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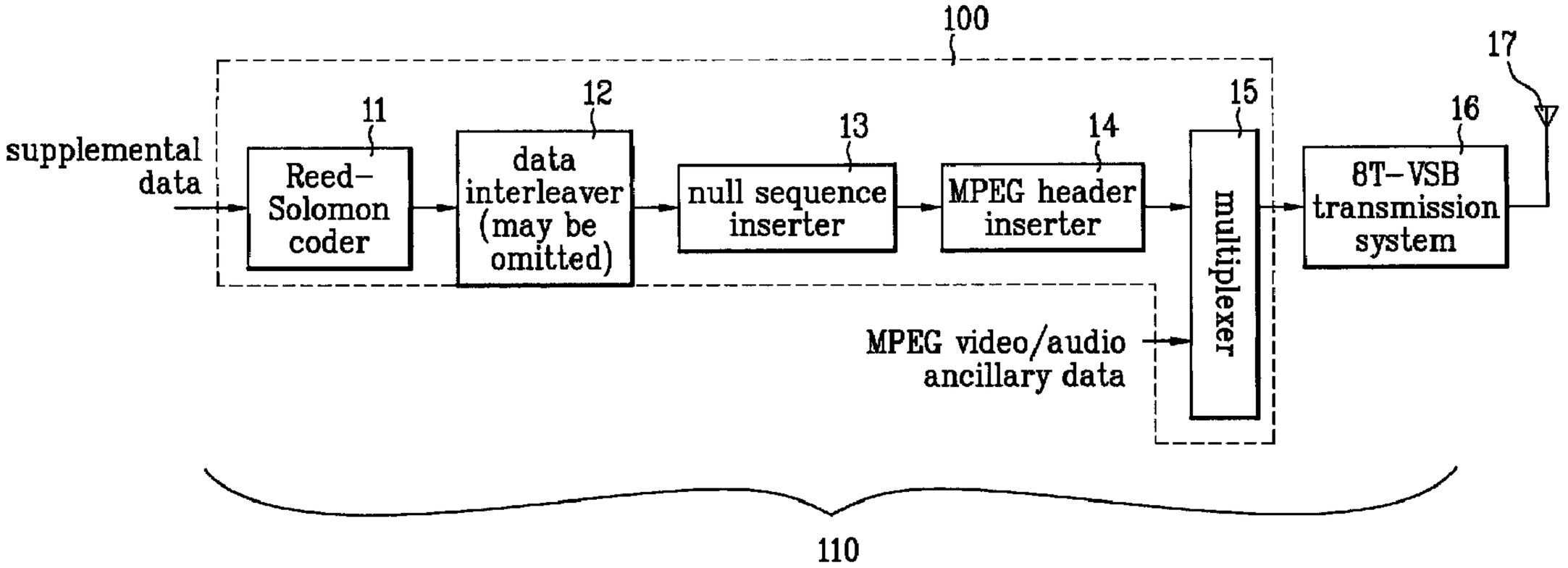

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A VSB communication system or transmitter for processing supplemental data packets with MPEG-II data packets includes a VSB supplemental data processor and a VSB transmission system. The VSB supplemental data processor includes a Reed-Solomon coder for coding the supplemental data to be transmitted, a null sequence inserter for inserting a null sequence to an interleaved supplemental data for generating a predefined sequence, a header inserter for inserting an MPEG header to the supplemental data having the null sequence inserted therein, a multiplexer for multiplexing an MPEG data coded with the supplemental data having the MPEG header added thereto in a preset multiplexing ratio and units. The output of the multiplexer is provided to an 8T-VSB transmission system for modulating a data field from the multiplexer and transmitting the modulated data field to a VSB reception system.

