激光技术
Vol.14,No.2

An experimental system of coherent optical TV transmission

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Abstract: A new experimental system of coherent optical communication is recently accomplished at the Guilin Institute of Optical Communications in China. The system is used to transmit TV signal. The receiving sensitivity of the system reaches -56 dBm at transmitting TV signal. It is about 12 to 14 dB increased in the receiving sensitivity as comparing with the direct detection of optical fiber transmission system nowadays.

相干光纤电视传输实验系统

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摘要：一种新型的相干光纤通信实验系统最近在桂林激光通信研究所完成。该系统用于传输彩色电视信号，其接收灵敏度达-56dBm，比目前的直接探测光纤彩电传输系统的接收灵敏度提高了近14dB。

Introduction

The coherent optical fiber communication is conspicuous by its advantages of high receiving sensitivity and broadband features. Its 1.5μm wavelength has been a noticeable research direction in the field of world wide optical fiber communication over the years. Papers of value to practical application on 1.3μm and 1.5μm wavelength coherent optical fiber communications were published by Japanese and British scientists one after another in 1979～1980, since then the research and develop-

ment in this aspect have been going on with a picked up speed and beginning the practical application up to now. In China, research work of coherent optical fiber communication technique has been developing vigorously. The TV transmission system of coherent optical fiber reported here with full utilization of domestic devices is giving excellent system performances and abundantly proving the advantages of coherent detection.

Constitution of experimental system

The experimental system is shown in Fig. 1. The schematic diagram of the system is shown in Fig. 2. In the system 1.52μm wavelength He-Ne lasers are used as a transmitting light source and a local oscillating light source, the acousto-optic device is used as an external modulator to modulate optical signal which is received and processed by a broadband photo diode PIN used as the opto-electronic detector, and an optical polarization controller is used to control and maintain the polarization state of local oscillating light to coincide with the transmitting light.

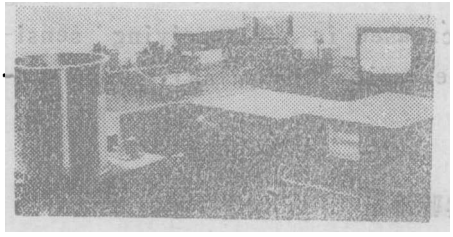

Fig.1 Photograph of hetrodyne detection experimental system arrangement

The transmitting laser is a longitudinal Zeeman frequency stabilizing laser[1], with a frequency stability better than 10^{-10} to 10^{-11} and a strong environmental adaptability without mode jumping for 24 hours continuously.

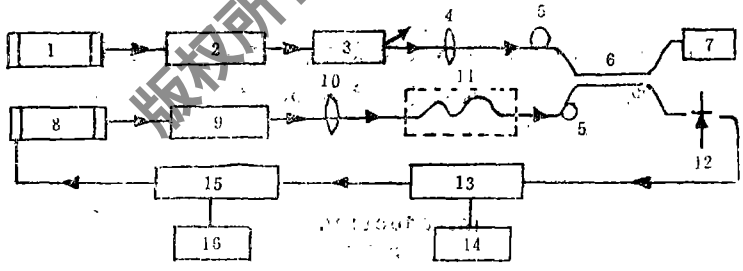

Fig.2 Schematic diagram for experimental system of Coherent O.F. TV transmission

1—Transmitting laser 2, 9—Polarizing prism 3—AOM 4, 10—Lens 5—SM fiber 6—3dB direction coupler 7—OPM 8—Local OSC laser 11—Polarization controller 12—PIN 13—Preamplifier 14—TV set 15—2nd heterodyne stabiliziing system 16—Oscilloscope

The frequency of local oscillation laser is controlled by phase lock-in tracking system of secondary beat[2], to maintain IF frequency stability of optical heterodyne. The controlling voltage applied on the PZT of local oscillation laser is in the range of 0 to 1000 V stabilizing the IF frequency to an order of 0 to hundreds of MHz. The stability and reproducibility all reach 10^{-9}.

There are many controlling techniques to be selected for the polarization state of local oscillation light. For controlling of polarization state of local oscillation laser in this experimental system, a polarization controlling device made according to bending-twisting principle is adopted. The device possesses a main feature of low insertion loss and convenient adjustment.

The selection of acousto-optic modulator(AOM) as an external modulator is based upon its stable performance and easy control. Besides, the performance of domestic waveguide modulator is not reaching practical requirement yet. Once the waveguide modulator is adopted, the signal transmitting speed and bandwidth will be further increased readily.

