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Tunnel Boring and Wall Breaking Detection System Based on Digital Filtering Technique

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Abstract - Security has been a major issue where crime is increasing exponentially and everybody wants to take proper measures to prevent intrusion. There is a need to automate so that user can enhance the technological advancement in such a way that a person getting off the office does not get melted with the hot climate. To minimize thefts and prison breaks we came with purely a new security system. This is a security system which is based on use of vibration sensors. The sensors are reinforced inside the floor, roof, side walls which are arranged with uniform distance between them. The sensor which senses vibration continuously over a period of time is used for detecting the tunnel boring/wall breaking activity. An algorithm is developed for detecting the tunnel boring/wall breaking activity which raises the alarm when one of the above activities is detected. The alarm is raised locally through a siren, informs the owner of the shop through GSM, and a message is sent to the police control room.

Keywords : *GSM, accelerometer, ADXL 150.*

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Tunnel Boring and Wall Breaking Detection System Based on Digital Filtering Technique

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Abstract - Security has been a major issue where crime is increasing exponentially and everybody wants to take proper measures to prevent intrusion. There is a need to automate so that user can enhance the technological advancement in such a way that a person getting off the office does not get melted with the hot climate. To minimize thefts and prison breaks we came with purely a new security system. This is a security system which is based on use of vibration sensors. The sensors are reinforced inside the floor, roof, side walls which are arranged with uniform distance between them. The sensor which senses vibration continuously over a period of time is used for detecting the tunnel boring/wall breaking activity. An algorithm is developed for detecting the tunnel boring/wall breaking activity which raises the alarm when one of the above activities is detected. The alarm is raised locally through a siren, informs the owner of the shop through GSM, and a message is sent to the police control room.

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I. Introduction

In the today's world we can infer that security has been one among the major challenges. People try out various types of security systems in order to safeguard valuable things.

"Every system has a flaw"

Recently in many cities jewellary shops and banks had been robbed. Jewels and huge amount of money had been stolen in these robberies through tunnel boring. Thief had entered the shop by boring tunnel from adjacent site or the drainage box which is running near the shop or by making hole on terrace/wall etc. Also, a lot of prisoners escaped the jail by making a tunnel under the jails. By considering all these problems and cost , we have come up with an new security approach in IR based security system the alarm buzzes only after the theft has incurred but in this security system alarm buzzes even when the thief tries to break through. Hence the main advantage of our security system over other security systems is that our security system does not allow the thief even to enter the shop.

II. Block Diagram

a) Vibration Sensor

Vibrations that are made on the wall, roof or floor in the range of few kHz for the fundamental up to 25kHz. The sensor which is used in this application is ADXL150 IC. The ADXL150 offer lower noise, wider dynamic range, reduced power consumption and improved "0" g bias drift. The ADXL150 offers lower noise and offers better signal to noise ratio. The scale factor can be increased from 38mV/g to 76mV/g by connecting a jumper between V_{OUT} and the offset null pin. Zero g drift has been reduced to 0.4 g over the industrial temperature. A power supply bypass capacitor is the only external component needed for the operation. The ADXL150 is available in a hermetic 14-pin surface mount package specified over the 0°C to +70°C temperature ranges.

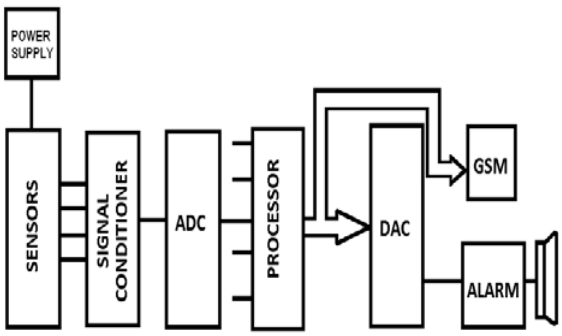

Figure 1 : Block Diagram

b) Signal Conditioning Circuit

When a true DC response is needed, the output of accelerometer is fed to the external amplifier's input. For high gain applications, a zero *g* offset trim will also be needed. The external offset trim permits the user to set the zero *g* offset voltage to exactly +2.5 volts (allowing the maximum output swing from the external amplifier without clipping with a +5supply).

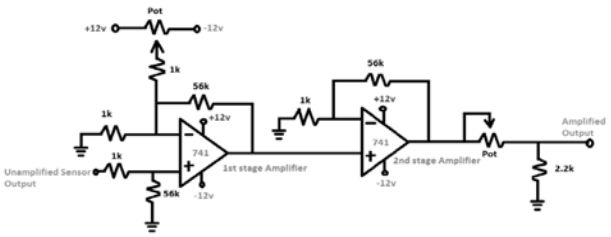

Figure 2 : Signal Conditioning Circuit

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With a dc coupled connection, any difference between the zero *g* output and +2.5 V will be amplified along with the signal. The external amplifier's maximum output swing should be limited to ±2 volts, which provides a safety margin of ±0.25 volts before clipping.

c) ADC

Unlike the other analog inputs used to sense different parameters, the vibration sensor does not deliver a steady state signal. It is sampled and held to get the instantaneous value of the vibration information so an anti-alias filter must be implemented (with a cut-off frequency at half the sampling frequency). During the vibration signal acquisition window conversion time is key parameter; it must be as fast as possible.

To be accurate, signal processing requires a stable and precise sampling period and time. Variations in acquisition timings result in errors and accuracy loss. Usually, a timer is configured to trigger the ADC sampling and conversion requests.

d) Processor

The signal which we obtained from vibration sensor is processed and program is developed using LabVIEW.

e) GSM

A GSM modem is a type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. The mobile operator charges for this message sending and receiving. To perform these tasks, a GSM modem must support an "extended AT command set" for sending/receiving SMS messages.