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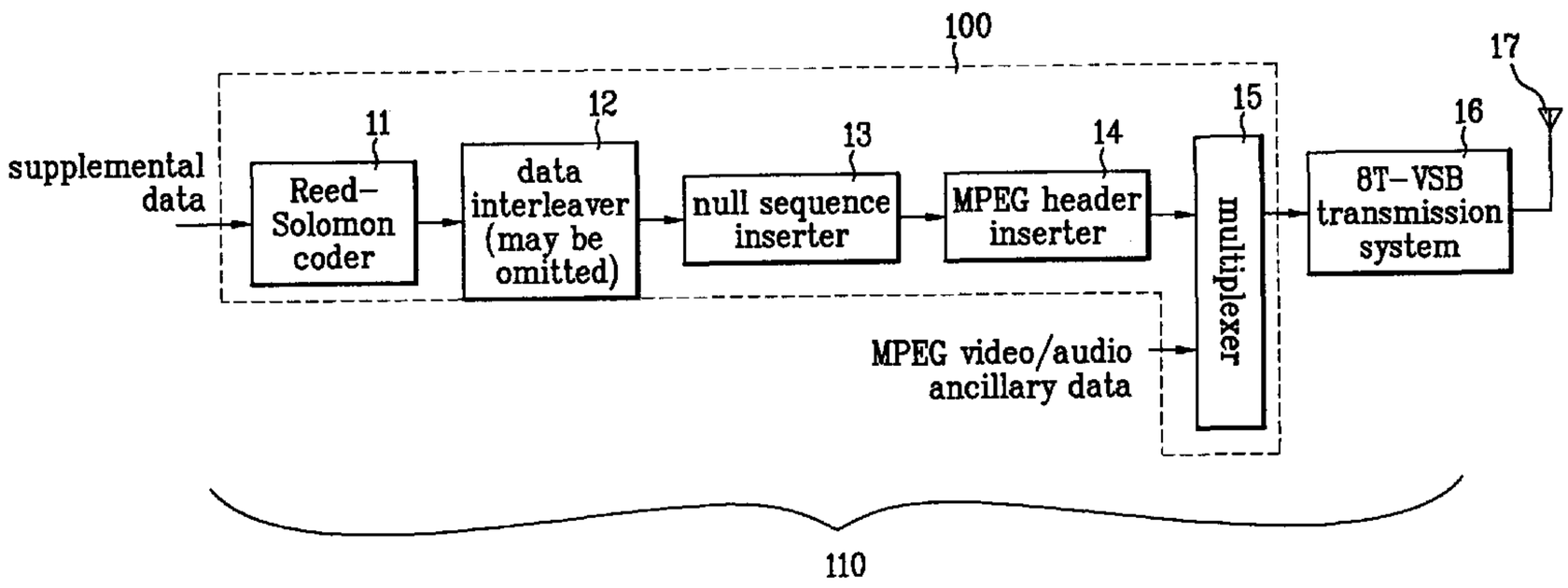

(57) Abstract: A VSB communication system or transmitter for processing supplemental data packets with MPEG-II data packets includes a VSB supplemental data processor and a VSB transmission system. The VSB supplemental data processor includes a Reed-Solomon coder for coding the supplemental data to be transmitted, a null sequence inserter for inserting a null sequence to an interleaved supplemental data for generating a predefined sequence, a header inserter for inserting an MPEG header to the supplemental data having the null sequence inserted therein, a multiplexer for multiplexing an MPEG data coded with the supplemental data having the MPEG header added thereto in a preset multiplexing ratio and units. The output of the multiplexer is provided to an 8T-VSB transmission system for modulating a data field from the multiplexer and transmitting the modulated data field to a VSB reception system.

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VSB TRANSMISSION SYSTEM FOR PROCESSING SUPPLEMENTAL TRANSMISSION DATA

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a digital television transmission system, and more particularly, to a 8T-VSB (Vestigial Sideband) transmission system for transmitting supplemental data in addition to MPEG data and to a signal format for the VSB transmission system.

Description of the Related Art

The United States of America has employed ATSC 8T-VSB (8 Trellis-Vestigial Sideband) as a standard since 1995, and has been broadcasting in the ATSC 8T-VSB since the later half of 1998. South Korea also has employed the ATSC 8T-VSB as a standard. South Korea started test broadcasting in May 1995, and has since August 2000 put in place a regular test broadcasting system. The advancement of technology allows the transmission of digital television (DTV) in the same 6 MHz bandwidth currently used by NTSC.

