FEASIBILITY MODEL OF A VIDEO INSTRUMENTATION RECORD/REPRODUCE SYSTEM

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Instrumentation video record/reproduce systems will be required for STADAN, ERTS, and Goddard Space Flight Center data processing facilities in the early 1970's. We began our program early in 1968 by conducting parallel feasibility studies to determine the system configuration that satisfied specific performance requirements. Two companies, RCA and Ampex, both competent in video record/reproducers, were given study contracts, and the better approach, by Ampex, was chosen for a prototype video record/reproduce system. Performance evaluation with this unit will serve as a basis for specifying production-type machines to satisfy both STADAN requirements and the new requirements coming from the ERTS project. These machines will require improvements in frequency response, high data rate PCM, multispeed capability, time displacement error, tape utilization, bit error rates, and reliability (Table 1). First, to obtain perspective, let us look at the Ampex FR-600. This is not intended as a one-to-one comparison, but the FR-600 is used because many people are familiar with this machine. The Ampex FR-600 series recorders used in STADAN have 0.6-MHz frequency response. The FR-2100 offers more than a ten-to-one improvement over the FR-600. This also applies to most of the other parameters listed in Table 1.

The design goals set in 1968 for frequency response were dc to 10 MHz with a 6-MHz minimum. The frequency response obtained in the Ampex FR-2100, on the other hand, was dc to 10 MHz and dc to 10 MHz/32 for a second speed. The PCM digital performance design goals were 14 Mbit/s with 11 Mbit/s minimum. Those obtained were 16 Mbit/s. Tests were conducted to 20 Mbit/s. This was achieved by using the 10-MHz bandwidth and Miller code PCM. For multispeed, two speeds were required. Those obtained were a longitudinal speeds of 38.1 cm/s (15 ips) and 1.19 cm/s (0.47 ips) and scanning speeds (rotating head) of 50.3 m/s (1980 ips) and 1.57 m/s (61.9 ips).

The design goal for time displacement error (TDE) was 25 ns minimum; less than 15 ns was obtained. Tape utilization (packing) of 116 kbit/cm^2 (750 kbit/in.^{2}) was the design goal; 85.3 kbit/cm^2 (9550 kbit/in.^{2} was obtained. A bit error rate of 1 error in 10^5 was the design goal. Presently it is estimated to be 1 error in 10^6 or an improvement by a factor of 10 over the design goal. Dual gap head assemblies were desired for improved reliability. Redundant recording eliminates tape dropouts. Manufacturing technology limits this development at this time, and dual gap heads were not incorporated in the FR-2100.

Figure 1 shows a picture of the developmental model, the FR-2100, scheduled for delivery in January 1971. In the lower left of the figure, a swept frequency response of the system is shown. The top curve is for the reproduce mode. The bottom curve shows a bipass of the tape, utilizing electronics only, that illustrates the near transparency of the tape medium. The picture on the right demonstrates a PCM non-return-to-zero at 16 Mbit/s from both off tape and electronics-to-electronics. The future plans for this system involve (1) verification of all performance parameters upon receipt of the equipment, (2) determination of the full capabilities of the digital system such as multilevel coding, and (3) determination of the reliability and head life characteristics.

In the development of such a system, one must continually look at other devices and sources to determine the present-day state of the art. This system has been five years in development, and other independent gains have been made. Some present-day performances are illustrated in Table 2. The two nearest competitors would be the Newell model AV-1500R wideband longitudinal recorder and the RCA modified TR-70. The Newell recorder is capable of a 15-MHz frequency response. This response is obtained by high speed longitudinal recording. This approach has a maximum recording time of 80 s/pass, unsuitable for continuous type recordings. The RCA TR-70 has a full 10-MHz frequency response. This should offer good competition on any new procurements. The system has been demonstrated as a laboratory setup, and some additional work will be required for a production system. The PCM digital capabilities for the Newell system are 20 Mbit/s per channel operating at 2440 cm/s (960 ips). The capability of the RCA unit should be equal to the Ampex FR-2100.

For multispeed, the Newell is supplied with the 7-speed transport at 38.1 cm/s (15 ips) to 2440 cm/s (960 ips). The multispeed capability was

demonstrated by RCA on another system. The time displacement error on the Newell recorder is of the order of 3000 ns because this is a different type of recorder, not built specifically for low TDE. The performance of the RCA is not known.

For tape utilization, the Newell provides a packing density of 124 kbit/cm^2 (800 bit/in.^{2}). The RCA system should be equal to the FR-2100. For bit error rate, one error in 10^5 is estimated for the Newell system. The performance of the RCA machine has not been measured.

