NBSIR 75-962

# An Outdoor Noise Monitoring System with Automatic Calibration and Remote Digital Display

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Applied Acoustics Section
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National Bureau of Standards
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Final Report

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**U.S. DEPARTMENT OF COMMERCE, Rogers C.B. Morton,** *Secretary*
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**NATIONAL BUREAU OF STANDARDS,** Ernest Ambler, *Acting Director*

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Key Words: Acoustics (sound); environmental acoustics; instrumentation; noise monitoring; outdoor noise.

## 1. INTRODUCTION

The National Bureau of Standards has developed an instrumentation system which provides the capability for measuring noise at a remote location and displaying the noise level on a large digital display. The system is automatically calibrated at approximately one hour intervals utilizing an electrostatic actuator. On the basis of this calibration signal, system gains are automatically adjusted to compensate for any ac and conversion gain errors. Overall dynamic range of the system is 70 dB. The system can measure noise levels in the range from 30 to 160 dB(A).

This system was developed for the Office of Noise Abatement and Control, U. S. Environmental Protection Agency. The outdoor microphone unit is mounted on the roof of the EPA offices in Arlington, Virginia. The digital display is located in the reception room of the Deputy Assistant Administrator for Noise Control Programs. A second digital display and remote interface are located in the building's analytical center. The interface enables a desk-top calculator to derive statistical descriptors from the collected data.

## 2. DESCRIPTION OF SYSTEM

The system consists of two major components: a commercially available outdoor microphone unit and NBS designed control and calibration instrumentation and remote readout. A simplified block diagram of the complete system is shown in Figure 1. A dashed line surrounds the NBS-designed portion of the system.

In order to provide reliable, all weather operation, the outdoor microphone unit (see Figure 2) utilizes a one-half inch air-condenser microphone with a thin quartz coating on the diaphragm to reduce the effects of corrosion. To reduce the effects of humidity, the microphone is back vented into approximately 75 grams of silica gel. The microphone is protected by a rain cover

