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EVALUATION OF A TELETTRA V.36 DATA MODEM AND ITS PERFORMANCE OVER VARIOUS GROUPBAND LOOPS

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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 were conducted on various groupband loops using CCITT V.36 compatible data modems. Modems from two different manufacturers, namely, Telettra and TRT (Sematrans), were first briefly characterized by laboratory tests, revealing a few distinct differences. These are sensitivity to groupband phase jitter and automatic gain control response time. Comparative transmission tests of the two modems were subsequently carried out on various groupband loops using commercial data test sets. For a given circuit, their error performances were found to be comparable, except for the long loops which involved five through-group filters, namely the Perth loop and the Sydney-Wagga Wagga tandem loop.

In addition, transmission tests were performed with the Telettra modem on the Melbourne-Adelaide loop (via Bordertown) and the Melbourne-Perth loop (extension of the previous circuit) using the microprocessor-based data test set developed by Transmission Branch. Over the test periods, the proposed DDN availability and error performance objectives were close to being met on the Adelaide loop, but not on the Perth loop. The results of this series of tests (with the Telettra modem) were also compared with those previously obtained with the Sematrans modem. Although the tests were conducted over different periods, the difference in performance characteristics, to a certain extent, can be explained in terms of the data modem characteristics mentioned earlier.

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1. INTRODUCTION

As part of an investigation into various transmission aspects of the proposed Telecom Digital Data Network (DDN), tests were conducted on a data modem which may be suitable for use on this network, namely, a Telettra V.36 compatible groupband modem operating at a data rate of 64 kbit/s and a line rate of 72 kbaud. The test programme was geared to emphasize the comparative performance between the Telettra modem and a Sematrans modem, which is also V.36 compatible.

In evaluating the Telettra modem, three main aspects were considered. First, some laboratory characterization tests of the modem were performed. These results were then compared against those results previously obtained for the Sematrans modem (Ref. 1). Second, comparative performance tests were conducted over various groupband loops using commercial data test sets for a three-week period. Lastly, the performance of the modem was measured over various groupband loops using a microprocessor-based data test set developed by Transmission Branch (Refs. 2 and 3), which allows the results to be expressed directly in terms of the DDN proposed performance objectives. These results were then compared against those previously obtained with the Sematrans modem over the same loops, using the same test set, but over a different test period. (Ref. 4).

This report summarizes the results of all these tests. Additionally, comparisons are made between interruption activity monitored by the South Australian Administration and the carrier fail occurrence measured with the Transmission Branch test set mentioned earlier.

2. TELETTRA V.36 COMPATIBLE DATA MODEM

This modem is intended for synchronous transmission of binary data signals over a standard groupband circuit, and is compatible with CCITT Recommendation V.36. It operates at a bit rate of 64 kbit/s. An 8 kHz timing signal (which includes some service or housekeeping information) is added to the input data sequence. The composite stream is then single sideband modulated into a pseudo-ternary class 4 partial response line signal operating at 72 kbaud. A manual carrier phase adjustment is provided, allowing the received (baseband) eye pattern to be optimised.

The 64 kbit/s data interface is in accordance with the co-directional arrangement of CCITT Recommendation G.703.

The modem is provided with straps to allow synchronization from one of the following three sources:

a. The timing derived from the incoming 64 kbit/s interface

b. The timing derived from the received groupband data line signal

c. An external 2048 kHz clock

Additionally, the modem can provide a 2048 kHz clock output, to synchronize other clocks in the network.

In any of the synchronization arrangements described above, elastic stores are normally used in both transmit and receive directions, thus allowing common transmit and receive timing. However, if the timing between transmit and receive directions are to be independent, then the card containing the elastic stores must be replaced by another card especially provided for this optional arrangement.

The alarms provided on the modem are as follows:

a. Loss of the input signal into the 64 kbit/s interface. This alarm is activated for losses of signal of greater than 750 µS, and has a dead time of 3 mS.

b. Loss of the incoming signal from the FDM groupband circuit (equivalent to carrier fail). This alarm is activated when the 100 kHz pilot carrier level drops 14 dB or more below its nominal level (-15 dBm0), and is restored when the level rises to 10 dB or less, thus having 4 dB of hysteresis.

c. Frame misalignment in the received signal. This alarm is activated when each of four consecutive segments of the alignment sequence have one or more errors. Each segment consists of two alignment bits and one service bit. These bits are successively attached to every octet in the 64 kbit/s data sequence. Correct alignment is established when eight correct segments are detected, thus giving a minimum possible alarm time of 3 mS.

d. High violation rate in the received line code sequence. This alarm is activated when the code violation rate in the received line signal is greater than 10^{-3}, and is restored when the violation rate is less than 10^{-4}. To determine the above violation rate, a block of 18 bits which has one or more bit errors is considered as a single error.

e. Loss of phase-lock of the timing VCO.

3. GENERAL INFORMATION ON THE TESTS

In all the tests on the Telettra modem an interface adaptor was used to convert from the G.703 interface to the V.24 interface, as a G.703 interface is not available on the commercial test equipment used or on the Transmission Branch test set mentioned earlier.

Alarms (b) and (c) were "OR-ed" together and extended to Circuit 109 (Data Channel Received Line Signal Detector) of the V.24 interface.

With both the Telettra and the Sematrans modems looped at their respective groupband points (via a 6 dB amplifier), it was observed that the eye pattern of the Telettra modem was degraded by approximately 10% in comparison with the Sematrans modem. This marginal difference was noted but not investigated due to the short availability of the modem from the supplier.

In all the comparative tests both modems were adjusted for equivalent send and receive groupband levels, except for tests where those levels were purposely varied.

4. LABORATORY CHARACTERIZATION TESTS OF THE DATA MODEM

These tests were conducted on the Telettra using the various test arrangements described in Ref. 1 (except for Section 4.4).

4.1 Bit Error Rate Under Additive White Gaussian Noise

This test showed that the two modems have similar performance under additive white gaussian noise conditions. This result can be explained as follows: the narrower receive filter of the Telettra modem offsets its poorer eye pattern which in turn is possibly due to the narrower filter itself, or to a poorer data signal generator in the transmitter.

4.2 Sensitivity to Groupband Phase Jitter

Results of this test are plotted in Fig. 1. For comparison purposes, the corresponding results previously obtained for the Sematrans modem are included. The curves plotted in Fig. 1 give a measure of the cut-off frequency of the phase locked loop (PLL) used in the modem receivers to recover the 100 kHz pilot carrier for demodulation purposes. Any phase jitter and/or phase hits on the received groupband signal with frequency components lower than the cut-off frequency of the PLL will have minimal effect on the modem operation, whereas higher frequency components of 20° peak-to-peak or more will cause data errors.

It can be seen from Fig. 1 that the cut-off frequency of the PLL in the Telettra modem is nearly an order of magnitude lower than the Sematrans modem. This difference in PLL cut-off frequencies could be a contributing factor to the difference in performance obtained in some comparative transmission performance tests.

4.3 Automatic Gain Control Response Time

The results of this test showed that the Telettra modem had an Automatic Gain Control (AGC) response time of up to 4 seconds. This is in distinct contrast to results previously obtained for the Sematrans modem, which had an AGC response time of less than 10 mS.

4.4 Alarm Response Time

As described in Section 3, alarms "b" and "c" were "OR-ed" together and extended to Circuit 109 of the V.24 interface. Although no accurate bench tests of alarm response times were performed, indications were that alarm "b" was activated by losses of signal of duration greater than 50 ms and alarm "c" gave a minimum alarm time of 3 ms.

As part of the data availability and error performance measurements as described in Section 6, the Transmission Branch test set also measured the duration of any "break" activity monitored from Circuit 109. This information was then compared to the interruption activity measured by the S.A. administration. This is shown on a daily basis in Tables 5 and 7.

