Evaluation of a Flutter Compensator for DSN Predetection Recording

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Results of evaluation tests conducted on an R&D model digital flutter compensator designed to reduce the effects of flutter, or time base error, in an instrumentation-quality magnetic tape recorder/reproducer are presented and discussed. These tests were conducted using machines exhibiting a wide range of transport servo stability in an effort to determine the effectiveness of the flutter compensator as a machine-independent device. The flutter compensation technique is potentially useful in the DSN for improving the reproduce capability of the pre/post detection recording subsystem.

I. Introduction

Tests have previously been conducted to determine the decrease in data degradation using a digital flutter compensator to reduce the effects of flutter, or time base error, in the process of recording and reproducing telemetry baseband data on existing record/reproduce machines in the pre/post detection recording subsystem. References 1 and 2 show that the flutter compensator consistently experienced buffer overflow, and Ref. 1 states that an increased buffer length would eliminate this problem. This article will discuss an evaluation of a later model R&D flutter compensator with a larger buffer length (16K by 6 bits vs 1K by 6 bits).

II. Objective

The purpose of evaluating the expanded buffer flutter compensator was to determine whether the previously experienced overflow problem has been conquered and to ascertain its capability of reducing the effects of transport servo time base error and dynamic skew. In addition, the desirability of formal implementation into the DSN was studied.

III. Test Configuration

Figure 1 is a block diagram of the expanded buffer R&D model flutter compensator. The circuit is operationally the same as that discussed in Ref. 1, where the circuit and its operation are described; therefore, it will not be repeated here. Figure 2 is a block diagram depicting the record and reproduce test configuration used to acquire the data reported here. The filters F1 through F3, shown in Fig. 2, would be essential and integral elements of a prototype flutter compensator. Since these were not included in the R&D model design, commercial electronic filters were used for this evaluation. And since the transfer function of the device is heavily dependent on the filter characteristics (e.g., phase linearity, harmonic distortion, and amplitude linearity), the scope of this evaluation was limited to determining its capability to correct time base error only; i.e., data degradation attributable to the compensator was not measured.

The two-channel strip chart recorder was used to monitor the behavior of the flutter compensator only: one channel recorded the position of the data in the buffer and the other channel recorded phase shift between input and output data. These data were recorded to observe malfunctions in the flutter compensator: buffer underflow/overflow, as previously reported, and incremental phase shift, which was observed while conducting evaluation tests. The data compiled in Table 1 are time base error plus dynamic skew, measured in accordance with IRIG Document 118-73.

IV. Discussion of Test Results

Considerable difficulty was encountered in obtaining observation repeatability for the data listed in Table 1. Access to the recorders/reproducers used to conduct the tests had to be on a non-interference as-available basis, and in some instances the machine's condition was altered between tests because of intervening usage by the prime user. In addition, the R&D model flutter compensator's erratic performance (primarily incremental phase shift) appeared to change as a function of its environment (e.g., ambient electromagnetic noise and temperature). Therefore, the data reported in Table 1 should be interpreted as an indication of the magnitude of performance improvement that the flutter compensator could be expected to provide over the range of machine servo stability listed. Nevertheless, the test results indicate that the flutter compensation technique significantly reduces the inherent flutter, or time base error, and dynamic skew associated with an instrumentation-quality record/reproduce machine.

Buffer overflow was experienced with the FR1400 and FR1900 machines. The nature of overflow with the FR1400 was random but persistent. Figure 3 is an extreme sample of data indicating the nature of the overflow and the incremental phase shift phenomena. This later problem was observed in all tests conducted. Overflow on the FR1900 occurred only once; however, the strip chart recorder data indicate that it would have occurred consistently given a longer test time. (The FR1900 was available for only 1 day, so more extensive tests were precluded.)

V. Conclusions

The results of tests reported in this article indicate that the flutter compensation technique will reduce the effects of flutter, or time base error, in a record/reproduce machine. However, as can be seen from an analysis of Table 1, the technique produces diminishing marginal returns as a direct function of machine quality. A significant disadvantage of the technique as presently implemented is the loss of bandwidth. In the existing design, the synchronization signal is recorded at the recorder upper bandedge on the same track as the data; therefore, the data and synchronization signal must be interspaced in frequency by at least 1/2 to 1 octave so that they can be separated upon playback without excessive filtering requirements. As a result, 1/3 to 1/2 of the available data bandwidth is sacrificed to the synchronization signal. Any future design effort should consider a more optimal synchronization signal frequency to reduce this loss of bandwidth.

