of zero indicates that the default playback sample rate should be used. Units are used to define the time base.

If the device is not capable of playing back the effect at the specified rate, it will choose the supported rate that is closest to the requested value.

Setting a custom Sample Period can be used for special effects. For example, playing a sine wave at an artificially large sample period results in a rougher texture.

Gain

DV - The gain to be applied to the effect. The gain is a normalized scaling factor that is applied to all magnitudes and envelopes of an effect.

Trigger Button

DV - The identifier or offset of the button to be used to trigger playback of this effect. A Null Trigger Button value indicates that this Effect is not tied to a button.

Trigger Repeat Interval

DV - The auto-repeat interval, for playback of effects triggered by holding down the trigger button. The interval is the time between the end of the playing effect and start of the next effect. If this effect is a one-time effect (no auto-repeat is desired), this value should be set to INFINITE (Null). Units are used to define the time base.

Axes Enable

US – The Axes Enable collection contains joint collections. Each joint collection contains axes or vectors from the Generic Desktop page. This usage changes the type of these Generic Desktop usages to Dynamic Flags (DF) where each usage identifies whether the respective axis or vector is enabled for this effect.

Direction Enable

DF – If the Direction Enable flag is set then the Axes Enable flags are ignored, only one Condition Parameter Block is defined and the Direction is applied to the Condition Parameter Block as a polar direction.

Direction

CL – The Direction collection contains joint collections. Each joint collection contains axes or vectors from the Generic Desktop page. Each axis usage is treated as a Dynamic Variable (DV).

If the values are in Cartesian coordinates then axes usages X, Y or Z or vector usages Vx, Vy or Vz will be declared in this collection as normalized values.

If the values are in polar coordinates then axes usages Rx, Ry or Rz or vector usages Vbrx, Vbry or Vbrz will be declared in this collection as normalized values.

Start Delay

DV - The start delay interval, for the playback of effect. The interval is the time between an Op Effect Start or Op Effect Start Solo command and initiation of the effect. If no delay is desired this value should be set to 0. Units are used to define the time base.

5.1.1.1 Type Specific Block Offsets

The number of Type Specific Block Handles declared in an Effect report is determined by the following rules:
1) Custom Downloaded Effects do not use Envelope Blocks.
2) Effects that use Condition Blocks do not use Envelope Blocks.
3) Effects that use Condition Blocks require 1 Condition Block per axis.
4) Effects that do not use Condition Blocks use 1 Parameter Block and an optional Envelope Block.
5) Rules 2 through 4 apply to each declared joint.

The number of Type Specific Block Handles equals the number of joints times the number axes or 2, which ever is greater. The minimum of 2 will support an Envelope and one additional parameter block.

\[
\text{Number of Type Specific Block Offset} = \text{joints} \times (\text{axes or 2, which ever is greater})
\]

The following table lists the type of parameter block that a Type Specific Block Offsets point to for each Effect Type. The table assumes that the device has declared a single joint with two axes, X and Y. If the device had 3 axes then a third Type Specific Block Offset would have been declared. The third Offset would only be used for those Effect Types that require a Condition Block for the axis.
### Table 3: Effect Types

<table>
<thead>
<tr>
<th>Effect Type</th>
<th>Type Specific Block Offset 1</th>
<th>Type Specific Block Offset 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ET Constant Force</td>
<td>Magnitude</td>
<td>Envelope</td>
</tr>
<tr>
<td>ET Ramp</td>
<td>Ramp</td>
<td>Envelope</td>
</tr>
<tr>
<td>ET Custom Force Data</td>
<td>Download Custom Force</td>
<td>NA</td>
</tr>
<tr>
<td>ET Square</td>
<td>Periodic</td>
<td>Envelope</td>
</tr>
<tr>
<td>ET Sine</td>
<td>Periodic</td>
<td>Envelope</td>
</tr>
<tr>
<td>ET Triangle</td>
<td>Periodic</td>
<td>Envelope</td>
</tr>
<tr>
<td>ET Sawtooth Up</td>
<td>Periodic</td>
<td>Envelope</td>
</tr>
<tr>
<td>ET Sawtooth Down</td>
<td>Periodic</td>
<td>Envelope</td>
</tr>
<tr>
<td>ET Spring</td>
<td>Condition (X Axis)</td>
<td>Condition (Y Axis)</td>
</tr>
<tr>
<td>ET Damper</td>
<td>Condition (X Axis)</td>
<td>Condition (Y Axis)</td>
</tr>
<tr>
<td>ET Inertia</td>
<td>Condition (X Axis)</td>
<td>Condition (Y Axis)</td>
</tr>
<tr>
<td>ET Friction</td>
<td>Condition (X Axis)</td>
<td>Condition (Y Axis)</td>
</tr>
</tbody>
</table>

**Type Specific Block Offset**

CL – This collection Ordinal usages to distinguish the individual Type Specific Block Offset fields. Depending on the effect type one or more fields will be valid. See Effect Types for a discussion of the required Offsets.

The Parameter Blocks pointed to by these offsets must remain valid throughout the life of the effect.

**Block Type**

NAry – This collection contains an array item that lists the parameter Block Types supported by the device. The Selectors in this Named Array are the various PID report usages: Set Effect Report, Set Envelope Report, Set Condition Report, Set Periodic Report, Set Constant Report and Set Ramp Force Report. These overloaded usages identify the respective parameter block report.

### 5.2 Envelope Block Parameters

The Envelope Block describes the envelope to be used by an effect. Note that not all effect types use envelopes. The minimal Envelope parameter block must contain (Envelope) Parameter Block Index, Attack Level, Attack Time, Fade Level and Fade Time values.

**Set Envelope Report**

CL – This usage applies the logical collection that identifies the report associated with setting the envelope parameters of a PID. This collection must contain the *Attack Level, Attack Time, Fade Level* and *Fade Time* usages.

**Attack Level**

DV - Normalized amplitude for the start of the envelope, from the baseline.

**Attack Time**

DV - The transition time to reach the sustain level. Units are used to define the time base.

**Fade Level**

DV - Normalized amplitude to end the envelope, from baseline.
Fade Time DV - The fade time to reach the fade level. Units are used to define the time base.

5.3 Condition Block Parameters
The minimal Condition parameter block must contain (Condition) Parameter Block Index, Center Point Offset, Positive Coefficient, Negative Coefficient, Positive Saturation, Negative Saturation and Dead Band values.

Different types of conditions will interpret the parameters differently, but the basic idea is that force resulting from a condition is equal to $A(q - q_0)$ where $A$ is a scaling coefficient, $q$ is some metric, and $q_0$ is the neutral value for that metric.

The simplified formula given above must be adjusted if a nonzero dead band is provided. If the metric is less than CP Offset - Dead Band, then the resulting force is given by the following formula:

$$force = \text{Negative Coefficient} \times (q - (\text{CP Offset} - \text{Dead Band}))$$

Similarly, if the metric is greater than CP Offset + Dead Band, then the resulting force is given by the following formula:

$$force = \text{Positive Coefficient} \times (q - (\text{CP Offset} + \text{Dead Band}))$$

A spring condition uses axis position as the metric.
A damper condition uses axis velocity as the metric.
An inertia condition uses axis acceleration as the metric.

