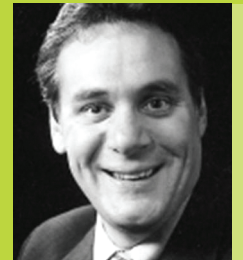




STORY_BRIAN COX,
ADVANCED AUTOMATION DIVISION OF
AEROTECH INC.

DEEP DIVE

[HOW-TO FOR TECHIES]



I think the article is well-written and informative. However, it is primarily geared towards Aerotech's core application focus, that being high-precision laser applications. I have found this feature to be very useful in doing a variety of what would be considered general purpose motion applications. For example, the PSO feature has been useful in triggering the movement of a saw in a flying shear application and in firing a knife in a cut-to-length application. In these applications we not only had the processing power to do the precise triggering of the actuator, we also had the overall horsepower in the product to control the entire process.

**Bill Hicks, Manager of Sales and Marketing
Integrated Industrial Technologies**



In this article the use of the PSO option with lasers is mentioned twice. The article mentions both welding and cutting and offers excellent examples of the PSO operation. However, it could expand upon why this is important for laser weld-

Precise Triggering of External Events Based on Axis Position

Added circuitry and software improve precision and capabilities of motion controller

Precision motion control applications often require triggering an external device based on the actual position of the axis in motion. For many applications, traditional methods of triggering compromise part quality and cycle time. An axis-based trigger in the controller can significantly improve part quality, reduce cycle time, and eliminate other processing problems.

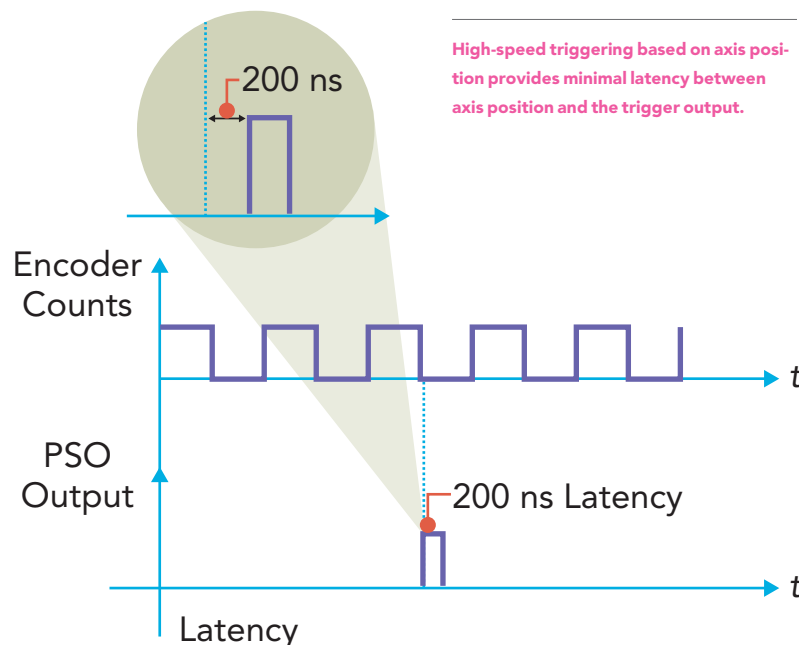
A unique high-speed position-based trigger option that Aerotech calls Position Synchronized Output (PSO) provides benefits to a number of applications. Enabled by a combination of proprietary hardware, software and innovative algorithms, the trigger allows starting, stopping or pulsing a laser for cutting or welding operations. Coordinate measuring machines and optical inspection machines can use PSO to take readings on the fly from measurement probes or cameras, significantly reducing cycle times. In fact, any application that requires precise data acquisition or process action linked to axis position can benefit from PSO functionality.

Traditional Triggering Methods

The first method used to tie an output to the position of a mechanical system consists of stopping the axes and waiting for them to settle to an acceptable value before triggering the output. This approach wastes valuable time, a costly disadvan-

tage in production environments. In addition, poorly tuned systems and those subject to external vibrations or other disturbances might never settle to an acceptable value. If the output is triggered during this time, the part quality or measurement will not be optimum. To overcome the uncertainty of the settle value, the machine designer could be forced to specify a tighter tolerance than would otherwise be required, which could increase the system cost.

