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Acoustic Emission Recording Using nonvolatile Digital Memories

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Abstract

The general trend in acoustic emission (AE) monitoring systems has been one of increasing complexity. This is particularly true in systems for continuous monitoring which are usually multichannel (perhaps 20 to 40) and incorporate a dedicated minicomputer. A unique concept which reverses this trend for selected applications has been developed at Battelle-Northwest, Richland, WA. This concept uses nonvolatile, postage stamp sized solid state digital memories to store acquired data in a permanent form which is easily retrieved. After data has been extracted the memories can be erased and reused. It also uses a fundamental method to accept AE data only from a selected area. The digital memory system which can be cattery operated is designed for short term or long term (months) continuous, unattended monitoring. It has been successfully applied in laboratory testing such as fatigue crack growth studies, as well as field monitoring on bridges and piping to detect crack growth. The features of simplicity, compactness, versatility, and low cost contribute to expanded practical application of acoustic emission technology.

Keywords

Nondestructive Evaluation

Disciplines

Materials Science and Engineering

ACOUSTIC EMISSION RECORDING USING NONVOLATILE DIGITAL MEMORIES

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ABSTRACT

The general trend in acoustic emission (AE) monitoring systems has been one of increasing complexity. This is particularly true in systems for continuous monitoring which are usually multichannel (perhaps 20 to 40) and incorporate a dedicated minicomputer. A unique concept which reverses this trend for selected applications has been developed at Battelle-Northwest, Richland, WA. This concept uses nonvolatile, postage stamp sized solid state digital memories to store acquired data in a permanent form which is easily retrieved. After data has been extracted the memories can be erased and reused. It also uses a fundamental method to accept AE data only from a selected area. The digital memory system which can be battery operated is designed for short term or long term (months) continuous, unattended monitoring. It has been successfully applied in laboratory testing such as fatigue crack growth studies, as well as field monitoring on bridges and piping to detect crack growth. The features of simplicity, compactness, versatility, and low cost contribute to expanded practical application of acoustic emission technology.

INTRODUCTION

The basic theory of acoustic emission monitoring is established and the technology is being applied in a wide range of material experiments and structural analysis programs. In the course of this work, the general trend in acoustic emission (AE) monitoring systems has been one of increasing complexity. This is particularly true of systems designed for continuous monitoring of a structure. These systems are usually multichannel (in the vicinity of 20 to 40 or more channels) and require a dedicated computer for data processing and storage. Such systems may cost from $100,000 to $500,000. Some applications require this degree of sophistication. An example is simultaneous monitoring of a large material volume such as a nuclear reactor pressure vessel during hydrostatic testing to detect and locate defects.

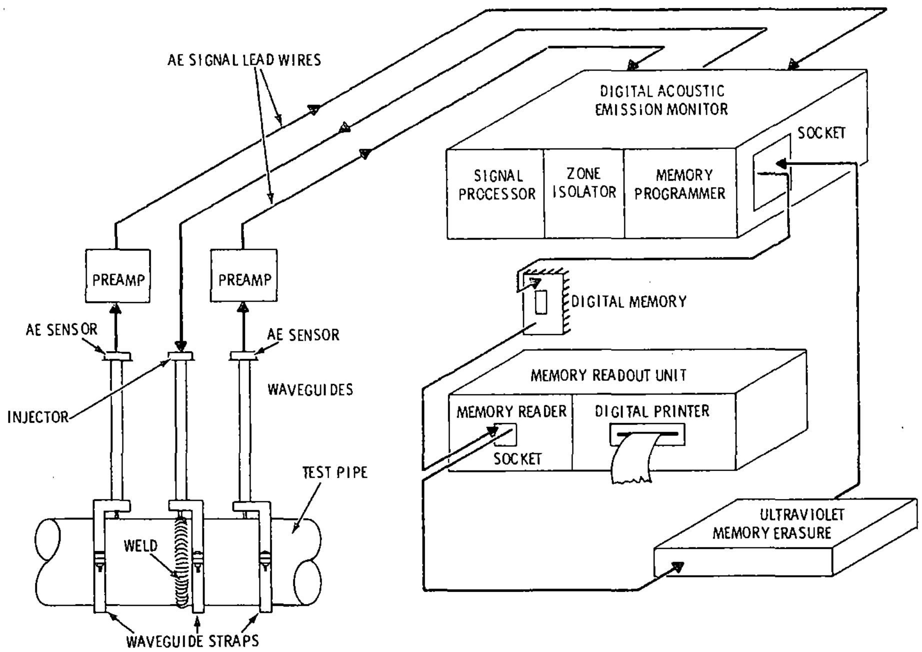
There are many structural monitoring applications of AE, however, where the system complexity just described is not needed. In a structure such as a pressure vessel or a bridge, once initial inspection has been accomplished, a large portion of the material volume is of no real concern to continued structural integrity. There remain selected areas of concern such as known high design stresses (e.g., nozzle penetrations of a pressure vessel) or portions of a structure which are especially critical to the integrity of the total structure (e.g., certain suspension members in a bridge). To apply a complex AE system to continuously monitor such selected areas over a long period of time would not only be very expensive but also may be impractical because an operator with the required skill may not be routinely available.