If the number of Condition report blocks is equal to the number of axes for the effect, then the first report block applies to the first axis, the second applies to the second axis, and so on. For example, a two-axis spring condition with CP Offset set to zero in both Condition report blocks would have the same effect as the joystick self-centering spring. When a condition is defined for each axis in this way, the effect must not be rotated.

If there is a single Condition report block for an effect with more than one axis, then the direction along which the parameters of the Condition report block are in effect is determined by the direction parameters passed in the Direction field of the Effect report block. For example, a friction condition rotated 45 degrees (in polar coordinates) would resist joystick motion in the northeast-southwest direction but would have no effect on joystick motion in the northwest-southeast direction.

**Set Condition Report**

| CL – This usage applies the logical collection that identifies the report associated with setting the effect condition parameters. This collection must contain the CP Offset, Positive Coefficient, Negative Coefficient, Positive Saturation, Negative Saturation and Dead Band usages. |
| CP Offset DV – The Normalized Center Point Offset. Offset from axis 0 position. |
| CP Offset DV – The Normalized Center Point Offset. Offset from axis 0 position. |
| Positive Coefficient DV - The Normalized coefficient constant on the positive side of the neutral position. |
| Negative Coefficient DV - The Normalized coefficient constant on the negative side of the neutral position. |
| Positive Saturation DV - The Normalized maximum positive force output. |
| Negative Saturation DV - The Normalized maximum negative force output. |
Dead Band DV - The region around $CP$ Offset where the condition is not active. In other words, the condition is not active between $Offset - Dead Band$ and $Offset + Dead Band$. This value is Normalized.

5.4 Custom Forces

Custom Forces are analogous to audio sound files, they are “played” by the device. The analog continues in that, stereo audio files consist of samples of interleaved right and left channel data. Custom Forces consist of samples of interleaved axis data. Downloaded Custom Forces are stored in the device and then played back in real-time by the device from local memory.

An Effect block is created of type ET Downloaded Custom Effect. This effect is similar to a Periodic effect however the waveform, rather than being predefined by ET Sine, ET Sawtooth, etc., is supplied by the host. The waveform is downloaded into the devices Pool. To provide this functionality the Download Custom Force Parameter Block must be declared.

To provide this functionality three reports must be declared:
1) Download Force Sample to define the format of the downloaded data.
2) Custom Force Data Report to define to the report that moves the data to the device.
3) Set Custom Force Report to define the parameter block that is pointed to by the Effect block.

A Download Force Sample collection is declared to identify the format of the effect sample that the device is capable of playing from memory. I.e. Two 8-bit samples of X and Y data, three 16-bit samples of X, Y and Z data, etc. The Download Force Sample is defined with it’s own Report ID. This report is never actually transferred to the device, it is simply used to declare the format of the downloaded samples.

The Custom Force Data Report is used to load the samples into the device. This report consists of 3 parts: Parameter Block Offset, Generic Desktop: Byte Count and the Custom Force Data itself. The Parameter Block Offset identifies the byte offset into the pool to start loading the Custom Force Data. The Byte Count identifies how many bytes of the Custom Force Data buffer are to be copied onto the pool.

The Set Custom Force Report defines the parameter block that is pointed to by the Type Specific Block Offset in the Effect parameter block. The Set Custom Force parameter block identifies the start offset in the pool and the size of the effect in samples of the data that has been loaded by the Custom Force Data Reports.

5.4.1 Sample Definition

A Sample declares the format of Custom Force data that the device is capable of handling. A sample consists of one or more axes. The size of the sample is a function of the number of axes and the size of their respective bit fields.

A Force Sample usage is a collection, which contains joint collections. Each joint collection contains axes from the Generic Desktop page or a Normal usage. These usages identify the number and types of axes in a sample. Each axis usage is treated as an Dynamic Variable (DV).

If the values are in Cartesian coordinates then linear axis (X, Y, Z) Axis or vector (Vx, Vy, Vz) usages will be declared in this collection.

If the values are in polar coordinates then a rotational axis (Rx, Ry, Rz) or vector (Vbrx, Vbry, Vbrz) usages will be declared in this collection.

Download Force Sample CL – The Download Force Sample collection contains joint collections. This usage identifies the format of the force data
sample that the host must store in the Pool for later playback by the device.

5.4.2 Data Downloading

Downloading of custom effect data is performed using the Custom Force Data Report. This report consists of 3 parts: Parameter Block Offset, Generic Desktop: Byte Count and the Custom Force Data itself. A Downloaded Custom Force parameter block consumes Byte Count bytes in the pool. This allows a Downloaded Custom Force parameter blocks to be loaded sequentially in the Pool, creating a custom force data buffer larger than the Report Count defined for the Custom Force Data field.

**Custom Force Data Report**

CL – This usage applies the logical collection that identifies the report associated with loading Custom Force data. This collection must contain Parameter Block Offset, Generic Desktop: Byte Count and Custom Force Data usages.

**Custom Force Data**

DV – The Custom Force Data usage is attached to a Buffered Bytes item that contains the data to be transferred. Units may be used to define the force value. If no units are declared then assume a normalized value.

**Custom Force Vendor Defined Data**

DV – The Custom Force Vendor Defined Data usage is attached to a Buffered Bytes item that contains the data to be transferred. The format of the data is vendor specific so a Download Force Sample is not required.

Samples are packed. A sample might not be an integral number of bytes in length, or the size of the Custom Force Data field may not be an integral number of samples in length, therefore a sample may not end on a byte boundary in the Custom Force Data buffer. If a custom force data buffer required in the device is larger than the Custom Force Data field, then sequential Custom Force Data buffers will have to be loaded into the Pool, and a sample may span Custom Force Data buffers.

For example, assume the following:

1) The Download Force Sample is defined as 3 axes (X, Y, Z) of 8 bit data, resulting in a 24 bit sample.
2) The Custom Force Data Field is 256 bytes in size.
3) The driver wants to load 100 samples (300 bytes).

The driver would send two Download Custom Data Reports, one with the Byte Count = 256, Data Offset = X and another with the Byte Count = 44, Data Offset = X+256. The first transfer would contain 85.33 samples and the second 14.66. This would form a contiguous 300-byte data buffer in the device’s memory.

5.4.3 Custom Force Block Parameters

The minimal Downloaded Custom Force parameter block must contain (Downloaded Custom Force) Parameter Block Offset, Downloaded Custom Force Block Offset and Sample Count values.

**Set Custom Force Report**

CL – This usage applies the logical collection that identifies the report associated with setting the downloaded custom force effect parameters.

**Custom Force Data Offset**

DV – Offset into the Pool where the Downloaded Custom Force data starts.

**Sample Count**

DV – The number of Downloaded Custom Force samples in a single period of the effect.
5.5 Periodic Block Parameters

The minimal Periodic parameter block must contain (Periodic) Parameter Block Index, Magnitude, Offset, Phase and Period values. Once started a periodic effect will loop every Period until a Pause or Stop command is received.

- **Set Periodic Report**
  - CL – This usage applies the logical collection that identifies the report associated with setting the periodic effect parameters. This collection must contain the Magnitude, Offset, Phase and Period usages.

