Génie Electrique

Electrical Engineering

REPORT ON THE PERFORMANCE EVALUATION OF THE MODIFIED IJF OQPSK MODEM OVER THE ANIK B SATELLITE

UNIVERSITÉ D'OTTAWA
UNIVERSITY OF OTTAWA

Submitted to:

COMMUNICATION RESEARCH CENTER
SPACE APLICATIONS

REPORT ON THE PERFORMANCE EVALUATION OF THE MODIFIED IJF OQPSK MODEM OVER THE ANIK B SATELLITE

PREPARED BY:

DOUGLAS W. PRENDERGAST, P.ENG.

ABSTRACT

This report is a record of the results taken during bit error rate (BER) measurements conducted at the University of Ottawa (U of O). The results include BER measurements in IF loop back, in RF loop back through the U of O test translator and through the satellite Anik B. A comparison with previously measured results for the IJF modem is also given.

INTRODUCTION

The purpose of the tests performed at the U of O was to determine if recent modifications made to the IJF modem circuitry would improve the modem's BER performance when measured over the satellite. Two periods of satellite test time were made available they were on the 5th and 8th November, both periods lasting from 1:00 pm to 9:00 pm.

All the results were measured using the same Up and Downconverters, and test equipment used by the U of O when the IJF modem's performance through the satellite was measured (ref. 1). The IJF modem used in these tests was identical (ie. 64 Kb/s, offset QPSK, IF: 70.13 MHz) except that various circuit modifications had been made to improve its IF loop back BER performance.

The test equipment set up for the satellite tests was the same as is shown in figure 2.

IF LOOPBACK TESTING

The test equiment set up is shown in figure 1 and it was identical to the set up used previously for modem evaluation. The measured results are shown below and have been plotted in figure 3.

Condition: pattern 2E20 - 1 IF loop back

Eb/No (dB)	BER
5.8	1.1 x 10E-2
6.8	4.7 x 10E-3
7.8	1.8 x 10E-3
8.8	5.2 x 10E-4
9.8	1.3 x 10E-4
10.8	2.4 x 10E-5
11.8	3.2 x 10E-6

RF LOOP BACK TESTING

BER test had been made through a 12/14 GHz test translator to obtain an indication of expected satellite BER degradation. It had also been possible to measure the phase noise degradation caused by the RF equipment by using the HP8901A modulation analyzer and thereby predict the expected BER degradation, in addition to actually measuring the BER degradation. Unfortunately due to the low input level required by the downconverter this phase noise characterisation could not be made. The input level to the downconverter has to be low to avoid overdriving amplifier stages within the downconverter and for this reason the phase noise contribution of the RF equipment then becomes indistinguishable from the thermal noise.

The measured BER results for the modem through the test translator are shown below and they have also been plotted in figure 3. The degradation in BER performance observed at the U of 0 was similar to the one observed therefore the phase noise contribution due to the RF converting stages although not measured quantitatively must have been very similar to the phase noise contribution of the RF equipment used in the tests

Conditions: pattern 2E20 - 1, RF loop back

EB/No (dB)	BER
8.2	1.4 x 10E-3
9.2	4.4 x 10E-4
10.2	3.3 x 10E-4
11.2	3.2 x 10E-5
12.2	6.2 x 10E-6

SATELLITE TESTING

After preliminary testing in the IF and RF loop back modes had been made 2 hours of satellite test time was left. The test equipment set up for the satellite testing is shown in figure 2.

During the course of the BER measurements and particularly at high Eb/No values, bursts of errors were observed. For example, when an Eb/No of approximately 14 dB was set which was giving a BER of about 10E-6, the measurement period was 10E7 bits wide and there were on average about one in three periods which contained an occurance where between 10 and 300 errors were suddenly observed. Where possible these measurement periods were excluded from the recorded results which are shown in Table 1 and have been plotted in figure 3.

The second satellite access period was used to measure in more detail the modem's performance at a BER of about 10E-6. The measurements began at about 1:30 pm, however, due to short term fluctuations of up to 10 dB and longer term variations of about 2 dB in the received signal level, valid results were not obtained until about 5 pm. This phenomenom had not been observed during the first satellite test. At about 5:00 pm the signal level and noise level variations which seemed to be caused by the downconverter (other satellite users were not observing any changes in level) stabilized which permitted the continuation of BER testing. The precaution of regularly calibrating the Eb/No was adopted during the course of the remaining satellite test period.

