INNOVATION HIGHLIGHT

Technology in Support of National Security

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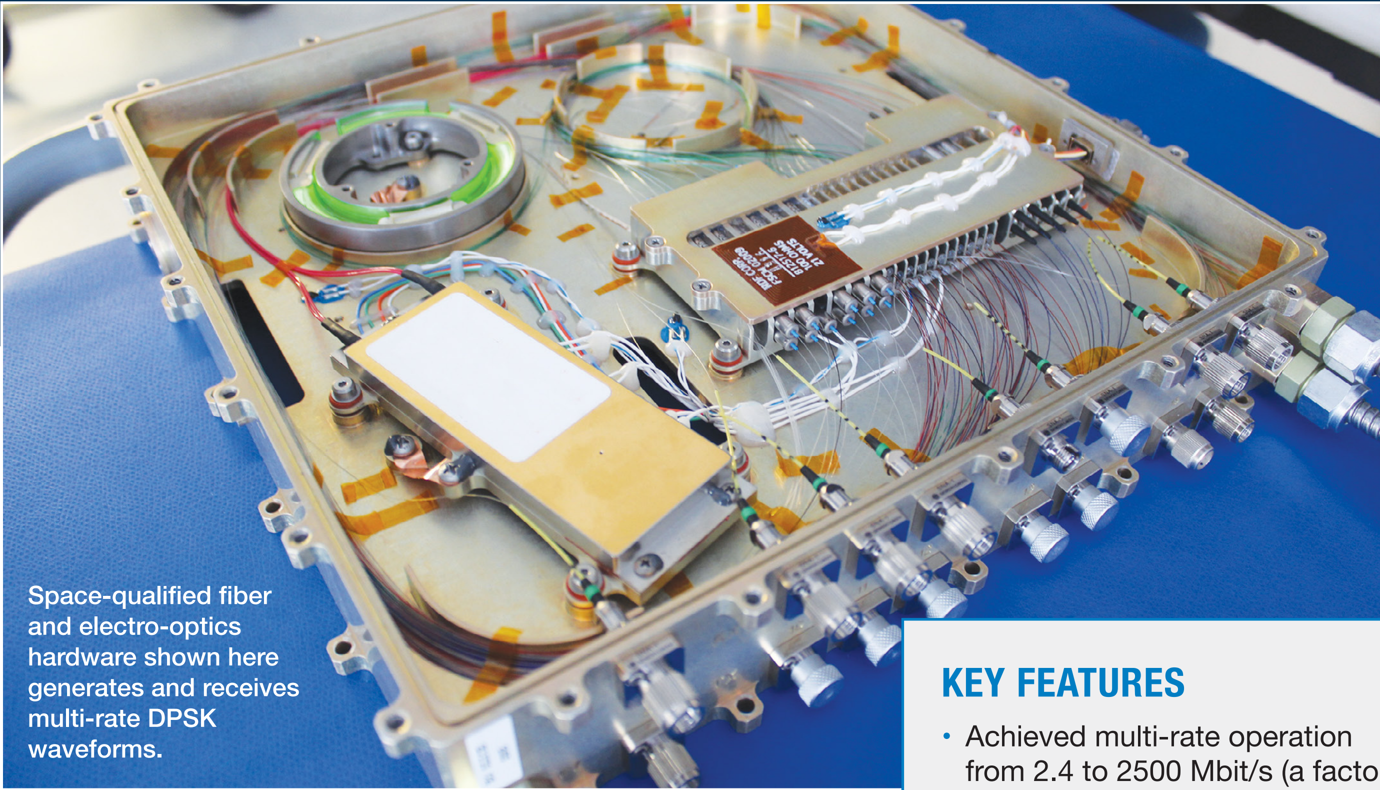
Multi-rate Differential Phase Shift Keying (DPSK) Optical Communications



Space-qualified fiber and electro-optics hardware shown here generates and receives multi-rate DPSK waveforms.

MIT Lincoln Laboratory developed the multi-rate DPSK format, which uses a single, easy-to-implement transmitter and receiver design to achieve free-space optical communications (FSOC) over a wide range of data rates with nearly ideal performance. Multi-rate DPSK is especially useful for dynamic FSOC systems because it allows efficient operation over an extended range of channel losses, link distances, and/or terminal types—making it an attractive paradigm for emerging space-based FSOC applications.