Fig. 1 illustrates a block diagram of a related art ATSC 8T-VSB transmission system ("VSB transmission system"). The VSB transmission system 16 generally comprises a data randomizer 1, Reed-Solomon coder 2, data interleaver 3, Trellis coder 4, multiplexer 5, pilot inserter 6, VSB modulator 7 and RF converter 8.

Referring to Fig. 1, there is a data randomizer 1 for receiving and making random MPEG data (video, audio and ancillary data). The data randomizer 1 receives the MPEG-II data output from an MPEG-II encoder. Although not shown in Fig. 1, the MPEG-II encoder takes baseband digital video and performs bit rate compression using the techniques of discrete cosine transform, run length coding, and bi-directional motion prediction. The MPEG-II encoder then multiplexes this compressed data together with pre-coded audio and any ancillary data that will be transmitted. The result is a stream of

compressed MPEG-II data packets with a data frequency of only 19.39 Mbit/Sec. The MPEG-II encoder outputs such data to the data randomizer in serial form. MPEG-II packets are 188 bytes in length with the first byte in each packet always being the sync or header byte. The MPEG-II sync byte is then discarded. The sync byte will ultimately be replaced by the ATSC segment sync in a later stage of processing.

In the VSB transmission system 16, the 8-VSB bit stream should have a random, noise-like signal. The reason being that the transmitted signal frequency response must have a flat noise-like spectrum in order to use the allotted 6 MHz channel space with maximum efficiency. Random data minimizes interference into analog NTSC. In the data randomizer 1, each byte value is changed according to known pattern of pseudo-random number generation. This process is reversed in the VSB receiver in order to recover the proper data values.

The Reed-Solomon coder 2 of the VSB transmission system 16 is used for subjecting the output data of the data randomizer 1 to Reed-Solomon coding and adding a 20 byte parity code to the output data. Reed Solomon encoding is a type of forward error correction scheme applied to the incoming data stream. Forward error correction is used to correct bit errors that occur during transmission due to signal fades, noise, etc. Various types of techniques may be used as the forward error correction process.

The Reed-Solomon coder 2 takes all 187 bytes of an incoming MPEG-II data packet (the sync or header byte has been removed from 188 bytes) and mathematically manipulates them as a block to create a digital sketch of the block contents. This "sketch" occupies 20 additional bytes which are added at the tail end of the original 187 byte packet. These 20 bytes are known as Reed-Solomon parity bytes. The 20 Reed-Solomon parity bytes for every data packet add redundancy for forward error correction of up to 10 byte errors/packet. Since Reed-Solomon decoders correct byte errors, and bytes can have anywhere from 1 to 8 bit errors within them, a significant amount of error correction can be accomplished in the VSB receiver. The output of the Reed-Solomon coder 2 is 207 bytes (187 plus 20 parity bytes).

The VSB receiver will compare the received 187 byte block to the 20 parity

bytes in order to determine the validity of the recovered data. If errors are detected, the receiver can use the parity bytes to locate the exact location of the errors, modify the corrupted bytes, and reconstruct the original information.

The data interleaver 3 interleaves the output data of the Reed-Solomon coder 2. In particular, the data interleaver 3 mixes the sequential order of the data packet and disperses or delays the MPEG-II packet throughout time. The data interleaver 3 then reassembles new data packets incorporating small sections from many different MPEG-II (pre-interleaved) packets. The reassembled packets are 207 bytes each.

The purpose of the data interleaver 3 is to prevent losing of one or more packets due to noise or other harmful transmission environment. By interleaving data into many different packets, even if one packet is completely lost, the original packet may be substantially recovered from information contained in other packets.

The VSB transmission system 16 also has a trellis coder 4 for converting the output data of the data interleaver 3 from byte form into symbol form and for subjecting it to trellis coding. Trellis coding is another form of forward error correction. Unlike Reed-Solomon coding, which treated the entire MPEG-II packet simultaneously as a block, trellis coding is an evolving code that tracks the progressing stream of bits as it develops through time.

