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(54) **Discontinuous comfort noise transmission**

(57) Communication links between elements of a communication system are used more efficiently by transmitting comfort noise messages discontinuously. When periods of silence or messages containing comfort noise are detected, a single comfort noise message is transmitted rather than a long sequence of comfort noise messages. As a result, the bandwidth of communication links is not wasted by sending large numbers of messages containing comfort noise. The comfort

noise is reconstructed at a communication element receiving the reduced number of messages by generating new comfort noise messages to replace the missing comfort noise messages. One method of regenerating comfort noise messages is to simply repeat the most recently received comfort noise message until a new comfort noise message is received.

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Description

Related Applications

[0001] Related subject matter is disclosed in the following application assigned to the same assignee hereof: U.S. Patent Application entitled "Efficient Comfort Noise Transmission", Serial No. 09/635739, filed August 11, 2000.

Background of the Invention

1. Field of the Invention

[0002] The present invention relates to communication; more particularly, wireless communications.

2. Description of the Related Art

[0003] Mobile communication systems typically transmit a sequence of frames or messages that are representative of the voice or data information being communicated. The frames or messages are passed between a mobile station and a base station over air links. The communications then continue between a base station and a mobile switching center over a communication link that is typically leased by the mobile communication services provider. This leased link is a source of significant cost to the mobile communication services provider. Communications then continue from the Mobile Switching Center (MSC) to the public switched telephone network (PSTN) and from there to a final destination.

[0004] During a typical communication session there are periods of silence, near silence or no voice either coming to a mobile or leaving a mobile. During these periods of silence, a user at either end of the communication link may feel uncomfortable and falsely believe that the communication path has been disrupted. In order to make users at both ends of the communication path feel more comfortable, comfort noise is injected into the communication link when periods of silence, near silence or no voice are detected. Comfort noise is simply a static-like sound or a sound representative of background noise that allows a user to hear something indicating that the communication link is still active during periods of silence in a conversation. When a user at a mobile is not speaking, the mobile generates comfort noise which is passed over the communication links composing the mobile communication system for delivery to a destination station via the PSTN. Similarly, when a user at a destination station does not speak, the silence or no voice condition is detected at the MSC. The MSC injects comfort noise into the communication path and thereby passes the comfort noise over the communication links within the mobile communication system for delivery to the mobile.

[0005] Voice communications typically include nu-

merous periods of silence which result in numerous transmissions of messages containing comfort noise. It is wasteful to transmit comfort noise over a costly link such as the leased link between the base station and MSC.

Summary of the Invention

[0006] The present invention provides a more efficient use of communication links between elements of a communication system. When periods of silence or messages containing comfort noise are detected, a single comfort noise message is transmitted rather than a long sequence of comfort noise messages. As a result, the bandwidth of communication links composing the mobile communication system is not wasted by sending large numbers of messages containing comfort noise. The comfort noise is reconstructed at a communication element receiving the reduced number of messages by generating new comfort noise messages to replace the missing comfort noise messages. One method of regenerating comfort noise messages is to simply repeat the most recently received comfort noise message until a new comfort noise message is received.

Brief Description of the Drawings

[0007]

FIG. 1 illustrates a communication system using a reduced number of comfort noise messages;
FIG. 2 illustrates a simplified block diagram of a base station;
FIG. 3 illustrates a simplified block diagram of a mobile switching center;
FIG. 4 illustrates a processor reducing the number of comfort noise messages transmitted;
FIG. 5 illustrates a processor replacing missing comfort noise messages;
FIG. 6 illustrates a comfort noise message used by a QCELP vocoder; and
FIG. 7 is a set of tables used to replace comfort noise used by QCELP vocoders.

Detailed Description

[0008] FIG. 1 illustrates a communication system embodying the present invention. Mobile communication system element 50 communicates with base station communication system element 52 using an air link comprising upward path 54 and downward path 56. Communications from mobile 50 pass through base station 52 over paths 58 and 60, and are passed to and from MSC communication system element 62 over communication paths 64 and 66 of link 68. Communications to and from mobile 50 then pass from MSC 62 to public switched telephone network communication system element 70 and destination communication system ele-

ment 72 via communication link 74.

