The present invention relates to the field of the transmission of digital data and more particularly relates to a method for the transmission of this type of data in frame-organised messages, and the device for carrying out this method.

A network or a chain for conveying digital data requires, in general, a plurality of transmission media each exhibiting specific characteristics: radio links, links by means of wires, by means of optical fibres, etc...

It is known that radio links are affected by a relatively large number of errors, especially under certain limiting conditions, range limits, fading due to mobility or to atmospheric conditions or, more generally, to the environment, interferences or jammings. Furthermore, such radio links may be affected by large transmission durations, especially in the case of satellite links or of links requiring relays. The distribution of the errors combines a distribution in terms of isolated errors and a distribution in terms of error strings.

On the other hand, the links of the type involving links by means of wires or by means of optical fibres are affected by significantly lower error rates.

The subject of the present invention is a method for the transmission of digital data by frame-organised messages, the internal organisation of which is related to that described for the HDLC format in an article taken from ntz Archiv vol.6 (1984) No.7, pages 152 and 153, that is to say distinguishing the instruction frames from the data frames and in which a repetition of the frames not received may be carried out after a period of time to be set in order that there should be no useless repetition, but that at the same time there should be no ill-timed waiting. Thus, the method described in this article is fixed and does not permit adaptation thereof, for example, to variations in the quality of the link.

The method according to the invention provides the transmission of these data virtually without residual errors and rapidly, even when the network or the chain

employed to convey the data makes use of links of poor quality, or modifies the transmission chain. Such a modification or "reconfiguration" of the transmission chain is reflected, in fact, by cut-offs, with or without loss of information.

In order to obtain this result, the method for the transmission of data according to the invention is adaptable in its characteristics as a function of the quality of the link: it combines a plurality of techniques for the correction and/or protection of the transmissions, this combination being adapted at each instant to the quality of the link. These techniques, which are known per se, are principally:

- the use of error detection-correction codes, the errors being detected and corrected by autocorrelation;
- the repetition of the transmitted frames;
- the interlacing of the transmitted frames;
- the selective retransmission of the frames which have been improperly received.

However, according to the invention, these various characteristics are combined in order to obtain at each instant the best efficiency of transmission and the greatest possible speed compatible with this quality at this instant.

According to the invention, the method for the transmission of data by frame-organised instruction messages or data messages via duplex links between transmitter-receiver stations is characterised

in that in each instruction message a source station acting as transmitter transmits frames which are composed of an information string containing the kind of an instruction and the corresponding data, and in each data message frames composed of N information strings each containing a string of data and the associated order number, and in that the transmission of each message, prior to the transmission of the following message by the source station

- gives rise to the transmission of discharge

frames by the addressee station, in which the kind of the instruction, in the case of an instruction message, and the numbers of the data strings which have been properly received, in the case of a data message, are retransmitted to the source station,

and gives rise, when the source station receives these discharge frames, to the repetition of the instruction message if the corresponding discharge frame has not been received, and to the selective repetition of the frames composed of the data strings whose numbers have not been detected in the discharge frames,

in that each message is composed of k.N elementary frames, with k elementary frames forming a superframe, and N being the length of the messages counted in terms of superframes, each superframe consisting of k_1 interlaced elementary frames comprising different information strings, each being repeated k_2 times, with $k = k_1 + k_2$,

in that the discharge frames and the messages constituted of discharge frames have the same formats as respectively the frames and the instruction and data messages whose proper reception they indicate,

and in that the decision relative to the proper or improper reception of the instruction and data frames in an addressee station and of the discharge frames, in the source station are obtained by a majority vote on the frames repeated for each type of message.

The subject of the invention is also a device for carrying out this method, the transmitter and receiver parts of this device being capable of being easily constructed in digital form.

The invention will be better understood and further features will become evident with the aid of the description which follows, with reference to the accompanying figures:

- Figure 1 represents the transmission part of a transmitter-receiver according to the invention;

- Figure 2 represents the reception part of a transmitter-receiver according to the invention;

- Figures 3, 4, 5 and 6 represent organisation charts which illustrate the method of transmission according to the invention.

