THE FUTURE OF FIBRE CIRCUITRY

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Although functional, interconnected, multi-path fibre devices (fibre circuits) have been around for some time, the development of the EDFA has given enormous impetus to the area, since the inclusion of an active element allows far greater versatility. Already a number of quite complex circuits have been reported for non-linear switching, soliton-generation, logic, multiplexing and demultipexing and a wide variety of fibre-lasers. To date, with the exception of the EDFA itself, the impact on current telecommunications networks has not been great, owing largely to the advanced nature of the devices, such as their very high bit-rate capability. It is therefore interesting to speculate on the future of fibre circuitry in the high-capacity telecommunications environment of the future.

The EDFA has removed the restriction on transmission distance and experiments reporting soliton transmission over 10,000km at multigigabit rates are common. In the trunk network, transmission rates in excess of 60Gbit/s over a few hundred km would appear possible and the challenge therefore is to generate, modulate, multiplex and demultiplex data streams at this speed. Whereas time multiplexing can be performed in parallel and individual pulses interleaved using simple time-delay paths, demultiplexing, i.e. switching out every nth pulse, is more complex. Demultiplexing has been demonstrated in fibre using soliton dragging, non-linear loop-mirror switches and four-wave mixing at data rates approaching 40Gbit/s.

Although a number of logic elements have been demonstrated using various fibre non-linear effects, the "pipeline" delay caused by the long fibre length is a problem which has yet to be addressed. Switching speeds in the tens of femtoseconds are possible and it is this very high speed which makes fibre circuitry attractive for signal-processing. However, an alternative route to high-transmission capacity and switching is through dense wavelength-division-multiplexing (WDM). Here fibre circuitry has yet to make an impact, although there are a number of fibre components (e.g. the fibre Fabry-Perot) which are essential constituents of any system. A number of groups are investigating the erbium-doped laser/EDFA combination for stable, single-frequency WDM sources, as well as WDM comb-generators.

In conclusion, fibre circuitry based around the erbium-doped fibre would appear set to play a major part in the development of the high-capacity telecommunications systems of the future. Widely-tunable, single-frequency fibre lasers, femtosecond signal-processing/logic elements, multiplexers and demultiplexers will all play a part. A number of these functions can also be achieved through the use of planar optical circuits or external-cavity laser diodes and it remains to be seen which of the technologies is most suited to a given application.

THE FUTURE OF FIBRE CIRCUITS

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The EDFA has removed limits on

1. Transmission distance

2. Bit rate (using solitons)

Challenge is to generate, modulate, mux and demux data streams at >50Gbit/s

OPTICAL TIME-DIVISION DEMULTIPLEXING

- Soliton dragging
- Non-linear loop-mirror switch
- 4-wave mixing

THE FUTURE?

- Efficient 1.3μm amplifiers
- Widely-tunable, single-frequency fibre lasers
- Femtosecond signal-processing/logic elements
- Increased fibre non-linearity
- 10W fibre amplifiers
- Upconvertors for blue emission
- IR fibre lasers
- Active planar circuitry

ACTIVE FIBRE DEVICES

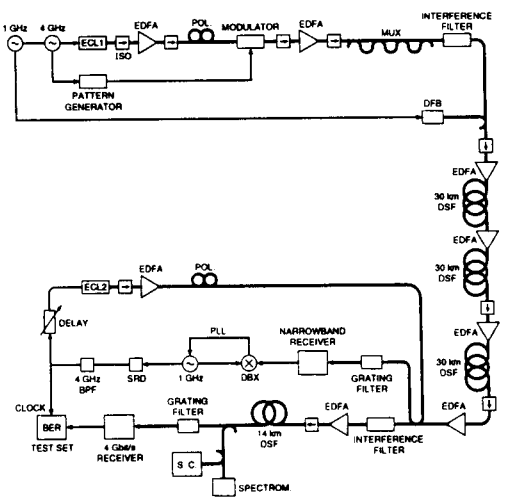
- Single-frequency, absolutely-stable, fibre lasers for WDM
- WDM comb generators
- Soliton generators
- Ultra-fast non-linear MUX/DEMUX
- Amplifiers for limiting, equalisation, spectral shaping

