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Effect of the Broadband Optical Source upon the Output of Optical Current Sensor

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Abstract. For optical current sensor, the effect of spectral width of optical sources on pulse broadening causing by fiber dispersion has been theoretically investigated and simulated. It is not proved how much this effect can affect the broad-band system up till now. The results show that when the spectra width of light sources varies between 15-25 nm, the pulse broadening of multimode fiber with length of 500 m and single-mode fiber varies between 1-3.5 ns and 1×10-6-2×10-6 ns, respectively. Finally, our experimental results verify above conclusions. That show that the effect is less enough and the treatment of using monochromatic model to describe broad-band systems is reasonable and feasible, if the wavelength accumulation effects of the other optical parameter of sensing head are not considered. The results might be a reference to the colleagues working in the optical current sensing techniques area.

Keywords: Optical Current Sensor, Broadband Optical Source, Fiber Dispersion, Pulse Broadening.

1 Introduction

Optical current sensors (OCSs) are the kind of devices that directly or indirectly realize the transformation or measurement of current in order to achieve the sensing of the current, it based on modern electronic technology and optics technology has many excellent characters. The substitution of OCS for the current-transforming techniques based on electromagnetic induction is a revolutionary evolution in the techniques of current measurement and power line protection in the industry of power delivery, it has already been accepted by electric power engineering with the development of electric power in dustry[1-3].

This paper focuses on the effect of spectral width of the optical source on the output of active optical current sensor (AOCS). For AOCS, the effect of broadband light sources on pulse broadening causing by fiber dispersion has been theoretically investigated and simulated, finally, our experimental results verify above conclusions. The work is significant in both theory and engineering applications.

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2 Theoretically Investigated

Material dispersion is the main sources of the pulse broadening by the source spectral width, in the AOCS system of multi-mode optical fiber transmission. Material dispersion origin of the refractive index is a function of wavelength, and the group velocity Vg is the mode function of refractive index, so transmission rates of different components of the spectrum is a function of wavelength [4,5].

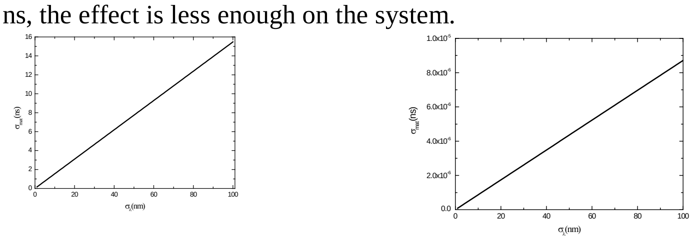
when the light spectrum is σ_λ , the pulse broadening σ_{mat} as in (1):

$$\sigma_{mat} = \left|\frac{d\tau_{mat}}{d\lambda}\right|\sigma_\lambda = \frac{\sigma_\lambda L}{c}\left|\lambda\frac{d^2 n}{d\lambda^2}\right| \tag{1}$$

Eq. (1) is the relationship of pulse broadening and the output of AOCS of multi-mode optical fiber transmission.

3 Theoretically simulated

For multi-mode optical fiber transmission system under the AOCS, by Eq. (1) and the Sellmeier dispersion formula for refractive index of the ZF-7 glass [6], and the experimental system with the length of fiber L = 500m, center wavelength of light = 620nm, using Mathematica software simulation available pulse width changes with the source spectral width in Figure 1 (a). Can be seen from the Figure 1 (a): optical source spectral width in the 0-100nm range of changes, the corresponding change in pulse width is small, the level of 10ns; with the source spectral width increases, the output signal of the pulse width increases; when the spectra width of light sources varies between 15-25 nm, the pulse broadening of multimode fiber with length of 500 m is 1-3.5 ns, the effect is less enough on the system.



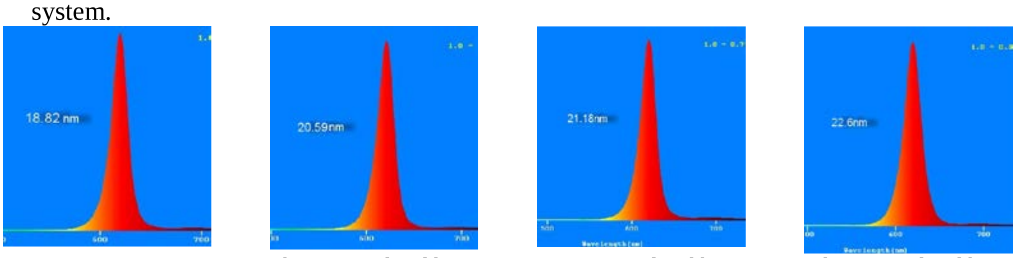
a. Multi-mode fiber transmission b. Single-mode optical fiber transmission

