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Simulation Model of Wireless Technology for Bridge Girder Monitoring

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Abstract: The paper deals the simulation model of the wireless sensor technology for monitoring the bridge girder. The main components of the wireless sensor technology are sensor, transmitter and receiver. The sensors are used to measure the structural behavior measurement parameters such as acceleration, sound, temperature, deflection, and strain. Transmitter and receiver are used as a communication media for collecting the sensor data to the main server without wire based communication. The simulation model of the transmitter and receiver have been developed using the Matlab/Simulink toolbox. The validation of the simulation model is done by the comparing the input and output signal results of the transmitter and receiver. This simulation model of the wireless technology would be useful to develop the hardware concept of the wireless sensor networking for monitoring the bridge girder.

Key words: Bridge Girder Monitoring, Wireless Technology, Simulation model of Transmitter and Receiver.

INTRODUCTION

Bridges are an integral part of a highway network and represent a multi-billion dollar investment. During the service life of the bridge structure are always open to traffic, resistant to natural disaster, and unshaken by millions of loading cycles per year (Mohsen et al. 2005). The girder is one of the most important elements of the bridge which is more affected by this type of loading. In addition, a significant number of factors such as dynamic loading, fatigue loading, sustained loading, concrete strength and aging, freezing and thawing frequency influence the girder service life. So, it is becoming imperative to monitor the bridge girders to know the actual health of the girders in their service life. In general, bridge girder health monitoring is performed to know the structural change of the girder and to prevent the collapses of the bridge. In the recent years, the wireless sensor technologies are used to monitor the bridge girder health (Hassan et al 2009). These technologies are increasingly facilitating real-time monitoring of the bridge girder. Although, the wireless sensor technology provides the information quickly in a form easily understood by the operators of the structure, wireless sensor technology is still new to the civil engineers. So, the details description of main functional elements of the wireless sensor technology is important to the civil engineers. The descriptions of main functional elements of the wireless sensor technology for bridge girder monitoring are highlight in this paper. Finally the simulation model of the main functional elements of the wireless technology has been developed for bridge girder monitoring. This simulation model can be useful to develop the hardware for monitoring the bridge girder and its validation.

Methodology:

2.1 Wireless Technology for Bridge Girder Monitoring:

The main components of wireless technology for monitoring the bridge girder are the sensor, transmitter and receiver. The methodogical block diagram of the wireless technology for bridge girder monitoring is shown in the Figure 1. It is seen that sensor is used to collecte the structural behavior measurement parameters such as sound, acceleration, temperature, deflection and strain. The sensor data are transmitted to receiver using transmitter. Receiver gather the transmitted data and then process the data to the original data. Finally all data are stored and visualized in the computer to evaluate the bridge girder.

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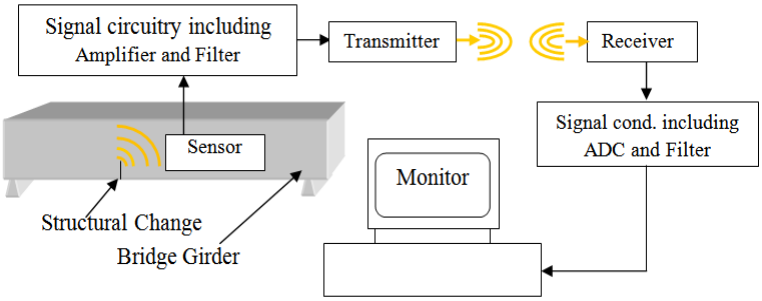

Fig. 1: Block diagram of a wireless technology for monitoring the bridge girder

Simulation Model of Wireless Technology:

Transmitter:

The main function of the transmitter is to generate the desired waveform, amplify it and transmit via an antenna. The transmitter consists of microcontroller, modulator, pulse generator, radio power amplifier and radio. Microcontroller generally help to read the sensor signal. The sensor signal is modulated using the modulator. In general, the modulating device convert sensor data into a carrier signal. The carrier signal is seperated into real and imagineray signal. These two signal are then mergerd with impulse signal and amplified using radio power amplifier.

