Reducing False Alarms Caused by Wind Effect in Automatic Security Perimeter System

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Abstract - *False alarms due to wind effect on the perimeter security system need to be reduced. Sensor cables are fastened to existing security fences. Main problem of the system is a false alarms generated by the strong wind. Input signals receiving from sensor cables are processed and analyzed by using the DSP (TMS320F2812) microcontroller. The system collects signal amplitude, duration time and frequency spectrum to distinguish the wind effect from intrusion signal. The result gives the real or false alarm. Frequency analysis was done for each duration of N=128 samples of input signal was using special algorithm of the fast Fourier transform through DSP microcontroller. The security system has been tested at border lines of Mongolia. A detection rate after apply the developed algorithm for reducing false alarms was improved up to 94%~95% of enough accuracy for real field application.*

Keywords: Triboelectric, Electrostatic Charge, Security Fence, Automatic Detection, Intrusion Detection, False Alarm

1 Introduction

The automatic electrical security systems with intrusion detection sensors become more critical problem for any security organization and countries. Many strategically important factories and facilities have been built recently by using rapid industrial it technology development. Security systems were developed with the advanced technologies. They are in high demand to ensure reliable security of industry buildings and special governmental institutions.

The physical security system has been developed from the first generation to the third generation by using the latest modern technologies. The first generation was dependent on the barbed wire fence and guards' eyes inspection. The second generation fence was based on electric fences and CCTV (Closed-circuit Television) cameras. The third generation includes a surveillance system based on GPS (Global Positioning System), cameras and wireless communication system, an alarm system with various sensor fences, an access control system from outside gates to the inside of the buildings. The systems are integrated into a central security control server. The purpose of the physical protection system is to detect an unauthorized intruder whereas the perimeter intrusion detection sensor fence detects the intruder right away by a surveillance monitoring system which covers before and after the intrusion. Also at the same time it prevents the intruders by a sensor at the earliest time. There are several kinds of fences in the second generation such as a taut-wire, a vibration, an electromagnetic induction sensor and a fiber optic cable and a micro wave, and an electric charge sensor in the third generation [1, 2]. The minimal charge is multiplied by semiconductor to be detected. It has the unique characteristics as charge amplifier in a circuit containing a tunnel diode biased for charge detection [3]. In paper [4], there is a polyelectric polymer sensor with an integrated charge amplifier.

The fence security systems with the fiber optic cable can define certain location of an intrusion. But the system cost and maintenance expense are higher than other similar systems [5, 6].

The first prototype device design of the security system based on the triboelectric effect was developed and investigated in the study [7]. The electric charge sensor fence was developed as the prospected system in this field. It is the first passive sensor in the world. It uses the special algorithm of electric charge displacement that is based on friction electromotive force change of the passive sensor cable. The electric charge technique is based on the triboelectric effect. If we rub two different types of materials with each other, the electrostatic charges are generated that are called the triboelectric effect. The physical protection security system can be realized by triboelectric effect. A simple telecommunication cable is used in the protection systems instead of the sensor transducer that is fastened to the various types of perimeter fences. Electrostatic charges are generated, when external force is applied to the sensor cable.

The ASM (Analog Sensing Module) [8, 9] detects the generated minimal charges and rings an alarm. The ASM doesn't generate any electric signals and electromagnetic fields. It only reacts against the change on electrostatic charge in specific range and is not affected by any external factors. Therefore there are no false alarms and perfect probability detection. Also the security detector does not generate the false alarm signals on and after exposure to the outdoor environment factors including humidity, rain, wind, fog, dust etc. the sensor cable reacts against the forced impact weighing 8-20 kg on the fence. It does not detect little forces including

small animals hit the fence. The system sensitivity can be regulated by switches. Electric charge sensor fences are not harmful to the human body. These types of security systems have much more advantages than any other systems. It has simple installation and easy maintenance and is (highly affordable) more economical than any other systems.

2 System design and its solution

2.1 System structure

Electrostatic charges are generated between the cable conductors and isolator when external force and impact are created by the intruders. Simple shielded 15 pair of telecommunication cable is used instead of the sensor transducer for sensing the external force and impact. Sensor cable is not connected to the power source. The lengths of sensor cable are limited up to 1000m. Fig. 1 shows the main operation diagram of the system.

Coaxial cable is used for transferring generated minimal electrostatic charge between the sensor cable and control device. Because of the very high input impedance of the charge amplifier, the sensor must be connected to the amplifier input with low-noise cable [9]. This cable is specially treated to minimize triboelectric noise which is generated within the cable due to physical movement of the cable. The coaxial cable is necessary to affect an electrostatic shield around the high impedance input lead, precluding extraneous noise pickup.

