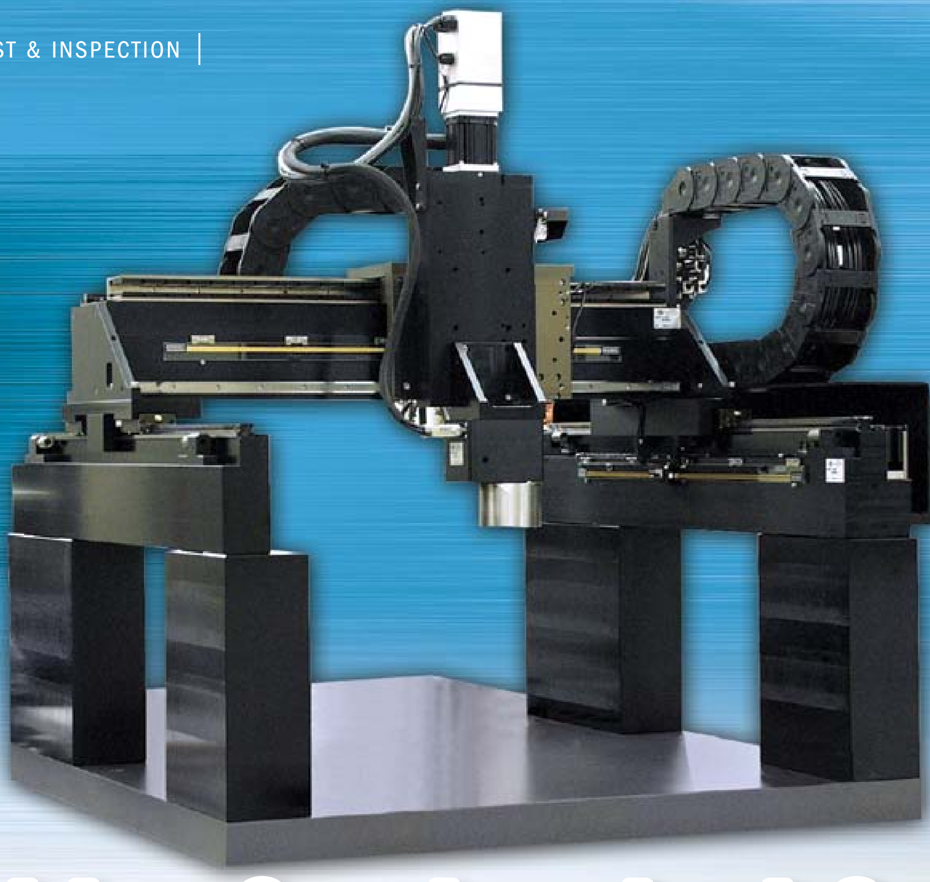


Post processing of sensor output can quickly cull points of nonconforming results. Because PSO ties sensor output to unique positions on the part under test, the motion system can be quickly and easily commanded to return to the offending location for either repair or retest. *Source: Aerotech Inc.*

Position Synchronized Output Provides Flexibility

Knowing the precise position at the moment of sensor triggering has powerful implications in a number of test and inspection applications. BY SCOTT SCHMIDT AND BRIAN COX

A large number of test and measurement requirements rely on data acquisition tied to a specific part feature or location. From defect detection and repair to surface mapping and profiling, the field of applications requiring a tight relationship between sensor output and location in 2- or 3-dimensional space is large and growing as sensor technology advances. Only by polling the sensor output at precisely the correct position can data be reliably gathered and tied to key spatial information.

While some traditional methods exist to attempt to tie part position to sensor output, these strategies often have nonidealities that corrupt the required synchronization or inhibit accurate data collection. In all cases, automated motion is assumed to be moving either the part under test or the sensor itself.