Table 2 is a record of the results measured on the satellite during the second test period. As usual in BER measurements, the data generator transmitted a predetermined number of bits (either 10E6 or 10E7). The number of errors that occurred during each measurement interval was recorded and the average BER was then calculated. The number of errors that occurred in each interval is shown in Table 2 and therefore an indication of the observed variation in BER is presented. (See figure 4)

There were periods of time when large bursts of errors were relatively frequent. The BER curves measured at these times always showed relatively large degradations from the test translator RF loop back performance even if the large batches of sudden errors were excluded from the results. Towards the end of the satellite measurement period, the BER performance became more and more stable and for extended periods of time large batches of errors were not observed. A BER measurement was therefore performed as quickly as possible during the quiet periods and the results which are included in Table 2 were plotted in figure 4; the result is almost identical to the RF loopback BER performance.

The received eye diagrams were continuously monitored during the course of the satellite measurement and were displayed on an oscilloscope in the form of a signal space diagram. When a large batch of errors occurred the signal space diagram was seen to quickly circle in the vicinity of the origin as though the input signal had momentarily disappeared.

TABLE 1

Condition: pattern 2E20 - 1, 1st satellite test

Eb/No (dB)	BER
7.9	2.5 x 10E-3
8.9	1.0 x 10E-3
9.9	3.2 x 10E-4
10.9	1.1 x 10E-4
11.9	2.9 x 10E-5
12.9	6.2 x 10E-6
13.9	1.4 x 10E-6

TABLE 2

Conditions: pattern 2E20 - 1, 2nd satellite test

Bits Transmitted	Eb/No (dB)	Errors measured	Average BER
10E6	7.4	3012	3.0 x 10E-3
10E6	8.4	1001	1.0 x 10E-3
10E6	9.4	382, 354, 348	3.5 x 10E-4
10E6	10.4	102, 120, 152, 154	1.2 x 10E-4
10E6	11.4	18, 28, 32, 32, 30, 24, 14, 38	2.6 x 10E-5
10E6	12.4	60, 38, 126, 20, 40, 6, 70, 26, 100, 48, 38, 56, 20, 30, 18,34, 67, 10, 24, 10, 6, 26, 30, 70, 60, 2, 12, 30, 14, 14, 12, 4, 2 2, 2, 0, 6	
10E6	11.7	16, 4, 19, 20, 6, 10, 12, 4, 14 10, 4, 12, 12, 14, 12, 2	
10E7	12.6	22, 22, <u>46</u> [4)], <u>165</u> [3)], <u>680</u> [2)]	1) 3.0 x 10E-4
10E6	12.6	6, 55, 4, 276, <u>301</u> [1)], 4, 4, 0, 6, 8, 4, 8, 10, 4, 4, 8, 4, 0, 4, 2, 6, 0, 0, 0, 0, 4, 2, 4, 0, 2, 2, 0, 2, 4, 0, 4, 6, 0, 0, 4, 6, 0, 2, 2, 0, 4, 0, 0, 0, 2, 2	2) 6.8 x 10E-5 3) 1.7 x 10E-5 4) 4.6 x 10E-6
10E7	12.6	28, 24, 22, 20	5) 2.3 x 10E-6
10E7	13.5	12, 10, 14, 10, 6, 16	1.1 x 10E-6

(The BER results 1) to 5) were plotted in figure 4 and they show the measured variation in BER at an Eb/No of 12.6 dB.)

RESULTS SUMMARY

Previous IF loop back tests results for the IJF modem have been considerably improved by the modifed IJF modem, as shown in figure 3. This improvement in test results also extends to both the RF loop back and the satellite link. Two items should be noted from the results. Firstly, the modified IJF modem's BER performance in RF loop back does not now tend to flatten off at high Eb/No. Secondly this effect was also not observed in the satellite BER measurement. A BER curve might, however, show this effect if measurements were made at a time when large bursts of errors were occuring.

There were two noise effects noted after 5:00 pm during the course of the second satellite measurements while measuring the Eb/No, both of which were not quantitatively defined and they were a short and a long term noise fluctuation. (The noise level was assumed to be the variable as the received signal which was monitored on a spectrum analyzer did not seem to change in level.) At certain times the noise floor seemed to contain higher peaks however no average increase in the noise floor was noted.

CONCLUSION

The modem's performance in IF loop back, in RF loop back and through the satellite have been improved by the changes made to the IJF modem. The improvements did not altogether make the modem perform as expected, as indicated by the RF loop back test because large BER degradations were still measured. There were periods of time when large batches of sudden errors occurred during the demodulation of the signal received from the satellite and these were responsible for the apparent degradation in modem performance. This unwanted effect was observed in both satellite test

This type of phenomenom would have a disasterous effect on the performance of error correcting circuitry as large bursts of errors cannot be corrected by conventional decoders.