In addition, the buffer overflow/underflow problem remains to be corrected. Reference 3 documents a successful demonstration of an R&D model flutter compensator. The authors of Ref. 3 state that "...the difference between the average writing rate and the average reading rate would inevitably cause the delay line buffer to either overflow or underflow, depending on the direction of the frequency offset." These writers conclude that a long-term read/write clock rate difference correction is mandatory. The flutter compensator developed at JPL does not contain a circuit to accomplish this.

References

1. Slekys, A. G., "Implementation of a Flutter Compensator for DSN Predetection Recording," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. XVI, pp. 132–139, Jet Propulsion Laboratory, Pasadena, Calif., August 15, 1973.

2. Slekys, A. G., "Open-Loop Receiver/Predetection Recording System for the DSN," in *The Deep Space Network Progress Report 42-20*, pp. 139–148, Jet Propulsion Laboratory, Pasadena, Calif., April 15, 1974.

3. Klein, M. S. and Tomback, S., "Digital Time-Base Error Compensator for Wideband Telemetry Recorder/Reproducers," International Telemetering Conference Proceedings, Washington, D. C., pp. 523–531, September 1969.

Table 1. Evaluation data

Tape speed, cm/s	Ampex FR1400			Ampex FR1900			Bell & Howell VR3700B			Ampex FR2000A		
	In	Out	In/Out	In	Out	In/Out	In	Out	In/Out	In	Out	In/Out
304.8	15	0.20	75	1.5	0.15	10	1.0	0.25	4.0	0.55	0.20	2.8
152.4	15	0.25	60	2.5	0.30	8.3	1.0	0.40	2.5	0.80	0.25	3.2
76.2	50	1.5	33	4.5	1.4	3.2	1.5	1.0	1.5	1.25	0.50	2.5
38.1	150	5.0	30	6.5	1.5	4.3	2.7	2.0	1.4	2.5	0.80	3.1

Notes: 1. The column labeled "In" is the signal at DATA IN and the column labeled "Out" is the signal at DATA OUT shown in Fig. 2.
2. The In and Out numbers are in microseconds.
3. The In and Out numbers are time base error plus dynamic skew measured in accordance with IRIG 118-73.

