REPORT 1158

# DATA COMMUNICATION IN THE MARITIME MOBILE SERVICES USING MF, HF AND VHF FREQUENCIES

(Question 76/8)

(19

## 1 Introduction

A service providing exchange of data between ships or oil rigs and coast stations could be provided in the MF, HF and VHF bands allocated to the maritime mobile service as an extension to existing services. This report details the results of trials conducted in the United Kingdom in providing medium speed (1200/2400 bit/s) data links using MF and VHF frequencies and of tests conducted in the German Democratic Republic carried out at a speed of 1200 bit/s on HF frequencies. Further tests will be conducted at speeds in the range of 300 to 2400 bit/s.

## 2. Background and Applications

Over recent years, there has been an increase in the use of computers and computerised equipment on board ships and oil rigs to handle stores, personnel and operational data. These data are sometimes required at shore based offices so it would be advantageous to provide data links to carry such information. A combination of radio link and land line can be used by employing existing MF, HF or VHF links into a coast station and interfacing to either leased lines or dial-up access to the Public Switched Telephone Network (PSTN).

## PART I: Data communication on MF and VHF

### 1. Trials

Trials were carried out in the United Kingdom to ascertain the viability of the service. The trials consisted of tests to establish the bit error rate followed by operational tests.

### 1.1 MF Data Trials.

#### 1.1.1 Error-Rate Tests.

##### 1.1.1.1 Details of Test.

A synchronous duplex data link was set up between a North Sea oil drilling rig approximately 200 km offshore and an oil company's office using an MF radio telephone link to a coast station and leased line. Multi-tone PSK HF data modems capable of operating at up to

2400 bit/s and conforming to the modulation scheme described in CCIR Report 864 [Volume III] were used at each end of the link. Data were sent in 400 bit blocks at data rates of 2400 and 1200 bit/s during day and night time hours and the corresponding bit and block error rates measured. The tests were repeated using standard CCITT V.22bis PSK line modems operating at 1200 bits per second to obtain a bench mark against which the performance of the HF data modems could be gauged. To obtain a true evaluation of the link, the measurements were taken without the use of error correcting equipment.

1.1.1.2 **Results**

The HF data modem tests results indicated the following bit error rates :-

| | | | | |
|---|---|---|---|---|
| 2400 bit/s | Day | $4.8$ in $10^5$ | to | $1.3$ in $10^4$ |
| | Night | $1.9$ in $10^4$ | to | $2.8$ in $10^4$ |
| 1200 bit/s | Day | $2.0$ in $10^6$ | to | $6.0$ in $10^5$ |
| | Night | $1.6$ in $10^5$ | to | $3.6$ in $10^4$ |

These error rates are well within the capability of any error correcting equipment and are significantly better than those measured for the standard PSK line modems for which bit error rates of between $2.2$ in $10^3$ and $1$ in $10^2$ were measured. The characteristics of the leased line caused some imbalance of the HF modem tone amplitudes which may have adversely affected the error rate so, had the HF modem been located at the coast station instead of the office, the overall error rates may have been improved.

1.1.2 **Operational Tests**

1.1.2.1 **Details of Tests**

A 1200 bit/s duplex asynchronous data link was set up between drilling monitoring equipment on a North Sea oil exploration rig approximately 250 km offshore and a computer sited in a drilling companies' office using a radio link to a coast station and a leased line as shown in Figure 1. ARQ units were used at each end of the link to provide error correction and asynchronous to synchronous conversion. In this test the land based HF data modem was located at the coast station and connected back-to-back with a V.22bis line modem. The office was equipped with a V.22bis modem. This configuration was more representative of an operational installation which would reduce the overall complexity by requiring one HF modem for the mobile and a standard line modem for the office instead of two HF modems. Access to any suitably equipped location via a PSTN link (instead of via a leased line) would then be possible.

Only limited quantative bit error rate tests were carried out, however, subjective observations of the drilling equipment data being received in the office indicated acceptable bit error rates during the day but poor bit error rates during the night.

1.1.2.2 Results

The poor performance of the link during the night was symptomatic of the poor propagation characteristics of the radio path at the frequencies used. This fact was borne out by the complete breakdown of reliable radio telex communications using similar frequencies during the same period. A choice of different frequencies during the night hours would have helped matters but operational restrictions precluded further tests.