CONCLUSIONS

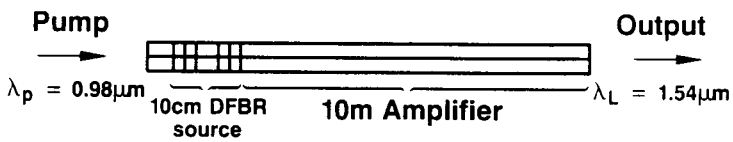
- Fibre circuitry has come of age
- Several new devices yet to appear
- Pressure from external-cavity diode lasers and planar glass circuitry

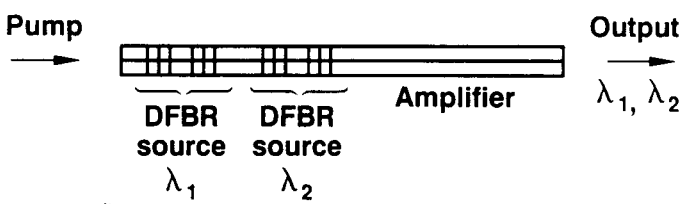
32 Gbit/S SOLITON TRANSMISSION AND 4 - WAVE MIXING DEMUX

Olsson et al

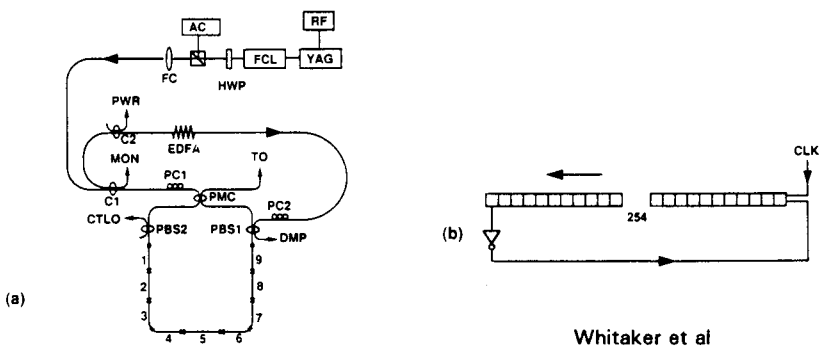


