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Single Laser Light Source Multi-Channel PSK Optical Communication

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Abstract: Two light waves which have same wavelength and same plane of polarization can interact with each other and produce interference pattern only if the path difference between two waves is less than coherent length. It also means that if path difference is more than coherent length then waves will not create interference pattern or decoding of signal will not be possible. Using this property, it was demonstrated that more than one channel can be transmitted as long as the difference in their path lengths is more than the coherence length of the light source used.

Key words: PSK communication, polarization maintaining fiber, coherent length, free space communication, optical communication

INTRODUCTION

In optical communication data transfer rate can be increase either by increasing bit rate of by increasing number of channels. So far 64 channels have been reported[1]. We have developed unique technique to increase the number of channels without changing the frequency or the plane of polarization. One of the most effective ways of sending signal is by Phase Shift Keying (PSK) with homodyne detection technique. The phase shift keying modulation technique has received renewed attention recently for long-haul and spectrally efficient wavelength-division multiplexing applications[2]. As all PSK communications are coherent length dependent, for decoding the signal, the path difference between the two light waves (signal carrying light wave and reference light wave) must be within the coherent length. If path length difference is more than coherent length then decoding of signal is not possible[3,4].

For PSK communication, there are certain limiting factors such as firstly, the light wave must have very stable frequency with very narrow line-width[5]. Secondly, all interacting light wave must have the same plane of polarization and the plane of polarization should be stable. Hence most of gas laser can not be used as light source for PSK communication because their plane of polarization tends to change with time. In the case of Direct Detection/Intensity Modulation (DD/IM) and frequency modulation (FSK), the change in phase does not affect the communication system. However in the case of PSK system, it is mostly sensitive to any phase change and hence the interacting light waves must be within the coherent length[6].

For coherent communication, the medium through which light wave signal passes must be polarization maintaining. This can be free space or Polarization Maintaining Fiber (PMF). We have tested our system using free space. In the following design we have used the coherent length properties to add more channels for sending more information over same space.

MATERIALS AND METHODS

The system arrangement of coherent length dependence multi-channel PSK communication system is shown in Fig. 1.

Laser Diode (LD with 630 nm wavelength, 3 mW output power and $1x10^9$ Hz full width at half maximum-FWHM, which is equivalent to about 30 cm coherent length) is used as light source (Fig. 1). A variable aperture is used to control the intensity of light while the half-wave plate is used for reorienting the plane of polarization. Polarized beam splitter PBS-1 is used for monitoring the power of light wave by rotating it along the beam. Most of the light wave simply passes through Polarized Beam Splitter (PBS-1). An isolator is used to protect laser from back reflection. Next light wave splits into two parts by Non-polarized Beam Splitter (NPBS). The light wave, which straight pass through NPBS, becomes reference light wave while the light wave, which is reflected at 90 degree, becomes signal-carrying wave. Polarization plane of reference light wave is rotated to 45 degree by Half-wave Plate (HWP-2) and then this light beam is again divided into two beams by Polarized Beam Splitter (PBS-2). Both of these light waves which are orthogonal

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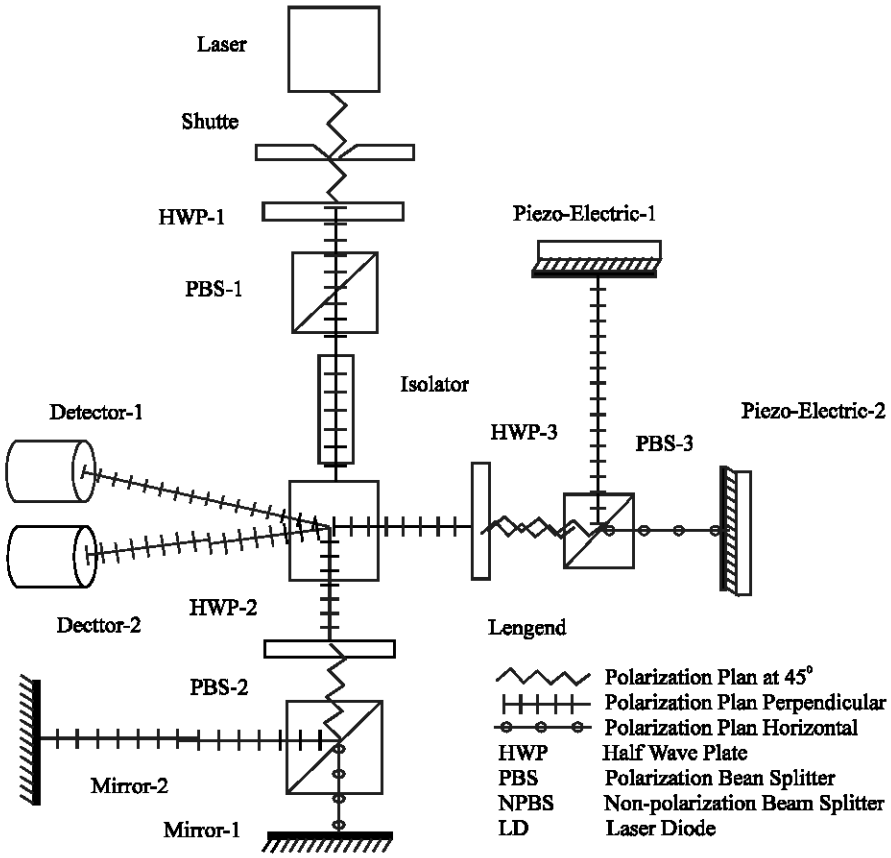