## 1.2 VHF Data Trials

### 1.2.1 Error-Rate Tests

#### 1.2.1.1 Details of Tests

A synchronous duplex data link using a VHF Appendix 18 channel was set up between an oil tanker sailing from Southampton to Plymouth in the English Channel and a coast station at Niton on the Isle of Wight. Data modems used at each end of the radio link were standard CCITT V.22bis line modems employing Quadrature Amplitude Modulation (QAM) at 2400 bit/s and Phase Shift Keying (PSK) at 1200 bit/s. At various ranges, data were sent in each direction in $10^5$ bit test message lengths and the received antenna voltage and number of bit errors noted at each end.

#### 1.2.1.2 Results

The results indicated that at received antenna voltages above +10 dB(1uV emf) the bit error rates were generally better than 1 in $10^5$ (shore to ship) and 2 in $10^4$ (ship to shore). These received signal levels are similar to the minimum levels considered adequate for speech channels so it would be possible to operate speech and data services at similar ranges. It was observed during the trials that errors tended to occur in bursts due to various sources of noise interference, for example, static and adjacent channel working by nearby ships. These burst type errors can be overcome by using ARQ or forward error correcting techniques. A further problem was encountered at extremes of range when other ships tried to access the channel when they could not hear speech, thinking that the data transmission was noise. Such a problem should, however, reduce when ships become aware of the existence of VHF data transmissions.

### 1.2.2 Operational Tests

#### 1.2.2.1 Details of Tests

The VHF data link described in para 1.2.1 was extended via the PSTN to the tanker company's office. Two V.22bis modems connected back-to-back were added at the coast station to regenerate the data signals at the radio/PSTN line interface. This was found to be necessary to reduce data errors caused by noise on the radio or line path and cause maximum modulation of the transmitter at the coast radio

station independent of the received telephone line levels. The data communication software on board the tanker and in the office used an ARQ error correcting protocol with a block length of 128 characters. Data files from spreadsheet and wordprocessor packages were transferred in both directions and the correct receipt and number of re-transmissions observed.

1.2.2.2 Results

The received files contained no errors although it was noticed that some blocks repeated due to errors. This indicates the importance of using software with error correcting protocol. If ARQ error correction is used, the optimum block size used is influenced by the error rate and for high error rates it is best to use small blocks to increase the probability of transferring error free blocks. If forward error correction is used the character throughput will be reduced independently of the error rate but correction of all errors may not be possible. It is considered preferable for the users to incorporate the error correction at each end of the link rather than providing error correction at the coast station for just the radio path. The coast station interface then becomes transparent and gives the user flexibility to incorporate whatever method is best for the data concerned.

## 2. Future Tests

Further tests are required to investigate data over HF radio, digital facsimile transmissions over radio and access to offices and databases via the PSTN and Packet Switched systems.

## 3. Conclusions

Test results have indicated the possibility of achieving successful low bit error rate transmission up to approximately 250 km using terrestrial maritime radio frequencies and employing standard CCITT V series modems (at VHF) or multi-tone PSK HF data modems (at MF). At the coast station it is advisable to regenerate the data signals (using back-to-back modems) but not to provide error correction. Error correction is however recommended to be used over the entire link but this should be provided by the end users. Further tests are required to further investigate the effectiveness of data communication over longer ranges using HF frequencies and facsimile transmission using such data links.