- **Offset**
  - DV - Normalized baseline offset. The range of forces generated by the effect will be Offset - Magnitude to Offset + Magnitude. The value of the Offset member is also the baseline for any envelope that is applied to the effect.

- **Magnitude**
  - DV - The Normalized magnitude of the effect. If an envelope is applied to this effect, then the value represents the magnitude of the envelope. If no envelope is applied, then the value represents the amplitude of the entire effect.

- **Phase**
  - DV - Determines the position in the wave that playback begins. This is a Normalized value between 0 and 360 degrees. The angular increment is defined by the resolution of the field. A device driver may not provide support for all values of Phase. In this case the value will be rounded off to the nearest supported value.

- **Period**
  - DV - The period of the effect. Units are used to define the time base.

5.6 Constant Force Block Parameters

The minimal Ramp Force parameter block must contain (Constant Force) Parameter Block Index and Magnitude values.

- **Set Constant Force Report**
  - CL – This usage applies the logical collection that identifies the report associated with setting the Constant Force effect parameters. This collection must contain the Magnitude usages.

5.7 Ramp Force Block Parameters

The minimal Ramp Force parameter block must contain (Ramp Force) Parameter Block Index, Ramp Start and Ramp End values.

Note: The Duration for a ramp force effect cannot be INFINITE.

- **Set Ramp Force Report**
  - CL – This usage applies the logical collection that identifies the report associated with setting the Ramp Force effect parameters. This collection must contain the Ramp Start and Ramp End usages.

- **Ramp Start**
  - DV - The Normalized magnitude at the start of the effect.

- **Ramp End**
  - DV - The Normalized magnitude at the end of the effect.
5.8 Vendor Defined Parameter Blocks

In a Vendor Defined Parameter Block a vendor can use:
1) Usages defined in the PID spec.; Offset, Magnitude, etc.
2) Vendor define usages from their own usage page.

To be consistent with this document, vendor defined parameter blocks should be defined using a similar format.
1) Using a unique Report ID for each vendor defined report
2) Wrapping the report in a Set xxx Report logical collection, where the Set xxx Report is the vendor defined name on their usage page.
3) Include a Parameter Block Offset or a Block Handle.

5.9 Effect Operations

This report is used to control the operation of effects.

<table>
<thead>
<tr>
<th>Effect Operation Report</th>
<th>CL – This usage applies the logical collection that identifies the report associated with setting the effect operational parameters. This collection must contain Effect Block Index, Operation and Loop Count usages.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation</td>
<td>NArty - Operation to perform on the effect identified by the Effect ID. This named array that contains Operation (Op) selectors.</td>
</tr>
<tr>
<td>Op Effect Start</td>
<td>Sel - Start the effect identified by the Effect Handle.</td>
</tr>
<tr>
<td>Op Effect Start Solo</td>
<td>Sel - Start the effect identified by the Effect Handle and stop all other effects.</td>
</tr>
<tr>
<td>Op Effect Stop</td>
<td>Sel - Stop the effect identified by the Effect Handle.</td>
</tr>
</tbody>
</table>
| Loop Count              | DV – The number of times the device will repeat the operation. i.e. a Stop command is not required. A INFINITE value implies “loop for ever”.

5.10 Device Operations

This report is used to control the operation of the overall device.

<table>
<thead>
<tr>
<th>Device Operation Report</th>
<th>CL – This usage applies the logical collection that identifies the report associated with setting the device operational parameters. This collection can contain a Device Gain usage.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device Gain</td>
<td>DV - The device gain to be applied to all effects on the device. The device gain is a normalized scaling factor applied to all magnitudes and envelopes of an effect, scaling the final output of the device.</td>
</tr>
</tbody>
</table>

5.11 Parameter Block Management

Parameter Blocks are stored in the PID class device. A vendor can choose whether to let the system driver manage the parameter block pool or manage it themselves.

When the driver manages the Parameter Block Pool, the device simply provides a block of memory (the Pool) where the driver loads Parameter Blocks. All decisions as to where to load Parameter Blocks, are made by the driver. The driver maintains a list of all Parameter Blocks that are currently stored in the pool and will perform any garbage collection that is required.
If a device manages its own pool then the driver simply passes Parameter Blocks to the device and receives either a negative acknowledgement if there was no room for the block or a positive acknowledgement and a handle for the block if there was room. The handle is used for all future references to the Parameter Block.

### 5.11.1 Driver Managed

A driver reads the PID Pool Report to identify the size of the RAM and ROM spaces on the device, and the size of the individual parameter blocks (Reports) to be stored there. The RAM Pool size identifies the amount of read/write storage available for parameter blocks. The pool is logically divided into two spaces: the Effect Parameter Block array and the general Pool. The driver manages the space allocation in the Pool and all parameter block types except Effect Parameter Blocks are referenced by their byte offset from the beginning of the Pool.

For efficiency, Effect Parameter Blocks are handled slightly differently. An array of Effect Parameter Blocks always starts at the first location of the Pool. Effect Parameter Blocks are accessed by their index in this array. If a driver determines it wants to store 10 Effects in the device at one time and the Effect Parameter Block is 12 bytes long then the first 120 bytes of the Pool will be occupied by the Effect Parameter Block array. The remainder of the pool will be allocated to the other types of parameter blocks. This approach allows a device with a large Pool (1 MByte) to have a compact Operation field in the PID Operation Output Report.

ROM based effects are also supported. ROM based parameter blocks are accessed the same way that RAM based effects are. The only difference is that they are read-only. A driver can read in the ROM parameter blocks to determine the effects that are stored in the device.

Because pool allocation for parameter blocks is managed by the driver, the driver will know which types of blocks it has loaded and where. The device uses the Effect Type field in the Effect Parameter Block to identify the type(s) of Parameter blocks that the Type Specific Block Offsets point to.
Figure 1 assumes the RAM Pool is initially empty. The Effect Parameter Block Array always starts at the beginning of memory. The Effect Block Index field determines the location in the Effect Parameter Block Array where the Effect Parameter Block will be loaded. In this example space is allocated for 10 Effects.

Note that the space allocated for a single Effect Parameter Block in the RAM Pool is the size of the Effect Report minus the size of the Report ID, Effect Block Index and ROM Flag fields if there is one. The same is true for all other types of Parameter Blocks however they can be placed anywhere in the available Pool space. The Report ID identifies the size and type of the Parameter Block while the Effect Block Index and ROM Flag fields identify the offset of the Parameter Block in the Pool. This information is stripped from the Parameter Block before it is stored in memory to save space.

Figure 1 shows the Parameter Blocks immediately following the Effect Parameter Block Area. The arrows on the right show how the Type Specific Block Offset of a Effect Parameter Block will point to any Parameter Blocks associated with that Effects Parameter Block.

**Figure 1: Report Allocation in the Pool**
Custom Effect Data is stored in memory as a large contiguous block that is formed by concatenating the Data portion of Set Custom Force Data Reports. In this case the Byte Count is also stripped before storing the data. Figure 2 shows two Set Custom Force Data Reports, the first containing 256 bytes of data and the second containing 200 bytes. The Data portions of these reports are concatenated starting at the Parameter Block Offset in the Pool. This will generate a 456 byte Custom Force Data Block in the Pool.