Fig. 1: System arrangement of coherent dependence multi-channel PSK communication

to each other are reflected back by the Mirror-1 and Mirror-2. Since these two mirrors are placed at different distances form NPBS, both have different path lengths. The light wave reflecting from Mirror-1 reaches Detector-1. The light wave reflecting from Mirror-2 reaches to Detector-2.

The light wave, which is perpendicular to the reference light, is rotated by Half-wave Plate (HWP-3) by 45 degree and then divided by polarized beam splitter PBS-3. One part of the light wave reflected back by the mirror which is attached to Piezo-Electric-1. The other part of the light wave is reflected back by the mirror which is attached to another Piezo-Electric-2.

These two piezo-electrics are attached with TTL signal generators. These piezo-electrics encode two independent signals on each light-wave by vibrating the attached mirrors which create phase shift for light waves. When these two encoded light waves reach the detectors, they interact with their respective reference light waves. Path length between NPBS and Mirror-1 is the same as the path length between NPBS and Piezo-Electric-1. This means that the signal-carrying light wave from Piezo-Electric-1 interacts only with reference light-wave coming back form Mirror-1 and hence gets detected by detector-1. It creates interference pattern on the surface of the Detector-1. A convex lens is placed just before the detector to get proper size of interference pattern. The same thing happens with signal carrying light wave coming from Piezo-Electric-2. This signal carrying light wave interacts with the reference light wave reflected form Mirror-2. Since both have the same path lengths it generates interference pattern on the surface of Detector-2 which can easily be detected. In this experiment we have misaligned the two light waves reaching at detectors but in case of real communication system we can rotate the light wave and then split it into two by polarized beam splitter. An isolator is used to block the reflected light wave to protect laser. The laser diode being used has about 30 cm coherent length. The total path length (from NPBS to piezo-electric-2 and back to NPBS) and the path length (from NPBS to piezo-electric-2 and back to NPBS) is more than twice the coherent length of laser diode. Signals are encoded by the two piezo-electric mirrors and detected by the two detectors.

RESULTS

To test the optical design, a circuit using simple TTL devices were constructed which generates two electrical signals. These two TTL signals are different and also have constant phase difference. These two TTL signals were used as input signals for channel-A and channel-B (Fig. 2).

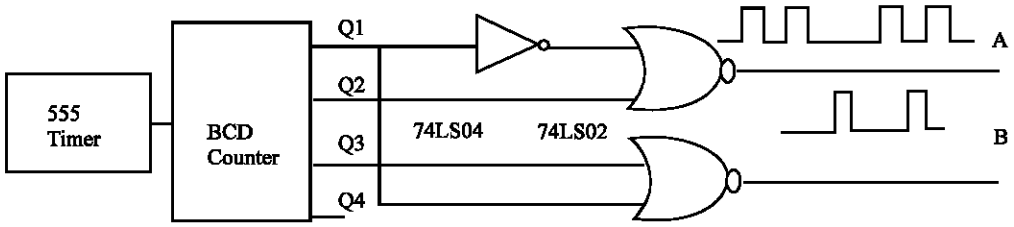

Fig. 2: TTL logic to generate two different signal with fixed phase difference

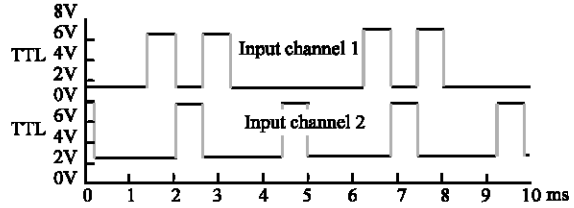

Fig. 3: Two input signals generated by TTL circuit with constant phase difference

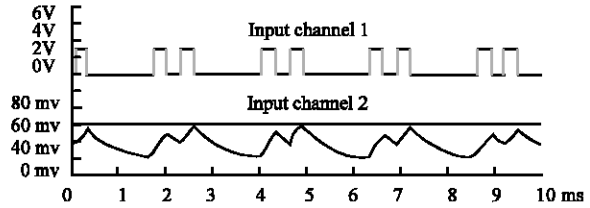

Fig. 4: Input channel-1 at TTL and corresponding optical output detected by detector-1

