REPORT 1027-1

ADAPTIVE CODING/DECODING METHODS FOR NARROW-BAND DIRECT-PRINTING EQUIPMENT

(Question 5/8)

(1986-1990)

1. Introduction

Narrow-band direct-printing equipment using ARQ and FEC modes (e.g. as described in Recommendation 476) has been in widespread use for a number of years and in general provides highly satisfactory performance. Under zero error rate conditions this type of equipment has a modulation rate of 50 Bd at the line input and output, compatible with the world-wide telex network. When conditions deteriorate, the effective throughput rate (in the ARQ mode) decreases until at a given point the equipment reverts to stand-by as a result of excessive ARQ cycling.

Document [CCIR, 1982-86a] based on an analysis carried out in the USSR, suggests an adaptive coding/decoding method for the ARQ mode which can increase the line modulation rate to 75 Bd under zero error rate conditions.

2. Technical and operational characteristics of narrow-band direct-printing equipment using the adaptive coding/decoding method in the ARQ mode

There are two methods for the transmission of information in the ARQ mode with automatic switching from one coding/decoding method to the other on the basis of a continuous analysis of the transmission rate in accordance with the sequences of control signals, namely ARQ3 and ARQ9, where:

- ARQ3 is the normal method described in Recommendations 476 and/or 625 in which each block consists of three information characters;
- ARQ9 is a method for the transmission of information in blocks, consisting of nine characters, with the following time parameters:
- block duration: 660 ms;
- transmission pause: 240 ms;
- operating cycle: 900 ms (Note 1).

The algorithm for the operation of narrow-band direct-printing equipment with an adaptive coding/decoding method is as follows:

2.1 Phasing and rephasing should be performed in the ARQ3 mode.

2.2 Switching from ARQ3 to ARQ9 (and vice versa) should be made automatically on the basis of an analysis of sequences of control signals CS1 and CS2 obtained on the return channel, as shown in the examples in Figures 1 and 2.

2.3 When switching over, the additional control signals shown in Table I are used.

Note 1 - To maintain a cycle duration which is a multiple of the cycle duration in ARQ3 (450 ms), three additional bits (30 ms) have to be added to the 9 characters of 7 bits each (9 x 70 ms = 630 ms) and the same 240 ms pause has to be used as in the ARQ3 mode. These three bits can be used for example for the sequential cyclical numbering of blocks from 0 to 7 (to detect block loss or insertion as a result of errors in the reception of control signals on the return channel).

TABLE I

Mode A	Signals transmitted
Control signal CS6	YBBYBBY
Control signal CS7	BBYBBYY

2.4 The Information Sending Station (ISS) groups the information in the ARQ9 mode into blocks of 9 characters (9 x 7 unit elements).

2.5 The ISS sends a 660 (9 x 70 + 30) ms block when using the ARQ9 method, after which there is a transmission pause of 240 ms.

2.6 The Information Receiving Station (IRS) sends 1 signal of 70 ms duration, consisting of 7 unit elements, after which there is an 830 ms pause in the ARQ9 mode.

2.7 On receipt of control signal CS7 in response to the transmitted combination "αβααβααβα", the ISS switches over to the ARQ3 mode and transmits a block of 3 characters.

2.8 A request for the repetition of a mutilated control signal is made by the ISS in the ARQ9 mode by the transmission of a block of 9 RQ signals.

2.9 A request for the repetition of a mutilated block is made by the IRS by transmitting the preceding control signal, in accordance with Recommendations 476 and 625.

2.10 Change in the direction of traffic flow in the ARQ9 mode

2.10.1 If the ISS is required to initiate a change in the direction of the traffic, it should send the signal sequence "↑", "+", "?". If necessary, "ß" signals are added to complete the block.

2.10.2 On receipt of a sequence of combinations "↑", "+", "?", the IRS sends control signal CS3 until signal sequence "ßαß" is received.

Note - The presence of the idle signals "ß" between the characters "+" and "?" should be ignored by the IRS.

2.10.3 If the IRS is required to change the direction of the traffic flow, it should send control signal CS3 until the signal sequence "ßαß" is received.

2.10.4 On receipt of the control signal CS3, the ISS sends a block consisting of the sequence "ßαßßαßßαß".

2.11 Switching over from the ARQ3 to the ARQ9 mode (and vice versa) is initiated by the ISS.

2.12 If in the ARQ3 mode in an interval of 128 control signals there are at least 103 sequences of control signals, the ISS sends the combination "αßß" to switch over to the ARQ9 mode.

2.13 On receipt of the combination "αßß" in the ARQ3 mode, the IRS sends control signal CS6 and switches over to the ARQ9 mode.

