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A MICROPROCESSOR-CONTROLLED DATA TEST SET : FACILITIES ASPECTS

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ABSTRACT

As part of an investigation into the performance of data links which may be used in the proposed Digital Data Network (DDN), tests are being conducted on selected intercapital data circuits. These are performed using a microprocessor-controlled data test set designed and constructed within Transmission Systems Branch.

This report considers the facilities aspects of the test set. It describes how the transmission parameters of interest are recorded. The collected information is subsequently analysed on the TACONET computer to yield the transmission performance of the tested data circuits. This can be then compared against the proposed DDN objectives. Other useful information, such as error behaviour characteristics is also obtained.

Hardware and software aspects of the data test set are described in a forthcoming report. (Ref ?)

1. INTRODUCTION

As part of an investigation into the performance of data links which may be used in the proposed Telecom Digital Data Network (DDN), tests were conducted on selected intercapital 48 kbit/s groupband data loops (Ref.1). From these measurements, it was found that the transmission quality of some microwave radio bearers is dependent on the prevailing weather conditions. Long-term measurements over some routes are therefore necessary to allow for seasonal weather patterns. Furthermore, it is desired to gauge the transmission performances of various data links and compare them with the DDN error and availability performance objectives. These are now being formulated. Long-term (12-month) objectives have been proposed. However, the short-term (15-minute) error performance objective is still to be defined.

The results reported in Ref. 1 were obtained from analysis of measurements made with specialised instrumentation designed and constructed within Transmission Systems Branch (Refs. 2 and 3). The instrumentation was specifically designed for the study of synchronisation, jitter and error performance of an experimental three-node synchronous digital data network.

As mentioned previously, the test results indicated that the error performance aspect requires additional studies. Furthermore, the DDN performance objectives have now been proposed. To fulfil these requirements, a fully automatic microprocessor-controlled data test set has been designed and constructed within Transmission Systems Branch. Improved data logging techniques have been adopted to allow certain new desirable transmission parameters to be monitored. In this report, only the facilities aspects of the data test set are described. Hardware and software aspects are discussed in a forthcoming Research Laboratories report (Ref. 4).

2. DDN PROPOSED PERFORMANCE OBJECTIVES

These objectives are being formulated by the DDN Working Party No. 1 - Data Transmission Performance Plan. To give the reader a preliminary view of the basic measuring requirements of the data test set, the proposals (yet to be confirmed) are reproduced in part in Appendix I. The desired transmission parameters to be measured are :

(a) Number of error-free seconds (EFS) within 15-minute intervals of a measurement period

(b) Total duration of 10 or more consecutive error-second events. In this report these are defined as error-second outages (ESO) or simply outages.

The above parameters are aimed at the short-term objective proposal from which long-term characteristics can be derived if measurements are conducted over a long enough period, preferably over many years.

3. MEASURING FACILITIES OF THE DATA TEST SET

3.1 Parameters Measured

Although the basic requirements are as listed in the previous section, the data test set measures the desired parameters in such a way as to provide some insight on bearer transmission characteristics. The following measurements are made :

(a) The frequency distribution of the bit error counts for each error-second within a 15-minute interval.

(b) The frequency distribution of error-free-second runs within the 15-minute interval above.

(c) The start and finish times (to the nearest millisecond) in real time of any modem detected carrier failures. In this report, these are also known as breaks.

(d) The start and finish times (to the nearest second) in real time of any events of 10 or more consecutive error-seconds (or error-second outages).

These are presently recorded on punched paper tape. The collected data is subsequently processed on the TACONET computer (see Section 4) and the measured performance characteristics can then be compared against the DDN proposals.

3.2 Description of Operation.

The test unit is designed to allow (with suitable interfaces) operation at all data rates up to 2.048 Mbit/s. A block diagram of the test arrangement is illustrated in Fig. 1. All measurements are performed in real time, with a clock driven by a high-stability oscillator providing time of day information. On-line monitoring of the recorded data is obtained with a visual display unit (VDU).

The data test set consists of independent transmit and receive stations.

