A low-power AE b-value sensor for structural health monitoring

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An increase in the quantity of aging infrastructure has become a major social issue. It is thus necessary to properly maintain and manage aging infrastructure, which incurs increasingly large maintenance costs. Therefore, there is a demand for maintenance and management using low-cost and wide-application technologies such as Internet of Things (IoT). We propose a unique, ultra-low-power acoustic emission b-value sensor for structural health monitoring. Acoustic emission (AE) is an elastic wave generated by crack generation or growth inside a material. The characteristics of AE, such as waveform, source frequency, source location, and velocity, can indicate damage affecting material strength. When focusing on the source frequency, the b-value, which is the slope of AE amplitude-frequency distribution derived from the source frequency, is important and widely used as an indicator of material integrity. The proposed sensor was developed to detect this b-value trend more conveniently than ever and to achieve continuous structural or machinery health monitoring. We pursued two key points: ultra-low power consumption and long-distance wireless transmission, which enabled the AE sensor to be applied as an IoT sensor. The wake-on-AE algorithm, which wakes the sensor when AE waves reach the sensor, enables AE sensing to consume a very low current of 172μA on two dry batteries. Generally, the waveform of AE is very short in duration, such as microseconds to milliseconds. If the sensor did not wake up and take measurements in such a short time, the AE wave would pass, and the sensor would fail to measure AE. Therefore, we developed a unique analog-digital co-circuit technology that uses a peak-hold circuit to extract AE features with less sampling. In addition, sensor edges reduce data rates through statistical analysis and transmit data using low-power wide-area networks. In this paper, we present validation results obtained with the sensor on bearings. We performed validation experiments with faulty and normal bearings, generating AEs with different b-values. The developed sensor, operated with two dry batteries, and the AE measurement systems for verification simultaneously acquired the AE generated by the bearing rotation. As a result, we successfully confirmed that the developed sensor provides almost the same results as conventional AE systems in b-value measurement with ultra-low power consumption.