

The present invention relates to a system for digital switching between n junctors (n an integer greater than 1) and more particularly to a digital switching system intended for exploiting security communications such as air and sea traffic control. In a digital switching system the junctor serves as interface for the operator stations, the various radio channels, telephone lines etc.

Such systems are known in which all the junctors are connected to a central control unit and to a central connection network which are combined in order to receive the data from the various junctors of the system and to control the junctor interconnections. The very centralised architecture of these switching systems means that the complicated whole consisting of the central control unit and the central switching network, when they are subject to a failure, may entail complete paralysis of the system.

It is known through the patent US-A-4228536 to construct a modular switching system which makes it possible to dispense with a central control unit so that the failure of a switching unit does not entail complete failure of the system; for this purpose, each junctor possesses its own control unit with failure detectors. It is also known from this same document that a direct connection exists between the various individual switching units so as to permit a simplification in the processing of the control signals.

Another document may also be mentioned here; this is an article: Proceedings of the International Switching Symposium, Florence, 7-11 May 1984, pages 1 - 5, part 1, session 23, K.E. HUHNS "System architecture of a future oriented complete digital PABX family". This document discloses a distributed switching network architecture where not only the control functions are distributed over each board with one microprocessor per board, but also the switching functions with one switching matrix per board.

The object of the present invention is to propose

a digital switching system without a central unit, as in the first document cited, in which the switching network is distributed, as in the second document cited, and in which the security of transmission of the data is strengthened.

This is obtained, in particular, via duplicated links between the junctors and appropriate utilisation of the choice offered by these duplicated links.

According to the invention, there is proposed a system for digital switching between n (n an integer greater than 1) junctors supplying speech and signalling data and comprising direct links between the junctors so that each junctor is able to directly exchange its data with the $(n-1)$ other junctors and each junctor comprises its own decision unit formed by a control unit with failure detectors, characterised in that each junctor comprises its own switching unit formed by a digital connection network controlled by its control unit and in that, since the set of links between the junctors is duplicated, the control unit of each junctor automatically selects that one of the two duplicated sets of links via which the data transmission is correct when the transmission via the other duplicated set is not correct, the selection being made as a function of the signalling data received by the junctor and of failure data picked up by the control unit in the junctor in question.

The present invention will be better understood and other characteristics will emerge with the aid of the description below and of the figures referring thereto which represent:

- Figure 1, a digital switching system according to the prior art,
- Figure 2, a digital switching system according to the invention,
- Figures 3 and 4, more detailed views of parts of the system according to Figure 2.

In the various figures the synchronising devices coming within current technology have not been represented in the hope of making the drawings clearer

and of simplifying the explanation.

Figure 1 represents diagrammatically a switching system according to the prior art. This system comprises n junctors J1' to JN' supplying data on the state of the
5 junctors, D, and digitised speech data, P. The data on the state of the junctors D, are transmitted, without being processed, to a control unit, Uc, constructed from a computer, which processes the data received and which, in return, despatches signals for controlling the state
10 of the junctors. The speech data, P, of a junctor are transmitted to a connection network Rc comprising a space-time distribution matrix ensuring, under the control of the control unit, Uc, the multiplexing of the speech data and their retransmission to the junctors; two
15 junctors are placed in communication by the central unit which controls, in the junctors, the choice to be made from the speech data received. To improve the security of operation of such a switching system it is known to duplicate the outputs of the junctors and to duplicate the control unit Uc and the connection network; nevertheless, the substantial hardware and the complexity of a control unit and a connection network mean that the risk of complete failure of the system, following a failure of both control units or of both connection networks, is a
20 serious risk to the security of operation.

Figure 2 shows how this risk of complete failure may be reduced. Figure 2 represents n junctors J1 to JN which differ from the junctors J1' to JN' of Figure 1 through the fact that they each have their own control
30 unit and their own connection network. The junctors J1 to JN may thus exchange directly among themselves the digitised speech data, P, and the signalling data, S, that is to say the data on the state of the junctors, after they have been processed by the control units relating to the junctors; direct exchange of data between
35 the junctors is understood here and in the Claims to be a dialogue between junctors in which the datum delivered by one junctor is received as is by another junctor, that is to say without having been processed other than by

amplifiers. Thus the failure of the control unit or of the connection network of a junctor affects only this junctor and dialogue can continue between the other junctors.