The trellis coder 4 adds additional redundancy to the signal in the form of more (than four data levels, creating the multilevel (8) data symbols for transmission. For trellis coding, each 8-bit byte is split up into a stream of four, 2-bit words. In the trellis coder 4, each 2-bit input word is compared to the past history of previous 2-bit words. A 3-bit binary code is mathematically generated to describe the transition from the previous 2-bit word to the current one. These 3-bit codes are substituted for the original 2-bit words and transmitted as the eight level symbols of 8-VSB. For every two bits that enter the trellis coder 4, three bits come out.

The trellis decoder in the VSB receiver uses the received 3-bit transition codes to reconstruct the evolution of the data stream from one 2-bit word to the next. In this way, the trellis coder follows a "trail" as the signal moves from one word to the next

through time. The power of trellis coding lies in its ability to track a signal's history through time and discard potentially faulty information (errors) based on a signal's past and future behavior.

A multiplexer 5 is used for multiplexing a symbol stream from the trellis coder 4 and synchronizing signals. The segment and the field synchronizing signals provide information to the VSB receiver to accurately locate and demodulate the transmitted RF signal. The segment and the field synchronizing signals are inserted after the randomization and error coding stages so as not to destroy the fixed time and amplitude relationships that these signals must possess to be effective. The multiplexer 5 provides the output from the trellis coder 4 and the segment and the field synchronizing signals in a time division manner.

An output packet of the data interleaver 3 comprises the 207 bytes of an interleaved data packet. After trellis coding, the 207 byte segment is stretched out into a baseband stream of 828 eight level symbols. The segment synchronizing signal is a four symbol pulse that is added to the front of each data segment and replaces the missing first byte (packet sync byte) of the original MPEG-II data packet. The segment synchronizing signal appears once every 832 symbols and always takes the form of a positive-negative-positive pulse swinging between the +5 and -5 signal levels

The field synchronizing signal is an entire data segment that is repeated once per field. The field synchronizing signal has a known data symbol pattern of positive-negative pulses and is used by the receiver to eliminate signal ghosts caused by poor reception.

The VSB transmission system 16 also has the pilot inserter 6 for inserting pilot signals into the symbol stream from the multiplexer 5. Similar to the synchronizing signals described above, the pilot signal is inserted after the randomization and error coding stages so as not to destroy the fixed time and amplitude relationships that these signals must possess to be effective.

Before the data is modulated, a small DC shift is applied to the 8T-VSB baseband signal. This causes a small residual carrier to appear at the zero frequency

point of the resulting modulated spectrum. This is the pilot signal provided by the pilot inserter 6. This gives the RF PLL circuits in the VSB receiver something to lock onto that is independent of the data being transmitted.

After the pilot signal has been inserted by the pilot inserter 6, the output is subjected to a VSB modulator7. The VSB modulator 7 modulates the symbol stream from the pilot inserter 6 into an 8 VSB signal of an intermediate frequency band. The VSB modulator 7 provides a filtered (root-raised cosine) IF signal at a standard frequency (44 Mhz in the U.S.), with most of one sideband removed.

In particular, the eight level baseband signal is amplitude modulated onto an intermediate frequency (IF) carrier. The modulation produces a double sideband IF spectrum about the carrier frequency. The total spectrum is too wide to be transmitted in the assigned 6 MHz channel.

The sidelobes produced by the modulation are simply scaled copies of the center spectrum, and the entire lower sideband is a mirror image of the upper sideband. Therefore using a filter, the VSB modulator discards the entire lower sideband and all of the sidelobes in the upper sideband. The remaining signal (upper half of the center spectrum) is further eliminated in one-half by using the Nyquist filter. The Nyquist filter is based on the Nyquist Theory, which summarizes that only a 1/2 frequency bandwidth is required to transmit a digital signal at a given sampling rate.

Finally, there is a RF (Radio Frequency) converter 8 for converting the signal of an intermediate frequency band from the VSB modulator 7 into a signal of a RF band signal, and for transmitting the signal to a reception system through an antenna 9.

