Technical Report Documentation Page

1. Report No. SPR-UAF-92-22F	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Sign Vandalism Detection		**5. Reporting Date** February, 1995 **6. Performing Organization Code**
7. Author(s) George "Bub" Mueller		**8. Performing Organization Report No.** INE/TRC 94.16
9. Performing Organization Name and Address Institute of Northern Engineering University of Alaska Fairbanks Fairbanks, AK 99775-5900		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.**
12. Sponsoring Agency Name and Address Alaska Dept. of Transportation and Public Facilities Engineering and Operations Standards 3 Mile Building 3132 Channel Drive Juneau, Alaska 99801-7898		**13. Type of Report and Period Covered.** Final **14. Sponsoring Agency Code**

15. Supplementary Notes

16. Abstract

Alaska, like most states, has a problem with road signs being vandalized and destroyed by firearms. To reduce this problem, a method was developed to attempt to photograph the offenders. Using a shock sensitive piezoelectric sensor on the sign and a weatherproof camera mounted in the hollow tubing sign support, an interface circuit was designed and built. The primary component of the interface is a single board computer or Programmable Logic Controller (PLC). The principal reason for using a PLC is that as conditions change the unit can be reprogrammed rather than hard wired circuits replaced.

17. Key Words Road sign, vandalism, piezoelectric sensor, Programmable Logic Controller, camera.		**18. Distribution Statement**	
19. Security Classif. (of this report) unclassified	**20. Security Classif. (of this page)** unclassified	**21. No. of Pages** 22	**22. Price**

Form F 1700.7 (8-72)

SIGN VANDALISM DETECTION

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A report on research sponsored by
Alaska Department of Transportation and Public Facilities

February 1995

Report No. INE/TRC 94-16

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ABSTRACT

Alaska, like most states, has a problem with road signs being vandalized and destroyed by firearms. To reduce this problem, a method was developed to attempt to photograph the offenders. Using a shock sensitive piezoelectric sensor on the sign and a weatherproof camera mounted in the hollow tubing sign support, an interface circuit was designed and built. The primary component of the interface is a single board computer or Programmable Logic Controller (PLC). The principal reason for using a PLC is that as conditions change the unit can be reprogrammed rather than hard wired circuits replaced.

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ACKNOWLEDGMENTS

The author would like to acknowledge the technical assistance provided by Mr. David Esch of the Alaska Department of Transportation and Public Facilities. Financial support was provided by the Alaska Department of Transportation and Public Facilities. Laboratory resources were provided by the Water Research Center. All support is greatly appreciated.

1. INTRODUCTION

Considerable sums of money are spent each year replacing signs that are vandalized by weapons. Mr. David Esch of the Alaska Department of Transportation and Public Facilities (AKDOT&PF) approached the investigator of this project with the idea of developing a system to photograph the vandals in an attempt to discourage others from destroying signs. The objectives and work tasks were assigned by AKDOT&PF using the Quick Response proposal method. All objectives and work tasks were completed in the time frame allotted for the work.

2. ANALYSIS OF COMPLETED TASKS

2.1. CAMERA AND FILM SELECTION

Camera stores were contacted to identify 35mm cameras and film that met project criteria:

A. Low cost
B. Remoter triggering
C. Auto light control for high speed films
D. Auto film advance
E. Small size (less than 3" x 3")
F. Weather proof
G. Day and time stamp on film
H. High resolution with low ambient light and no flash

The lowest cost camera that met the above criteria is the IQ Zoom90-WR (Date) manufactured by Pentax. The camera specifications follow:

Type: 35mm fully automatic leaf-shutter camera with zoom lens and weather-resistant design.

Film: 35mm perforated cartridge, DX-coded film, 24mm x 36mm format. Automatic film-speed setting with DX-coded film from ISO 25 to ISO 3200.

Lens: Pentax power zoom 38mm-90mm f/3.5-f7.5; 8 elements in 7 groups.

Focusing System: Pentax infrared active automatic focusing system. Two focusing modes: three pointed and spot.

Auto Focusing Range: 0.8m (2.6ft) to infinity in normal range; 0.5m (1.6ft) to 0.8m (2.6ft) in macro range.