The transmission device according to the invention comprises transmitter-receivers each having a transmission part and a reception part. For a given link, a transmitter-receiver operating as transmitter makes use of its transmission part to send the frames constituting the message, while it makes use of its reception part to receive the frames referred to as receipt frames as explained hereinbelow. Conversely, a receiver station makes use of its reception part to receive the frames constituting the expected message, while it makes use of its transmission part to return the discharge frames corresponding to the acquired message frames. Each of the stations is, of course, capable of fulfilling the role of transmitter station or of receiver station depending upon the transmission direction, in a duplex link.

The description which follows of Figures 1 and 2 representing respectively the transmission and reception parts of the transmitter-receivers according to the invention will subsequently permit the detailed description of the method of transmission of digital data according to the invention. The central element of the transmission part is a transmission instruction circuit 1 which manages a memory 2 by means of an address pointer 3. The transmission instruction circuit is also connected to the instruction input of a frame generator 4, the data input of which is connected to the corresponding data output of the memory 2; this frame generator is connected to an encoder 5 which receives the data emanating from the memory 2 via the frame generator and reconstructs them for it after encoding. The encoded frames are then transmitted to a repeating and interlacing circuit 6 which is connected to the output of the frame generator; the output of the interlacing circuit is connected to a transmission device 7. The adaptation circuits which are appropriate to the electrical nature of the transmission network have not been shown.

The data memory 2 is divided into two zones, the one referenced 8 constitutes the buffer of the data to be transmitted, and the other referenced 9 constitutes the buffer of the data for monitoring the message.

With each data string "PQ(D_i)" or instruction string "PQ(C_i)" there is associated in this memory a bit "ACK(D_i)" or "ACK(C_i)" indicating whether the string under consideration has or has not been "discharged", that is to say considered as properly received, by the receiving terminal.

The transmission pointer 3 may address independently in read the "data" field of a string, and in write the "discharge" field of a string.

This assembly may be constructed by means of discrete integrated circuits, it being organised as a sequencer encoder, or by means of a computer or microprocessor executing a recorded program and having recourse to its own resources or to resources added to ensure the encoding and framing functions. The memory may be a memory with simultaneous read and write, or may make use of the random access memory of the computer or of the microprocessor, in time-sharing mode.

Figure 2 shows the reception part of a transmitter-receiver according to the invention. A reception device 10 transmits the detected data to a disinterlacing circuit 11, the output of which is connected to a correlating circuit 12. The correlating circuit reconstructs decoded frames which it transmits to a decision circuit 14 operating according to a majority vote principle, as will be explained hereinbelow. This circuit 14 indicates the numbers of the frames received to a reception instruction circuit 15 which generates and transmits to the transmission part a command to send a discharge receipt for these frames. The decoded data emanating from the decision circuit are transmitted to a memory 16 addressed by the reception instruction circuit 15. This memory 16 is divided into two zones, in the same manner as the memory 2 in the transmission part, the first zone referenced 17 constitutes the buffer of the data

received, and the other referenced 18 constitutes the buffer of the instruction data. With each memory zone intended for the storage of a data string, there is associated a zone of 1 reception indicator bit R.

The decision circuit 14 is further connected to an annexe memory 19 for the frames which are not accepted on first reception. This memory permits the use of the frames obtained in the course of a first reception together with those received in the course of the following reception, in the decision circuit 14. The reception instruction circuit 15 has an output connected to a corresponding input of the decision circuit 14, to instruct, if appropriate, a modification of the conditions of decision of the "majority" vote. The correlating circuit 12 is further connected to the input of a circuit 20 for measuring the error rate, the output of which is connected to an instruction input of the reception instruction circuit 15. This circuit 20 for measuring the error rate receives indications of correction of errors from the correlating circuit 12 and supplies to the reception instruction circuit 15 the information necessary to instruct the suppression or, on the other hand, the re-establishment of a redundancy applied to the transmission with respect to the frames. This operation linked to the method of transmission according to the invention will be explained in greater detail hereinbelow.

