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The Development of Vibration Frequency Measurement Equipment for Bridge Pier

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Abstract. This study developed a vibration frequency measurement equipment to receive the vibration frequency of bridge pier. The system included a front station and a middle station. A multi-hop wireless routing is employed to transmit the data from the front to the middle station. The front station includes a receiver equipped to receive the vibration frequency, and a wireless sensor network to transmit the data. The middle station is designed by an embedded system for storing the data. The pressure test shows that the loss rate of received data is less than 0.6%.

Keywords: vibration frequency, multi-hop, wireless sensor network.

1 Introduction

Scour on bridges usually damages piers and abutments, and is a major risk causing many bridge failures [1]. In Taiwan, Typhoon Morakot (Aug. 6-9, 2009) attacked Gaoping River Basin and severely damaged the bridge, where the modes of bridge failure can be subjected into four types: flood induced scour, debris flow, woody debris, and dammed lake break [2]. Local scour occurred at the bridge pier should be monitored during the flood period to supply the decision basis of bridge damage. For example, a Scour Monitoring Decision Framework (SMDF) allows to select the best technologies for specific sites [3].

In addition, the progress of micro-electro-mechanical system (MEMS) enables the application of wireless sensor networks (WSN) in the environmental monitoring field. Based on the MEMS technology, a wireless scour monitoring system has been established and examined to measure the scouring and deposition process due to variation of water levels at a bridge pier [4]. A Mote-Integrated Converter Module (MICM) is designed and implemented to servo velocity sensors (SVS) of bridge pier and WSN [5]. This study developed an MICM to measure the vibration frequency of bridge pier. An embedded system was involved within the system to store monitoring data immediately.

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2 Vibration Frequency Measurement System

The system includes SVS, infrastructure nodes and the gateway. Firstly, the SVS detected velocity of the vibrated bridge pier, while the data can be broadcasted by infrastructure nodes to the gateway by multi-hop transmission. The equipments designed in the proposed system are illustrated as follows.

(1) Sensors: The servo velocity seismometer NO. VSE-15D (Figure 1) made by the TOKYO SOKUSHIN CO was adopted as the SVS.

Fig. 1. VSE-15D

(2) Infrastructure node: Tmote mini plus developed by Moteiv Corporation was used as the infrastructure node. This study developed a circuit board to connect the SVS and mote ((Figure 2). With the built in 24-bit analog to digital converter (ADC), Tmote mini plus can deliver the sensing data to the gateway by multi-hop transmission.

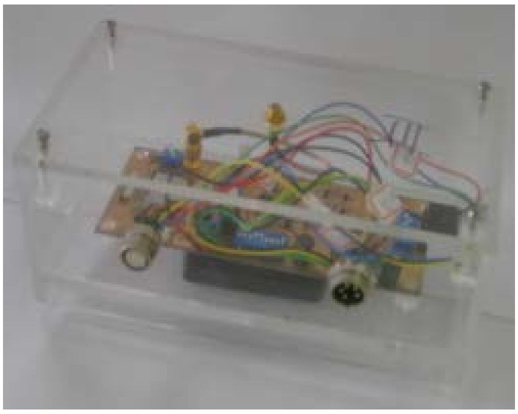

Fig. 2. Infrastructure node

(3) Gateway: Tmote Sky (Figure 3) developed by Moteiv Corporation was used to receive the sensor data from the infrastructure nodes.

Fig. 3. Tmote Sky

3 Equipment install

The TAJIMI-8Pin cable plug is used to connect the SVS and the circuit board shown in Figure 4. The Universal Serial Bus (USB) is used to connect the Tmote Sky and XP-8401 shown in Figuere 5.