DBR FIBRE LASER / AMPLIFIER



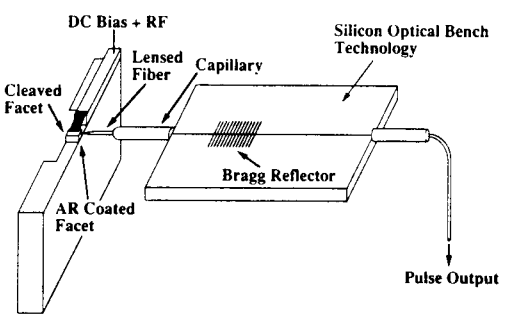


ALL - OPTICAL SHIFT REGISTER

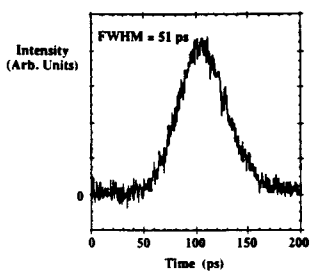


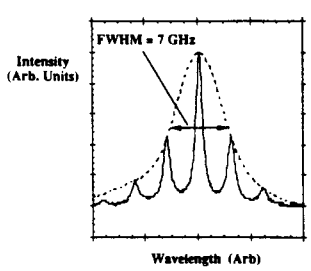
Whitaker et al

EXTERNAL - CAVITY MODE - LOCKED DIODE LASER SOLITON (?) GENERATOR AT 3.84 Gbit/s

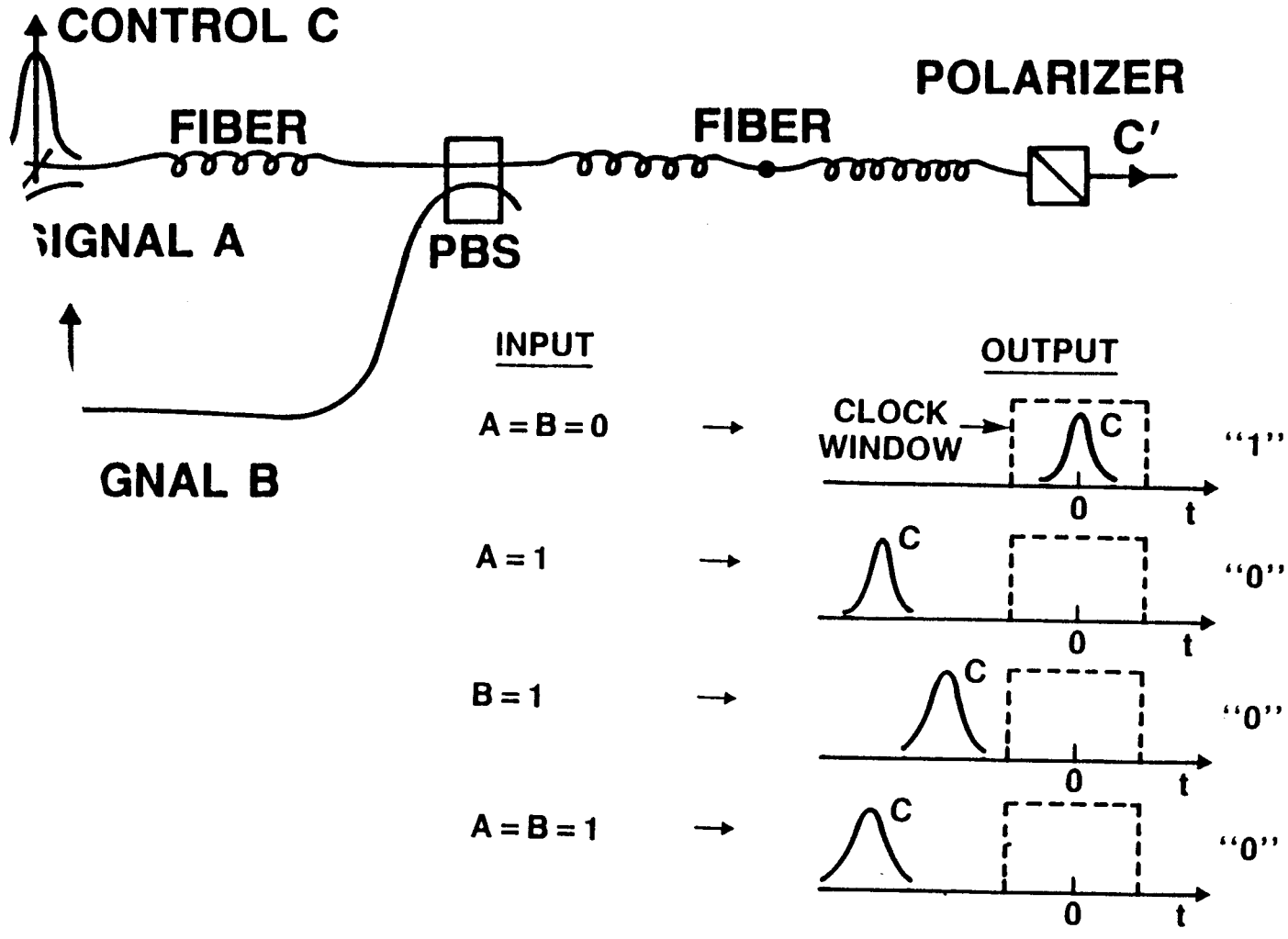


Morton et al





