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Applications of WDM System in US Patents

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Abstract - In fiber-optical telecommunications, wavelength division multiplexing (WDM) is a multiplexing and transmission scheme in which distinct wavelengths, each emitted by multiple lasers, carry specific information. WDM filters are used to multiplex these wavelengths. Similarly, at the receiving end, they are demultiplexed or separated using coherent detection with tunable local oscillators or similar filters. This paper explains the most recent applications of the WDM System in US patents. A succinct explanation of the WDM System is also given.

Keywords: US Patents, WDM, structure and applications

I. INTRODUCTION

The technique known as wavelength-division multiplexing (WDM) in fiber-optic communications multiplexes several optical carrier signals onto a single optical fiber by employing various wavelengths of laser light [1]. Wavelength-division duplexing, another name for bidirectional communications over a single fiber strand, and capacity multiplication are made possible by this technique [1].

While frequency-division multiplexing usually refers to a radio carrier, which is more frequently described by frequency, WDM is frequently used to refer to an optical carrier, which is usually described by its wavelength [2]. Since wavelength and frequency convey the same information, this is strictly conventional. In particular, the velocity of the carrier wave is equal to the product of frequency (measured in Hertz, or cycles per second) and wavelength (the actual length of one cycle). This is the speed of light in a vacuum, and it is typically represented by the lowercase letter c. The velocity in glass fiber is significantly slower, typically 0–7 times c. In real-world systems, the carrier frequency is a fraction of the data rate.

II. WDM METHOD & STRUCTURE

In Fig.1, a multiplexer at the transmitter joins the multiple signals together, and a demultiplexer at the receiver separates them. This is how the WDM system works. It is feasible to create a device that can serve as an optical add-drop multiplexer and do both at the same time with the correct kind of fiber. Etalons (stable solid-state single-frequency Fabry–Pérot interferometers in the form of thin-film-coated optical glass) have traditionally been employed as optical filtering devices. Since there are three distinct types of WDM, one of which is referred to as WDM, the notation xWDM is typically used when discussing the technology in general. Only two signals were combined in the initial WDM systems. A simple 100 Gbit/s system can be expanded to over 16 Tbit/s over a single fiber pair using modern systems, which can handle 160 signals. There is also a 320-channel system.

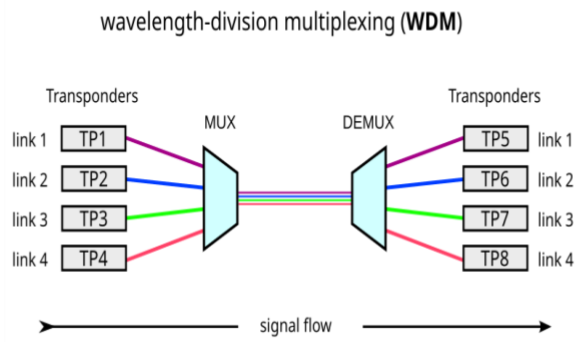

Fig.1: WDM Structure

Telecommunications companies favor WDM systems because they enable them to increase network capacity without installing additional fiber. Without having to completely redesign the backbone network, they can integrate multiple generations of technological advancements into their optical infrastructure by utilizing WDM and optical amplifiers. Simply upgrading the multiplexers and demultiplexers at each end of a link will increase its capacity. At the very edge of the transport network, optical-to-electrical-to-optical (O/E/O) translation is frequently used to accomplish this, allowing for interoperability with already-existing equipment that has optical interfaces [3].

The majority of WDM systems use single-mode optical fiber cables with a 9 µm core diameter. Multi-mode optical fiber cables, also referred to as premises cables, with core diameters of 50 or 62.5 µm can also use specific types of WDM.

Unlike laser sources, optical receivers are typically wideband devices. Consequently, in the WDM system, the demultiplexer needs to supply the receiver's wavelength selectivity.

