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ON-BOARD/PORTABLE DIGITAL DATA ACQUISITION SYSTEM

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With data acquisition requirements of 50 or more data channels per test, it is difficult for us to use the traditional system of off-board amplifiers. Sled umbilical cables become large and impractical and analog multiplexing is required to record all data on a single analog tape recorder. Cables, multiplexors, and analog tape recorders are also additional sources of signal degradation, maintenance, and potential problems. With the development of relatively inexpensive large scale integrated circuits it is possible to put signal conditioners, analog-digital converters, and memory all on board the sled in a compact and rugged package. The on-board system must at least meet the performance of present off-board systems plus additional features to suit the sled environment.

The development of this system was undertaken to:

1. Expand our system capabilities
2. Improve data quality and reliability by eliminating sled cables, analog tape recorders, and analog multiplexing
3. Reduce setup time and improve turnaround time
4. Add versatility by being compact and portable

Some other required features are durability to withstand crash deceleration pulses and vibration, low power for portable battery operation, easy to use, and flexible to accept various kinds of transducers.

Two prototype units have been built and used in many tests. One unit is used in a back-pack as a portable system and has a capacity of 16 channels. Figures 1 and 2 show this unit outside the backpack and in use in a gait experiment. It weighs 5 kg without batteries and measures 150 by 280 by 330 mm. The other unit is mounted on a sled and has a capacity for 32 channels. Figures 3 and 4 show this unit. It measures 200 by 280 by 530 mm and weighs 11.1 kg. The power supply is mounted on one end and the controls and connections are at the other. Standard five pin amphenol connectors are used for transducer input connection and bridge completion board is included for the use in making full bridges when half bridge transducers are used. The system only accepts full bridge input. Also shown in Figure 4 are a pair of boards which form the basis of the system. One is called the analog board, which is 150 by 216 mm in size, and contains the signal conditioning amplifiers, filters, multiplexing and auto balance components. The other board is called the digital board, and measures 114 by 200 mm, and contains the sample and hold amplifier, A/D converter, memory, timing and control logic, and power regulators. Each pair of boards handles four channels of signal conditioning.

36A/mh

DESCRIPTION

A block diagram of the system is shown in Figure 5. The output of a transducer is fed into a Burr-Brown 3606 instrumentation amplifier which contains integrated resistor networks for programmable gains from 4 to 1024. With the addition of an external resistor range is increased from 4 to 4096. These are programmable through a 4 -bit input port which is wired to a DIP switch on the board at present. Addition of components to the last stage of the 3606 effects a simple low pass filter for anit-aliasing purposes. The output of the amplifiers is brought out to an edge connector and wired to a connector on the end of the rack as an analog output port or for debugging purposes. The output of four amplifiers goes to an analog multiplexor where the data are time-multiplexed into one channel and fed to an edge connector.

The multiplexed analog signal is fed into a commercial sample-and-hold amplifier and then to an A/D converter. The converter is a 10 -bit successive approximation type with a ±5 volt input range and a 25 micro-second conversion time. Output of the converter is connected via a data bus to a 4k by 10-bit CMOS memory bank. Logic for the system and address generation for the memory is also done on the digital board. The rate of conversion is adjustable through DIP switch components and most other components are CMOS for low power consumption and the possibility of battery operation. A battery back-up for the memory has not been incorporated as yet, although the portable system has been run on batteries as was an earlier 4-channel prototype system. Auto balance is done by digitizing the offset from zero and feeding it back through a D/A converter to the 3606 to electrically counteract the offset.

Communication with an external computer for the reading of memory is made directly to the data bus of each board through an interface/buffer board. The system runs off a plus and minus DC power of approximately 100 ma each for four channels. The digital board contains a DC-DC regulator for the 5 volt bridge excitation of transducer bridge circuits.

A microprocessor is not required to run the system, although one could be interfaced to control the system. The functioning of the system is controlled by individual external signal lines:

- Reset - resets the memoryaddress to zero;
- Calibrate - performs an n-point (adjustable) 0, +, -, 0 shunt calibration and stores the results in memory. The shunt calibration resistors and logic are on a separate board called the calibration board;
- Write - commences digitizing until memory is full or the end of the write signal (Schmitt trigger);
- Read - directs memory to put data on the data bus;
- Zero - performs a balance of each channel.

Without a microprocessor in the system it makes the system cheaper and simpler but, does not allow the system to have any "intelligence" to do such things as self-testing and communications with an external operator. By having a communication link, gains and rates could be set through a terminal or by another computer making possible a more automated system. It is possible to add these features to this system in the future. Preliminary design work has already been done.