Exposure Control: Programmed auto exposure control. Metering range for Flash-Off or Auto mode in interval setting: EV6 to EV16.5 in wide setting and EV8 to EV16.5 in tele and macro settings (at ISO 100). Auto exposure compensation provided.

Shutter: Programmed AE electronic shutter with shutter speeds from approximately 1/400 second to 1/5 second.

Viewfinder: Actual-Image zoom viewfinder. Viewfinder area: 82% (at 3m), LED indication (next to viewfinder); focus and flash ready status.

Film Loading: Automatic film loading with first-frame positioning.

Film Winding: Automatic film winding (single-frame and consecutive).

Film Rewinding: Automatic film rewinding at end of roll. Automatic stop upon rewind completion. (Mid-roll rewinding possible.)

Remote Controller: Infrared wireless remote controller. Step zooming at 90mm, 60mm and 38mm. Effective range: 5m from the front and 0.7m from the rear.

Power Source: Two 3V lithium batteries (CR-123A or DL-123A). (Can be modified for external power.)

Dimensions: 149mm(W) x 76mm(H) x 63.5mm(D) (5.9" x 3" x 2.5").

Weight: 455g (16oz.) without batteries.

Data Imprinting: Five modes available: "Year-Month-Day:, "Month-Day-Year", "Day-Month-Year", "Day-Hour-Minute" and blank.

Power Source for Imprinting: One lithium battery (CR-2025).

The camera is not stocked locally in Fairbanks, Alaska. The camera was purchased from Wolf Camera & Video in Fort Worth, Texas. The camera cost $269.95 plus tax.

The film selected is Kodak TMAX P3200, black-and-white professional film. The film is ISO 3200 allowing very low ambient light photographs. The film is available locally. The film cost is approximately $7.00 per 36 exposure roll in Fairbanks for unit purchases.

2.2. VIDEO CAMERA

Microminiature CCD camera (DOT provided information) that is manufactured by Marshall Electronics was Investigated. The camera was purchased and interfaced with a 8mm portable video recorder. Price, size and sensitivity were all excellent; however, the resolution was not acceptable. The camera test was conducted on a medium sunny day with markers at 25ft., 50ft., 75ft. and 100 ft. The licensee plate of the vehicle is not readable with this camera at even the closest marker.

No further information was compiled as to power requirements or other criteria. Nor was it investigated as to how the CCD camera could be integrated into a system with a camcorder (portable video recorder) or total system power requirements.

2.3. EVENT TRANSDUCER

The trigger sensor was identified by conducting a literature search and contacting relevant vendors and manufacturers. Four types of sensors were investigated as to cost, reliability and sensitivity:

A. Acoustic
B. Vibration
C. Pressure wave
D. Shock

The least expensive sensor with high reliability and sensitivity is the shock sensor. The sensor is a piezoelectric transducer that can be purchased locally from Radio Shack (Archer #273-073) for $1.64. The transducer has the following specifications:

Resonant Frequency: 2,500 +/- 500Hz
Operating Voltage: 30v peak-to-peak (maximum)
Current Consumption: 5ma (maximum) @ 5v
Capacitance: 2,500pF =/-30%
Operating Temperature: -20° to +70° C

