# REMOTE TESTING AND INTERROGATION OF STRONG MOTION ACCELEROGRAPHS

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ABSTRACT

An instrument is described which allows a strong motion accelerograph to be linked to a regional computer center for remote maintenance and interrogation. This system (SIFI) consists of a computer with memory, analog to digital converter, real time clock, modem and other needed circuitry, all of which are contained in a small box that can be installed near the strong motion accelerograph. The accelerograph operates independently and records any strong motion it senses. SIFI allows the user to call the strong motion station from a remote location through a telephone line, and to interrogate the accelerograph for the purpose of maintenance and/or any transfer of data on peak motions that accelerograph has recorded. The testing of ten SIFI units presently utilized with the University of Southern California Strong Motion Accelerograph Network indicates very high reliability of operation.

## INTRODUCTION

The University of Southern California (U.S.C.) strong motion accelerograph network (Figure 1) consists of 80 strong motion accelerographs (SMA-1) that were installed in 1979 and 1980 in the Los Angeles basin and its vicinity. The selection of the site locations was based on the existence of major faults and the frequent occurrence of earthquakes in the area. This network is to help understand the distribution of strong motion shaking, attenuation of strong motion, and its relationship to the geological structure and near surface sediments.

Presently the University of Southern California strong motion accelerograph network is maintained by U.S.C. Typically one maintenance visit is required per year. Some sites may require more frequent visits. During an inspection, calibration of SMA-1 is performed, battery voltage and lamp voltage with and without load are recorded, trace alignment is checked and adjusted if necessary, trigger sensitivity and the starter are inspected and the batteries are replaced if needed. Since the SMA-1's of U.S.C. array are equipped with time code generator (TCG-1), a portable reference clock (TDC-2) is used to inspect and/or adjust the clock time of TCG-1. The film supply is also inspected and, if necessary, a new roll of film is inserted into SMA-1. Before leaving the site a calibration run is performed in order to have on the film the necessary data to compute the most recent value of the natural frequencies and dampings of the three tranducers (Longitudinal, Vertical and Transverse).

With reference to the geographical locations of the sites and preparation before each visit, it takes considerable amount of time and effort for each maintenance visit. After a strong motion earthquake all sites starting with the closest to the epicenter are visited to recover the data. Depending on the location, magnitude of earthquake, etc., not all stations may trigger and record the data. However, all stations are to be visited to gather data, replace the film, and go through a rapid maintenance check (Trifunac 1989).

## DESCRIPTION OF SIFI-1

System for Interrogation of Field Instrument (SIFI-1) allows a strong motion accelerograph to be linked to a computer center for remote testing and maintenance. It is a computer based system that consists of memory, analog to digital converter, real time calendar clock, modem and other components all contained in a box that is installed near the strong motion accelerograph.

There is no interference between the accelerograph operation and SIFI-1. The accelerograph operates independently and records any strong motion it senses. SIFI-1 allows the user to call a given station (strong motion