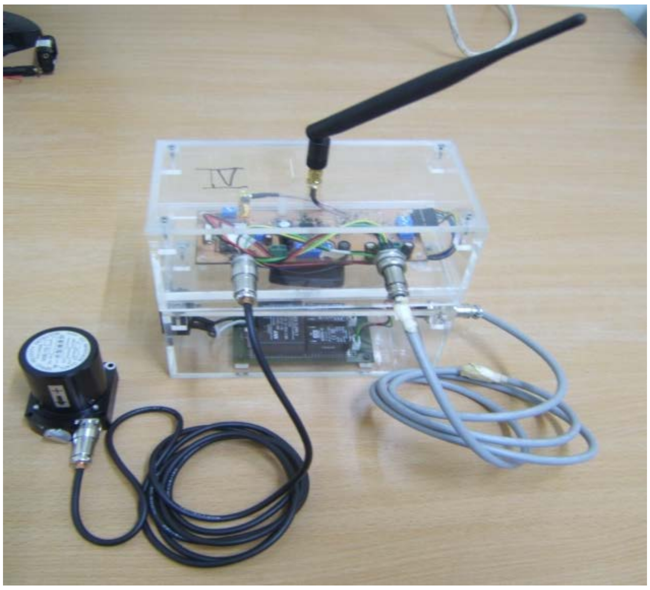

Fig. 4. Sensors and Infrastructure node

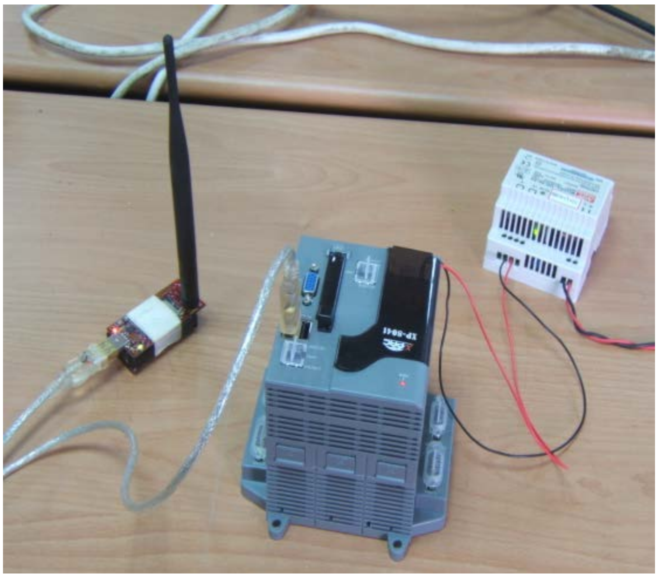

Fig. 5. Gateway

4 System Testing

The packet loss rate of data transmission between infrastructure node and gateway should be small, so as the packets quantities received at the gateway are enough to estimate the vibration frequency. The packet loss rate L is defined as:

$$L = (1-(A/B)) \times 100\% \tag{1}$$

where A is the amount of resorption packets in the gateway; B is the amount of outgoing packets in the infrastructure node. The experiment was executed in a water circulation channel. The SVS was put on the bridge pier model on the channel.

The infrastructure node was set up to deliver 50 packets every second, and the experimental time is one hour. The total outgoing packets are 183600. After one hour test, the total reception packets are 182546, and the loss rate L = 0.57%, which is really small. In conclusion, the system developed by this study can deliver enough sensing data to the decision making center for further analysis.

5 Conclusion

This study developed a vibration frequency measurement equipment by combining servo velocity sensors, wireless sensor network and embedded system. For the future application in the field, this study tested the packet loss rate between infrastructure node and gateway. The result shows that the packet loss rate is less than 0.6 %. The vibration frequency can be calculated accurately.

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References

1. Zarafshan, A., Amirhossein I. & Farhad A.:Vibration-Based Method and Sensor for Monitoring of Bridge Scour. Journal of Bridge Engineering 17(6), 829--838 (2012)
2. .Tsai, C. P., Lin C.:Field Investigation and Analysis for the Causes of Bridge Failure during Typhoon Morakot. Institute of Transportation, Taiwan (2010) (in Chinese)
3. Lueker, M., Marr, J., Ellis, C., Winsted, V., & Akula, S. R.:Bridge Scour Monitoring Technologies: Development of Evaluation and Selection Protocols for Application on River Bridges in Minnesota. Minnesota Department of Transportation (2010)
4. Lin, Y.-B., Lai, J.-S., Chang, K.-C., Chang, W.-Y., Lee, F.-Z., & Tan, Y.-C.:Using MEMS Sensors in The Bridge Scour Monitoring System. Journal of the Chinese Institute of Engineers, 33(1), 25--35 (2010)
5. Kan, Y.-C., Lin, C.-C., Sung, W.-P., Lin, H.-C., & Hong, Y.-M.:Wireless Sensor Network Enabled Servo Velocity Sensors for Bridge Vibration. Disaster Advances, 6(S4), 395--402 (2013)

