

Detecting Mode Hops During Current Tuning of a 670 nm Laser

Simultaneous wavelength and intensity monitoring with the standard Si-detector KISA

Key result. During two up-and-down laser-current ramps, KISA resolved four transient mode-hop signatures. The strongest adjacent-point wavelength discontinuity was 16.6 pm, while the low-current baseline changed by only about 2.7 pm over the 127 s measurement.

Measurement at a glance

Parameter	Result
Laser wavelength	670 nm class (670.940-671.022 nm)
Sensor	Standard Si-detector KISA
Nominal precision	~ 1 pm (~ 1 GHz class)
Current ramps	Two complete up-and-down cycles
Observed mode-hop signatures	4 transient excursions
Largest adjacent jump	16.6 pm (about 11 GHz at 671 nm)
Total observed wavelength span	81.9 pm



Why mode-hop-free tuning matters

A tunable laser should ideally move continuously and predictably from one wavelength to the next.

A mode hop occurs when the laser switches from one resonant longitudinal mode to another. Instead of following the control input smoothly, the wavelength changes discontinuously. Research on external-cavity diode lasers therefore treats mode stability and continuous mode-hop-free tuning range as key performance characteristics [1-4].

- Spectroscopy: a discontinuity can skip or duplicate spectral regions and distort the relationship between scan position and optical frequency.
- Sensing and metrology: sudden wavelength changes can create false features, interrupt a lock, or move the laser away from a target transition.
- Laser development and production: the current and temperature regions where hops occur define the usable operating window and are important during alignment, qualification, and burn-in.
- Closed-loop operation: mode-hop-free tuning gives control algorithms a continuous, reproducible wavelength response instead of a hysteretic or discontinuous one.

Measurement approach

The drive current of a 670 nm-class laser was ramped upward and downward twice. KISA recorded center wavelength and optical intensity at the same time. The measurement used the regular Si-detector configuration with approximately 1 pm wavelength precision. No thermal correction was applied to the sensor data. The laser was free-space directed onto the entrance aperture of the KISA sensor, no fiber coupling was used.

Results: smooth tuning interrupted by discrete wavelength excursions

The measured intensity shows two reproducible triangular ramps. Over most of each cycle, the wavelength follows the ramp continuously, covering an overall range of approximately 81.9 pm. Against this smooth trajectory, four isolated points are displaced by about 13-16 pm. Three occur during the downward section of the first ramp; one occurs close to the upper section of the second ramp.

The largest adjacent-point change is 16.6 pm, corresponding to roughly 11 GHz at 671 nm. This is more than an order of magnitude larger than the nominal 1 pm precision of the standard KISA configuration, making the events directly visible without a high-end laboratory wavemeter.