The Matlab based overall simulation model of the transmitter is shown in Figure 4. All main fuctional elements of transmitter are simulated except microcontroller. The sensor signal is an important part during the development of the simulation model of the transmitter. The sensor out put signal i.e. input signal of the transmitter is considered as a random signal. Because the sensor signal which is picked up from the bridge girder during the real time of the bridge girder monitoring are generally random signal. In Matlab simulink tools, the random integer generator block is utilized to generate the random signal. OQPSK modulator is used to convert the sensor signal in to carrier signal and separated into real and imaginary signal using complex to real-imag block. Finally, the real and imaginary signal are merged with the impulse signals using impulse generator block and amplified using quadrature raise cos filter block. Radio channel carry that signals and send to the receiver.

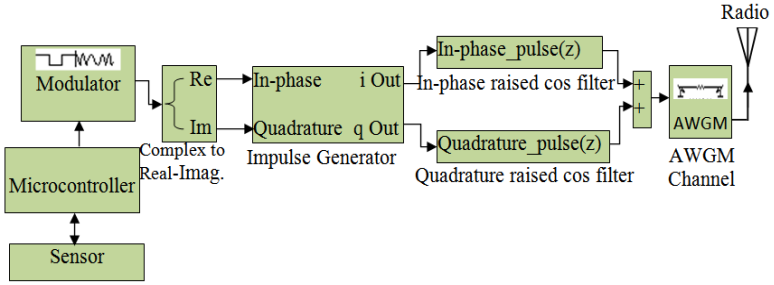

Fig. 2: Simulation model of main functional elements of the transmitter

Receiver:

In the receiver, there are five main components such as radio, filter, DAC (digital to analog converter), demodulator and microcontroller. Radio is used to receive the transmitted signal of the transmitter. Filter is used to remove the unexpected signal or noise. DAC is used to convert the digital signal into analog signal. The main function of the demodulator is to change the carrier signal into the original sensor signal. The microcontroller controls the receiver by programming the receiver and helps the receiver to communicate with transmitter and computer.

The functional diagram of the receiver including computer is shown in Figure 3. In the Matlab based simulation model of the receiver, microcontroller is not considered. The received signal is Figure 3: Simulation model of functional elements of the receiver filtered and mached in to in-phase signal and guadrature-phase signal. These two signal are converted into one complex signal using real-imaginery to complex block. OQPSK demodulator is used to convert the complex signal in to original sensor signal.

RESULTS AND DISCUSSION

The simulation model of the wireless technology consists of transmitter and receiver are simulated using Matlab Simulink Toolboxs. The main things of the wireless technology which are considerd in the simulation model are sensor, modulatation, noise additing into sensor signal, filtering the noisy signal and demodulation. The results of the simulation model of the transmitter and receiver are shown in the Figure 4, Figure 5, Figure 6 and Figure 7. Figure 4 shows the sensor signal which is considered in the simulation model of the wireless technology. Figure 5 shows the transmitted signal of the transmitter and Figure 6 shows the received signal and Figure 7 shows the final out put of the receiver. From the Figure 5, it is seen that when the sensor signal is modulated and merged with impuls signal, th transmitted signal forms a desired waveform signals and this signal patterns are continuously transmitted to the receiver. Similarly, Figure 6 shows the received signal pattern of the receiver during receiving the signal from the transmitter and before demodulating the signal. If the signal pattern of the Figure 5 is compared with the signal pattern of the Figure 6, it is seen from these two figures that the behavior of the signal pattern of the transmitter and receiver is almost same. Its mean that the sensor signal can be transmitted and received using this type of wireless technology. It is also seen from simulation results that the output sensor signal (as shwon in Figure 4) and out put receiver signal (as shown in Figure 7) are almost same. It means that the lost of sensor signal during the transmission of the sensor signal from the collection point of sensor signal to main center of the bridge station are zero. So, this type of wireless technology would be useful for real-time bridge girder monitoring and to detect its structural change.