[0009] When a user of mobile 50 is not speaking or there is near silence, mobile 50 generates a message containing comfort noise which is transmitted over upward path 54 to base station 52. Base station 52 detects the comfort noise message in communication path 58 and transmits one out of every N consecutive comfort noise messages to the next communication system element, which in this case is MSC 62. N may be any integer, for example N may equal 16. When the MSC 62 receives a comfort noise message, it uses the received message to replace the missing comfort noise messages that were not transmitted by the base station. This is illustrated in FIG. 1 where communication path 58 consists of inward section 90 which carries a complete set of messages containing comfort noise, and outward section 92 which carries only a portion of the total number of comfort noise messages received by base station 52. The reduced number of comfort noise messages are passed over communication path 64 of link 68 to MSC 62. Inward section 110 of communication path 112 of MSC 62 carries the reduced number of comfort noise messages. In response to receiving the reduced number of comfort noise messages, MSC 62 replaces the missing comfort noise messages using copies of the most recently received comfort noise message, and passes a complete set or sequence of messages along section 114 of communication path 112, across link 74 and eventually to destination 72 via PSTN 70.

[0010] In a similar fashion, when a user at destination 72 does not speak, a period of silence is detected by MSC 62 by examining the data in a message or packet received along inward section 116 of communication path 118. In response to detecting a period of silence or near silence, MSC 62 creates a comfort noise message that is transmitted to a receiving communication system element, which in this case is base station 52. In order to minimize the amount of bandwidth used to transmit comfort noise to base station 52, MSC 62 transmits one comfort noise message for each N consecutive messages or packets that it receives which correspond to silence or near silence. MSC 62 sends the reduced number of comfort noise messages along outward section 120 of communication path 118 and over communication path 66 of link 68 to base station 52. Base station 52 then receives the reduced number of comfort noise messages on inward section 106 of communication path 60. In response to receiving the reduced number of messages, base station 52 uses the most recently received comfort noise message to replace the missing comfort noise messages that were not transmitted by MSC 62. The complete sequence of comfort noise messages is sent along outward section 108 of communication path 60 and then over downward path 56 to mobile 50.

[0011] As a result of sending less than a complete sequence or set of comfort noise messages between base

station 52 and MSC 62, communication link 68 is used more efficiently. It is also possible to use the bandwidth of the communication links between base station 52 and mobile station 50 more efficiently by sending less than a complete set of comfort noise messages during periods of silence or near silence. In this case, it is helpful to transmit the headers of the comfort noise messages that are not being transmitted. Transmitting the headers prevent the mobile and base station from mistakenly assuming that the air link has been lost.

[0012] FIG. 2 illustrates a simplified block diagram of base station 52. Base station 52 sends and receives signals on antenna 121. Signals to and from antenna 121 are passed through modulator/demodulator 122 and then through multiplexer/demultiplexer 124 which supplies signals to and receives signals from processors 126 and 128. Typically, a processor is provided for each communication channel handled by the base station. To simplify the figure, only two processors are shown. A processor, such as processor 126, receives messages that were transmitted by mobile 50 and received via modulator/demodulator 122 and multiplexer/demultiplexer 124. Processor 126 performs functions such as encryption and decryption, encoding and error correction. In addition to these functions, processor 126 determines whether a message contains comfort noise. This can be detected, for example, by a relatively low amplitude associated with the data in the message. In response to receiving a message containing comfort noise, processor 126 outputs one out of N consecutive comfort noise messages. It is also possible for processor 126 to output any subset of the received comfort noise messages. In this example, processor 126 outputs the reduced number of comfort noise messages and passes them to multiplexer/demultiplexer 130. Multiplexer/demultiplexer 130 then passes the message through communication link 68 to MSC communication system element 62.

[0013] FIG. 3 illustrates a simplified block diagram of MSC 62. A comfort noise message is received over link 68 by multiplexer/demultiplexer 150. Multiplexer/demultiplexer 150 then provides an output to vocoders and/or processors 152 through 154. A vocoder/processor is typically assigned to each communication channel or mobile user being serviced by MSC 62. Vocoder/processors 152 through 154 are typically used to encode and decode speech to minimize the amount of data required to represent the speech. In order to simplify the diagram, only two vocoder/processors are shown. When vocoder/processor 152 receives the reduced set of comfort noise messages, it uses the most recently received comfort noise message to replace the missing comfort noise messages. Vocoder/processor 152 then sends a complete set of messages or packets indicative of silence or near silence, or representative of comfort noise to switch 160. Switch 160 then passes the complete set of messages or packets to PSTN 70 for eventual delivery to destination communication system element 72.

