Allen-Bradley

Application Note

Simple PLC-Based Motion Control for the Ultra1500™

Thanks to the advent of more cost-effective and easy to implement servo-based motion control products, motion control can be used in applications that could not previously bear the cost. However, the servo hardware (drive, motor, and interconnect cables) are only part of the overall motion solution. In many applications, engineers also need the control functionality of a programmable controller. Thus, one of the most effective approaches to providing a complete cost-effective motion control solution is to use a programmable control system that has motion capabilities.

Such motion control systems can be broken into two broad categories:

- Simple, non-interpolated motion refers to single axis or dual axes control. It is primarily used for positioning – moving an object from point A to point B. Examples of simple motion include pick-and-place systems and conveyor control. A simple motion model may have multiple axes, but each axis is controlled independently of the other axes.

- Interpolated motion is a complex and coordinated motion. It has multiple axes that are constantly being positioned with regard to each other. Interpolated motion is used extensively in machining processes and complex 3-D positioning applications.

One of the easiest and least expensive methods of implementing non-interpolated motion control is selecting a control device that includes Pulse Train Output (PTO) functionality. Simply put, PTO functionality is the ability of a controller to accurately generate a specific number of pulses at a specified frequency. These pulses are sent to a motion device, such as a servo drive, which in turn controls the number of rotations (position) of a servo motor. A control device's ability to generate pulses is only the tip of the iceberg. How a device generates those pulses as well as its ability to define frequency at multiple stages truly determines the motion control system's capabilities. Rudimentary pulse generation is of course necessary to initiate and conclude motion within the system. However, a more sophisticated motion profile – marked by gradual acceleration, operation at a constant speed for a given distance, and gradual deceleration – is usually needed to reduce or eliminate the likelihood of damage to both products and equipment. Figure 1 shows two such motion profiles.

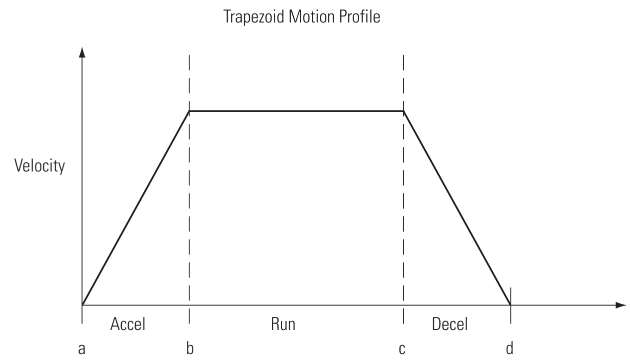
Figure 1. Two Motion Control Profiles

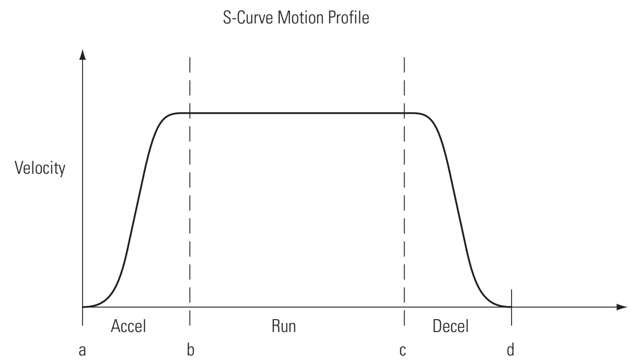
On the top is a trapezoid slope, which shows acceleration and deceleration at a constant rate.

The S-curve on the bottom is more sophisticated, it shows gradual acceleration and deceleration.

Either of these profiles eliminates the problem of going from a stopped position straight to full speed. The application, or work to be performed determines which profile is appropriate. A trapezoid slope provides the most basic level of acceleration and deceleration. The S-curve is more advanced. It allows products and equipment to be moved at higher speeds because abrupt changes in movement are avoided, by velocity transitions that are absent from a trapezoid move.

Refer to the legend table below to identify the components of each profile.





Velocity	Pulse train output in pulses/sec (frequency)
Accel	Acceleration ramp to reach Run (in pulses)
Run	Number of pulses at selected velocity
Decel	Deceleration ramp to full stop (in pulses)
a	Home (start)
a – b	Accel phase ramp (a to b run in pulses)
b	Run (start)
b – c	Run phase (number of pulses at maximum velocity)
c	Decel (start)
c - d	Decel phase (c to d in pulses)
d	Destination (end) Total length of move (a to d) in pulses

The MicroLogix™ Motion Control Solution

MicroLogix is an excellent choice for non-interpolated, trapezoidal motion, both because of its PTO functionality as well as its ability to interface with motion hardware (drives, motors, etc.).

The MicroLogix PTO Functionality

The 1762-L24BXB or 1762-L40BXB (MicroLogix 1200) has one 20 kHz PTO function that can provide a single axis of motion control. The 1764-28BXB (MicroLogix 1500) controller has two 20 kHz PTO functions that can provide two axes of motion control. The two PTOs are independent of each other and can run completely separate and unique motion profiles.

