Implementation of New-Generation Recorders/Reproducers Into the DSN

G. B. Hamilton
DSN Data Systems Section

New-generation recorder/reproducers are being installed in the Pre/Post-Detection Recording Subsystem at DSSs 14 (Goldstone), 43 (Australia), 63 (Spain), and the JPL Compatibility Test Area CTA 21. The performance of these new-generation machines is discussed, and representative corroborating data acquired at CTA 21 are presented.

I. Introduction

New-generation high-performance instrumentation recorder/reproducers have been introduced into the Pre/Post-Detection Recording Subsystem (PPR) in the DSN. The PPR has been committed to recovery or playback of baseband data recordings with a maximum degradation of 2 dB at encounter signal-to-noise ratios. Use of the new-generation recorders enables the PPR to meet this commitment. This report will discuss the results of performance tests that have been conducted on these machines at CTA 21. Conclusions from results of these tests will be discussed.

II. Objective

The purpose of performing these evaluation tests was twofold: first, a recording and playback procedure for baseband data was developed and proven; second, limits of baseband data recovery and degradation were established. The design review for the PPR produced a commitment to recover baseband data down to telemetry threshold (-5 dB ST_S/N_0) with 2 dB degradation. This means that the actual playback telemetry threshold is -3 dB ST_S/N_0. Thus if the real-time normal path data SNR were at threshold and it was required to insure playback recovery, it would be necessary to decrease the data rate to allow for degradation loss. It becomes important, therefore, for this reason alone, to seek ways to predict and minimize degradation losses due to the entire playback process.

At the present time, data are recorded on the DSS FR 1400s and recovered, when necessary, on a new-generation recorder. A large time base error on the FR 1400s precludes their use as playback machines. A large dynamic skew from the FR 1400 recording inherent in these tapes, even when played back on a newer recorder, contributes to a 2-dB or greater degradation. Procurement is in process for additional new-generation recorders at 64-m stations to replace the FR 1400s. These will minimize time base error and dynamic skew at the 64-m stations.

III. Test Configuration

Figure 1 is a block diagram showing the record and reproduce configuration used to acquire the data and support the conclusions reported here. Baseband data were recorded in the direct record mode on a track adjacent (within the same head stack) to a servo control signal track. This proximity minimizes dynamic skew. Signal levels, telemetry channel settings, and the record/reproduce procedure used are derived and presented in the report by John Molinder in this issue of the Progress Report. When recovering data, it is essential that the servo control signal be used to obtain recorder servo lock in order to minimize time base error or jitter of the data.

IV. Test Results

Tests indicate that under laboratory conditions, degradation on the order of 1 dB or less can be obtained if the 3rd harmonic of the subcarrier plus data can be accommodated within the bandwidth of the recorder. This is subject to the restriction that the components of the subcarrier plus data signal fall upon a linear portion of the phase response curve of the recorder system being used. In practice, this means that performance at a new subcarrier and data rate is difficult to predict and should be tested at various tape speeds. It may well be, and has happened, that less degradation results from discarding the 3rd harmonic by limiting tape speed than by including it in an out-of-phase condition.

Other factors involved which may preclude the direct transfer of laboratory results to DSN use should be mentioned. In addition to losses suffered due to bandwidth limitations are those due to skew and time base error of the recorder. For this discussion, these may be assumed to be interchangeable and cumulative. Tests have been conducted showing that as dynamic skew is increased, degradation increases until finally loss of lock occurs. Such a small matter as removing the tape from the recording machine and replacing it for reproduction, or reproducing the tape on a second machine, increases time base error and skew. In general, it would seem that phase error also must be affected by reproducing on another machine. As a practical matter, removal and replacement of tape is unavoidable in DSN use. On new-generation tape recorders, cleanliness of the tape path, especially the vacuum chamber, affects the skew and time base error directly.

During testing, using essentially the same type of tape, it was observed that a reel of tape failed to lock up the system. No visible defect was noted. As a last resort, a different reel of tape was used and lockup achieved. This is mentioned to stress the necessity of good tape as a prerequisite for successful recovery of data.

Reliance is placed upon the one-to-one correspondence of machines when recording and reproducing in the direct record mode. (FM recording is impractical because of bandwidth and tape speed limitations.) A standard calibration of the tape recorders is specified and agreed upon as a baseline such that signals recorded on one machine, when reproduced on another machine, agree in amplitude and wave shape. This uniform calibration is important to baseband recovery in the DSN. Representative laboratory results of data recovery are given in Table 1. More extensive tables are presented in John Molinder's article.

V. Conclusions

Results of tests at CTA 21 and actual data recovery in the DSS indicate that the commitment of a maximum degradation of 2 dB on encounter-level baseband recovery can be met using new-generation recorders at a reasonable tape speed. Constraints are the requirements for good maintenance, including receiver phasing, tape path cleaning, and recorder calibration, and the necessity for good tape and strict adherence to record/reproduce procedures. It is expected that, with further practice, more confidence, and more convenient and uniform calibration of the recorders, the 2-dB degradation figure may be improved.