In the same manner as on transmission, the reception function may be provided by means of discrete integrated circuits organised as a sequencer-decoder, or by means of a computer or microprocessor executing a recorded program, and having recourse to its own resources or to resources added to ensure the functions of deframing and of decoding.

In a general way, the transmission of data from a transmitter-receiver station acting as transmitter to a transmitter-receiver station acting as receiver is performed in the following manner, via a duplex channel: the connection is established between the terminals in

accordance with the customary signal transmission protocols, which are specific to the communication network, and which will not be described here. The exchanges of data between terminals are performed by messages, each of which may comprise at most 256 frames, and the frames will be specifically defined hereinbelow. Each new message may be transmitted only if the preceding one has been entirely discharged by the addressee, that is to say properly received by it, subject to interruption and then re-establishment of the link, or to introduction of a time delay.

The messages are either instruction messages or data messages.

Each data message is constituted of a certain number of frames; each frame comprises a head portion, for example a pseudo-random sequence of 31 or 32 bits, the autocorrelation properties of which are known, this head portion being followed by an octet comprising the number of the frame, then by a data string of four octets. The bits of each of the octets of the field of the frame number and of the data field are "overcoded" by means of a pseudo-random sequence, for example of seven bits, the bits 0 and 1 being overcoded by complementary pseudo-random sequences. The data field is of constant format during the transmission and zero in the discharge frames which thus comprise only the head portion and the frame number octet.

In the case of the instruction messages, a frame is constituted in the following manner: the first field of 4 octets is the head portion, of the same type as that described hereinabove; the second field, of length equal to one octet, has the significance of the kind of the instruction: ready to transmit, ready to receive, request for confirmation of authenticity, message available, request to send a message, frame redundancy, etc... The following field of length equal to four octets contains the data necessary for the instruction, for example the number of messages available, the number of the message requested, the category of a subscriber, the degree of

frame redundancy, etc...

The instruction messages are of prime importance for the correct execution of the communication. Consequently, in a preferred embodiment each octet may carry only one of the sixteen combinations corresponding to a 4-8 encoding, that is to say to an encoding where 2^4 words are expressed by combinations of eight bits, each combination being different from all the others with a degree of difference or a "minimum distance" equal to 4. Thus, any risk of confusion between the instructions is virtually eliminated.

In the preferred embodiment, all the frames are transmitted at least four times (possibly 8 times):

- Each frame comprising data is transmitted four times and itself interlaced with three other frames which are likewise transmitted four times; this constitutes a "superframe" of length equal to 16 frames.

- In the case of the instruction messages, each frame is transmitted four times and interlaced three times with itself; this amounts, in fact, to constituting, as for the data frames, a "superframe" of 16 frames, with 16 times the instruction frame under consideration. If the data field of 4 octets is not entirely used, the available bits may be used to carry parity elements which will permit the reception to perform error detections after decoding.

An instruction message is constituted of a single "superframe", while a data message may comprise a plurality of "superframes", at most 16 if the length of the messages is limited to 256 frames.

In the transmitter part, the buffer memory 2 is loaded with strings of data bits $PQ(D_i)$ with $D_i = D_0 \ldots D_{max}$ and strings of instruction bits $PQ(C_i)$ with $C_i = C_0, \ldots C_{max}$ constituting the message to be transmitted, and comprising at most 256 strings of 4 octets. At the outset, the ACK segments, which correspond to the discharge by the addressee of each string received, are vacant. In the receiver part of the addressee, the buffer memory 16 which comprises for each frame a segment PQ, of

data D_0, D_1 ... D_{max}, or of instruction C_0, C_1 ... C_{max}, and a segment R indicating frame received is vacant, the frame indicator segments being in the condition 0. The communication between two transmitter-receiver stations may utilise a protocol which relies upon the exchange of instruction messages, and then of a data message, and finally of instruction messages. If other data are to be transmitted, the communication is pursued in accordance with the same interlinking until interruption.