MicroLogix PTO functionality consists of bit, integer and double integer status and control variables. Each variable is protected by access privileges (read only, read/write) and is accessed via program logic. To provide the type of motion that is needed at a given time, the user has only to write the control program to interface with these variables. This implementation method provides extreme versatility in how the PTO function and the user program can work together.

MicroLogix uses separate custom circuitry to implement its PTO functionality. It's not part of the main system processor; rather it runs asynchronously to the system processor. The interface between the user program and the PTO subsystem consists of PTO function files (PTO:0 and PTO:1), and PTO instructions (PTO0 and PTO1).

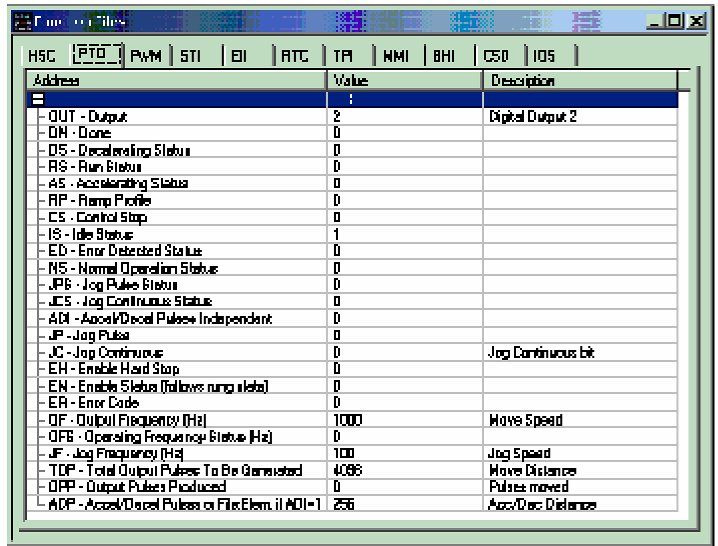
The PTO instruction is basically a command that instructs the main system processor to update the corresponding PTO function. For example, when the PTO0 instruction is scanned on a rung of logic, the main system processor will update the PTO:0 function file. This allows the PTO subsystem to run independent of the controller scan while still providing an efficient interface for the main program to read PTO status and provide the PTO data.

PTO:0 function file and an example rung as shown in RSLogix 500 programming software is illustrated in Figure 2.

To generate a motion profile, the user simply configures the PTO function file sub elements. Afterward, the PTO instruction for that PTO function must be scanned on a true rung of logic. Using the example in Figure 2, when the direction output time delay is complete (T4:12/DN), PTO:0 will be scanned on a true rung of logic. When scanned, the current PTO:0 function file values will be loaded into the PTO:0 circuitry, and the output profile will be started using those values. Once started, the rung state of the PTO instruction does not have any bearing on the generation of pulses. The PTO function is a handoff operation; if the user wants to abort the profile, the hard stop bit must be set (PTO:0/EH). Simply opening the PTO:0 rung will NOT stop generation of pulses.

As the main control program continues to scan the user program, each time the PTO:0 instruction is scanned, the sub elements within the PTO:0 function are updated to represent the current status of the PTO:0 function. When the motion profile completes, all that is required to run PTO:0 again is to toggle the PTO:0 instruction rung from false to true. This generates the same motion profile. If a different profile is needed, you simply load new variables into the respective locations in PTO:0 function file and then toggle the PTO:0 rung.

Figure 2. Function File and Example Rung



Address	Value	Description
OUT - Output	2	Digital Output 2
DN - Done	0	
DS - Decelerating Status	0	
RS - Run Status	0	
AS - Accelerating Status	0	
RP - Ramp Profile	0	
CS - Control Stop	0	
IS - Idle Status	1	
ED - Error Detected Status	0	
NS - Normal Operation Status	0	
JPS - Jog Pulse Status	0	
JCS - Jog Continuous Status	0	
ADI - Accel/Decel Pulses Independent	0	
JP - Jog Pulse	0	
JC - Jog Continuous	0	Jog Continuous bit
EH - Enable Hard Stop	0	
EN - Enable Status (follows rung state)	0	
ER - Error Code	0	
OF - Output Frequency (Hz)	1000	Move Speed
OFS - Operating Frequency Status (Hz)	0	
JF - Jog Frequency (Hz)	100	Jog Speed
TOP - Total Output Pulses To Be Generated	4096	Move Distance
OPP - Output Pulses Produced	0	Pulses moved
ADP - Accel/Decel Pulses or File:Elem. if ADI=1	256	Acc/Dec Distance

The control program can read sub elements of each PTO, and can write a subset of sub elements. Sub elements and their respective data ranges are shown in the MicroLogix 1500 Programmable Controllers User Manual (publication 1764-UM001x-EN-P), downloadable from the Literature Library website **http://www.rockwellautomation.com/literature.**

The MicroLogix – Ultra1500 Motion Control Hardware Interface

When using a PLC in non-interpolated motion applications, the control system basically breaks down into two primary systems - the PLC and the motion hardware. Generally, motion hardware consists of drives, cables, and motors. The type of motor - stepper or servo - determines the type of drive necessary for the application.