PERFORMANCE

The system performance was checked statically and dynamically on the bench to make sure everything was functioning properly. Then it was used in sled tests and its data was compared to the results from the usual analog tape instrumentation system. A typical data result and some comparisons are shown in Figures 6 through 9. Figure 6 shows a complete memory dump for one channel with the calibration signal on the front of the run data. Approximate system check can be done from the shunt cal voltage level if the sensitivity of the transducer is known as well as the gain of the amplifier. Figure 7 shows the two systems data overlaid on one another after the calibration signal has been removed. Small differences are only visible in the noise level. Figures 8 and 9 show a deceleration pulse which over drove the analog tape system but not the digital system. The differences are visible in the expanded traces of Figure 9.

CONCLUSIONS

The features of the present systems are summarized in Table 1. Compared to other similar packages being developed (1, 2) these sytems are compact, light -weight and consume less power. However the system is not optimal considering the present state of the art. Modifications are continually being made and some future improvements presently being worked on and soon to be incorporated are listed in Table 2. Programmability, self-calibration/test and communication require a micro-processor unit in the system and this has been planned and can be accommodated on an additional board. Changing the sampling rate really cannot be done without a concommitant change in filter frequency, so the feature of adjustable filter should be incorporated to take advantage of the adjustable sampling rate feature. Memory expansion and a master clock can also be accommodated on the MPU board . With a master clock all boards will be time synchronized rather than running independently as they are at present. The system is accomplishing our goals and will be a superior method of data acquisition.

ACKNOWLEDGEMENT

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REFERENCES

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2. Fouts, P.G., Griggs, G.A., and Holdren, E.J.: Digital Recording of Vehicle Crash Data. SAE Paper 810810, Passenger Car Meeting, Dearborn, MI, Jung 1981.

