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A Vibration Detecting Instrument Integrated with a Network Transfer Capability[1]

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Abstract: - In this paper, based on the micro-chip control theory, we design an instrument, "NT&SD Transducer" that owns the ability of network transferring to shut off the master safety switch of dangerous installation before it causes the second disaster. The "NT&SD Transducer" will be implemented in two fields: a distributed area and a building. Through the simulation, the second disaster caused by the earthquake will be largely decreased due to this instrument.

Key-Words: - Seismic waves, transducer, vibration measurement, microcomputer, network

1 Introduction

Even in the high-technique age, earthquake is one of the natural disasters that can't be predicted or forbidden. The disaster of the earthquake is terrible. The area of Pacific Ocean belongs to the area where earthquake frequently occurs. The damage of the earthquake brought to the human beings couldn't be described.

Japan and Taiwan are located at the pacific earthquake channel areas, the earthquake occurs many times, some of them are very strong. According to the detecting data of the past ninety years collected by the Central Weather Center [1], there is an average number of 2200 times of earthquake occurred in Taiwan each year (the Central Weather has estimated the ability of earthquake detecting shade that has been widely improvement in 1991, so the average number of the earthquake increases to 8217times from 1991 to 1994.). Most of them can't be felt by human. But there is an average number of 214 times that can be felt by human. In 1951, there is about 858 times of earthquake (felt by human) occurred in Taiwan. This is the maximum times of the earthquake history. According to the history records, there is one dangerous earthquake that brings disaster to Taiwan per year.

The earthquake may not bring direct harm to the human and animals; but the building build by people may break down after serious shaking, it may hurt other people and animals, the status of damage would be very serious.

There are many literature papers concerning the reason of earthquake occurrence and the signals in advance [2]-[4]. Some papers concern the detection of the earthquake and the warning instruction after earthquake occurs [5]-[7]. Some papers concern how to strengthen the material and structure of the building to against the disaster of strong earthquake [8], [9]. But fewer papers concern vibration detection device. There is a theory that applies the Gravitational Field to use the Michelson interferometer to measure earthquake magnitudes mentioned in [10]. But it didn't mention about how people should adapt the immediate solving methods after earthquake occurrence. In [11], a new generation Spectrum Intensity (SI) transducer has been developed utilizing micromachining three-axial accelerometer and a newly developed SI calculation algorithm for the earthquake damage detection. This is a precisely seism scope, but it didn't mention the real time processing methods. While the strong earthquake occurs, the seismic center spreads out the earthquake waveform, it moves toward the four direction by the speed of 7km/sec. If we can shut off the master safety switch of the high dangerous installation (such as, nuclear power plant and natural gas plant) immediately before the seismic waves arrive, then, the disaster resulted from earthquake would be lowered.

In this paper, we do not predict the time of

[1] The Danger Eliminated Monitoring System in a Distributed Area: This device has attended the 'NSC Creativity Competition 2003 Taiwan' and won the 'Technique Integration Special Prize'. This research work is supported by National Science Council under Grant NSC 92-2517-S-129-001.

earthquake and we do not discuss the reason of earthquake occurrence. The purpose of this paper is to design the Vibration Detecting Transducer with Network Transfer and Shut-Off Dangerous Installation Switch Function. We abbreviate this detection device as "NT&SD Transducer". While the earthquake occurs, the main control center will focus on the dangerous installation that causes secondary disaster, such as natural gas plant and power plant, then shut down them immediately before the seismic waves arrive. People will be protected from those equipments. We organize this paper in the following manner. In Section 2, we state the technology of the design of "NT&SD Transducer". In Section 3, we make two Application examples. Finally, we make a brief simulation and conclusion in Section 4.

2 The "Nt&Sd Transducer" Technology

Right before we make a description about the "NT&SD Transducer", we are going to describe the design objective of this vibration detection device. The design objective is: while the magnitude of the strong earthquake reaches 7 (M=7), the earthquake wave moves to the four direction at the velocity of 7km/sec. The speed of the network transfer is about 400 times over the seismic waves. If we can use the network transfer method to shut off the master safety switch of dangerous installation before the seismic waves arrive while the strong earthquake occurs, the disaster will be decreased. Therefore, the purpose of the "NT&SD Transducer" is to adapt required methods before the seismic waves destroys the dangerous installations. The "NT&SD Transducer" must own the following functions: Detecting shaking degree, Network Transfer (NT) & Shut-Off Dangerous Installation (SD). In the following, we will describe the design rule analysis, the production method, the calibration of the "NT&SD Transducer", and the corresponding real time algorithm of the "NT&SD Transducer" in Local and Central Area Monitoring Center.