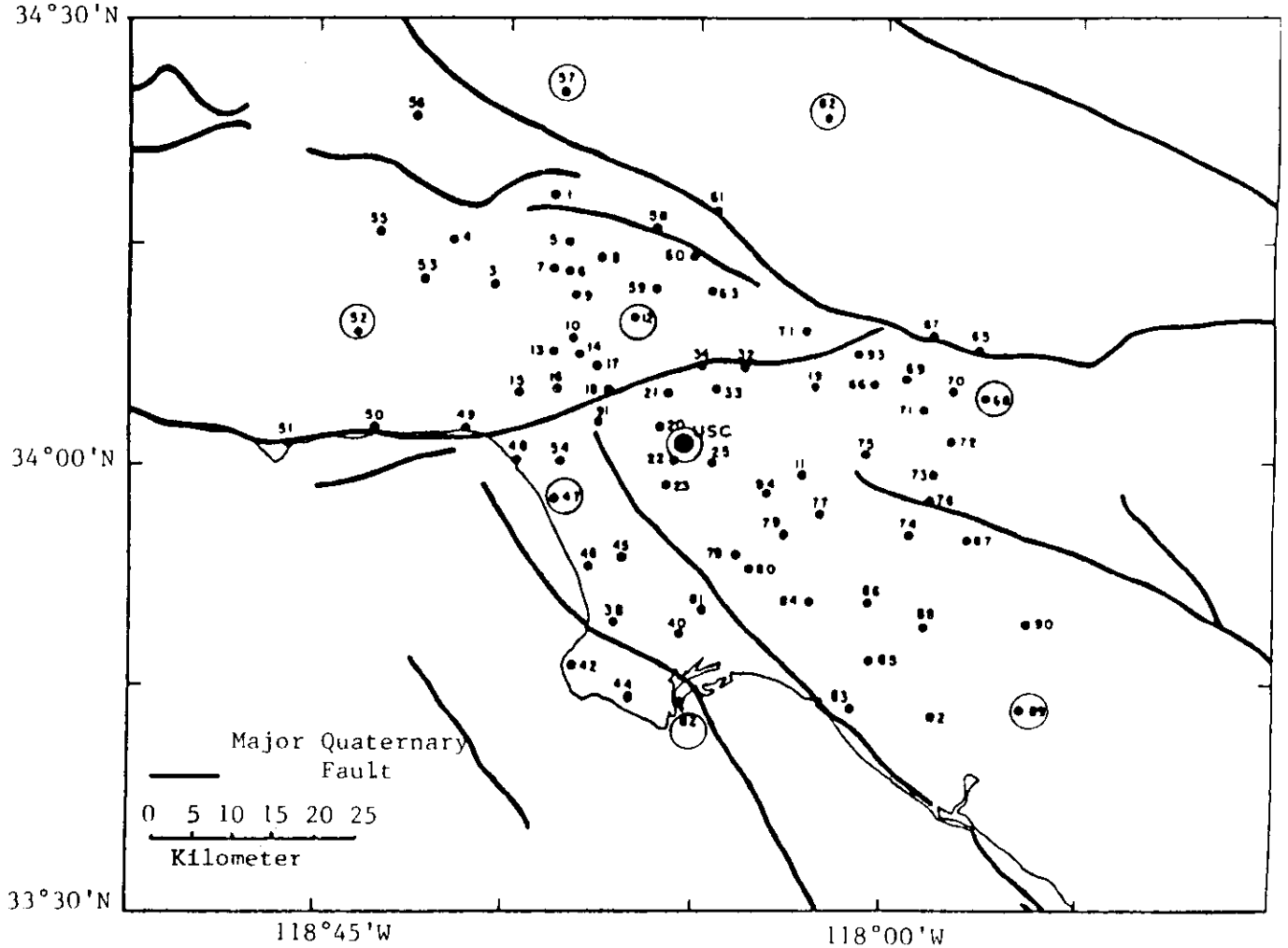


Figure 1 - USC Stations as Installed in the Spring of 1980

accelerograph) from a remote location (a computer center) through a telephone line and interrogate the accelerograph for the purpose of general maintenance and/or any transfer of data that accelerograph has recorded.

## Hardware Description

SIFI-1 is composed of three circuit boards and a low power switching power supply. The configurations of these boards are shown in Figure 2. The first is a CPU board. This board consists of a Zilog 4MHz Z80, day/date clock calendar real time clock with crystal base timing, 24K bytes of ROM, 24K bytes of RAM, and a dual channel serial interface for local and remote user communications. The local serial interface allows the user to connect a terminal on site to interrogate the strong motion accelerograph. The remote channel is connected to the modem interface for telephone communications.

The second board in the system is the modem interface board. It is an auto-dial/auto-answer Hayes compatible 1200 baud programmable modem. Through this interface one can interrogate the system on a diagnostic level, or receive any accumulated information that is stored in the SIFI-1.

The third board is the interface board. This board consists of fifteen reed relays. These relays are used to isolate the SIFI-I unit from the accelerograph during the normal operation mode and provide the needed connections during the interrogation mode. This board also contains an eight channel high speed eight bit analog to digital converter for data acquisition. Three of these analog channels are connected to high gain operational amplifiers to pick up information directly from the longitudinal, vertical and transverse transducers of the strong motion accelerographs.

The final portion of the system, is a low power switching power supply which gives superior immunity to line voltage variations and transients which may be encountered in remote sites having poor power line connections.

