COMPUTERIZED TEST TECHNIQUES FOR INSTRUMENTATION MAGNETIC TAPE RECORDERS

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ABSTRACT

Since development of the initial system in 1980, the Western Space and Missile Center (WSMC) has been refining computerized test techniques for instrumentation magnetic tape recorder/reproducers. These tests include standard IRIG tests such as flutter, time base error (TBE), interchannel time displacement error (ITDE), harmonic distortion, frequency response and signal-to-noise ratio (SNR), as well as slot noise, crosstalk and intermodulation distortion (IMD). The test philosophy is to duplicate results that can be obtained manually, but at the same time greatly reduce test time and operator intervention. Such parameters as data sampling periods and number of samples have been refined to obtain maximum correlation and minimum test times. Also, a complete set of self-check and troubleshooting programs have been developed.

INTRODUCTION

The initial Automatic Recorder and Data Evaluation System (ARDES I) was developed in 1980 and described in a paper at ITC in 1981. The system automatically tests various types of instrumentation magnetic tape recorders using the recorder remote control input to control functions such as start, stop, record, reproduce and rewind. The system will also cue the operator to start, rewind, etc. for manual operation of the recorder. Figure 1 shows the system in the final configuration. An example of the data is in Figure 2. Test technique improvements have evolved in four major areas: (a) data computation, (b) valid data identification, (c) troubleshooting, and (d) test equipment characteristics.

DATA COMPUTATION

Prior to testing, the recorder is adjusted for 1 volt rms in and out, which is set to 0 dB level on the front panel meter. Originally, when a track was more than 6 dB below this level, the track was not tested and “no signal” was printed. The system was changed to print the exact signal level so the operator could determine if any discernible signal was present. This change in all tests results in a more exact understanding of the recorder's condition.

In the flutter test, the acceptable range of numbers (array) was expanded to minimize "no signal" printouts and give the operator a chance to examine the data.

Another area to consider in data computation is the speed at which the equipment can operate. When collecting sufficient samples, response times will have a major effect on total test time. This is particularly important when running automatic tests at the higher tape speeds of 120 ips and 240 ips.

For example, in the harmonic distortion test, 40 samples are taken at the fundamental, second and third harmonic levels. Each set of 40 samples takes approximately 400 milliseconds (10 milliseconds per sample). The time is determined by the spectrum analyzer response time, data transfer time and computer program execution time. Some additional time should be taken to allow for test equipment stabilizing. This is accomplished by taking twenty readings and discarding them, and then using the next 40 readings as a measurement.

In the case of TBE and ITDE, a frequency counter is used to measure the time interval. This is the same interval as displayed on oscilloscope for manual tests. In each case, 500 time intervals are read over a period of approximately 12 seconds. These time intervals are stored and statistically evaluated to yield the two sigma (95 percentile) measurement. IRIG specifies five percent of the readings on the oscilloscope are to be discarded, therefore, the oscilloscope reading and the ARDES readings will correlate.

VALID DATA IDENTIFICATION

Techniques used to control tape movement were changed to allow for variances from machine to machine. Different manufacturers recorders and even individual recorders of the same type exhibit variations in start, stop and fast rewind times, which can result in sampling data at the wrong times. Therefore, the signal level is now monitored during rewind in the case of crosstalk, rather than relying on timing techniques. In the case of ITDE and TBE, rewind is used instead of fast reverse for more precise data acquisition.

TROUBLESHOOTING

Maintenance software was developed to expedite fault analysis. The maintenance program allows relay closures for a selected period of time (30 second segments) to facilitate signal tracing. Tests (TBE and ITDE) can be repeated a selected number of times for correcting recorder faults and making adjustments.

A cable assembly was also made for looping the record and reproduce on the ARDES system. This cable, representing the tape recorder, facilitates checking record and reproduce system inputs, all relay contacts and test equipment interfaces.

TEST EQUIPMENT CHARACTERISTICS

Test equipment characteristics including input/output impedances, filters and response times were evaluated in order to obtain closer correlation with manual test techniques.

Input/output impedances of the test equipment should match. Mismatches will naturally result in incorrect signal levels and thus the data taken will be a misrepresentation of the true condition of the recorder. For example, in the ARDES I application, the signal source (an HP 3325A function generator) is terminated in 50 ohms, while the tape recorders are terminated in 75 ohms. Therefore, the amplitude must be adjusted to assure one volt rms into the tape recorder.