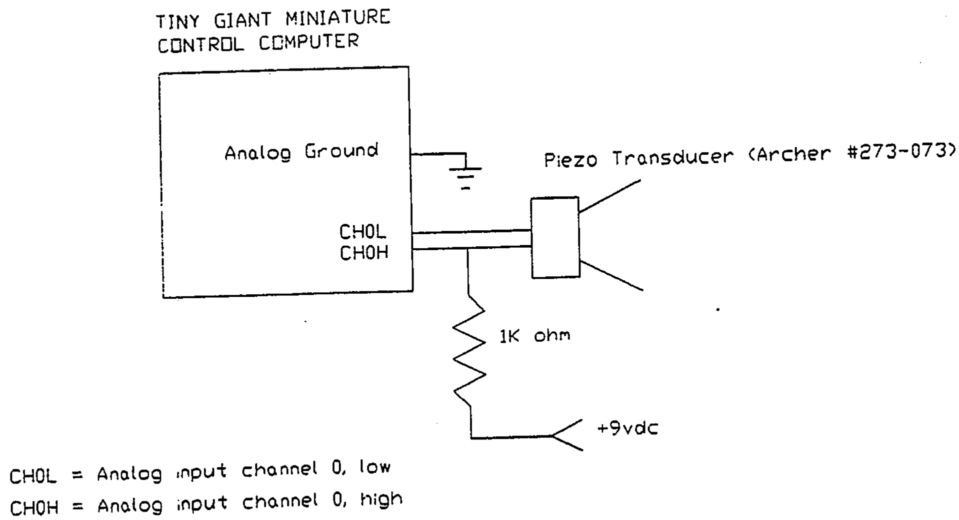

Figure 1. Schematic of Circuit Connecting Shock Transducer to PLC.

The current consumption is so low in an operating circuit (with 9v battery) that it is not measurable with a HP3438A Digital Multi Meter on the 200µA (most sensitive) scale. Therefore, a small 9v battery will last at least a year.

2.4. FILM AND CAMERA TESTING

The film and camera were tested to determine the distance that will produce usable photographs at the same time the CCD camera was tested (using parking lot with distance markers). Photographs were also taken in reduced light conditions without a flash. The film and camera (TMAX 3200 film in the Pentax camera) were able to produce good quality photographs (without flash) from near dark to bright sun on snow conditions.

2.5. SENSOR/CAMERA INTERFACE

An interface between the sensor and camera was assembled (see Figure 2) for camera control. Three photographs are taken in succession with each photograph at a different zoom factor (38, 60 & 90mm starting with the widest angle first).