The explanation which follows specifies the principal phases of the method of transmission which will be described in detail and in a more systematic manner hereinbelow.

When an interlaced "superframe" is received, it is first of all disinterlaced by the circuit 11 (Figure 2), and then each of the components is decoded by correlation with error correction in the correlating circuit 12. The head portion constituted of a pseudo-random sequence of 31 or 32 bits leads, by autocorrelation, to the acquisition of the frame synchronism. The correlation is undertaken modulo 7 bits, the correlator being open to effect a correlation at each clock stroke. The correlation is referred to as sliding. The frame being of fixed format, the device is able to recognise a frame start.

The pseudo-random sequence of 7 bits which is then used for the overcoding of the frame number field (or the field indicating the kind of the instruction) and of the data field is less powerful as regards the possibility of error corrections, but it permits the increasing of the data rate as compared with the case where the same type of encoding as for the head portion is used. This relative reduction of the power of correction of this second part of the frames is "compensated" by the repetition of the frames and their interlacing, and by their retransmission in the event of non-reception. At most five errors are corrected on the pseudo-random sequence incorporating 31 or 32 bits, and three errors are corrected on a pseudo-random sequence incorporating 7 bits.

On account of the fact that each data frame is transmitted four times, the useful elements extracted after decoding of the superframe permit the reconstruction of the original data by comparison of the results of the four decodings and majority vote in the decision circuit 14.

As the instruction frames are themselves transmitted sixteen times, the results of the first four votes may undergo in cascade a second comparison and a second 2/4 majority vote. When a frame is acknowledged as valid, the data string is arranged in the memory at the address inferred from the frame number, and the corresponding received frame indicator segment, R, is placed in the condition 1. At the same time, this reception part of the station transmits a command to the transmission part for sending towards the source station a discharge frame bearing the number of the frame received and accepted.

The discharge frames comprise only the head portions and number indications; as the frames are of constant format, the five octets of the "number" and "data" fields are used to carry five times the number of the frame discharged. This arrangement increases the probability of reception of this discharge frame by comparison and 2/5 majority vote in each frame upon reception, in the reception part of the source terminal. The same applies to the frames discharging the instruction frames. The source station notes the dischargings by forcing the discharged frame indicator ACK to the condition 1; this indicator prevents the subsequent transmission of these discharged frames, i.e. those which have already been properly received by the addressee terminal.

The frames which are not discharged, that is to say those for which a test by the transmission instruction circuit with respect to the indicator ACK shows that they have not been properly received by the addressee terminal, are retransmitted selectively at the end of the first transmission of the message, and this takes place until the discharge or, where appropriate, until the expiry of a predetermined period of time fixed by a time

delay.

The instruction frames convey information permitting the performance of a validity check concerning the entire message: the strings of instruction data of these frames C_0, C_1 ...C_{max} are stored in the part 9 of the buffer memory of the transmission circuit and in the part 18 of the buffer memory of the reception circuit where they are used to decide upon the acceptance or the rejection of a message; accordingly, these data constitute an overall standard of error detection.

Once the transmission of the message has been effected, whether the data message has been accepted or rejected, the terminals are again ready to exchange instruction messages, and the possible transmission of a data message is resumed in the manner indicated hereinabove.

The circuit 20 for measuring the error rate, which circuit is connected to an output of the correlating circuit 12 in the reception part, counts the number of errors detected and corrected by the correlating circuit 12; this gives a measure of the quality of the link:

- If the link is of good quality, that is to say that the number of errors detected remains below a certain threshold, and that this quality is relatively steady, the addressee terminal sends, intercalated between two data discharge superframes, a message to instruct the reduction or the suppression of the frame redundancy in the transmitter terminal.