The arrows in the center represent how the Type Specific Block Offset of a Effect Parameter Block will point to a Custom Effect Parameter Block which in turn points to the Custom Effect Data. This all assumes that the Type of the Effect is Custom Effect.

Other than the Effect Parameter Blocks the placement of Parameter Blocks and Custom Effect Data in the Pool is determined strictly by the driver. The driver may group blocks of like size or employ other techniques to minimize fragmentation of the Pool.

---

**Figure 2: Custom Effect Allocation in the Pool**

<table>
<thead>
<tr>
<th>Parameter Block</th>
<th>Report ID</th>
<th>Parameter Block Offset</th>
<th>Byte Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect Block 0</td>
<td></td>
<td>( x )</td>
<td>256</td>
</tr>
<tr>
<td>Effect Block 9</td>
<td></td>
<td>( x )</td>
<td>200</td>
</tr>
<tr>
<td>Parameter Block 0</td>
<td></td>
<td>( x )</td>
<td></td>
</tr>
<tr>
<td>Custom Effect Parameter Block</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parameter Block n</td>
<td></td>
<td>( x )</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Set Custom Force Data Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report ID</td>
</tr>
<tr>
<td>Parameter Block Offset</td>
</tr>
<tr>
<td>Byte Count</td>
</tr>
<tr>
<td>Data</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Parameter Block</th>
<th>Report ID</th>
<th>Parameter Block Offset</th>
<th>Byte Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter Block n</td>
<td></td>
<td>( x + 256 )</td>
<td>200</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Set Custom Force Data Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Report ID</td>
</tr>
<tr>
<td>Parameter Block Offset</td>
</tr>
<tr>
<td>Byte Count</td>
</tr>
<tr>
<td>Data</td>
</tr>
</tbody>
</table>
The following usages are only used by devices that let the driver manage their Parameter Block pool.

**PID Pool Report**

CL – This usage applies the logical collection that identifies the report associated with setting the overall PID control parameters.

**RAM Pool Size**

DV - The size of the PID RAM parameter pool in bytes.

**ROM Pool Size**

SV - The size of the PID ROM parameter pool in bytes.

**ROM Effect Block Count**

SV - The number of ROM Effect Parameter blocks in the ROM parameter pool.

**Simultaneous Effects Max**

SV – The maximum number of simultaneous effects supported by the device. A device declares this usage to indicate the total number of effects that it can execute at one time.

**Pool Alignment**

SV – The block start address alignment boundary in bytes. This usage can be defined by a device so that parameter blocks start on 16-bit (Pool Alignment = 2) or 32-bit boundaries (Pool Alignment = 4) etc. If undefined then Pool Alignment = 1 is assumed.

**Parameter Block Size**

CL – This usage only applies to a Driver Managed pool. It is a logical collection that identifies the size that host should allocate for each fixed size Parameter Block in the Pool. That is, any Report collection that contains an Parameter Block Index usage declaration and does not declare a Generic Desktop:Byte Count. This collection changes the meaning of the Usages that it contains. The possible included usages are: the Set Effect Report, Set Envelope Report, Set Condition Report, Set Custom Force Report, Set Periodic Report, Set Constant Force Report and Set Ramp Force Report Logical Collection (LC) usages. These LC usages each define specific reports that require space in the Pool. When found in a Parameter Block Size collection the type of these usages change from a Logical Collection (LC) to a Static Variable (SV), which define the size, in bytes, of the respective report.

Note that the Custom Force Data Report normally defines a variable sized parameter block that can be loaded in the Pool. A Generic Desktop: Byte Count usage is used to define the size of the parameter block dynamically.

When the Pool gets fragmented the driver must perform garbage collection to compact the valid Parameter Blocks and to free the unused ones. The PID Pool Move Report is issued to the device to copy data form one place to another in the Pool. This also allows the device to move any private data that it may have associated with a Parameter Block.

**PID Pool Move Report**

CL – This usage applies the logical collection that identifies the report associated with moving Parameter Blocks in the Pool for garbage collection. The host must update any effect specific references. Moving a parameter block of an effect that is playing will result in undefined behavior.

**Move Source**

DV – The source offset of the Parameter Block.

**Move Destination**

DV – The destination offset of the Parameter Block.

**Move Length**

DV – The size of the Parameter Block to move in bytes.
Note: The *Data Offset* fields must be declared large enough to access the full extent of the RAM and ROM Pools.

### 5.11.2 Device Managed

When the device manages Parameter Blocks, the Pool is not visible to the driver. Instead of the *Parameter Block Offset* in Set PB Reports, the *Handshake Key* would be used. The *Handshake Key* is a unique identifier generated by the driver. This key is passed back by the device to identify the *PID Block Load Report* that corresponds to the originating Set PB Report. The *PID Block Load Report* with the associated *Block Load Status* and *Block Handle* will indicate whether the device was able to load the Parameter Block. If successful, then the driver can use the *Block Handle* to refer to the Parameter Block in the device.

The *Type Specific Block Handle* will be used in the *Set Effect Report* (rather than the *Type Specific Block Offset*) to reference the associated Parameter Block.

When the driver is done with a Parameter Block it will issue a *PID Block Free Report* to inform the device that it could release the parameter block and perform any necessary garbage collection.

This approach allows a device vendor to manage it’s own Pool memory, however every Set PB Report command will have to wait for a *PID Block Load Report* to be returned before the driver knows whether the command was successful.

The device uses the Effect Type field in the Effect Parameter Block to identify the type(s) of Parameter blocks that the *Type Specific Block Handles* point to.

The following usages are only used by devices that manage their own Parameter Block pool.

<table>
<thead>
<tr>
<th><strong>PID Block Load Report</strong></th>
<th>CL – This usage applies the logical collection that identifies the report associated with a device’s response to a Set PB Report.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handshake Key</td>
<td>DV – When the parameter block pool is managed by the device this field is found in the Set PB Report and the PID Block Load Report. The Handshake Key is used by the driver to match the Set PB Reports and the PID Block Load Reports.</td>
</tr>
<tr>
<td>Block Load Status</td>
<td>NAry – Identifies the completion status of a Set PB Report request. This named array contains Block Load selectors.</td>
</tr>
<tr>
<td>Block Load Success</td>
<td>Sel – The Set PB Report command successfully completed.</td>
</tr>
<tr>
<td>Block Load Full</td>
<td>Sel – The Set PB Report command failed to complete because there was no room in the device’s parameter block pool.</td>
</tr>
<tr>
<td>Block Load Error</td>
<td>Sel – The Set PB Report command failed to complete because an error occurred in the device.</td>
</tr>
<tr>
<td>Block Handle</td>
<td>SV – A unique identifier that can be used to access a Parameter Block.</td>
</tr>
<tr>
<td><strong>PID Block Free Report</strong></td>
<td>CL – This usage applies the logical collection that identifies the report associated with freeing a Parameter Block in a device. This report will contain the Block Handle to free.</td>
</tr>
<tr>
<td><strong>Type Specific Block Handle</strong></td>
<td>CL – This collection uses Ordinal usages to distinguish the individual Type Specific Block Handle fields. Depending on the effect type one or more fields will be valid. See Effect Types for a discussion of the required Handles.</td>
</tr>
</tbody>
</table>
The Parameter Blocks referenced by these handles must remain valid throughout the life of the effect.