The transmitter generates a 511-bit pseudo-random sequence driven from the internal clock of the modem transmit section. In the receive section of the test set, an error detector with automatic synchronisation checks for errors in the incoming data stream. Any errors detected increment an error counter. Under microprocessor control, each 15-minute measuring interval is quantised into 1-second intervals. At the end of each 1-second interval, the current content of the error counter is fed into the microprocessor and the counter is then reset to zero. For each 15-minute interval, the microprocessor processes the bit error count for each error-second, categorises this according to Table 1 and increments the corresponding bin content by one. Similarly, the length of error-free-second runs is categorised as in Table 2. At the end of the 15-minute interval, the previous information is fed to the paper tape punch. If any runs of 10 or more consecutive error-seconds (or error-second outages) are detected by the microprocessor, the start and finish times of these events are fed to the tape punch as they occur. Similar action is taken for any breaks that are detected by the modem carrier fail detector.

Bin Category	Range of Bit Error Count per Error-Second
a	1-2
b	3-4
c	5-8
d	9-16
e	17-32
f	33-64
g	65-128
h	129-256
i	257-512
j	513-1024
k	1025-2048
l	2049-4096
m	4097-8192
n	8193-16384
o	>16385

Table 1. Categorisation of Bit Error Counts per Error-Second

Bin Category	Range of Error-Free-Second Run
a	1-2
b	3-4
c	5-8
d	9-16
e	17-32
f	33-64
g	65-128
h	129-256
i	257-512
j	513-899
k	900

TABLE 2. CATEGORISATION OF ERROR-FREE-SECOND RUNS

4. COMPUTER ANALYSIS OF THE RECORDED DATA

The performance data recorded on paper tape is analysed on the TACONET computer and the results are summarised on a weekly basis. To help the reader follow how the transmission performance is evaluated, Fig. 2 illustrates the relationship of various parameters used. The following processing steps take place in the analysis :

(a) Any periods of time over which no measurement was made or the recorded data is invalid are ignored. This may be caused by :

- measuring or recording equipment failures
- planned withdrawals of broadband systems for maintenance purposes
- local loopback tests

The remaining time is then labelled as valid time. The corresponding percentage is calculated.

$$\% \text{ Valid Time} = \frac{\text{Valid Time}}{\text{Weekly Period}} \times 100$$

where all times are expressed in seconds.

(b) The unavailable time is determined by the total duration of all error-second outages. The percentage of available time is then :

$$\% \text{ Availability} = \frac{\text{Available Time}}{\text{Valid Time}} \times 100$$

(c) The percentage of error-free seconds (EFS) within various time intervals of interest (e.g., 15-minute, 1-hour, 1-day, etc.) is evaluated.

$$\% \text{ EFS} = \frac{\text{Error-Free-Second Time}}{\text{Available Time}} \times 100$$

The result is then graphed in a bar chart form (as exemplified in Fig. 3).

[Needs Qualifying] (d) The percentage of time intervals having a % EFS equal to or better than proposed error performance objective is evaluated. Although no objectives were set for 1-hour and 1-day intervals, some nominal figures are adopted for internal use within Transmission Systems Branch. These are :

% EFS objective = 99.0 for 1-hour intervals
" " = 99.5 for 1-day "

in addition to the proposed

% EFS objective = 99.0 for 15-minute intervals
" " = 99.5 for 12-month "

(e) In addition to the above error and availability performances, the following results are also derived on a weekly basis :

- Percentage histogram of bit error count/error-second (as exemplified in Fig. 4).
- Percentage histogram of error-free-second runs (as exemplified in Fig. 5).
- Listing of start and finish times and duration of carrier failures (or breaks) and bar chart of error-seconds caused by those breaks of duration less than 10 seconds.
- Listing of start and finish times and duration of error-second outages and bar chart of error-seconds caused by the outages.

With the above additional information, some insight can be obtained as to the type of errors (random/burst), the distribution of error-free seconds, and the occurrence of breaks and outages. The latter two events can also be checked against the analogue performance results of broadband bearers measured by some State administrations.

(f) In order to estimate the long-term (12-month) performance figures, a summary of total duration of valid time, available time and error-free-second time is maintained for the weekly measurement periods. In addition, any outages lasting 4 hours or more are listed in the summary.

