Research Laboratories Report 7320

A Microprocessor-controlled Data Test Set: Facilities, Aspects

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REPORT 7320

A MICROPROCESSOR - CONTROLLED DATA TEST SET: FACILITIES ASPECTS

BY N.Q DUC & R.B. COXHILL

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(ITS REPORT NO. 7320

I. Duc, N.Q
II. Coxhill, R.B.
1.DATA RECORDING
2.DATA TRANSMISSION
3.DIGITAL TRANSMISSION
4.DIGITAL SYSTEMS

SUMMARY

As part of an investigation into the performance of data links which may be used in the proposed Telecom Australia 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 the Line and Data Systems Section, Transmission Branch.

This report (RL 7320) considers the facilities aspects of the test set. It describes how the digital transmission performance 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, and the computer analysis program are described in two companion reports (RL 7321 and RL 7322, respectively).

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A MICROPROCESSOR-CONTROLLED DATA TEST SET : FACILITIES ASPECTS

1. INTRODUCTION

As part of an investigation into the performance of data links which may be used in the proposed Telecom Australia Digital Data Network (DDN), some tests were previously conducted on selected intercapital groupband 48 kbit/s data loops (Ref. 1). The results reported therein were obtained from an analysis of measurements made with specialized instrumentation designed and constructed by Line and Data Systems Section, Transmission Branch (Refs. 2 and 3). The instrumentation was specifically designed for the study of synchronization, jitter and error performance of an experimental three-node synchronous digital data network.

From the above measurements, it was observed that the transmission quality of some microwave radio bearers is very much 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 availability and error 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. It is therefore highly desirable to conduct any subsequent data tests in accordance with these proposed performance requirements. A microprocessor-based data test set has been developed by Transmission Branch allowing such performance monitoring to be carried out along with measurement of other desirable digital transmission performance parameters. The collected information is subsequently processed on the Telecom Australia Computer Network (TACONET) using an analysis program developed with the cooperation of Telecom Technology Branch (Ref. 5).

In this report, only the facilities aspects of the data test set are described. Hardware and software aspects are discussed in a companion RL report (Ref. 4).

2. DDN PROPOSED PERFORMANCE OBJECTIVES

These objectives have been 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 objectives 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. THE MICROPROCESSOR CONTROLLED 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 information is obtained:

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

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

c. The start and finish times (to the nearest millisecond) in real time of any externally detected alarm condition (e.g. modem detected carrier failures).

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).

3.2 Description of Operation

A block diagram of the test arrangement is illustrated in Fig. 1. The data test set consists of independent transmit and receive sections. The transmitter generates a pseudo-random sequence that is transmitted over the data link as a test sequence. In the receiver, an error detector with automatic synchronization checks for errors in the incoming data stream and increments an error counter for each error detected. Under microprocessor control, each 15-minute measuring period is quantised into 1-second intervals. At the end of each 1-second interval the current content of the error counter is fed to the microprocessor and the counter is then reset to zero. 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. This process is repeated for each 1-second interval of a 15-minute measuring period. Similarly, the length of error-free-second runs is categorised as in Table 2. If an error-free-second run follows on from, and/or extends into, the previous or the following 15-minute periods respectively, then additional information is added to the collected bin information denoting this. At the end of the 15-minute period, the collected bin information is stored on a digital cassette recorder and all bin contents are reset to zero. If any runs of 10 or more consecutive error-seconds (ESO) are detected by the microprocessor, the start and finish times of these events are stored on the digital cassette as they occur. Similar action is taken for any externally detected alarm condition (e.g. modem detected carrier failure).

Bin Category	Range of Bit Error Count per Error-Second (BEC/ES)
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 (EFSR)
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

* Maximum EFSR within a 15-minute interval.

All information stored on the digital cassette is encoded as a sequence of ASCII characters. This information is also available via a serial output from the test set, thus allowing on-line monitoring of the recorded data using a printer or a Visual Display Unit (VDU).

