ELECTRONIC SIMULATOR OF AN FBG SENSOR INTERROGATOR

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Key words : optical sensor, FBG, PPM, electronic simulator

ABSTRACT

Fiber-Optical sensor and interrogation systems are expensive, particularly the optical set-up. In this study, an electronic circuit is designed and implemented to generate electric pulses that mimic those that would be produced by a scanned Fabry-Pérot filter of a typical interrogator to detect the central-wavelength shift of the light pulses received from the FBG sensors.

I.INTRODUCTION

Fiber Bragg grating (FBG) sensors have widespread use in the measurement of strain, temperature, pressure, flux, vibration, acoustic, acceleration, electric and magnetic fields, and certain chemical effects. Perturbations due to these measurands are sensed by the shift of the central wavelength of the light reflected or transmitted by the FBGs. Extraction of this information is called interrogation of the sensor, and is achieved by various techniques to determine the Bragg shift associated with the wavelength [1-5].

We based our study on the optical sensor and interrogation system shown in Figure 1, where the light reflected by the FBG sensor is filtered by the Fabry-Pérot filter (FPF) and detected by a photodetector. As the FPF is scanned by a ramp signal, the central wavelength of the light that it transmits is as well scanned. The electric current generated by the photodetector attains its maximum value when the light from the FBG sensor has the same central wavelength with the FPF's resonance wavelength. The spectrum of the reflected light is approximately Gaussian, thus in every scanning period, a Gaussian-shaped electric pulse is generated at the photodetector output. In this way, the temporal position of the peak of the current determines the central wavelength of the light from the sensor. As the FBG is perturbed by information signal the central wavelength shifts accordingly, and the information signal is recovered by electronic signal processing.

II.SIMULATOR CIRCUIT

Our simulator replicates the optical part of the sensor system as shown in Figure 2. The electronic signal processing unit is connected to the simulator. We electronically generate Gaussian-like pulses that shift in time according to the information signal. These pulses mimic those that would be generated at the photodetector output. The electronic simulator incorporates a pulse position modulator (PPM), a high pass filter, integrator and clipper circuits. The differentiator and the zero–crossing detector (ZCD) tracks the peak of the electric pulses, and produces pulses of a fixed height at the zero-crossing instant. The differential amplifier (DA) takes the difference between these pulses of fixed height and the value of the ramp voltage at that instant. This difference becomes the measure of the shift of the pulse peak in a given scanning period. The idle output between any two pulses generates a negative signal, and is clipped. Clipper output signal is a discrete-time analog signal which is converted to a continuous signal by a hold circuit, and thus the recovered information signal is displayed on a digital oscilloscope.

III.EXPERIMENTAL RESULTS

A 4−Volt (peak to peak), 8 −kHz, square wave clock signal is applied to PPM. Information signal is a 3−V (peak to peak), 4−Hz sinusoidal signal. All test signals in the simulator circuit were monitored and measured on a oscilloscope. The PPM output of is a 4−V (peak to peak), 8−kHz of positive square signal. FBG reflection spectrum is simulated by the output of the integrator (Figure-3). The ZCD produces 24−V (peak to peak) pulses. The 6−V (peak to peak), 8−kHz ramp signal is synchronized with the clock. The outputs of the ZCD and the DA are shown in Figures 4 and 5, respectively, where channel-1 is the clock signal. Figures 5, 6, and 7, show the output of the DA, captured by the oscilloscope. The shadiness is due to the shift of the pulses. Amplitudes of output signals of DA are changes due to position changes of themshelves in clock time period. The recovered information signal at the interrogator output is shown in Figure 8 for 4-Hz input and in Figure.9 for 100-Hz input.

IV.CONCLUSIONS

We realized an electronic simulator to produce pulses that mimic the output of the photodetectors in a typical fiber-optic sensor system interrogator. In this way, we configure and test the electronic signal processing unit before building the optical sensor network. Usually in a real FBG sensor system, an optical spectrum analyzer is required to see the full spectrum of the light pulses. However, our electronic signal processing unit once combined with a Fabry-Pérot filter may serve as a low-cost spectrum analyzer.