The "break" information measured by the test set was analysed in detail to determine if the alarm response times of the Telettra modem could be characterized. Minimum "breaks" (OR-ed signal of carrier failures and frame misalignment) of 3 mS were measured by the test set, which are due to the frame misalignment alarm. These "breaks" were sometimes not detected as interruption activity by S.A., as this alarm can be activated by data errors. "Breaks" of greater than 100 mS that were detected by the test set were also detected as interruption activity by S.A. However, the activity detected by S.A. was generally confined to a small number of events for those hourly periods that contained activity, whereas for the same time periods the test set recorded a greater number of events, and the total duration of these events was greater. It appears that the Telettra modem translates any long "breaks" into a series of "breaks", with the total duration of these events much larger than the original ones. This discrepancy could be partly explained by the difference in level drop detection thresholds between the Telettra modem and the S.A. interruption monitoring instrument. The thresholds being 14 dB below nominal for the former, and 6 dB below nominal for the latter.

5. COMPARATIVE TRANSMISSION TESTS ON VARIOUS GROUPBAND LOOPS

The comparative tests of the Telettra and Sematrans modems were conducted on groupband loops to Sydney (which includes an extra loop to Wagga-Wagga), Canberra, Launceston and Perth with the test equipment located at the Research Laboratories, Clayton. Details on these loops are shown in Table 1.

Two Hewlett-Packard 1645A test sets were used to measure the data transmission performance of each modem. The test sets were identically configured as follows:

a. The block length was set to 100,000 bits. This approximately corresponds to the number of bits transmitted per second. The other standard block rates offered on the test set are either too small or too large.

b. The number of carrier losses (or failures) as detected by the data modems was counted, rather than the number of data dropouts.

c. The test set has been internally modified to allow block error counting to continue during any carrier losses or clock slips.

d. An external counter was used to count the bit errors that the test set does not count during any carrier losses.

The procedure adopted during the tests was to simultaneously operate each modem on separate groupband loops and to interchange the modems at intervals of about an hour. This "interleaving" procedure ensured that the bearer variability was not a factor in the comparison.

The results of these comparative tests are shown on a daily basis in Table 2 and the overall performances in Table 3.

5.1 Melbourne-Canberra

The two modems gave comparable performance over this loop (about 1000 km) which is carried on a microwave radio bearer.

5.2 Melbourne-Sydney and Melbourne-Wagga Wagga

These two loops are on co-axial bearers and the combined loop length is about 2600 km. Initially, comparative testing was carried out over the combined Melbourne-Sydney and Melbourne-Wagga Wagga loop. However, it was observed that the Sematrans modem had a superior performance over the Telettra modem over this combined loop, even with the transmit level of the latter increased by 2 dB (see results of days 11 and 12/6). To investigate this aspect in more detail, comparative tests were performed separately over the Melbourne-Sydney and the Melbourne-Wagga Wagga sections. The Sematrans modem was only marginally better over each of these sections, causing us to speculate that the Telettra modem had a poorer eye pattern than the Sematrans modem after transmission via 5 through group filters. To check this hypothesis white gaussian noise was added in the laboratory to the received line signals after they had been transmitted over the loop and with the level of the noise sufficiently high to cause the majority of errors rather than noise on the line. The results of this measurement negated our hypothesis.

From the results obtained in the characterization tests on the modem (Section 4) a significant difference between the modems is the cut-off frequency of the PLL used to recover the 100 kHz pilot (Section 4.2). The Telettra modem would be more sensitive than the Sematrans modem to phase jitter or transients with frequency components in the range of 10-100 Hz. Furthermore, over the combined loop the group delay caused by five through-group filters would reduce the eye opening of the Telettra modem received line signal, making it even more sensitive to phase hits. It was thought that the difference in performance between the modems is due to the difference in their ability to track phase jitter or hits. Periodic phase jitter on the loop could not be the cause as it would have shown up in the test referenced to in the previous paragraph. Finally the phase hits only cause errors when the eye pattern has been degraded by transmission via 5 through group filters.

It is believed that the FDM terminal equipment on this co-axial bearer is an older design and possibly introduces significant phase jitter.

5.3 Melbourne-Perth

This loop of length 6768 km is over a microwave bearer. The error performance of this loop was poor for both modems; However, the Telettra modem does appear to perform significantly worse over this loop. This poorer performance could be explained using similar arguments as discussed in the previous Section.

5.4 Melbourne-Launceston

This loop of about 1200 km is over a microwave radio bearer. The error performance of this loop was poor for both modems, so no firm conclusions can be drawn. However, the results do indicate that the two modems gave comparable performance over this loop.

6. DATA AVAILABILITY AND ERROR PERFORMANCES OF TWO GROUPBAND LOOPS WITH THE TELETTRA MODEM

These results were obtained for the following two groupband loops:

- Melbourne-Adelaide (via Bordertown)
- Melbourne-Perth (extension of the above loop)

using the microprocessor-based data test set developed by Transmission Branch.

6.1 Melbourne-Adelaide Loop

The overall data performance of the Melbourne-Adelaide test loop between 15.6.79 and 28.6.79 is summarized on a weekly basis in Table 4. For this test period, the proposed availability and long-term error performance objectives for a long-haul DDN circuit segments, namely, 99.98% and 99.55% EFS, respectively, were close to being met. In addition, a high percentage (greater than 88%) of 15-minute intervals achieved the short-term objective of 99.1% EFS for a long-haul segment. Similar results were obtained for 1-hour intervals, but poorer results were observed for 1-day intervals.

The error characteristics of the test circuit during the previously mentioned period are represented on a weekly basis by the percentage histograms of bit error counts per error-second (BEC/ES) and of error-free-second runs (EFSR) in Figs. 2(a)-(b) and 3(a)-(b), respectively. These indicate that the majority of bit errors occurred in short bursts (3-4 bit errors) and that these error bursts were separated by about 100 error-free seconds on average.

It is believed that each of these bursts is due to a single decision error of the received 72 kbaud line signal and which is then converted to a triple error by the "self-synchronizing" descrambler in the Telettra modem. However, it is of interest to note that the BEC/ES 1-2 category contains a significant percentage of occurrences which is obviously higher than expected by the overlapping of triple bit errors at the beginning and end of an error-second. This can be explained by the fact that the bits errors are measured in the 64 kbit/s data stream which is formed by stripping off every 9th bit (service or housekeeping bit) of the 72 kbit/s received data. It is easy to show that for the particular 20-stage descrambler used in the V.36 compatible modem there is a 1/3 probability of any error bit in the triple error burst coinciding with a framing bit and hence converting the burst into a double bit error burst.

From the previous performance and error characteristic results, the equivalent bit error rate (BER) performance of the test loop can be readily estimated using the expression derived in Ref. 5. Fig. 4 illustrates the equivalent DDN BER performance objective for a long-haul segment operating at 64 kbit/s. Any BER results that are on or below the line labelled "Equivalent DDN BER Objective" are said to achieve the performance objective. It can be seen that the Adelaide BER results were close to meet this objective.

Comparison is also made on the data performance parameters obtained with the Transmission Branch test set and those monitored by the South Australian Administration with the Transmission Performance Tester (TPT). Reasonably good agreement was obtained with the data performance of the test circuit being dictated by one or a combination of the following impairments:

- Long/short interruptions (or breaks)
- Noisy bearer conditions.

Table 5 shows a comparison between the measured data unavailability results and the analogue interruptions recorded by SA. Although the total daily duration of these two types of events showed a reasonable agreement, their actual occurrence did not show a strong correlation (see Section 7).

6.2 Melbourne-Perth Loop

The overall data performance of the Melbourne-Perth test loop between 23.5.79 and 5.6.79 is summarized on a weekly basis in Table 6. For this test period, none of the proposed availability and long-term error performance objectives for a long-haul DDN circuit segment was met. In addition, an insignificant percentage of 15-minute intervals achieved the corresponding short-term error performance objective.

The error characteristics of the test circuit are represented on a weekly basis by the percentage histograms of BEC/ES and EFSR in Figs. 5(a)-(b) and 6(a)-(b), respectively. These indicate that the majority of bit errors occurred in groups of 5-8 within one error-second and that the error-seconds were separated by only 1 or 2 error-free seconds. This is in contrast to the Adelaide test loop (over a different period) where shorter error events (1-2 bit errors) were separated by longer error-free second gaps (about 100 on average). It is observed that the BEC/ES 1-2 category also contains a percentage of occurrence (as already explained in Section 6.1), but not to the same extent as the Melbourne-Adelaide test.

