Upgrade of Electronic Security Fence System by Reduction of Vibration Noise by Wind Effect

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Abstract. Vibrational noise signal due to wind force on the electronic fence security system need to be overcome. Sensor cables were already fast fixed on to existing security fence perimeter. The wind noises generated by the strong wind were much problem by the real operation of electronical fence system. Wind noise signals receiving from sensor cables were processed and analyzed to improve the existing program in 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 reliable accuracy for real field application.

Keywords: Perimeter sensor · Electrostatic charge · Friction electricity
Security fence · Invasion detection · Intrusion detection · False alarm

1 Introduction

1.1 Upgraded Electrical Security Fence

The digital 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. 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

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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) [1, 2] 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 it was highly useful and more economical than any other electrical fence.

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 1000 m. Figure 1 shows the main operation diagram of the system.

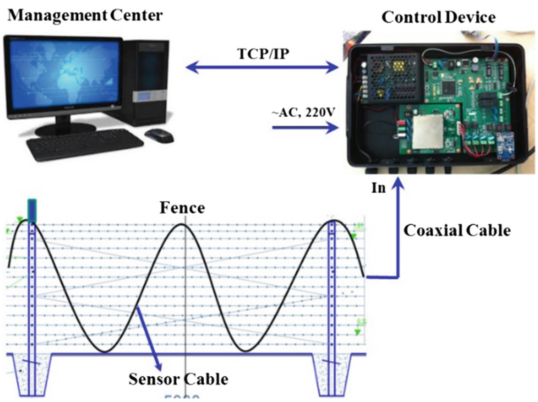

Fig. 1. Operation diagram of the electronic fence system

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 [3]. 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.

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 500 m 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 [1] 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 Eq. (1).

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

x(n): Input signal

N = Count of sample (128)

The 1 Hz ± 0.5 Hz 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).

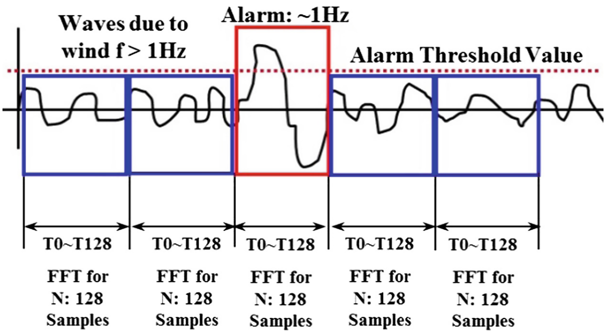

Fig. 2. Condition of fast Fourier transform in input signal

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

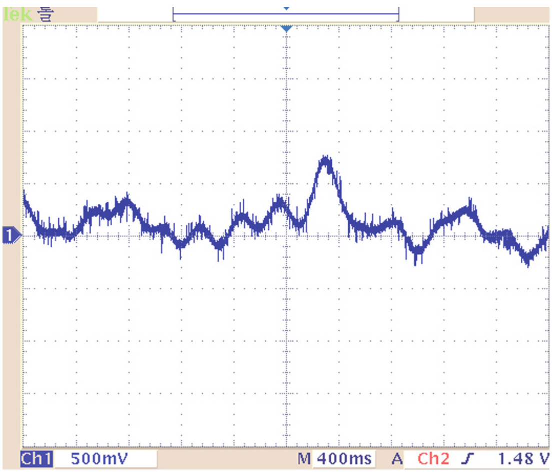

Fig. 3. Wave form of noise signal of wind force vibration on the electrical fence

Algorithm for reducing false alarms was developed. This algorithm reduces false alarms due to strong wind effect. ADC of control device processes N = 128 sample data by 10 ms 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 1.28 ms
- Vmin: Minimum value of amplitude in each duration time of 1.28 ms

- Fmax: Maximum frequency in each duration time of 1.28 ms 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 these signal characteristics values are compared to the reference values. After that system decides which alarms are real or false. 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 Field 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 snow stormy during winter seasons. Also there is strong wind during spring and fall seasons.

Figure 4 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. 4. Installation of sensor cable in the real field test

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. List of all registered invasion 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

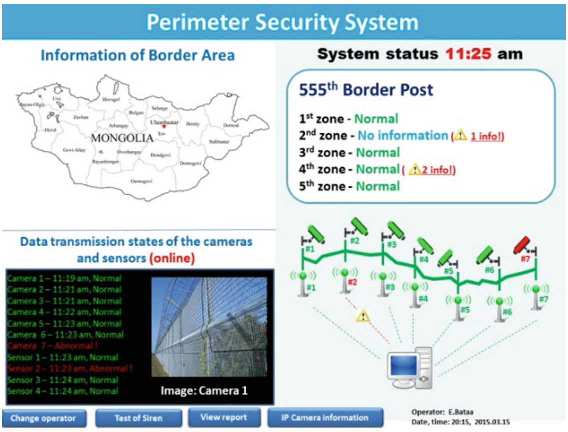

Fig. 5. Screen capture of fence security program

3.2 Monitoring Program of Security Fence

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 (Fig. 5).

4 Conclusions

The first version of the electrical fence security system was upgraded and applied in real field experiment under the hard and severe climate conditions of Mongolia. False alarms were the main problem by real operation of the fence security system. These false noise was generated due to strong wind force. 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 precision detection rate of the invasion was improved up to 95% as seen from experimental data of the previous 5 months. A new algorithm for reducing wind noise problems was developed to increase positive detection rate. Two CCTV cameras of IP protocol was installed on to this security system to improve further comfortability.

When it is very cold weather, the sensor cable is frozen by outside temperature of −30 °C coldness. In this severe case, the electronic fence sensitivity was decreased. So it needs to be adjusted automatically to increase sensitivity range by 1–2 steps in very cold winter season.

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