[0014] When a period of silence or near silence is detected in a message or packet coming from PSTN 70 to vocoder/processor 152 via switch 160, vocoder/processor 152 generates one comfort noise message for N consecutive messages or packets that it receives which correspond to silence or near silence. It is also possible for vocoder/processor 152 to generate a larger number of comfort noise messages where the number of comfort noise messages is less than the number of silence or near silence messages received. Vocoder/processor 152 detects periods of silence or near silence, for example, by detecting a message or packet with data representing voice or sound where the amplitude associated with that voice or sound is below a threshold. The threshold may be, for example, 5% of the maximum available amplitude associated with the data representing the voice or sound. The reduced set of comfort noise messages is then passed through multiplexer/demultiplexer 150 and over link 68 to multiplexer/demultiplexer 130 of base station 52. The reduced set of comfort noise messages is then received by processor 126 which uses the most recently received comfort noise message to replace the missing comfort noise messages. The complete set of messages containing comfort noise are then passed through multiplexer/demultiplexer 124 and modulator/demodulator 122 for transmission over antenna 121 to mobile 50.

[0015] FIG. 4 illustrates a processor reducing the number of comfort noise messages transmitted. Processor 180 receives comfort noise messages 182, or in the case of transmissions from a PSTN, messages or packets indicative of silence or near silence. A typical comfort noise message includes header portion 184 and comfort noise section 186. After receiving a set of one or more comfort noise messages, processor 180 transmits one of N comfort noise messages received. Transmitted comfort noise messages 188 illustrates the comfort noise messages transmitted by processors 180 in response to receiving comfort noise messages 182. It should be noted that the sequence of comfort noise messages transmitted by the processor includes periods 190 that do not contain comfort noise messages. It should also be noted that processor 180 transmitted the first two received comfort noise messages before entering period 190 where comfort noise messages are not transmitted. Processor 180 may receive any number of comfort noise messages before entering period 190; however, transmitting the first two comfort noise messages provides a more stable response by a receiving vocoder.

[0016] FIG. 5 illustrates a processor replacing missing comfort noise messages. Processor 200 receives a reduced sequence or set of comfort noise messages 202. Upon receiving a comfort noise message, processor 200 transmits the received message. After receiving the initial comfort noise message processor 200 generates and transmits a comfort noise message for each missing

comfort noise message until another comfort noise message or until a message containing voice or data is received. When processor 200 receives comfort noise message 204 it simply repeats the message by transmitting it as comfort noise message 206. During period 208 when processor 200 is not receiving comfort noise messages, or messages containing voice or data, processor 200 simply repeats transmitting comfort noise message 206 which may be identical to comfort noise message 204. When processor 200 receives comfort noise message 210 it transmits comfort noise message 212 which is a copy of message 210. During period 214 when processor 200 is not receiving messages, processor 200 continues to transmit comfort noise message 212. This process continues until communication messages containing voice or data are received.

[0017] In the case where a QCELP (Quantized Code Excited Linear Productive coding) vocoder receives the output from processor 200, processor 200 does not simply repeat the most recently received comfort noise message until the next comfort noise message is received. FIG. 6 illustrates a comfort noise message used by a QCELP vocoder. The message includes header section 220, LSP (linear spectrum pair) section 222, GAIN (quantized energy difference) section 224 and SEED (random number seed) section 226. In the QCELP case, processor 200 retransmits received comfort noise messages and generates missing comfort noise messages in accordance with the tables of FIG. 7 until a new comfort noise message is received, or until a message containing voice or data is received. Table 230 is used to replace the bits in LSP section 222. Top row 232 indicates which replacement comfort noise message is to be generated. For example, the values under column 1 are used to generate the first replacement comfort noise message and the values under column 2 are used to replace the second replacement comfort noise message. Table 230 provides the values for the ten bits composing LSP section 222 for 16 replacement comfort noise messages. If additional comfort noise messages are required the table is simply reused beginning at column 1. Each time a new comfort noise message is received and transmitted by processor 200, replacement comfort noise messages are generated beginning with column 1 of table 230. Remaining sections 224 and 226 are similarly populated with bits using tables 234 and 236, respectively. Table 234 provides the values used for the two bits composing GAIN section 224 and table 236 provides the values of the four bits composing SEED section 226. In the case of table 236, it should be noted that the columns may also be used in any order as long as the same SEED value is not transmitted in consecutive comfort noise messages.