A unique concept for continuous AE monitoring in selected applications such as those described above has been developed at Battelle-Northwest. It reverses the trend to increasing complexity while retaining such important requirements as reliability, permanent data record, and easy retrieval of data for analysis. The original concept grew out of a special need in a program being performed for the U.S. Federal Highway Administration to apply AE to bridge monitoring.

BNW Digital AE Monitor (DAEM) System(s) are designed for long term monitoring of identified areas of concern in a structure. Their concept is centered around a solid state programmable read-only digital memory (EPROM) which is used to record acoustic emission information. Electronic time gated logic circuitry restricts the acceptance zone for acoustic signals thus providing a monitor which can selectively accept information only from a pre-determined material volume in a complex structure. The digital memory provides the basis for reducing system complexity and system cost without sacrifice of sensitivity or versatility. These memories are intended for use as a pre-programmed instructional device for use in computer systems. Through the use of specially designed programming circuitry, they were adapted to use as a dynamic recording device for BNW's DAEM system. One very important feature of the PROM's compared to other types of solid state digital memories is the fact that they are nonvolatile, i.e., recorded information is retained indefinitely without continued power supply. The memories can be erased by exposure to ultraviolet light and reused after the stored data is recovered.

The PROM's currently being used are 16K memories. This capability is utilized to provide 1024 address locations with a capacity of 65,535 counts in each address. The programming is controlled on a time basis normally. When the preset accumulation period is complete, the data is stored and a new counting period is started immediately. This process continues in sequential manner until the monitoring is completed or all the memory addresses are used. When a memory is full or at the end of a test, the used memory is removed and replaced with a fresh one. The used memory is then read out to a digital printer to provide a hard numerical copy. The memory is then erased and reused.

TYPICAL DIGITAL MEMORY APPLICATION



DIGITAL MEMORY FEATURES

- NONVOLATILE
- PERMANENT STORAGE >5 YEARS
- HIGH STORAGE CAPACITY >66 MILLION COUNTS
- COMPACT
- EASE OF USE
- LOW COST
- LOWER POWER DRAIN

AE PARAMETERS STORED IN DIGITAL MEMORY

- EVENT OR RINGDOWN COUNT
- ENERGY
- PEAK TIME
- PULSE HEIGHT
- LOCATION
- POLARITY

MECHANICAL PARAMETERS STORED IN DIGITAL MEMORY

- LOAD CYCLE NUMBER
- AE POSITION ON LOAD CYCLE
- RAMP LOAD LEVEL
- CRACK OPENING DETECTOR LEVEL

DATA LISTING FROM DIGITAL MEMORIES

BATTELLE NORTHWEST AE TEST PROFILE

AE TEST: 1-2A-6B
DATE: 5-8-78
TEMP. 550 F
INSTR. GE,OMO GEMINI NRC MTS
LOAD: 7.0/70.0 KIP
LOAD RATE: 2 HZ
TOT CYCLES: 70,000
DELTA CYCLES: 10,000
EPROM# 2716
PARAMETER: ZONE AE 2.2
UPDATE: 100 CYCS
ADDRESS: 100
PT\PH CORRELATOR: #1=A/B A/B #2=A/B B/C

