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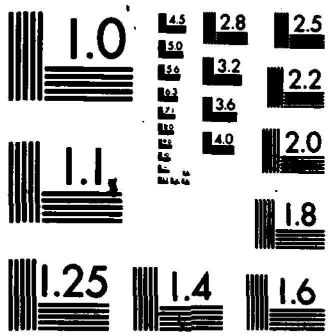

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DEVELOPMENT OF A NON-VOLATILE PROGRAMMABLE DIGITAL TO ANALOG CONVERTER SUBSYSTEM FOR PCM TELEMETRY SYSTEMS

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

THIS REPORT DESCRIBES THE DEVELOPMENT OF A PROGRAMMABLE DIGITAL TO ANALOG CONVERTER SYSTEM WITH A NON-VOLATILE MEMORY THAT EXPEDITES THE ACQUISITION OF CERTAIN TELEMETRY DATA RECEIVED FROM SOUNDING ROCKETS.

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SUMMARY

It became apparent to PSL that a programmable digital to analog (D/A) converter subsystem with a non-volatile memory would be an extremely useful asset for sounding rocket missions. Therefore, the Physical Science Laboratory developed such a system and incorporated it into a PCM Decommutator unit. This report provides background information and rationale for the need for such a system, as well as details on the functioning of the PCM Decom Model 82A.

I. INTRODUCTION

Under the terms of contract F19628-82-C-0111 the Physical Science Laboratory (PSL), New Mexico State University, provides a variety of support services for the Air Force Geophysical Laboratory (AFGL) sounding rocket program. A portion of these services is devoted to the development of new or improved ground-based instrumentation which serve to enhance mission success through significant increases in data quality and quantity while minimizing down times, turn-around times and difficulties for the experimenter related to data assessment. A recent example of this PSL support for AFGL was the development of a non-volatile, programmable digital to analog converter subsystem for the PCM telemetry system. This development and its significance and application are described in the sections following.

II. BACKGROUND

The growth in complexity of sounding rocket scientific missions and support instrumentation has lead to the increased use of Pulse-Code Modulation (PCM) systems. PCM lends itself to time-division multiplexing and, because of its true digital nature, is very adaptable to microprocessor-controlled communications equipment and to transmission of digital data. PCM generally provides an increased number of data channels at higher data sampling rates compared to older systems such as FM/FM, PAM/FM or PPM/FM. For these reasons PCM is the fastest growing method of data transmission in rocket telemetry.

III. DIGITAL TO ANALOG CONVERTER SUBSYSTEM

One of the objectives of the modern telemetry ground station is to rapidly provide accurate analog strip-chart records. This requires a minimum of set-up time, turn-around time, playback time, reduced channel selection error, and reduces the occurrence and duration of any countdown holds during testing. Due to range scheduling requirements some tests of different payloads are scheduled with little time for turn-around.

Analog strip-chart records can be obtained via appropriate configuration of the telemetry ground station equipment and the use of a Digital to Analog (D/A) converter subsystem. Programming of D/A converter subsystems used on large sounding rocket programs can be a major problem when literally hundreds of parameters necessary for GO/NO GO decisions must be evaluated from strip-chart records or data from other analog media. Versatile programming has been accomplished by several methods in the past. One of the early methods was with patch wires or patch boards. This method is tedious and quite error prone. Attempts to modify the patching to additional D/A converter outputs or correcting previous patching often resulted in errors. Another slow and error prone method is through manual entry by keyboard or switch. Another method commonly employed is the reading of punched or marked cards. While accurate and repeatable results are usually obtained, the program is difficult to modify in a realtime situation.

Computer control of the D/A subsystem solves most of these problems, but involves considerable investment in both hardware and software and requires a non-volatile storage media, such as disc or tape. If the computer is being used for other tasks, it may be difficult to interrupt and reload a D/A unit during realtime operations.

IV. DEVELOPMENT OF THE DIGITAL TO ANALOG CONVERTER SUBSYSTEM

Based on the experience with, and limitations of, available digital to analog converter subsystems, PSL opted to design and develop a non-volatile storage system for programming up to 32 digital to analog converters with storage for up to 16 unique groups (formats) of data. A number of operational considerations were carefully evaluated. Among these were cost, reliability in a field environment where dust and other contaminants are common, maintenance by field technicians using only oscilloscopes and portable meters, and future availability of parts.