III. APPLICATIONS OF WDM IN US PATENTS

Receiving an optical coherence tomography ("OCT") signal or signals, dividing them into a number of subspectra, averaging the subspectra, and then creating the image or images of the three-dimensional anatomical flow map(s) based on the averaged subspectra are examples of exemplary systems, methods, and computer-accessible media for creating an image(s) of a three-dimensional anatomical flow

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map(s) in [4]. One or more OCT signals may be swept-source signals. A Hamming window can be used to divide the OCT signal or signals into subspectra. For each subspectra, the nearest side lobe can be minimized by optimizing the Hamming distance window. Before the subspectra are averaged, the position of at least one of them can be changed. Before the subspectra are averaged, the positions of all but one of them can be changed.

Wavelength splitter structures and formation techniques for a wavelength-division-multiplexing filter stage are described in [5]. The first waveguide core of the structure is made up of a first section, a second section, and a phase delay line connecting the first and second sections. In the first waveguide core, the phase delay line consists of a delay section and several longitudinally arranged segments. The second waveguide core of the structure is made up of a first section, a second section, and a phase delay line connecting the first and second sections. A first directional coupler is defined by placing the first section of the second waveguide core next to the first section of the first waveguide core, and a second directional coupler is defined by placing the second section of the second waveguide core next to the second section of the first waveguide core.

In [6], a photonics frequency comb generator consists of two integrated dies: a silicon photonics die with a microring resonator coupled to the laser and frequency modulators, and an indium phosphide die laser of a first wavelength grown on from it. The first wavelength is changed into several second wavelengths by the microring resonator. A hybrid non-linear optical wavelength generator is one kind of microring resonator that uses silicon and non-silicon materials like SiC or SiGe to produce a non-linear wavelength generation. By varying the ring's geometric size and the separation between it and the traverse waveguide, the second wavelengths are produced. A different kind of microring resonator divides the first wavelength into several second wavelengths, which are then sent to filters and modulators. Each of these devices chooses and modifies one of the second wavelengths in a one-to-one correspondence. Applications for this frequency comb generator include multi-chip modules in high-speed transceivers and WDM/CWDM.

Coherent photonic circuit architectures that optically carry out linear algebraic calculations are revealed in [7]. Coherent optical linear neurons arranged in a crossbar configuration can be used to implement individual neural network layers in neuromorphic applications of such photonic circuit architectures. Electronic circuitry is integrated at the interfaces between neural network layers to determine the neuron inputs to one layer based on the neuron outputs of the layer before it. When combined with electro-optic switches, wavelength division multiplexing can effectively implement specific network models and make a general hardware configuration programmable.

Configurable intensity-modulation direct-detection (IM-DD) optical transceivers that can switch between single-polarization (SP) and dual-polarization (DP) operation are the focus of implementations in [8].

Systems, procedures, and equipment for single-ended electro-absorption modulators (EAMs) with electrical combining are revealed here in [9]. Systems and techniques for carrying out optical encoding and multiplication operations for optical signals without the use of a sign value are specifically disclosed. It is possible to transform the optical output into a photocurrent input and then apply the sign value to the photocurrent input on an electrical layer.

A multicore optical fiber with first and second cores, a first communication device optically coupled to a first end of the multicore optical fiber's first core, a second communication device optically coupled to a second end of the multicore optical fiber's first core, a first sensing device optically coupled to a first end of the multicore optical fiber's second core, and a second sensing device optically coupled to a second end of the multicore optical fiber's second core are all components of a hybrid sensing-communication system described in [10]. The communication data is distinct from the sensing data, and the first and second communication devices only exchange communication data along the first core, while the first and second sensing devices only exchange sensing data along the second core.

An optical source is described in [11]. A semiconductor laser chip with multiple epitaxial gain layers, which function as a gain medium and provide multiple lasing wavelengths in a band of frequencies without mode hopping and/or with significantly reduced mode beating below a predetermined value, and an optical cavity with at least one mirror are two examples of this optical source. Aperiodic gratings, echelle gratings with a common arm that contains the epitaxial gain layers and multiple output arms that provide the lasing wavelengths, or a set of ring resonators that provide the lasing wavelengths are some examples of optical components that can be included in the optical source to select laser modes of the optical cavity.

Wherever radio service coverage is required, an antenna port is created by tapping an optical medium, like fiber, in [12]. A digital optical signal is received from a host unit via each antenna port, which is a bi-directional remote unit that converts the signal to a radio frequency signal for transmission. Radio frequency signals are received by the remote unit, converted to digital signals, combined with signals from other remote units, and then transformed into an optical signal that is sent to the host unit..