### 5.12 PID State

**PID State Report**

- **CL** – This usage applies the logical collection that identifies the report associated with identifying and setting the PID state.

**PID Effect State**

- **NAr** – The state of the effect identified by the Effect Handle. This is a named array that contains Effect State (PES) selectors.

- **ES Playing**
  - **Sel** – The effect identified by the Effect Handle is playing.

- **ES Stopped**
  - **Sel** – The effect identified by the Effect Handle is stopped.

**PID Device Control**

- **NAr** – This usage controls the overall state of the device. This is a named array that contains Device Control (DC) selectors.

- **DC Enable Actuators**
  - **Sel** – Enable all device actuators.

- **DC Disable Actuators**
  - **Sel** – Disable all the device actuators.

- **DC Stop All Effects**
  - **Sel** – Issues a stop on every running effect.

- **DC Reset**
  - **Sel** – Clears any device paused condition, enables all actuators and clears all effects from memory.

- **DC Pause**
  - **Sel** – The all effects on the device are paused at the current time step.

- **DC Continue**
  - **Sel** – The all effects that running when the device was paused are restarted from their last time step.

- **Device Paused**
  - **DF** – Indicates that all effects on the device are paused. All effects on the device are paused at the current time step.

- **Actuators Enabled**
  - **DF** – Indicates that the device’s actuators are enabled.

- **Safety Switch**
  - **DF** – A control indicating the state of the Safety switch on the device. If the Safety Flag is set and the device is usable. (Read-only)

- **Actuator Override Switch**
  - **DF** – This is an actuator override switch available to the user. The user enables the device’s actuators if this flag is set.

- **Actuator Power**
  - **OOC** - When read back this usage indicates the current actuator power status. (Read-only)
6. PID Example

This is an example of a joystick with force feedback capabilities. This device does support Effects, isochronous and downloaded Custom Force operations. The RAM Pool Size is 256 bytes and the ROM Pool size is 32 K bytes.

In this example the Generic Desktop Pointer is considered a joint and items related to that joint are tied together in Generic: Desktop Pointer physical collections. You will see this demonstrated in the input report axes, Axes Enable fields and the Custom Effect Force axes.

This device supports all Effect Types except Friction.

There are 2 Input Reports: PID Data (stick and button state) and PID State (effect state). 10 output reports: Set Effect, Set Envelope, Set Condition, Set Periodic, Set Constant Force, Set Ramp Force, Set Custom Force, Download Force Sample, Set Custom Force and Effect Operation. And 1 Feature report: Pool

```plaintext
; Start Joystick input definition

USAGE_PAGE(Generic Desktop) 05 01
REPORT_ID (1) 85 01
LOGICAL_MINIMUM (0) 15 00
USAGE(Joystick) 09 04
COLLECTION(Application) A1 01

; Define the axes

USAGE_PAGE(Simulation Controls) 05 02
USAGE(Throttle) 09 BB
LOGICAL_MINIMUM(-127) 15 81
LOGICAL_MAXIMUM(127) 25 7F
REPORT_SIZE(8) 75 08
REPORT_COUNT (1) 95 01
INPUT(Data,Var,Abs) 81 02
USAGE_PAGE(Generic Desktop) 05 01

; Define the hat switch

USAGE(Hat switch) 09 39
LOGICAL_MINIMUM(0) 15 00
LOGICAL_MAXIMUM(3) 25 03
PHYSICAL_MINIMUM(0) 35 00
PHYSICAL_MAXIMUM(270) 46 0E 01
UNIT(Eng Rot:Angular Pos) 66 14 00
REPORT_SIZE(4) 75 04
REPORT_COUNT (1) 95 01
INPUT(Data,Var,Abs) 81 02
PHYSICAL_MAXIMUM(0) 45 00
UNIT(None) 66 00 00
```
Define the buttons

- **USAGE_PAGE (Button)**: 05 09
- **USAGE_MINIMUM (Button 1)**: 19 01
- **USAGE_MAXIMUM (Button 4)**: 29 04
- **LOGICAL_MAXIMUM (1)**: 25 01
- **REPORT_COUNT (4)**: 95 04
- **REPORT_SIZE (1)**: 75 01
- **PHYSICAL_MINIMUM (0)**: 35 00
- **INPUT (Data,Var,Abs)**: 81 02

End Joystick Input definition

Start Force Feedback command definitions

Usage Page (Physical Interface)**: 05 0F

Effect Report Definition

- **USAGE (Set Effect Report)**: 09 21
- **COLLECTION (Logical)**: A1 02
  - **REPORT_ID (1)**: 85 01
- **USAGE (Effect Block Index)**: 09 22
  - **LOGICAL_MAXIMUM (127)**: 25 7F
  - **REPORT_SIZE (7)**: 75 07
  - **REPORT_COUNT (1)**: 95 01
  - **OUTPUT (Data,Var,Abs)**: 91 02
- **USAGE (ROM Flag)**: 09 24
  - **LOGICAL_MAXIMUM (1)**: 25 01
  - **REPORT_SIZE (1)**: 75 01
  - **OUTPUT (Data,Var,Abs)**: 91 02

Define the available effect types. Effect Type is a named array that will accept any of the ET usages listed.

- **USAGE (Effect Type)**: 09 25
- **COLLECTION (Logical)**: A1 02
  - **USAGE (ET Constant Force)**: 09 26
  - **USAGE (ET Ramp)**: 09 27
  - **USAGE (ET Square)**: 09 30
  - **USAGE (ET Sine)**: 09 31
  - **USAGE (ET Triangle)**: 09 32
  - **USAGE (ET Sawtooth Up)**: 09 33
  - **USAGE (ET Sawtooth Down)**: 09 34
  - **USAGE (ET Spring)**: 09 40
  - **USAGE (ET Damper)**: 09 41
  - **USAGE (ET Inertia)**: 09 42
  - **LOGICAL_MINIMUM (1)**: 15 01
  - **LOGICAL_MAXIMUM (10)**: 25 0A
  - **REPORT_SIZE (8)**: 75 08
  - **OUTPUT (Data,Ary,Abs)**: 91 00
- **END_COLLECTION**: C0

- **USAGE (Duration)**: 09 50
- **USAGE (Trigger Repeat Interval)**: 09 54
  - **LOGICAL_MINIMUM (0)**: 15 00
  - **LOGICAL_MAXIMUM (10000)**: 26 10 27
  - **PHYSICAL_MAXIMUM (10000)**: 46 10 27
  - **REPORT_SIZE (16)**: 75 10
  - **UNIT (Eng Lin:Time)**: 66 03 10
  - **UNIT_EXPONENT (-3)**: 55 0D
REPORT_COUNT (2) 95 02
OUTPUT (Data,Var,Abs) 91 02

