RESEARCH NEWS

Future applications with fiber optics

More Power for Fiber Optic Networks

Applications such as self-driving vehicles, 6G mobile communications and quantum communications are pushing fiber optic networks to their limits. Fraunhofer researchers have joined forces with partners to devise clever ways to optimize data transmission. Optical switches with liquid crystal on silicon (LCoS) mirrors shrink data packets down to size so the network can carry more data, while signals are distributed across different fiber strands to create more flexibility.

Fiber optic cables transport signals at near light speed and can transmit even large volumes of data at blazing speeds. Even so, conventional fiber optic systems are no longer powerful enough to accommodate the technologies of the future. In two projects, WESORAM and Multi-Cap, the Fraunhofer Institute for Applied Optics and Precision Engineering IOF in Jena teamed up with partners to get fiber optic networks ready for the world of tomorrow.

Fiber optic networks already use technologies such as wavelength-division multiplexing. In this method, light is used as a carrier for a stream of data, with an optical switch splitting the light into multiple frequencies. A spectrometer grating divides the signal into different wavelengths and then transmits them to an LCoS mirror. This forwards the signals to the output fibers, which makes it possible for each fiber to transport multiple streams of data. However, this method can only be used over a limited frequency range.

Cross-wiring of signals

In the WESORAM project, short for *Wellenlängenselektive Schalter für optisches Raummultiplex* (Wavelength-Selective Switches for Optical Space-Division Multiplexing), Dr. Steffen Trautmann and his team at Fraunhofer IOF worked with project partners to refine this technology. First the team added flexibility to the switching mechanism in the LCoS switch so it would be able to redirect the data stream to any fiber. Once the spectrometer grating has split the incoming light signal into frequencies, the LCoS mirror sends each frequency to a different fiber. This expands conventional wavelength-division multiplexing into a space-division multiplexing technique. To supplement the principle of "multiple frequencies on one fiber," this means the principle of "one frequency, multiple fibers" can also be applied.

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“In our project, we succeeded in sending signals from eight input channels to 16 output channels at will. This kind of cross-wiring increases network capacity since there is much more flexibility to the transmission and forwarding of data streams. This is especially useful when data is being sent over longer distances such as between cities,” says Trautmann, the project manager and an expert on optical systems.

Another advantage is that fewer optical switches are needed for the fiber optic network overall. This lowers the costs of both installation and ongoing operation.

Smaller data packets, higher throughput

As their next step, the researchers from Jena succeeded in increasing the resolution of the optical module with a newly developed grating. “Right now, spectral resolution of 100 GHz, or about 0.8 nm, is the state of the art. The mirror we developed can achieve up to 25 GHz, or approximately 0.2 nm,” Trautmann explains. The higher resolution means the light frequency for the data stream is narrower in band by a factor of four, so the data packets are proportionally smaller. And that in turn means the light conductors can transmit many more data packets simultaneously.

The project partners were Adtran, a company in Meiningen (Thuringia) that specializes in networks, and Berlin-based Holoeye, which focuses on optical systems and built the LCoS mirror. The experts from Fraunhofer IOF were responsible for the optical design. They also used ultra-precision technology to develop a beam splitter for the spectrometer grating and integrated all of the components into a single tiny part.

Multi-Cap amplifier serves multi-core fibers

WESORAM dovetails neatly with another project, Multi-Cap. In this project, researchers are working to increase the number of channels for parallel data transmission. Traditional fibers contain one data channel and one signal core, while multi-core fibers use multiple cores to transmit data. Although these cables contain many more conductors, they are barely thicker at all. The team at Fraunhofer IOF developed the signal amplifiers needed for multi-core fibers. They can serve up to 12 channels at the same time, achieving more than 20 dB of amplification per channel. This technology is significantly more energy-efficient, as only one amplifier module is needed for 12 channels.

Both projects received funding from the German Federal Ministry of Education and Research (BMBF) and VDI – the Association of German Engineers.

Fig. 1 WESORAM project: The LCoS mirror splits the frequencies of the data signals and distributes them flexibly to various outputs.

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Fig. 2 Multi-Cap project: The amplifier can serve up to 12 data channels in a single fiber strand.

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