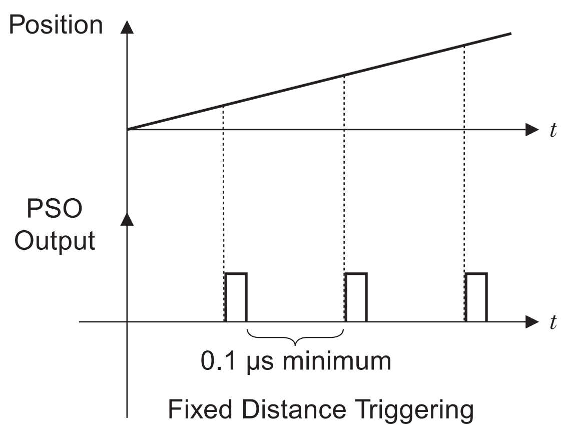
TRADITIONAL METHODS

One method used to tie a sensor output to the position of a mechanical system consists of stopping the automated motion, waiting for it to settle to an acceptable level, and then polling the sensor. This approach wastes valuable time, which is a costly disadvantage in production environments.

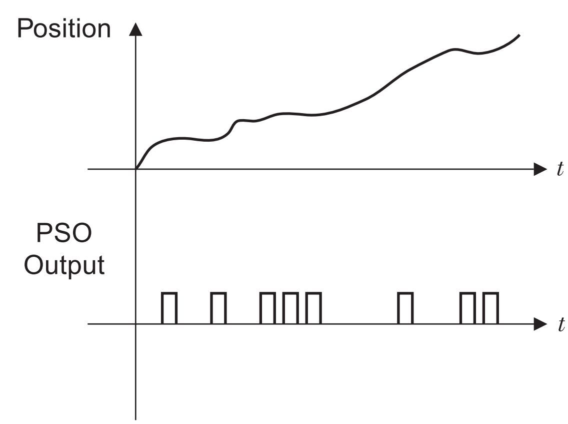
Also, systems whose servo feedback loops are poorly tuned, as well as those

TECH TIPS

- Position synchronized output uses innovative circuitry to deliver the actual encoder-based positional information to the laser in real time.
- Because PSO can be configured for up to three axes of motion, the triggering output pulse can be dependent on a vector position in 3-D space and not simply tied to one moving axis.
- The most common means of implementing PSO in a testing application is to trigger the output pulse on a fixed distance. This method allows the operator to trigger a single pulse, or multiple pulses, at constant, pre-specified intervals along the travel.



The most common means of implementing PSO in a testing application is to trigger the output pulse on a fixed distance. This method allows the operator to trigger a single pulse, or multiple pulses, at constant, prespecified intervals along the travel. The fixed-distance method is typically used to strobe the system's sensor to begin collecting data. ***Source: Aerotech Inc.***



Array-based triggering allows the user to specify trigger points that are unequally spaced along the travel. This style of PSO firing can be used to trigger imaging sensors at precise positions for mapping or contouring operations, or perhaps when working with irregular part geometries. ***Source: Aerotech Inc.***

subject to external vibrations or other disturbances, might never settle to an acceptable value. If the output is triggered during this mechanical instability, measurement quality and synchronization to part position will not be optimum. To overcome the uncertainty and instability of the settle value, the machine designer could be forced to specify a tighter tolerance than would otherwise be required, thereby increasing system cost.

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

Also, external tracking hardware often is incapable of high tracking rates, resulting in slower processing. Custom software can be used to track the axes, but this adds complexity to the system, limits the tracking speed and can delay the trigger due to software execution time. Hardware and software triggering solutions are often custom-designed by the user, requiring significant design time and expense while hampering overall system integration efforts.

A third method triggers the sensor based on time and presents at least three major problems. First, the operator is tied to a time base that can be difficult to accurately maintain, and is typically asynchronous to the actual part/sensor motion—recall that the critical parameter is part position, not time.

Second, this method does not allow for any errors in motion. For instance, velocity regulation, which is difficult to quantify, becomes important, and any variation of the velocity can cause significant errors in the location at which the trigger occurs.

Third, the accuracy of the time base and the frequencies of the inputs must be chosen carefully to prevent any machine counts from being missed by the motion feedback loop, leading to lower maximum speeds.

Clearly, a highly synchronized, integrated and truly position-based means of polling sensor output is required to address the needs of precision test and measurement applications.

POSITION SYNCHRONIZED OUTPUT

A unique solution to this problem lies in the realm of laser processing systems. Because fast shuttering of laser pulses is required for precision welding and marking applications within the laser market, closely tying the motion control system to the laser output is crucial.