- If, on the other hand, the quality of the link becomes degraded, the addressee terminal sends in the same manner, between two "superframes", an instruction message to the effect that the frame redundancy should be re-established.

Just like any other message, the instruction message will be discharged by the transmitter terminal if it is properly received by it, and the discharge is provided for with indication of the modification or non-modification of the redundancy.

The decision circuit of the receiver terminal which, as indicated hereinabove, operates by comparison of the various repeated decoded frames, and majority vote, has an adaptable decision rate. The level necessary to obtain a discharge by the majority vote is variable as a function of the redundancy rate introduced in the link, that is to say of the number of repetitions of a frame. In the course of a modification of the redundancy in the transmitter terminal, consequent upon a change of quality of the link, the addressee terminal thus adapts its majority vote in the decision circuit 14. The data frames and the instruction frames may be alternated, as indicated hereinabove; in order to particularise them, the frame head portions are pseudo-random sequences incorporating 31 or 32 complementary bits.

The memory circuit 19 holds in memory the frames received and decoded which are not accepted by the decision circuit in the course of a first reception. This memory circuit permits avoidance of the loss of the benefit of the information received in the course of the first reception; this permits the reduction of the number of repetitions necessary, and the reduction of the proportion of frames considered as correct to be received in the course of a second repetition: for example, in the course of a first reception, with a redundancy of order 4, that is to say where each frame is transmitted four times, the decision circuit implements a majority vote of 2/4 type, that is to say that the frame is considered as properly received where two frames out of four are identical. When such a frame is considered as improperly received, that is to say that there are not two identical data strings in the four repetitions of a given frame, these decoded frames are held in memory in the memory 19, and the frames received in the course of a second repetition, i.e. four frames, are used with the four old decoded frames received. The decision circuit may then consider as properly received a frame detected three times in the eight frames repeated in total. The power of the transmission method is thus increased.

The transmission method according to the invention which utilises a transmitter-receiver of the type described with reference to Figures 1 and 2 will be described in greater detail hereinbelow, with reference to Figures 3 and 4 which represent the organisation charts appertaining to the management of a station, for the transmission respectively of an instruction message, and then of a data message, by a station acting as transmitter, and with reference to Figures 5 and 6 which represent the organisation charts appertaining to the management of a station acting as receiver for the reception of an instruction message, and then of a data message and the transmission of the corresponding discharge frames.

The sequencing of a sequencer circuit or the programing of a computer or of a microprocessor in accordance with these organisation charts is within reach of a person skilled in the art.

The procedure for establishing the link between these two stations, the source station and the addressee station, in accordance with the customary protocols for signal transmission, has not been detailed.

Once the connection between these two stations has been established, the transmission per se of the instruction messages and of the data messages can commence. The first type of message sent by the source station, Figure 3, is an instruction message constituted of one "superframe". In order to decide upon its transmission, a test on the discharge bit $ACK(C_j)$ of the first instruction message $j = 0$ is carried out. The result of this test being negative, the first phase is the composition of the instruction frame in accordance with the model indicated hereinabove, with a head portion, the octet relative to the kind of the instruction, and the data octets of this instruction forming the string of instruction data C_j (the first one being C_0) to be transmitted. The second phase, still within the source station, then consists in overcoding this frame, in repeating it 16 times, in interlacing these 16 frames, and then

in instructing the transmission of the "superframe" thus constituted and forming the instruction message to the addressee station acting as receiver.

The receiver station receives the instruction "superframe", Figure 5. In the course of this first reception, an index n which is initially at zero is set to 1 by the operator n = n+1. After the reception, the receiver executes the disinterlacing and then the decoding of the encoded fields. It then executes a succession of 4 2/4 majority votes, per group of four decoded frames, one frame being at a first stage considered as correct if it appears twice in each group of four frames. Then, a fifth 2/4 majority vote is executed, on the basis of the four preceding results:

- if the result of the fifth vote is positive, the instruction frame is considered as properly received, the index n is reset to 0, and a discharge frame is composed in the addressee station. This frame comprises the head portion and repeats the kind of the instruction on five octets, no data item having to be transmitted in this type of frame. This frame is encoded and then repeated 16 times and interlaced to form a discharge "superframe" which is then transmitted to the source station.