A real time clock in the microprocessor driven by a high-stability oscillator provides time of day information that is periodically added to the collected data.

As the basic unit of measurement in the test set is one second, the functions of the microprocessor are not related to the data rate of the channel being tested; the only constraint being the hardware speed limitations imposed by the front end of the unit. With suitable interfaces (e.g. V.24, V.35, V.36, G.703-64 kbit/s, G.703-2.048 Mbit/s-HDB3) the unit will operate up to 2.048 Mbit/s.

Owing to the complexity of the test set internal operation, and the importance of long-term measurements, an automatic self-test mode for one 15-minute interval of each day is provided. In this mode, the test set is internally looped between transmit and receive parts and predetermined bit error patterns are injected into the test data sequence. The information output by the test set for this self-test interval can then be checked via the analysis program for any deviation from the preset pattern.

4. COMPUTER ANALYSIS OF THE RECORDED INFORMATION

The performance information recorded on the cassette 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:

- planned withdrawals of broadband bearers
- local loopback tests
- test set malfunctions.

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

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

d. The percentage of time intervals having a % EFS equal to or better than the relevant proposed error performance objective for the circuit under test is evaluated. In this calculation, any intervals containing

error-second outages are weighted according to their availability percentage. Although no objectives were set for 1-hour and 1-day intervals, some nominal figures are adopted for internal use within Transmission Branch. These are:

% EFS objective $\geq$ 99.0 for 1-hour intervals.
% EFS objective $\geq$ 99.5 for 1-day intervals.

in addition to the proposed performance objectives viz:

% EFS objective $\geq$ 99.0 for 15-minute intervals
% EFS objective $\geq$ 99.5 for 12-month intervals.

The results derived from calculations (a)-(d) are summarized in a weekly performance table (as exemplified in Fig. 3).

In order to have some insight into this short-term 15-minute performance, a sensitivity analysis is also available for a range of % EFS criteria.

In addition to the summary table described above, the following secondary results are available which can be used to further characterize the performance of a data link:

a. Percentage histogram of bit error counts/error-second (As exemplified in Fig. 4).

b. Percentage histogram of error-free-second runs (As exemplified in Fig. 5).

c. Listing of the total duration of error-second outages in each 15-minute interval (As exemplified in Fig. 6).

d. Listing of the number and total duration of any externally detected alarm conditions in each 30-minute interval (As exemplified in Fig. 7)

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 error-second outages and external alarms (e.g. modem detected carrier failures). The latter two events can also be checked against the analogue performance results of broadband bearers monitored by some State Administrations.

In order to estimate the long-term performance characteristics, the total durations of valid time, available time and error-free-second time for the week are appended in the percentage histogram plots. Additionally, the median range of bit error counts per error-second is also indicated to allow the estimation of bit error rate from error-free-second performance (Ref. 6). Note that the histogram median value is determined in preference to mean value in view of the non-linear nature of the range categorization.

5. 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 companion report (Ref. 4). We note here that the test set can also be used to monitor the performance of other types of digital transmission circuits (e.g. PCM circuits). In addition, by a switchable option, it can act as a "pseudo-demultiplexer" to allow the recording of the transmission characteristics of one 64 kbit/s channel within a 2.048 Mbit/s data stream.

6. ACKNOWLEDGEMENTS

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APPENDIX I : SUMMARY OF DDN PROPOSED PERFORMANCE OBJECTIVES

1. OVERALL AVAILABILITY PERFORMANCE OBJECTIVES

1.1 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 1).

1.2 All services will have an availability of better than 99.9% in any 12-month period.

1.3 The longest duration of an outage shall not exceed 4 hours in any 12-month period for all services.

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

NOTE 1: For services longer than 2500 km, a lower availability figure is acceptable.