The total noise in the Melbourne-Perth loop groupband was measured to be -28 dBm0. The data transmit level of the modems is -6 dBm0 and allowing the received eye pattern to be at least half closed by the 5 through-group filters on this loop, there remains very little margin against errors due to additional noise. In a further report it is planned to discuss the implication of this small margin with respect to the fade margins on individual hops of the Melbourne-Perth loop.

The groupband noise has been broken up into the continuous and single frequency components as shown in Table 8. This indicates that at least half the noise is due to the spurious tones, probably carrier leaks.

The equivalent BER performances of the Perth loop over the two test weeks have been estimated and these are illustrated in Fig. 4. They do not meet the equivalent DDN BER performance objective for 64 kbit/s data rate.

Comparison of data performance parameters and SA analogue performance records is also made and similar conclusion is reached as in the Adelaide tests. In particular, Table 7 shows the comparison of the unavailability-related results. Note that a very large number of error-second outages occurred during the test and that these were mainly caused by sustained noisy conditions and/or frequent short interruptions (less than 10 seconds in duration) in the bearer concerned.

7. DISCUSSIONS AND SUMMARY

The results obtained in the modem characterizing tests indicate that the Telettra modem has significantly different characteristics than the Sematrans modem with respect to sensitivity to groupband phase jitter and AGC response time. The sensitivity of these modems to groupband phase jitter is primarily determined by the cut-off frequency of the PLL used to recover the 100 kHz pilot carrier in the modem receiver. In the Telettra modem this cut-off frequency is nearly an order of magnitude lower than the Sematrans, making it more sensitive to certain phase hits and/or phase jitter that may occur in the groupband circuit. This is considered to be the main reason why the Telettra modem performed slightly poorer than the Sematrans modem in some comparative transmission tests.

In comparing the interruption activity monitored by S.A. and the "breaks" detected by the Transmission Branch test set, it is apparent that there were some periods of uncorrelated activity between these two type of events (Tables 5 and 7). On the other hand, previously conducted comparisons of these two events using the Sematrans modem over the same groupband loops, but for a different test period, gave good correlation (Ref. 4). It is considered that the main reason for the uncorrelated results when using the Telettra modem is due to the long AGC response time of the modem; whereas in contrast, the Sematrans has a short AGC response time.

The results obtained in the data availability and error performance measurements for the period from 15.6.79 to 28.6.79 using the Transmission Branch test set over the Melbourne-Adelaide loop show that for a long-haul DDN circuit segment the proposed DDN objectives were nearly met. In comparison to previously conducted tests using the Sematrans modem, over the same loop, but for a different test period, the Sematrans modem performed marginally better (Ref. 4).

The recorded error characteristics of the Melbourne-Adelaide test circuit using the Telettra modem indicate that the majority of bit errors occurred in short bursts (3-4 bit errors), and that these bursts were separated by about 100 error-free seconds on average. This is in contrast to results previously obtained for the Sematrans modem where the bit errors occurred in bursts of 24 bit errors on average, and were separated by about 672 error-free seconds on average (Ref. 4).

The availability and error performance of the Melbourne-Perth loop for the period 23.5.79 to 5.6.79 using the Telettra modem was poor and did not meet the proposed DDN objectives. In particular, the availability of this circuit was low, due to the high proportion of error-second outages (Table 7). In previously conducted tests using the Sematrans modem the performance of the Melbourne-Perth loop was described as fair, although this test was for a different period. It should be noted that the Melbourne-Perth loop distance is over twice the maximum route distance for which DDN performance objective proposals apply. Furthermore, the route contains five through-group filters which is above the recommended number for both modems.

8. ACKNOWLEDGEMENTS

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9. REFERENCES

1. COXHILL, R., "Evaluation of a CCITT Recommendation V.36 Compatible Group Band Modem", Telecom Australia Research Laboratories Report No. 7271.

2. DUC, N.Q. and COXHILL, R.B., "A Microprocessor-Controlled Data Test Set: Facilities Aspects", Transmission Systems Branch, Paper No. 16, March 1979.

3. COXHILL, R.B. and WEBSTER, R.J., "A Microprocessor-Controlled Data Test Set : Hardware and Software Aspects", Telecom Australia Research Laboratories Report No. 7278, to appear.

4. DUC, N.Q., COXHILL, R.B. and ENGLISH, K.S., "Loop Performance of Two 72 kbit/s Groupband Data Circuits", Transmission Branch Paper No. 18, July 1979.

5. DUC, N.Q., "Estimation of Bit Error Rate from Error-Free Second Performance", Transmission Branch Paper No. 20, July 1979.

Test Route Section	Bearer	15-SGA No	SG No	G No	Group Used from Clayton to Lonsdale
Melbourne - Adelaide (via Bordertown)	SV602	-	8	2	3
Adelaide - Perth	WS601	-	9	2	N/A
Melbourne - Canberra	2RT2	1	5	2	4
Melbourne - Launceston (via Flinders Island)	TV605	1	11	2	5
Melbourne - Sydney	VN608	3	9	2	2
(Melbourne-Wagga Wagga)	VN607	1	15	2	

TABLE 1 Details of the Tested Groupband Circuits

15-SGA : 15-Supergroup Assembly
SG : Supergroup
G : Group

Note: Three through-group filters are used on the Adelaide, Canberra and Launceston loops while five filters are used on the Perth and Sydney-Wagga Wagga loops.

TE	PARAMETER	MELBOURNE-CANBERRA LOOP (1000 km)		MELBOURNE-SYDNEY MELBOURNE-WAGGA WAGGA LOOP (2600 km)	
		TELETTRA	SEMATRANS	TELETTRA	SEMATRANS
/5/79	Duration (hrs)	1	1	1	1
	Bit errors	7	823	572	0
	Block errors	2	7	206	0
	Carrier losses	0	1	0	0
	BER	$3x10^{-8}$	$3x10^{-6}$	$2x10^{-6}$	0
	BKER	$9x10^{-4}$	$3x10^{-3}$	$9x10^{-2}$	0
/5/79	Duration (hrs)	4.5	5	4	4
	Bit errors	4404	324	1444	1873
	Block errors	26	47	503	5
	Carrier losses	6	0	0	1
	BER	$4x10^{-6}$	$3x10^{-7}$	$2x10^{-6}$	$2x10^{-6}$
	BKER	$3x10^{-3}$	$4x10^{-3}$	$5x10^{-3}$	$5x10^{-4}$
/5/79	Duration (hrs)	3	5.5	4.5	3
	Bit errors	85019	383	*	10
	Block errors	87	39	1519	1
	Carrier losses	0	0	73	0
	BER	$1x10^{-4}$	$3x10^{-7}$	*	$1x10^{-8}$
	BKER	$1x10^{-2}$	$3x10^{-3}$	$1x10^{-1}$	$1x10^{-4}$
/5/79	Duration (hrs)	4.5	4.5	4.5	4.5
	Bit errors	336	96	123757	15
	Block errors	25	21	512	1
	Carrier losses	1	0	21	0
	BER	$2x10^{-7}$	$8x10^{-8}$	$1x10^{-4}$	$1x10^{-8}$
	BKER	$2x10^{-3}$	$2x10^{-3}$	$5x10^{-2}$	$1x10^{-4}$
/5/79	Duration (hrs)	4	3	3	4
	Bit errors	1192	290	7054	12
	Block errors	42	37	183	4
	Carrier losses	3	0	25	0
	BER	$1x10^{-6}$	$4x10^{-7}$	$1x10^{-5}$	$1x10^{-8}$
	BKER	$5x10^{-3}$	$5x10^{-3}$	$3x10^{-2}$	$4x10^{-4}$

Legend : BER = Bit Error Rate
BKER = Block Error Rate (Block length = 10^5 bits)
* = Overflow in Counter

Table 2 Comparative Error Performance of the Telettra 64 kbit/s Modem and the Sematrans 72 kbit/s modem on a daily basis