- if the result of the fifth vote is negative, the instruction frame is not correctly received. A test is then carried out on the duration of the time delay by a test on a value N_1, the limiting number of repetitions of an instruction message before interruption. The index n, which undergoes an iteration upon each new reception of an instruction message, is tested in relation to N_1.

- if n is less than N_1, the duration of the time delay is not exceeded and the addressee station remains operative as a receiver. As the transmitter station has not received any discharge frame, the same instruction frame will be retransmitted as described hereinbelow, until such time as a discharge frame is received by the source station or the test on the duration of the time delay reveals an exceeding.

- when this duration is exceeded, n being greater than or equal to N_1, the link results in a failure.

In the transmitter station, the discharge frame is received, and then disinterlaced and decoded, and in each of the discharge elementary frames a 2/5 majority vote is executed on the field concerning the kind of the instruction, which field is repeated on five octets. Then, the octets retained in the 16 frames form the subject, per group of four, of 2/4 majority votes. A final test is then carried out on the results of these four votes, by a final 2/4 majority vote:

- if the result is positive, the instruction message which is properly received and correctly discharged permits the updating of the corresponding discharge bit $ACK(C_j)$ in the part 9 of the memory 2, and the following instruction message, or a data message, may then be transmitted;

- if the result of this final test is negative, the message cannot be discharged, and a test on the duration of time delay is then carried out by means of the index n as in the addressee station; this index n is tested in relation to the number N_1 which is the limiting number of repetitions of the message, and this index n undergoes an iteration, $n = n+1$, upon each new transmission of an instruction message.

- if n is less than N_1, the limiting duration is not exceeded and the transmission of the same instruction message in accordance with the same process is reinitiated.

- on the other hand, if n is greater than or equal to N_1, the result is a failure of the link, as previously in the addressee station.

Following the transmission of the first instruction message, it is possible to retransmit either another instruction message with $PQ(C_{j+1})$ (to A) or a data message (to B).

The transmission of data message is executed in the following manner, which is described with reference to Figures 4 and 6 respectively relating to the source

station of the data message and to the corresponding addressee station.

First of all in the source station, a test on the discharge bits ACK of the data strings leads to the extraction of the first four data fields to be transmitted, which have not yet been acquired by the addressee station. The corresponding four data frames are composed in accordance with the model indicated hereinabove together with the head portion field, the field concerned with the frame number of an octet, and the data field of four octets. These four frames are then encoded, repeated four times, and then interlaced to form a data "superframe". If N is the length of the data message to be transmitted, counted in terms of the number of "superframes", an index i which is initially at zero is set to 1, through i = i+1 for this first "superframe" ready to be transmitted, and then a test is carried out on the value i in relation to N:

- if i is less than N, then the management circuit instructs the composition of another "superframe" in the same manner as hereinabove, searching for the four data fields which follow, which have not yet been discharged.

- if i is equal to N, then the data message is complete and its transmission to the addressee is instructed.

The source station is then set to act as receiver, for the reception of the discharge frames relating to the data messages transmitted which will be generated by the addressee station.

In the latter, as shown in Figure 6, after disinterlacing and decoding of the "superframes" of the data message, a 2/4 majority vote in the decision circuit 14 of the addressee station, for each group of four frames corresponding to the repetition of one and the same frame, leads to the storage of the data strings which have been properly received among the four frames of each "superframe", and to the updating in the memory 16 of the corresponding received frame indicators R. The

numbers of the frames which have been properly received are stored with a view to their transmission via the discharge frames.