2. OVERALL ERROR PERFORMANCE OBJECTIVES

2.1 The performance objectives below constitute the design objectives for DDN services with a route distance up to and including 2500 km (see also Note 2).

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

2.3 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.

2.4 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 2: For services longer than 2500 km a lower percentage of error-free seconds is acceptable.

NOTE 3: The following error-second allowance is adopted:

- 1 long-haul segment (2476 km) : 90%
- 2 metropolitan segments (16 km) : 5%
- 2 local segments (8 km) : 5%

3. SUMMARY TABLES

3.1 Long-Term (12 months) Availability and Error Performance Objectives

Parameter / Route Segment	% Availability	% Error-Free Seconds
Overall Route (2500 km)	99.90	99.50
Long-Haul Segment (2476 km)	99.98	99.55
Two Metroplitan Segments (16 km)	99.996	99.975
Two Local Segments (8 km)	99.94	99.975

3.2 Short-Term (15 minutes) Error Performance Objectives

Parameter / Route Segment	% Error-Free Seconds		
	T=15 Minutes	T=1 Hour (see note)	T=1 Day (see note)
Overall Route (2500 km)	99.00	99.00	99.50
Long-Haul Segment (2476 km)	99.10	99.10	99.55
Two Metropolitan Segments (16 km)	99.95	99.95	99.975
Two Local Segments (8 km)	99.95	99.95	99.975

Note: The short-term error performance objectives over T = 1 hour and T = 1 day are for Transmission Branch use only.

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.