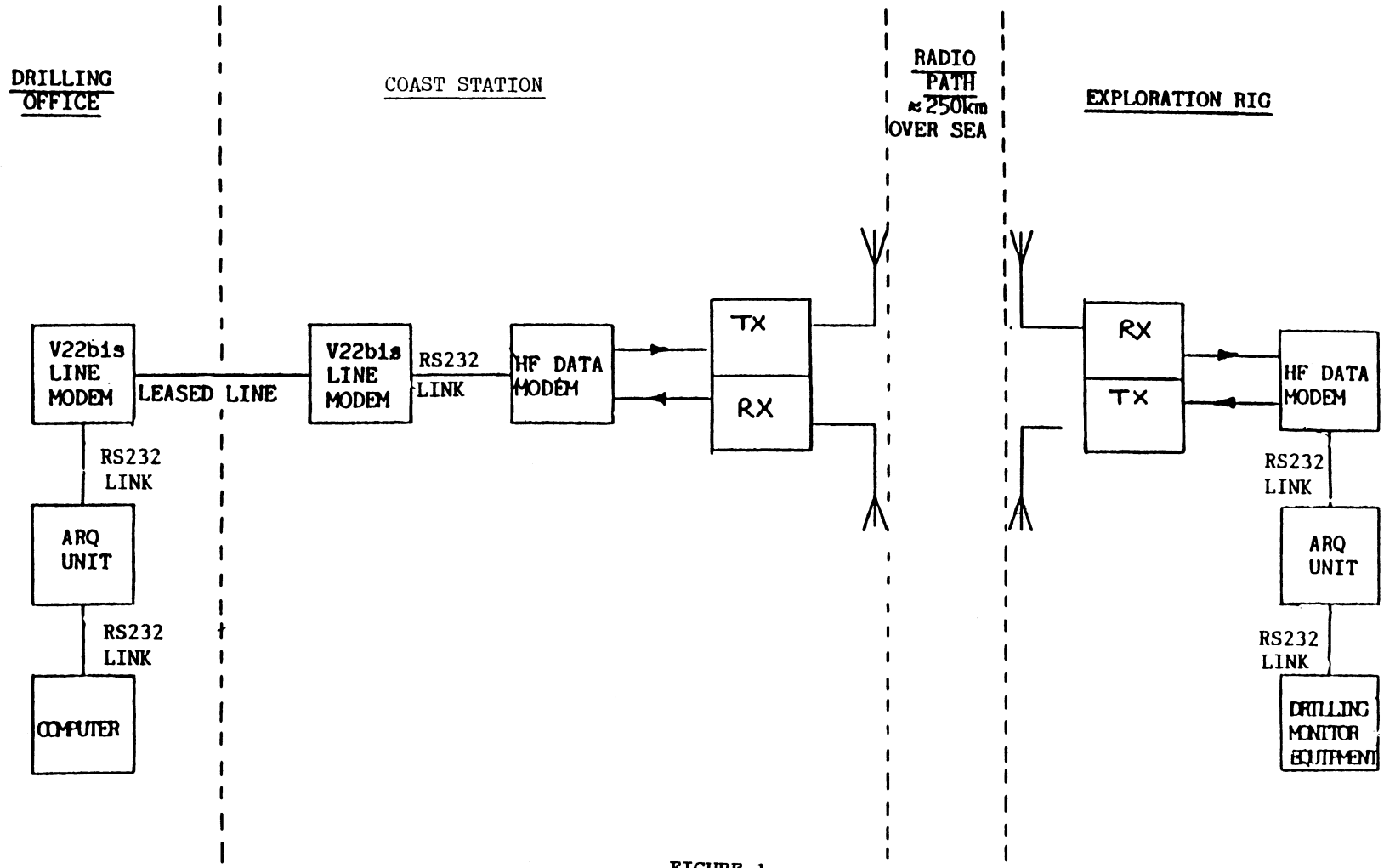


FIGURE 1

Block diagram of equipment used on MF data operational trials

PART II: Data communication on HF

1. Introduction

In the German Democratic Republic a data communication system has been developed and tested, which allows data transfer over long distances up to 15,000 km on HF channels, using speeds between 300 and 2400 bit/s.

2. System

A combination of a personal computer, a modem, an HF transmitter and HF receiver is used at coast- and ship-stations for data communication. Transfer of ASCII characters is possible as well as that of object codes. Protection of characters is performed by means of a transmission protocol specifically developed for HF data communications. An appropriate transmission speed may be selected between 300 and 2400 bit/s to optimize for channel quality and transmission distance.

3. Equipment

- personal computer (8 bit) with interface in accordance with CCITT Recommendation V.24 Interface (synchronous data transfer), 5.25" floppy disks;
- special HF data modem adjustable to 300, 600, 1200 or 2400 bit/s;
- standard HF transmitter and receiver.

4. Software

The software realizes a transmission protocol developed for the special requirements of HF communication. It contains elements of error detecting and error correcting methods and allows selective calling and communication.

The software is based on CP/M and is written in FORTH/ComFORTH. Compatibility exists up to 16 bit computers.