For a real network using several sensors, multiplexer and demultiplexer circuits should be added to both the simulator circuit and the signal processing unit.

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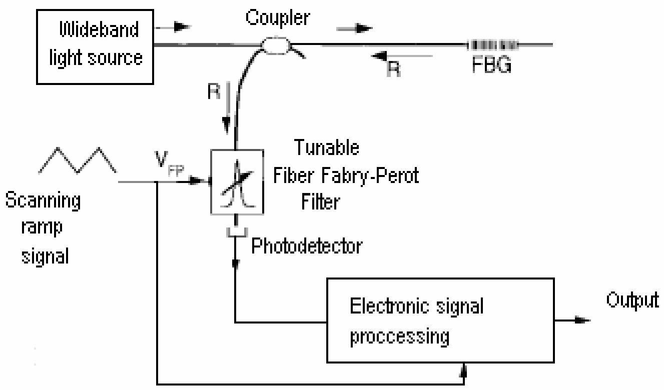

Figure-1 : Tunable Fabry-Pérot filter demodulation method.

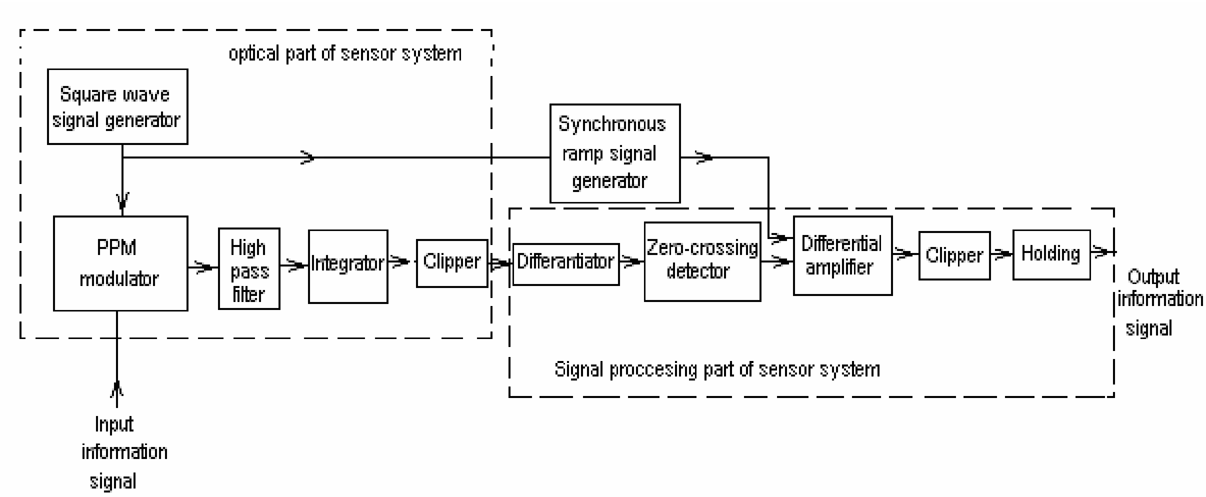

Figure-2 : The block diagram of the simulated sensor system.

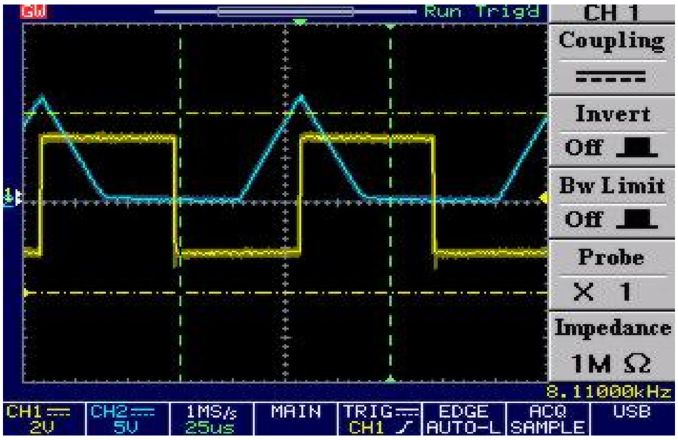

Figure-3 : The input to the differentiator.