DATE	PARAMETER	MELBOURNE-CANBERRA LOOP (1000 km)		MELBOURNE-SYDNEY MELBOURNE-WAGGA WAGGA LOOP (2600 km)	
		TELETTRA	SEMATRANS	TELETTRA	SEMATRANS
21/5/79	Duration (hrs)	3	5	5	3
	Bit errors	1480	1537	1522	0
	Block errors	22	59	544	0
	Carrier losses	2	1	0	0
	BER	$2x10^{-6}$	$1x10^{-6}$	$1x10^{-6}$	0
	BKER	$2x10^{-3}$	$5x10^{-3}$	$5x10^{-2}$	0
22/5/79	Duration (hrs)	2	3	3	2
	Bit errors	13082	1934	1745	9
	Block errors	74	29	463	6
	Carrier losses	25	1	1	0
	BER	$3x10^{-5}$	$1x10^{-6}$	$3x10^{-6}$	$2x10^{-8}$
	BKER	$2x10^{-2}$	$4x10^{-3}$	$7x10^{-2}$	$1x10^{-3}$
23/5/79	Duration (hrs)	2	2	2	2
	Bit errors	761	809	1475	123
	Block errors	49	17	361	3
	Carrier losses	1	1	1	0
	BER	$2x10^{-6}$	$2x10^{-6}$	$3x10^{-6}$	$2x10^{-7}$
	BKER	$1x10^{-2}$	$3x10^{-3}$	$8x10^{-2}$	$6x10^{-4}$
25/5/79	Duration (hrs)	4	4	4	4
	Bit errors	4120	1340	1381	3
	Block errors	99	77	495	1
	Carrier losses	9	1	0	0
	BER	$4x10^{-6}$	$1x10^{-6}$	$1.5x10^{-6}$	$3x10^{-9}$
	BKER	$1x10^{-2}$	$7x10^{-3}$	$5x10^{-2}$	$1x10^{-6}$
28/5/79	Duration (hrs)	2	2	2 Note 1	2
	Bit errors	32	9	0	3
	Block errors	17	3	0	1
	Carrier losses	0	0	0	0
	BER	$7x10^{-8}$	$2x10^{-8}$	0	$6x10^{-9}$
	BKER	$4x10^{-3}$	$6x10^{-4}$	0	$2x10^{-4}$
29/5/79	Duration (hrs)	2	2	2	2
	Bit errors	5	399	10	0
	Block errors	2	51	4	0
	Carrier losses	0	1	0	0
	BER	$1x10^{-8}$	$8x10^{-7}$	$2x10^{-8}$	0
	BKER	$4x10^{-4}$	$9x10^{-3}$	$9x10^{-4}$	0
30/5/79	Duration (hrs)	3.5	4.5	4.5 Note 2	3.5
	Bit errors	3260	*	26	0
	Block errors	147	1540	2	0
	Carrier losses	3	3	0	0
	BER	$4x10^{-6}$	*	$3x10^{-8}$	0
	BKER	$2x10^{-2}$	$1x10^{-1}$	$2x10^{-4}$	0

Table 2 (cont)

Notes : 1. Melbourne-Sydney section only
2. Melbourne-Wagga Wagga section only

DATE	PARAMETER	MELBOURNE-CANBERRA LOOP (1000 km)		MELBOURNE-SYDNEY MELBOURNE-WAGGA WAGGA LOOP (2600 km)	
		TELETTRA	SEMATRANS	TELETTRA	SEMATRANS
31/5/79	Duration (hrs)	2	2	2 Note 2	2
	Bit errors	1233	2521	11	0
	Block errors	29	391	2	0
	Carrier losses	3	0	0	0
	BER	$3x10^{-6}$	$5x10^{-6}$	$2x10^{-8}$	0
	BKER	$6x10^{-3}$	$8x10^{-2}$	$4x10^{-4}$	0
1/6/79	Duration (hrs)	1	2	2	1
	Bit errors	15	*	1465	10
	Block errors	6	822	514	2
	Carrier losses	0	0	0	0
	BER	$7x10^{-8}$	*	$3x10^{-6}$	$4x10^{-8}$
	BKER	$3x10^{-3}$	$2x10^{-1}$	$1x10^{-1}$	$8x10^{-4}$
11/6/79	Duration (hrs)	3	4.5	4.5	3
	Bit errors	0	15	2445	0
	Block errors	0	3	810	0
	Carrier losses	0	0	0	0
Note 3	BER	0	$1x10^{-8}$	$2x10^{-6}$	0
	BKER	0	$3x10^{-4}$	$8x10^{-2}$	0
12/6/79	Duration (hrs)	3.5	4	4	3.5
	Bit errors	1076	8126	1332	199
	Block errors	2	8	414	38
Note 3	BER	$1x10^{-6}$	$8x10^{-6}$	$1x10^{-6}$	$2x10^{-7}$
	BKER	$2x10^{-4}$	$8x10^{-4}$	$5x10^{-2}$	$4x10^{-3}$
13/6/79	Duration (hrs)	2	2	2	2
	Bit errors	1384	9	*	297
	Block errors	75	3	*	47
	Carrier losses	3	0	0	0
Note 4	BER	$3x10^{-6}$	$2x10^{-8}$	*	$6x10^{-7}$
	BKER	$2x10^{-2}$	$6x10^{-4}$	*	$9x10^{-3}$

Table 2 (Cont)

Notes :
2. Melbourne-Wagga Wagga section only
3. Transmit level of Telettra modem increased by 2 dB
4. Transmit level of Telettra modem decreased by 2 dB

.TE	PARAMETER	MELBOURNE-PERTH LOOP (6768 km)		MELBOURNE-LAUNCESTON LOOP (1200 km)	
		TELETTRA	SEMATRANS	TELETTRA	SEMATRANS
6/79	Duration (hrs)	2.5	1.5	1.5	2.5
	Bit errors	*	854	*	*
	Block errors	1592	118	306	398
	Carrier losses	84	0	*	57
	BER	*	$2x10^{-6}$	*	*
	BKER	$3x10^{-1}$	$3x10^{-2}$	$9x10^{-2}$	$6x10^{-2}$
6/79	Duration (hrs)	3	5	5	3
	Bit errors	*	*	*	*
	Block errors	*	338	623	407
	Carrier losses	121	6	118	14
	BER	*	*	*	*
	BKER	*	$3x10^{-2}$	$5x10^{-2}$	$5x10^{-2}$
6/79	Duration (hrs)	5.5	4	4	5.5
	Bit errors	*	3650	8250	2369
	Block errors	2499	61	392	544
	Carrier losses	75	2	12	0
	BER	*	$4x10^{-6}$	$9x10^{-6}$	$2x10^{-6}$
	BKER	$2x10^{-1}$	$6x10^{-3}$	$4x10^{-2}$	$4x10^{-2}$

Table 2 (cont)

PARAMETER	TELETTRA	SEMATRANS	TELETTRA	SEMATRANS
	MELBOURNE - CANBERRA		MELBOURNE - SYDNEY MELBOURNE - WAGGA WAGGA	
ation (hrs)	28	35	30.5	27.5
Errors	110401	6540	138950	2045
ck Errors	426	333	4786	21
rier losses	47	5	48	1
	$2x10^{-5}$	$2x10^{-7}$	$2x10^{-5}$	$3x10^{-7}$
R	$7x10^{-3}$	$4x10^{-3}$	$7x10^{-2}$	$3x10^{-4}$
	MELBOURNE - SYDNEY		MELBOURNE - WAGGA WAGGA	
ation (hrs)	4	4	6.5	5.5
Errors	10	3	37	0
ck Errors	4	1	4	0
rier Losses	0	0	0	0
	$1x10^{-8}$	$3x10^{-9}$	$2x10^{-8}$	0
R	$4x10^{-4}$	$1x10^{-6}$	$3x10^{-4}$	0
	MELBOURNE-PERTH		MELBOURNE-LAUNCESTON	
ation	8	10.5	10.5	11
Errors	*	*	*	*
ck Errors	4091	517	1321	1349
rier Losses	159	8	*	71
	*	*	*	*
R	$2x10^{-1}$	$2x10^{-2}$	$6x10^{-2}$	$5x10^{-2}$

Legend : BER = Bit Error Rate
BKER = Block Error Rate (Block Length = 10^5 bits)
* = Overflow in Counter

TABLE 3 Overall Comparative Error Performance of the Telettra 64 kbit/s modem and the Sematrans 72 kbit/s modem