Table 1
Present Features

Compact - 54 cu. in. per channel

Light weight - 0.7 lbs. per channel

Low power - +/- 25 ma per channel

Precision gain selection - 4 to 4096 in binary steps

Adjustable sampling rate - 125 to 8000 per sec per channel

Auto balance

Auto shunt calibration

Analog outputs available

Easy to use

Flexible

Table 2
Future Features

Programmable gain and sampling rate

Battery backup for memory

Memory expansion board

Self-calibration/testing

Master clock

Adjustable filters

External communication

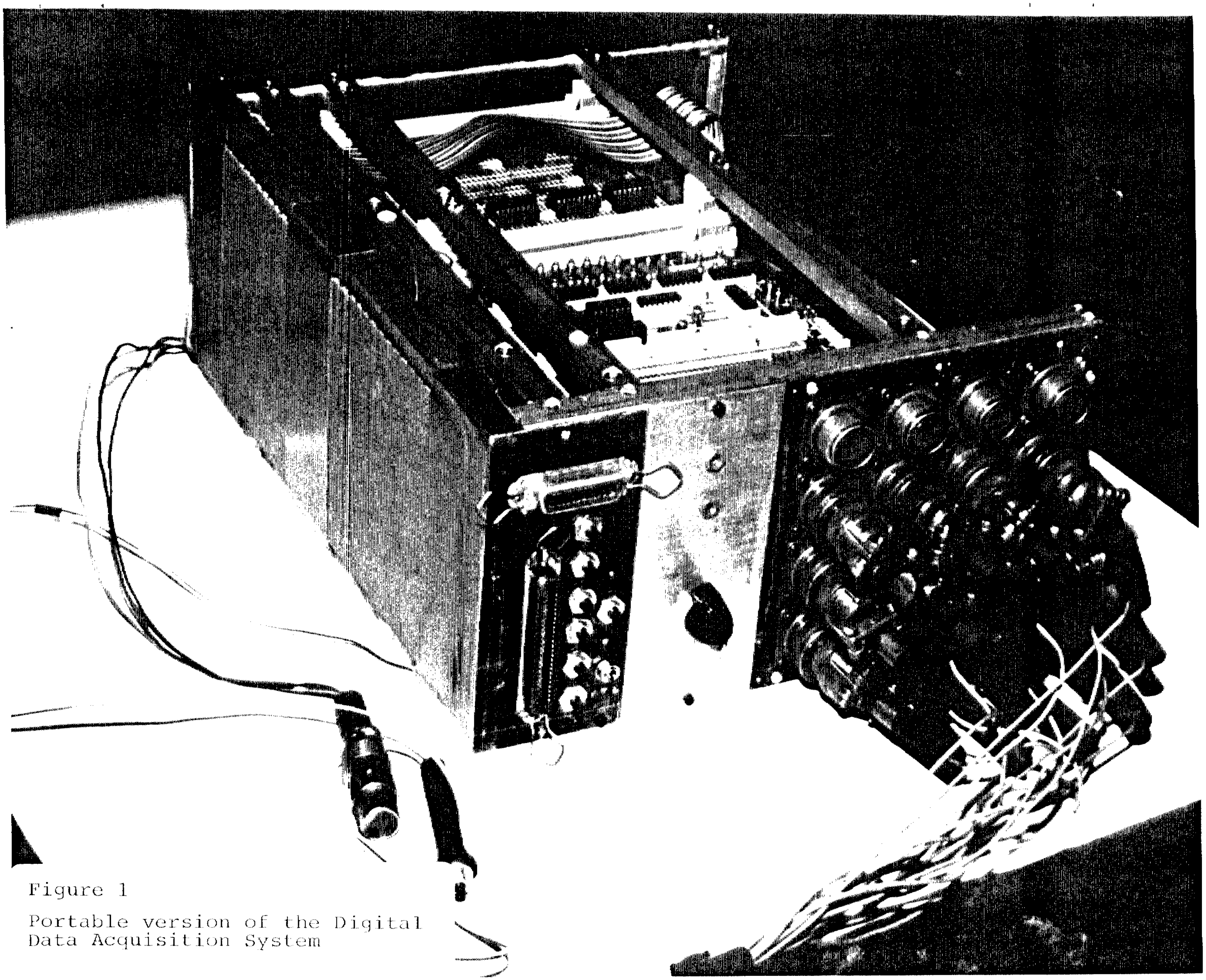

Figure 1

Portable version of the Digital Data Acquisition System

Figure 2

Portable system in use for gait experiments

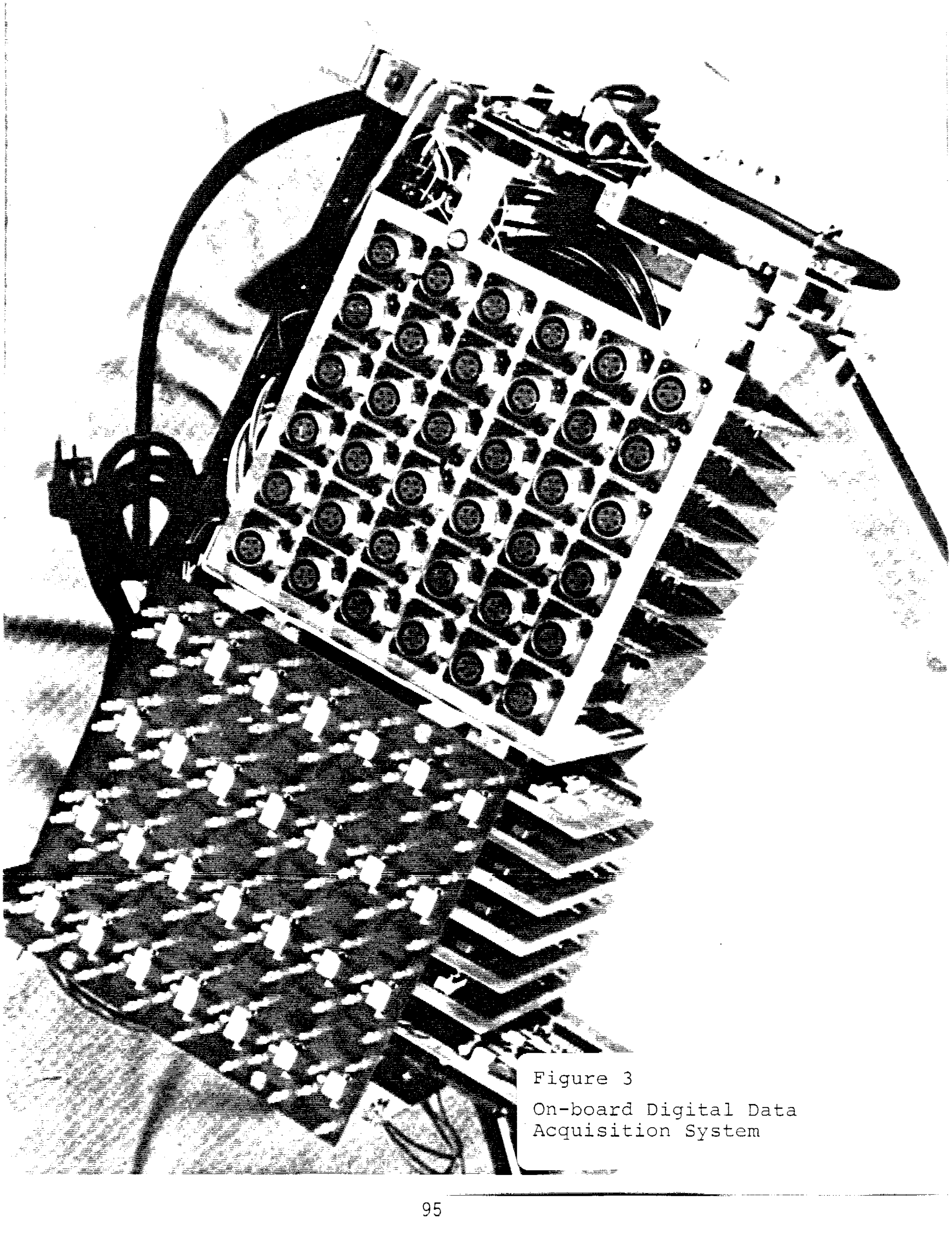

Figure 3
