

Kent Academic Repository

Full text document (pdf)

Citation for published version

Wang, Chao (2013) Dispersive Fourier transformation for microwave photonics applications.
In: 34th Progress in Electromagnetics Research Symposium (PIERS 2013), 12-15 Aug 2013, Stockholm, Sweden.

DOI

Link to record in KAR

<https://kar.kent.ac.uk/56279/>

Document Version

UNSPECIFIED

Copyright & reuse

Content in the Kent Academic Repository is made available for research purposes. Unless otherwise stated all content is protected by copyright and in the absence of an open licence (eg Creative Commons), permissions for further reuse of content should be sought from the publisher, author or other copyright holder.

Versions of research

The version in the Kent Academic Repository may differ from the final published version.

Users are advised to check <http://kar.kent.ac.uk> for the status of the paper. **Users should always cite the published version of record.**

Enquiries

For any further enquiries regarding the licence status of this document, please contact:

researchsupport@kent.ac.uk

If you believe this document infringes copyright then please contact the KAR admin team with the take-down information provided at <http://kar.kent.ac.uk/contact.html>

Dispersive Fourier Transformation for Microwave Photonics Applications

Chao Wang

School of Engineering and Digital Arts, University of Kent
Canterbury, CT2 7NT, United Kingdom

Abstract— Dispersive Fourier transformation (DFT) maps the broadband spectrum of an optical pulse into a time stretched waveform using chromatic dispersion [1]. Owing to its capability of real-time pulse-by-pulse spectroscopic measurement and manipulation, DFT has become an emerging technique for ultrafast signal generation and continuous single-shot measurements in optical communications, optical sensing, spectroscopy and imaging, where the speed of traditional instruments falls short [2].

In this paper, the principle and implementation methods of DFT are introduced and its widespread applications in microwave photonics systems are presented. The most obvious and straightforward application of DFT is real-time spectroscopy, where the instantaneous spectral characteristics of an ultrashort optical pulse are encoded onto its temporal intensity variation. Fast dynamic phenomena that are encoded onto the optical spectrum can be now acquired and slowed down in the time domain so that they can be digitized and analyzed in real-time. Compared to traditional optical spectroscopy instruments, DFT-based real-time spectroscopy offers a few orders of magnitude higher measurement speed. As two examples of ultrafast real-time spectroscopy, ultrafast gas absorption spectroscopy [3] and fiber Bragg grating interrogation [4] are introduced. DFT technique can also be applied in photonic-assisted microwave arbitrary waveform generation [5], where the spectrum of the optical pulse is manipulated on purpose using an optical spectral shaper. By properly designing the response of the spectral shaper, a microwave waveform with its shape identical to that of the shaped optical spectrum can be produced [6–9]. In another application of DFT, due to the one-to-one mapping relation between spectrum and time, the spectrum shape of the pulse can be changed in a fast and reconfigurable manner using temporal modulation — a technique called time-domain spectral shaping. One example of this technique is instantaneous microwave frequency identification based on temporal channelization [10]. The final microwave photonics application of DFT technique is ultrafast real-time imaging [11], which is made possible by employing additional spatial dispersion to encode the spatial information (image) onto the pulse spectrum. The images can then be reconstructed from the temporally stretched optical pulses. With its capability of fast continuous capturing, DFT-based imaging technique is expected to be useful for high-throughput screening of rare objects or events.

REFERENCES

1. Muriel, M. A., J. Azana, and A. Carballar, “Real-time Fourier transformer based on fiber gratings,” *Opt. Lett.*, Vol. 24, 1, 1999.
2. Goda, K. and B. Jalali, “Dispersive Fourier transformation for fast continuous single-shot measurements,” *Nat. Photon.*, Vol. 7, 102, 2013.
3. Goda, K., C. Wang, and B. Jalali, “Broadband dispersive Fourier-transform spectroscopy in the 800 nm range,” submitted.
4. Wang, C. and J. P. Yao, “Ultrafast and ultrahigh-resolution interrogation of a fiber Bragg grating sensor based on interferometric temporal spectroscopy,” *J. Lightwave Technol.*, Vol. 29, 2927, 2011.
5. Wang, C. and J. P. Yao, “Advanced fiber Bragg gratings for photonic generation and processing of arbitrary microwave waveforms,” *2010 IEEE International Topical Meeting on Microwave Photonics*, 414–417, 2010.
6. Wang, C., F. Zeng, and J. P. Yao, “All-fiber ultrawideband pulse generation based on spectral-shaping and dispersion-induced frequency-to-time conversion,” *IEEE Photon. Technol. Lett.*, Vol. 19, 137, 2007.
7. Wang, C. and J. P. Yao, “Simultaneous optical spectral shaping and wavelength-to-time mapping for photonic microwave arbitrary waveform generation,” *IEEE Photon. Technol. Lett.*, Vol. 21, 793, 2009.
8. Wang, C. and J. P. Yao, “Photonic generation of chirped millimeter-wave pulses based on nonlinear frequency-to-time mapping in a nonlinearly chirped fiber Bragg grating,” *IEEE Trans. Microw. Theory Tech.*, Vol. 56, 542, 2008.

9. Wang, C., M. Li, and J. P. Yao, "Continuously tunable photonic microwave frequency multiplication by use of an unbalanced temporal pulse shaping system," *IEEE Photon. Technol. Lett.*, Vol. 22, 1285, 2010.
10. Wang, C. and J. Yao, "High-resolution microwave frequency measurement based on temporal channelization using a mode-locked laser," *2012 IEEE MTT-S International Microwave Symposium Digest (MTT)*, 2012.
11. Goda, K., A. Mahjoubfar, C. Wang, A. Fard, J. Adam, D. R. Gossett, A. Ayazi, E. Sollier, O. Malik, E. Chen, Y. Liu, R. Brown, N. Sarkhosh, D. Di Carlo, and B. Jalali, "Hybrid dispersion laser scanner," *Sci. Rep.*, Vol. 2, 445, 2012.