The foregoing VSB communication system is at least partially described in USP Nos. 5636251, 5629958 and 5600677 by Zenith Co. The 8T-VSB transmission system, which is employed as the standard digital TV broadcasting in North America and South Korea, was developed for the transmission of MPEG video and audio data. As technologies for processing digital signals develop and the use of the Internet increases, the trend currently is to integrate digitized home appliances, the personal computer, and the Internet into one

comprehensive system.

Therefore, in order to satisfy the variety of the demands of users, there is a need to develop a communication system that facilitates the addition and transmittal of a variety of supplemental data to the video and audio data through the digital broadcasting channel. It is predicted that the use of supplemental data broadcasting may require PC (Personal Computer) cards or portable appliances, with simple indoor antennas.

However, there can be a substantial reduction of signal strength due to walls and nearby moving bodies. There also can be ghost and noise caused by reflective waves, which causes the performance of the signal of the supplemental data broadcasting to be substantially poor. Supplemental data broadcasting is different from general video and audio data in that it requires a lower error ratio in transmission. For general video and audio data, errors imperceptible to the human eye or ear are inconsequential. In contrast, for supplemental data, even one bit of error in the supplemental data (which may include program execution files, stock information, and other similar information) may cause a serious problem. Therefore, the development of a communication system that is more resistant to the ghost and noise occurring on the channel is absolutely required.

In general, the supplemental data is transmitted by a time division system on a channel similar to the MPEG video and audio data. After the incorporation of digital broadcasting, there has already been a widespread emergence in the home appliance market of receivers equipped to receive ATSC VSB digital broadcast signals. These products receive MPEG video and audio data only. Therefore, it is required that the transmission of supplemental data on the same channel as the MPEG video and audio data has no adverse influence on the existing receivers that are equipped to receive ATSC VSB digital broadcasting.

The above situation is defined as ATSC VSB backward compatibility, and the supplemental data broadcasting system must be a system that is backward-compatible with the ATSC VSB communication system.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a VSB communication system, and a signal format for the VSB communication system that substantially obviates one or more of the problems due to the limitations and disadvantages of the related art.

An object of embodiments of the present invention is to provide an ATSC VSB transmission system, which can transmit the present MPEG video and audio data together with supplemental data.

Another object of embodiments of the present invention is to provide an ATSC VSB transmission system that is more robust to ghost and noise.

A further object of embodiments of the present invention is to provide a new ATSC VSB transmission system that is fully backward-compatible with a related art ATSC VSB transmission system.

A still further object of embodiments of the present invention is to provide a transmission data format that is suitable to an ATSC VSB transmission system which is robust to ghost and noise.

Additional features and advantages of the invention will be set forth in the description that follows, and in part will be apparent from the description, or may be learned by practice of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described, the VSB transmitter for use with an MPEG data signal and a supplemental data signal comprises a VSB supplemental data processor and a 8T-VSB transmission system. The VSB supplemental data processor comprises a forward error correction coder that codes the supplemental data signal; a null sequence inserter for inserting a null sequence to the supplemental data signal subjected to the forward error correction coder for generating a predefined sequence; a header inserter for inserting a header to the supplemental data signal having the null sequence inserted therein; and a multiplexer for multiplexing the MPEG data signal and the supplemental data signal having the header inserted thereto in at least one

of a predetermined multiplexing ratio and unit.

The VSB transmission system is responsive to the VSB supplemental data processor for modulating an output from the multiplexer to form at least one data field comprising a plurality of segments that includes at least one segment representing the supplemental data signal and at least one segment representing the MPEG data signal.

According to one aspect of the present invention, the forward error correction coder is a Reed-Solomon coder. The supplemental data signal includes at least one data packet having X bytes and the Reed-Solomon coder provides parity bytes of Y bytes, wherein a total of X and Y bytes is 184 bytes.

According to another aspect of the present invention, the header inserter adds three bytes of header information to the data packet. Preferably, the null sequence inserter divides the one data packet of the supplemental data signal into two data packets. The predefined sequence has substantially the same occurrence of bits "1" and "0".

According to another aspect of the present invention, the VSB transmitter further comprises an interleaver receiving data from the forward error correction coder and outputting to the null sequence inserter. The interleaver interleaves the supplemental data signal with forward error corrected code.