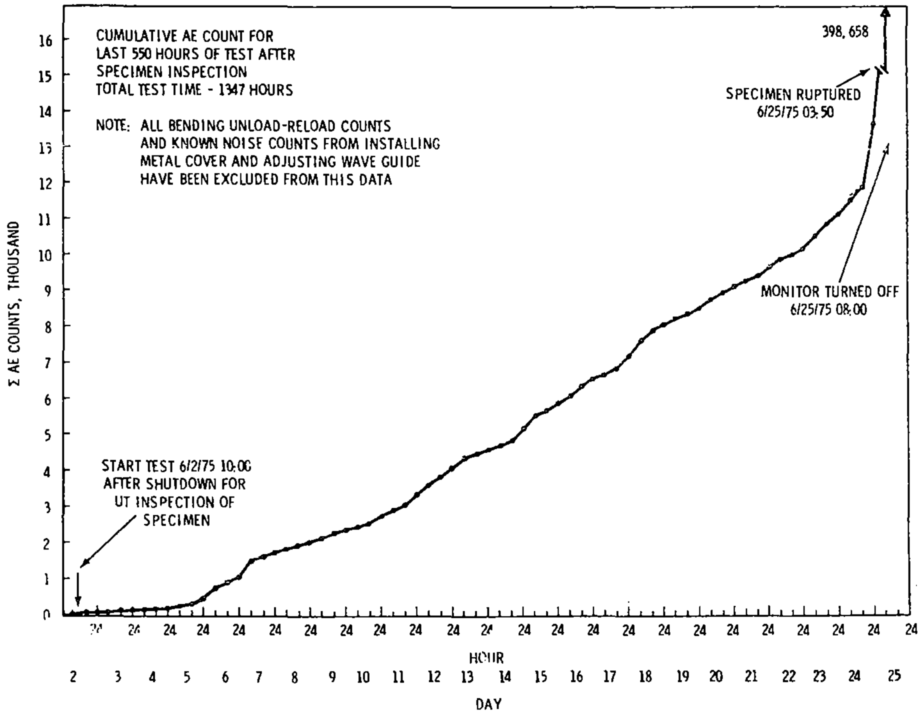
EPROM# LISTING

H	F	6	D	J	G	8	Q	10	V	3	5

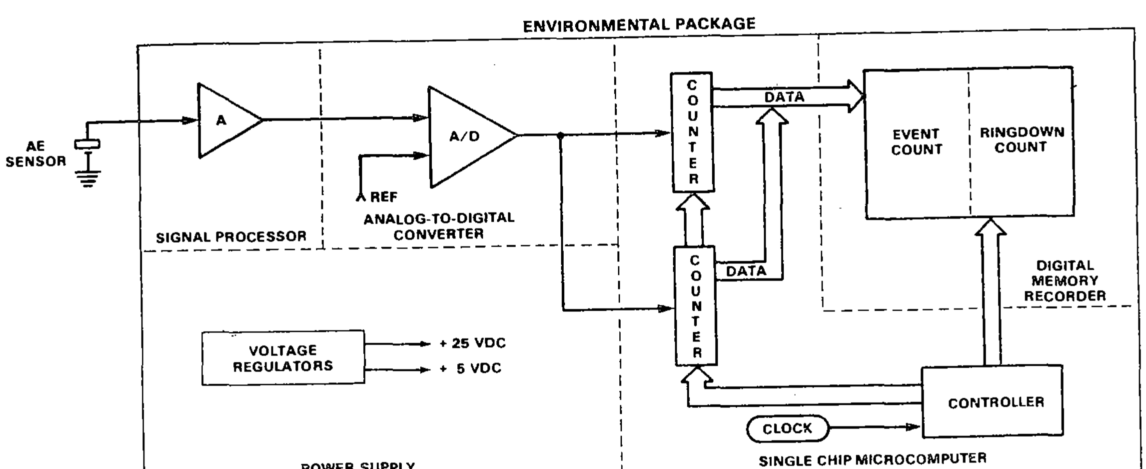
BLOCK #01 (0000-0024)

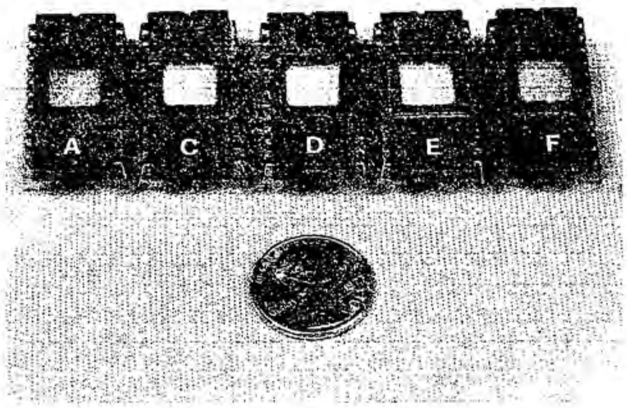
TOTAL	VALID	PT\PH	LD\VC	ENRGY	PT #1	PT #2	PT #3	PH #1	PH #2	PH #3	-POL.
00043	00011	00003	00004	00271	00011	00000	00000	00003	00002	00000	00004
00024	00004	00001	00002	00174	00003	00000	00000	00001	00000	00000	00003
00022	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
00107	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
00109	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
00089	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
00074	00001	00000	00001	00067	00001	00000	00000	00000	00000	00000	00000
00061	00002	00000	00002	00183	00001	00001	00000	00001	00000	00000	00000
00012	00001	00000	00001	00014	00000	00001	00000	00000	00000	00000	00000
00008	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
00008	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
00056	00004	00000	00003	00204	00002	00000	00001	00000	00000	00000	00002
00205	00009	00000	00008	01063	00005	00000	00003	00000	00000	00000	00007
00197	00011	00000	00011	01329	00011	00000	00000	00000	00000	00000	00006
00214	00006	00000	00006	00328	00005	00000	00001	00000	00000	00000	00005
00202	00007	00000	00007	00681	00007	00000	00000	00000	00000	00000	00005
00133	00005	00000	00005	00629	00005	00000	00000	00000	00000	00000	00003
00128	00005	00000	00005	00294	00005	00000	00000	00000	00000	00000	00003
00159	00009	00000	00008	00430	00008	00000	00000	00000	00000	00000	00006
00025	00002	00001	00002	00122	00002	00000	00000	00001	00000	00000	00002
00065	00002	00000	00001	00002	00001	00000	00000	00000	00000	00000	00002
00018	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
00005	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000	00000
00059	00001	00000	00001	00112	00001	00000	00000	00000	00000	00000	00000
00105	00002	00000	00002	00190	00002	00000	00000	00000	00000	00000	00000