2.14 On receipt of control signal CS6 in response to the transmitted combination "αßß", the ISS switches over to the ARQ9 mode and sends a block of 9 characters.

2.15 If in an interval of 64 control signals and with the ISS in the ARQ9 mode, less than 34 control signal sequences or 16 successive mutilated control signals or blocks are registered, the ISS sends the combination "αßααßααßα" to switch over from the ARQ9 to the ARQ3 mode.

2.16 On receipt of the combination "αßα" in the ARQ9 mode, the IRS sends control signal CS7 and switches over to the ARQ3 mode.

2.17 On receipt of character sequence "ßαß", the IRS changes to ISS and sends either:

- an information block consisting of 9 RQ signals if it is the slave station; or
- one RQ signal if it is the master station,

until control signal CS1 or CS2 is received or until rephasing.

2.18 On receipt of just one RQ signal in response to a transmitted block consisting of the sequence "ßαßßαßßαß", the ISS changes to IRS and sends control signal CS1 or CS2.

2.19 The input and output of information from and into narrow-band direct-printing terminal telegraph equipment with the adaptive coding/decoding method should be effected at a transmission rate of not less than 75 bit/s (600 char/min).

2.20 Narrow-band direct-printing equipment using the adaptive coding/decoding method should be connected to 50 bit/s (400 char/min), networks (for example the telex network) via buffer stores at the line input and output.

3. Results of investigations

The effectiveness of the adaptive coding/decoding method in narrow-band direct-printing equipment was assessed in three stages.

3.1 The percentage of communication sessions during which the ARQ9 mode might be used was determined on the basis of statistical material (see Report 743-1) relating to the investigation of HF-channels in accordance with Recommendation 626 which was obtained during the period 1976-1988. The calculated results showed that the requisite value was 61%.

3.2 Between January 1986 and February 1987 ship/shore communications between the coast station Leningrad and the motor ship "Komsolosk" of the Leningrad-Cuba line were studied (see also Report 1026) and a stream of CS1 and CS2 control signal sequences was obtained using narrow-band direct-printing equipment in conformity with the specifications of Recommendation 476. Using this stream of data, it was assumed that the adaptive coding/decoding (ARQ3, ARQ9) method had been used with the equipment and the effectiveness of this hypothetical system was evaluated. It was considered that the system switched over from the ARQ3 to the ARQ9 mode if at least 103 control signal sequences were observed at an interval of 128 transmitted cycles (of 450 ms each), and that it switched back from the ARQ9 to the ARQ3 mode if not more than 34 control signal sequences were observed at an interval of 64 transmitted cycles (of 900 ms each). Finally, an evaluation was made of the information transmission rate in the ARQ3 mode on sections where ARQ9 operation was possible, the information transmission rate in the ARQ9 mode over the same sections and the total information transmission rate in the adaptive mode (ARQ3 and ARQ9).

Finally the following results were obtained:

- total number of blocks registered - 159424;
- mean information transmission rate in the ARQ3 mode on sections where ARQ9 operation was possible - 43.4 bit/s (347 char/min), and in the ARQ9 mode - 56.7 bit/s (454 char/min);
- transmission rate gain obtained by using the ARQ9 mode - 21%;
- time during which ARQ9 operation was possible - 67% of the total observation time.

3.3 To test the efficiency and evaluate the transmission rate of narrow-band direct-printing equipment in the adaptive mode, an adaptive narrow-band direct-printing equipment mock-up was tested in ship/shore communications between the coast station Leningrad and the motor ship "Anatoly Vasilev" of the Leningrad-Cuba line between December 1987 and February 1988. Notwithstanding the small size of the sample, the data obtained during testing of the mock-up operating in real channels confirmed the calculated and statistical evaluations of the efficiency of the adaptive method. On the basis of these tests, the following results were obtained:

- total number of characters transmitted - 102799;
- number of characters received in the ARQ3 mode - 62402;
- number of characters received in the ARQ9 mode - 40397;
- mean information transmission rate:
  - in the ARQ3 mode - 24.9 bit/s (199 char/min);
  - in the ARQ9 mode - 53.7 bit/s (430 char/min);
  - in the adaptive mode - 31.6 bit/s (253 char/min).

Transmission rate gain - 21%.

4. Conclusions

These investigations have shown that equipment using adaptive coding/decoding can be used efficiently in channels with a commercial quality of service, which according to the statistics may amount to 60% and more of the total. The information transmission rate increases on average by about 20%. Compatibility with existing equipment in conformance with Recommendation 476 and Recommendation 625 is maintained in the ARQ3 mode, however the advantage of the adaptive coding method can only be achieved if both stations (i.e. coast station and ship station) are equipped for this adaptive method.