5 Figures 1 and 2 are very simplified figures which do not show either the duplicating of certain elements and of certain connections, or the duplicated clock which supplies the time base signals. Similarly Figure 2 does not show either the interfaces laid out between the
10 junctors, or the supervisory unit gathering the data on the state of the system and whose role is to facilitate maintenance; it should moreover be noted that these interfaces are signal-transparent interfaces and that the supervisory unit could possibly be omitted, with the
15 exception of the clock which it contains.

 The concrete example which will be described below relates to a digital switching system utilising digital junctors each having their own microprocessor-based control unit and their own digital switching
20 network. The junctors of the system are junctors each having two speech channels and are of three types: a junctor for an operator station which interfaces an operator station with two speech channels (one radio channel and one telephone channel), a telephone junctor
25 which ensures the handling of two telephone lines and a radio junctor which handles two radio channels; apart from their control unit and their switching network, which are moreover simpler than the corresponding control unit and corresponding switching network of the prior art
30 (Figure 1), the construction of these junctors comes within current communications practice and will not therefore be described so as not to burden the text with explanations which are not of use in understanding the invention. It should moreover be noted that, since the
35 signals which they exchange among themselves are similar for the three types of junctors, it will not be specified whether a junctor in question is of the operator station type, of the telephone type or of the radio type.

 Generally, in the description of the concrete

embodiment which is taken as an example, the circuits within the capability of the expert and in particular those which are simpler than in the prior art, will not be detailed in order to simplify the explanation.

5 The example described refers to a system made from operational units of fifteen junctors each having their own supply and this system may comprise up to fifteen operational units which therefore represents $15 \times 15 = 225$ junctors, that is to say a maximum capacity
10 of $2 \times 225 = 450$ channels.

Figure 3 shows, in the case of maximum capacity, how the speech-multiplexing part of the digital switching system taken by way of example is wired. Only the first, U1, and the fifteenth, U15, of the fifteen operational
15 units have been represented and, in these operational units, only the first and the fifteenth junctor, out of the fifteen which the unit includes, have been represented; these junctors bear the references J1 to J15 in all the operational units and therefore, in order to be
20 accurately designated, require that the operational unit to which they belong be indicated. As well as the fifteen junctors each operational unit comprises two interfaces which bear the references L and L' in all the units, this requiring, in order to designate them accurately, that
25 the unit of which they form part be indicated.

To simplify the writing and the use of the references, only the elements represented inside the junctor J1 and inside the interface L of the operational unit U1 have been indicated. Apart from differences which
30 do not appear in Figure 3 and which are due to the type of channel to be switched, the other junctors and the other interfaces comprise the same elements as this junctor J1 and this interface L respectively; this makes it possible in what follows to designate a reference-free
35 element with the reference of the corresponding element in J1 or L from U1, followed by the reference of the junctor or of the interface to which it belongs as well as of that of the operational unit in which it is located.

The transmission pathways are indicated in the left part of Figure 3; two per junctor, corresponding to the two speech channels of each junctor; the reception pathways of the juncctors are indicated in the right part of Figure 3, corresponding to the two channels which each junctor may choose from the $2 \times 15 \times 15 = 450$ channels which were discussed earlier.

The two transmission pathways of a junctor correspond respectively to the inputs of two analogue/digital convertors A1/1, A1/2 which each create a digital interval of time, usually denoted I.T., in a desire for conciseness, in what follows; these two I.T. are therefore the images of the two channels specific to the junctor. By virtue of the duplicated time base specific to the system, 30 different temporal square-waves are assigned to the $2 \times 15 = 30$ I.T. of each operational unit, by the analogue/digital converters. At the output of the two convertors A1/1, A1/2 the two I.T. are transmitted on the same conductor and applied to the inputs of two control amplifiers B1 and B1', in order to thus be duplicated.

The outputs of the amplifiers B1 and those of the amplifiers B1' of the fifteen juncctors of an operational unit are connected to the input of the interface L and to that of the interface L' respectively; these two interfaces therefore each receive the 30.I.T. relating to the 30 transmission pathways. Each interface comprises 15 input amplifiers, C1 to C15, and 15 output amplifiers, D1 to D15. The outputs of the amplifiers C1 to C15 of the interface L of the unit U1 are connected respectively to the input of the amplifier D1 of the interface of the unit U1, to the input of the amplifier D1 of L of U2, which are not shown, and so on as far as the input of the amplifier D1 of L of U15; the same connections exist between the amplifiers C1 to C15 of the interface L' and the inputs of the amplifiers D1 of L' of U1, D1 of L' of U2, ..., D1 of L' of U15. Similar connections ensure the links of the input amplifiers C1 to C15 of the interfaces L and L' of the operational units U2 to U15, with the

output amplifiers D1 to D15 of the interfaces L and L' of the units U1 to U15; thus the outputs of the amplifiers C1 to C15 of L' of U15 are respectively connected to the input of the amplifier D15 of L' of U1, D15 of L' of U2, ..., D15 of L' of U15.