5. FUTURE FACILITIES

As the data test set is microprocessor-controlled, its capability can be readily enhanced to allow monitoring of certain other transmission characteristics. For example, the inclusion of bearer alarms is being investigated. This information is expected to yield useful information such as identification of bearer sections that consistently suffer transmission impairments. In addition, owing to the complexity of the test unit and the importance of long-term measurements, a periodic self-checking facility is being studied. The provision of a cassette/floppy disc recorder in place of the paper tape punch is being carried out.

6. CONCLUDING REMARKS

Long-term monitoring of transmission performance of data circuits requires a system whereby the measured parameters are recorded in an efficient manner for subsequent analysis. This report has described the facilities aspects of one such data test set. As it is microprocessor-controlled, these facilities can be readily re-arranged or modified as required. In addition to allowing comparison of the measured performance of tested data links with the proposed DDN objectives, the test set also enables the error behaviour of the circuits to be characterised. Hardware and software aspects of the unit are described in a forthcoming report (Ref. 4).

7. ACKNOWLEDGMENTS

The authors wish to thank Dr. B.M. Smith for helpful discussions, Mr. R.I. Webster for microprocessor software development and Mr. K.S. English for analysis software development.

8. REFERENCES

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APPENDIX I : EXTRACTS OF DDN PERFORMANCE OBJECTIVE PROPOSAL

A. OVERALL ERROR PERFORMANCE OBJECTIVES

A.1 The performance objectives below constitute the design objectives for DDN services with a route distance up to and including 2500 km (see also Note 1).

A.2 Long-term performance : equal to or better than 99.5% error-free seconds (EFS) over any 12-month period.

A.3 Short-term performance : for x% * of 15-minute intervals in any 12-month period, the performance in each interval shall be equal to or better than 99% error-free seconds.

A.4 The service is regarded as unavailable when 10 or more consecutive error-seconds are encountered.

* Due to the lack of test data, assignment of a numerical value to the factor "x" is deferred. The value of "x" will be set to be consistent with the performance measured during the proposed data transmission tests.

NOTE 1. For services longer than 2500 km a lower percentage of error-free seconds is acceptable.

NOTE 2. The following error-second allowance is adopted :

- 1 long-haul segment : 90%
- 2 local loop segments : 5%
- 2 baseband loop segments : 5%

B. OVERALL AVAILABILITY PERFORMANCE OBJECTIVES

B.1 The performance objectives below constitute the long-term targets for DDN services with a route distance up to and including 2500 km (see also Note 3).

B.2 99% of services will have an availability of better than 99.9% in any 12-month period.

B.3 The longest duration of an outage shall not exceed 4 hours in any 12-month period for 99% of services.

B.4 The service is regarded as unavailable when 10 or more consecutive error-seconds are encountered.

NOTE 3. For services longer than 2500 km, a lower availability figure is acceptable.

APPENDIX II : SUMMARY OF TERMS USED

Total Time (TT). Period over which performance test was conducted (1 week minimum).

Non-Valid Time (NVT). Time over which no measurement was made or the recorded data is invalid (15 minutes minimum). This may be caused by :

- measuring/recording equipment failures
- planned withdrawals of broadband systems
- local loopback tests

Valid Time (VT). Time over which recorded data is considered for computer analysis.

Error-Free Seconds (EFS). These constitute one-second transmission intervals over which no bit error was detected.

Error-Seconds (ES). These are one-second transmission intervals over which bit errors were detected.

Error-Second Outages (ESO). These are events of 10 or more consecutive error-seconds. They are also simply called outages.

Non-Outage Error-Seconds (NOES). These are events of less than 10 consecutive error-seconds.

Unavailable Time (UAT). This corresponds to the total duration of events of 10 or more consecutive error-seconds (or error-second outages).

Available Time (AT). This is the transmission time over which no error-second outages (ESO) were encountered.