Further testing of the IJF modem on the satellite is required so that more samples of the modem performance can be taken thus giving an indication of the source and nature of this unwanted effect. This effect could possibly be attributed to an equipment malfunction or even observer error however other independent observers (see ref. 2) have also indicated the non-Gaussian nature of a satellite channel, therefore such a conclusion would be dangerous.

During the course of the satellite measurements there were occasions when large batches of sudden errors did not occur. The conclusion could therefore be drawn that this effect is caused simply by the intermodulation interference produced by other satellite users. As suggested earlier, additional satellite testing using more sophisticated noise measuring techniques and using equipment more sophisticated than a power meter reading only average power is the recommended course of action.

REFERENCES

1. D. Prendegast et al, "IJF-OQPSK Modem Evaluation. Report on the Evaluation of the Spar IJF-OQPSK Modem".

2. C.Tsai and L. Kruz, "Viterbi Decoding for Impulsive Interference Satellite Channels", International Journal of Sat. Comms., Vol. 2, pp. 129-136 (1984).

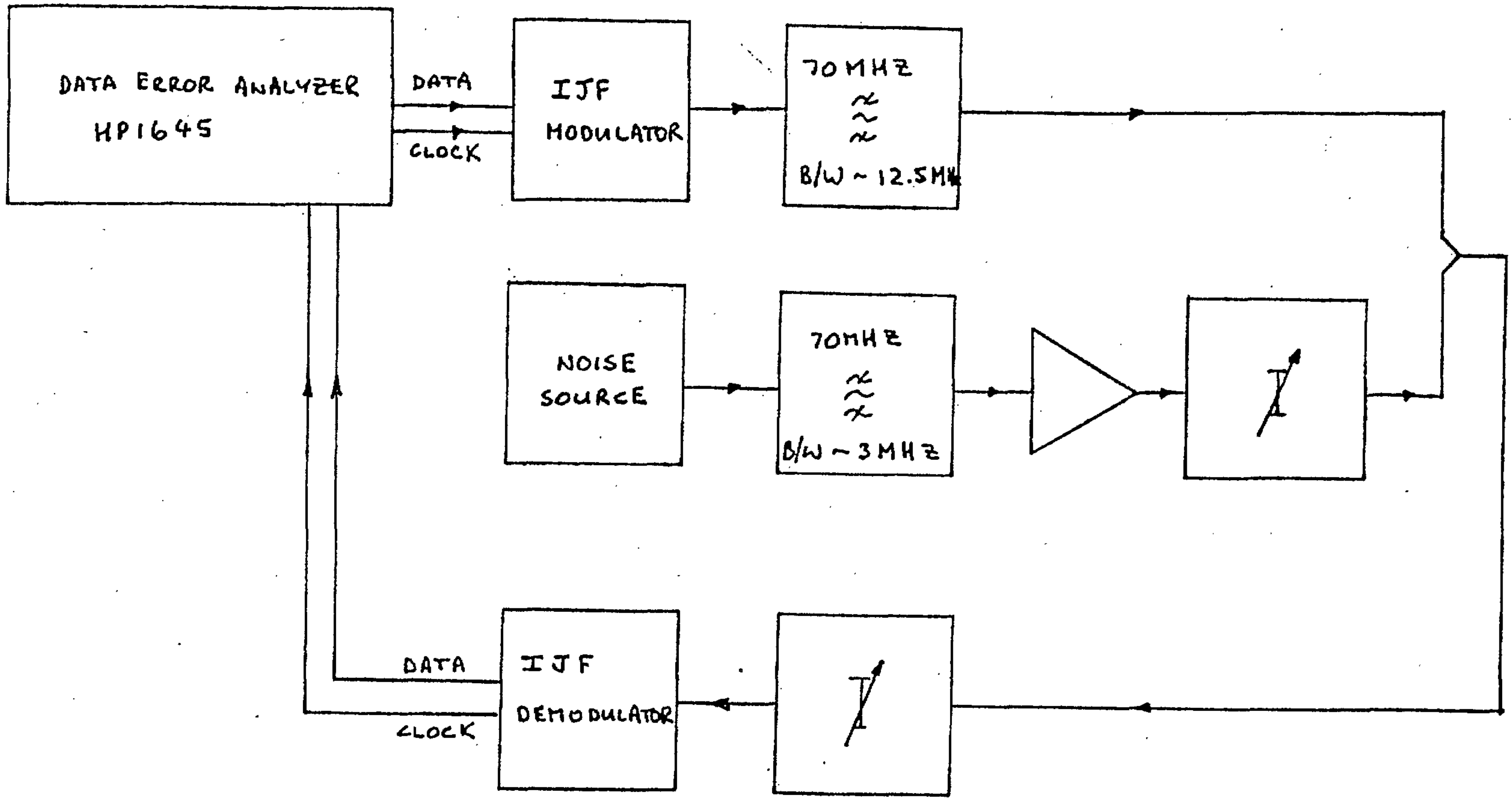
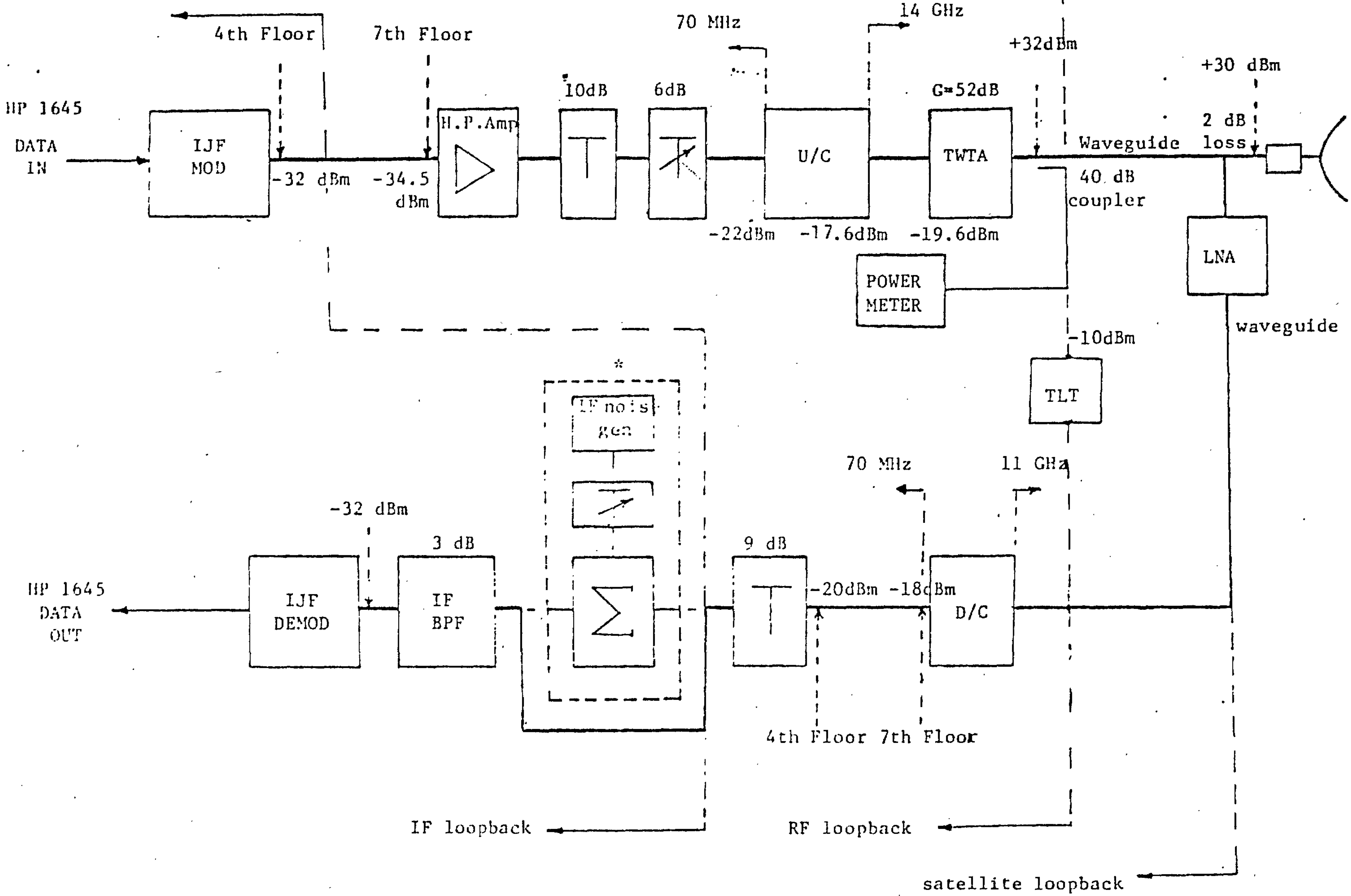