A second method uses special tracking hardware or software external to the motion controller to monitor the position of the axes. External tracking hardware is often capable of tracking only a single axis and is not a viable option for



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ing and cutting specifically. It may help readers of the article less technical in motion control to understand if some examples of the benefits were covered. The same would be true for data collection capabilities using the PSO option.

At 181 Engineering, Inc. we have used the PSO option in the integration of laser systems for both welding and cutting applications. This enhanced feature of the Aerotech motion control has allowed our customers to gain precise control of their application. It is an extremely important feature for many aerospace, semiconductor and medical device manufactures. These manufacturers depend on a valid repeatable process that demands close tolerance and inspection criteria. For this reason, the benefit of the PSO features was a crucial part of the decision process in selecting the equipment.

The benefit is apparent in both welding and cutting applications. In cutting application it is important to maintain both kerf width and edge quality of the cut. When cutting complex geometry with fixed laser pulses it is impossible to maintain proper overlap of the laser spot. Even in velocity profiling modes, you will tend to see serrations in the material and deviations in the kerf width during the acceleration and deceleration of the stages. The same is true in hermetic welding applications where weld overlap must be maintained to insure proper penetration of the material.

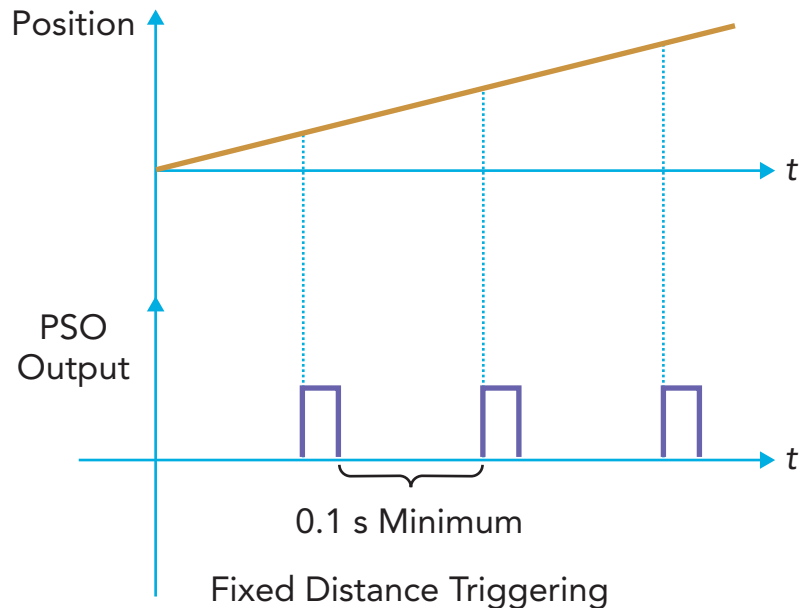
During normal operations the laser is fixed at a specific repetition rate and the control of this nonvariable parameter relies entirely on the motion. The motion must be capable of maintaining velocity during the tight trajectories in complex profiles. In most cases this is not only impossible, but when combined with other process variables

multi-axis tracking. Also, external tracking hardware often is not capable of high tracking rates, resulting in slower processing. Similarly, software can be used to track the axes. This adds complexity to the system and limits the tracking speed, and can also delay the trigger due to the execution time of the software. Hardware and software triggering solutions are often custom-designed by the user, requiring significant time and monetary expense versus using an existing integrated solution.