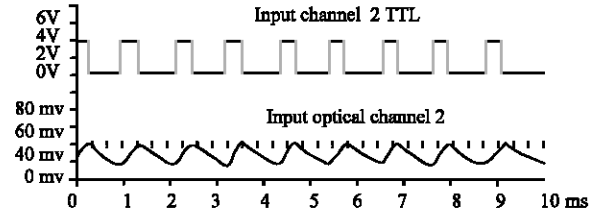

Fig. 5: Input channel-2 at TTL output and corresponding output at detector-2

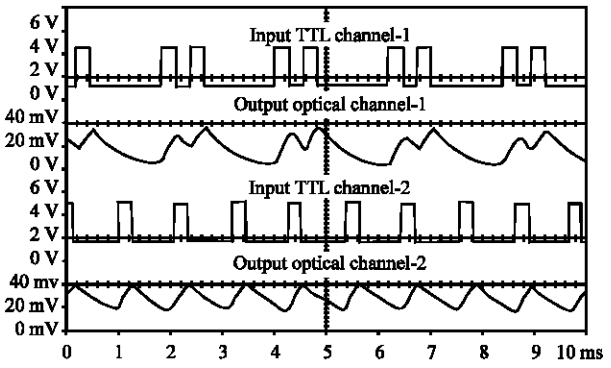

Fig. 6: Two inputs and two outputs signal plotted simultaneously

Two signals generated by TTL are plotted and is shown in Fig. 3. When this TTL signal is applied to piezo-electric which is attached to plane mirror, it vibrates. Due to its vibration optical path difference also changes. In this way signal is encoded on the light beam which is reflected from the mirror. When this encoded signal light wave interacts with reference light wave of same path length it generates time varying interference pattern. By using bulk optic information can be decoded from this interference pattern. Firstly channel-1 was activated while channel-2 remains off. TTL input and optical output was plotted (Fig. 4).

Similarly channel-2 was activated while channel-1 was off. TTL input and optical output is plotted (Fig. 5).

There are two types of inputs signal and two types of optical outputs signals. First two inputs which are generated by TTL, are like square waves. Once these two inputs are connected with the peizo-electric, optical outputs signals are generated. These optical outputs are not exactly square waves. This is due to the inertia of the piezo-electric and the inertia of the mirror which is attached with piezo-electric device. Optical outputs at PBS-2 and optical signal outputs at PBS-3 after reflection from piezo-electric-1 and pieso-electric-2 are transmitted.

Close observation reveals that there are two kinds of distortions. First one is in the shape of the wave. Input signal is square wave and optical output looks like a sine wave. It is due to the high capacitance of pieso-electric. Secondly, there is a time delay between input and output signal. This time delay is less than 10^{-3} second. This time delay is due to inertia of mirror attached with piezo-electric. Finally both signals are activated their outputs are recorded simultaneously (Fig. 6). It is noted that there is no interference between two optical output signals.

DISCUSSION

The present research shows that as long as the path difference for different signal sources is more than the coherent length of light source signal for this source, then there will be no interference with one another. For decoding these signals we must have reference light waves with the same path lengths as the path length of

the respective signal light wave. In other words, the two light waves don't interfere with one another even if they have same plane of polarization, same frequency but different path length. But difference in the path length must be greater than the coherent length of light source used.

CONCLUSIONS

We have clearly shown that more optical channels can be added even when optical wave with same frequency and same plane of polarization is used. This is only possible if difference in path length for two channels is more than coherent length.

The results also demonstrate that there is no interference between two signals using same space, same plane of polarization and same frequency. In addition, it is obvious from the above research that we can have more than one channel for PSK communication by using different path lengths for each signal source. In fact there may not be any limit for the number of channels as long as the reflected signals are strong enough and the coherence conditions are met.

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REFERENCES

1. Kikuchi, V., Y. Shibata, H. Okamoto, Y. Kawaguchi, O. Oku, H.Ishii, Y. Yoshikuni and Y. Tohmori, 2001. Monolithically Integrated 64-Channel WDM Channel Selector on InP. Optical Communication Proceeding of 27th Eur. Conference (ECOC '01-Amsterdam), pp: 331.
2. Keang-Po, H. and J. Kahn, 2004. Electronic Compensation Technique to Mitigate Nonlinear Phase Noise. Lightwave Technologies, 22: 779-783.
3. Mahdi, M., F. Adikan, P. Poopalan, S. Selvakennedy, Y. Chanand and H. Ahmed, 2000. Gain-clamped fiber amplifier using an ASE end reflector. Elsevier, Optic Commu. 177: 195-199.
4. John, M.S., 1992. Optical Fiber Communications. 2nd Edn., New York, Prentice Hall.
5. Genty, G., M. Kaivola and H. Ludvigsen, 2002. Measurements of linewidth variations within external-cavity modes of grating-cavity laser. Elsevier Sci. Optic. Commun., 203: 295-300.
6. Mendieta, F., M. Corona and A. Arvizu, 1996. A coherent optical communications demonstration experiment using a self-heterodyne interferometric technique with controlled-spectral density laser fields. Instrument. Dev., 3: 29-36.