A control device is connected to the data center through the TCP/IP protocol. The control device includes the TCP/IP module. The data center registers fence alarms and control device's conditions when some problems are occurred on the security fence. For example, there are generated alarms when the sensor or coaxial cable is cut or short.

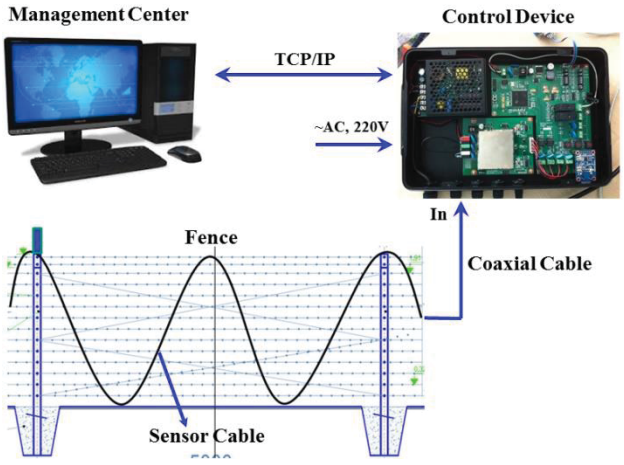

Fig. 1. Main operation diagram of the system

Installation configuration of the sensor cable is dependent on the fence type, structure, and size, height, and installation weather conditions. System sensitivities can be adjusted by hardware method in the control device. Also sensitivities can be adjusted by software in the monitoring application program at the data center. Sensitivity is adjusted by less when sensor cable is fastened on flexible and moving fences. Conversely, sensitivity is adjusted by high when cable is fastened on rigid and less moving fences. The control device controls up to two security zones. Each zone are covered with 500m sensor cable.

2.2 Operation principle of a control device

The control device contains two main parts named as ASM (Analog Sensing Module) and SCM (Sensitivity Control Module).

The ASM [7, 8, 9] detects the electrostatic charges on the passive sensor cable by intruder and raises the alarm. The ASM contains a charge sensitive device, voltage amplifier, signal shaping, filtering, and comparator. The charge sensitive device consists of the charge preamplifier and filters.

The SCM is the digital part of the control device that processes and analyses analog signals from a ASM using by TMS320F2812 32 bit DSP (Digital Signal Processing) microcontroller. The input signal of the sensor cable is fluctuated due to outside environment effects (strong wind, storm) then the SCM analyses all conditions and adjusts sensitivity automatically. For instance SCM reduces sensitivity during strong wind and increases sensitivity during low wind.

Also SCM analyses the input signal amplitude, duration time and frequency. These parameters are changed due to the wind effect. After analyzing input signal, system decides which alarms are real or false. Each N=128 samples of input signal were analyzed special algorithm of the discrete Fourier transform by using equation (2.1).

$$X(k)=\sum_{n=0}^{N-1}x(n)*e^{\frac{-j2\pi k}{N}n};0\le k\le N-1 \qquad (2.1)$$

x(n): Input signal
N=Count of sample (128)

The 1Hz±0.5Hz frequency is generated in the control device when someone forces by 8~20 kg impact on the fence. This is an invasion frequency. The band bass filter is designed in the ASM of control device [8, 9]. Other frequencies are generated due to strong wind effects.

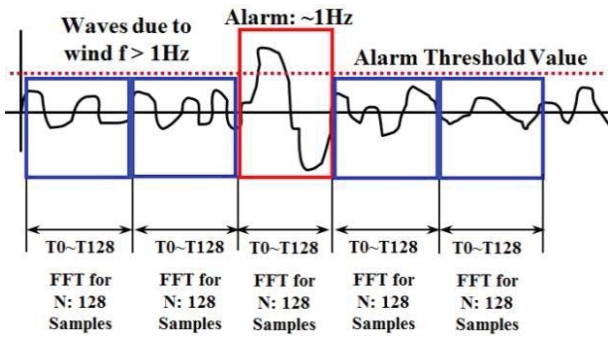

Fig. 2. Condition of fast Fourier transform in input signal

Fig. 2 shows alarm condition of the system. Input analog signal of the sensor cable is sampled by 10ms time step in each N=128 samples using by ADC of the control device. Frequencies are defined every T=1ms*128=1.28s with the fast Fourier transform.