On-board Digital Data Acquisition System

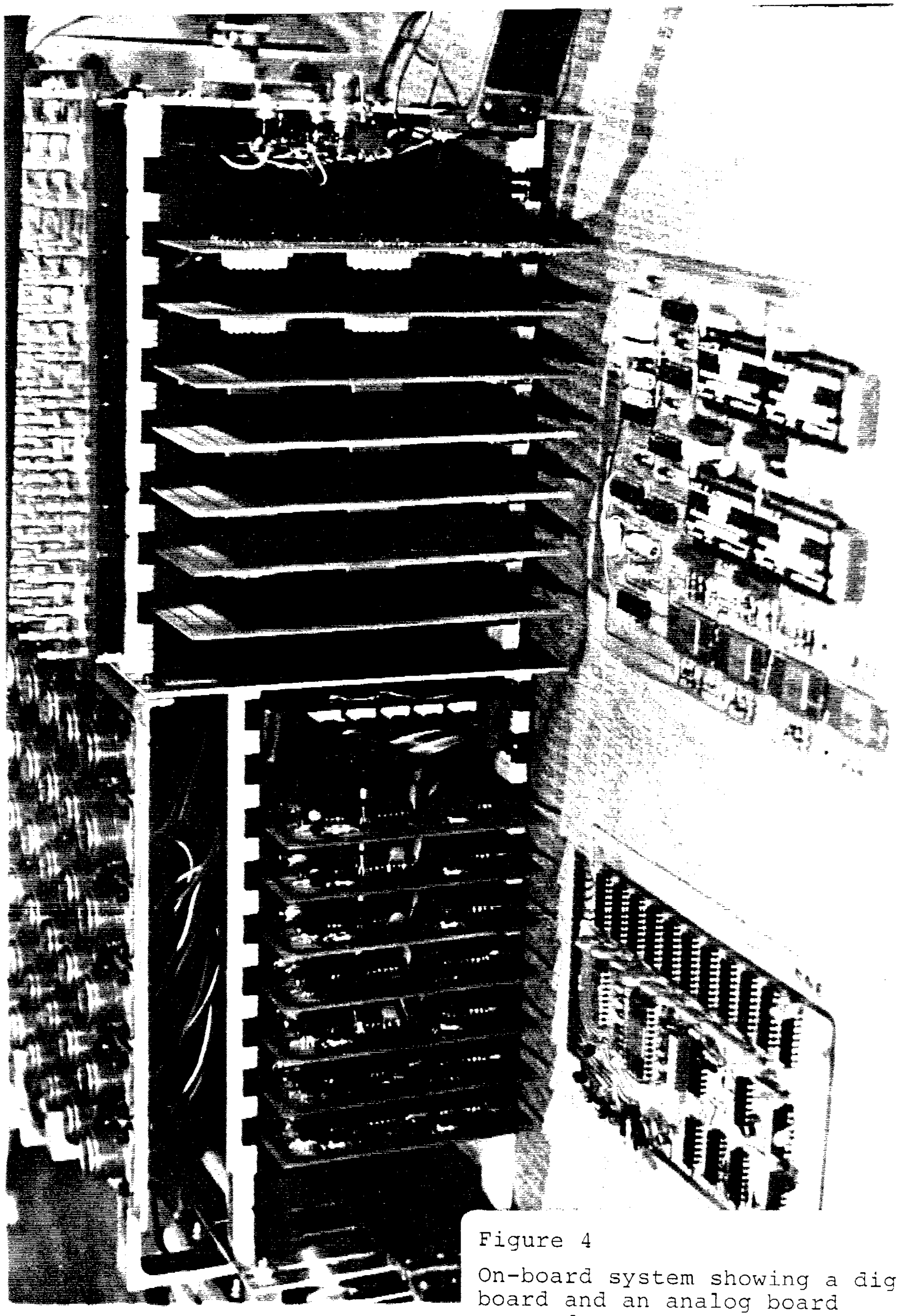

Figure 4

On-board system showing a digital board and an analog board removed

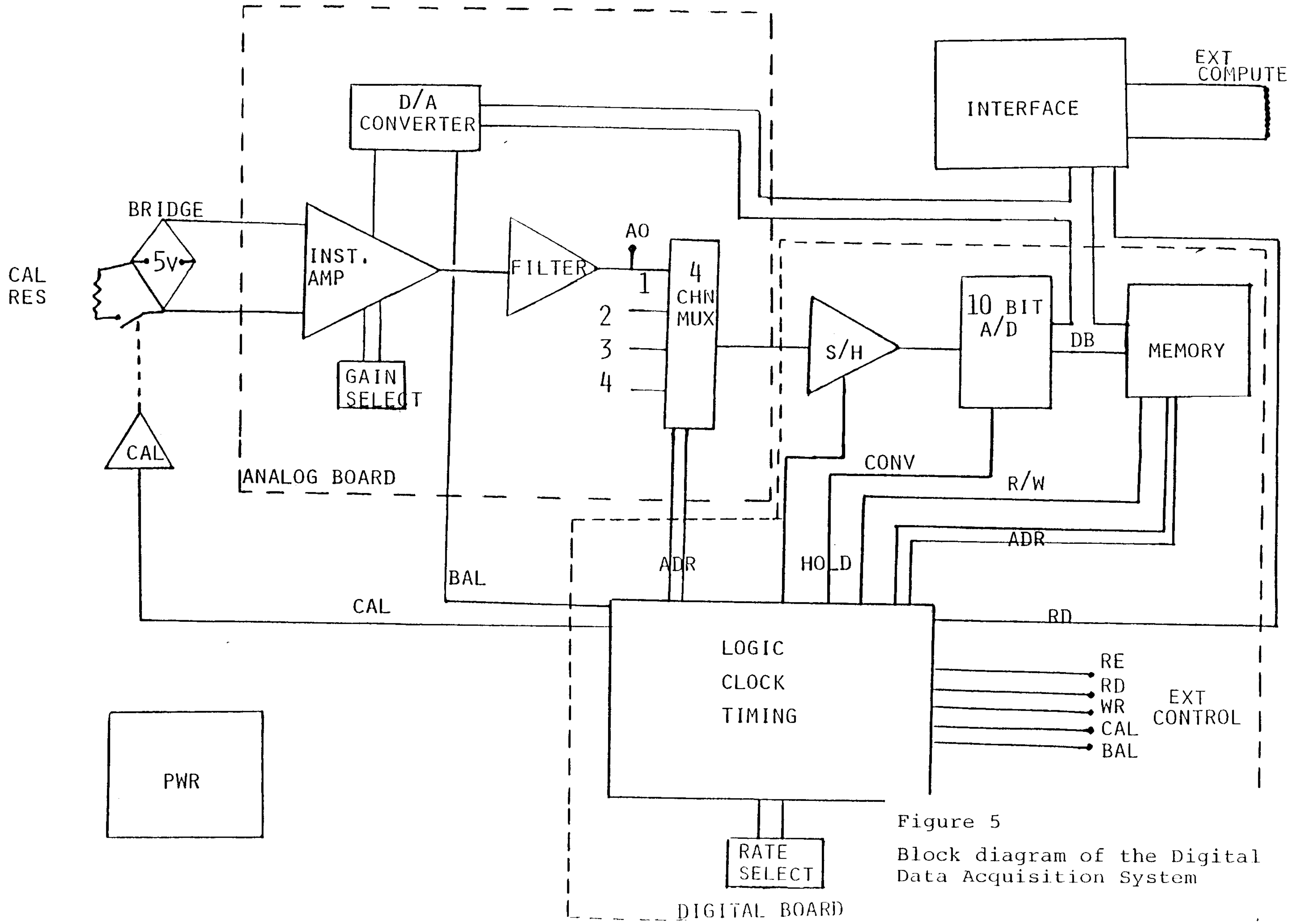

Figure 5

Block diagram of the Digital Data Acquisition System

