BUBBLE MEMORY INSTRUMENTATION PACKAGE REPLACES DATA LINK IN PARACHUTE TEST SYSTEM AT NWC

James L. Rieger
engineer / PTBW
Naval Weapons Center
China Lake, California

ABSTRACT

A bubble-memory recorder for data taken from a parachute-measurement system is used to replace UHF telemetry using FM subcarriers. Significant savings in manpower for the test results, along with greater data quality and simpler, more repeatable data playback. New devices and a ground-based playback decommutator provide greater utility and normally end the requirement for a ground station.

INTRODUCTION

Parachute test systems are used to measure various characteristics of equipment and biomedical data for analysis. The “payload” for the parachute system may be a dummy or a live jumper. In the past, data measured was fed into FM subcarriers and the combination transmitted to the ground on L-Band (1435-1535 MHz) telemetry, and recorded for later playback and analysis. To accomplish this, a test range with appropriate receivers, antennas, and recorders was required, as was appropriate frequency coordination and clearance for the telemetry channels used. Transmitter power is limited by size and the approximate 20% efficiency of present UHF transmitters, causing weight (mainly for batteries) and heat-sinking limitations. The low transmitter power thus possible in such a package and the difficulty of providing a proper antenna mount--much less gain--requires ground-station antenna gain and thus the mechanical tracking of the parachute package from the air to the ground, a difficulty complicated both by the fact that the signal is not normally present until the parachute package has been ejected from the aircraft, and because of ground clutter and obstructions when it lands. When the National Parachute Test Range (NPTR) was transferred from El Centro to China Lake, California, the parachute group lost some telemetry receiving capability, and the combination of frequency scheduling and receiving facility availability further exacerbated the problem. Replacing the telemetry link with on-board magnetic tape presented the usual “Moving parts” problem, and would require either multi-track recording or a single track with multiplexed data at speeds which would dictate the use of open-reel tape, a type of

machine rarely characterized as “small.” The use of a bubble-memory recorder and digital PCM in the present package thus overcomes quite a variety of problems, and except for capacity does not appear to create any new ones.

BUBBLE MEMORY CHARACTERISTICS

Bubble memories are effectively solid-state tape transports, with internal tape loops in the form of magnetic loops circulated by coils driven in quadrature. While the loops are circulating, they may be written into or nondestructively read. If the coils and power supplies to the bubble are powered down in a specific order, the recording remains and can be recovered if power is again reapplied in a specific order. The support circuitry, much larger than the bubble memory itself, provides these functions even if external power to the support circuit is terminated abruptly, and also provides an address counter to locate the designated “start” position as it travels around the loops.

A bubble memory has a definite capacity, and loads data serially into the loops within. Since a chip as large and complex as the bubble memory is seldom perfect, more loops are present within the chip than are actually used, and several of the loops are used to store addresses of good loops and to direct data to them. These loops are programmed with the address information at the factory, but the data within them is also provided should it be accidentally erased, in which case they must be reloaded by a somewhat tedious process. A microprocessor and external buffer storage are used within the bubble memory recorder package to direct this activity and to allow loading at a constant rate as various delays occur within the actual recording circuit, thus the internal workings appear transparent to the input and output of the system.

As a consequence of the uneven loading rates, the bubble memory cannot be loaded evenly at quite the rate the bubble’s manufacturer advertises, but a rate of 40 KHz, sufficient for the parachute system requirements, is easily accomodated. Speed is further limited by formatting overhead in the bubble support system, and by the analog-to-digital conversion scheme used. With the 40 Kbit/second rate, a recording of 2045 pages of 68 bytes/page and 8 bits/byte has a duration of nearly 28 seconds is possible. As seen from the outside, the bubble memory could be made to function like a tape loop, recording over the oldest material as the loop comes around again, and could be started and stopped at any point, but to do so would add a certain amount of confusion in most normal uses, so the starting point for any recording (or playback) is taken at the same location--address zero--and the recording or playback runs through the memory completely exactly once, as if it were an open reel tape. Since it is a loop, however, no rewind function is needed, and the zero position is always acquired by rolling the recording forward, sort of like an eight-track tape.