Table 1. Representative baseband recovery data

Subcarrier, kHz	Data (coding)	Tape speed and bandwidth	SNR (ST_B/N_0 or $ST_S\ N_0$), dB		Degradation,[a] dB	Comments
			Direct	Playback		
360	16 kb/s (32,6)	60 i/s, 1 MHz	4.35	4.05	0.03	
240	16 kb/s (32,6)	60 i/s, 1 MHz	2.9	2.45	0.45	
240	16 kb/s (32,6)	30 i/s, 500 kHz	5	3.45	1.55	Bandwidth limited.
24	33-1/3 b/s (UC)	15 i/s, 250 kHz	6.75	5.85	0.9	Strong signal and increasing skew.

[a]The path chosen for comparison or "direct" includes the SDA up converter, so the degradation contributed by it (normally about 0.5 dB) is chargeable to the recovery process and should be added to the above playback degradation in order to arrive at an estimate of the degradation compared to the normal real-time telemetry SNR.

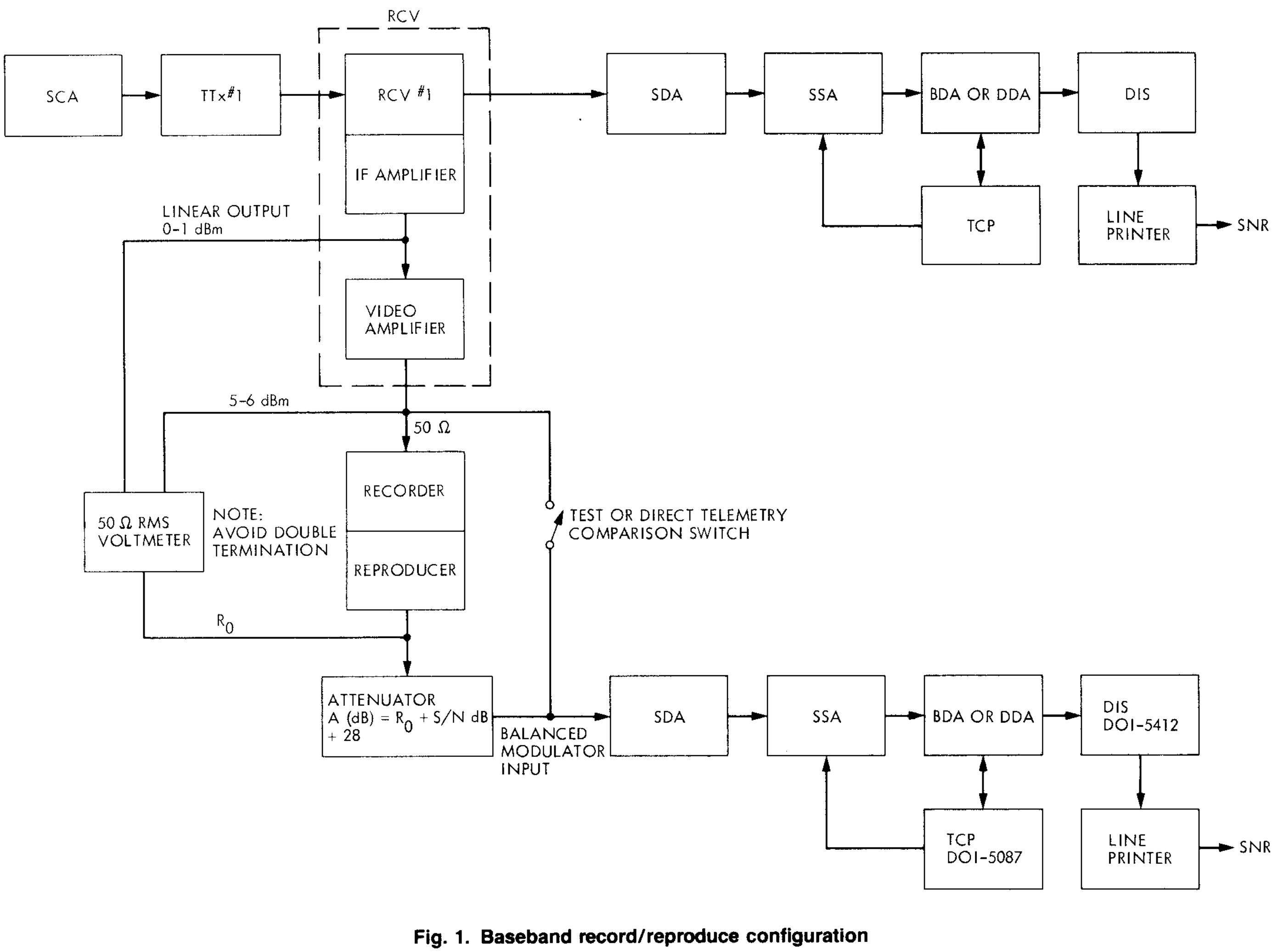

Fig. 1. Baseband record/reproduce configuration