Double-Sided Fiber Optic Alignment with H-206 Hexapod

Leveraging the multi-axis alignment features of an industry workhorse

Background and History

H-206 is a unique industrial tool since it integrates fast alignment algorithms, six-axis positioning, virtualized rotation and fast optical or analog metrology. Introduced in 1997 as the first photonics/telecom boom began to emerge, PI has continuously invested in engineering to enhance its speed, capabilities and integrability into fab automation systems.

Figure 1. The H-206 HexAlign hexapod microrobot provides six degrees of freedom of 0.1μm-precision motion in a vastly more compact and responsive package than any equivalent stack of stages.

Today, the H-206 and its C-887 controller offers fast, networkable interfacing, 0.1μm/0.1millidegree resolution and micron-scale step/settle responsiveness on the order of 25msec. But one of its biggest contributors to photonics manufacturing economics is its wealth of built-in scan/align algorithms and their flexibility and speed.

A good example of an application benefiting from this integration is the case of waveguide characterization and packaging.

Meeting the Waveguide Alignment Challenge

One of H-206's signature capabilities is to find first-light for a coupling and then optimize it rapidly …with a single command, and without bandwidth- and time-consuming repetitive communications with the controlling computer. It achieves this through an automated sequence called (sensibly enough) "Fast Scan and Align."

As with all commands in PI's General Command Set (leveraged throughout all controller product offerings to facilitate software commonality across models), the corresponding command is mnemonic and easy to use: *FSA.*

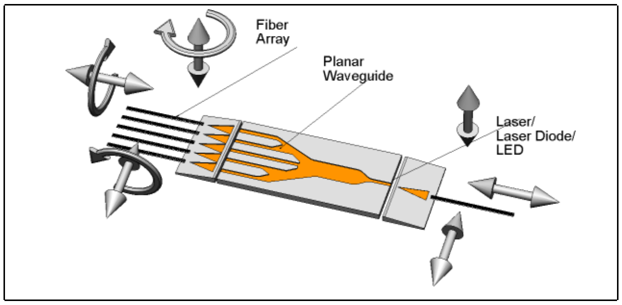
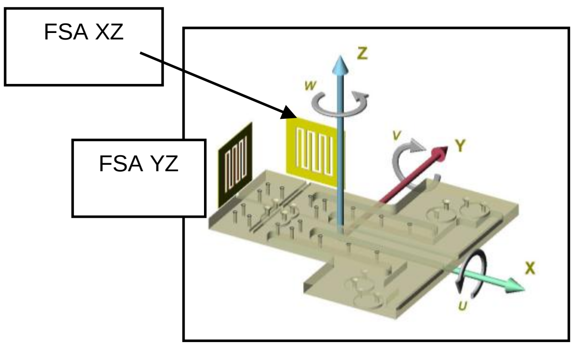


Figure 2. Waveguide alignment process economics benefit from F-206's array of built-in alignment algorithms.

The process engineer can choose between issuing the command to PI's Windows .dll, Linux .so, OS X .dylib, LabVIEW .vi or just issue the equivalent ASCII string.

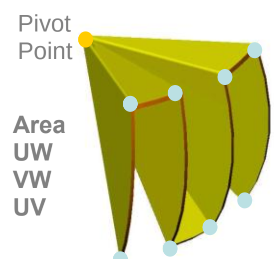


Parameters for *FSA* are the scan axes (linear or angular), scan extent, first-light threshold, and the step size appropriate for the coupling.
FSA will then commence a fast raster scan with fully integrated synchronous optical or analog metrology via the C-887's built-in fast, FC-connectorized optical power meter and analog-digital converter.

As the specified first-light threshold is achieved, *FSA* automatically transitions to a hill-climb gradient search, allowing the system to fully optimize coupling.

This hybrid approach, which combines fast-raster and gradient-search modes, leverages the strengths of each. The wide-area capture capability of the raster scan combined with the programmable first-light threshold ensure that the gradient search commences on the main mode of the coupling, avoiding spurious lock-on to local maxima. Meanwhile the gradient search allows high-resolution localization of the optimum coupling position.

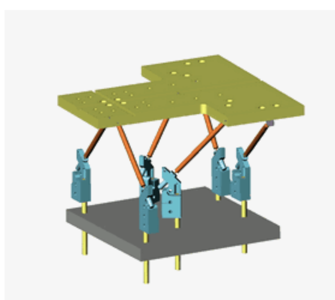
For angular *FSA* alignments, rotational motions are performed around the user-settable rotational center-point, a valuable capability that allows the user to programmatically place the pivot-point at an optical sweet spot, such as the focus of a lensed element or the output face of a waveguide channel.



All this is achieved without requiring time-consuming back-and-forth interaction between the controller and the commanding computer. Alignment is typically complete within seconds.

Solving the First-Light Problem on Both Sides

FSA is a key building-block for high-throughput alignments of double-ended devices that initialize with zero coupling. Here another critical element to achieving good process economics is the general responsiveness of the system to general motion commands. The H-206's capability of performing µm-scale motions that settle to nanometers within ~25msec is key here. A signature benefit of parallel kinematic mechanisms is the high positioning bandwidth enabled by actuating a single workpiece by six actuators operating in parallel.



Compared to massive stacks of stages, the positioning bandwidth can be an order of magnitude faster.

So, a typical approach for aligning input and output devices to a double-sided waveguide is to

- Step the input device,
- Perform the *FSA* fast-scan on the output device, and
- Iterate until a threshold amount of coupling is achieved.

At that point, *FSA* can be commanded to the input device to fully optimize the coupling.

Figure 3. By integrating six degrees of freedom, H-206 facilitates complex alignments like this 10-DOF waveguide MUX/DEMUX packaging.

A Deep Toolkit

Other, specialized scan/align algorithms built into C-887 include array-alignment routines for multichannel waveguide devices, and fast I/O optimization routines for single-sided devices.

For applications benefiting from custom algorithm integration, a rich macro language and non-volatile macro storage are standard features.

Summary: A Wealth of Solutions to Meet Every Need

The industry enters its renaissance with no shortage of production applications needing high throughput and high uptime.

Fortunately, a well-stuffed toolbox with industrial-class solutions to meet all needs is available. We look forward to meeting a new generation of device and applications challenges.