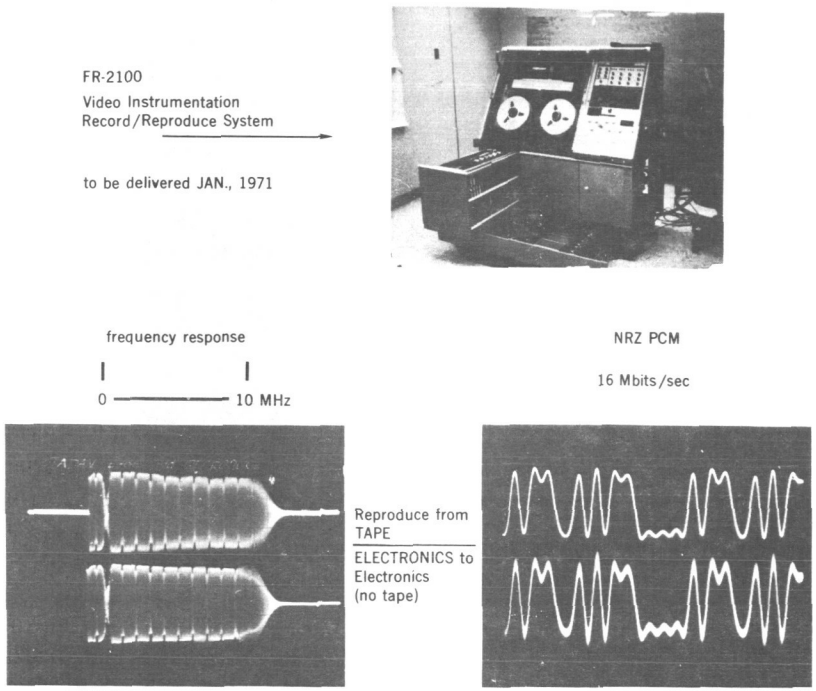

Figure 1

Table 1–Performance evaluation of AMPEX FR-2100.[1]

PERFORMANCE PARAMETERS	DESIGN GOALS 1968	AMPEX FR-2100, VIDEO INSTRUMENTATION RECORD/REPRODUCE SYSTEM PERFORMANCE. SEPT. 1970
a. Freq. response Analog	DC to 10MHz (6MHz-minimum)	DC-10MHz and DC-10MHz / 32 (2nd speed)
b. PCM Digital System performance	14 Mbits/s (11Mbits/s	16M bits/s - Test conducted to 20Mbits/s. This was achieved on the 10 MHz bandwidth using Miller Code - PCM.
c. Multi-speed	2 speeds required	Longitudinal speeds-38.1cm/s and 1.19cm/s(15ips and 0.47ips) Scanning speed(rotating head) 50.3 m/s (1980ips) and 1.57m/s (61.9ips)
d. Time Displacement Error (TDE)	25ns min.	Less than 15 ns
e. Tape utilization	116kbits/cm² (750 kbits/sq.in.)	85.3kbits/cm² (550 kbits/sq.in.)
f. Bit Error Rate	1 Error in 10^5	Estimated to be 1 error in 10^6. Improvement of 10.
g. Reliability	Dual gap heads	Redundant recording to eliminate tape drop outs. Mfg technology limits this develop't at this time.

note: PERSPECTIVE; Ampex FR-600 series recorders used in STADAN have 0.6 MHz freq. response. The FR-2100 offers more than a 10 to 1 improvement. This also applies to most other parameters.

Table 2–Performance evaluation of three present-day systems.

PERFORMANCE PARAMETERS	AMPEX FR-2100	NEWELL MODEL AVI500R		RCA MODIFIED TR-70	
a. Frequency Response	10 MHz	15 MHz	Excellent response has non continuous recording. 2,195m(7200') tape has 80s/pass recording time.	10 MHz	Good freq. response should offer competition on new procurements. System demonstrated as lab set-up. Some additional develop't req'd.
b. PCM Digital System	16Mbits/s	20 Mbits/s/channel at 2440cm/s(960ips)			Same as FR-2100
c. Multi-speed	2 speeds	7 speeds 38.10cm/s to 2440cm/s(15ips to 960ips)		No.	Capability was demon. on other system.
d. Time displacement error	Less than 15ns	3000 ns		?	
e. Tape utilization	85.3kbits/cm²(550 kbits/sq.in)	124 kbits/cm² (800kbits/sq.in.)			Same as FR-2100
f. Bit error rate	1 error in 10^6	1 error in 10^5	Not confirmed	?	