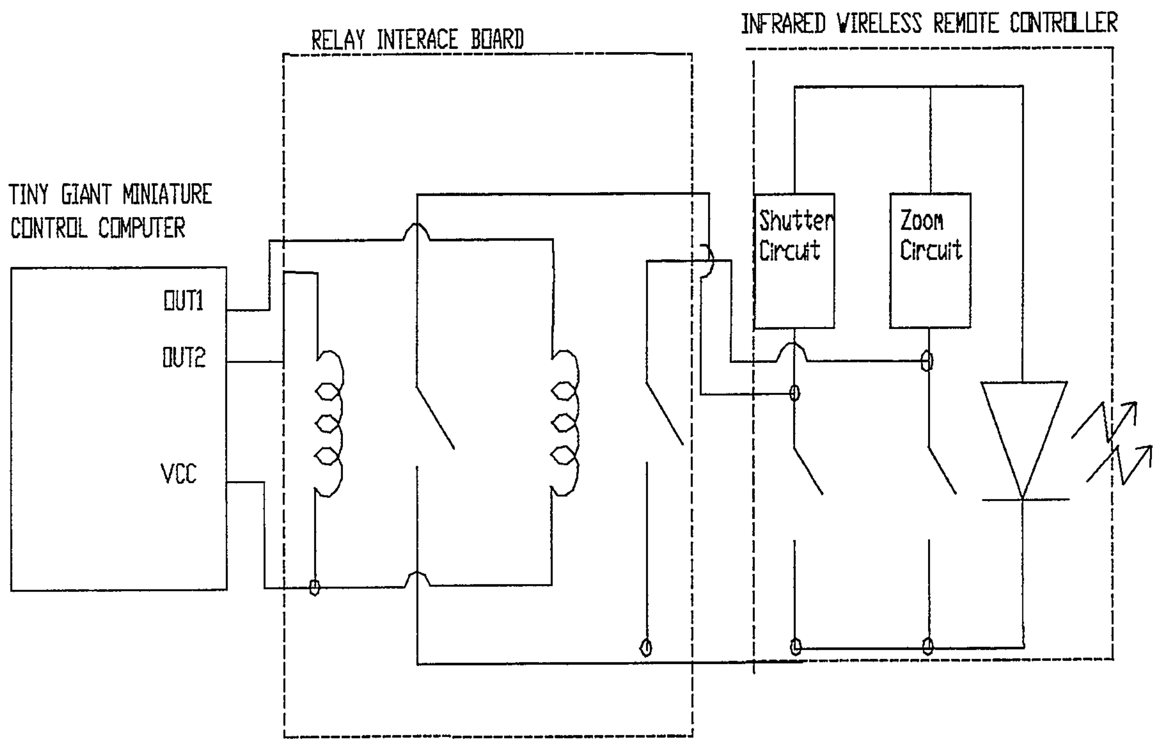

Figure 2. Schematic Representation of Interconnections

The principal component of the interface is a single board computer or Programmable Logic Controller (PLC). The principal reason for using a PLC is that as conditions change the unit can be reprogrammed rather than changing hard wired circuits. PCL's are designed as a low-cost, general purpose unit for either stand-alone use or incorporation into equipment. The PLC purchased is the Tiny Giant manufactured by Z-World Engineering. The cost of the Tiny Giant is $249.00 each plus shipping. A programming compiler (Dynamic C) for program development is also needed with a one time cost of $195.00 plus shipping.

The Tiny Giant miniature controller has the following specifications:

Size: 11.2 x 13.0cm (4.4 x 5.1 inches)

Operating Temperature: -40°C to +70°C

Power Consumption: Approximately 300mA @12vdc

Serial Ports: Two, asynchronous, each operable at baud rates up to 57,600 bits

Analog to Digital Converter Subsystem: Four channels, with independent input amplifier for each channel. 8-bit accuracy. Single-ended input. Gain adjustable by feedback resistor. Can be adapted to most types of sensors.

High Current/High Voltage Port: Four outputs, each capable of sinking up to 0.75A at 35 volts. Capable of driving inductive loads such as relays.

Single Voltage Supply: On-board linear power supply accepts input from 9v-15vdc.

Other Features: Z180 Processor with 9.216mhz Clock, Programmable Timers, EPROM, Lithium Battery Backup for SRAM, Time/Date Clock, and Watchdog Timer.

The PLC was programmed (see software listing in Appendix) to keep the camera active for instant picture capability. The zoom is activated every 5 minutes to provide the continuous-on condition and to exercise the mechanical components for cold weather operation.

2.6. COMPLETE SYSTEM TESTING

The completed system has been tested and modified so that only minimum false signaling has been achieved. With the camera and film selected, the longest distance appears to be approximately 100 feet using the 38mm (widest) zoom factor. A distance of approximately 150 feet appears possible at 90mm. The high speed of the film should provide near dark without flash capabilities. Using a PLC, the majority of any further modifications should involve only software changes.

2.7. SYSTEM DEMONSTRATION

A demonstration of the completed apparatus for Mr. David Esch of the Department of Transportation and Public Facilities was made on 21 June 1994.

3. CONCLUSIONS AND FUTURE WORK

The completed system should provide a low cost, highly reliable and flexible method of photographing vandals that shoot signs. This system will take three photographs at three different focal lengths (38, 60 & 90 mm) each time an event (bullet striking the protected sign) is detected. The first photograph is taken within 10 msec (milisecond or 1/1000 of a second). The next two photographs are delayed approximately one second each to allow the focal length and focus adjustments to be made. The flash capability of the camera is turned off, but with the high ISO film (3200 ISO) near dark photographs are possible. The date and time is recorded on each photographic frame as part of the permanent record. An identifiable license plate should be possible to 150 ft. at the highest focal length. With the automatic focus capability of the camera, the central objects of the frame should be in focus from 3 ft. to infinity.

False signals appear to have been minimized. Wind and loud noises do not appear to trigger the system because they do not have the magnitude or the fast rise time of a bullet striking the sign. Rocks hitting the sign would trigger the system as it is presently programmed. Small changes in the software could alter the discrimination threshold and raise time requirements, thus change the event detection characteristics.

A weatherproof camera with infrared remote control of shutter and focal length was chosen so that weather protection would not have to be provided for the camera during system installation. The piezoelectric transducer is also weather protected. The prototype interface and PLC were mounted in a weatherproof enclosure. Only the power supply for the PLC (12 volt deep cycle battery) would have to be weather protected. If a marine battery were used, minimum protection would be required.

However, physical security has not been investigated for the system. The following is assumed by the investigator: 1. the camera would be mounted in the hollow channel sign support as those dimensions were specified by AKDOT&PF. 2. The piezoelectric shock sensor would have to be attached to the rear of the sign (epoxy was used in the prototype). 3. The other components could be buried near the base of the sign. But actual field conditions may alter one or all of these assumptions.