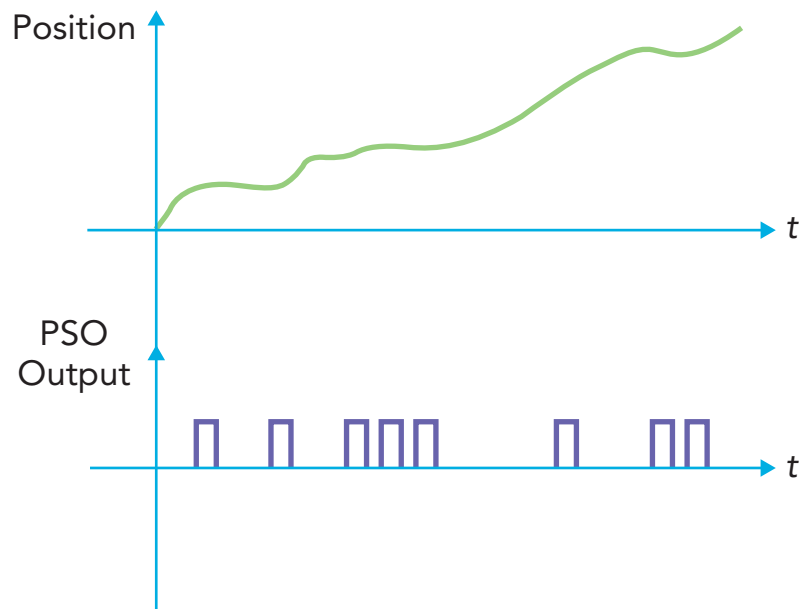
A third method triggers the output based on time, which presents three major problems. First, the user is tied to a time base that can be difficult to accurately maintain, and is asynchronous to the axis' motion. Remember that the critical parameter is axis position, not time. Second, this method does not allow for any errors in the motion. Therefore, velocity regulation (which is difficult to quantify) becomes important, and any variation of the velocity can cause significant errors to the location at which the trigger occurs. The uncertainty of the velocity might lead the machine designer to require unobtainable velocity regulation. Third, the accuracy of the time base and the frequencies of the inputs must be chosen carefully to prevent any missed counts, which can lead to lower maximum speeds.

Position-Based Trigger Advantages

The key feature of PSO is its ability to trigger the output based on the actual position of the axis. Triggering on the actual position eliminates effects that external disturbances may have on the process. For example, velocity regulation and settle values become unimportant since the process is not affected by their uncertainty. Also, the latency between when the axis is at the target position and the actual trig-



A fixed-distance trigger fires a pulse at constant intervals is easily implemented with PSO.



Array-based triggering supports firing an output at arbitrary position intervals.

gering of the output is very low, in the sub-microsecond range. This allows for much higher speeds than traditional high-latency tracking methods because the chance of missed or overlapping events is avoided.

Combined with the low latency of PSO is its ability to trigger multiple pulses in close succession. Trigger rates can be up to 10 MHz, allowing not only high-speed tracking but also the ability to directly control the output puls-

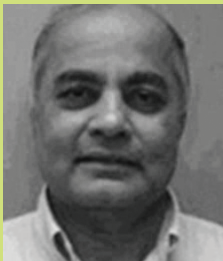


will most likely cause unacceptable results. By precisely controlling the laser repetition through the PSO the laser spot overlap remains the same regardless of velocity variations. The result is not only better cosmetic welds and cleaner cuts, but also more repeatable throughput and increased product yields.

The data collection benefits of the PSO deserves its own complete article.

For replies or response, please contact: Dexter Gocha, General Manager (408-734-8725)

Kevin Woolbright, President, 181 Engineering, Inc.



Having a device which can trigger outputs based on inputs without delay or "dead time" can be very useful, especially in high-end processes where throughput is an important criterion.

Theoretically, the ideal dead time is zero, but this is seldom achievable in practical systems. It takes a finite amount of time for any mechanism to reach its commanded position due to the inevitable settling time before it can be confirmed that the mechanism is indeed at its commanded position and the programmed output can be triggered. Typically, such dead time is in the order of milliseconds and has a direct bearing on the throughput of the motion control system. Narrowing this gap to the micro seconds range can be a real advantage in high-end inspection systems and the like.

