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A Condition Monitoring Technique of a Cooling Tower Fan Using CW Radar

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1. Introduction

From the viewpoint of aging management in a research reactor, condition monitoring of the rotating machinery is important. In addition, many condition monitoring techniques have been investigated [1, 2]. To prevent incipient machinery failures, condition monitoring techniques mainly focus on a spectrum analysis owing to the vibrational nature of machinery.

With respect to condition monitoring techniques of blades in the cooling tower fan, few researches have been carried out. Unlike other rotating machinery, it is difficult to sense an incipient failure of the blades. In this case, a failure is likely to occur unexpectedly, and if so, the operation should be stopped immediately.

In this work, a microwave CW (Continuous Wave) radar system monitoring the conditions of the cooling tower fan is presented. A major advantage of using CW radar is the low cost, and easy installation and maintenance. Also, it is suitable for an outdoor installation in that microwaves are less sensitive to scattering from dust or mist.

2. Condition Monitoring of a Cooling Tower Fan

2.1 Fundamental of a Micro-wave CW Radar

In various radar technologies, micro-wave CW radar is one of the simplest types of radar that can be easily implemented. A functional block diagram of a general CW radar is shown in Fig. 1. A sinusoidal signal is generated by an oscillator, and the signal is transmitted through a TX antenna after splitting the signal path in the power divider. The reflected signal, owing to the blades motion, is received by a RX antenna. The signals are mixed in the frequency mixer, and the IF (Intermediate Frequency) signal, or Doppler frequency, is then extracted after passing the low-pass filter [3]. By means of this motion signal, the condition of the blades can be determined.

2.2 RPM Measurement of HANARO cooling tower fan

Appropriate signal processing techniques are required to observe the conditions of a rotating fan. Both a Hilbert transform and a Fourier transform are well-known techniques to make an envelope signal and analyze the signal spectrum, respectively [1]. Fig. 2 shows the measurement setup of the RPM, and Fig. 3 shows the envelope signal made using a Hilbert transform. The spectral response of the envelope signal is shown in Fig. 4. Note that the spectrum, or APSD (Auto Power Spectral Density), depends on RPM_{motor}, the gear reducer ratio (R_{gear}), and the number of the blades (N_{blade}). If RPM_{motor} is 1800, R_{Gear} is 6.5, and N_{blade} is 6, then the $f_{Envelope}$ is 27.7 Hz based on Equation (1). The peak frequency response in Fig. 4 is about 28 Hz, which corresponds with the calculation results.

$$f_{envelope} = (RPM_{motor} / 60) / R_{gear} \times N_{blade} \quad (1)$$

3. Conclusions

Microwave CW radar technology was shown for a condition monitoring system of a cooling tower fan. CW radar can be used to monitor the conditions of the cooling tower fans. The motion signal from a cooling fan can be represented through an envelope signal, and a frequency response can be analyzed based on the Hilbert and the Fourier transform.

Acknowledgement

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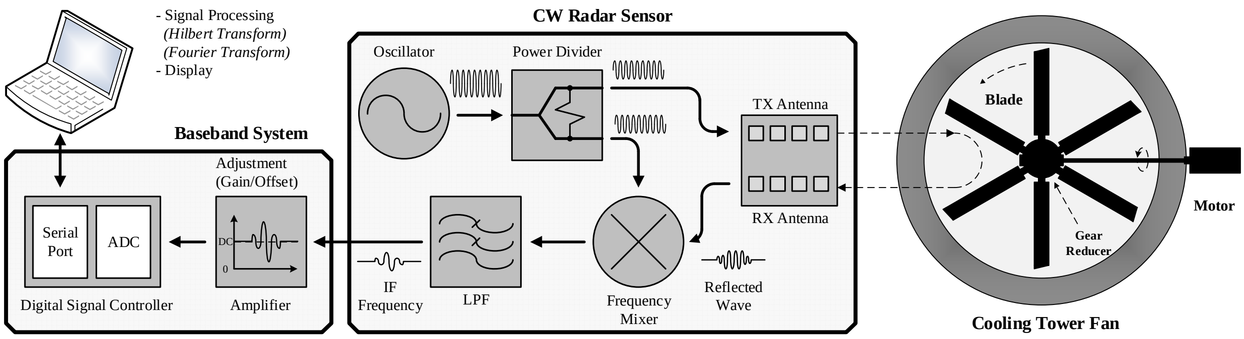

Fig. 1. Overall block diagram of the RPM measurement in the cooling tower fan.

Fig. 2. Measurement setup of the RPM of the HANARO cooling tower fan. The CW radar sensor operates at 24 GHz (K-band), and it was temporarily installed for the experiment.

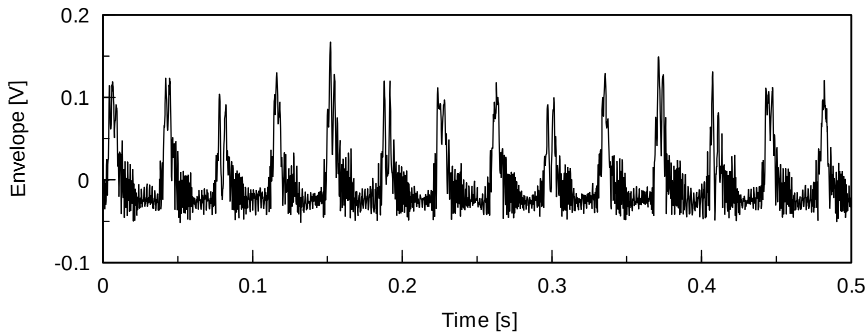

Fig. 3. The measured envelope signal after the Hilbert transform of the received IF signal.

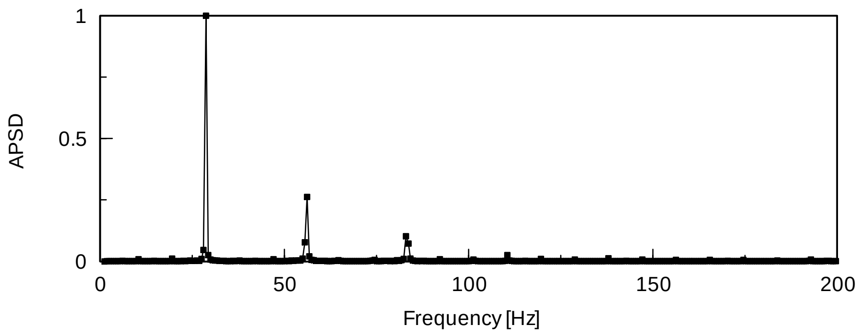

Fig. 4. The linear-scaled frequency response of the measured envelope signal (APSD of $f_{envelope}$).