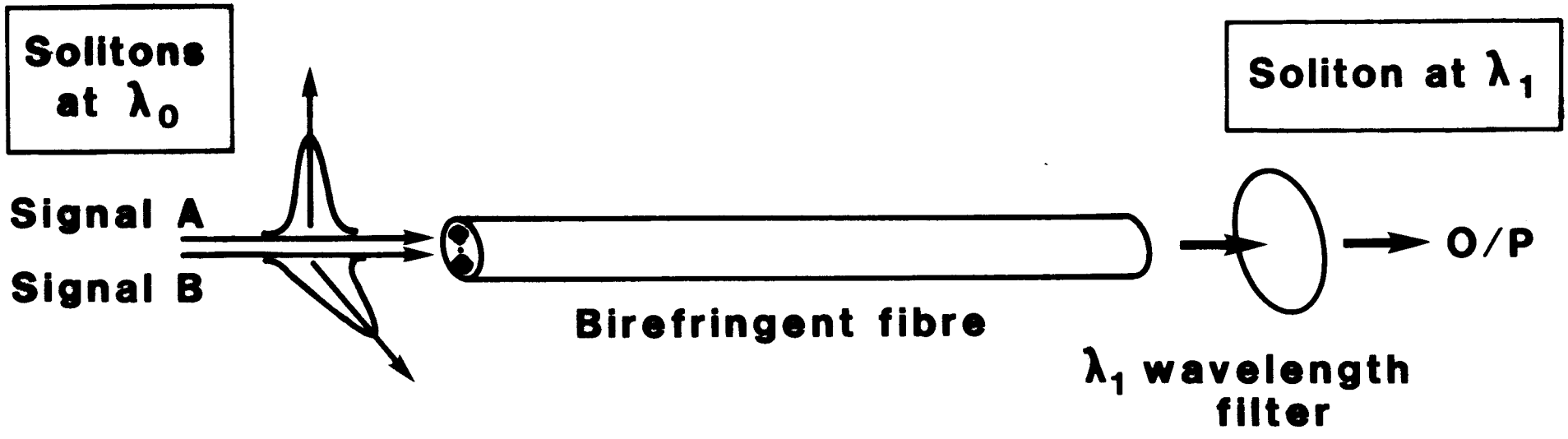
SOLITON DRAGGING NOR-GATE

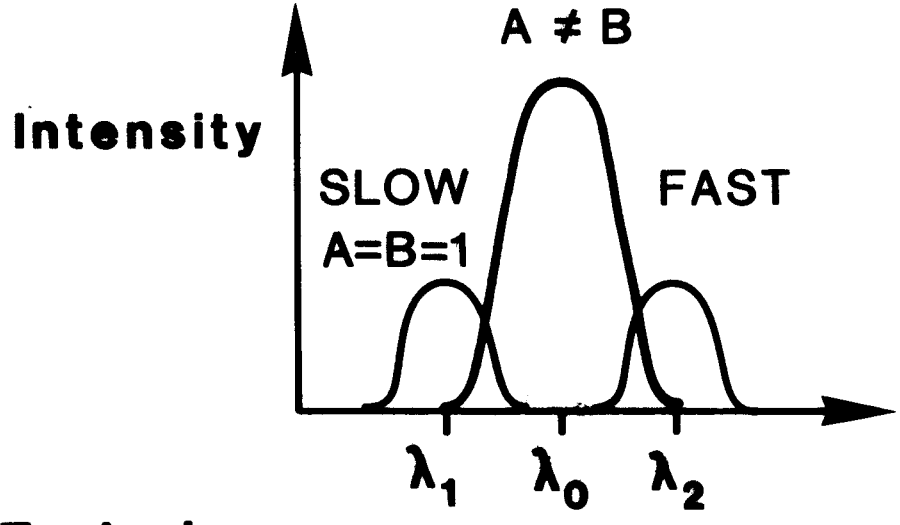


OPTICAL TIME-DIVISION DEMULTIPLEXING

- Soliton dragging
- Non-linear loop-mirror switch
- 4-wave mixing

SOLITON - TRAPPING AND GATE





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CHBAT et al

71 Gbit/s SOLITON PULSE GENERATION