DIGITAL MEMORY AE GRAPH

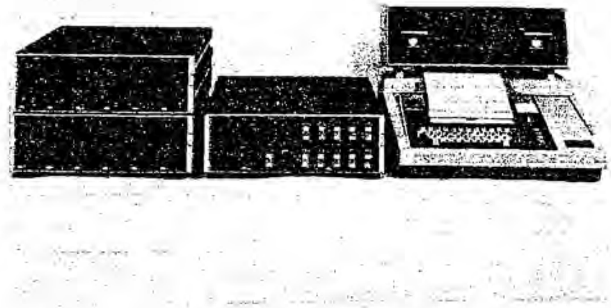


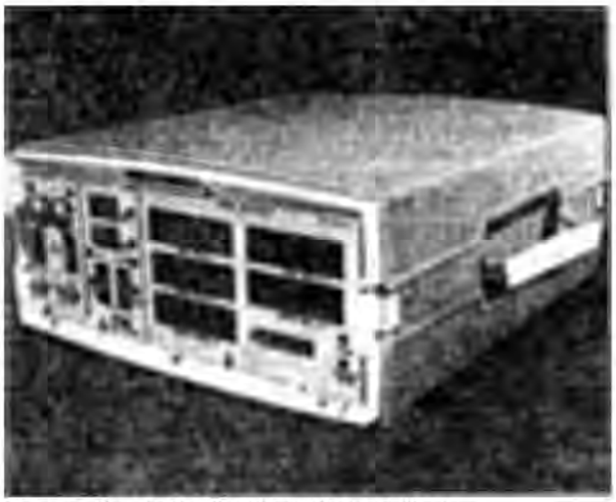
SINGLE CHANNEL TWO PARAMETER AE MONITOR

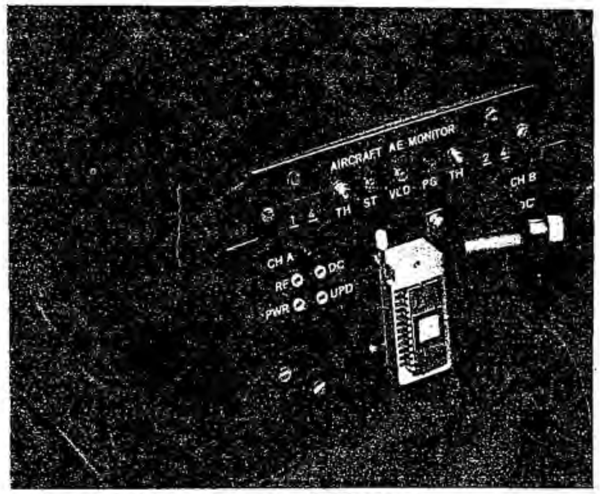




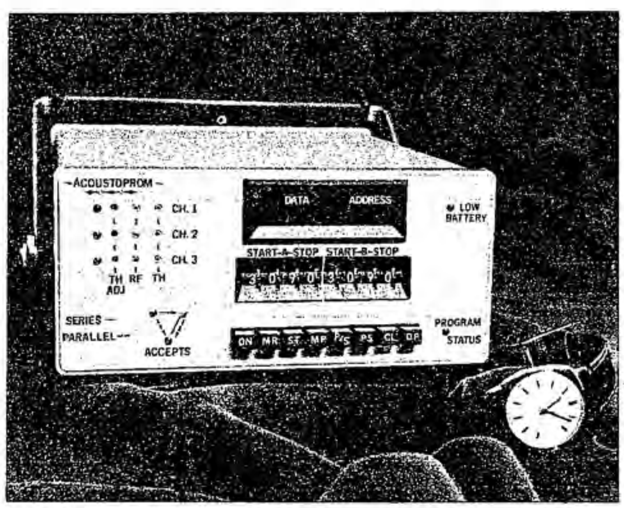
Digital Memories


Multiparameter Digital Memory AE System


Stress Corrosion Cracking Digital Memory AE Monitor



Aircraft Digital Memory AE Monitor



Battery Operated Digital Memory AE Monitor for Highway Bridges