Claims

1. A method, characterized by the steps of:

receiving a first plurality of messages indicative of at least near silence; and transmitting a second plurality of messages representative of comfort noise, the second plurality having at least one message and having less messages than the first plurality.

2. The method of claim 1, **characterized in that** the first plurality of messages are messages representative of comfort noise.

3. The method of claim 1, **characterized in that** the step of transmitting comprises transmitting at least one message representative of comfort noise for a plurality of consecutive received messages indicative of at least near silence.

4. A method **characterized by** the steps of:

receiving a first plurality of messages representative of comfort noise; and transmitting a second plurality of messages indicative of at least near silence, the second plurality having more messages than the first plurality.

5. The method of claim 4, **characterized in that** the second plurality of messages are messages representative of comfort noise.

6. The method of claim 4, **characterized in that** the step of transmitting **characterized by** transmitting copies of received messages.

FIG. 1

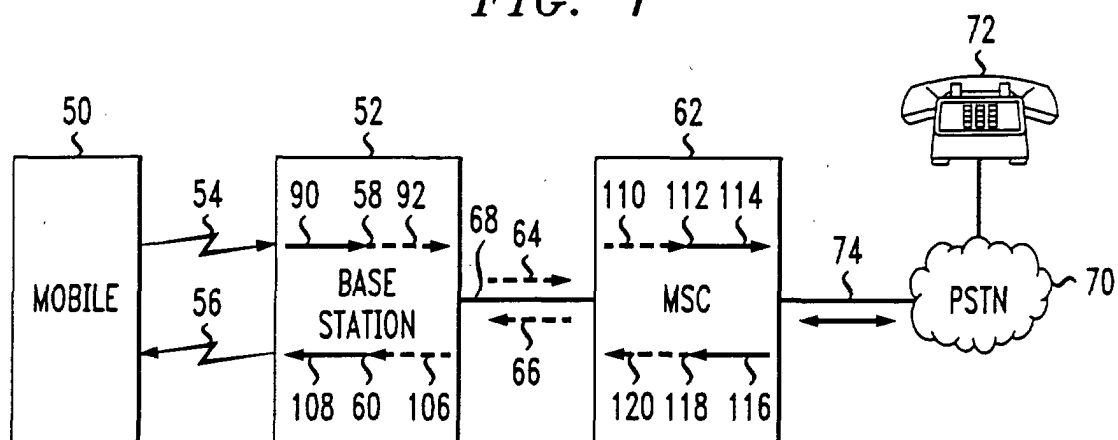


FIG. 2

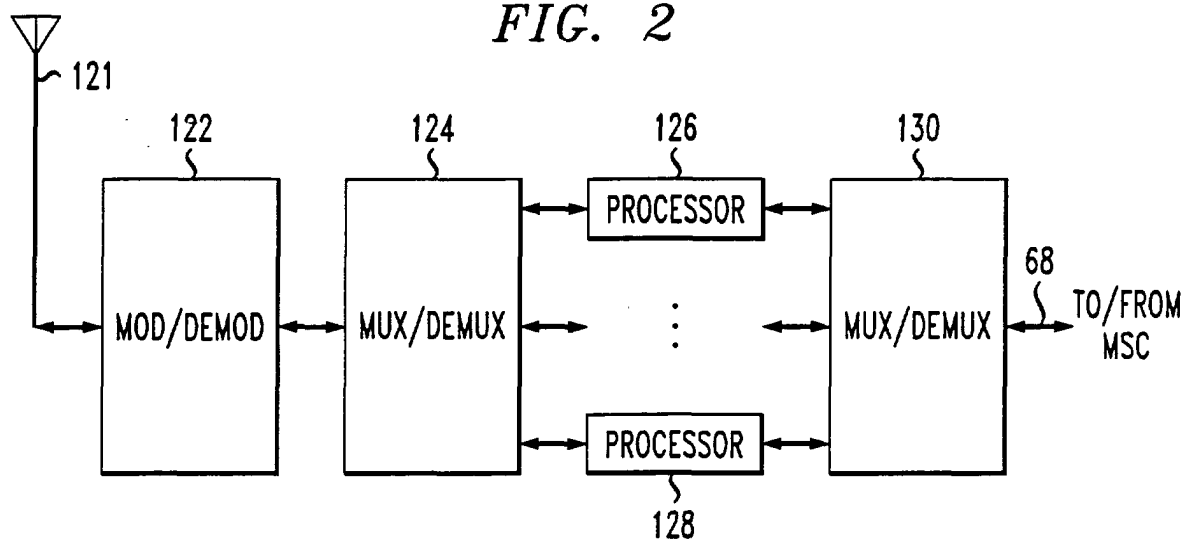


FIG. 3

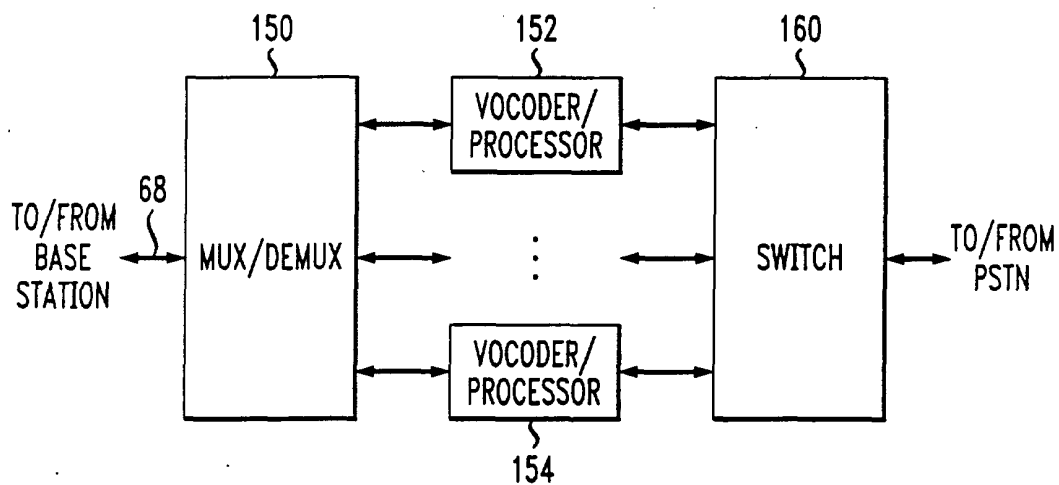


FIG. 4

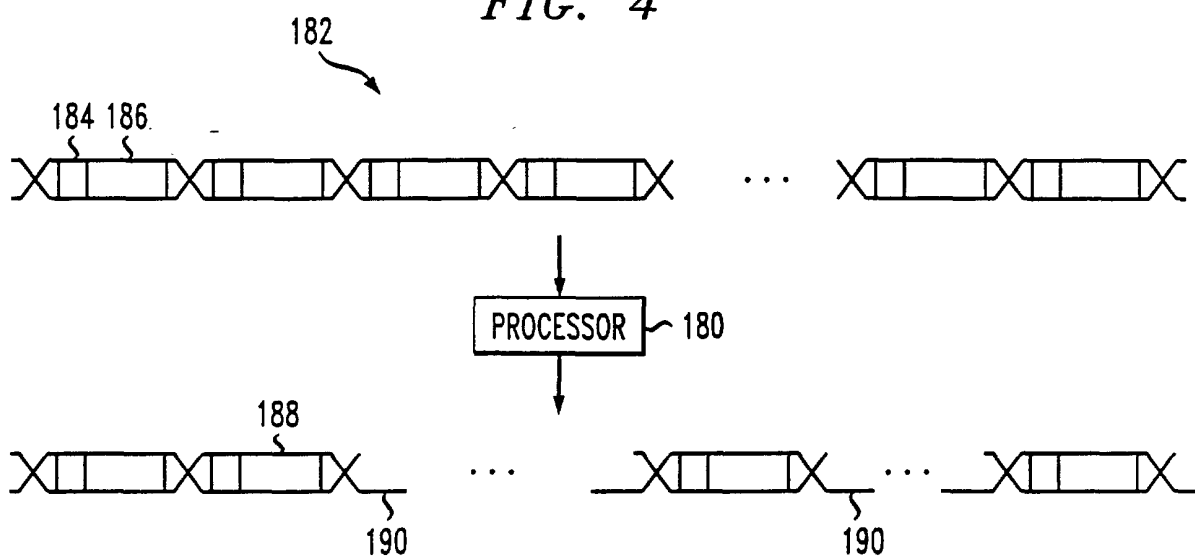


FIG. 5

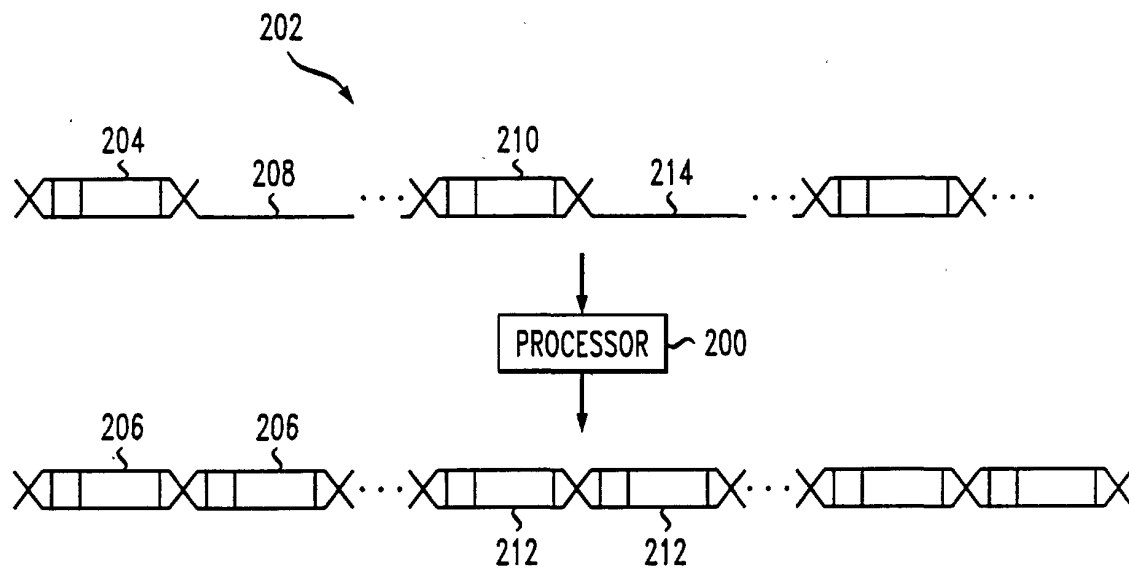


FIG. 6

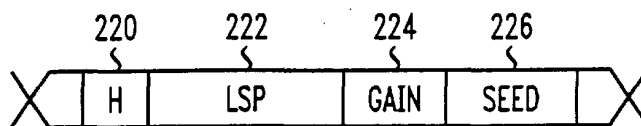


FIG. 7

230
S

232

INPUT PATTERN FOR LSP																
MSG #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
LSP 0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
LSP 1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
LSP 2	0	1	0	1	0	1	0	1	0	1	0	1	0	0	1	0
LSP 3	0	1	0	1	0	1	0	1	0	0	1	0	1	0	1	0
LSP 4	0	1	0	1	0	1	0	0	1	0	1	0	1	0	1	0
LSP 5	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0
LSP 6	0	1	0	1	0	0	1	0	0	1	0	1	0	0	1	0
LSP 7	0	1	0	0	1	0	0	1	0	1	0	0	1	0	1	0
LSP 8	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
LSP 9	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0

234
S

INPUT PATTERN FOR GAIN																
MSG #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
GAIN 0	1	1	1	1	0	1	1	1	1	0	1	1	1	1	0	0
GAIN 1	0	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1

236
S

INPUT PATTERN FOR SEED																
MSG #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
SEED 0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
SEED 1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1
SEED 2	0	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1
SEED 3	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 01 30 4280

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	BENYASSINE A ET AL: "ITU-T RECOMMENDATION G.729 ANNEX B: A SILENCE COMPRESSION SCHEME FOR USE WITH G.729 OPTIMIZED FOR V.70 DIGITAL SIMULTANEOUS VOICE AND DATA APPLICATIONS" IEEE COMMUNICATIONS MAGAZINE, IEEE SERVICE CENTER, PISCATAWAY, N.J, US, vol. 35, no. 9, 1 September 1997 (1997-09-01), pages 64-73, XP000704425 ISSN: 0163-6804 * page 67, left-hand column, line 59 - right-hand column, line 57 *	1-6	G10L19/00
A	EP 0 768 770 A (FRANCE TELECOM) 16 April 1997 (1997-04-16) * page 4, line 22 - line 54; claim 1; figure 2A *	1-6	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			G10L
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		31 October 2001	Wanzeele, R
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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31-10-2001

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