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According to another aspect of the present invention, there is provided a VSB transmitter for use with an MPEG data signal and a supplemental data signal, the VSB transmitter comprising: a VSB supplemental data processor configured to preprocess the supplemental data signal, the VSB supplemental data processor comprising: a forward error correction coder that codes the supplemental data signal; a null bits inserter for inserting a plurality of null bits into the supplemental data signal subjected to the forward error correction coder; a header inserter for inserting a header to the supplemental data signal having the null bits inserted therein; and a multiplexer for multiplexing the MPEG data signal and the preprocessed supplemental data signal having the header inserted thereto in at least one of a predetermined multiplexing ratio and unit; and a VSB transmission system connected to the VSB supplemental data processor for coding the multiplexed data signal for forward error correction, and for modulating the coded multiplexed signal to form at least one data field comprising a plurality of segments that includes at least one segment formed from the supplemental data signal and at least one segment formed from the MPEG data signal.

According to another aspect of the present invention, there is provided a VSB supplemental data processor for use with a VSB transmission system to provide a supplemental data signal and an MPEG data signal thereto, wherein the VSB transmission system modulates at least one data field comprising a plurality of segments that includes at least one segment formed from the supplemental data signal and at least one segment formed from the MPEG data signal, the VSB supplemental data processor being configured to preprocess the supplemental data signal, the VSB supplemental data processor comprising: a forward error

correction coder that codes the supplemental data signal; a null bits inserter for inserting a plurality of null bits to the supplemental data signal subjected to the forward error correction coder; a header inserter for inserting a header to the supplemental data signal having the null bits inserted therein; and a multiplexer for multiplexing the MPEG data signal and the supplemental data signal having the header inserted thereto in at least one of a predetermined multiplexing ratio and unit.

According to another aspect of the present invention, there is provided a method for a supplemental data packet and an MPEG data packet in a VSB transmitter comprising a VSB supplemental data processor and a VSB transmission system, the method comprising the steps of: preprocessing the supplemental data packet, the preprocessing step comprising: subjecting the supplemental data packet comprising a first preset number of bytes to a Reed-Solomon coding and adding a Reed-Solomon parity data comprising a second preset number of bytes to the supplemental data packet; interleaving the coded supplemental data packet; inserting null bits into the interleaved supplemental data packet for producing at least one supplemental data packet comprising a third preset number of bytes; and adding an MPEG header comprising a fourth preset number of bytes to each one of the supplemental data packets; multiplexing the MPEG data packet with the preprocessed supplemental data packet at a preset multiplexing ratio; and modulating the data multiplexed at the preset multiplexing ratio through the VSB transmission system.

According to another aspect of the present invention, there is provided a method of processing a digital television (DTV) signal in a DTV receiver, the

method comprising: receiving a DTV signal including a data frame, the data frame including normal data and robust data multiplexed with the normal data, wherein the normal data result from performing interleaving operation once and the robust data result from pre-processing original robust data before multiplexing with the normal data by coding the original robust data for first forward error correction (FEC), by interleaving the FEC-coded robust data, and by periodically inserting predefined sequences into the interleaved robust data, coding the pre-processed robust data for second FEC, and interleaving the robust data coded for second FEC; and performing channel equalization on the robust data in the data frame using the predefined sequences in order to enhance ghost cancellation performance of the robust data.

According to another aspect of the present invention, there is provided a transmission system for processing AV data, the transmission comprising: a first interleaver configured to interleave first AV data having first attribute for first burst error correction, the first AV data including at least one of audio and video data and being input to the first interleaver through a first path, the first interleaver dispersing the first AV data; a multiplexer configured to multiplex the interleaved first AV data with second AV data having second attribute different from the first attribute, the second AV data including at least one of audio and video data and being input to the multiplexer through a second path different from the first path; and a second interleaver configured to interleave the multiplexed first and second AV data for second burst error correction, the second interleaver dispersing the multiplexed first and second AV data.