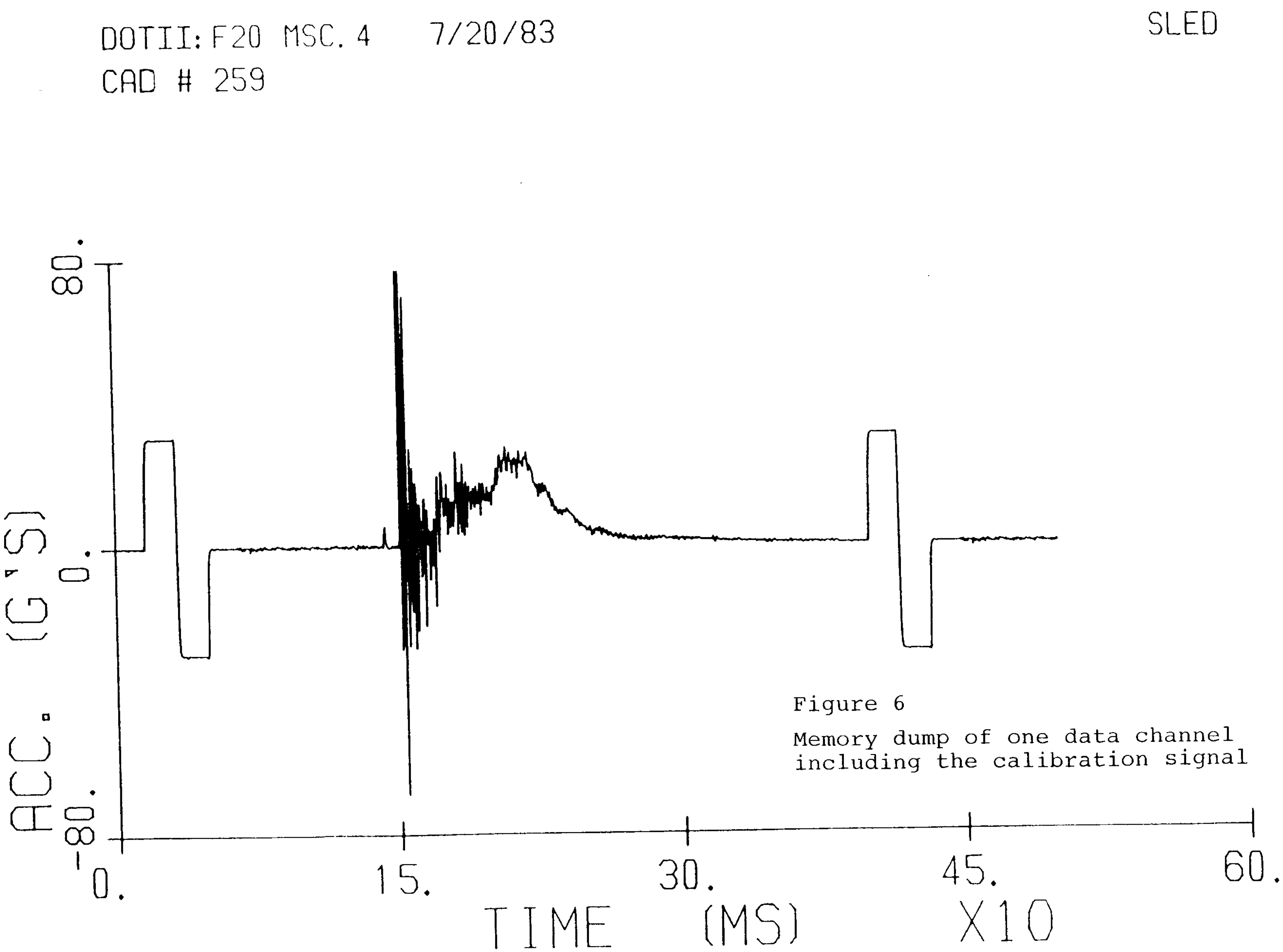

Figure 6
Memory dump of one data channel including the calibration signal

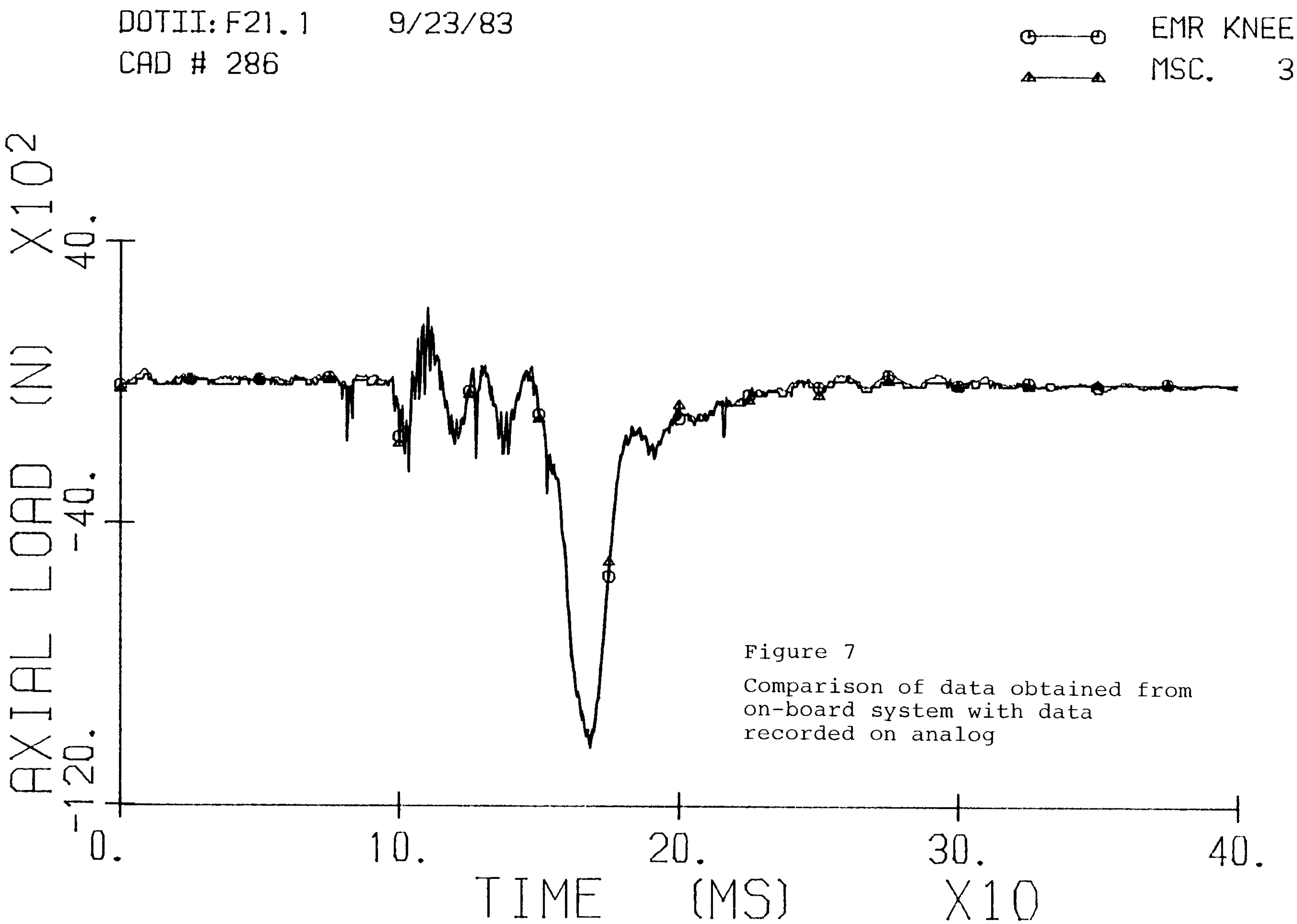

Figure 7

Comparison of data obtained from on-board system with data recorded on analog