Figure-4 : The zero-crossing detector output.

Figure-5: The differential amplifier output.

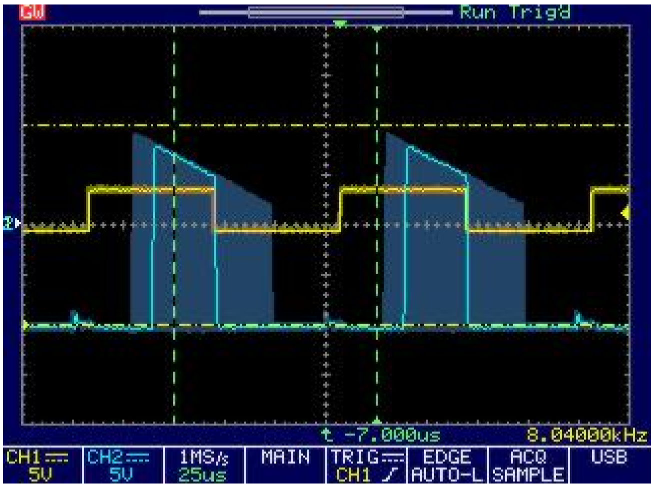

Figure-6 : The differential amplifier output.

Figure-7: The differential amplifier output.

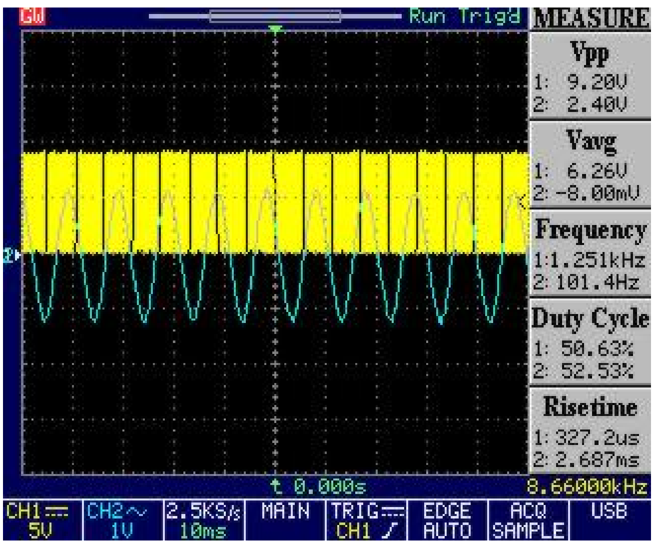

Figure-8: The recovered 4-Hz signal.

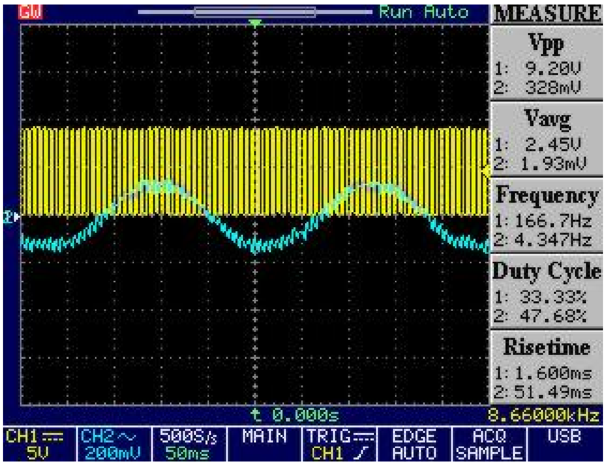

Figure-8 :The recovered 100-Hz signal.