The light transmitted by transmitting laser is turned into polarized light after polarizing by Glan-Tompson prism and then coupled into a SM optical fiber of 1.4 km in length by applying TV signal on AOM for modulation. The tail end of optical fiber is connected with a 3 dB direction coupler. The light emitted from the local oscillation laser is also injected into polarization controlling device and polarizing through Glan-Tompson prism, the other end of polarization controlling device is connected to the 3 dB direction coupler too. The transmitting signal light and local oscillation light are mixed and amplified by broadband PIN photo diode detector after combined coupling. The output is divided into two path, one is sent to TV monitor reproducing a TV signal, the other path is sent into phase lock-in tracking system of secondary beat. The system is an IF tracking feed back controlling system. The frequency drift error signals of optical frequency differences between two lasers are sent to local oscillator for feed back tracking to realize stabilization of optical beaten IF frequency. The output light from another end of direction coupler is monitored by optical power meter.

Experimental results

In the experiment, a TV signal as a distinct picture can be reproduced on the TV monitor screen after passing through an optical fiber of 1.4 km in length. Here, the detective sensitivity of the system is evaluated

by reducing a signal injection power to -58 dBm. A TV signal, although comparative blurred, is still appeared on the screen of oscilloscope. Fig.3 shows the TV stairstep signal photograph taken from oscilloscope after coherent transmission when fiber injection optical powers of transmitting and local oscillation are 69 nW (-41 dBm) and 2.6 μW (-26 dBm) respectively. Fig.4 shows waveforms of the first IF induced by heterodyne of

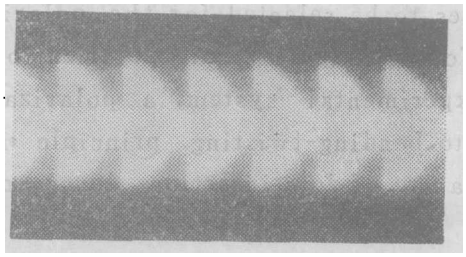

Fig.3 TVsignal received by heterodyne detection

Fiber injection optical power of transmitting signal 69nW(-41dBm)
Fiber injection optical power of local OSC laser 2.6μW(-26dBm)

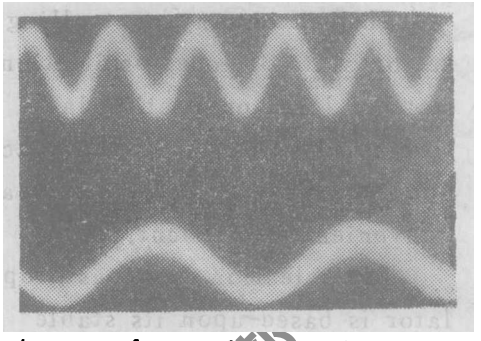

Fig.4 Waveform of optical heterodyne 1st IF and electrical heterodyne 2nd IF signal under the condition of Fig.3

two lasers and the locked-in 2nd IF by electronical beat. Fig. 5 shows the waveforms comparison between receiving signal and transmitting signal at -58 dBm of optical injection power for transmitting optical signal.

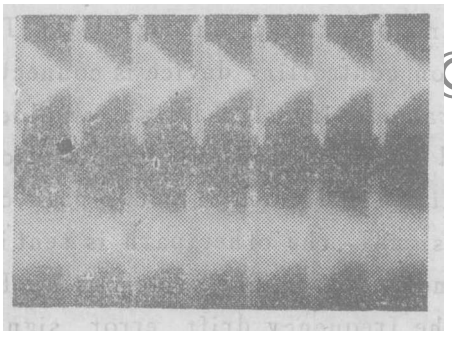

Fig.5 Comparison of (a) TV test signal generator transmitting signal and (b) received TV signal

a—From TV test signal generator
b—Signal at -58 dBm by heterodyne detection

The preliminary experimental results showing that the experimental system is able to transmit TV signal excellently and the receiving sensitivity is better than -56 dBm. As comparing with the nowaday direct detection of optical fiber TV transmission system, the receiving sensitivity is improved about 12 to 14 dB.

The research results of the experimental system is preliminary. Improvements are needed for the system, such as the increase of modulation speed, long term stability of IF locking-in, effective coupling with optical fiber, etc..

The authors would like to give their appreciation to Xiao Shilin,

激光技术
Vol.14,No.2

对散斑杨氏干涉条纹质量改进的研究

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摘要：本文对同轴散斑干涉条纹渐晕斑的不良影响进行了分析。并提出了消除渐晕斑的方法，进行了比较实验。理论与实验结果相符。

A research for improvement in the fringe quality of speckle Young's inference

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Abstract: The pernicious effects of vignetting spot on the coaxial speckle inference fringes are analysed and a method for eliminating the vignetting spot is given. Comparative experiments have been carried out and results consist with theoretical analysis.

一、对同轴散斑条纹的分析

当对一张记录了物体位移信息的同轴散斑图用细激光束照射时，将观察到杨氏双孔干涉

Li Haibo, Fan Xiaohung and the research group for their helpful cooperation during the experiment.

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马　迅，请参阅本刊1990年Vol.14, No.1, P.38.

收稿日期：1989年7月13日。