UNIT_EXPONENT (-6) 55 0A
USAGE (Sample Period) 09 51
REPORT_COUNT (1) 95 01
OUTPUT (Data,Var,Abs) 91 02
PHYSICAL_MAXIMUM (0) 45 00
UNIT_EXPONENT (0) 55 00
UNIT (None) 65 00

USAGE (Gain) 09 52
USAGE (Trigger Button) 09 53
LOGICAL_MAXIMUM (127) 25 7F
REPORT_SIZE (8) 75 08
REPORT_COUNT (2) 95 02
OUTPUT (Data,Var,Abs) 91 02

USAGE (Axes Enable) ; Tie these axes to the stick 09 55
COLLECTION (Logical) A1 02
USAGE_PAGE (Generic Desktop) 05 01
USAGE (Pointer) 09 01
COLLECTION (Physical) A1 00
  USAGE (X) 09 30
  USAGE (Y) 09 31
  LOGICAL_MAXIMUM (1) 25 01
  REPORT_SIZE (1) 75 01
  REPORT_COUNT (2) 95 02
  OUTPUT (Data,Var,Abs) 91 02
END_COLLECTION C0

REPORT_COUNT (6) ; 6-bit pad 95 06
OUTPUT (Cnst,Var,Abs) 91 03

USAGE_PAGE (Physical Interface) 05 0F
USAGE (Direction) 09 57
COLLECTION (Logical) A1 02
USAGE_PAGE (Generic Desktop) 05 01
USAGE (Pointer) ; Tie these axes to the stick 09 01
COLLECTION (Physical) A1 00
  USAGE (X) 09 30
  USAGE (Y) 09 31
  LOGICAL_MINIMUM (0) 15 00
  LOGICAL_MAXIMUM (255) 26 FF 00
  PHYSICAL_MAXIMUM (360) 46 68 01
  UNIT (Eng Rot:Angular Pos) 66 14 00
  REPORT_SIZE (8) 75 08
  REPORT_COUNT (2) 95 02
  OUTPUT (Data,Var,Abs) 91 02
  UNIT (None) 65 00
  PHYSICAL_MAXIMUM (0) 45 00
END_COLLECTION C0
END_COLLECTION C0

USAGE_PAGE (Physical Interface) 05 0F
USAGE (Type Specific Block Offset) 09 58
COLLECTION (Logical) A1 02
  USAGE (Ordinals:Instance 1) 0B 01 00 0A 00
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 USAGE (Ordinals:Instance 2) 0B 02 00 0A 00
 LOGICAL_MAXIMUM (32765) ; 32K RAM or ROM max. 26 FD 7F
 REPORT_SIZE (16) 75 10
 REPORT_COUNT (2) 95 02
 OUTPUT (Data,Var,Abs) 91 02
 END_COLLECTION C0
END_COLLECTION C0

;Envelope Report Definition
 USAGE (Set Envelope Report) 09 5A
 COLLECTION (Logical) A1 02
 REPORT_ID (2) 85 02
 USAGE (Parameter Block Offset) 09 23
 LOGICAL_MAXIMUM (32765) ; 32K RAM or ROM max 26 FD 7F
 REPORT_SIZE (15) 75 0F
 REPORT_COUNT (1) 95 01
 OUTPUT (Data,Var,Abs) 91 02

 USAGE (ROM Flag) 09 24
 LOGICAL_MAXIMUM (1) 25 01
 REPORT_SIZE (1) 75 01
 OUTPUT (Data,Var,Abs) 91 02

 USAGE (Attack Level) 09 5B
 USAGE (Fade Level) 09 5D
 LOGICAL_MAXIMUM (255) 26 FF 00
 REPORT_SIZE (8) 75 08
 REPORT_COUNT (2) 95 02
 OUTPUT (Data,Var,Abs) 91 02

 USAGE (Attack Time) 09 5C
 USAGE (Fade Time) 09 5E
 LOGICAL_MAXIMUM (10000) 26 10 27
 PHYSICAL_MAXIMUM (10000) 46 10 27
 UNIT (Eng Lin:Time) 66 03 10
 UNIT_EXPONENT (-3) 55 0D
 REPORT_SIZE (16) 75 10
 OUTPUT (Data,Var,Abs) 91 02
 PHYSICAL_MAXIMUM (0) 45 00
 UNIT (None) 65 00
 UNIT_EXPONENT (0) 55 00
 END_COLLECTION C0

;Condition Report Definition
 USAGE (Set Condition Report) 09 5F
 COLLECTION (Logical) A1 02
 REPORT_ID (3) 85 03
 USAGE (Parameter Block Offset) 09 23
 LOGICAL_MAXIMUM (32765) 26 FD 7F
 REPORT_SIZE (15) 75 0F
 REPORT_COUNT (1) 95 01
 OUTPUT (Data,Var,Abs) 91 02

 USAGE (ROM Flag) 09 24
 LOGICAL_MAXIMUM (1) 25 01
 REPORT_SIZE (1) 75 01
 OUTPUT (Data,Var,Abs) 91 02

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Usage (CP Offset) 09 60
Usage (Positive Coefficient) 09 61
Usage (Negative Coefficient) 09 62
Usage (Positive Saturation) 09 63
Usage (Negative Saturation) 09 64
Usage (Dead Band) 09 65
Logical Maximum (255) 26 FF 00
Report Size (8) 75 08
Report Count (6) 95 06
Output (Data,Var,Abs) 91 02
End_COLLECTION C0

; Periodic Report Definition
Usage (Set Periodic Report) 09 6E
Collection (Logical) A1 02
Report_ID (4) 85 04
Usage (Parameter Block Offset) 09 23
Logical Maximum (32765) 26 FD 7F
Report Size (15) 75 0F
Report Count (1) 95 01
Output (Data,Var,Abs) 91 02

Usage (HRM Flag) 09 24
Logical Maximum (1) 25 01
Report Size (1) 75 01
Output (Data,Var,Abs) 91 02

Usage (Magnitude) 09 70
Usage (Offset) 09 6F
Usage (Phase) 09 71
Logical Maximum (255) 26 FF 00
Report Size (8) 75 08
Report Count (3) 95 03
Output (Data,Var,Abs) 91 02

Usage (Period) 09 72
Logical Maximum (10000) 26 10 27
Physical Maximum (10000) 46 10 27
Unit (Eng Lin:Time) 66 03 10
Unit Exponent (-3) 55 0D
Report Size (16) 75 10
Report Count (1) 95 01
Output (Data,Var,Abs) 91 02
Physical Maximum (0) 45 00
Unit (None) 65 00
Unit Exponent (0) 55 00
End_COLLECTION C0

; Constant Force Report Definition
Usage (Set Constant Force Report) 09 73
Collection (Logical) A1 02
Report_ID (5) 85 05
Usage (Parameter Block Offset) 09 23
Logical Maximum (32765) 26 FD 7F
Report Size (15) 75 0F
Report Count (1) 95 01
Output (Data,Var,Abs) 91 02
USAGE (ROM Flag) 09 24
LOGICAL_MAXIMUM (1) 25 01
REPORT_SIZE (1) 75 01
OUTPUT (Data,Var,Abs) 91 02