MELBOURNE-ADELAIDE(LOOPED) TELETTRA MODEM 64KBIT/S				% 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
15/ 6/79 - 21/ 6/79	98.81	99.92	99.34	88.68	88.23	42.90
22/ 6/79 - 28/ 6/79	98.51	99.98	99.52	94.85	95.29	28.70

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

Table 4 Availability and Error Performance of Melbourne-Adelaide 64 kbit/s Data Loop (15.6.79 - 28.6.79)

Day	Date	Duration (Sec)			Note
		Error Second Outages (ESO)	Carrier Failures	Analogue Interruptions (S.A. Report)	
166	15/6/79	0	0.04	1.10	
167	16/6/79	0	0.03	0.03	
168	17/6/79	0	0.06	0.04	
169	18/6/79	287	0.45	0.25	
170	19/6/79	109	28.58	0.24	
171	20/6/79	27	0.08	0.06	
172	21/6/79	52	0.17	0.21	
173	22/6/79	27	2.74	0	
174	23/6/79	0	0	8.10	1
175	24/6/79	0	0.06	0.03	
176	25/6/79	0	0	0	
177	26/6/79	61	0	0	
178	27/6/79	43	0.06	73.63	2
179	28/6/79	12	0.04	10.69	2

Table 5 Comparison of Unavailability-Related Results for Melbourne-Adelaide Loop

Notes:
1. Test of SA Transmission Performance Tester (TPT)
2. Fault on SA VF test circuits at Adelaide Carrier Centre.

MELBOURNE-PERTH(LOOPED) TELETTRA MODEM 64KBIT/S				% 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
23/ 5/79 - 29/ 5/79	97.77	52.21	30.21	0.00	0.	0.
30/ 5/79 - 5/ 6/79	91.37	41.29	29.48	0.01	0.01	0.

($)... IN THIS CALCULATION, ANY INTERVALS CONTAINING ERROR-SECOND OUTAGES ARE WEIGHTED ACCORDING TO THEIR AVAILABILITY PERCENTAGES.

(*)... FOR TRANSMISSION BRANCH USE ONLY.

Table 6 Availability and Error Performance of Melbourne-Perth 64 kbit/s Data Loop (23.5.79 - 5.6.79)

Day	Date	Duration (Sec)			Note
		Error Second Outages	Carrier Failures	Analogue Interruptions (S.A. Report)	
143	23/5/79	50226	0.39	0.05	
144	24/5/79	52808	1.28	0.16	
145	25/5/79	50235	8.71	1.85	
146	26/5/79	32617	0.42	0.15	
147	27/5/79	22880	0.01	1883.32	1
148	28/5/79	37588	685.94	1.97	2
149	29/5/79	36221	585.04	48.21	2 & 3
150	30/5/79	49474	22.61	0.08	
151	31/5/79	52129	30.46	12.71	4
152	1/6/79	49820	31.61	0.44	
153	2/6/79	41234	2.07	0.05	
154	3/6/79	44263	0.21	0.05	
155	4/6/79	31214	0.38	0.20	
156	5/6/79	56311	4.58	45.42	5 & 6

Table 7 Comparison of unavailability-related results for Melbourne-Perth Loop

Notes :

1. Planned outage (31 minutes) at Mt Bonython (SA). ESO and carrier failure information with the corresponding time interval has been excluded.
2. Data unavailability suspected to occur mainly in Russell-Lonsdale-Clayton section (Vic).
3. Suspected modem switching fault at Pt. Pirie (SA).
4. Testing at Mt Bonython (SA)
5. Fault caused by TV Switching between Perth and Northam (WA)
6. Data test period contains invalid intervals.

Spurious Tones or Single Frequency Components

Frequency (kHz)	Level (dBm0)
72	-33 to -36
74	-46 to -59
96	-33 to -43
104	-40 to -48
105.10	-48
108	-36 to -43

Note: Some levels shown above are time-varying. This is because the tones are in reality the sum of tones each of slightly differing frequencies (presumably carrier leaks at different locations) which beat-together.

Background (Continuous Spectral Density) Noise Component

Using a narrowband (500 Hz) bandwidth the continuous noise was measured in the band between each spurious tone and this was found to be constant. From the measured results the total background noise in the 49 kHz groupband was -33 dBm0.

Total Noise (Background plus Spurious Tones)

-28 dBm0

Table 8 Measured Power Levels of the Various Noise Components in the Melbourne-Perth Groupband Loop.

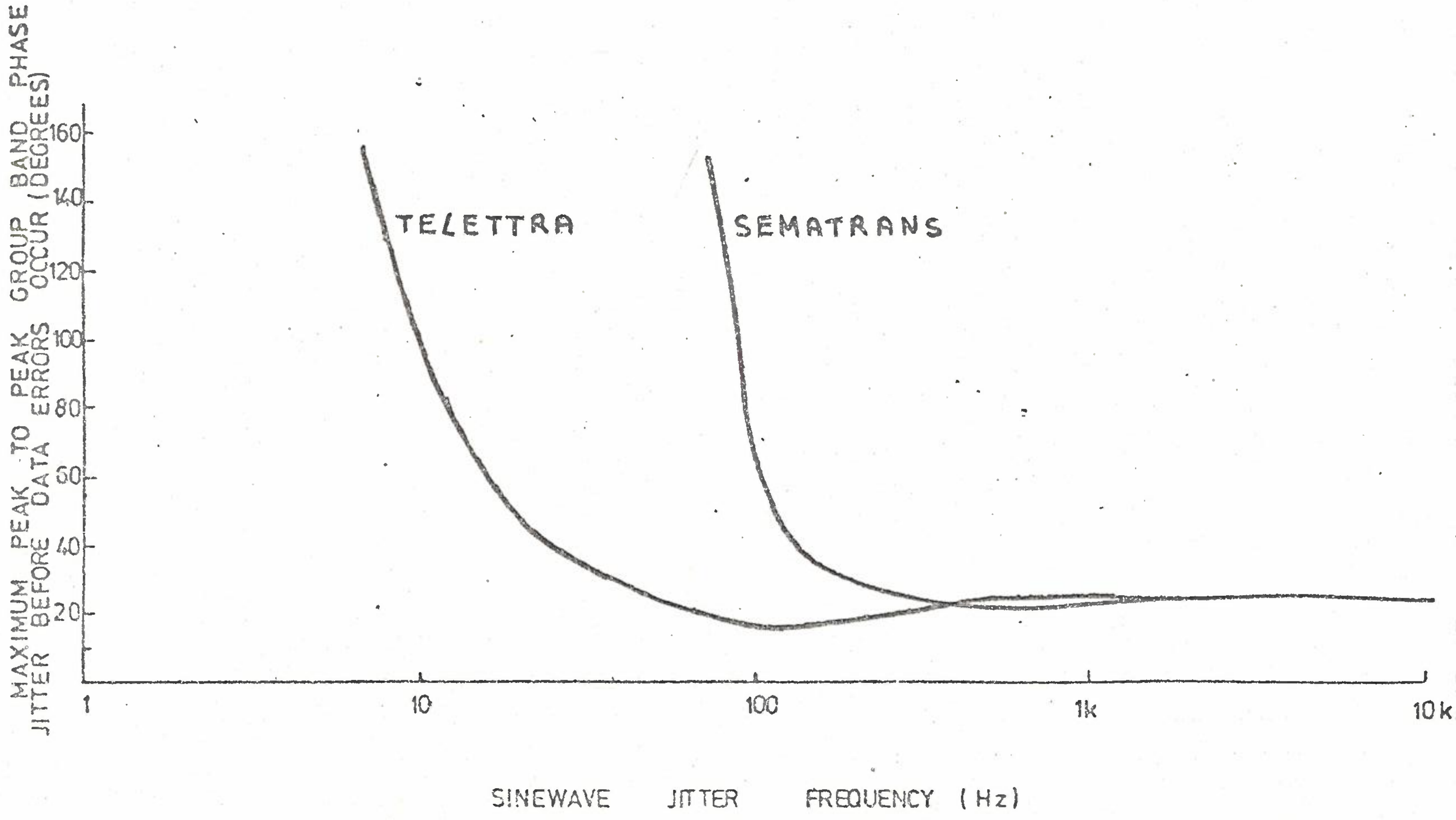
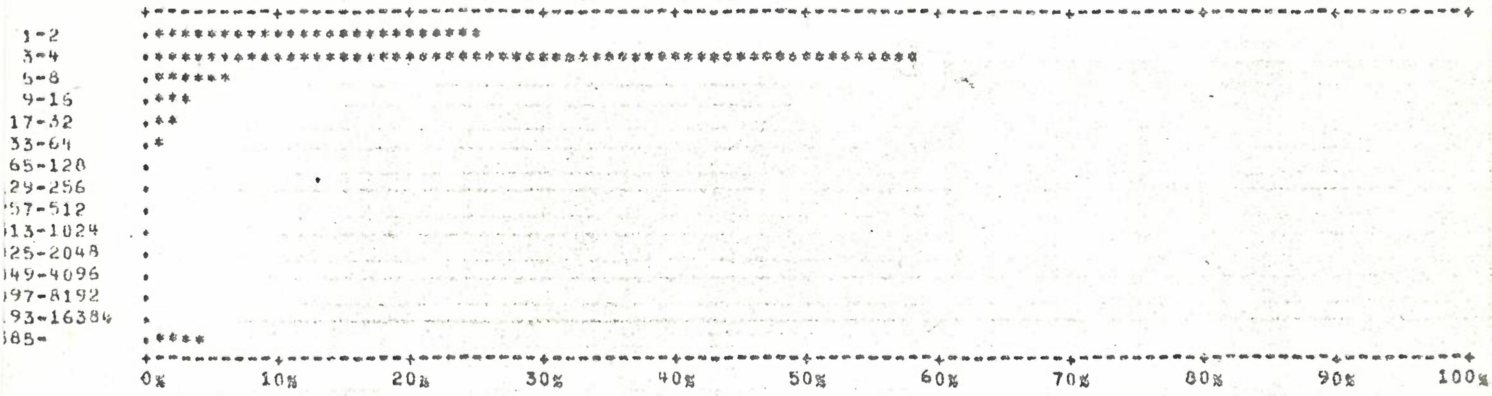