2.1 The Design Rule Analysis

The "NT&SD Transducer" uses the vibration sensor to detect the occurrence of the shaking. The characteristic of the vibration sensor is: while the shaking sensor stands stationary, the resistance of the vibration sensor is infinite, then it is at the OFF status; while the "NT&SD Transducer" is suffered by the external power, it reaches at the status of centrifugal force, the plane surface slants, the characteristic of the resistance of the vibration sensor has been changed to 0, then it is at the "ON" status. While the external power disappears, the vibration sensor turns back to the 'OFF' status. And the data of the shaking will be analyzed through the micro chip 89C51 [12]; then judge the level of the shaking; through the detecting of 89C51 and the calculation of the occurrence times of 'ON', 'OFF'. Therefore we can decide the magnitude of the earthquake. As to the earthquake magnitudes calibration of the "NT&SD Transducer", we will have a detailed discussion in Section 2.3. Through the network, we can transfer the "shaking data", detected by the "NT&SD Transducer" to the PC computers of the Local Area Monitoring Center. We can also transfer the detected "shaking data" by the parallel bus, then the data reaches the 8255 interface card [13], then transfer to the PC Computer of the Local Area Monitoring Center finally. The Local Area Monitoring Center collected all the shaking data of the "NT&SD Transducer", then through the TCP/IP communication protocol [14], the data transfers to the Central Area Monitoring Center.

The Central Area Monitoring Center will judge whether it is the earthquake or not. At the meantime, the Central Area Monitoring Center will judge if the earthquake magnitude exceeds the dangerous status. If the reliability of the earthquake is ensured,, the Control Instruction will be send out immediately. The UPS will be turned on. And by using of the TCP/IP protocol, the Control Instruction will be transferred to the Local Area Monitoring Center. The Local Area Monitoring Center will execute the mission to shut off the master safety switch of the dangerous installation finally.

2.2 The Production Method

The block diagram of the "NT&SD Transducer" and the internal hardware structure are shown in Fig.1 and Fig.2 respectively. There are three key functions of the "NT&SD Transducer": one is the real time Detecting Unit; the other is the real time Data Transfer Unit; and another is the real time Control Unit.

2.2.1 The real time Detecting Unit:

Firstible, we design a filter that can filter out the noise of the external shaking signals while the earthquake waveform signals enter the "NT&SD Transducer". Then the shaking degree of the rest of the signals will be going through the micro-chip 89C51 analysis.

2.2.2 The real time Data Transfer Unit

The "NT&SD Transducer" has two ways to transfer the detected shaking data to the Local Area Monitoring Center computer. (i) By using the Ethernet Wire Network Transfer (ii) By using the Parallel Bus and the 8255 interface card of the Local Area Monitoring Center computer.

2.2.3 The real time Control Unit:

The Central Monitoring Center will detect the transferred shaking signal analysis, and judge the shaking magnitude and the shaking source, as Fig. 3. If there are 70% of the "NT&SD Transducer" in the Local Area has detected the magnitude exceeds the safety range, a Control Instruction will be sent to the Local Area Monitoring Center. The Local Area Monitoring Computer will execute the "SD" action through the "NT&SD Transducer" and shut down the master safety switch of the dangerous equipment that could reflect the secondary disaster easily, such as the power plant and the natural gas plant. In Fig.4, an Electric Relay Device is designed to shut off the master safety switch of power.

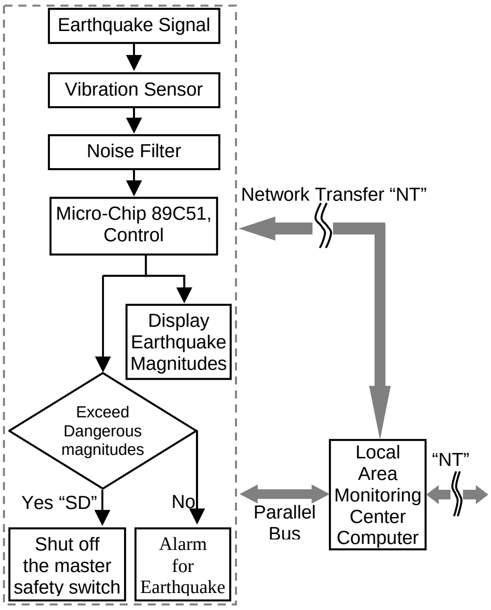

Fig. 1 Block Diagram of the "NT&SD Transducer"