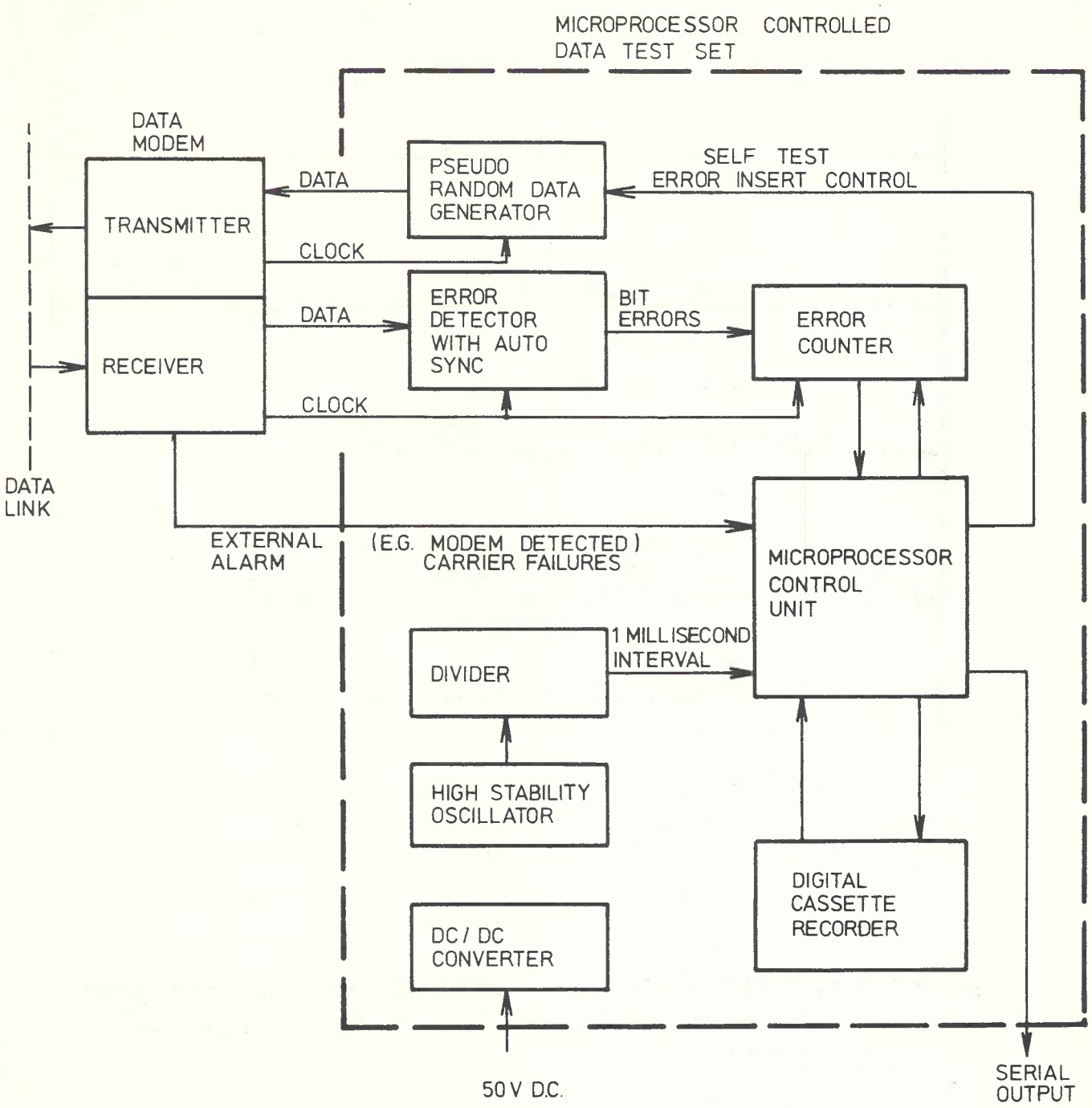
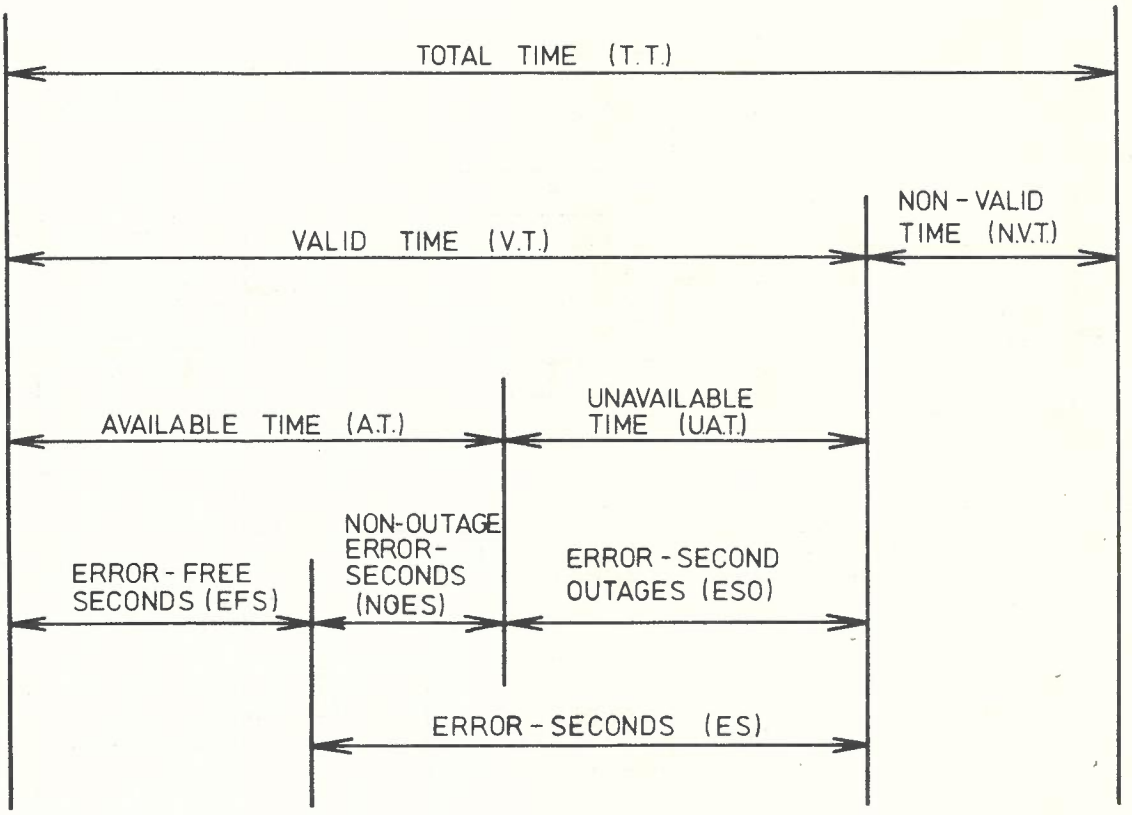