5. Transmission parameters

- HF bands 4, 6, 8, 12, 16, 22, 25 MHz;
- Transmission speed: 300, 600, 1200 or 2400 bit/s;
- Occupied bandwidth: 500 ... 3 000 Hz;

- Receiver bandwidth 2700 Hz;
- Class of emission: G2D;
- Two frequency simplex.

6. Synchronous data modem

- realizes the above-mentioned transmission speeds;
- subcarrier frequency: 1800 Hz;
- two-step phase shift modulation: 300, 600, 1200 bit/s (= Bd)
- four-step phase shift modulation: 2400 bit/s; (= 1200 Bd)
- Interfaces: in accordance with CCITT Recommendations V.2, V.26 alternative B, V.26bis, V.10 compatible to V.28, V.52, V.25.

7. Trials

Vessels of the German Democratic Republic are fitted with data communication equipment. This equipment is used in conjunction with standard transmitters and receivers. The system provides continuous radio communications between ships and shore.

The chosen transmission speed was generally 1200 bit/s. The influence of interference to HF communications upon the effective transmission speed can be clearly seen from the details of these data communications which are given in the annex.

ANNEX

| Date 1989 | Time of communication UTC | Distance km | HF-Band MHz ship/coast | chosen transmission speed bit/s | effective transmission speed bit/s |
|---|---|---|---|---|---|
| 22.5. | 1531-1540 | 11430 | 22 / 22 | 1200 | 375 |
| | 1544-1546 | 1695 | 16 / 17 | 1200 | 700 |
| 23.5. | 0952-0954 | 1695 | 12 / 17 | 1200 | 998 |
| 26.5. | 1520-1523 | 1695 | 12 / 17 | 1200 | 944 |
| 27.5. | 1459-1505 | 11430 | 22 / 22 | 1200 | 218 |
| | 1505-1510 | 11430 | 22 / 22 | 1200 | 324 |
| | 1736-1737 | 1695 | 17 / 17 | 1200 | 922 |
| 29.5. | 1007-1009 | 6825 | 17 / 17 | 1200 | 154 |
| | 1010-1013 | 6825 | 17 / 17 | 1200 | 221 |
| 31.5. | 1546-1547 | 1695 | 16 / 17 | 1200 | 1024 |
| | 1634-1636 | 13950 | 22 / 22 | 1200 | 341 |
| | 1850-1859 | 13950 | 22 / 22 | 1200 | 290 |
| 01.6. | 1009-1011 | 1695 | 12 / 16 | 1200 | 657 |
| | 1111-1116 | 1695 | 16 / 16 | 1200 | 751 |
| | 1133-1233 | 13950 | 22 / 26 | 1200 | 533 |
| | 1455-1508 | 11430 | 22 / 22 | 1200 | 447 |
| | 1602-1610 | 11430 | 22 / 22 | 1200 | 318 |
| | 1620-1621 | 1695 | 17 / 17 | 1200 | 1126 |
| 04.6. | 1528-1531 | 1695 | 16 / 16 | 1200 | 592 |
| 05.6. | 0857-0900 | 1695 | 12 / 17 | 1200 | 478 |
| 06.6. | 0807-0810 | 1695 | 12 / 17 | 1200 | 225 |
| | 1528-1529 | 11430 | 22 / 22 | 1200 | 68 |
| | 1549-1553 | 11430 | 22 / 22 | 1200 | 77 |
| 08.6. | 1114-1152 | 13950 | 22 / 22 | 1200 | 136 |
| | 1735-1741 | 13950 | 22 / 22 | 1200 | 219 |
| | 1805-1816 | 13950 | 22 / 22 | 1200 | 212 |
| 09.6. | 1513-1518 | 11430 | 22 / 22 | 1200 | 129 |
| 11.6. | 1527-1528 | 11430 | 22 / 22 | 1200 | 74 |
| 13.6. | 1530-1540 | 11430 | 22 / 22 | 1200 | 116 |
| | 1540-1541 | 11430 | 22 / 22 | 1200 | 119 |
| 14.6. | 1540-1541 | 11430 | 22 / 22 | 1200 | 85 |
| 22.6. | 1255-1256 | 6825 | 16 / 17 | 1200 | 239 |
| 23.6. | 1828-1829 | 6825 | 16 / 17 | 1200 | 239 |