Fig. 1. Pulse width changes with the source spectral width

For single-mode optical fiber transmission system under the AOCS, the use of correlative concluded [7], the corresponding 500m long optical pulse broadening corresponding to the Figure 1 (b). Can be seen from the Figure 1 (b): the source spectral width in the rms value of changes in the range 0-100nm, the corresponding change in pulse width of the lever of 10-6 ns; with the source spectral width increases, the output signal of the pulse width increases; in the source spectral width of 15-25nm range, the pulse broadening in the 1×10-6-2×10-6ns range of changes, less impact on the system.

4 Experimental

The single-mode optical fiber transmission system under the AOCS broadband light source effects on the difference between the 10-5 relative to the multi-mode optical fiber, from the conclusions of the previous simulation, so system output that can be ignored. We verify in the experiment only under a multi-mode fiber of AOCS system.



a. Spectral width is 18.82 nm of LED-1 b. Spectral width is 20.59 nm of LED-2 c. Spectral width is 21.18 nm of LED-3 d. Spectral width is 26.60 nm of LED-4

Fig. 2. (Colour online) Spectrogram of the optical source

We have measured the spectral width of light sources of different system output voltage with variation of current in the experiment, under test to verify the above simulation of light in different spectral width of the output signal of the AOCS system the impact of pulse width. spectral width were selected in four different Light-emitting diode (LED), the grating spectrometer to measure the spectrum LED before the experiment. The spectra are shown in Figure 2. The figure shows, the spectral width were 18.82nm, 20.59nm, 21.18nm and 22.60nm, respectively.

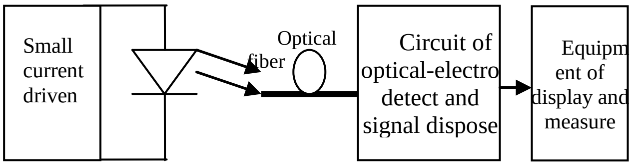
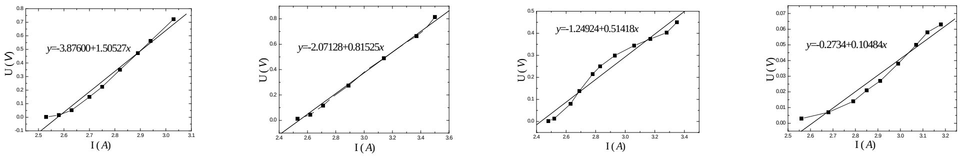


Fig. 3. Sketch map of experimental installation of ACOS

Devices used in the experiment shown in Figure 3. Large current signal under test by using conventional CT is transformed into a small current-driven, light source to achieve electro-optical signal conversion. The output optical signal light transmitted through optical fiber to the area of low pressure achieved by the photoelectric detector photoelectric conversion, transfer to amplify the signal processing circuit, filtering and display. The size of the current signal changes in experiments, then low-pressure side with a voltage meter test data and records.



a. Spectral width is 18.82 nm of LED-1

b. Spectral width is 20.59 nm of LED-2

c. Spectral width is 21.18 nm of LED-3

d. Spectral width is 26.60 nm of LED-4

Fig. 4. Experimental curves

The corresponding experimental curve be shown in Figure 4. From Figure 4: Output voltage is linear with the change of the current under test, the slope of the line 1.50527, 0.51418, 0.81525 and 0.10484, with the spectral width were 18.82nm, 20.59nm, 21.18nm and 22.60nm, respectively. In the AOCS, the system output signal is larger with the bigger spectral width of the LED. And then, experimental verification of the above qualitative conclusion, i.e., as the light source line width increases, the system output decreases.

5 Conclusions

In this paper, we discussed in the broadband light source in the AOCS impact on the system output by theoretical analysis, simulation and experimental studies. Theoretical and experimental results show that, AOCS in the source spectral width has little effect on the system output that can be ignored. Therefore, the treatment of using monochromatic model to describe broadband systems is reasonable and feasible, if the other optical parameters′ dispersion of the sensing head are not considered. The results provide a possible reference for further research in the optical current sensing techniques area.

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