Additional funding is required to actually install the system and to determine if it meets the needs of AKDOT&PF in a working situation. Feedback from AKDOT&PF would be used for modifications (if required) for software parameters.

4. APPENDIX

Software for Programmable Logic Controller

```
/************************************************************************
To read CH 0 A/D on Tiny Giant (piezoelectric device);
Written and Modified by Bub Mueller 6/22/94
************************************************************************/


struct timer72421
{
  char sec1, sec10, min1, min10, hour1, hour10;
  char day1, day10, mon1, mon10, year1, year10;
  char week;
} timer;

int read_timer(struct timer72421 *tim);
int exercise ();
int testem ();
int gotem ();
int hv_wr ();
int hv_enb ();
int ad_rd8 ();
int k;

hv_enb ();

main()
{
        int j;
        j = 1;
        while (j>0)
        {
           read_timer(&timer);
           /* printf("the min1 is %1d %d%1d\n",
           timer.min1,timer.sec10,timer.sec1);  */
           if (( timer.min1 == 0) && (timer.sec1==0) && (timer.sec10 == 0))
              exercise ();
           if (( timer.min1 == 5) && (timer.sec1==0) && (timer.sec10 == 0))
```

```
          exercise ();
        testem ();
      }
  hv_wr ( 0x00 );
}

int read_timer (struct timer72421 *tim)
{
    int ioadr,errcnt;
    char *ptr;

    errcnt=10; /* max trys */
    while (errcnt--)
    {
      outport (TREGD, 1);  /* set hold bit */
      if (!IBIT (TREGD,2))  /* if busy bit not set */
      {
        ioadr=SEC1;
        ptr=(char*)tim;
        while (ioadr != TREGD) /* load time structure */
          *(char*)ptr++ = inport (ioadr++) & 0xf;

        outport(TREGD,0);      /* clear hold bit */
        tim->sec10=tim->sec10 & 7;
        tim->hour10=tim->hour10 & 3; /* ignore am/pm bit */
        tim->day10=tim->day10 & 3;
        tim->mon10=tim->mon10 & 1;
        tim->week=tim->week & 7;
        return 0;              /* good return */
      }
      else
      {
        outport(TREGD,0); /* busy on, clear hold delay 200us, try again */
        for(ioadr=0; ioadr<20; ioadr++); /* delay loop */
      }
    }
  return 1;      /* error return clock not responding */
}


int exercise ()
{
  hv_enb();
  hv_wr (0x88);
  for (k=0; k<30000; k++);
```

```
    for (k=0; k<30000; k++);
    hv_wr (0x00);
    for (k=0; k<30000; k++);
    for (k=0; k<30000; k++);
    testem ();
    hv_wr (0x88);
    for (k=0; k<30000; k++);
    for (k=0; k<30000; k++);
    hv_wr (0x00);
    for (k=0; k<30000; k++);
    for (k=0; k<30000; k++);
    testem ();
    hv_wr (0x88);
    for (k=0; k<30000; k++);
    for (k=0; k<30000; k++);
    hv_wr (0x00);
    for (k=0; k<30000; k++);
}


int gotem ()
{
    hv_enb();
    hv_wr (0x44);
    for (k=0; k<30000; k++);
    hv_wr (0x00);
    for (k=0; k<30000; k++);
    hv_wr (0x88);
    for (k=0; k<30000; k++);
    hv_wr (0x00);
    for (k=0; k<30000; k++);
    for (k=0; k<30000; k++);
    hv_wr (0x44);
    for (k=0; k<30000; k++);
    hv_wr (0x00);
    for (k=0; k<30000; k++);
    hv_wr (0x88);
    for (k=0; k<30000; k++);
    hv_wr (0x00);
    for (k=0; k<30000; k++);
    for (k=0; k<30000; k++);
    hv_wr (0x44);
    for (k=0; k<30000; k++);
    hv_wr (0x00);
    for (k=0; k<30000; k++);
```

```
    hv_wr (0x88);
    for (k=0; k<30000; k++);
    for (k=0; k<30000; k++);
    hv_wr (0x00);
    for (k=0; k<30000; k++);
}


int testem ()
{
    /* printf ("The value is %d\n",ad_rd8(0)); */
    if (ad_rd8(0) > 4000)
      gotem ();
}
```