Photonic chip with record-breaking radio frequency dynamic range

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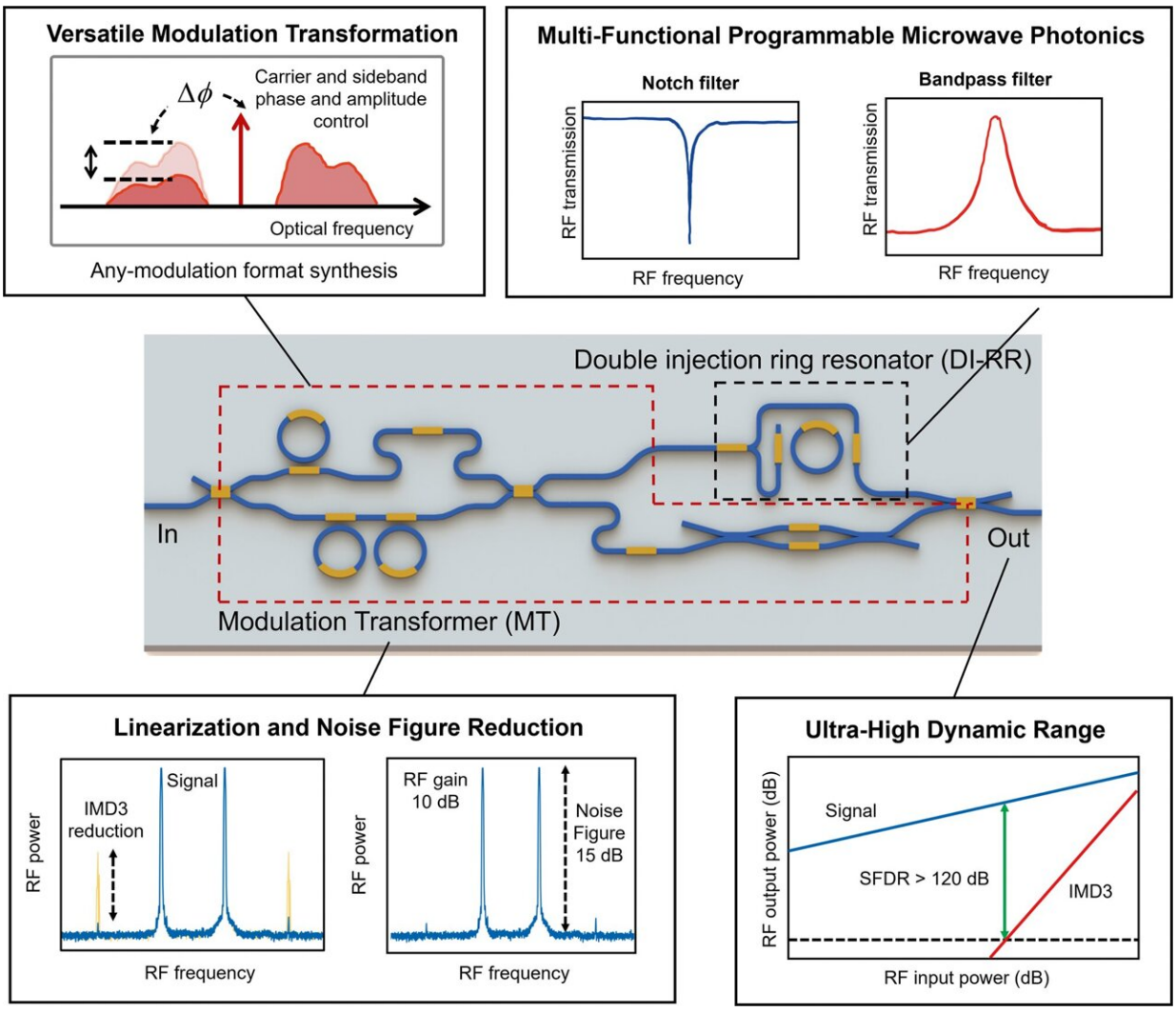

Artistic impression of an ultra-high dynamic range programmable integrated MWP circuit. The circuit contains of a versatile modulation transformer (MT) to independently tailor the phase and amplitude of optical modulation spectrum and

an equally versatile double-injection ring resonator (DI-RR) to synthesize a variety of responses, including programmable RF filters. The combination of MT and DI-RR also allows for linearization through cancellation of intermodulation distortion (IMD) and noise figure (NF) reduction through low biasing and carrier suppression technique, leading to ultra-high dynamic range. SFDR: spurious-free dynamic range. Credit: *Nature Communications* (2022). DOI: 10.1038/s41467-022-35485-x

Researchers at the University of Twente have developed a revolutionary programmable integrated microwave photonic filter with a record-breaking dynamic range. This represents a major breakthrough in the integration of functionality and performance in radio frequency photonic signal processors.

The paper is published in the journal *Nature Communications*.

Prof. Dr. David Marpaung, one of the authors of the study says, "Our work breaks the conventional and fragmented approach of integration, functionality and performance that currently prevents the adoption of these photonic systems in real applications. Traditional radio frequency filters can only work in a narrow frequency range, meaning you need several separate filters for broadband operation. Our device is integrated, broadband, and has an enormous dynamic range, making it possible to use just a single photonic circuit for various frequency ranges."

Many applications

The research shows that the filter can play a key role in modern radio frequency and microwave applications, including cognitive radio, multi-band all-spectrum communications, and broadband programmable front-ends. Before this discovery, programmable microwave photonic circuits

with such advanced functions had poor performance. "Versatile programming of the chip can easily give in to various disturbances like loss, noise, and distortion of the signal," explains Marpaung.

To prevent this, the researchers employ programmable resonators and interferometers to reduce the impact of noise and nonlinear distortion together while at the same time providing a large number of filtering functions. Marpaung says, "Solving the noise figure and dynamic range problem is one of the hardest challenges in microwave photonics. This breakthrough proves that integrated microwave photonics can indeed achieve very high performance. This will help the adoption of this technology in next-generation communication systems (6G) and satellite communications, for example."

Record-low noise figure

The researchers used a special tool—a so-called modulation transformer—to adjust the strength and timing of light waves and radio frequency signals. This enables enhancement of the chip noise and dynamic range performance.

By combining these elements in a single microwave photonics circuit, the team was able to demonstrate programmable filter functions with a record-low noise figure of 15 dB and a radio frequency notch filter with an ultra-high dynamic range of more than 123 dB in 1 Hz bandwidth. Which is a similar range as the noise levels between complete silence and a rock concert.

More information: Okky Daulay et al, Ultrahigh dynamic range and low noise figure programmable integrated microwave photonic filter, *Nature Communications* (2022). DOI: 10.1038/s41467-022-35485-x

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