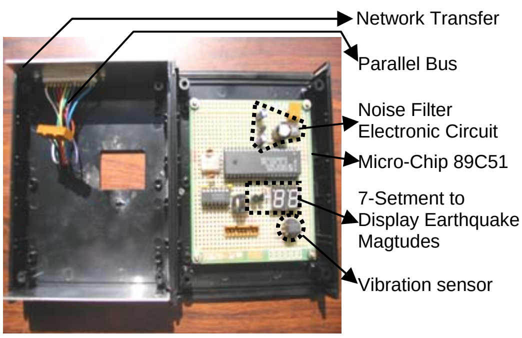

Fig.2 Internal Hardware Structure of the "NT&SD Transducer"

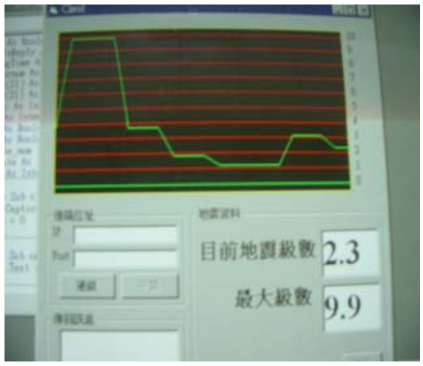

Fig.3 Central Monitoring Center Display of Earthquake waveform and magnitudes

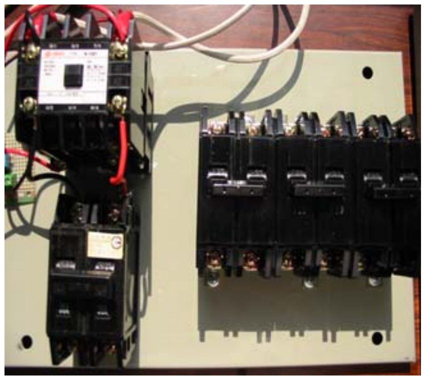

Fig.4 An Electric Relay Device Used To Shut Off The Master Safety Switch of power

2.3 The "NT&SD Transducer" Calibration

In order to forbid to bring people the loss of Economics and the inconvenient of Life by executing incorrect "SD" action of the incorrect earthquake magnitudes detected by the "NT&SD Transducer". The most important part before we actually apply the "NT&SD Transducer" is to establish the calibration table. The distinction of the magnitudes of the earthquake is based on the ON-OFF times of the vibration sensor that is detected by the inner "micro-chip" of the "NT&SD Transducer". During the same period of time, if the ON-OFF times of the vibration sensor are higher, then the magnitudes of the earthquake is stronger, and vice versa.

Before we describe the "NT&SD Transducer" calibration table, we are going to display the vibration experiments. Based on the analysis of the vibration signal of the earthquake signal on the computer, we establish a vibration platform in the laboratory, it simulates to generate the 1 to 7 magnitude's earthquake vibration of the real earthquake. We have made various times of rehearsal experiments to establish the calibration table of the relation between the ON-OFF times of the vibration sensor and the magnitudes of the

Table 1: Within 1000 vibration experiments, the relation between the simulated actual earthquake magnitudes and the average value of the total ON-OFF times detected by the micro-chip inside the "NT&SD Transducer" (owned 1 vibration sensor) every 5 seconds.

Earthquake Magnitudes \ ON-OFF values of Vibration Sensor	5	10	15	20	25	30	35	40	45	50
1	10	21	29	41	51	59	68	78	92	99
2	14	27	41	54	67	81	94	108	121	135
3	18	35	52	69	89	105	123	142	161	180
4	25	49	74	99	124	152	174	199	224	248
5	28	59	83	112	138	168	180	216	252	279
6	31	63	92	119	148	179	209	238	270	298
7	36	71	109	144	178	216	251	286	321	355

Table 2: Within 1000 vibration experiments, the relation between the simulated actual earthquake magnitudes and the average value of the total ON-OFF times detected by the micro-chip inside the "NT&SD Transducer" (owned 8 vibration sensors) every 5 seconds.