In each operational unit the outputs of the amplifiers D1 to D15 of L and of L' therefore supply respectively, in duplicate, the 30 I.T. of the units U1 to U15. Each of the 15 junctors of each of the 15 units has its own digital connection network consisting of a space-time matrix, M, with fifteen pathways which are coupled respectively to the outputs of 15 controlled OR gates, E1 to E15; these OR gates have two inputs and these two inputs are connected, in the case of E1, to the outputs of D1 of L and L', ..., in the case of E15, to the outputs D15 of L and L'; thus each matrix M receives, from the OR gates, D1 to D15, the 450 I.T. corresponding to the 450 speech channels of the system and can select any two therefrom in order to deliver them to its output.

As apparent in Figure 3, each junctor comprises its own control unit, based on a microcomputer and detectors, referenced Pr in the junctor J1 of the operational unit U1, and each interface also comprises its own control unit based on a microcomputer and detectors, referenced Pc in the interface L of the operational unit U1. It is the control unit Pr of the junctor which, depending on the state of the system and of the two channels to be received in the junctor in question, controls, for each OR gate, E1 to E15, of the junctor, which one of the two duplicated inputs of this gate should be connected to the matrix M of the junctor. The two intervals of time thus selected are processed in two digital/analogue convertors, F1/1, F1/2 respectively, which each select one of the two I.T. by virtue of a temporal square-wave supplied by the time base of the system and under the control of the control unit specific to the junctor in question. The output of the convertors F1/1, F1/2 restores to analogue form the signal from the selected speech channel.

Figure 4, still in the case of the example which was begun to be described with the aid of Figure 3, shows the wiring relating to the local signalling network of the system which allows dialogue between the various control units of the system by exchange between the various junctors and interfaces of the system and a supervisory unit U_s mentioned earlier, of data on the state of the various junctors and of the various interfaces; each junctor and each interface delivers the data on its state after processing them in its own control unit represented in Figure 3 but which has not been redrawn in Figure 4.

As for the wiring for the speech multiplexing, the local signalling network is duplicated in a first and a second identical network, and this will make it possible to describe just one of these networks in what follows. In a desire for simplification and clarity, only the elements of Figure 4 which need to be designated individually have a reference. Moreover, as in the case of Figure 3, the $15 \times 15 = 225$ junctors of the system not exhibiting any differences, like the $15 \times 2 = 30$ interfaces, at least as regards the local signalling network, everything to be stated on the subject of the junctor J_1 and the interface L of the operational unit U_1 will apply to the other junctors and to the other interfaces respectively.

Figure 4 shows the operational unit U_1 with the interfaces L , L' and the junctors J_1 , J_{15} with an operator station K which utilises the two speech channels of the junctor J_1 and two radio sets N_1 , N_2 which utilise the two speech channels respectively of the junctor J_{15} . Figure 4 also represents the operational unit U_{15} and the supervisory unit U_s .

The first local signalling network has a bus topology, it comprises two lines: a data line B_s and a busy line B_o which indicates the seizure or otherwise of the local network, making it possible to limit the risk of data coming from different origins being simultaneously present on the line B_s ; when a junctor wishes to

transmit a message it must therefore wait for the busy line Bo to be free. The lines Bs and Bo are connected in identical fashion to the 15 operational units U1 to U15 and to the supervisory unit.

5 The junctor J1 is connected by two lines to the line Bs and by two lines to the line Bo: a data transmission line with a controlled amplifier Se, a data reception line with a controlled amplifier Sr, a transmission busy line with a controlled amplifier Oe and a reception busy line with a controlled amplifier Or. These lines, at
10 the output of the junctor J1, are common to the other 14 junctors of the operational unit. The lines relating to the amplifiers Se, Sr, Oe and Or pass through the interface L via four controlled amplifiers Hde, Hdr, Hoe and
15 Hor respectively, being connected, in the case of the first two lines, to the data line Bs, and in the case of the other two lines, to the busy line Bo; in the interface L four lines equipped with four operational amplifiers Gde, Gdr, Goe and Gor are connected in
20 parallel to the lines equipped with the amplifiers Hde, Hdr, Hoe and Hor respectively.