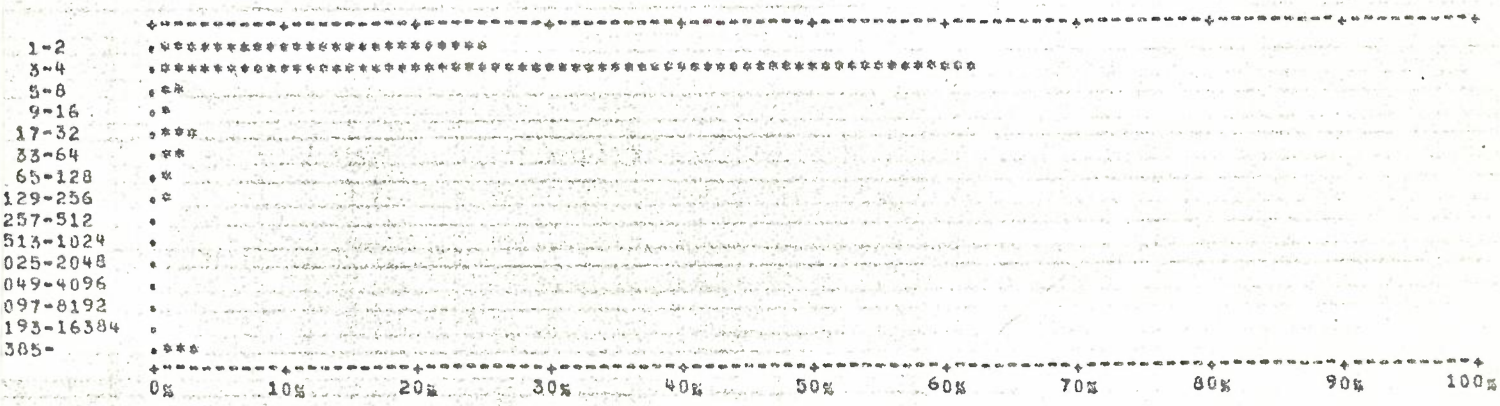
FIG.1 MODEM PERFORMANCE UNDER GROUP BAND PHASE JITTER CONDITIONS

(a) MELBOURNE-ADELAIDE(LOOPED) TELETTRA MODEM 64KBIT/S
DISTRIBUTION OF BIT ERROR COUNTS PER ERROR SECOND FOR THE PERIOD 15/ 6/79 - 21/ 6/79



MEDIAN RANGE OF BIT ERROR COUNTS = 3-4
TOTAL NO. OF ERROR SECONDS = 4393
TOTAL NO. OF AVAILABLE SECONDS = 597125
TOTAL NO. OF VALID SECONDS = 597600

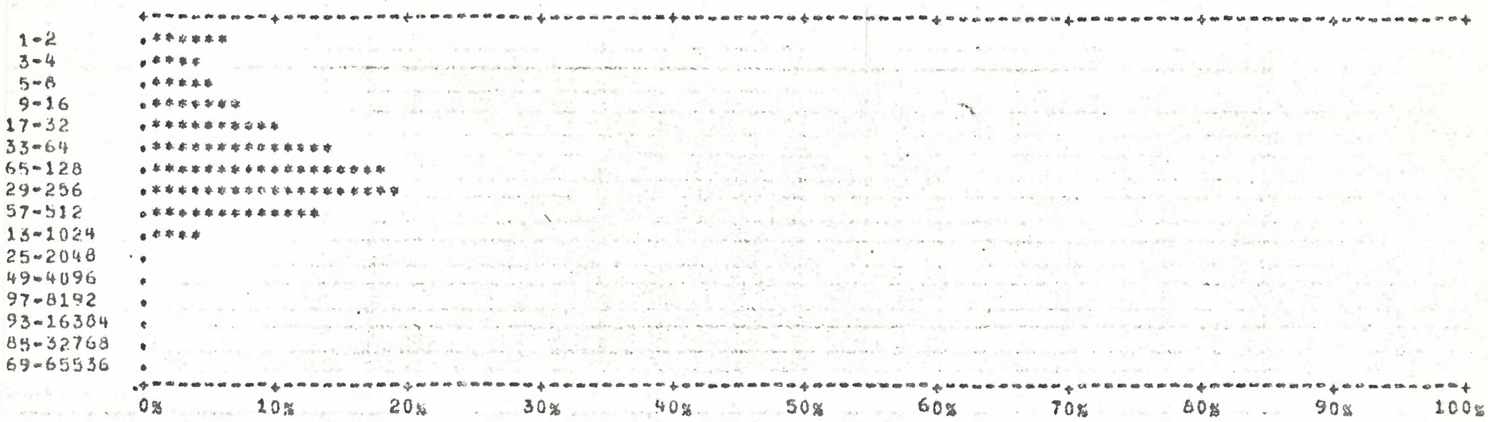
(b) MELBOURNE-ADELAIDE(LOOPED) TELETTRA MODEM 64KBIT/S
DISTRIBUTION OF BIT ERROR COUNTS PER ERROR SECOND FOR THE PERIOD 22/ 6/79 - 28/ 6/79



MEDIAN RANGE OF BIT ERROR COUNTS = 3-4
TOTAL NO. OF ERROR SECONDS = 2977
TOTAL NO. OF AVAILABLE SECONDS = 595657
TOTAL NO. OF VALID SECONDS = 595800