KEY FEATURES

- Achieved multi-rate operation from 2.4 to 2500 Mbit/s (a factor of 1000×) on a single optical wavelength with record receiver sensitivity
- Can scale to higher data rates by using conventional wavelength division multiplexing (WDM) and be implemented with dramatically reduced SWaP via photonic integration
- Complies with emerging Near-Earth Optical High Data Rate standards established by the Consultative Committee for Space Data Systems (CCSDS)

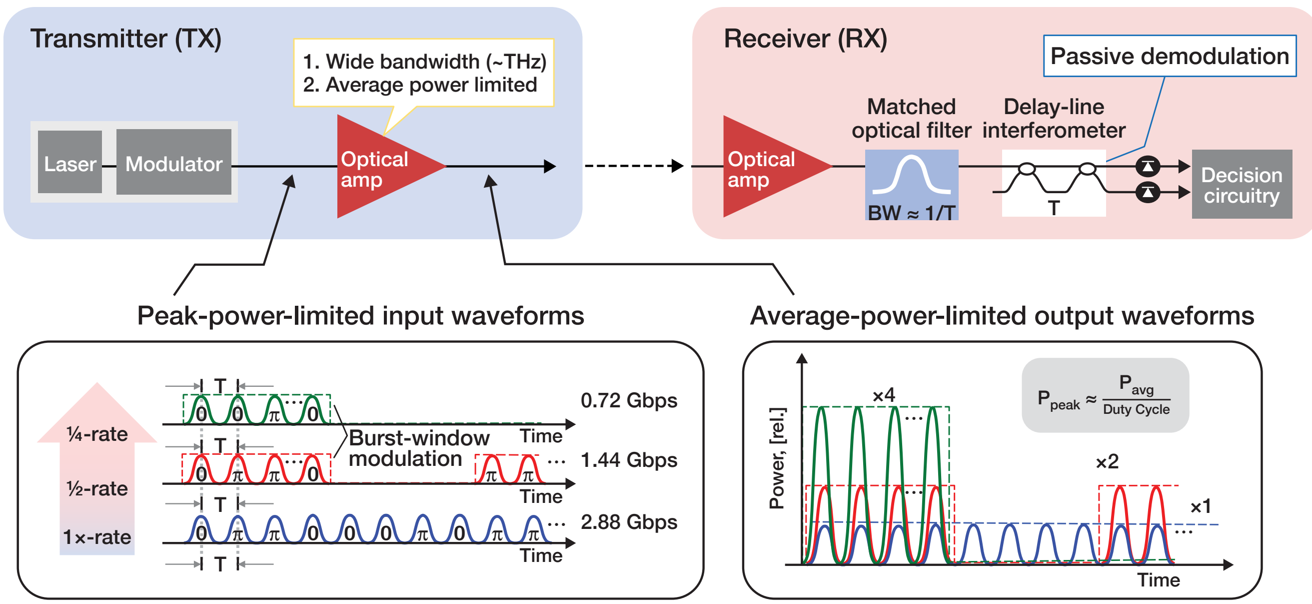
LINCOLN LABORATORY
Massachusetts Institute of Technology

Advantages of Multi-rate DPSK

Because conventional DPSK receivers require customized optical filters and delay-line interferometers (DLIs) for each data rate to achieve good performance, multi-rate capability is cumbersome to implement, especially for space-based systems constrained by size, weight, and power (SWaP) requirements. Lincoln Laboratory constructed space-compatible DPSK multi-rate modems with near-theoretical communication performance over a wide dynamic range of rates and received input power levels.

This multi-rate capability provides valuable architectural flexibility for free-space applications by extending the operational range of receiver power levels to enable bandwidth on demand when conditions are favorable, fallback modes, and the ability to operate with a variety of link conditions (e.g., distance and channel state) and transmitter and receiver designs.

Furthermore, multi-rate DPSK designs can be easily implemented with SWaP-efficient integrated-photonic designs that can readily scale to higher rates via multichannel wavelength division multiplexing.



The illustration of multi-rate DPSK transmitter (TX) and receiver (RX) shows peak-power-limited input waveforms to the TX optical amplifier and average-power-limited output waveforms for full, half, and quarter rates. A Gaussian-like TX pulse shape and fixed separation time (T) are used for all rates to enable robust match-filtered multi-rate performance with processing from a single optical filter and passive delay-line interferometer demodulation in the RX. Multi-rate operation is achieved by varying the on-to-off duty cycle, and an average-power-limited optical amplifier such as a saturated erbium-doped fiber amplifier efficiently translates the lower-duty-cycle lower-rate waveforms to higher-peak-power levels with average power maintained at all rates. This approach enables a single TX and RX to operate from the Mbit/sec regime to the Gbit/sec regime with nearly ideal performance.

INTERESTED IN ACCESSING THIS TECHNOLOGY?

Contact the MIT Technology Licensing Office
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U.S. PATENTS #7,181,097; 7,414,728; 9,647,765; and 10,075,245

More Information

D.O. Caplan, et al., "Multi-rate DPSK Optical Transceivers for Free-Space Applications," *Proceedings of SPIE 8971*, 25 March 2014.

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