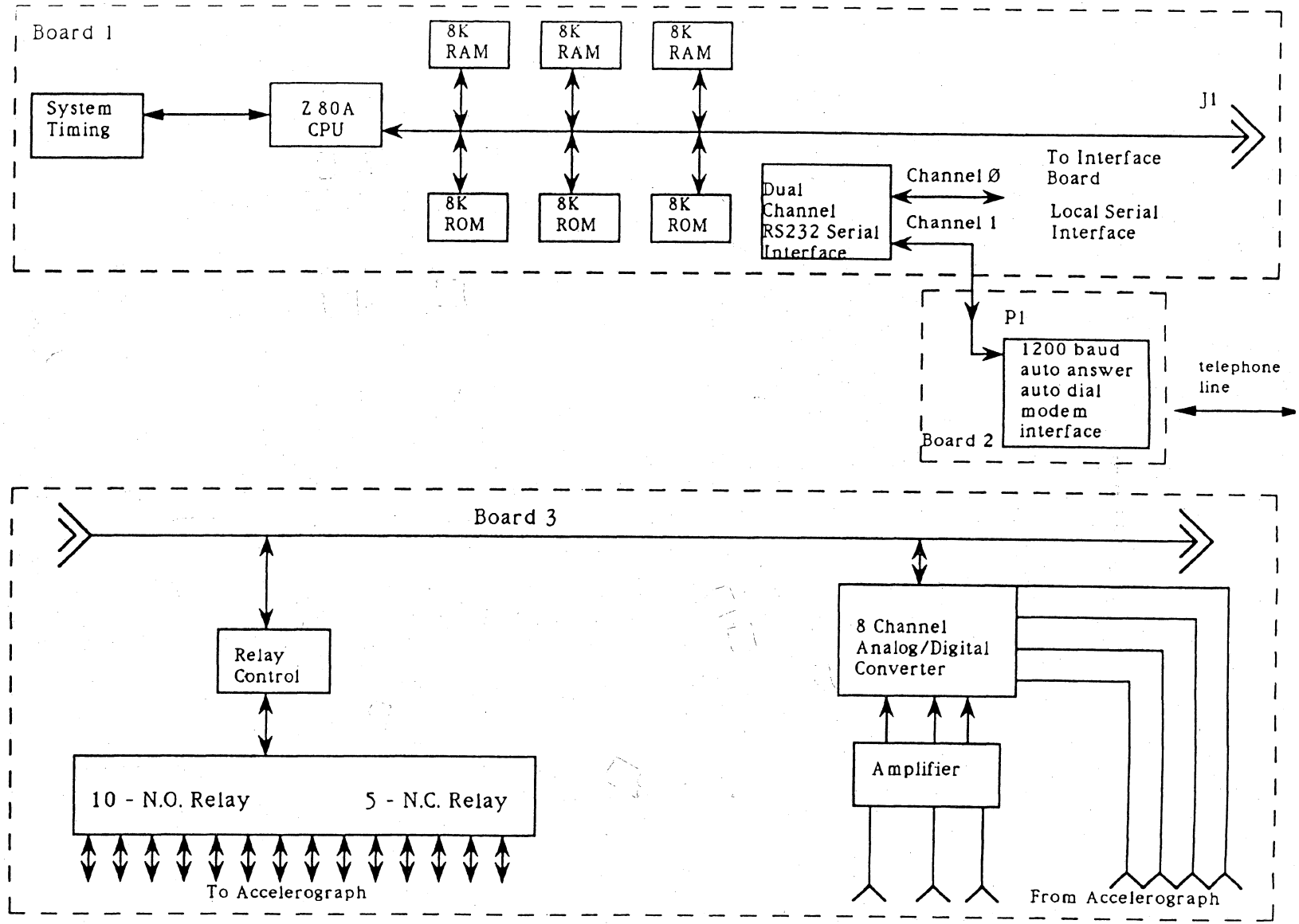


Figure 2 - SIFI Hardware Configuration

Software Description

Once the connection is made between the computer center and the field station, a user friendly program is initiated by the SIFI-1. It lists the various options the user can choose from. These options include the general maintenance check of the accelerograph such as the battery voltage, lamp voltage, film supply, number of times instrument has triggered, clock correction (if there is a time code generator in the accelerograph) and calibration data such as natural frequencies and damping values of all the transducers within the accelerograph. SIFI-1 also gives the user the option to see the peak velocity levels of any recorded strong motion by the accelerograph as well as the exact time of an event based on SIFI-1's internal clock. Furthermore, the program allows the user to reset and/or correct the SIFI-1's clock from a remote location. This option is particularly useful when the exact start time of an event is important to the user. This option not only makes it simple to evaluate the clock correction of the time code generator within the accelerograph, it simply eliminates its requirement. The user also has the option of clearing the RAM, once he has completed the maintenance check and transferred all the recorded peak values and the earthquake's arrival time. There is enough memory to record time of occurrences of earthquakes and their peak values for at least 50 events. However, extra memory can be added if needed.