The new, non-volatile, programmable D/A subsystem design described in this report is a significant improvement over earlier designs. The non-volatile storage of the format programming maintains the programming configuration from the first rocket pre-launch test through the launch. This reliability instills user confidence, prevents errors and unnecessary confusion. The system is simple, reliable and maintainable. The operation of D/A programming is easy and straightforward.

When design commenced in July 1982, several semiconductor companys had abandoned development efforts on bubble memories. The serial format available would have required the use of an additional slaved random access memory due to the slow access time of bubble memories. These considerations precluded their use in this system.

Electrically erasable programmable read-only memory (EEPROMS) at that time were just entering production. Limited lifetime and size imposed severe restraints, although they are currently much more attractive.

Complementary metal oxide semiconductor (CMOS) random access memories (RAMs) were readily available and the price was dropping rapidly; therefore, the Harris HM-6504 CMOS RAM was selected. The HM-6504 is a fully static RAM and may be maintained in any state for an indefinite period of time. The addition of a small rechargable battery provides excellent non-volatility; so this was the approach taken.

With the selection of an appropriate storage device complete, the design effort shifted to the loading device to preset the various memories to the desired configuration. The two approaches considered were a hardware loader and a microprocessor controller. Since the logic involved was relatively simple and no benefits were apparent from using a microprocessor, the hardware loader was chosen as the simplest, lowest cost approach.

In order to fully test the non-volatile programmable D/A converter subsystem, it was necessary to fabricate (borrowing on past proven designs) an entire PCM decommutator system. An overall block diagram of the system is presented in Figure 1. Figures 2, 3, and 4 show the front, top, and oblique view of the PCM Decom Model 82A.

A block diagram of the non-volatile memory and D/A converter subsystem is presented in Figure 5. Only one memory set is shown for clarity, but 32 memory sets and D/A's were fabricated. Control circuitry is common for all sets, except for select logic. A "1" is written in the word memory for the address corresponding to the selected channel. If supercommutation is used, an interval counter adds a "1" at that interval until the end of frame. If subcommutation is used, a "1" is written in the frame memory at the selected frame address. If subcommutation is not used, the frame memory is filled with all "1's". Supercommutation may be used in either the word or frame memory. The contents of the switch-selected memory set is displayed on the front panel for verification. The frame display is blanked when subcommutation is not used.