FIGURE 1 IF LOOPBACK TEST SET UP



All levels shown are per channel

*Used for IF loopback & RF loopback measurements

FIGURE 2 RF AND SATELLITE TEST SET UP

FIGURE 3 MODIFIED AND ORIGINAL IJF MODEM BER PERFORMANCE

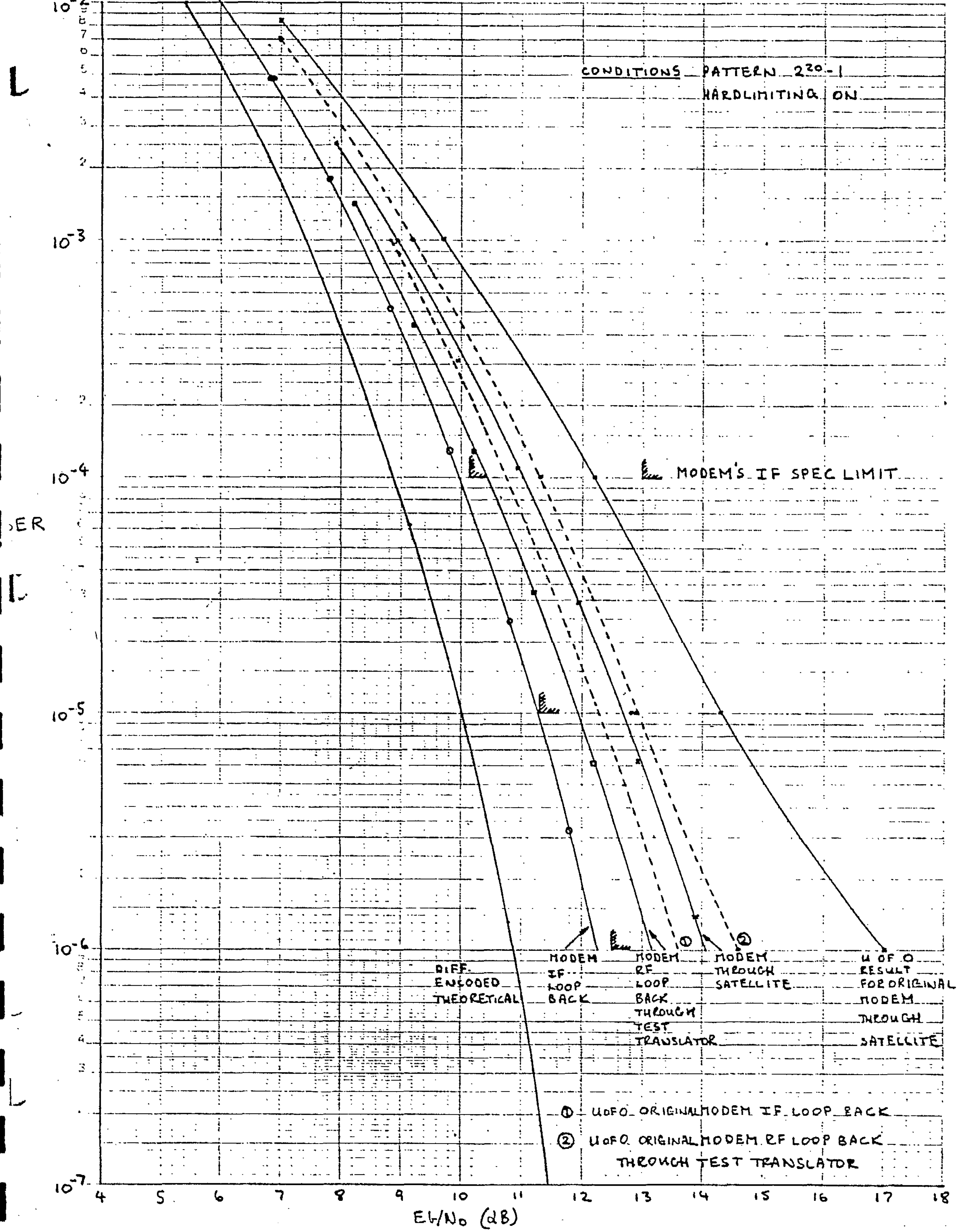


FIGURE 4 IJF MODEM BER PERFORMANCE MEASURED DURING A 'QUIET' PERIOD ON THE SATELLITE