THE SYSTEM PACKAGE

The parachute recording package, built by Eon Instrumentation in Van Nuys, adds the functions of analog multiplexer (24 differential low-level, 4 differential high-level), analog-to-digital converter, digital formatter (which adds sync, frame count, and eight discrete digital signals). The multiplexer output is available without the bubble memory engaged, so that a continuous multiplex signal can be used for calibrations. The system can operate in three modes: the aforementioned multiplexer-only mode, and modes corresponding to "record" and "playback". When 28 volt DC power is applied, the system goes through a self-test sequence, and then indicates that it is ready to continue. After the self-test is complete, the multiplexer starts to deliver its output if continuous mode is selected. If record mode is selected, and after self-test is completed, a trigger starts the recording process which continues until the bubble is full, after which time the output halts. For playback, the output plays the contents of the memory immediately after self-test and halts at the end of the recording. Playback of the contents of the memory can be made as many times as desired, even though power has not been continuously applied to the unit (which makes recordings of parachute events possible in the first place). The data output from the package is a standard NRZ-L PCM signal for demultiplexing on a standard ground station decommutator, and an additional multi-pin output connector is provided for use with the companion bubble memory ground unit. If the system is stopped partway through a playback by power failure (which might occur by accident), the recording is again played from the beginning after initialization when power is reapplied. If stopped partway through a recording, the portions of the recording made before the power failure is preserved. A record interlock plug is available to prevent accidental recording when recording is not desired.

The selector for continuous conversion, read, and write, plus a reset function which causes the self-test to be performed at a time other than power-on or the end of another function is plugged into the airborne system for ground use only. These functions are not required when the package is in the air, since the only function desired is the recording function. Switching the selector to record position does not start the recording, but allows for a trigger to cause the recording to commence. This record trigger is provided by a ripcord switch in the parachute test system.

GROUND UNIT

As versatile as the system is, however, a companion unit provides a number of additional conveniences that the airborne unit does not. The ground unit, also manufactured by Eon Instrumentation and called their BUB-101A, operates on 120 volts AC and can be used to provide 28 volts DC to the airborne unit. The ground unit also contains a bubble memory, so the contents of the airborne (or air-dropped, in this case) unit can be loaded

nondestructively into it. The ground unit has a four-channel analog multiplex output, so analog reconstructions of the original signals can be provided four at a time for analysis, and a microcomputer-operated thermal printer can provide a running printout of data on a single channel or for the entire frame. Figures can be expressed in percentage of full scale, or in binary count from zero to 255. For playbacks, the printer displays the start time of the display, so the printer can provide data as a function of time. Through the keyboard interface, the desired start time is entered, and the printer proceeds to print the next 68 (twice 34, also the number of words in a frame) data points. For calibrations, the printer provides direct hard copy. The bubble memory itself is on a removeable card, so data recordings may be saved by changing cards if desired. Like the airborne unit, the ground unit provides a serial NRZ pulse train for use with an external decommutator.

ASSOCIATED SAVINGS

The bubble memory package provides considerable savings in time and manpower as well as data quality as good as the best signals RF could provide. System calibration also requires no radio frequency use and thus no coordination, and is greatly simplified by the use of PCM and the printer on the ground unit. The preflight checkout on the runway is usually eliminated entirely, but can be provided if requested again without use of RF. The parachute group still operates a spin tower facility at El Centro, which no longer requires a truckfull of equipment and telemetry operators. Since most data playbacks can be done without the aid of a ground station, scheduling is greatly simplified. Due to the "robustness" of the recording, tape copies of any test can be made at any time from the bubble recording without degradation. Transmitters and antennas require considerably more attention than does the bubble package, as would a tape medium. While the potential of an incomplete recording resulting from a power interruption is a possibility, it has never been observed, and the consequences of power interruption with RF or tape would be as bad or worse.

FUTURE SYSTEMS

The future of bubble memory recording for instrumentation is encouraging, even though bubble memories are not exactly designed for this purpose, even given the bailout of Texas Instruments and National Semiconductor from the bubble business. The unit described here uses an Intel memory, for which second sources are anticipated. A four-megabit chip is forthcoming, which will quadruple the capacity of the present system with minor modifications. Parallel recording on multiple memories will allow recording entire words at the same rate that individual bits are now recorded, thus increasing apparent bit rate, as would be a necessity for most instrumentation uses. The output of such a system may be provided in serial mode as traditionally done, or fed into whatever device is used for processing and display as a parallel word. A bubble recording can be used as a backup to

transmitted data on missile flights whose shot geometry might preclude telemetry reception at points along the flight, or if the missile is, for example, underwater at the beginning and/or end of the flight and thus incapable of transmitting a useful signal. Finally, on-board recording is a perfect security device, since data not radiated cannot be intercepted. While bubble recorders are larger than telemetry transmitters, they draw somewhat less power. It can be safely concluded that bubble-memory data recorders will be more common in the future.