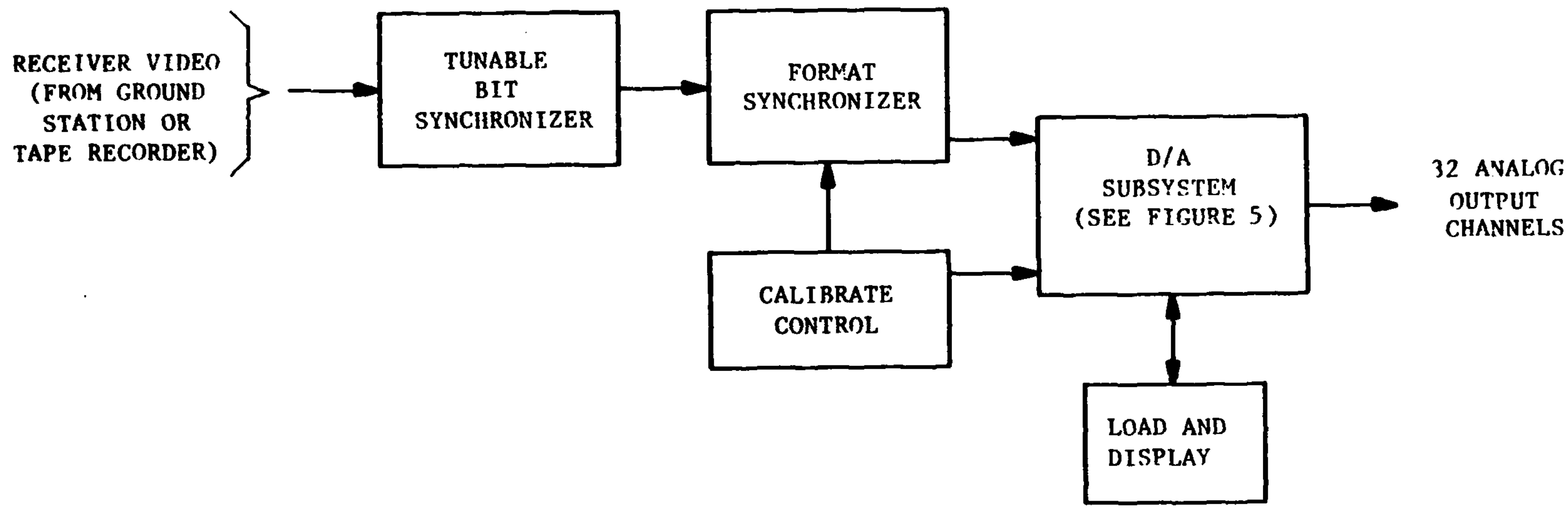

Figure 1. Block Diagram of PCM Decom Model 82A

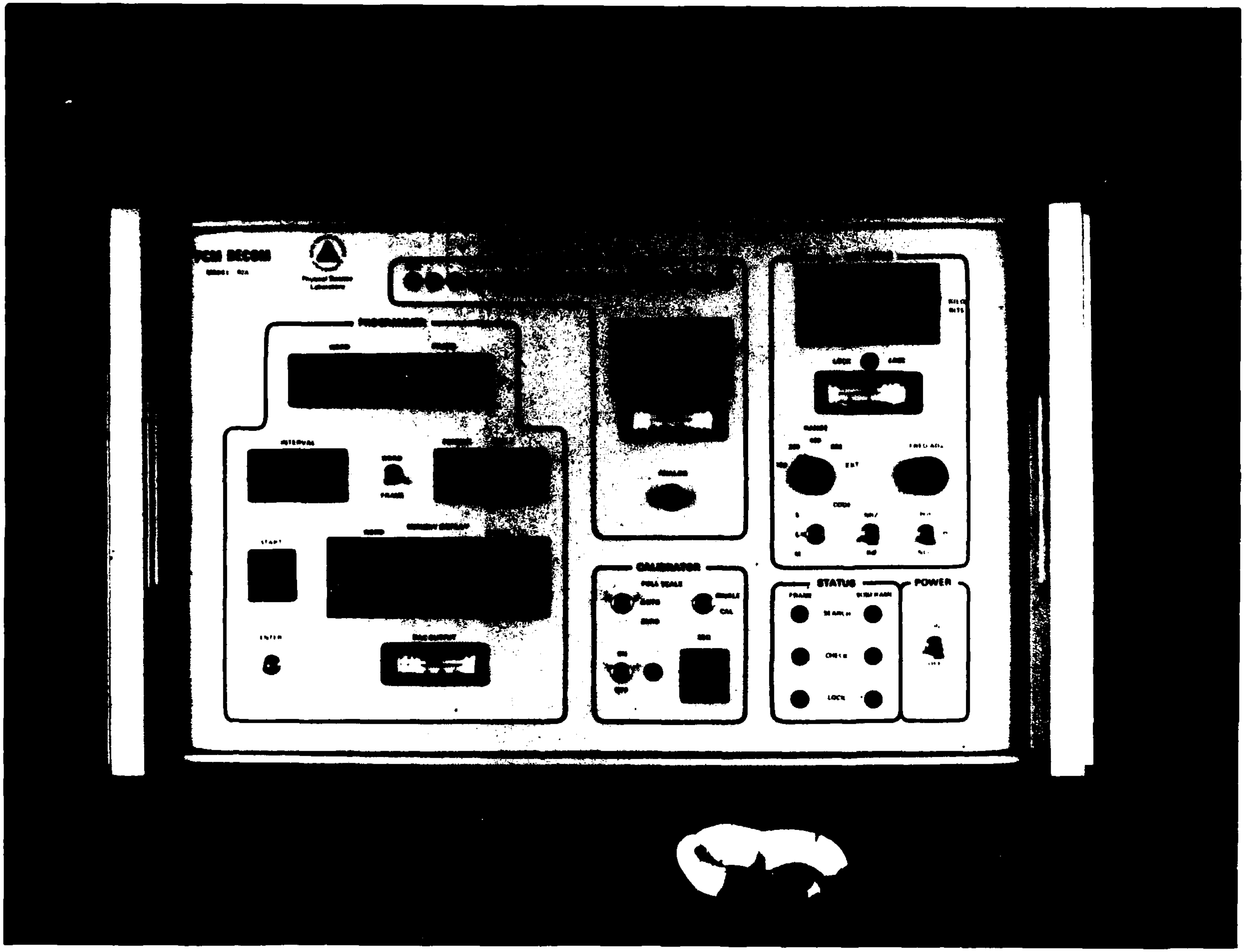

Figure 2. Front View of PCM Decom Model 82A

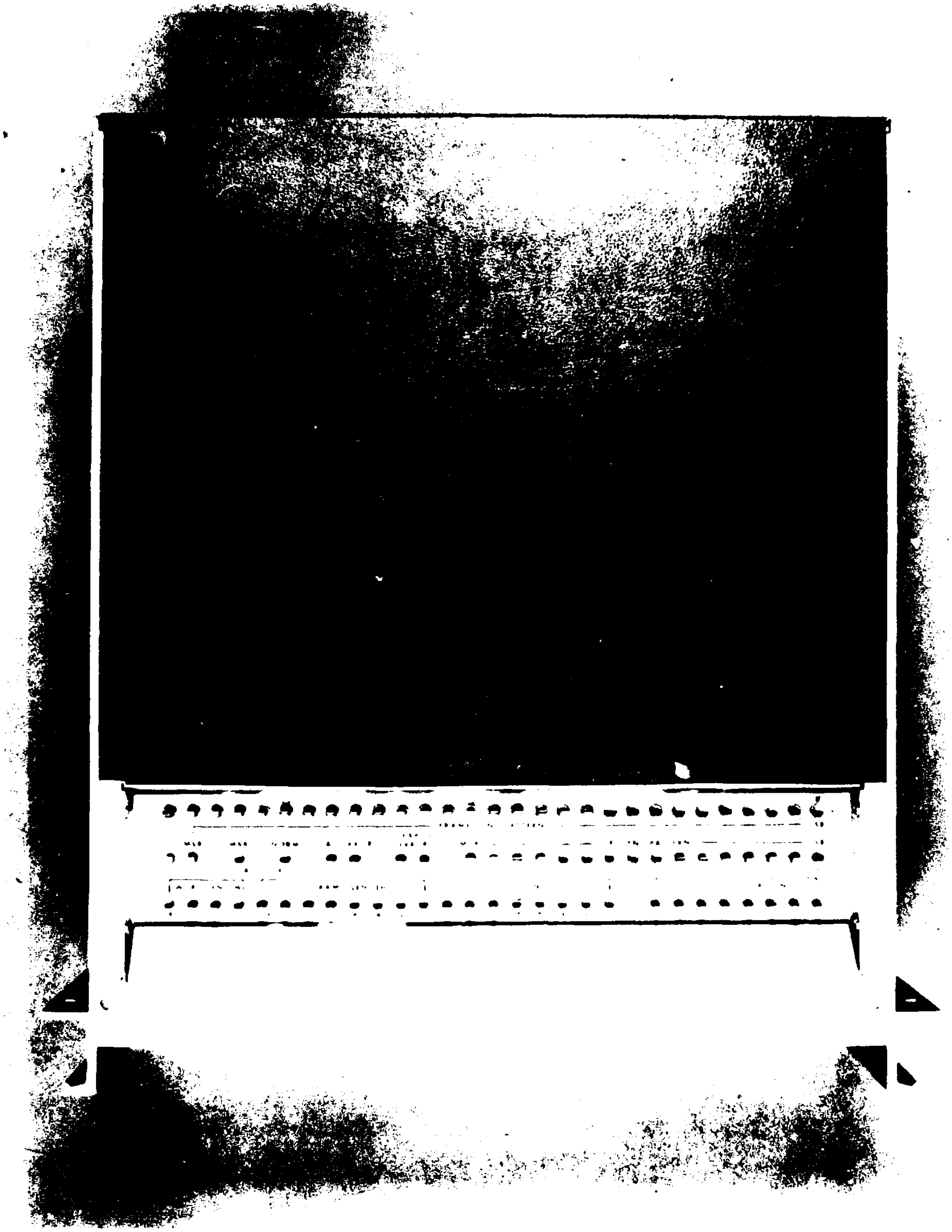

Figure 3. Top View of PCM Decom Model 82A

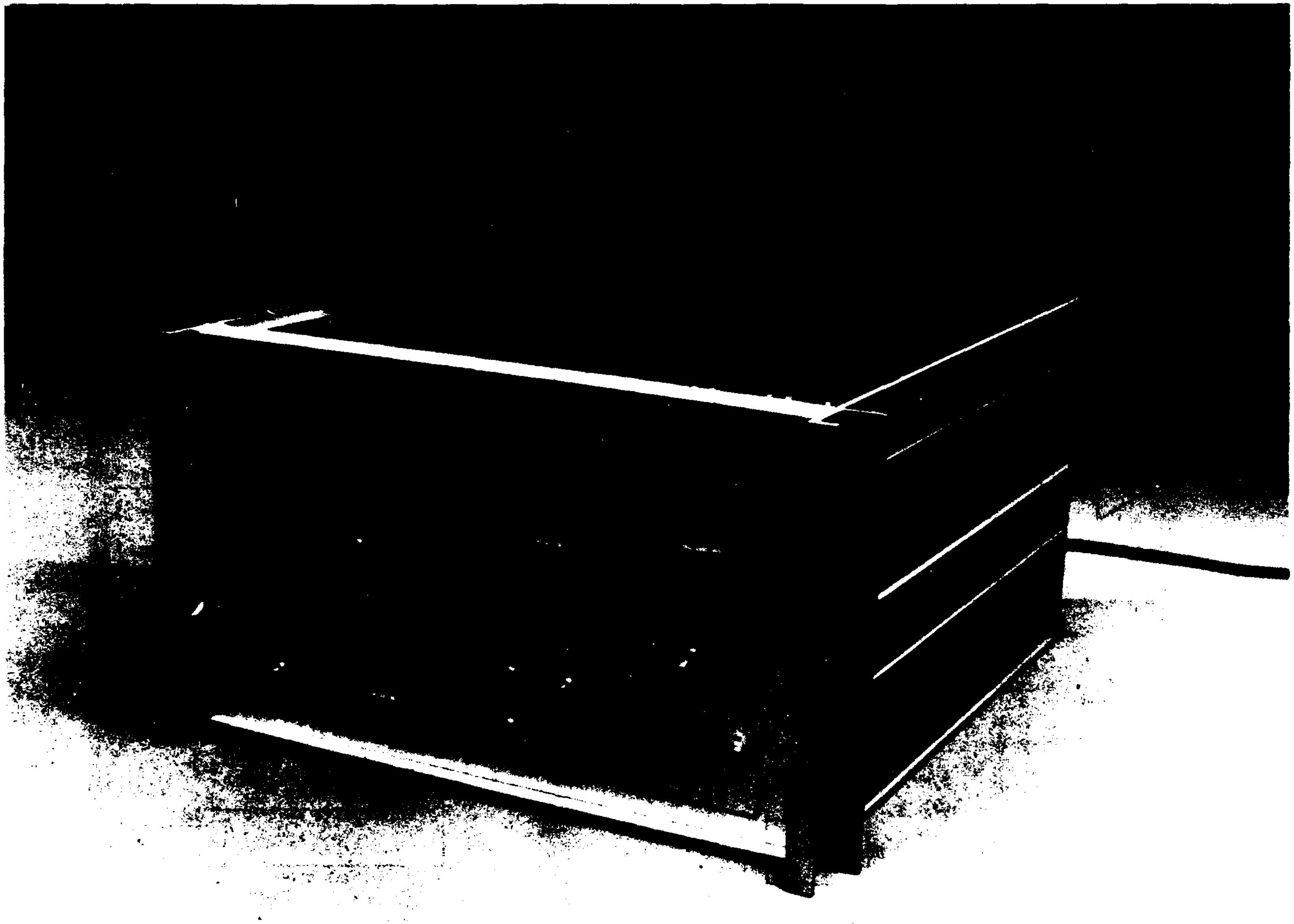

Figure 4. Oblique View of PCM Decom Model 82A

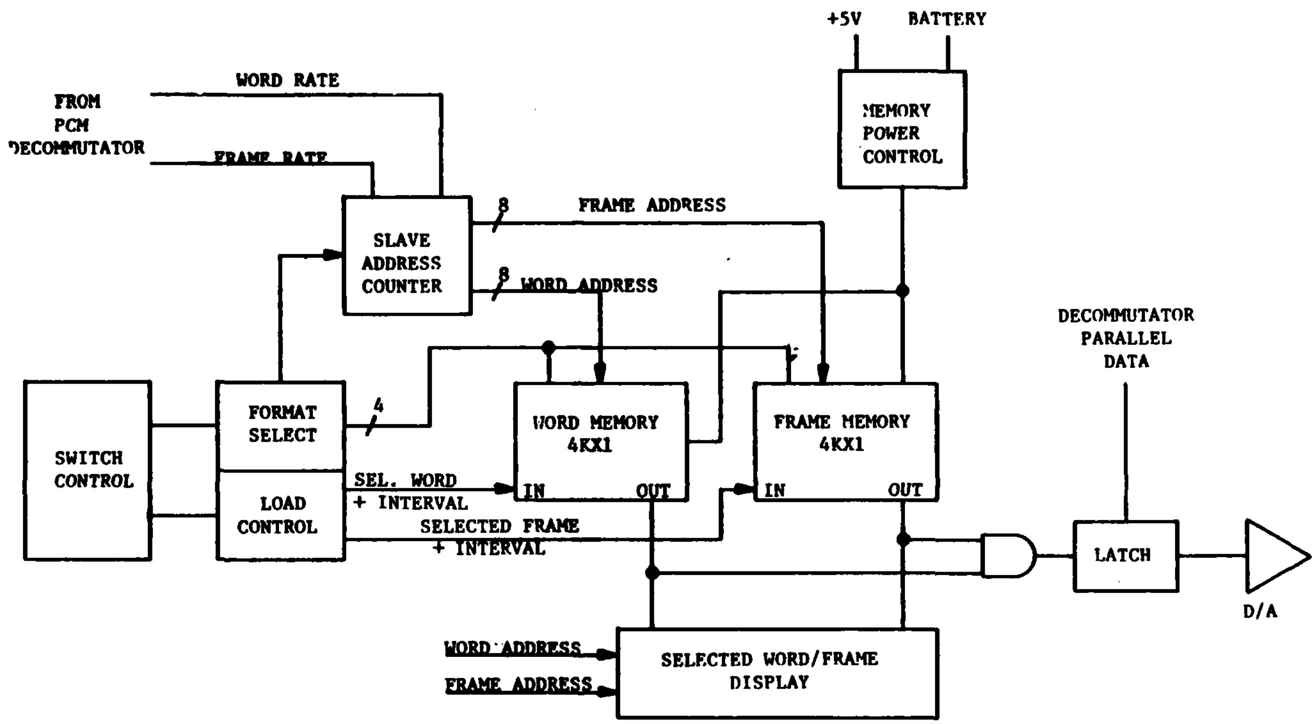

Figure 5. Non-Volatile Memory and D/A Converter Subsystem

Referring to Figure 1, the tunable bit synchronizer provides clocks and data to the format synchronizer. The format synchronizer controls the D/A subsystem which supplies analog data output. The Load and Display cards are used to program the D/A subsystem and display whatever is programmed. The bit sync, the load, the calibration and