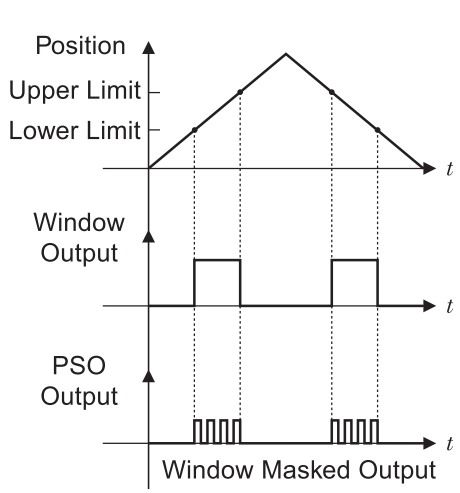
Position synchronized output (PSO) uses innovative circuitry to deliver the actual encoder-based positional information to the laser in real time. Because the signals are transmitted with nanosecond latency, the laser can be shuttered/fired at precisely the correct positions to achieve accurate welds, cuts or marks on the target substrate. Low latency is achieved because the position information is sent by way of dedicated circuits, and not via a software-controlled algorithm.

Because PSO can be configured for up to three axes of motion, the triggering output pulse can be dependent on a vector position in 3-D space and not simply tied to one moving axis. Furthermore, the encoder signals on which the triggering is based are corrected with calibration tables—generated at the actual system work point and applied in real time—enhancing system accuracy.

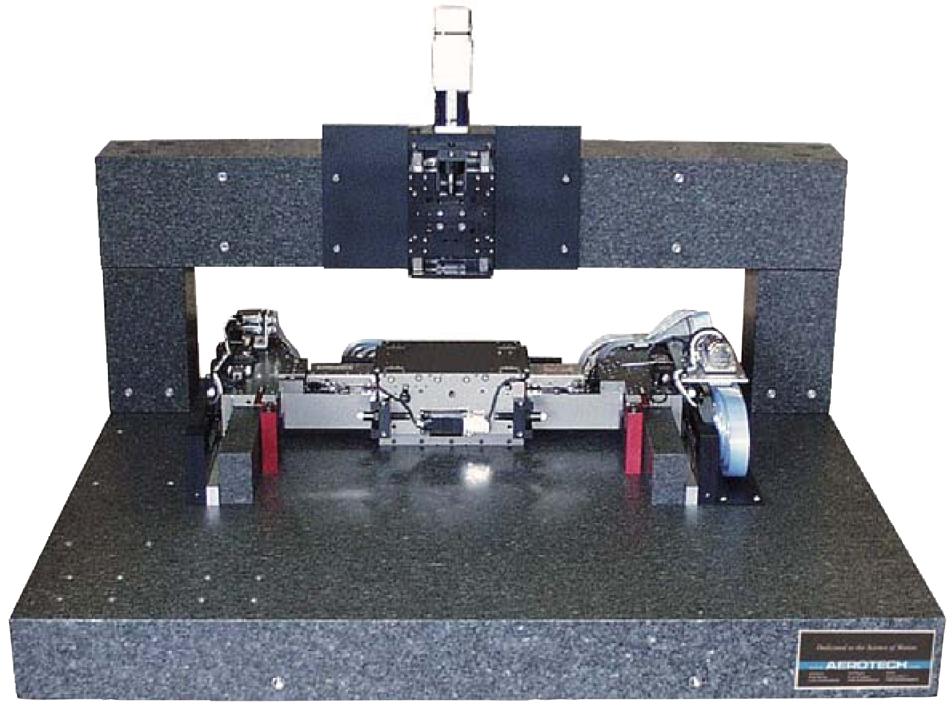
PSO AS A SOLUTION

Knowing the precise position at the moment of sensor triggering has powerful implications in a number of test and inspection applications. As noted earlier, having precise and accurate positional information tied to the moment of the sensor's data collection enhances almost all inspection routines and allows such post-processing features as:

- The ability to retrace to a defect location to effect repairs.
- Post-measurement contour- or feature-mapping based on sensor outputs over an array of positions or scanned areas.
- Coordinate measuring machine (CMM) or modeling of a scanned surface.



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. This functionality also can be coupled with fixed distance triggering to mask the triggering to certain areas of travel. This is particularly useful when direction reversals are required during large area scan routines. ***Source: Aerotech Inc.***



Shown is one example of a motion control platform intended to be used for noncontact surface profilometry. The system mechanics shown feature air-bearing motion to reduce motion-induced flatness errors, and a linear-motor vertical axis provides automated focus of the light-based sensor used for data collection. ***Source: Aerotech Inc.***

- Collection of other motion system-related information such as I/O states, system velocity and dynamic error information at the instant of PSO firing.