FIG.1 BLOCK DIAGRAM OF DATA TEST ARRANGEMENT



NOTES: - TIME UNIT = 1 SECOND
- THE DEFINITIONS OF THE TERMS USED ARE GIVEN IN APPENDIX II.

FIG. 2 RELATIONSHIP BETWEEN VARIOUS PARAMETERS USED IN DETERMINING TRANSMISSION PERFORMANCE OF DATA LINKS.

MELBOURNE-LAUNCESTON(LOOPED) MODEM 72KBIT/				% OF TIME INTERVALS (T) FOR WHICH ERROR PERFORMANCE OBJECTIVE WAS MET ($)		
WEEKLY PERIOD	% VALID TIME	% AVAILA-BILITY	% ERROR-FREE SECONDS	T=15 MIN	(*) T=1 HOUR	(*) T=1 DAY
24/ 7/79 - 30/ 7/79	59.52	100.00	92.91	0.	0.	0.
31/ 7/79 - 6/ 8/79	98.66	100.00	92.25	0.	0.	0.
7/ 8/79 - 13/ 8/79	97.92	99.95	95.32	0.	0.	0.
14/ 8/79 - 20/ 8/79	98.96	99.99	92.67	0.	0.	0.
21/ 8/79 - 27/ 8/79	98.96	99.97	93.68	0.	0.	0.
28/ 8/79 - 3/ 9/79	98.96	100.00	93.24	0.	0.	0.

($)... IN THIS CALCULATION, ANY INTERVALS CONTAINING ERROR-SECOND OUTAGES ARE WEIGHTED ACCORDING TO THEIR AVAILABILITY PERCENTAGES.
(*)... FOR TRANSMISSION BRANCH USE ONLY.