 The control unit of the junctor J1 comprises its failure detectors making it possible, if a failure is detected on one of the two duplicated networks, to cross
25 to the other network, and, if the junctor has failed, to isolate it from the remainder of the system. The crossing from one network to another or the isolating of the junctor are performed by command of the OR gates E1 to E15 (Figure 3) and by blockage of the controlled ampli-
30 fiers of the junctor: amplifiers B1, B1' of Figure 3 and amplifiers Se, Sr, Oe and Or of Figure 4. In the situation where a short-circuit appears at the output of an amplifier, the control unit of the junctor cannot inhibit it, so the interfaces L, L' of the operational unit
35 intervene; their control unit, Pc (Figure 3), comprises detectors of faults in the messages. These detectors make it possible to determine whether the messages coming from the 15 junctors of the operational unit are all coherent, and if such is not the case, to block the amplifiers Hde,

Hdr, Hoe and Hor (Figure 4).

It should be observed that, in order to ensure greater reliability and easier locating of failure in the signalling networks, as Figure 4 shows, each interface L, L' ensures an isolation and a separation into a transmission bus and into a reception bus in the operational unit, as compared with a single transmission/reception bus between the various units, for the exchanges of signalling data.

It should also be noted that the time base signals supplied by the supervisory unit Us to each junctor, in a duplicated manner through the interfaces, are controlled by detectors, at interface and junctor level; this makes it possible, again by virtue of the control units of the juncctors and of the interfaces, to operate a junctor with either one of the two time base signal distributions when they are both valid but to automatically select the better distribution in the situation in which a malfunction is noticed in the other.

The present invention is not limited to the example described; thus, in particular, the number of juncctors per operational unit may differ from fifteen, or even be reduced to one only. Similarly, the number of operational units of a digital communication system may differ from fifteen and possibly be reduced to one. The monitoring unit, as has been indicated, may be reduced to a time base circuit and therefore no longer in fact have any monitoring role but simply a synchronising role. Similarly the interfaces may be replaced by simple conductive links without controlled amplifiers and without a control unit with detectors, it being understood that the security of operation will be markedly inferior, all other things being equal, to that of the system described with the aid of Figures 3 and 4.



CLAIMS

1. System for digital switching between n (n an integer greater than 1) junctors (J1-J15) supplying speech (P) and signalling (S) data and comprising direct
5 links between the junctors (J1-J15) so that each junctor is able to directly exchange its data with the ($n-1$) other junctors and in which each junctor comprises its own decision unit formed by a control unit with failure detectors (Pr), characterised in that each junctor
10 comprises its own switching unit formed by a digital connection network (M) controlled by its control unit and in that, since the set of links between the junctors (J1-J15) is duplicated, the control unit (Pr) of each junctor automatically selects that one of the two duplicated sets
15 of links via which the data transmission is correct when the transmission via the other duplicated set is not correct, the selection being made as a function of the signalling data received by the junctor and of failure data picked up by the control unit in the junctor in
20 question.

2. System for digital switching according to Claim 1, in which n is equal to at least 4, characterised in that the junctors (J1-J15) are grouped in m (m an integer greater than 1) separate operational units (U1-U15) each
25 comprising at least two of the n junctors and at least one interface (L, L') transparent to the data, in order to ensure the exchange of data between the junctors of the operational unit in question and the interfaces of the other operational units, and in that each interface
30 comprises a control unit with a detector (Pc) of



coherence of data, in order to be able to block the despatching via the interface in question of data considered to be incoherent.

5 3. System for digital switching according to Claim
2, characterised in that it comprises, in each operation-
al unit (U1-U15), two identical interfaces (L, L') each
ensuring the exchange of data between the junctors of the
operational unit in question and the other junctors of
10 the system, in that the links between junctors (J1-J15),
relating to the exchanges of signalling data (S), when
they pass through an interface (L, L'), are duplicated
and, by means of amplifiers (Hde, Hdr, Hoe, Hor), ensure
a separation into a transmission bus and a reception bus
15 in the operational unit (U1-U15) as compared with a
single transmission/reception bus (Bs, Bo) between the
various operational units.

20 4. System for digital switching according to any one
of the preceding claims, characterised in that each link
relating to the exchanges of signalling data (S) com-
prises two conductors: a first conductor for transfer of
the data proper, and a second conductor on which a busy
signal is transmitted by the junctor which is transmit-
ting on the first conductor.