Using a multimode pump source, an optical fiber was set up in [13] to increase the pump conversion efficiency of an L-band fiber amplifier. An active fiber core region co-doped with both erbium and ytterbium can directly absorb multimode light, including 915 nm, and use stimulated emission to add gain to the L-band signals. Another active fiber core region doped with erbium can absorb the undesired C-band amplified spontaneous emission (ASE) light produced by this active fiber core region, adding gain to the L-band signals. It is possible to set up active regions and cladding to correspond with a specific spatial mode of the optical signal. It is possible to use signal-pump combiners with side or end coupling.

A digital baseband unit that can split a baseband signal into in-phase and quadrature components and output the in-phase and quadrature components is one example of a transmitting apparatus that complies with the current disclosure in [14]. Another is an outphasing signal generation unit that can generate first and second outphasing signals based on the in-phase and quadrature components, and a time-division combining unit that can create a time-division combined signal by combining the first and second outphasing signals in a time-division fashion.

Continuous wave signals with varying wavelengths at a channel spacing from one another are employed in an optical circuit in [15]. A photonic integrated circuit is used to implement a portion of the optical circuit. In a modulation stage, modulators create modulated signals by modulating continuous wave signals. The continuous wave or modulated signals are multiplexed to create multiplexed signals by a multiplexing stage, which may include multiplexing filters, power combiners, or power couplers. The modulation stage may come before or after the multiplexing stage. In a final step, the multiplexed signals are combined into an output signal by one or more polarization rotator and combiner (PRC) devices. A first set of distinct wavelengths at a first polarization and a second set of distinct wavelengths at a second polarization orthogonal to the first polarization are both present in the output signal.

In [16], a distributed acoustic sensor (DAS) box is connected to an optical fiber that is positioned to extend to a tree as part of an integrated system for detecting soil moisture, farm fire, and red palm weevil (RPW). In order to ascertain whether the RPW is present from the first optical signal, the temperature at a point along the optical fiber from the second optical signal, and the moisture at a point around the tree from the third optical signal, the DAS box is set up to process the first three distinct optical signals reflected from the optical fiber.

An optical device that can enhance O-band light is comprised of a Praseodymium (Pr)-dope waveguide optical amplifier in [17]. It is possible for the substrate to form the waveguide optical amplifier (e.g. either glass or silicone) and consists of cladding that borders at least one side of the core and a core that defines an optical path through the waveguide optical amplifier. The core is made of a silicon-based substance, like silicon nitride, doped with Praseodymium (Pr) in such a way that the waveguide optical amplifier amplifies the O-band signal light when pump light and O-band signal light are passed through it.

An optical source is described in [18]. A silicon-photonics chip that creates an optical cavity and a semiconductor laser chip are two possible components of this optical source. In a band of wavelengths, the semiconductor laser chip may offer gain at several lasing wavelengths. Additionally, the silicon-photonics chip has the ability to modify the size of an optical signal close to an interface between the silicon-photonics chip and the semiconductor laser chip. Additionally, a center frequency of a micro-ring resonator's passband may be matched to a non-zero integer multiple of a cavity-mode spacing by varying the phase of a phase shifter and resonance frequencies of a micro-ring resonator in the silicon-photonics chip. By suppressing undesired lasing wavelengths and re-enforcing the lasing wavelengths, this could enable the optical source to mode-lock its lasing wavelengths. In certain configurations, the optical source's free-spectral range could fall between 100 GHz and 800 GHz.

To authenticate client devices on a communication network, a server device is offered in [19]. The server device has a processor with memory that can hold computer-executable instructions and a transceiver that can communicate with at least one client of the communication network. When the instructions are carried out by the processor, the server device receives an authentication request from a client device, generates a seed for the client device's first key if the client device authenticates, transmits the seed to the client device, receives a hash of the first key from the client device, and validates the first key using the hash of the first key.

IV. Conclusion

It was demonstrated that the most recent use of WDM system in US patents highlights the significance and range of services that WDM system offers. Additionally, the WDM's general structure was displayed.

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