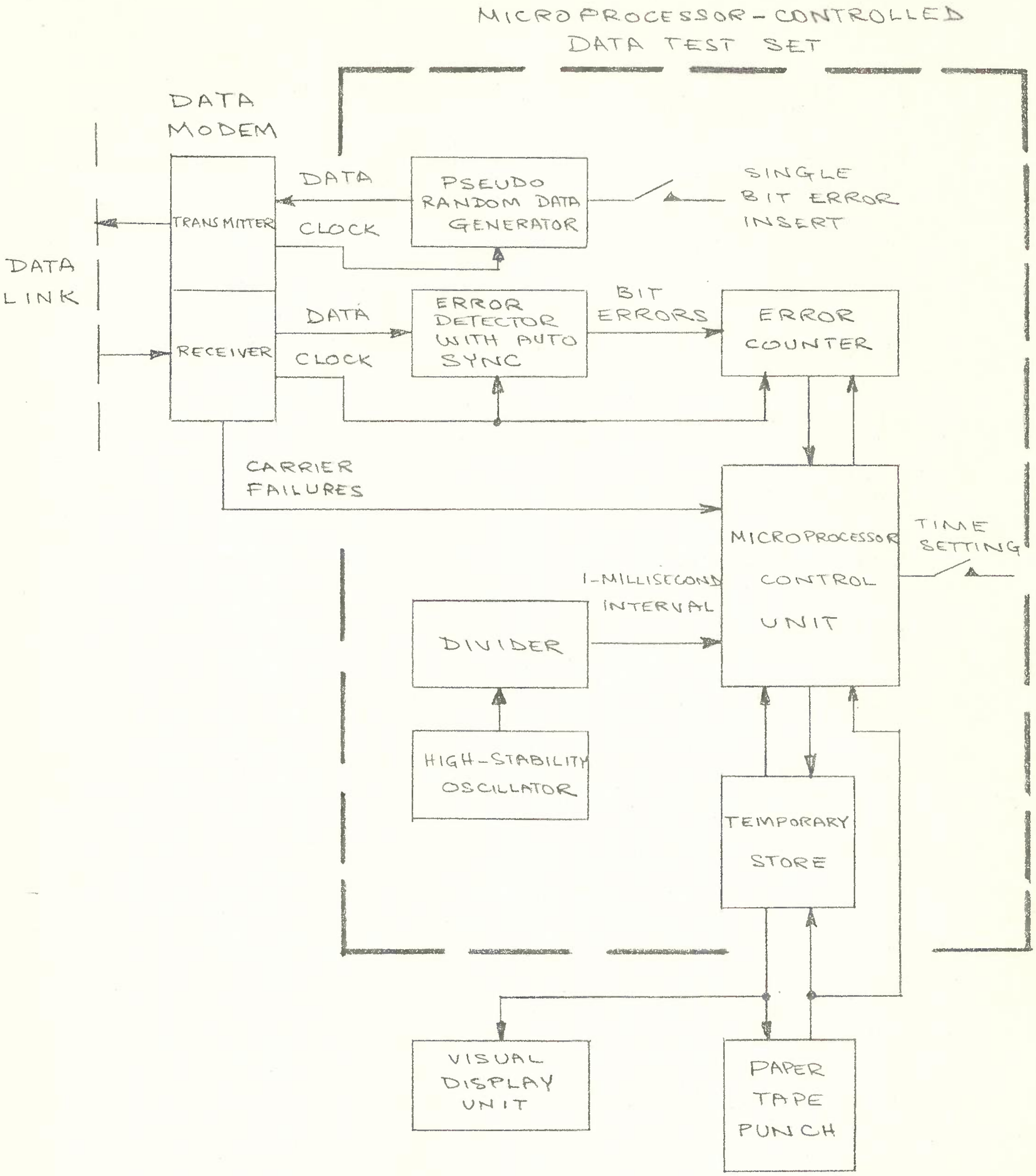

Fig. 1. Block Diagram of Data Test Arrangement

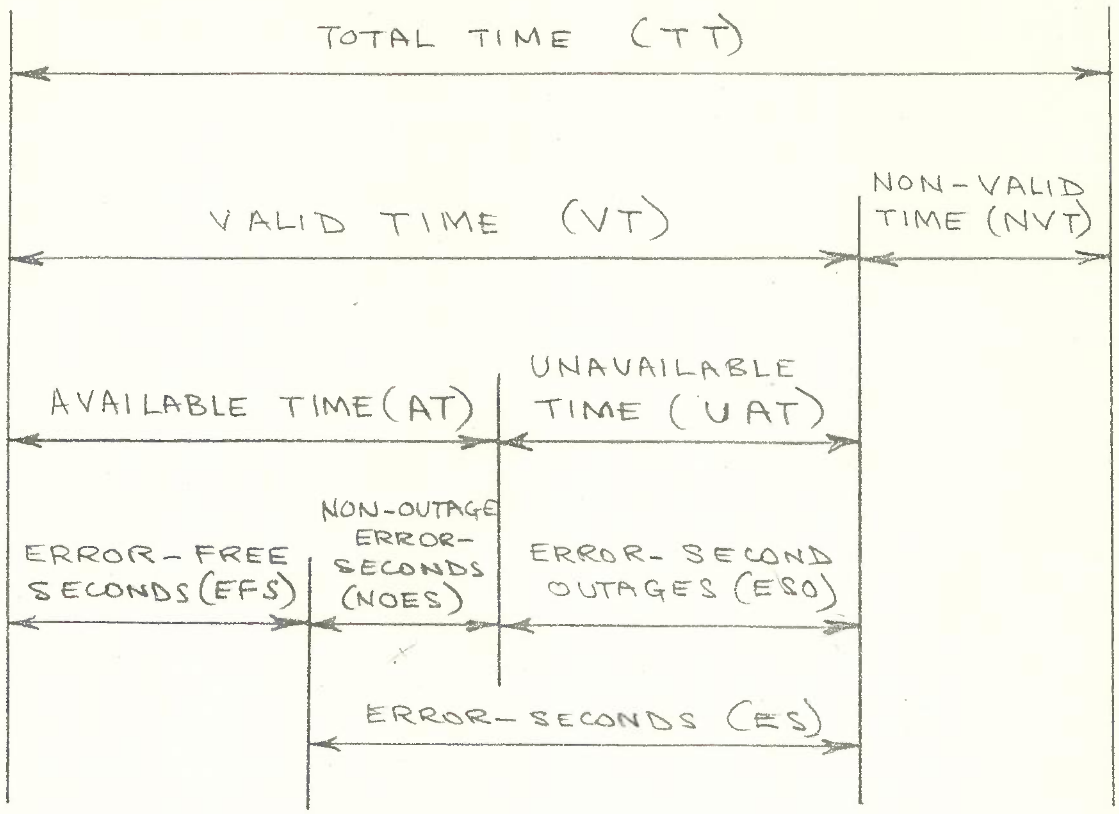

Fig. 2. Relationship Between Various Parameters Used in Determining Transmission Performance of Data Links

(Notes : - Time unit = 1 second
- The definitions of the terms used are given in Appendix II)

