WiAMS

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Overview

WiAMS is a wireless system for estimating the impedance magnitude ($|Z|$) of a PZT device that is utilized for concrete integrity monitoring. Particularly, WiAMS offers extensive features such as remote control, high processing power, wireless data upload to SQL database, email notifications, scheduled, iterative $|Z|$ estimations and frequency span from 5 kHz to 300 kHz resolution down to 1 Hz.

$|Z|$ estimation

In order to estimate the $|Z|$ of the PZT the circuit of Fig. 1 is utilized. A frequency generator produces an alternative current (AC) signal with frequency f. The signal is driven to a resistor and to the PZT as shown in Fig. 1. The value of the voltage V_{pzt} is estimated as:

$$V_{\text{pzt}}(f) \approx \frac{|Z(f)|}{|Z(f)| + R_{\text{f}}} V_{\text{in}}(f), \tag{1}$$

where $|Z|$ is the magnitude of the PZT impedance, R_{f} is the value of the resistor connected in series with the PZT and V_{in} is the voltage output of the frequency generator. Based on (1), an estimation of $|Z|$ is given by:

$$|Z(f)| \approx \frac{V_{\text{pzt}}(f)}{V_{\text{in}}(f) - V_{\text{pzt}}(f)} R_{\text{f}}. \tag{2}$$

Variations to the equations above may occur due to component non-idealities, temperature variation etc.

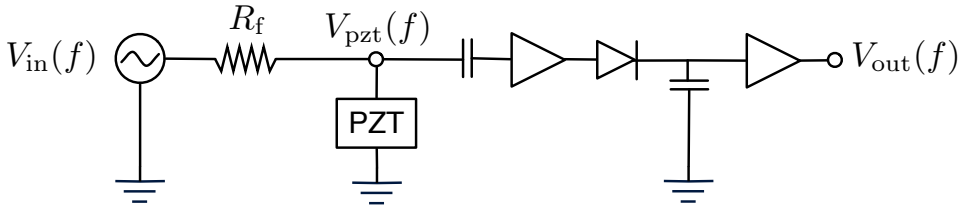

Figure 1: PZT driver basic circuit. The AC signal from a frequency generator is DC-cut, amplified and the peak voltage is found with the utilization of a peak detector circuit. The DC signal at the output can be sampled with a relatively low frequency and low cost components.

Based on the above, It is obvious that $V_{\text{pzt}}(f)$ and particularly the peak voltage provides a solid indication for the value of $|Z|$. The peak voltage of the AC signal is detected using a peak detector module similar to the one described in [2]. The peak detector's output is a direct-current (DC) voltage that corresponds to the maximum value of the input voltage $V_{\text{pzt}}(f)$. With the utilization of this circuitry that is implemented using only a few, low-cost, commodity components, precise $|Z|$ estimation is provided without the need for fast sampling rates. Such an architecture was proposed in [1] but it is limited in connectivity, and interface capabilities compared to WiAMS as it will be shown in the next section.

System architecture

WiAMS consists of multiple modules that conduct the $|Z|$ estimation and the architecture is depicted in Fig. 2. Particularly the modules are:

1. A single board computed (SBC) raspberry pi.
2. A custom board with the AD7357 ADC.
3. A custom board with the AD9837 frequency generator.
4. The PZT driver module.

The SBC is used as the coordinator of the system that performs multiple tasks. Particularly the SBC controls the frequency output of the frequency generator and collects the digital data from the ADC, via serial peripheral interface (SPI). The SBC accommodates a powerful ARM processor and its operating system is Linux-based. Therefore it has extended connectivity and calculating capabilities that WiAMS takes advantage of, in order to facilitate remote concrete integrity monitoring.

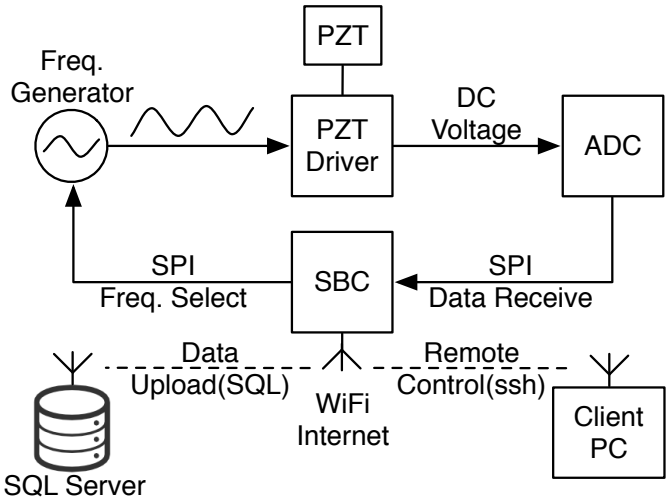

Figure 2: The single board computer (SBC) is used to control the frequency synthesizer and the analog to digital converter (ADC). The PZT driver converts the AC voltage signal to a DC signal based on (1). The digital data from the ADC are saved locally and uploaded to a remote SQL database using a wifi interface. The procedure is controlled remotely from a client PC via ssh protocol.

The system operates as follows. When the SBC is initialized (boots-up) it automatically connects to internet via a WiFi usb dongle. Followingly, the IP address and the Raspberry Pi serial number are sent via email to a preprogrammed email address. The user can connect to the SBC and have full control over it with a simple secure-shell (ssh) client such as Putty.

References

[1] Cortez NE, Vieira Filho J and Baptista FG (2013) A new microcontrolled structural health monitoring system based on the electromechanical impedance principle. Structural Health Monitoring 12(1): 1422.

[2] Franco S. Design with operational amplifiers and analog integrated circuits. 3rd ed. New York: McGraw-Hill, 2002, 658 pp.