III. Methodology

As the computational power the processors are increasing, digital filtering is becoming more and more common in vibration detection.

The principle for digital filtering based algorithms is the following: during the vibration window the signal from the sensor is converted to digital, the digital samples are then pass-band filtered to detect the amplitudes of the signal in this frequency-band, the filtered amplitudes of the signal are then processed for final decision.

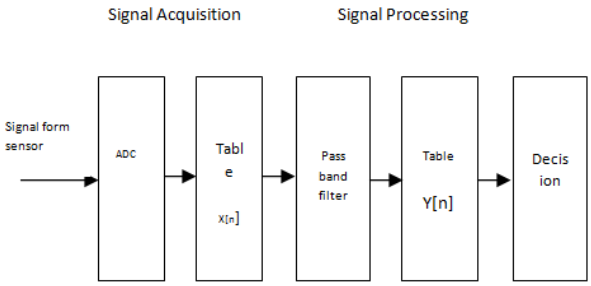


Figure 3.1 : Digital Filtering Based Detection

Vibration detection with digital filters requires narrowband processing specifically to detect the fundamental and optionally the other frequencies of the vibrations while rejecting non relevant frequencies. The digital implementation of Chebyshev or Butterworth analog filters are the Infinite Impulse response (IIR) type filters. Software tools like MathLab allow to select different types of filters and to compute the coefficients that better match the desired filter characteristics.

a) IIR digital filters can be implemented in different ways: the most common forms of IIR filters are Direct Form1, Direct Form2.

Direct Form1

The Nth-order equation for an IIR filter in Direct Form1 is:

$$y(n) = \sum_{k=1}^{N} a(k)y(n-k) + \sum_{k=0}^{M} b(k)x(n-k)$$

x(n) = input signal at time n
y(n) = output signal at time n
a(k), b(k) = IIR coefficients

Direct Form2

The following equations equally represent the Nth Order IIR filter but in Direct Form2. These equations use the intermediate state variable vector U = {u(n), u(n-1), u(n-2),..., u(n-N)}. This representation is called "Direct Form 2".

$$u(n) = x(n) + \sum_{k=1}^{N} a(k)u(n-k)$$

$$y(n) = \sum_{k=0}^{N} b(k)u(n-k)$$

x(n) = input signal at time n
u(n) = intermediate state vector at time n
y(n) = output signal at time n
a(k), b(k) = IIR coefficients

Direct Form 2 has an advantage over Direct Form1 as it requires less data memory.

b) Computation

IIR Filter Computation is made using – Block computing, the computing is scheduled once all samples have been collected. The advantage of using block computing is to minimize the real time constraints; a shorter CPU time is required for the samples when they are available after the AD conversion.

Figure 3.2 illustrates Memory Map for Nth Order IIR Filter Direct Form 2 and the execution of a multiplication and accumulation with parallel data move, shift operands in the delay line.

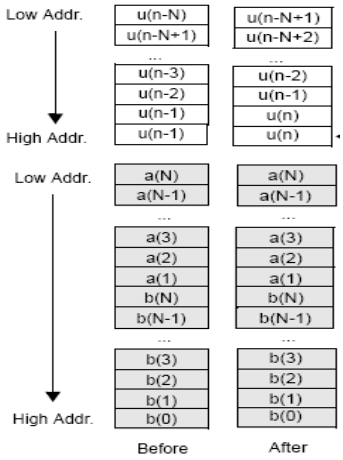


Figure 3.2 : Memory Map for Nth Order IIR Filter Direct Form 2

After each execution, the intermediate state variable is shifted so that the same algorithm can be re-applied to the next input sample. Both coefficients and samples have been initialized by a different routine. The table of samples and computed amplitudes are stored in the memory.

c) Decision

Once the amplitudes of a given frequency are computed, the results are analyzed to decide if there are Vibrations. The digital implementation of the integrator used for analog detection is to sum-up all the filtered amplitudes.

IV. Result

The experiment was conducted by taking the 350 samples of the input signal, which is as shown in figure 4.1.a. IIR filtering technique is applied on the input vibration signal and output of IIR filter is as shown in figure 4.1.b. The average amplitude is calculated. The average amplitude was then compared with the reference amplitude. Based on the comparison, the siren was activated locally if the measured amplitude is greater than the reference amplitude, and also SMS message was sent to the owner of the shop or concerned using GSM technology. The same is tabulated in the table 4.2

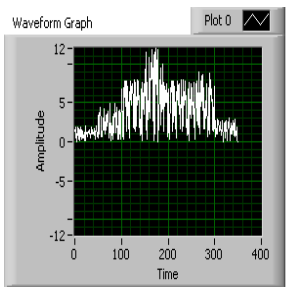
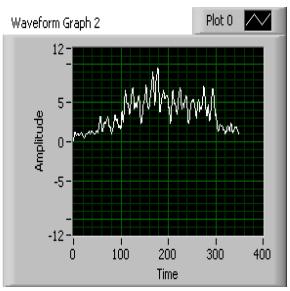


Figure 4.1.a : Signal from sensor



4.1.b : IIR filter output

Sl no.	Average amplitude	Reference Amplitude	Action
1	4.475	4	Siren, message to owner
2	2.312	4	No siren, No Message

Table 4.2 : Results

V. Conclusion

Digital filters allow better accuracy than the analog detection method.

Vibration detection algorithm requires analysis before implementation to optimize CPU time usage, memory mapping, coefficients and samples, choice between cascaded 2nd order sections in 16*16-bit or single section in 32*16-bit arithmetic.

With improved DSP capabilities like spectral based detection, bring access to more sophisticated vibration detection.

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