These data discharge frames are constituted in the same manner as the data frames themselves, but each frame number is repeated five times, as for the discharge frames of the instruction messages. When the transmission of the corresponding discharge frame has been performed, the addressee station carries out a test on the state of the indicators of received frames R to establish whether all the frames have been discharged. If this is not the case, the addressee station reverts to acting as a receiver, awaiting the retransmission of the data frames which have not been correctly received (to D).

- If, on the other hand, all the frames have been properly discharged, a counter referred to as a "holding" counter is triggered to maintain the station in its mode of operation awaiting reception, in the case where discharge frames have not been properly received by the source station and the corresponding data frames are retransmitted. A test on the duration of the counting is carried out until such time as the limiting value is reached.

The transmission of an instruction frame may then be initiated, if the transmission of the data contained in the first data messages, and possibly retransmitted in the event of improper reception, is terminated.

During this holding period, the discharge frames transmitted by the addressee station are received by the source station. They are disinterlaced and then decoded (see Figure 4). For each one of the elementary discharge frames, a 2/5 majority vote on the five octets of each of them is carried out. The results of these majority votes then undergo another 2/4 majority vote to utilise the repetition on four frames of the numbers of frames discharged. This test leads to the ordered storage of the numbers of discharged frames, the corresponding indicators ACK changing condition for each one of them. An index i is transmitted (sic) to one, and then undergoes

an iteration for each data discharge "superframe" received, and a test on the value of this index in relation to the length of the data message N, such data being counted in terms of "superframes", is carried out.

- If all the data discharge "superframes" have not been received, that is to say if i is less than N, the source station is reset to operate as receiver for the data discharge "superframes". If, on the other hand, i is equal to N, then the system is reset to operate for a test on the bits to indicate discharged frames ACK of the corresponding message to establish whether all the data have been properly received. If some of the discharge bits have not been updated, the corresponding data frames have not been properly received, and the transmitter station retransmits the frames which have not yet been discharged, reverting to the step of composition of the frames which have not yet been discharged. On the other hand, if all the frames have been discharged, the source station may then instruct the transmission of the instruction frames which follow the transmission of a data message (to A).

In the precise description indicated hereinabove, the auxiliary functions permitting the increasing of the data rate, for example by suppressing the repetition of the frames when the link is considered to be of good quality, or on the other hand the reintroduction thereof when the quality of the link deteriorates, have not been described in the organisation charts of Figures 4 to 6. However, it is within reach of a person skilled in the art to introduce them in these schemes.

The invention is not limited to the embodiment which has been specifically described and represented. In particular, in the description of the method according to the invention, the repetition of the frames has been indicated as being executed on the basis of an interlacing of order 4, each frame being repeated four times, and then this set of four frames being interlaced. The order of interlacing may be different; in particular, it is possible to provide a repetition of the frames with an

interlacing of order 8.

CLAIMS

1. Method for the transmission of data by frame-organised instruction messages or data messages via duplex links between transmitter-receiver stations, characterised

in that in each instruction message a source station acting as transmitter transmits frames which are composed of an information string containing the kind of an instruction and the corresponding data, and in each data message frames composed of N information strings each containing a string of data and the associated order number, and in that the transmission of each message, prior to the transmission of the following message by the source station

- gives rise to the transmission of discharge frames by the addressee station, in which the kind of the instruction, in the case of an instruction message, and the numbers of the data strings which have been properly received, in the case of a data message, are retransmitted to the source station,

- and gives rise, when the source station receives these discharge frames, to the repetition of the instruction message, if the corresponding discharge frame has not been received, and to the selective repetition of the frames composed of the data strings whose numbers have not been detected in the discharge frames,

in that each message is composed of k.N elementary frames, with k elementary frames forming a superframe and N being the length of the messages counted in terms of superframes, each superframe consisting of k_1 interlaced elementary frames comprising different information strings, each being repeated k_2 times, with $k = k_1 + k_2$,

in that the discharge frames and the messages constituted of discharge frames have the same formats as respectively the frames and the instruction and data messages whose proper reception they indicate,

and in that the decision relative to the proper

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or improper reception of the instruction and data frames in an addressee station, and of the discharge frames in the source station are obtained by a majority vote on the frames repeated for each type of message.