Stepper drives and motors typically provide the lowest cost motion solution. In stepper applications, the stepper drive sends signals to the motor to move a certain number of pulses. Generally stepper-based systems are open-loop motion systems, i.e. stepper motors rarely provide feedback to the control system. If the motor loses pulses or can't respond correctly to pulses from the drive, the position of the stepper motor relative to what the controller commanded is lost. If this occurs, neither the drive nor the PLC will know the position of the stepper motor.

In servo systems, by comparison, the servo motor usually has a built-in encoder. Because the encoder is wired back to the drive through a separate cable, a servo system is considered to be a closed-loop motion system. Thus, if the motor does not move the distance requested by the PLC, the drive would generate a fault condition, which in turn can be communicated back to the PLC. The PLC can likewise be programmed to clear the fault and start a "homing" sequence to a known position, which is typically a limit or proximity switch for the faulted axis.

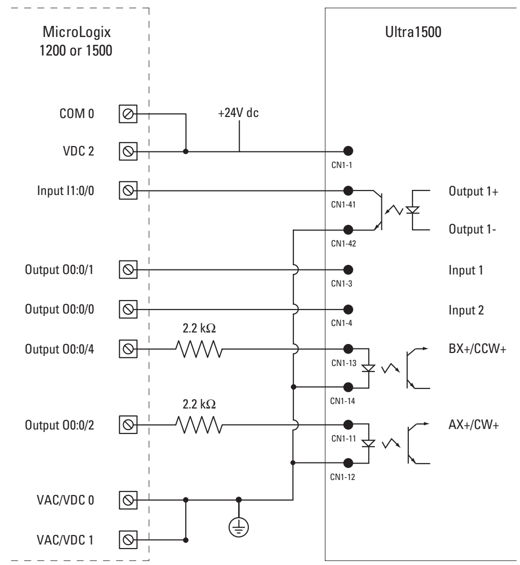
If closed loop positioning is required, a PLC with high speed counter inputs can be connected to the Ultra1500 to provide the position feedback. If extracting absolute position from the drive, the inputs must be rated as greater than (>) 1 MHz/line. External encoders allow the PLC to monitor the actual position and make adjustments as necessary via programmed logic. The Ultra1500 User Manual (publication 2092-UM001x-EN-P) provides application examples in Chapter 5.

Although the PLC and the drive are two independent systems, they must function as a complete motion control system. The following are typical adjustments:

- The Ultra1500 Position Command accommodates open collector inputs to a maximum of 250 kHz, and differential driver inputs to a maximum of 900 kHz. While the frequency of the pulse train output from the MicroLogix controller is limited to 20 kHz, greater frequencies can be accommodated by using a third party stepper card.

- The Allen-Bradley Ultra1500 servo drive, as well as many other motion drives, requires 5Vdc levels for step/direction. At present all MicroLogix modules are powered by 24Vdc, have 24Vdc inputs, and have a combination of 24Vdc solid state and relay outputs. As such, connecting a MicroLogix to the Ultra1500 servo drive, for example, requires a signal conversion. This can be accomplished a number of ways; the simplest is illustrated in Figure 3.

Figure 3. Connecting a MicroLogix 1500 to an Ultra1500 Servo Drive.



- Ultra1500 Step/Direction inputs (AX and BX) are for 5V interfaces, but MicroLogix outputs are 24V. A 2.2 kΩ resistor limits current through the opto-isolated input of the Ultra1500.
- MicroLogix inputs are active low NPN and are wired as sourcing inputs. Refer to the appropriate MicroLogix User Manual for additional information.
- Ultra1500 discrete inputs are active low NPN, but are not compatible with MicroLogix FET outputs. Connect only MicroLogix relay outputs to Ultra1500 inputs.
- Ultra1500 inputs and outputs must be configured using Ultraware software as follows:
  - Input 1 = Fault Reset
  - Input 2 = Drive Enable
  - Output 1 = Drive Ready

The Ultra1500/MicroLogix 1200 demo is available. It ships with an operational program similar to that in Figure 3. If interested, contact you local Allen-Bradley representative.

Reference Documents

The following documents contain additional information concerning related Allen-Bradley products.

- Publication 2092-UM001x-EN-P, Ultra1500 User Manual
- Publication 1762-UM001x -EN-P, MicroLogix 1200 Programmable Controllers - User Manual
- Publication 1764-UM001x -EN-P, MicroLogix 1500 Programmable Controllers - User Manual

To obtain a copy, of these publications contact your local Allen-Bradley office, distributor, or download them from **http://www.rockwellautomation.com/literature**.

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