Earthquake Magnitudes \ ON-OFF values of Vibration Sensor	5	10	15	20	25	30	35	40	45	50
1	72	143	210	279	349	419	502	563	640	718
2	120	238	357	479	602	718	838	954	1073	1212
3	136	275	405	541	678	750	934	1080	1221	1351
4	198	402	598	803	998	1215	1395	1614	1795	1992
5	224	442	669	898	1121	1341	1543	1785	2034	2241
6	243	482	725	972	1213	1432	1673	1883	2133	2324
7	279	558	839	1011	1368	1652	1902	2201	2453	2765

simulated earthquake.

2.3.1 The experiment of the "NT&SD Transducer" that owns one vibration sensor.

To implement the test of the "NT&SD Transducer" that owns one vibration sensor located on the vibration platform, then the vibration platform will simulate to occurred earthquake magnitude M=1~7. The micro-chip inside the "NT&SD Transducer" records the data of the total ON-OFF times of the vibration sensor every 5 seconds. If there are 10 intervals, the total time is 50 seconds. We implemented the experiment for 1000 tests repeatedly. The average value of the 1000 tests is shown in Table 1.

2.3.2 The experiment of the "NT&SD Transducer" that owns eight vibration sensors.

In Table1, we have tested the "NT&SD Transducer" that owned one vibration sensor. But, in order to increase the accuracy of the detection, we installed vibration sensors on the front side and the reverse side of the four corners. There are eight vibration sensors in the "NT&SD Transducer" now. The electric circuit becomes more complicate than before. The detection and calculation of the micro-chip inside the "NT&SD Transducer" becomes more difficult than before, too. But the result becomes more precise. We put the "NT&SD Transducer" that contains eight vibration sensors on the vibration platform in the laboratory. Then, the vibration platform occurred the earthquake magnitudes M=1~7. The micro-chip inside the "NT&SD Transducer" records the data of the total ON-OFF times of the eight vibration sensors every 5 seconds. There are 10 intervals the total time is 50 seconds. We implemented the experiment for 1000 tests repeatedly. The average value corresponding to the total ON-OFF times and the earthquake magnitudes of the 1000 tests are shown in Table 2.

2.4 Comparing with Traditional Seismometer Equipment

The traditional earthquake seismometers use the electronic moving roller to record the time and the magnitudes of the earthquake. It has to change the recording paper、battery、and ink after period of time. This traditional seismometer needs to be adjusted and maintained regularly, it is very inconvenient for the user. Today, the electronic self-recording earthquake detecting equipment is adapted widely, but the price and the usage procedure bothers the users more, too. Therefore, the electronic self-recording earthquake detecting equipment is used a lot in the research unit and college related departments.

The "NT&SD Transducer" designed by us will keep monitoring while earthquake occurs. And the data would be stored in the computer automatically. The system we designed could add extra totally automatic recording attachments. These would be stored in the hardware or CD (MO) continuously. And the data stored in the computer could be printed out for an extra back-up.

2.5 The Real Time Algorithm of the Distributed Area Control System

Now, we are going to present the real time Algorithm of Local Area Data Processing Unit, Local Area Control Instruction Executing Unit, Central Area Monitoring Center Data Processing & Control Instruction Unit.

2.5.1 Local Area Data Processing Unit

For every local area, it receives the transferred shaking data from all the "NT&SD Transducer" those are connected with the Local Area. Then, it filters out the useless data (Communication Transferring Mistake and Vibrate Sensor out of work). Then, it assigns the number and records the time and place of each shaking data. Then, it transfers back to the Central Area Monitoring Center through the network wire. As shown in Fig.5 is the Flowchart of the real time Local Area Data Processing Program.

2.5.2 Local Area Control Instruction Executing Unit

While receiving the "Control Instruction" from the Central Area Monitoring Center, Local Area Control Center decode the data. The Re-check Action is made (comparing the total shaking data of all the "NT&SD Transducer" in the Local Area Monitor Center computer, then. After that, it judges if the average earthquake magnitude is greater than 4 (Mav>4) of 70% "NT&SD Transducers" in the Local Area. If it does, it shuts off the master safety switch of the dangerous installation. As shown in Fig.6 is the Flowchart of the real time Local Area Control Instruction Executing Program.