Filter selection effects the results when looking for signal levels close to the noise level such as in crosstalk and IMD. Filter widths should be carefully defined and compensation should be included in the software when needed.

In the ARDES I system, the HP 3330B automatic synthesizer and its associated HP 3571A tracking spectrum analyzer were previously used to measure SNR. Following the example of the HP applications note 206-1, a wideband SNR reading was taken. A 10 kHz bandwidth was used and properly spaced readings were taken across the frequency band of the recorder. The readings were converted to power, summed, and then converted back to dB. This technique is valid for pure white noise, but is not accurate for measuring the tape recorder noise floor. We now measure SNR with a digital voltmeter which yields wideband SNR. Data correlation is within ±0.3 dB checked against external manual equipment.

CONCLUSION

Computerized testing of instrumentation magnetic tape recorder/reproducers can significantly decrease test time while obtaining accurate, repeatable results. In order to obtain accurate and useful results, attention must be paid to the methods of data computation, identifying where the valid data is on the tape and test equipment characteristics. Inclusion of troubleshooting programs is also useful.

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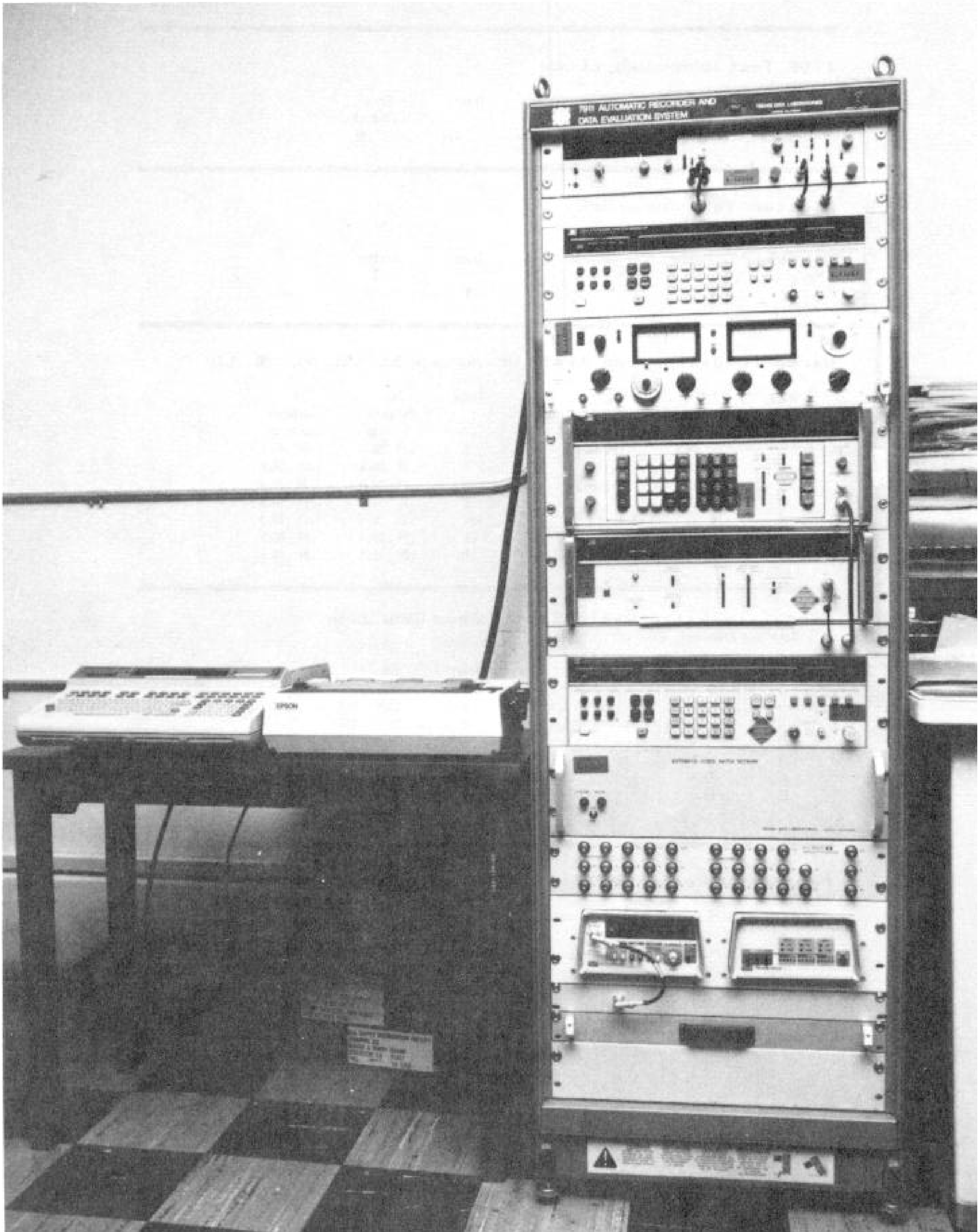