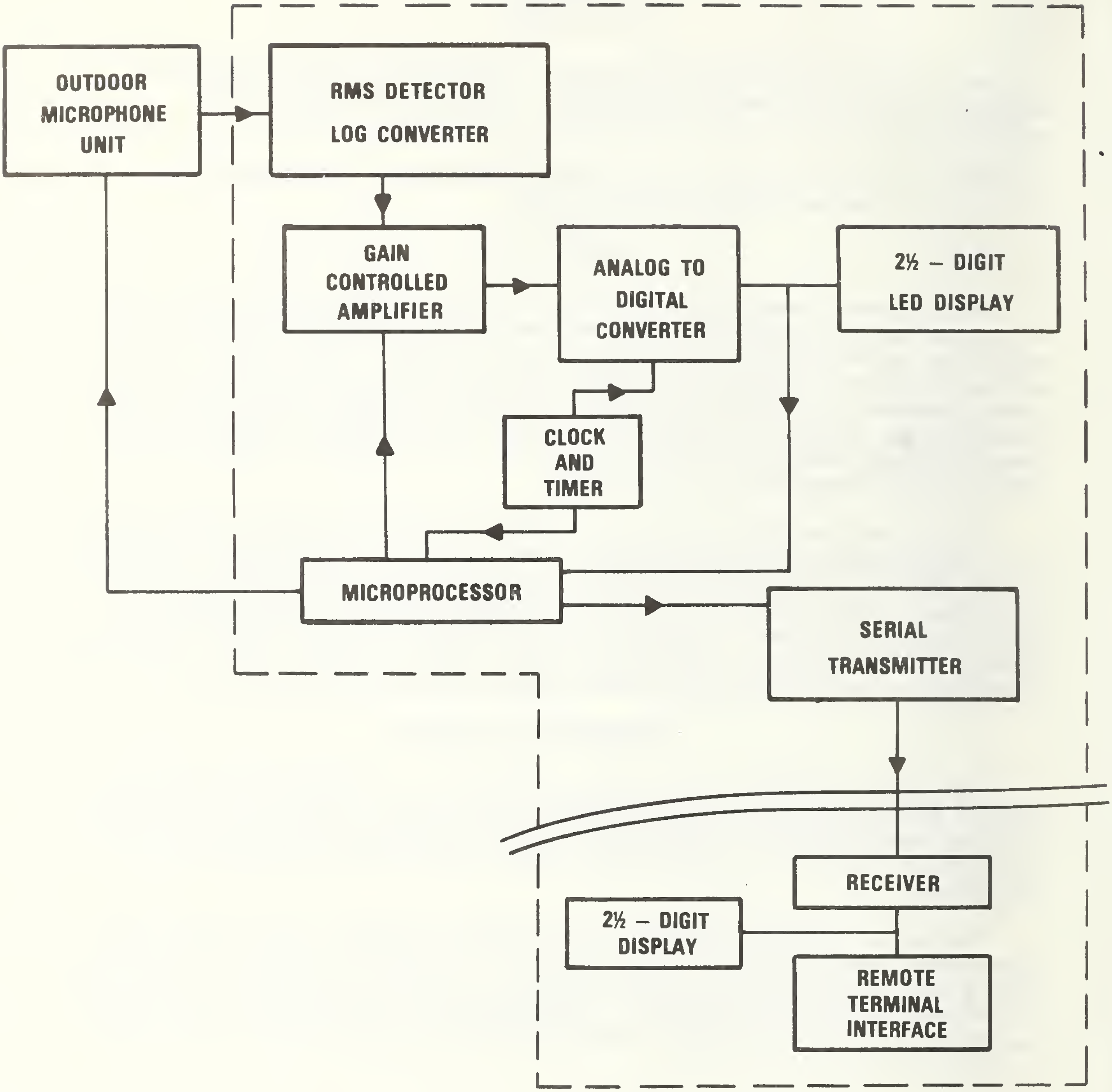


Figure 1. Simplified block diagram of monitoring system.

Figure 2. View of outdoor microphone unit mounted on the roof of the EPA offices in Arlington, Virginia.

that has a built-in electrostatic actuator. The microphone and rain cover are enclosed in a windscreen. The electronics for the outdoor microphone system are housed in a waterproof case and include a preamplifier, an A-weighting network, an amplifier with up to 50 dB of gain in manually-selected 10 dB steps and a calibration oscillator. When the calibration signal is applied to the electrostatic actuator, the microphone experiences the equivalent of a 90 dB sound pressure level. The oscillator design is such that calibration can be initiated by remote control.

The output signal from the outdoor microphone unit is fed through approximately 30 metres of cable to a remote readout to a true root-mean-square (rms) detector/log converter. The detector has an averaging time which is equivalent to the fast dynamic characteristics of ANSI S1.4-1971 and an output that is directly proportional to the logarithm of the rms value of the amplitude of the input signal. The detector output signal is connected, through a system to correct for ac and conversion gain errors, to a three-digit, binary-coded-decimal (BCD) analog-to-digital converter (ADC). The output of the ADC is connected to a 2 1/2 digit light emitting diode (LED) display and to a four bit microprocessor. As will be discussed subsequently, the microprocessor is utilized to control the system calibration and to make the necessary gain changes in order to achieve a calibrated output from the ADC. The clock commands the ADC to digitize the input signal ten times per second and signals the microprocessor to calibrate the system every 54 minutes. The system also has an analog output available which allows one to drive a variety of output devices; e.g., a tape recorder or a loudspeaker. This output is turned "off" when the electrostatic actuator is turned "on".

Details of the gain error correction system used for calibration are shown in Figure 3. The microprocessor has been included in this diagram for purposes of explanation. When the microprocessor receives the calibrate command pulse from the clock, it samples the output of the ADC. If the value sampled is less than 80 dB (10 dB less than the 90 dB calibration level), the microprocessor turns on the electrostatic actuator and initiates calibration. If the noise level is greater than 80 dB, the microprocessor continues sampling the ADC until the ambient noise is less than 80 dB. Once the electrostatic actuator is on, the microprocessor samples the 90 dB calibration signal. If the calibration signal is between 85 and 95 dB, the microprocessor will change offset signal in steps corresponding to 0.5 dB until the output of the ADC is 90 dB. If the calibration signal is not within the correction range (85-95 dB), the microprocessor will turn on the decimal points for the two least significant digits of the local display, indicating a malfunction. During the normal calibration sequence the decimal point of the most significant digit is on.

To change the offset of the gain error correction system, the microprocessor shifts out serial information into a storage register. The storage register is parallel-connected to a digital-to-analog converter (DAC). The DAC produces a voltage proportional to the digital number. The DAC output is connected to a summing amplifier which sums the output of the DAC with the output of the log converter. Since the output of the log converter is the logarithm of the input signal, the addition of a dc offset effectively corrects for gain and conversion errors in the system.