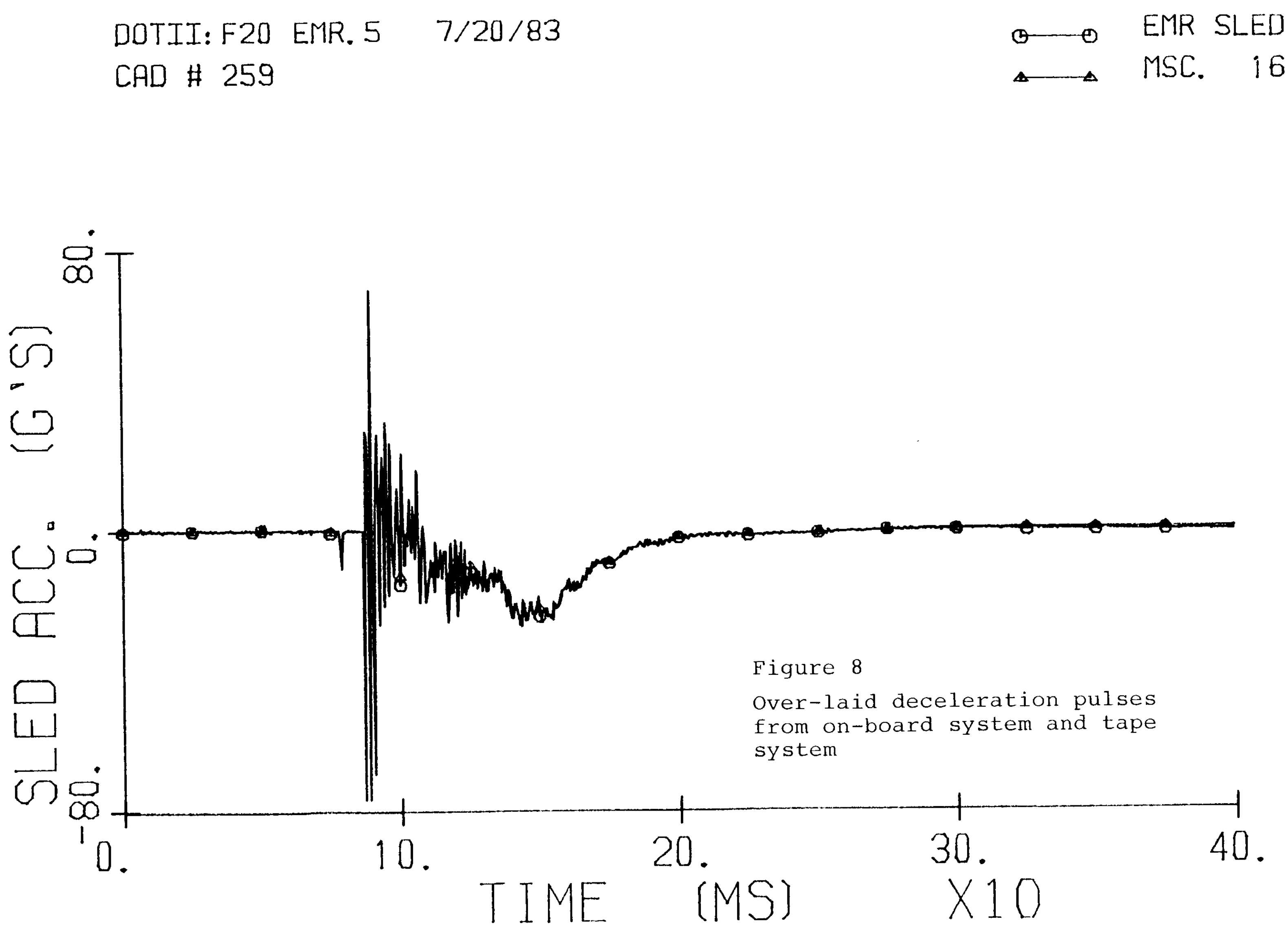

Figure 8
Over-laid deceleration pulses from on-board system and tape system

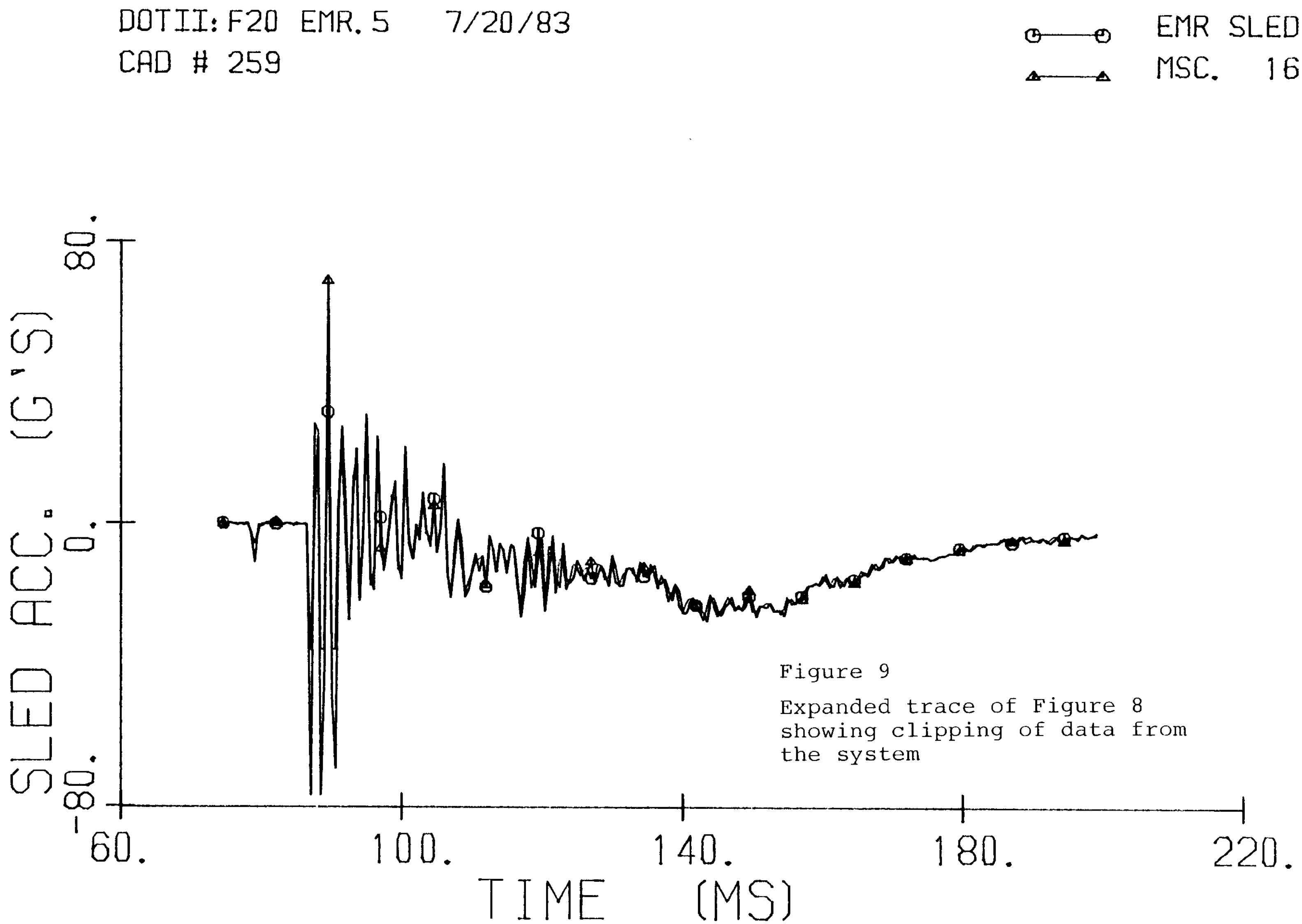

Figure 9

Expanded trace of Figure 8 showing clipping of data from the system