Real wind configuration is shown in Fig. 3. False alarms are generated when signal amplitude of strong wind exceeds a reference value.

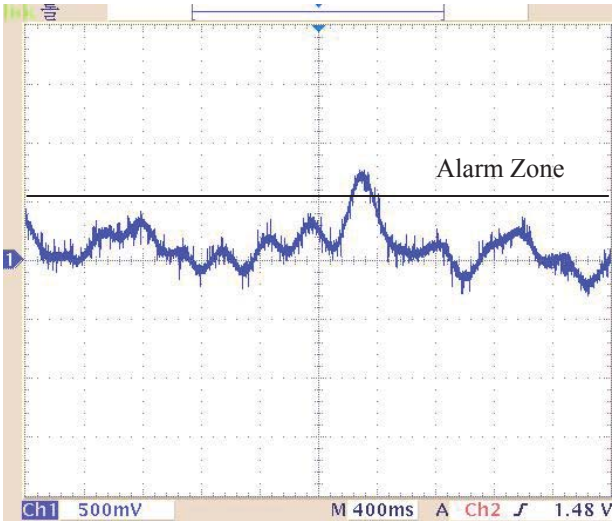

Fig. 3. Noise Signal Generated by Wind Effect on the Electrical Fence

Fig. 4 shows algorithm for reducing false alarms. This algorithm reduces false alarms due to strong wind effect. ADC of control device processes N=128 sample data by 10ms steps. An algorithm reviews and analyses frequency value using FFT, maximum and minimum value of amplitudes.

- ✓ Vmax: Maximum value of amplitude in each duration time of 1.28ms
- ✓ Vmin: Minimum value of amplitude in each duration time of 1.28ms
- ✓ Fmax: Maximum frequency in each duration time of 1.28ms by FFT
- ✓ Vpw: Value of plus wind level that is regulated by DIP switch on control device
- ✓ Vmw: Value of minus wind level that is regulated by DIP switch on control device
- ✓ Vpth: Plus threshold value
- ✓ Vmth: Minus threshold value

Then all of these values are compared to the reference values. After that system decides which alarms are real or false.

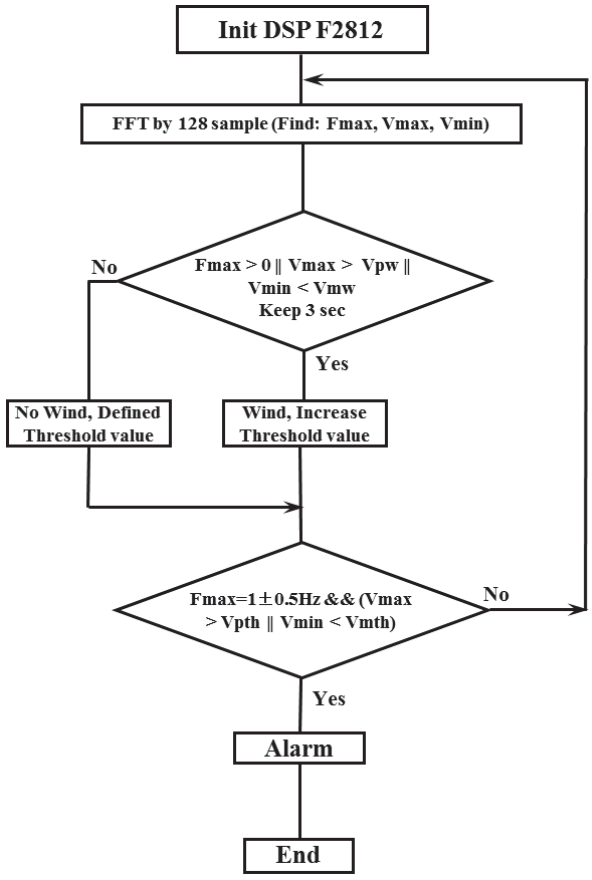

Fig. 4. Algorithm of the DSP Program for Reducing False Alarms

A detection rate was 85~88% before implementing algorithm for reducing false alarms. Detection rate of the system is improved up to 94~95% after implementing that algorithm. That means system does not alarm during strong wind. All data of the wind effect is saved to data center. We have to improve this algorithm using by saved data.

3 Experiment and results

3.1 Experiment area and conditions

The perimeter security system has been tested at the border of Mongolia (2014.11.09 ~ to present). The area has special weather conditions. In the north of Mongolia it is very cold and snowstormy during winter seasons. Also there is strong wind during spring and fall seasons.