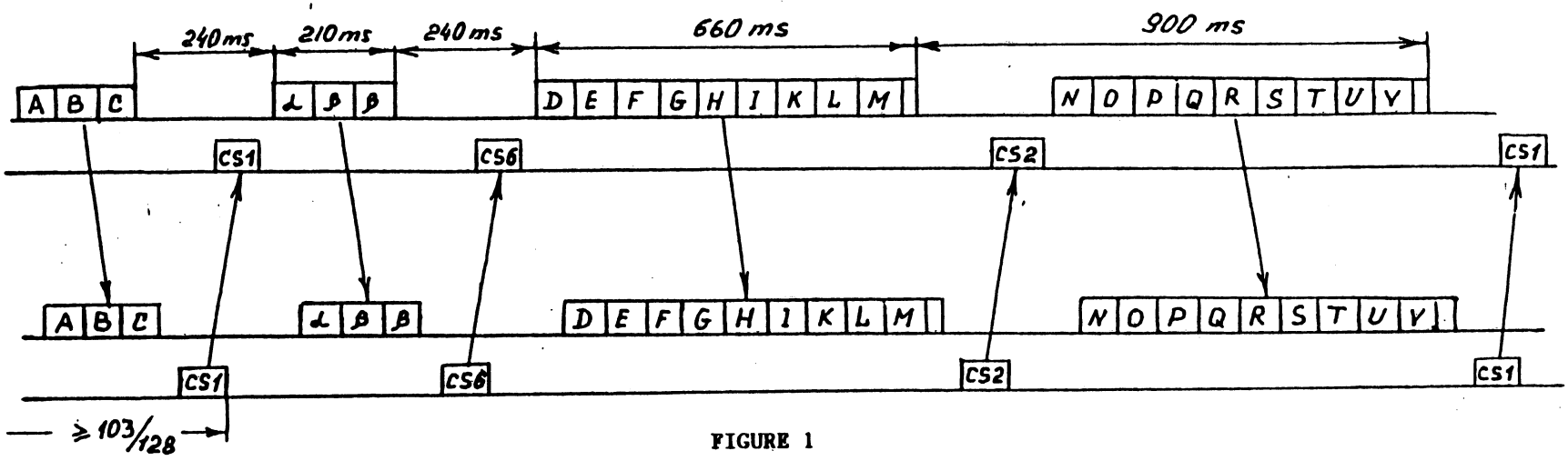

FIGURE 1

Example of change-over from ARQ3 to ARQ9 mode

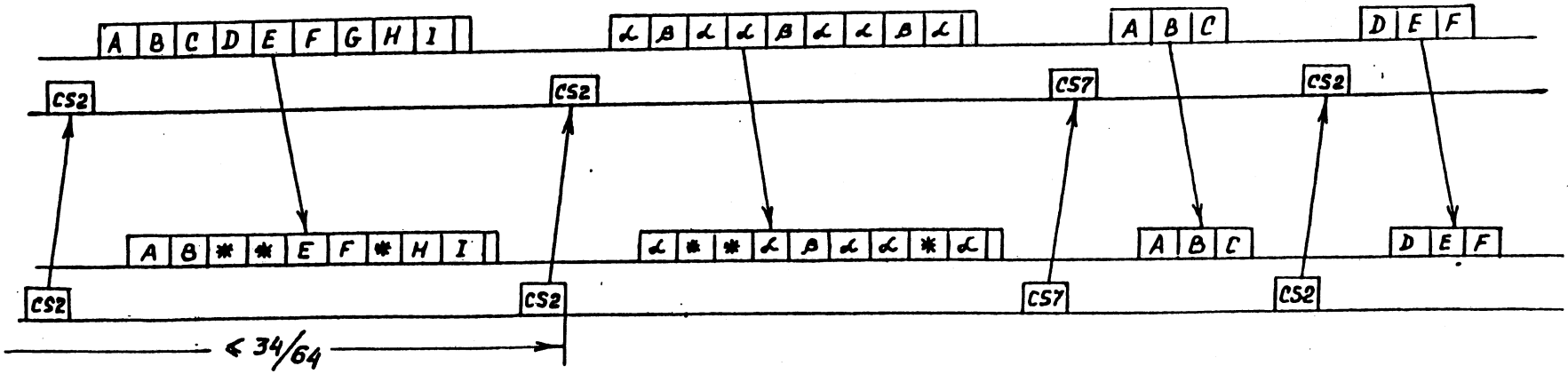

FIGURE 2

Example of change-over from ARQ9 to ARQ3 mode