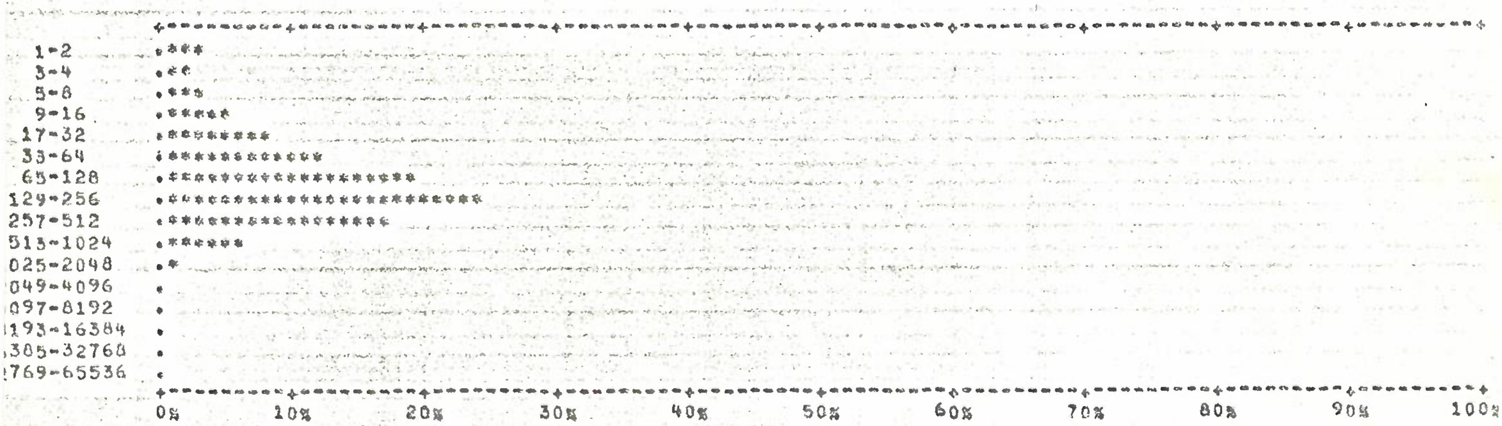
Fig. 2 Percentage Histogram of Bit Error Counts per Error-Second for Melbourne-Adelaide 64 kbit/s Data Loop

(a) MELBOURNE-ADELAIDE(LOOPED) TELETTRA MODEM 64KBIT/S
DISTRIBUTION OF ERROR FREE SECOND RUNS FOR PERIOD 15/ 6/79 - 21/ 6/79



MEDIAN RANGE OF ERROR-FREE SECOND RUNS = 65-128
TOTAL NO. OF E.F.S.R. = 4331

(b) MELBOURNE-ADELAIDE(LOOPED) TELETTRA MODEM 64KBIT/S
DISTRIBUTION OF ERROR FREE SECOND RUNS FOR PERIOD 22/ 6/79 - 28/ 6/79



MEDIAN RANGE OF ERROR-FREE SECOND RUNS = 65-128
TOTAL NO. OF E.F.S.R. = 3388

Fig. 3 Percentage Histogram of Error-Free-Second Runs for Melbourne-Adelaide 64 kbit/s Data Loop

FIG. 4

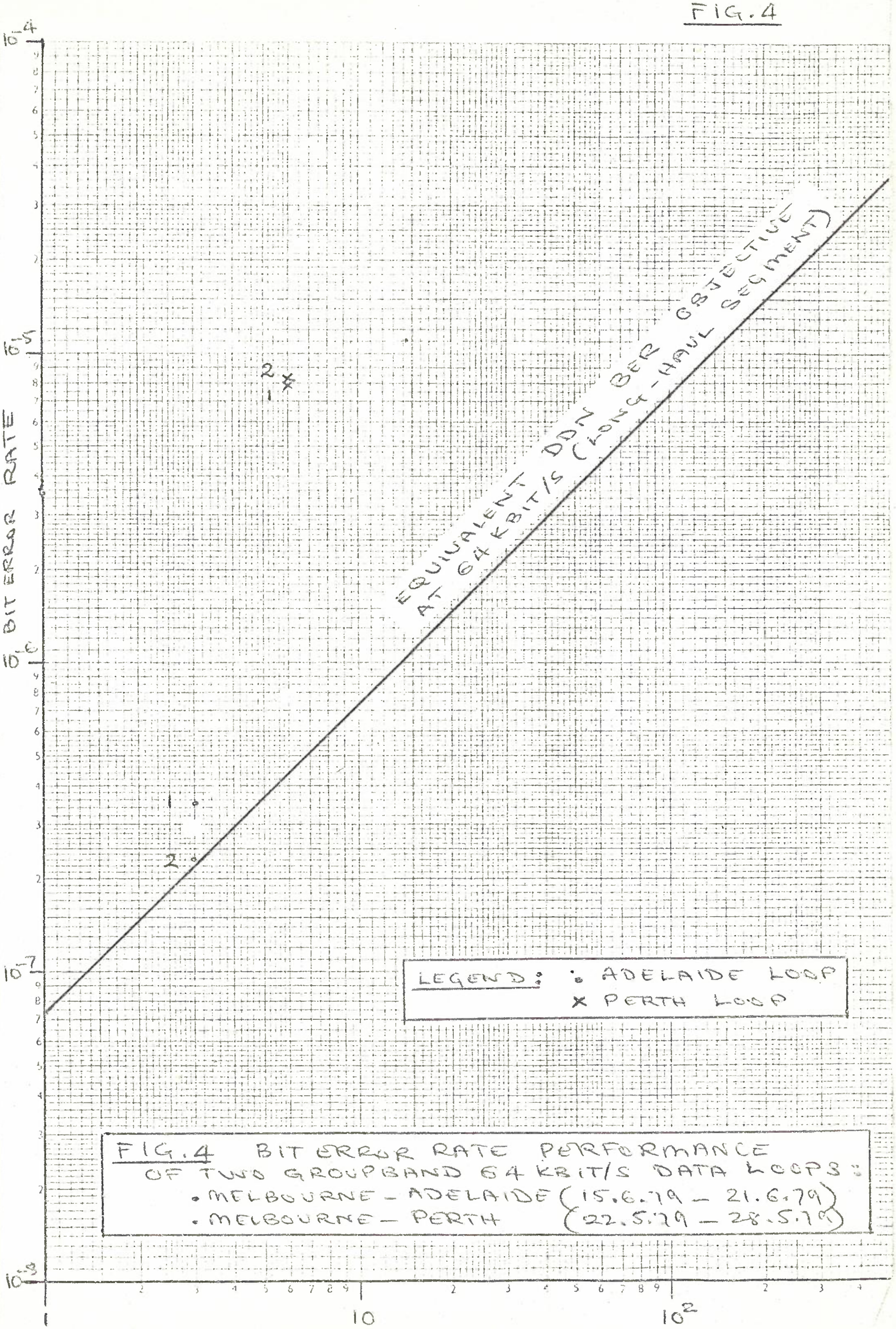
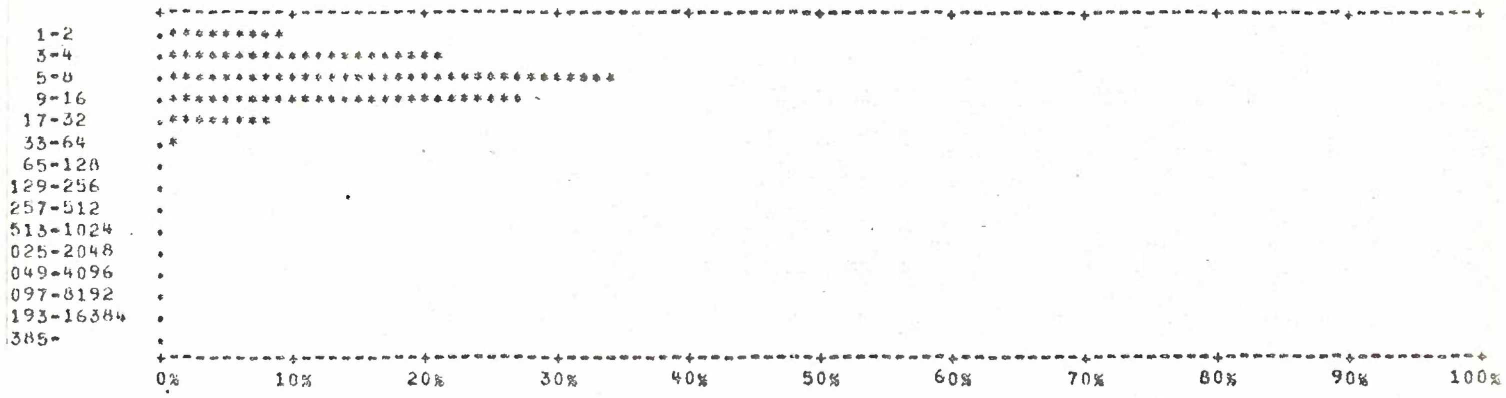


