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High-frequency bright and dark soliton sources based on dispersion-profiled fibre circuitry and their applications

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Abstract

We report advances in the area of soliton generation using beat signal conversion. In particular, we describe the development of a diode-driven, 40 GHz bright soliton source with sub 300 fs pulse jitter. Furthermore we report pulse transmission and all-optical data encoding at 40 Gbit/s.

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There has been considerable recent interest in the development of optical techniques for the generation of high-frequency soliton trains based on nonlinear beat signal to soliton train conversion in dispersion profiled fibre circuits (see e.g. Refs.[1-5]). The techniques offer advantages of ultra-high repetition rates, high pulse quality (bright and dark solitons), as well as broad wavelength and repetition rate tunability. However, although impressive source demonstrations have been made, their practical applications to date have been limited due primarily to issues relating to timing jitter [2,3], Brillouin scattering [2,3] and difficulties in applying the techniques to repetition rate ranges <40 GHz to allow compatability with state of the art, high data rate, electronics [5].

In this presentation we review recent advances in the development of the basic techniques that should enable a true assessment of their suitability for practical usage. In particular, we report on the development and performance of a diode-driven, ultra-low jitter, 30-40 GHz bright soliton source with potential for telecommunication applications. The source incorporates technical solutions to the previously mentioned problems and demonstrates that stable, high-quality pulse sources can be constructed based on beat-signal conversion.

The source configuration (Fig.1.) consists of three principle components: an optical beat-signal source, an Er^{3+}/Yb^{3-} optical power amplifier and a dispersion varying fibre section. In order to obtain a low timing jitter beat signal the output of a cw DFB laser was externally modulated using a 20 GHz amplitude modulator tuned to a transmission null and driven at 17.5 GHz to obtain 35 GHz sinusoidal modulation. The dispersion decreasing fibre section consisted of 2 km of DSF and an 8 km Dispersion Decreasing Fibre (DDF). The DDF dispersion followed a hyperbolic profile at 1550 nm tapering along the 8 km length from 13.75 to 2.75 ps/(nm.km). The source was tested under a wide range of input powers and beat frequencies in the range 32-40 GHz. Transform-limited, soliton pulses of durations 4.5-6.5 ps were obtained for input beat signal powers <20 dBm within the wavelength range of the available diodes 1547-1563nm. A typical autocorrelation function (ACF) and spectrum of a 35 GHz pulse train at the source output are shown in Fig.2. Due to the low jitter beat signal seed source we were able to perform clock recovery on the pulse train and to make direct electrical domain measurements [5]. From examination of the fundamental frequency component (mixed down electronically to 1 GHz) we were able to measure the timing jitter and found it to be fully determined by the phase noise of the frequency synthesizer (<300 fs). Furthermore, using the clock recovery circuit we have recently been able to synchronise a 40 Gbit/s data stream with the soliton train and use this in conjuction with an all-optical modulator based on nonlinear polarisation switching in an optical fibre to impose real data on a 40 Gbit/s continuous wave soliton stream (see Fig.3). We believe these results illustrate that many of the problems frequently associated with the beat frequency technique can be overcome and should facilitate real-world applications.

References

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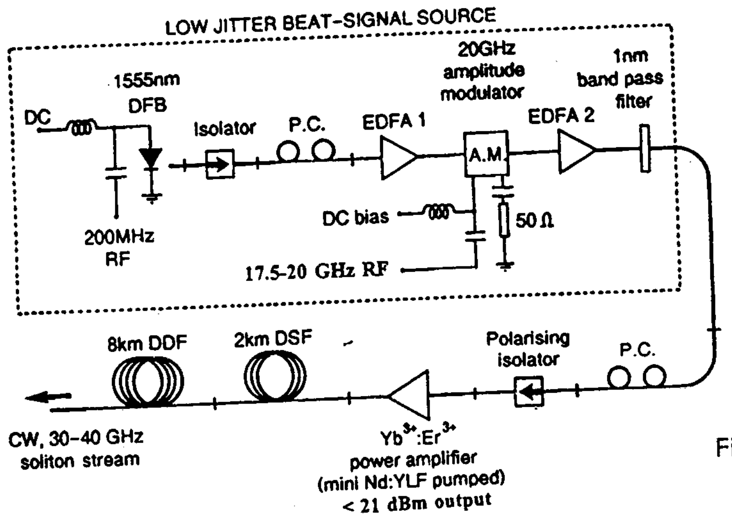

Fig.1 Source configuration

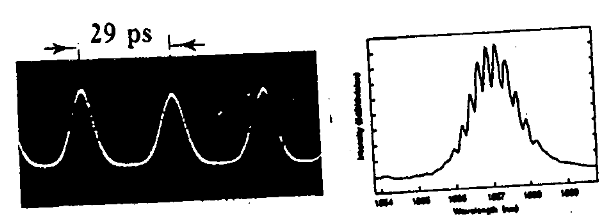

Fig.2 Autocorrelation and optical spectrum of 35 GHz 5.0ps pulse trains

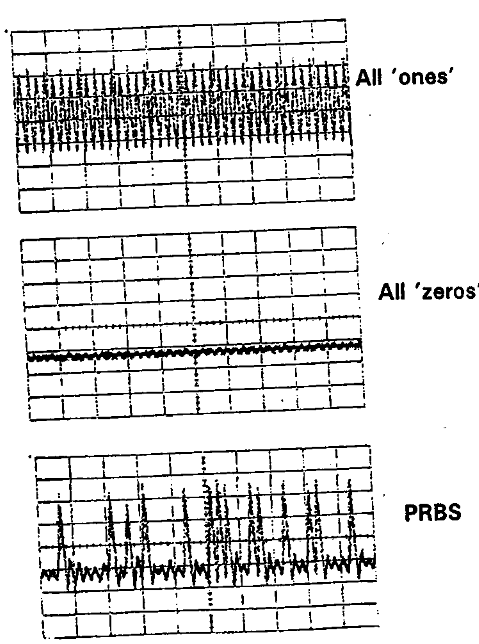

Fig.3 40 Gbit/s modulated soilton stream at optical modulator output.