No knowledge of programming is needed to use SIFI-1. A central computer can be programmed to call stations periodically, to file all the data from every station, to put these into a file and make the necessary decision to correct any problem the accelerograph may have. Hence SIFI-1 acts as a technician who is continuously in the field next to the accelerograph. Moreover, SIFI-1 has been programmed to perform a calibration after the accelerograph has recorded an earthquake. This calibration is required for the strong motion data correction. The fact that peak values of recorded motion are reported by SIFI-1 allows the user to do a remote damage study of the area where the array of strong motion accelerograph is available.

During the times when there is no telephone connection between thecentral computer and the station, the SIFI-1 is in the hibernation mode. It is just waiting to record any peak ground motion, or to be contacted by the central computer to interrogate the strong motion accelerograph.

## MAIN FEATURES

The main feature of SIFI-1 are as following:

1. Continuous (or periodic) trouble shooting of an accelerograph from a remote location through a telephone line. This includes:

a. The number of times instrument has triggered.
b. Battery voltage (no load and load).
c.. Lamp voltage.
d. Estimation of film supply.

2. Continuous (or periodic) calibration of an accelerograph from a remote location through a telephone line. This includes:

   a. Measurement of instrument damping values for Longitudinal, Vertical, and Transverse transducers.
   b. Measurement of instrument natural frequencies for Longitudinal, Vertical, and Transverse transducers.

3. Automatic storage of peak motions of all three traces (L,V, and T).
4. Clock correction of the accelerograph's crystal clock.
5. The time of occurrence of an event based on SIFI-1's internal clock.
6. Capability of resetting the SIFI-1's internal clock to the exact time from remote location through a telephone line.
7. Clearing the SIFI-1's RAM.
8. Capability of interrogation by the central computer system to obtain all the above information and perform calibration.
9. Performing calibration after an event.
10. Security system for prevention of tampering.

To obtain access to a SIFI-1 site and use the SIFI:

a. Dial SIFI-1 for the particular station.
b. Make selection from SIFI-1 Menu.
c. Exit SIFI-1 by selecting option 8

Once connection is made through the modem with a SIFI-1, a SIFI Menu as shown in Figure 3 becomes available to the user. The user can then select different option to test and/or transfer data recorded by the strong motion accelerograph.

WELCOME TO SIFI VERSION 1.0

Instrument has triggered_____ times

1. Display System I.D.
2. Display Time Code.
3. Display Peak Acceleration.
4. Check Lamp Voltage.
5. Check Battery Voltage.
6. Check Film Supply.
7. Calibrate SMA-1.
8. Start Hibernation & Logout.
9. Exist to SIFI Core.
10. Display/Set CPU Clock.
11. Clear SIFI RAM.

Select?

Figure 3 - SIFI MENU

## SITE LOCATIONS EQUIPPED WITH SIFI-1

Nine out of the eighty U.S.C. strong motion stations are equipped with SIFI-1's. These sites are circled in Figure 1. For Each SIFI-1 installation a telephone line close to the accelerograph was required to provide the communication between the central computer at U.S.C. and the accelerograph. The wiring of each accelerograph connected to SIFI-1 had to be slightly modified to provide the needed linkage to the SIFI-1 and to make sure that there is no interference between SIFI-1 and the accelerograph operation. Normally only a modem and a terminal is required to communicate from any location with a strong motion accelerograph through SIFI-1. The nine SIFI-1's indicated in Figure 1 were all installed in August of 1987 and have been operating free of maintenance, ever since. An extra SIFI-1 is used as a spare.

## CONCLUSION AND SUMMARY

The nine SIFI-1's utilized with the U.S.C. strong motion array provide the remote maintenance and interrogation of the accelerographs. They also provide a digital recording system with real time calendar clock. The utilization and the design of SIFI-1 suggests the possibility of having all the future strong motion sensors/recorders equipped with similar modules to maintain and calibrate the accelerographs remotely, to make a rapid study and evaluation of earthquake damage for a particular area, and perhaps to

provide a starting point of considering the early warning system by altering the form of communication from telephone line to a satellite.

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