FIG. 3. SAMPLE SUMMARY TABLE OF AVAILABILITY AND ERROR PERFORMANCES

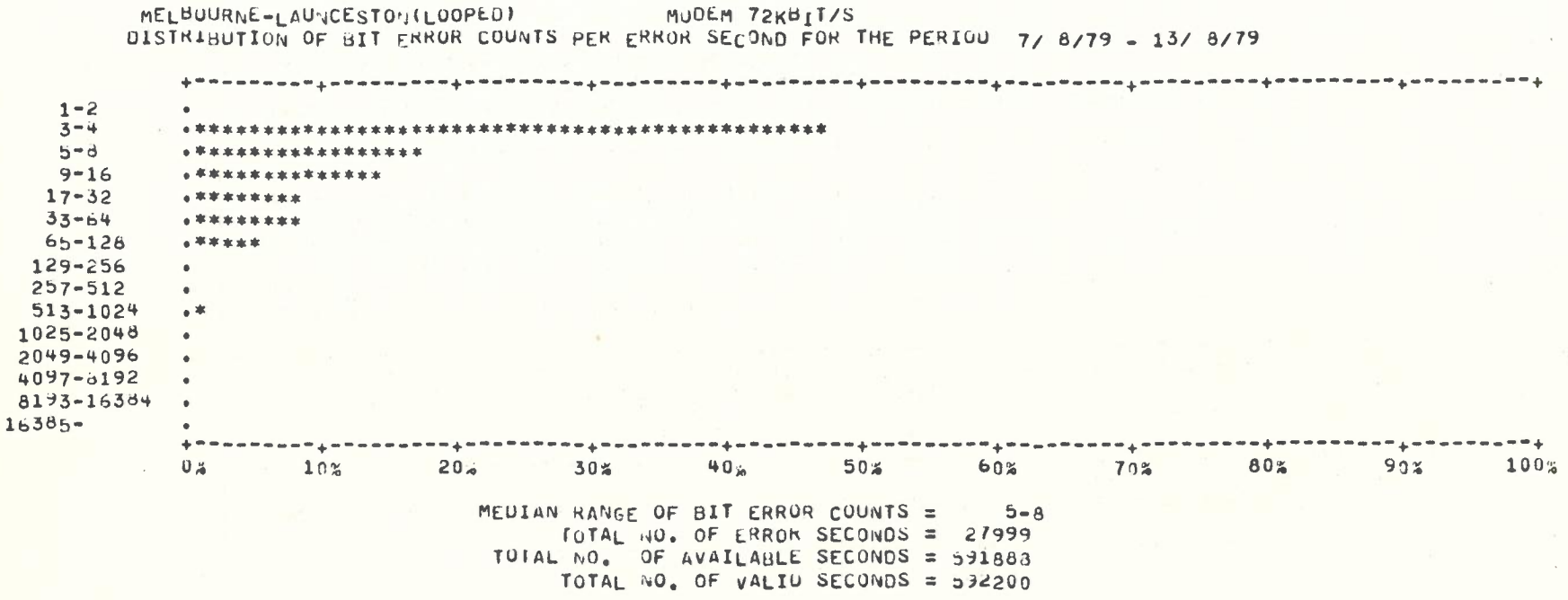


FIG. 4 SAMPLE PERCENTAGE HISTOGRAM OF BIT ERROR COUNTS PER ERROR-SECOND

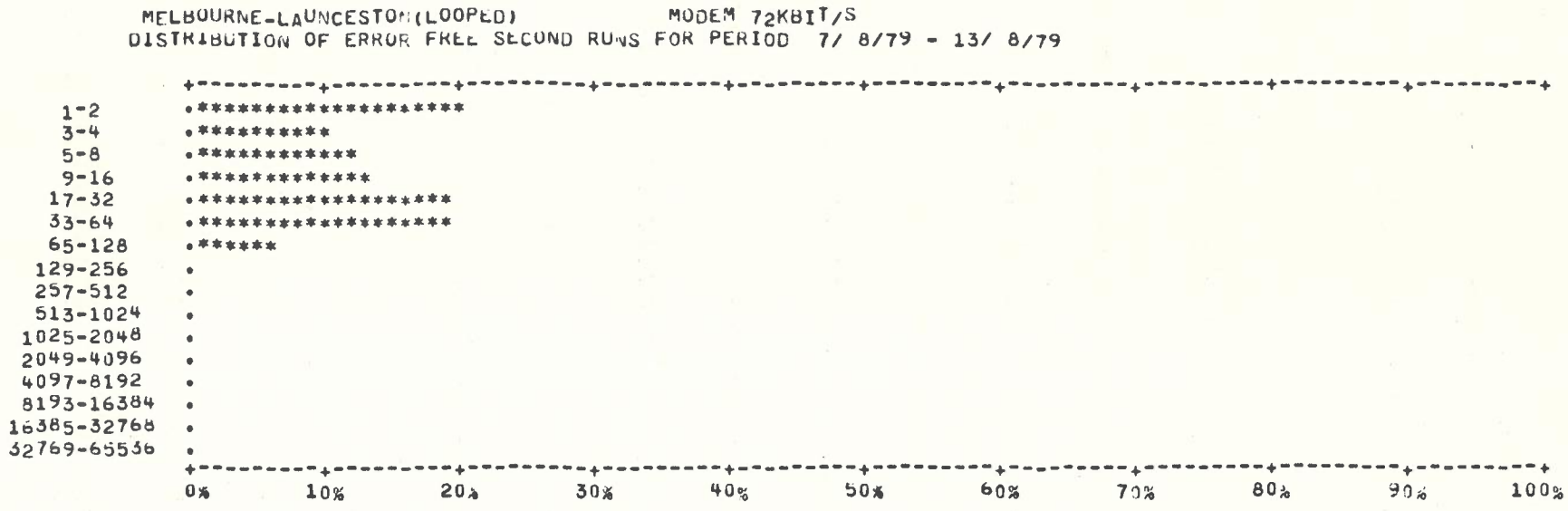


FIG. 5. SAMPLE PERCENTAGE HISTOGRAM OF ERROR-FREE-SECOND RUNS

MELBOURNE-LAUNCESTON(LOOPED) MODEM 72KB1T/S
CARRIER-FAIL DURATIONS AND COUNTS FOR WEEK 31/ 7/79 - 6/ 8/79

	DAY 212		DAY 213		DAY 214		DAY 215		DAY 216		DAY 217		DAY 218	
	DUR.	CNT.	DUR.	CNT.	DUR.	CNT.	DUR.	CNT.	DUR.	CNT.	DUR.	CNT.	DUR.	CNT.
0 - 30														
30 - 100	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
100 - 130	0.	0	0.	0	2.00	3	0.	0	0.	0	0.	0	0.	0
130 - 200	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
200 - 230	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
230 - 300	0.	0	2.06	2	0.	0	0.	0	0.	0	0.	0	0.	0
300 - 330	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
330 - 400	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
400 - 430	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
430 - 500	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
500 - 530	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
530 - 600	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
600 - 630	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
630 - 700	0.	0	0.	0	0.	0	0.	0	0.	0	0.06	1	0.	0
700 - 730	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
730 - 800	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
800 - 830	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
830 - 900	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
900 - 930	0.04	1	0.	0	0.22	5	0.	0	0.	0	0.	0	0.	0
930 - 1000	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