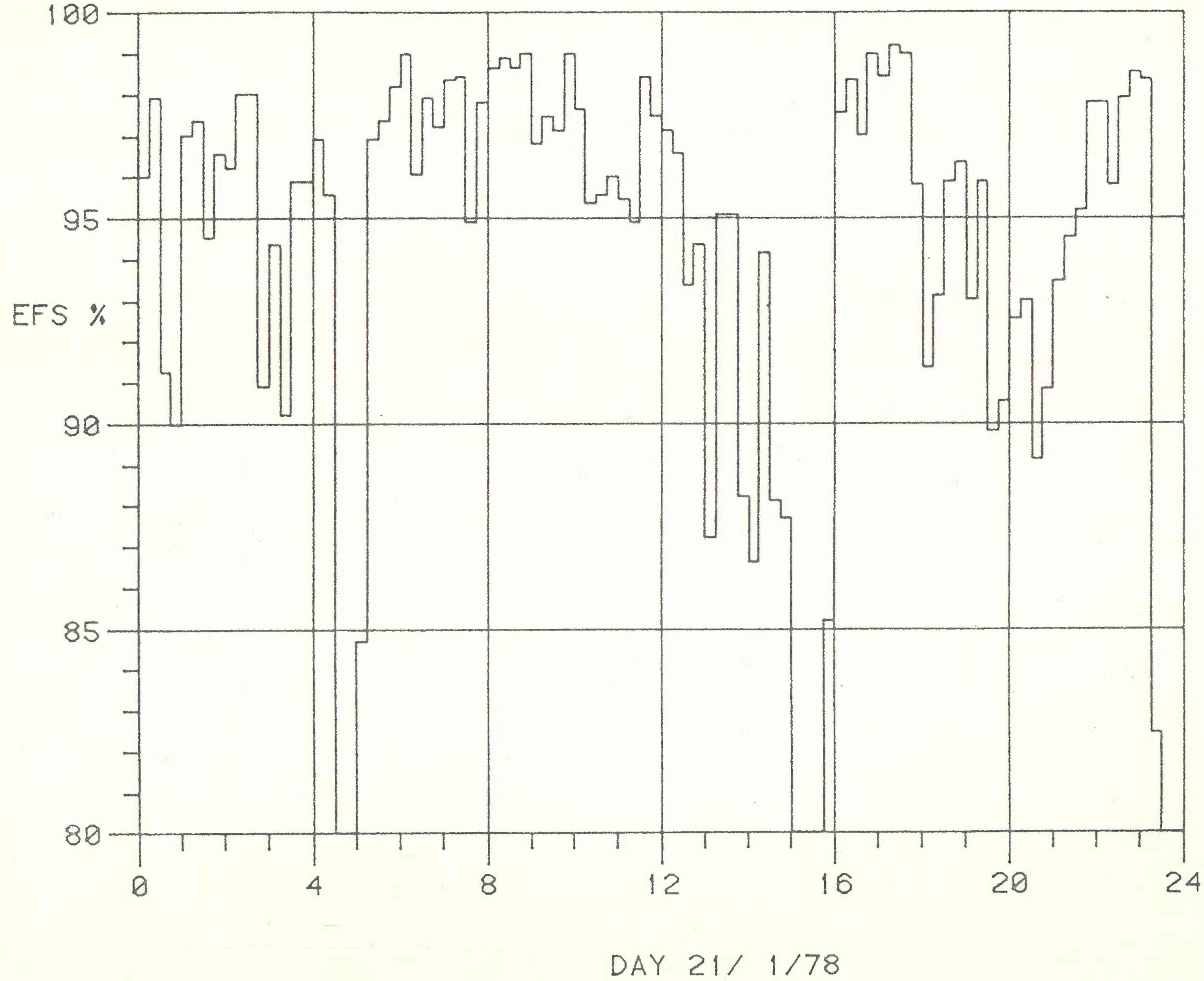

Fig. 3. Sample Bar Chart of Percentage of Error-Free Seconds
(15-minute intervals)

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DISTRIBUTION OF BIT ERROR COUNTS PER ERROR SECOND FOR THE PERIOD 15/ 1/79 - 21/ 1/79

              +---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
    1-2       *
    3-4       **************************************
    5-8       ***********************
   9-16       *****************
  17-32       ********
  33-64       *****
 65-128       ****
129-256       ****
257-512       *****
513-1024      ***
1025-2048     **
2049-4096     *
4097-8192     *
8193-16384    *
16385-        *
              +---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
              0%       10%       20%       30%       40%       50%       60%       70%       80%       90%      100%

TOTAL NO. OF ERROR SECONDS = 16114
```

Fig. 4. Sample Percentage Histogram of Bit Error Counts per Error-Second

Fig. 4

```
DISTRIBUTION OF ERROR FREE SECOND RUNS FOR PERIOD 15/ 1/79 - 21/ 1/79

         +---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
  1-2    ************************
  3-4    ********************
  5-8    ******************
  9-16   ****************
 17-32   **************
 33-64   ***********
 65-128  ****
129-256  **
257-512  *
513-899  *
    900  *
         +---------+---------+---------+---------+---------+---------+---------+---------+---------+---------+
         0%       10%       20%       30%       40%       50%       60%       70%       80%       90%      100%

                                        TOTAL NO. OF E.F.S.R. = 18085
```

Fig. 5. Sample Percentage Histogram of Error-Free-Second Runs

Fig. 5