Fig. 5 shows installation of sensor cables in the selected special zones of experiment area. Sensor cable is fastened to the border fence by sine configuration. Sensor cable configuration is depended on fence types.

Fig. 5. Installation of Sensor Cable in the Testbed Experiment in Real Field

Two separated zones for testing security system were set up on the barbed fence. This type of fence is flexible and easy moving that is very sensitive in wind effect.

Experiment has been done two-three times in a day. Operators have pull and push barbed fence then alarms are generated on the data center. Monitoring application program registers all generated alarms and system conditions.

Table 1 shows some registered alarms in the data center from 2014.11.10 to 2015.04.25. As shown in experiment results, there are no false alarms when there are windless days. Alarms are generated when a dog and a cow touches the fence. Also some alarms are generated when bevy of pies and crows seat and fly on the barbed wire of the fence. This type of alarms are normal operation of system. But some false alarms are generated during snowstorm in 2015.01.05,06.

Table. 1. Registered alarms

Alarm time	Alarm zone	Alarm reason	Operator
11/15/2014 12:3	1	Test	P.Davaadorj
11/28/2014 12:3	2	Test	S.Chuluun
12/16/2014 8:29	2	A dog touch	G.Olzii
12/27/2014 9:03	1	Test	P.Davaadorj
1/5/2015 2:06	2	Snowstorm	B.Shinebayar
1/5/2015 12:19	1	Snowstorm	B.Shinebayar
1/6/2015 14:12	2	Snowstorm	G.Olzii
1/8/2015 11:58	1	A cow touch	B.Shinebayar
1/13/2015 14:05	1	A bevy of pies	E. Erdene
1/16/2015 11:29	2	A bevy of crows	S.Chuluun
1/18/2015 15:13	1	A cow touch	B.Shinebayar
2/8/2015 11:58	2	Test	B.Shinebayar
2/23/2015 14:05	1	A dog touch	G.Olzii
3/11/2015 11:29	2	Test	P.Davaadorj
3/28/2015 15:13	1	A cow touch	B.Shinebayar
4/17/2015 13:35	1	Test	S.Chuluun
4/25/2015 14:05	2	Test	G.Olzii

3.2 Monitoring application program

Fig. 6 shows a screenshot of the monitoring application program.

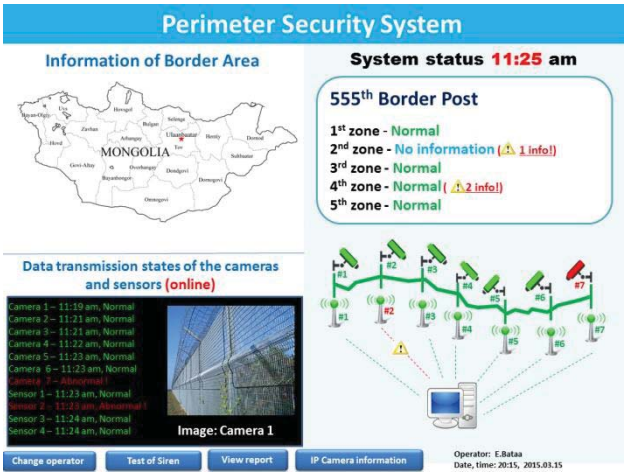

Fig. 6. Screenshot of monitoring program

All log data is stored to the data center. Monitoring program receives all zones information by real time from control device and displyas these states. For example there are intruders' alarms, sensor and coaxial cable is cut or short, control device's cover open. A report can be printed and viewed with many options.

4 Conclusions

The perimeter security system was developed and tested in real field experiment under the severe weather conditions of Mongolia. Main problem of the perimeter security system was false alarms. False alarms are generated due to strong wind effect. In order to reduce false alarms, special algorithm was researched and implemented in the system. As shown in experiment results, alarms are generated when a dog get in under barbed fence and a cow touches the fence. Also some alarms are generated when bevy of pies and crows seat and fly on the barbed wire of the fence. These types of alarms are normal operation. But some false alarms are generated when snow is stormed continuously.

The detection rate of the invasion is improved up to 95% as seen from experimental data of the last 5 months. To increase detection rate, algorithm for reducing false alarm has to be improved. Also to improve detection quality, IP camera has to be introduced to the system in the further work.

The sensor cable is frozen when outside temperature is decreased to -30C. So fence sensitivity is decreased. In this case we have to increase sensitivity by 1-2 steps in winter season.

5 Acknowledgment

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