1000 - 1030	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
1030 - 1100	0.	0	0.	0	0.	0	0.	0	0.41	1	0.	0	0.	0
1100 - 1130	0.	0	0.	0	0.	0	0.	0	0.	0	0.36	3	0.	0
1130 - 1200	0.	0	0.	0	0.	0	0.	0	0.	0	0.27	7	0.	0
1200 - 1230	0.	0	0.	0	0.	0	0.	0	0.	0	0.04	2	0.	0
1230 - 1300			0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
1300 - 1330	0.03	1	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
1330 - 1400	0.	0	0.04	1	0.	0	0.	0	0.	0	0.	0	0.	0
1400 - 1430			0.05	2	0.	0	0.	0	0.	0	0.60	8	0.	0
1430 - 1500	0.02	1	0.35	9	0.	0	0.	0	0.	0	0.	0	0.	0
1500 - 1530	0.	0	0.09	3	0.	0	0.	0	0.	0	0.	0	0.04	1
1530 - 1600	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
1600 - 1630	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
1630 - 1700	0.	0	0.02	1	0.78	5	0.	0	0.	0	0.	0	0.	0
1700 - 1730	0.	0	0.05	3	0.	0	0.	0	0.	0	0.	0	0.	0
1730 - 1800	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
1800 - 1830	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
1830 - 1900	0.	0	0.	0	0.	0	0.21	3	0.	0	0.	0	0.	0
1900 - 1930	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
1930 - 2000	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
2000 - 2030	0.	0	0.	0	0.	0	0.	0	0.	0	0.46	3	0.	0
2030 - 2100	0.	0	0.	0	0.08	1	0.	0	0.	0	0.13	1	0.	0
2100 - 2130	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
2130 - 2200	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
2200 - 2230	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
2230 - 2300	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
2300 - 2330	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
2330 - 2400	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0	0.	0
TOTAL DURATION	0.09		2.65		3.08		0.21		0.41		1.97		0.04	
TOTAL COUNT		3		21		14		3		1		25		1