2. Method according to Claim 1, characterised in that the instruction messages comprise only a single information string, $k_1 = 1$, repeated $k = k_2 = 16$ times, and in that the data messages comprise $k_1 = 4$ information strings, repeated $k_2 = 4$ times before interlacing, with the superframes having the same length irrespective of the type of messages transmitted.

3. Method according to Claim 1, characterised in that the kind of the instruction or the number of a data string are respectively repeated, in the discharge frames, along the entire length allocated to an information string in an instruction frame or in a data frame.

4. Method according to any one of Claims 1 to 3, characterised in that each frame comprises a head portion having correction properties by way of autocorrelation, and in that the information string following the head portion is encoded by means of a correlation-based error correction code.

5. Method according to Claim 4, characterised in that the head portion is constituted of a pseudo-random sequence having a length equal to 4 octets to within one bit and presenting autocorrelation features authorising up to 6 error corrections, the encoded information string comprising one octet concerning the kind of the instruction or the number of a data string, and 4 octets concerning the instruction data or the data string.

6. Method according to Claim 5, characterised in that the kind of the frames, instruction and data, is indicated by the use of different pseudo-random sequences in the head portion.

7. Method according to one of Claims 4, 5 or 6, characterised in that the error correction code applied to the information strings is an expansion code using a pseudo-random sequence of 7 bits, with the decoding by correlation on reception authorising up to 3 error

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corrections.

8. Method according to Claim 5, characterised in that the octets relative to the kind of the instructions are pre-encoded, each octet being allowed prior to encoding to consist of only one of the 16 octets selected among the 2^8 possible octets, and each selected octet differing from all the others by at least 4 bits.

9. Method according to Claim 8, characterised in that the instruction data are pre-encoded in the same manner as the octet relative to the kind of instruction.

10. Method according to Claim 4, characterised in that a measurement of the quality of the link is performed on reception in the addressee station by way of counting the errors detected and corrected by correlation.

11. Method according to Claim 10, characterised in that the number of repetitions k_2 of the transmitted information is modified according to the measurement of the quality of the link, said number being reduced when the link is of a very high quality and increased when the quality of the link decreases.

12. Method according to Claim 1, characterised in that the information strings considered as having been improperly received in the addressee station are stored and used with the frames received after repetition, the conditions of the majority vote being then modified consequently.

13. Device for transmitting data by way of frame-organised messages, constituted for transmitter-receiver stations intended to operate in duplex mode, characterised in that each station comprises:

- in its transmitter part a transmit instruction circuit (1), a memory (2) for storing information strings to be transmitted in the frames and for storing a discharge indicator associated with each of said strings, whose address input is connected to an output of the instruction circuit, a frame generator (4) controlled by the instruction circuit (1) and connected to the data output of the memory (2), the generator having its output

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connected to a repetition and interlacing circuit (6) in turn connected to a transmit device (7), with the frame generator being further connected to an encoder circuit (5),

- in its receiver part a reception device (10) connected to a disinterlacing circuit (11) in turn connected to a correlation circuit (12), whose data output is connected to a decision circuit (14) operating by way of a majority vote, the output of the decision circuit for the validated data being connected to the data input of a memory (16) for storing properly received information strings and for storing a reception indicator associated with each of these strings, and a reception control circuit (15) for the management of the circuits of this receiver part.

14. Device according to Claim 13, characterised in that it further comprises in the receiver part a circuit (20) for measuring the error rate, coupled to an output of the correlation circuit (12), and whose output is connected to an input of the reception control circuit (15) for measuring the quality of the link.

15. Device according to one of Claims 13 and 14, characterised in that it further comprises in the receiver part an additional memory (19) for storing the information strings considered as having been improperly received, which is coupled to an additional data output of the decision circuit (14).

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