display, and format synchronizer are each contained on one card. The D/A subsystem consists of two cards of memory and two cards of D/A converters.

The memory power control circuit switches the memories to back up battery power when prime AC power is removed. A low power comparator senses falling +5V and inhibits any write operation to prevent corrupting the memory contents during transient power conditions. The battery is trickle charged when the system is energized.

V. OPERATING CHARACTERISTICS AND TEST RESULTS

An evaluation unit or prototype of the non-volatile, programmable digital to analog converter subsystem was designed, fabricated and tested successfully. The subsystem was incorporated into an existing PCM decommutator design and implemented as a new, complete PCM decommutator unit. Tests have shown that the battery is capable of holding memory contents for over 30 days without prime power. After testing, the unit was used at the Vehicle Assembly Building (VAB) telemetry ground station, WSMR, on the Air Force Astrobee - "F" rocket, number A31.200, launched on 1 March 1983, and on the Air Force Aerobee 170 rocket, number A04.902, launched on 19 April 1983. The unit was also used and tested on a number of NASA sounding rockets. The unit operated successfully.

VI. CONCLUSION

The use of sixteen recallable formats, each with thirty-two D/A outputs, has proven to be fast and reliable. The availability of the PCM Decom Model 82A has increased versatility enormously, and the unit will interface with all of the sounding rocket PCM encoder formats currently in use. The PCM Decom Model 82A containing the programmable D/A converter subsystem with a non-volatile memory will enhance considerably the ability to provide analog strip-chart records on future sounding rocket missions.

APPENDIX A

LIST OF ABBREVIATIONS

AC	-	Alternating Current
CMOS	-	Complementary Metal Oxide Semiconductor
D/A	-	Digital to Analog
EEPROMS	-	Electrically Erasable Programmable Read-Only Memory
FM	-	Frequency Modulation
NASA	-	National Aeronautics and Space Administration
PAM	-	Pulse-Amplitude Modulation
PCM	-	Pulse-Code Modification
PPM	-	Pulse-Position Modulation
PSL	-	Physical Science Laboratory
RAM	-	Random Access Memory
VAB	-	Vehicle Assembly Building
WSMR	-	White Sands Missile Range

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