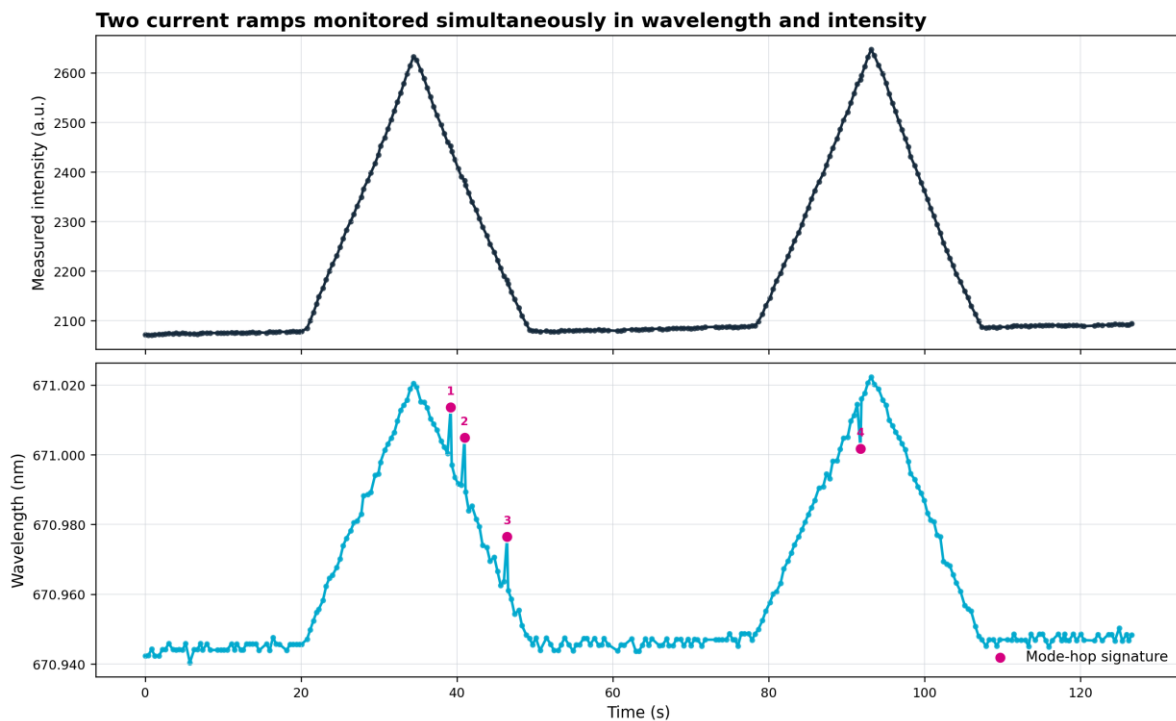


Figure 1. Simultaneous intensity and wavelength traces. The magenta markers identify four transient wavelength excursions that depart clearly from the otherwise smooth tuning response.

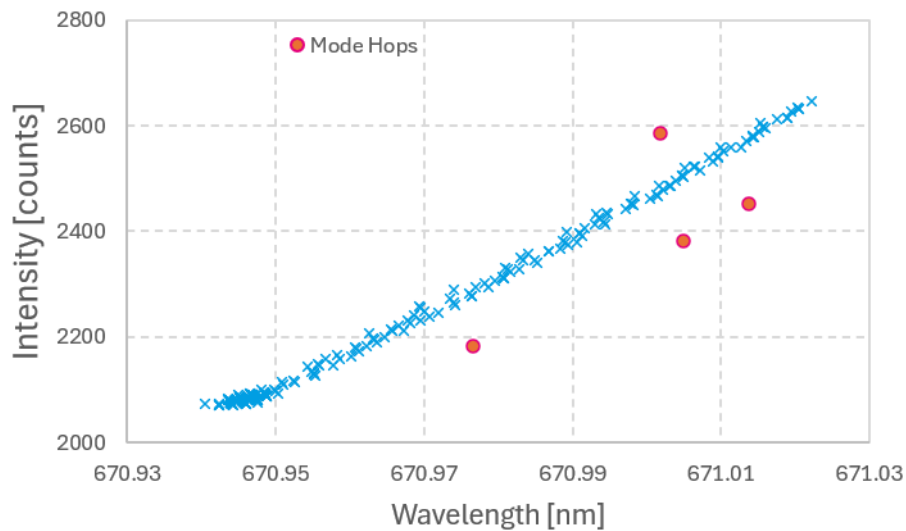


Figure 2. Intensity as a function of measured wavelength. Most points form a narrow tuning trajectory; the four highlighted measurements lie well outside it and reveal the mode-hop signatures.

Event detection for this example used a dataset-specific threshold of 10 pm. This threshold was selected because the supplied dataset does not contain adjacent-point jumps of 20 pm or more: the measured maximum is 16.6 pm. A 20 pm threshold can be used for future measurements when larger hops are expected, but it would miss the events shown here.