MELBOURNE-LAUNCESTO (LOOPED) MODEM 7248IT/S
ERROR SECOND OUTAGES FOR WEEK 7/ 8/79 - 13/ 8/79

	DAY 219		DAY 220		DAY 221		DAY 222		DAY 223		DAY 224		DAY 225	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
0 - 15		0		0		0		0		0		0		0
15 - 30	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30 - 45	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45 - 100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100 - 115	0	0	0	0	0	0	0	0	0	0	0	0	0	0
115 - 130	0	0	68	0	0	0	0	0	0	0	0	0	0	0
130 - 145	0	0	0	0	0	0	0	0	0	0	0		0	0
145 - 200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200 - 215	0	0	0	0	0	0	0	0	0	0	0	0	0	0
215 - 230	0	0	0	0	0	0	0	0	0	0	0	0	0	0
230 - 245	0	0	0	0	0	0	0	0	0	0	0	0	0	0
245 - 300	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300 - 315	0	0	0	0	0	0	0	0	0	0	0	0	0	0
315 - 330	0	0	0	0	0	0	0	0	0	0	0	0	0	0
330 - 345	0	0	0	0	0	0	0	0	0	0	0	0	0	0
345 - 400	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400 - 415	0	0	0	0	0	0	0	0	0	0	0	0	0	0
415 - 430	0	0	0	0	0	0	0	0	0	0	0	0	0	0
430 - 445	0	0	0	0	0	0	0	0	0	0	0	0	0	0
445 - 500	0	0	0	0	0	0	0	0	0	0	0	0	0	0
500 - 515	0	0	0	0	0	0	0	0	0	0	0	0	0	0
515 - 530	0	0	0	0	0	0	0	0	0	0	0	0	0	0
530 - 545	0	0	0	0	0	27	0	0	0	0	0	0	0	0
545 - 600	0	0	0	0	0	0	0	0	0	0	0	0	0	0
600 - 615	0	0	0	0	0	0	0	0	0	0	0	0	0	0
615 - 630	0	0	0	0	0	0	0	0	0	0	0	0	0	0
630 - 645	0	0	0	0	0	0	0	0	0	0	0	0	0	0
645 - 700	0	0	0	0	0	0	0	0	0	0	0	0	0	0
700 - 715	0	0	0	0	0	0	0	0	0	0	0	0	0	0
715 - 730	0	0	0	0	0	0	0	0	0	0	0	0	0	0
730 - 745	0	0	0	0	0	0	0	0	0	0	0	0	0	0
745 - 800	0	0	0	0	0	0	0	0	0	0	0	0	0	0
800 - 815	0	0	0	0	0	0	0	0	0	0	0	0	0	0
815 - 830	0	0	0	0	0	0	0	0	0	0	0	0	0	0
830 - 845	0	0	173	0	0	0	0	0	0	0	0	0		0
845 - 900	0	0	31	0	0	0	0	0	0	0	0	0		0
900 - 915	0	0	0	0	0	0	0	0	0	0	0	0		0
915 - 930	0	0	0	0	0	0	0	0	0	0	0	0		0
930 - 945	0	0	0	0	0	0	0	0	0	0	0	0		0
945 - 1000	0	0	0	0	0	0	0	0	0	0	0	0		0
1000 - 1015	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1015 - 1030	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1030 - 1045	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1045 - 1100	13	0	0	0	0	0	0	0	0	0	0	0	0	0
1100 - 1115	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1115 - 1130	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1130 - 1145	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1145 - 1200	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	13	0	272	0	0	27	0	0	0	0	0	0	0	0

FIG. 7. SAMPLE LISTING OF ERROR-SECOND OUTAGES