

## Introduction

AMC Digiflex Performance servo drives with CANOpen communication support a mode of operation defined as Interpolated Position Mode in the CANOpen DS-402 servo drive device standard.

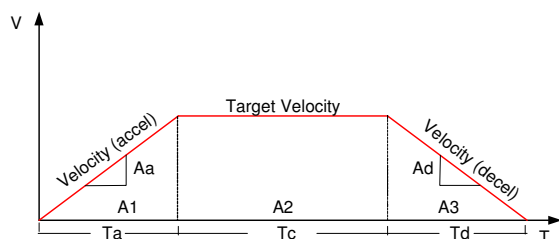
## What is PVT?

Interpolated Position Mode or PVT as it is known is a method of distributing some of a servo systems trajectory generation into the servo drive. The drive accepts as its command over the CAN network a series of PVT points. Each PVT point consists of a Position, a Velocity, and a Time. The servo drive is responsible for interpolating between the points to come up with the desired position trajectory. For a more detailed explanation of PVT, consult the AMC CANOpen Communication Manual.

## Describing a PVT Trajectory

To describe a trajectory, the controller needs to derive a collection of PVT points that define the trajectory. This can be a difficult task for newcomers to PVT. This paper will examine the derivation of PVT points for one of the most common types of trajectories, a trapezoidal velocity profile. Below is a typical trapezoidal velocity profile.

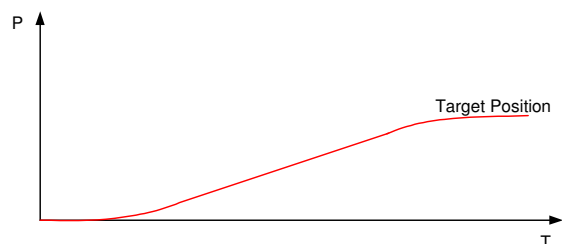
### Trapezoidal Velocity Profile



The trapezoidal profile can be broken down into three segments. Segment A1 is the region of constant acceleration. The acceleration is the rate of change of velocity and is denoted by Aa. Segment A2 is the region of zero acceleration the drive has reached the target velocity and no further change in speed is needed. Segment A3

is the region of constant deceleration and is denoted by Ad. When the parameters for acceleration, deceleration, and target velocity are chosen properly, the resulting motion resembles an S-curve shape. This results in a smooth position profile with minimal jerk. A typical S-curve move is shown below.

### Resulting S-Curve Position



Using the velocity profile depicted, a set of equations can be derived to generate the necessary PVT points.

## Determining Total Profile Time

Given the desired velocity, acceleration and deceleration, the total time required to make the move can be calculated. The approach is to break the velocity profile down to three discrete intervals as described by the areas A1, A2 and A3. For the interval denoted A1, the time it takes for the velocity to reach the target velocity can be found:

$$T_a = \frac{\text{Target Velocity}}{A_a} \quad (\text{eqn 1})$$

Likewise, the time it takes for deceleration can be found using Eqn 1 and substituting in the deceleration value:

$$T_d = \frac{\text{Target Velocity}}{A_d} \quad (\text{eqn 2})$$

To determine the time at zero acceleration Tc, the distance moved during constant acceleration and constant deceleration must be known. The

areas A1 and A3 represent the distance during these regions, and knowing that the total area under the velocity curve represents the total position to move:

$$T_c = \frac{\text{TargetPos} - \left[ \frac{1}{2} \cdot \text{TargetVel} \cdot (T_a + T_d) \right]}{\text{TargetVel}} \quad (\text{eqn 3})$$

The total time to move is:

$$T_{TOTAL} = T_a + T_c + T_d \quad (\text{eqn 4})$$

The total time required to make the desired motion is useful to determine the interval necessary between PVT points. The interval of PVT points is calculated given a desired number of PVT points as:

$$PVT \text{ interval} = \frac{T_{TOTAL}}{\# PVT \text{ points}} \quad (\text{eqn 5})$$

Careful consideration must be given as to the number of PVT points to use. Too few points and the drive will not be able to follow the velocity profile accurately. Too many points results in excessive network traffic over the CAN Bus.

**Note:** The maximum PVT interval depends on the network being used. For CANopen, do not exceed 255msec.

### Position during acceleration interval

The position traveled during the interval of acceleration is calculated by integrating the velocity equation at each interval of PVT points:

$$Pos = \int Aa \cdot t \cdot dt + \int Vo \cdot dt \quad (\text{eqn 6})$$

With a zero starting velocity ( $Vo$ ) and constant acceleration this equation reduces to:

$$Pos = \frac{1}{2} Aa \cdot t^2 \quad (\text{eqn 7})$$

The position at the end of the interval is given by:

$$A1 = \frac{1}{2} \cdot T_a \cdot \text{TargetVel} \quad (\text{eqn 8})$$

The velocity for this interval is given by:

$$Vel_{ACCEL} = Aa \cdot t \quad (\text{eqn 9})$$

### Position during zero acceleration interval

The distance traveled during the interval of zero acceleration is given by the following equation:

$$Pos = \int \text{TargetVel} \cdot dt + Pos_{Begin} \quad (\text{eqn 10})$$

Where:

$$Pos_{Begin} = \frac{1}{2} T_a \cdot \text{TargetVel} \quad (\text{eqn 11})$$

The area under the interval of zero acceleration represents the distance gained while at constant velocity:

$$A2 = \int \text{TargetVel} \cdot dt \quad (\text{eqn 12})$$

At the end of the zero acceleration interval (constant velocity) this equation reduces to:

$$A2 = \text{TargetVel} \cdot T_c \quad (\text{eqn 13})$$

Position is given at the end of the interval as:

$$Pos = \text{TargetVel} \cdot T_c + Pos_{Begin} \quad (\text{eqn 14})$$

Or simply stated as:

$$Pos = A1 + A2 \quad (\text{eqn 15})$$

### Position during deceleration interval

During the deceleration interval, the position gained is given by:

$$A3 = \frac{1}{2} \cdot Td \cdot T \text{ arg etVel} \text{ (eqn 16)}$$

$$Pos = \int Ad \cdot dt + \int T \text{ arg etVel} \cdot dt + Pos_{\text{Begin}} \text{ (eqn 17)}$$

Where:

$$Pos_{\text{Begin}} = A1 + A2 \text{ (eqn 18)}$$

This reduces to:

$$T \text{ arg etPos} = -\frac{1}{2} Ad \cdot t^2 + T \text{ arg etVel} \cdot t + (A1 + A2) \text{ (eqn 18)}$$

The velocity for this interval is given by:

$$Vel_{\text{DECEL}} = Ad \cdot t + T \text{ arg etVel} \text{ (eqn 19)}$$