USAGE (Magnitude) 09 70
LOGICAL_MAXIMUM (255) 26 FF 00
REPORT_SIZE (8) 75 08
OUTPUT (Data,Var,Abs) 91 02
END_COLLECTION C0
END_COLLECTION C0

;Ramp Force Report Definition
USAGE (Set Ramp Force Report) 09 74
COLLECTION (Logical) A1 02
REPORT_ID (6) 85 06
USAGE (Parameter Block Offset) 09 23
LOGICAL_MAXIMUM (32765) 26 FD 7F
REPORT_SIZE (15) 75 0F
REPORT_COUNT (1) 95 01
OUTPUT (Data,Var,Abs) 91 02

USAGE (ROM Flag) 09 24
LOGICAL_MAXIMUM (1) 25 01
REPORT_SIZE (1) 75 01
OUTPUT (Data,Var,Abs) 91 02

USAGE (Ramp Start) 09 75
USAGE (Ramp End) 09 76
LOGICAL_MAXIMUM (255) 26 FF 00
REPORT_SIZE (8) 75 08
REPORT_COUNT (2) 95 02
OUTPUT (Data,Var,Abs) 91 02
END_COLLECTION C0

;Custom Force Data Report Definition
; Downloads are always into RAM space so the ROM usage is not declared.
USAGE (Custom Force Data Report) 09 68
COLLECTION (Logical) A1 02
REPORT_ID (7) 85 07
USAGE (Parameter Block Offset) 09 23
LOGICAL_MAXIMUM (32765) 26 FD 7F
REPORT_SIZE (15) 75 0F
REPORT_COUNT (1) 95 01
OUTPUT (Data,Var,Abs) 91 02

USAGE (Generic Desktop:Byte Count) 0B 3B 00 01 00
LOGICAL_MAXIMUM (256) 26 00 01
REPORT_SIZE (9) 75 09
OUTPUT (Data,Var,Abs) 91 02

USAGE (Custom Force Data) 09 69
LOGICAL_MAXIMUM (255) 26 FF 00
REPORT_SIZE (8) 75 08
REPORT_COUNT (256) 96 00 01
OUTPUT (Data,Var,Abs,Buf) 92 02 01
END_COLLECTION C0
Download Force Sample Definition

```plaintext
; Define the Custom Force parameter block
; Custom Effects are always RAM based
; so ROM flags are not declared.

; Report Definition
```
REPORT_SIZE (8) 75 08
OUTPUT (Data,Ary,Abs) 91 00
END_COLLECTION C0

USAGE (Loop Count) 09 7C
LOGICAL_MINIMUM (0) 15 00
LOGICAL_MAXIMUM (255) 26 FF 00
OUTPUT (Data,Ary,Abs) 91 00
END_COLLECTION C0

;PID Pool Report Definition
USAGE (PID Pool Report) 09 7F
COLLECTION (Logical) A1 02
REPORT_ID (1) 85 01
USAGE (PID Pool Report) 09 7F
USAGE (RAM Pool Size) 09 80
USAGE (ROM Pool Size) 09 81
LOGICAL_MAXIMUM (32765) 26 FD 7F
REPORT_COUNT (3) 95 03
REPORT_SIZE (16) 75 10
FEATURE (Data,Var,Abs) B1 02

USAGE (Parameter Block Size) 09 A8
COLLECTION (Logical) A1 02
USAGE (Set Effect Report) 09 21
USAGE (Set Envelope Report) 09 5A
USAGE (Set Condition Report) 09 5F
USAGE (Set Periodic Report) 09 6E
USAGE (Set Constant Force Report) 09 73
USAGE (Set Ramp Force Report) 09 74
USAGE (Set Custom Force Report) 09 6B
LOGICAL_MAXIMUM (255) 26 FF 00
REPORT_SIZE (8) 75 08
REPORT_COUNT (7) 95 07
FEATURE (Data,Var,Abs) B1 02
END_COLLECTION C0

LOGICAL_MAXIMUM (1) 25 01
REPORT_SIZE (7) 75 07
REPORT_COUNT (1) 95 01
FEATURE (Cnst,Var,Abs) ; 7-bit pad B1 03
USAGE (Isoch Custom Force Enable) 09 67
REPORT_SIZE (1) 75 01
FEATURE (Data,Var,Abs) B1 02
END_COLLECTION C0

;PID State Report Definition
USAGE (PID State Report) 09 92
COLLECTION (Logical) A1 02
REPORT_ID (2) 85 02
USAGE (Effect Block Index) 09 22
LOGICAL_MAXIMUM (127) 25 7F
REPORT_SIZE (7) 75 07
FEATURE (Data,Var,Abs) B1 02

USAGE (ROM Flag) 09 24
LOGICAL_MAXIMUM (1) 25 01
REPORT_SIZE (1) 75 01
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REPORT_COUNT (1) 95 01
INPUT (Data,Var,Abs) 81 02

USAGE (PID Effect State) 09 93
COLLECTION (Logical) A1 02
USAGE (ES Playing) 09 94
USAGE (ES Stopped) 09 95
LOGICAL_MINIMUM (1) 15 01
LOGICAL_MAXIMUM (2) 25 02
REPORT_SIZE (2) 75 02
FEATURE (Data,Ary,Abs) B1 00
END_COLLECTION C0

USAGE (Actuators Enabled) 09 A0
USAGE (Safety Switch) 09 A4
USAGE (Actuator Power) 09 A6
LOGICAL_MINIMUM (0) 15 00
LOGICAL_MAXIMUM (1) 25 01
REPORT_SIZE (1) 75 01
REPORT_COUNT (3) 95 03
FEATURE (Data,Var,Abs) B1 02

FEATURE (Cnst,Var,Abs) ; 3-bit pad B1 03
END_COLLECTION C0

;PID Pool Move Report Definition
USAGE (PID Pool Move Report) 09 85
COLLECTION (Logical) A1 02
REPORT_ID (11) 85 0B
USAGE (Move Source) 09 86
USAGE (Move Destination) 09 87
USAGE (Move Length) 09 88
LOGICAL_MAXIMUM (32767) 26 FF 7F
REPORT_SIZE (16) 75 10
REPORT_COUNT (3) 95 03
OUTPUT (Data,Var,Abs,Buf) 92 02 01
END_COLLECTION C0
END_COLLECTION C0

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# 7. Example Reports

**Figure 3: Example PID Data Input Report**

<table>
<thead>
<tr>
<th>Byte</th>
<th>Bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Report ID = 1</td>
</tr>
<tr>
<td>1</td>
<td>Throttle</td>
</tr>
<tr>
<td>2</td>
<td>X-axis</td>
</tr>
<tr>
<td>3</td>
<td>Y-axis</td>
</tr>
<tr>
<td>4</td>
<td>Button 4</td>
</tr>
</tbody>
</table>