FIGURE 1

TEST RESULTS

TBE Test (Tolerance Limit: .5 usecs)

Track	Error [usecs]	Track	Error [usecs]
7	.10	8	.09

ITDE Test (Tolerance Limit: 1.6 usecs)

Tracks	Error [usecs]	Tracks	Error [usecs]
1 &13	.30	2 &14	.37

Flutter Test (Tolerance Limit: .11%)

Test Frequency: 200.000 KHz

Track	Flutter %	Track	Flutter %
7	.07	8	.09

Harmonic Distortion Test (Tolerance Limits: 2nd, .50%; 3rd, .75%, 1.5%)

Track	2nd Harmonic %	2nd Harmonic db	3rd Harmonic %	3rd Harmonic db	Track	2nd Harmonic %	2nd Harmonic db	3rd Harmonic %	3rd Harmonic db
1	.34	49.4	.98	40.2	2	.15	56.5	1.01	40.0
3	.44	47.0	.98	40.2	4	.19	54.4	1.01	39.9
5	.16	55.8	.96	40.4	6	.19	54.3	1.20	38.4
7	.23	52.9	.99	40.1	8	.15	56.7	1.14	38.8
9	.74	42.6 O/T	1.11	39.1	10	.16	56.0	1.12	39.0
11	.44	47.1	1.14	38.9	12	.24	52.4	.94	40.5
13	.63	44.0 O/T	1.23	38.2	14	.27	51.5	1.04	39.7

Signal-to-Noise Ratio Test (Tolerance Limits: 25.0 dB)

Reference Frequency: 200.0 KHz

Track	SNR	Track	SNR
1	24.7 O/T	2	24.6 O/T
3	25.9	4	23.9 O/T
5	26.7	6	23.6 O/T
7	27.4	8	24.2 O/T
9	26.4	10	24.9 O/T
11	26.4	12	23.3 O/T
13	28.0	14	26.4

Frequency Response Test (Tolerance Limits: 3.0 db;-4.0 db)

Fundamental Frequency: 200 Khz

Reference Level: 1 Vrms =0 dbV at Fundamental

Freq [KH]	Track 1 [db]	Track 2 [db]	Track 3 [db]	Track 4 [db]	Track 5 [db]	Track 6 [db]	Track 7 [db]
.4	4.1 O/T	.3	.7	.3	.9	.6	.6
.8	5.1 O/T	1.3	2.0	1.9	2.6	1.8	1.9
1.2	6.8 O/T	3.0	3.1 O/T	3.6 O/T	4.4 O/T	3.7 O/T	3.7 O/T
1.6	6.7 O/T	2.5	3.0	2.5	3.9 O/T	3.3 O/T	3.0
2.0	6.5 O/T	2.5	3.1 O/T	3.0	4.0 O/T	2.8	2.7
3.2	5.7 O/T	1.8	1.6	1.7	3.0	1.7	2.3
6.0	5.8 O/T	2.2	2.3	2.7	3.1 O/T	2.4	2.3
12.0	5.4 O/T	1.8	2.3	1.9	2.7	2.2	2.2
24.0	5.2 O/T	1.7	1.4	2.0	2.4	2.0	2.0
40.0	5.1 O/T	1.3	1.1	1.4	2.7	1.4	1.4
80.0	3.3 O/T	.6	.8	1.2	1.6	.5	.8
120.0	2.3	.3	.6	.4	.8	0.0	.5
240.0	-.2	0.0	.4	.2	0.0	-.1	.1
480.0	-3.4	-.1	.2	-1.5	-1.1	.1	-.3
960.0	-6.4 O/T	.7	1.0	-3.3	-1.8	.9	-.3
1200.0	-7.3 O/T	1.3	1.0	-3.6	-1.6	1.3	-.2
1500.0	-8.9 O/T	1.1	.3	-3.2	-1.6	1.0	0.0
1714.3	-7.9 O/T	0.0	.4	-1.5	-.6	2.1	1.8
2000.0	-12.1 O/T	-2.9	-4.2 O/T	-3.5	-4.8 O/T	-1.7	-2.2

FIGURE 2