PSO functionality unlocks all of these capabilities as well as many others and can be implemented using several flexible design schemes.

The most common means of implementing PSO in a testing application is to trigger the output pulse on a fixed distance. This method allows the operator to trigger a single pulse, or multiple pulses, at constant, prespecified intervals along the travel. The fixed-distance method is typically used to strobe the system's sensor to begin collecting data.

Array-based triggering allows the user to specify trigger points that are unequally spaced along the travel. This style of PSO firing can be used to trigger imaging sensors at precise positions for mapping or contouring operations, or perhaps 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. This functionality also can be coupled with fixed distance triggering to mask the triggering to certain areas of travel. This is particularly useful when direction reversals are required during large area scan routines.

Furthermore, PSO also can trigger asynchronously, allowing it to work as a function generator to output an arbitrary frequency with programmable duty cycle to third-party devices.

APPLICATIONS

One application example that highlights the power of PSO is surface profiling or contouring of optical flats and other shapes. Although sensor technology such as chromatic aberration, white light, as well as many other noncontact techniques, have matured over the past few years, tying the high-precision outputs from these sensors to actual optical-flat positions is mandatory if the resulting data is to have any actionable meaning.

PSO triggering during continuous scans over the circular optical flat permits a number of sensor images to be collected at precise and, more importantly, well-known positions across and along the part.

Because the positional data is trustworthy and tightly tied to sensor output timing, a contour map of the resulting image data can be easily reconstructed by stitching the data points together.

This specific application also highlights the use of windowing. Only data points over the surface of interest—in this case the central 300 millimeters by 300 millimeters of the optical flat—were measured. Extraneous data points were not gathered, and overall data buffering and system memory requirements were reduced as a result of this decreased data load.

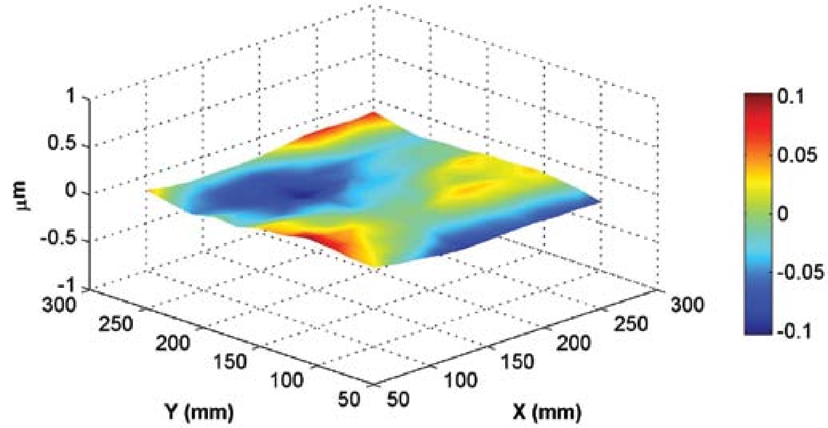
Furthermore, the multiaxis nature of PSO allows 3-D mapping to be accomplished, with the third dimension in the plot provided by the sensor output. The fact that vector position is tied to the moment of sensor triggering guarantees positional fidelity instead of forcing the user to infer off-axis positional stability in the case of step and scan applications.

Note that if PSO had not been employed, either the scanning process would have been slowed to a point-to-point process with settle times in-between each data collection, or the system would have had to accommodate velocity errors from the motion system and simply trust in the now uncontrolled timing of the automation system.

A second interesting use of PSO for inspection lies in defect detection. Post processing of sensor output can quickly cull points of nonconforming results. Because PSO ties sensor output to unique positions on the part under test, the motion system can be quickly and easily commanded to return to the offending location for either repair or retest.

Clearly without PSO capability, a system such as this one would rely on complicated and expensive external mapping circuitry or software to reliably return to defect locations.

With the addition of PSO to an automation controller, the operators obtain great flexibility in interfacing with a number of external devices and complete difficult measurement processes. The high-speed triggering 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.



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