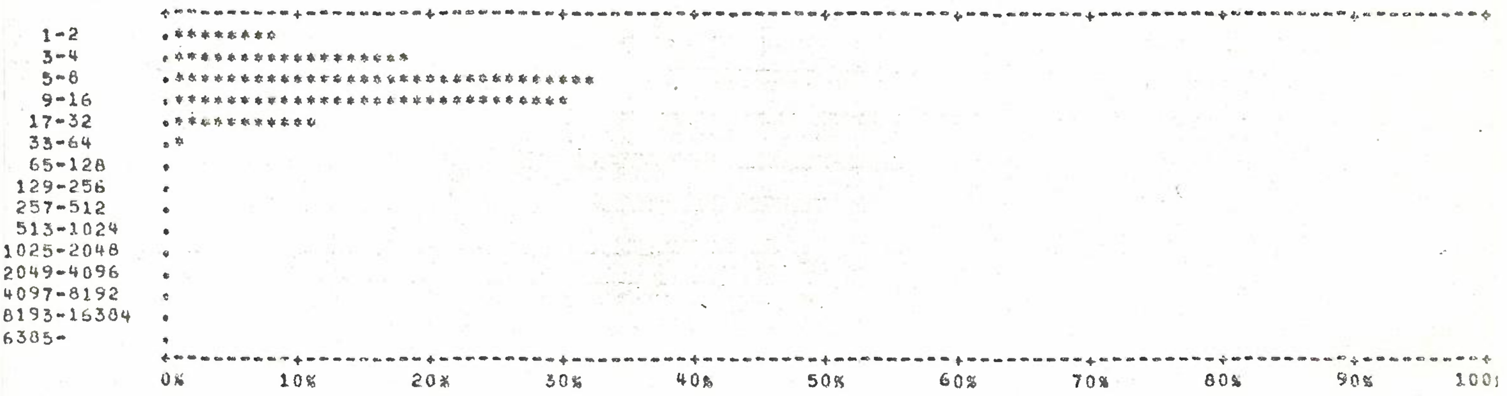
FIG. 4 BIT ERROR RATE PERFORMANCE OF TWO GROUPBAND 64 KBIT/S DATA LOOPS:
• MELBOURNE – ADELAIDE (15.6.79 – 21.6.79)
• MELBOURNE – PERTH (22.5.79 – 28.5.79)

a) MELBOURNE-PERTH(LOOPED) TELETTRA MODE4 64KBIT/S
DISTRIBUTION OF BIT ERROR COUNTS PER ERROR SECOND FOR THE PERIOD 23/ 5/79 - 29/ 5/79



MEDIAN RANGE OF BIT ERROR COUNTS = 5-8
TOTAL NO. OF ERROR SECONDS = 498045
TOTAL NO. OF AVAILABLE SECONDS = 308725
TOTAL NO. OF VALID SECONDS = 591300

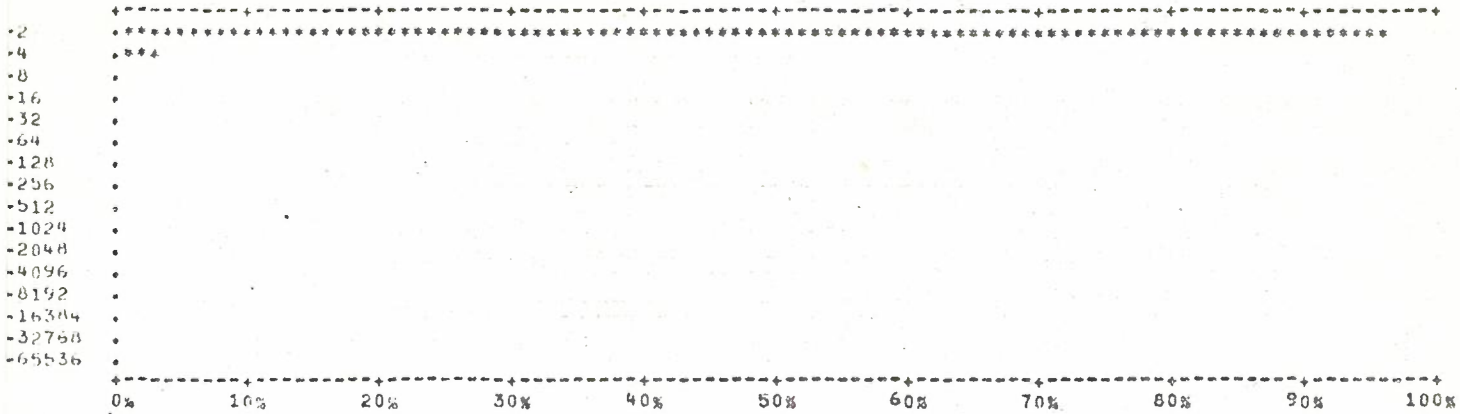
b) MELBOURNE-PERTH(LOOPED) TELETTRA MODEM 64KBIT/S
DISTRIBUTION OF BIT ERROR COUNTS PER ERROR SECOND FOR THE PERIOD 30/ 5/79 - 5/ 6/79



MEDIAN RANGE OF BIT ERROR COUNTS = 5-8
TOTAL NO. OF ERROR SECONDS = 485336
TOTAL NO. OF AVAILABLE SECONDS = 228155
TOTAL NO. OF VALID SECONDS = 552600

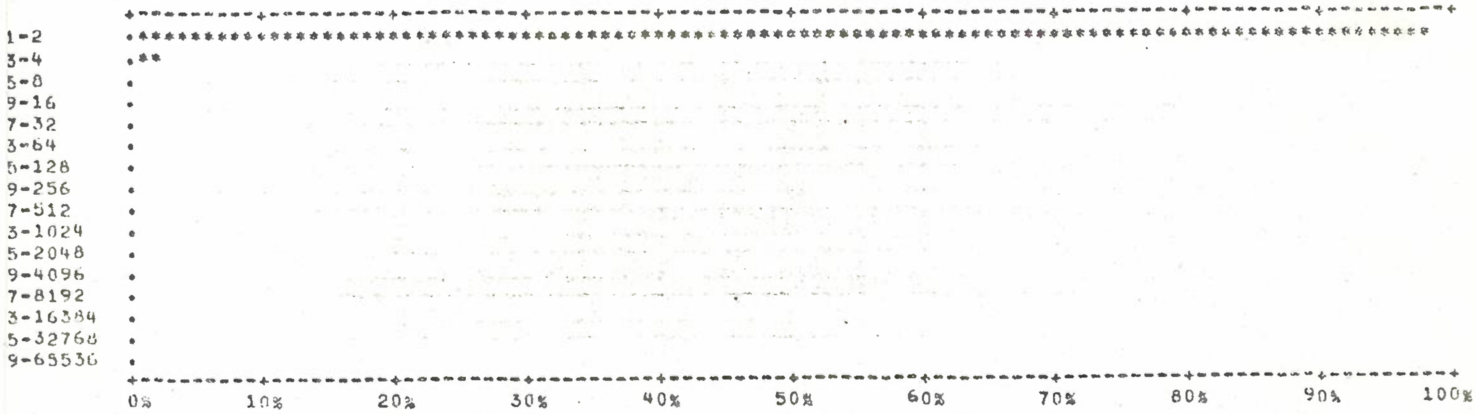
Fig. 5 Percentage Histogram of Bit Error Counts per Error-Second for Melbourne-Perth 64 kbit/s Data Loop

.) MELBOURNE-PERTH(LOOPED) TELETTRA MODEM 64KBIT/S
DISTRIBUTION OF ERROR FREE SECOND RUNS FOR PERIOD 23/ 5/79 - 29/ 5/79



MEDIAN RANGE OF ERROR-FREE SECOND RUNS = 1-2
TOTAL NO. OF E.F.S.R. = 76870

) MELBOURNE-PERTH(LOOPED) TELETTRA MODEM 64KBIT/S
DISTRIBUTION OF ERROR FREE SECOND RUNS FOR PERIOD 30/ 5/79 - 5/ 6/79



MEDIAN RANGE OF ERROR-FREE SECOND RUNS = 1-2
TOTAL NO. OF E.F.S.R. = 58231

Fig. 6 Percentage Histogram of Error-Free-Second Runs for Melbourne-Perth 64 kbit/s Data Loop