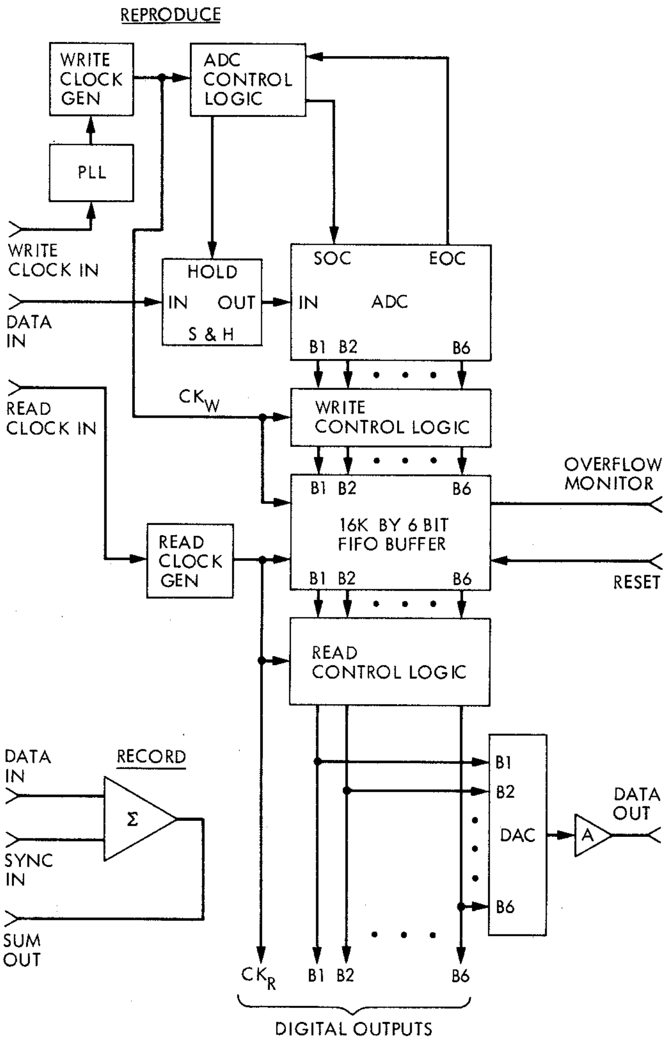

Fig. 1. Block diagram of R&D model flutter compensator

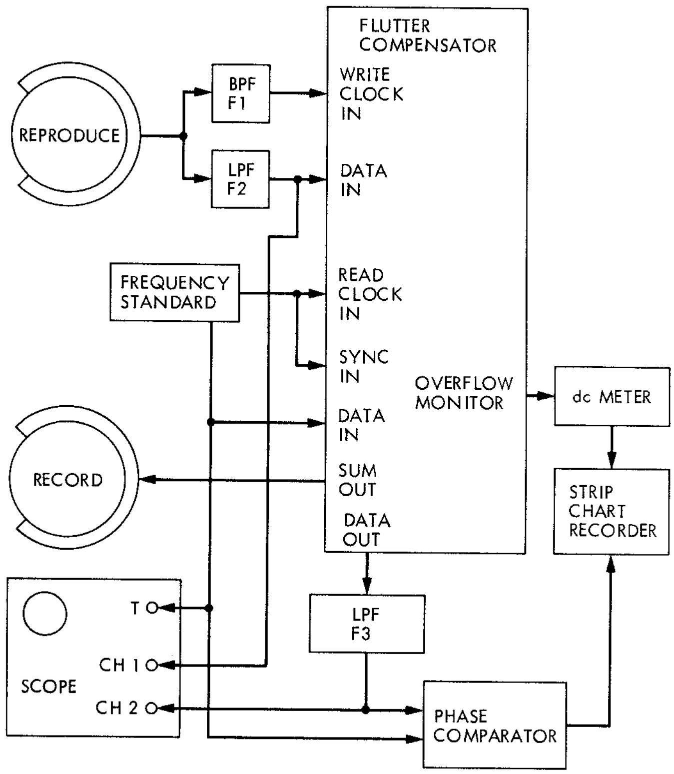

Fig. 2. Block diagram of flutter compensator test configuration

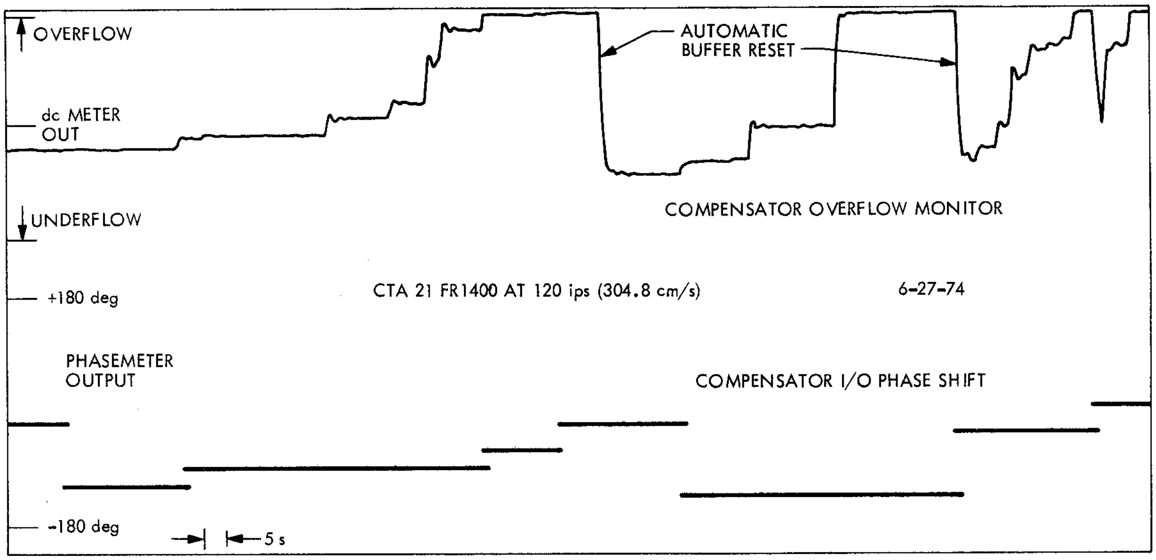

Fig. 3. Sample of compensator behavior