**Figure 4: Example PID Set Effect Output Report**

<table>
<thead>
<tr>
<th>Byte</th>
<th>Bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Report ID = 1</td>
</tr>
<tr>
<td>1</td>
<td>ROM Flag</td>
</tr>
<tr>
<td>2</td>
<td>Effect Type</td>
</tr>
<tr>
<td>3</td>
<td>Duration</td>
</tr>
<tr>
<td>5</td>
<td>Sample Period</td>
</tr>
<tr>
<td>6</td>
<td>Gain</td>
</tr>
<tr>
<td>7</td>
<td>Trigger Button</td>
</tr>
<tr>
<td>8</td>
<td>Trigger Repeat Interval</td>
</tr>
<tr>
<td>9</td>
<td>Pad</td>
</tr>
<tr>
<td>10</td>
<td>X Axis Direction</td>
</tr>
<tr>
<td>11</td>
<td>Y Axis Direction</td>
</tr>
<tr>
<td>12 - 13</td>
<td>Type Specific Block Offset 1</td>
</tr>
<tr>
<td>14 - 15</td>
<td>Type Specific Block Offset 2</td>
</tr>
</tbody>
</table>
## Figure 5: Example PID Set Envelope Output Report

<table>
<thead>
<tr>
<th>Bit</th>
<th>Byte</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>ROM Flag</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Report ID = 2
- Parameter Block Offset (bits 0 – 7)
- Parameter Block Offset (bits 8 – 14)
- Attack Level
- Attack Time
- Fade Level
- Fade Time

## Figure 6: Example PID Set Condition Output Report

<table>
<thead>
<tr>
<th>Bit</th>
<th>Byte</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>ROM Flag</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Report ID = 3
- Parameter Block Offset (bits 0 – 7)
- Parameter Block Offset (bits 8 – 14)
- CP Offset
- Positive Coefficient
- Negative Coefficient
- Positive Saturation
- Negative Saturation
- Dead Band
### Figure 7: Example PID Set Periodic Output Report

<table>
<thead>
<tr>
<th>Byte</th>
<th>Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7–0</td>
<td>Report ID = 4</td>
</tr>
<tr>
<td>1</td>
<td>7–0</td>
<td>Parameter Block Offset (bits 7–0)</td>
</tr>
<tr>
<td>2</td>
<td>ROM</td>
<td>Parameter Block Offset (bits 14–8)</td>
</tr>
<tr>
<td>3</td>
<td>Flag</td>
<td>Magnitude</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Offset</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Phase</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Period</td>
</tr>
</tbody>
</table>

### Figure 8: Example PID Set Constant Force Output Report

<table>
<thead>
<tr>
<th>Byte</th>
<th>Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7–0</td>
<td>Report ID = 5</td>
</tr>
<tr>
<td>1</td>
<td>7–0</td>
<td>Parameter Block Offset (bits 7–0)</td>
</tr>
<tr>
<td>2</td>
<td>ROM</td>
<td>Parameter Block Offset (bits 14–8)</td>
</tr>
<tr>
<td>3</td>
<td>Flag</td>
<td>Magnitude</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Figure 9: Example PID Set Ramp Force Output Report

<table>
<thead>
<tr>
<th>Byte</th>
<th>Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7–0</td>
<td>Report ID = 6</td>
</tr>
<tr>
<td>1</td>
<td>7–0</td>
<td>Parameter Block Offset (bits 7–0)</td>
</tr>
<tr>
<td>2</td>
<td>ROM</td>
<td>Parameter Block Offset (bits 14–8)</td>
</tr>
<tr>
<td>3</td>
<td>Flag</td>
<td>Ramp Start</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Ramp End</td>
</tr>
</tbody>
</table>
### Figure 10: Example PID Set Custom Force Data Output Report

<table>
<thead>
<tr>
<th>Byte</th>
<th>Bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Report ID = 7</td>
</tr>
<tr>
<td>1</td>
<td>Parameter Block Offset (bits 7 – 0)</td>
</tr>
<tr>
<td>2</td>
<td>Parameter Block Offset (bits 14 – 8)</td>
</tr>
<tr>
<td>3</td>
<td>Byte Count (bits 8-1)</td>
</tr>
<tr>
<td>4-259</td>
<td>Custom Force Data (256 bytes)</td>
</tr>
</tbody>
</table>

### Figure 11: Example PID Download Force Sample Output Report

<table>
<thead>
<tr>
<th>Byte</th>
<th>Bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Report ID = 8</td>
</tr>
<tr>
<td>1</td>
<td>X Axis</td>
</tr>
<tr>
<td>2</td>
<td>Y Axis</td>
</tr>
</tbody>
</table>

Note: This report is never actually transferred.

### Figure 12: Example PID Set Custom Force Output Report

<table>
<thead>
<tr>
<th>Byte</th>
<th>Bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Report ID = 9</td>
</tr>
<tr>
<td>1-2</td>
<td>Parameter Block Offset</td>
</tr>
<tr>
<td>3-4</td>
<td>Custom Force Data Offset</td>
</tr>
<tr>
<td>5-6</td>
<td>Sample Count</td>
</tr>
</tbody>
</table>

### Figure 13: Example PID Effect Operation Output Report

<table>
<thead>
<tr>
<th>Byte</th>
<th>Bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Report ID = 10</td>
</tr>
<tr>
<td>1</td>
<td>ROM Flag</td>
</tr>
<tr>
<td>2</td>
<td>Operation</td>
</tr>
<tr>
<td>3</td>
<td>Loop Count</td>
</tr>
</tbody>
</table>
### Figure 14: Example PID Pool Feature Report

<table>
<thead>
<tr>
<th>Byte</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- **Bit 0**: Report ID = 1
- **Bit 1**: RAM Pool Size
- **Bit 3**: ROM Pool Size
- **Bit 5**: ROM Effect Block Count
- **Bit 7**: Parameter Block Size (Set Effect Report)
- **Bit 8**: Parameter Block Size (Set Envelope Report)
- **Bit 9**: Parameter Block Size (Set Condition Report)
- **Bit 10**: Parameter Block Size (Set Periodic Report)
- **Bit 11**: Parameter Block Size (Set Constant Force Report)
- **Bit 12**: Parameter Block Size (Set Ramp force Report)
- **Bit 13**: Parameter Block Size (Set Custom Force Report)
- **Bit 14**: Custom Force Enable

### Figure 15: Example PID State Feature Report

<table>
<thead>
<tr>
<th>Byte</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- **Bit 0**: Report ID = 2
- **Bit 1**: ROM Flag
- **Bit 2**: Effect Block Index
- **Bit 2**: Pad
- **Bit 3**: Actuator Power
- **Bit 4**: Safety Switch
- **Bit 5**: Enable Actuators
- **Bit 6**: PID State

### Figure 16: Example PID Custom Force Streaming Output Report

<table>
<thead>
<tr>
<th>Byte</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- **Bit 0**: X Axis
- **Bit 1**: Y Axis
**Figure 17: Example PID Pool Move Output Report**

<table>
<thead>
<tr>
<th>Byte</th>
<th>Bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Report ID = 11</td>
</tr>
<tr>
<td>1</td>
<td>Move Source</td>
</tr>
<tr>
<td>3</td>
<td>Move Destination</td>
</tr>
<tr>
<td>5</td>
<td>Move Length</td>
</tr>
</tbody>
</table>
8. Parameter Blocks
Depending on the Effect Type the Type Specific Parameters of the Effect Parameter Block will point to or provide a Handle for other Parameter Block types.

Position Dependence and Position Independence is related to the position of the actuator not the position in the Pool.

Figure 18: Parameter Blocks