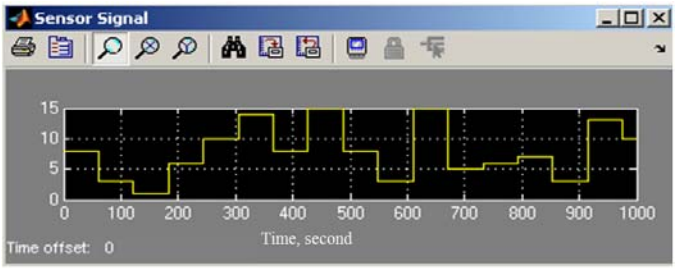

Fig. 4: Sensor output signal

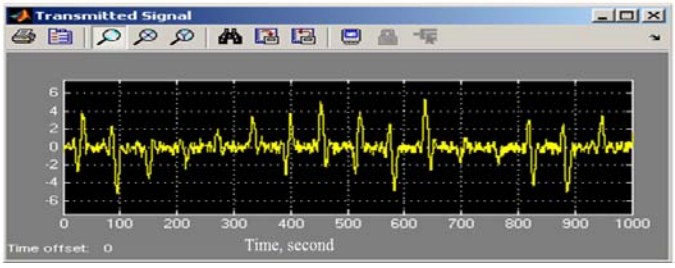

Fig. 5: Transmitted signal of transmitter during sensor signal transmitting to receiver

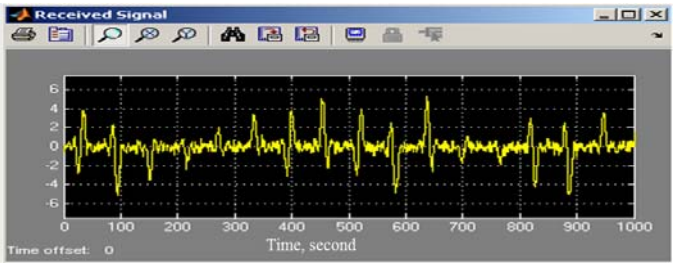

Fig. 6: Received signal of receiver during sensor signal receiving from transmitter

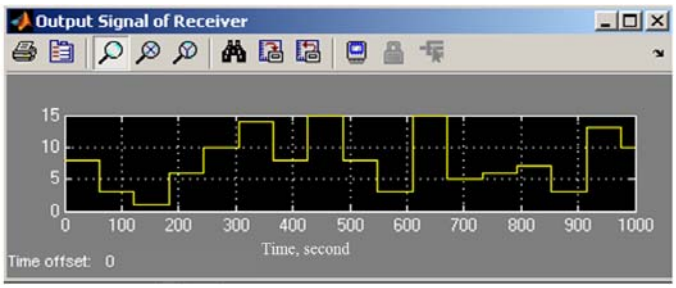

Fig. 7: Output signal of receiver

Conclusion:

The main function of the transmitter is to send the sensor signal as a desired waveform to the receiver. Receiver is used to collect the transmitted sensor signal and to process this received signal in to the original sensor signal through filter. The simulation model of the transmitter and receiver was developed using the Matlab/Simuink Toolbox. The parameter that is checked in the simulation model of the transmitter and receiver is the accuracy of the sensor signal transmission. The results of the simulation model of the transmitter and receiver show that the the output sensor signal and out put receiver signal are same. It means that the lost of the sensor signal during the transmission of the sensor signal from the collection point of sensor signal to main center of the bridge station are zero. So, the sensor signal can be transmitted and received using this type of wireless technology during the real-time bridge girder monitoring. In addition, this simulation model of the wireless technology can be useful to develop thes hardware concept of the wireless sensor networking for monitoring the bridge girder.

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