Muhammad Mubeen Sr. Research Associate Motion Tech Trends

PSO ALLOWS TRACKING OF UP TO THREE AXES, TRIGGERING THE OUTPUT BASED ON A THREE-DIMENSIONAL VECTOR LENGTH, WHICH CAN BE VERY USEFUL WHEN INSPECTING OR MANUFACTURING COMPLEX PARTS.

es of a laser or perform high-speed data acquisition. PSO allows tracking of up to three axes, triggering the output based on a three-dimensional vector length, which can be very useful when inspecting or manufacturing complex parts. The PSO option reduces cost and system complexity because it does not add any external hardware to the motion system. PSO is an extremely versatile tool, offering a number of tracking and firing options, as well as easy programming.

positions for bitmap type operations, or when working with irregular part geometries. Another common triggering method known as "windowing" allows an input to be set when the axis is precisely within a specified position window. PSO provides up to two windows that can be used to specify two distinct areas of interest in one axis or for two-dimensional windowing. The window functionality can also be coupled with fixed distance triggering to mask the triggering to certain areas of travel. This is particularly useful

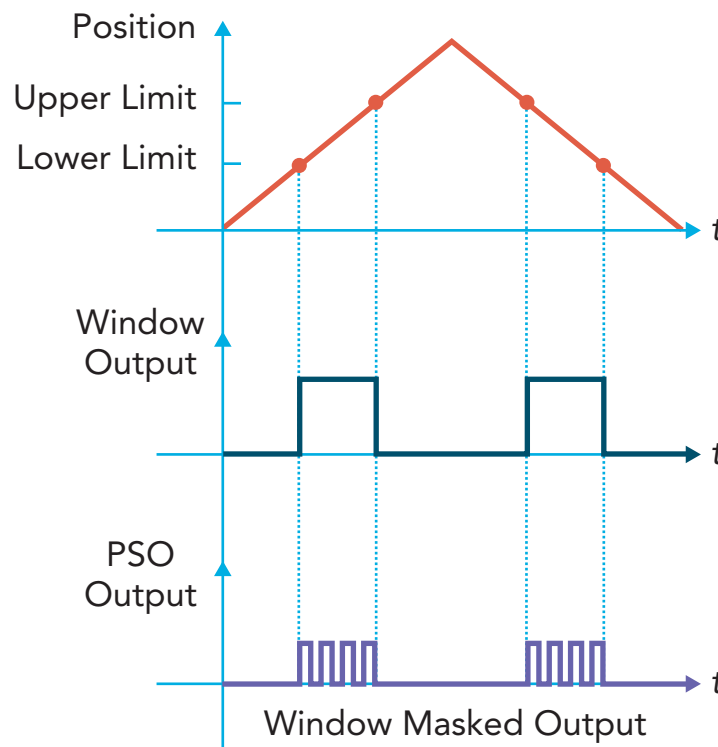
when the processing of a part requires that the axes travel beyond the part for settling or direction reversal when scanning large areas. The PSO can also trigger asynchronously, allowing it to work as a function generator to output an arbitrary frequency with programmable duty cycle.

Because of the inherent high-speed hardware required for PSO functions, its addition to a controller provides some other features such as high-speed data capture and high-speed data update. High-speed data capture allows the user to capture axis position based on a high-speed input with a latency of 100 ns. These position values can be uploaded from the controller and stored in a file for further analysis. The high-speed data update allows the user to set the digital or analog outputs to a specific state or value when the high-speed input or the PSO output is triggered. The data capture/update is useful for applications that require the motion controller to interface with additional complex hardware to complete the process.

When PSO is added to a controller, the user obtains many options to interface to a number of external devices and

complete difficult processes. The high-speed firing options provide precision and speed that is unmatched by home-grown and other traditional solutions, while the data capture/update features provide rapid data collection and status updates for quick and easy integration with external hardware without increasing system cost.

Brian Cox is an applications engineer with five years of motion control experience. He works for the Advanced Automation Division of Aerotech, Inc., and can be contacted at bc Cox@aerotech.com



Windowing coupled with fixed-distance triggering limits triggering to certain areas of travel for improved process control.

Application Examples

PSO has a number of different triggering options, both general and application specific, that make it a useful tool for a variety of applications. The most common option is to trigger on a fixed distance. This method allows the user to trigger a single pulse, or multiple pulses, at constant, pre-specified intervals along the travel. The fixed-distance method is typically used to pulse a laser or to trigger data collection. Array-based triggering allows the user to specify trigger points that are unequally spaced along the travel. Array-based firing can be used to trigger a laser at precise