2.5.3 Central Area Monitoring Center Data Processing & Control Instruction Unit

To receive all the shaking data from the "NT&SD Transducers" that is connected to all the Local Area. After that, it decodes the transferred shaking data and displays the earthquake magnitudes and the earthquake waveform of each Local Area, at the same time. It also judges if 70% of all the "NT&SD Transducers" that detected the average earthquake magnitude is greater than 4. If it does greater than 4 (Mav>4), it executes shut off program. The Central Area Monitoring Center computer will send the Control Instruction to shut off the master safety switch of the dangerous installation in those earthquake Local Areas. As shown in Fig.7 is the Flowchart of the real time Central Monitoring Center Data Processing & Control Instruction Program

3 Application

We apply the "NT&SD Transducer" (owned 8 vibration sensors) in two fields: (1) the danger eliminated monitoring system in a distributed area (2) the danger eliminated monitoring system in a building.

4 Simulation And Conclusion

In this paper, we have designed an instrument, "NT&SD Transducer" that owns the ability of network transferring to shut off the master safety switch of dangerous installation before it causes the second disaster. We have tested the instrument "NT&SD Transducer" on numerous experiments and obtain successful results.

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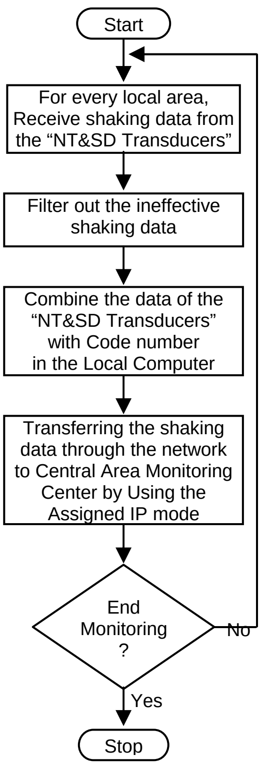

Fig.5 The Flowchart of the real time Local Area Data Processing Program

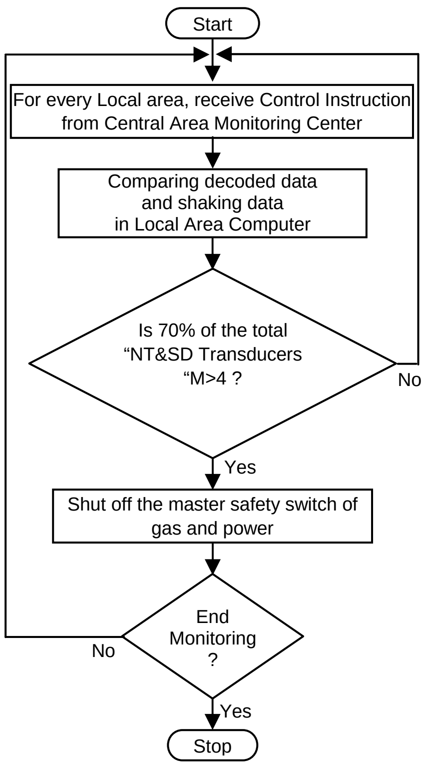

Fig.6 The Flowchart of the real time Local Area Control Instruction Executing Program

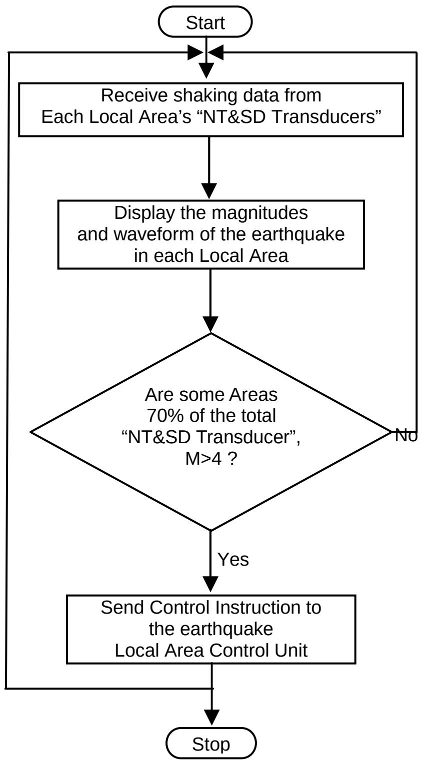

Fig.7 The Flowchart of the real time Central Area Monitoring Center Data Processing & Control Instruction Program