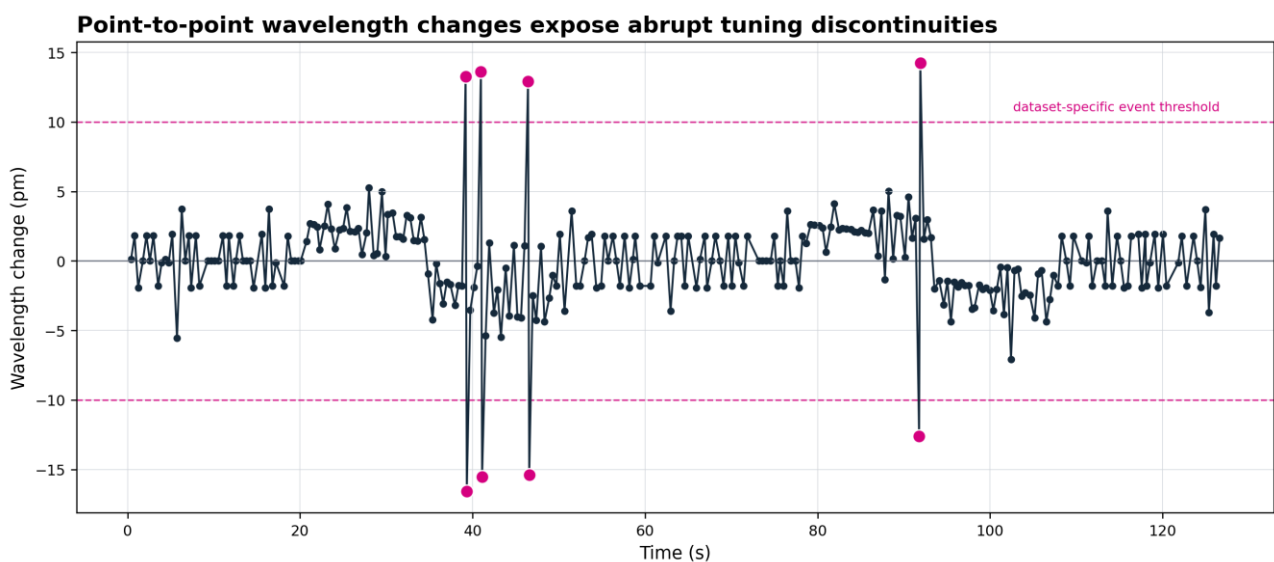


Figure 3. Point-to-point wavelength change. The mode-hop transients appear as paired positive and negative spikes because the laser briefly leaves and then returns to the main tuning trajectory.



APPLICATION NOTE

Distinguishing mode hops from slow thermal drift

The low-current wavelength baseline shifts gradually by approximately 2.7 pm from the beginning to the end of the measurement. This slow change is consistent with a small ambient-temperature influence on the sensor and is minor compared with both the 81.9 pm tuning range and the 13-17 pm transient excursions. The different timescales also make the two effects easy to distinguish: thermal drift changes the baseline smoothly, while a mode hop appears as an abrupt discontinuity.

What KISA sensors add to laser development and qualification

This measurement illustrates a practical role for KISA sensors beyond reporting a single wavelength value. By recording wavelength and intensity continuously, the sensor reveals how a laser behaves as operating conditions change. That behavioral information supports:

- identification of mode-hop-free current and temperature windows;
- optimization of feed-forward or closed-loop tuning parameters;
- comparison of upward and downward ramps for hysteresis;
- screening and acceptance testing of laser modules;
- long-term monitoring of wavelength drift, output intensity, and intermittent instabilities.

Conclusion

A standard Si-detector KISA sensor captured the complete tuning behavior of a 670 nm-class laser during two current ramps and resolved four transient mode-hop signatures of approximately 13-17 pm. The measurement demonstrates that compact, continuous wavelength and intensity monitoring can expose operating instabilities that are invisible in power data alone - and can help engineers define and maintain mode-hop-free laser operation.

Need to characterize wavelength behavior in your laser or optical system?

References

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- [2] K. S. Repasky, A. R. Nehrir, J. T. Hawthorne, G. W. Switzer, and J. L. Carlsten, "Extending the continuous tuning range of an external-cavity diode laser," *Applied Optics* 45, 9013-9020 (2006). DOI: 10.1364/AO.45.009013.
- [3] A. V. Carr, Y. H. Sechrest, S. R. Waitukaitis, J. D. Perreault, V. P. A. Lonij, and A. D. Cronin, "Cover slip external cavity diode laser," *Review of Scientific Instruments* 78, 106108 (2007). DOI: 10.1063/1.2801006.
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