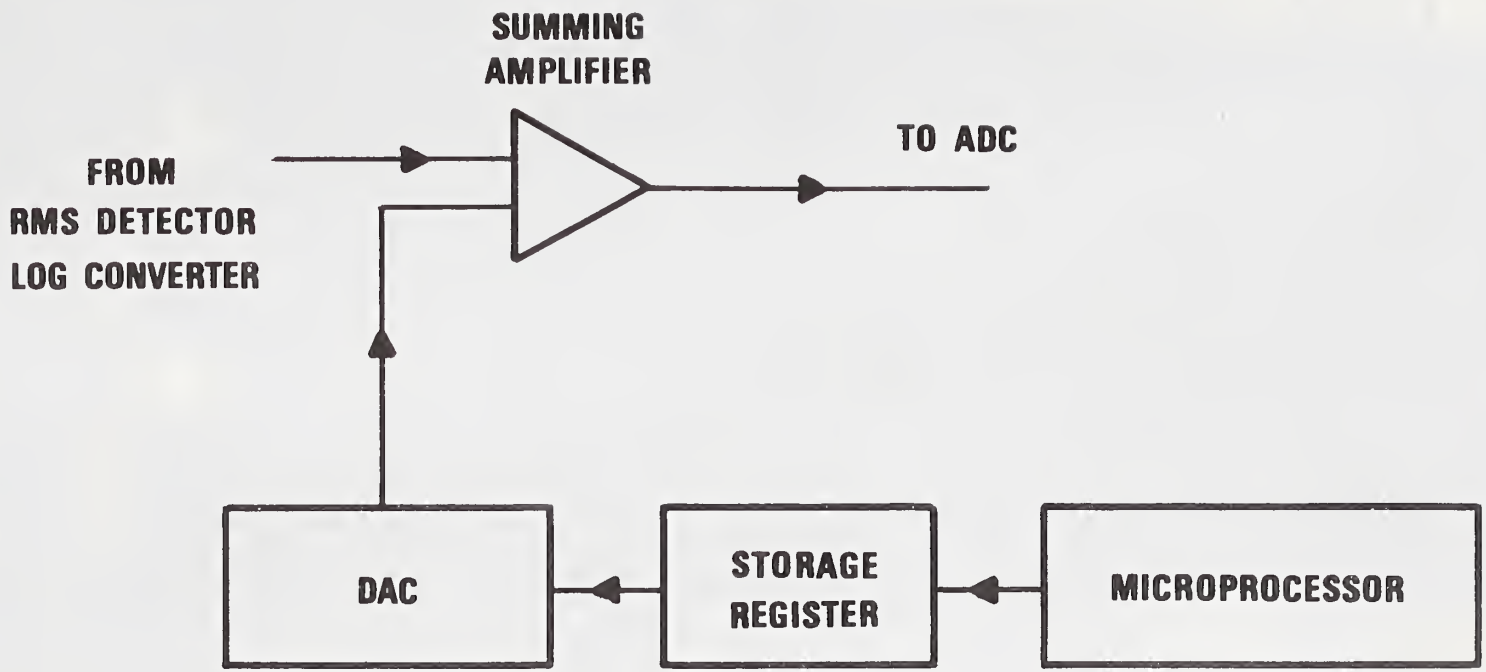


Figure 3. Gain error correction system.

To ensure calibration was satisfactorily achieved, i.e., no high level noises during calibration, the microprocessor continues to sample the output of the ADC after performing the calibration. If the value sampled immediately after calibration is greater than 80 dB the calibration routine is repeated. It should be noted that the entire calibration routine can be completed in a few seconds.

When the system is initially powered, a thirty second warm-up time is required for the system to stabilize. The calibration routine should then be initiated manually by pushing the "start" switch on the display unit. Each time the calibration routine is initiated (either manually or automatically) a constant is shifted into the storage register to provide nominal calibration for the system.

To allow remote digital data processing of the data, a remote readout (see Figure 4) is included in the system. The output of the ADC is connected to a universal asynchronous receiver/transmitter (UART). The UART converts the parallel data from the ADC to a serial word. A start bit and odd parity bit are also generated. The most significant digit (one bit) is transmitted as a separate digit. The data are transferred through approximately 20 metres of cable to the remote readout which contains a second UART for converting the data stream to a parallel word for a digital data processor.

## 3. CONCLUSION

This design has demonstrated the feasibility of a microprocessor controlled outdoor noise monitoring system with remote digital display. This design concept is directly applicable to other noise monitoring systems especially where automatic calibration is required.

## ACKNOWLEDGEMENTS

The authors wish to thank James Heinen and Mitchell Tarica for help in assembly of the circuits and other hardware. This work was supported by the Office of Noise Abatement and Control, U. S. Environmental Protection Agency.


Figure 4. View of remote digital display located in the reception room of the EPA Deputy Assistant Administrator for Noise Control Programs.

NBS-114A (REV. 7-73)

| U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET | 1. PUBLICATION OR REPORT NO. NBSIR 75-962 | 2. Gov't Accession No. | 3. Recipient's Accession No. |
|---|---|---|---|

4. TITLE AND SUBTITLE
An Outdoor Noise Monitoring System With Automatic Calibration and Remote Digital Display

5. Publication Date
October 1975

6. Performing Organization Code

7. AUTHOR(S)
D. S. Blomquist, J. S. Forrer, and D. M. Corley

8. Performing Organ. Report No.
NBSIR 75-962

9. PERFORMING ORGANIZATION NAME AND ADDRESS

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

10. Project/Task/Work Unit No.
2000451

11. Contract/Grant No.

12. Sponsoring Organization Name and Complete Address *(Street, City, State, ZIP)*

Office of Noise Abatement and Control
U. S. Environmental Protection Agency
Washington, D. C. 20460

13. Type of Report & Period Covered
FINAL

14. Sponsoring Agency Code

15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

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17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Acoustics (sound); environmental acoustics; instrumentation; noise monitoring; outdoor noise.

18. AVAILABILITY [X] Unlimited

[ ] For Official Distribution. Do Not Release to NTIS

[ ] Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Cat. No. C13

[X] Order From National Technical Information Service (NTIS) Springfield, Virginia 22151

| 19. SECURITY CLASS (THIS REPORT) | 21. NO. OF PAGES |
|---|---|
| UNCLASSIFIED | 10 |
| 20. SECURITY CLASS (THIS PAGE) | 22. Price |
| UNCLASSIFIED | $3.25 |

USCOMM-DC 29042-P74