According to another aspect of the present invention, there is provided a method of processing AV data in a transmission system, the method comprising: interleaving in a first interleaver first AV data having first attribute in for first burst error correction, the first AV data including at least one of audio and video data and being input to the first interleaver through a first path, wherein interleaving first AV data comprises dispersing the first AV data; multiplexing in a multiplexer the interleaved first AV data with second AV data having second attribute different from the first attribute, the second AV data including at least one of audio and video data and being input to the multiplexer through a second path different from the first path; and interleaving in a second interleaver the multiplexed first and second AV data for second burst error correction, wherein interleaving the multiplexed first and second AV data comprises dispersing the multiplexed first and second AV data.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

Fig. 1 illustrates a block diagram showing a conventional VSB transmission system;

Fig. 2 illustrates a block diagram showing a VSB transmitter for transmitting supplemental and MPEG data in accordance with a preferred embodiment of the present invention;

Fig. 3 illustrates the frame architecture of a transmission data for a VSB transmission system in accordance with a preferred embodiment of the present invention;

Fig. 4 illustrates a diagram showing a process for multiplexing supplemental data and MPEG data for forming a VSB data field;

Fig. 5 illustrates an example of inserting the null sequence into the supplemental data by the null sequence inserter and generating a predefined sequence;

Fig. 6 illustrates a schematic diagram of a data interleaver for interleaving supplemental data;

Fig. 7 illustrates an example of coding supplemental data; and

Fig. 8 illustrates another example of coding supplemental data.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

Fig. 2 illustrates a block diagram showing a VSB transmitter 110 for the transmission of the supplemental and MPEG data in accordance with a preferred embodiment of the present invention. Fig. 3 illustrates the frame architecture of transmission data for a VSB transmission system in accordance with a preferred embodiment of the present invention. Fig. 4 illustrates a diagram showing a process for multiplexing supplemental data and MPEG data for forming a VSB data field. Fig. 5 illustrates a diagram showing a process for inserting a null sequence to generate a predefined sequence. Fig. 6 illustrates a diagram showing a data interleaver for interleaving supplemental data. Fig. 7 illustrates a diagram showing an example of coding supplemental data, and Fig. 8 illustrates a diagram showing another example of coding supplemental data.

In Fig. 2, the VSB transmitter 110 in accordance with a preferred embodiment of the present invention includes a VSB supplemental data processor 100 and a VSB transmission system 16. The description of the VSB transmission system 16 is described above in connection with Fig. 1, and thus, will not be repeated. According to the preferred embodiment of the present invention, the VSB supplemental data processor includes a Reed-Solomon coder 11, a data interleaver 12, a null sequence inserter 13, an MPEG header inserter 14, a multiplexer 15, an 8T-VSB transmission system 16, and an antenna 17.

As shown in Fig. 2, for the transmission of the supplemental data from the VSB transmitter 110 (i.e., a broadcasting station) to a VSB reception system on a channel (terrestrial or cable), the VSB transmitter 110 subjects the supplemental data to various digital signal processes. To provide backward compatibility of the present invention with existing devices, the supplemental data is preferably 164 byte packet which will eventually be processed to be a 187 byte packet before entering the VSB transmission system 16. However, the size of the supplemental data packet may be varied so long as the output of the VSB supplemental data processor 100 is compatible with the VSB transmission system 16.

In the VSB supplemental data processor 100, there is provided a Reed-Solomon coder 11 for the correction of errors. The supplemental data is coded at a Reed-Solomon coder (or R-S coder) 11. Preferably, the Reed-Solomon coder 11 is used for subjecting the supplemental data to Reed-Solomon coding and adding a 20 byte parity code to the output data. As described above, Reed Solomon encoding is a type of forward error correction scheme applied to the incoming data stream. Forward error correction is used to correct bit errors that occur during transmission due to signal fades, noise, etc. Various other types of error correction techniques known to one of ordinary skill in the art may be used as the forward error correction process.

According to the preferred embodiment, the Reed-Solomon coder 11 of the VSB supplemental data processor takes 164 bytes of an incoming supplemental data packet and mathematically manipulates them as a block to create a digital sketch of the block

contents. The 20 additional bytes are added at the tail end of the original 164 byte packet. These 20 bytes are known as Reed-Solomon parity bytes. Since Reed-Solomon decoders of the VSB reception system correct byte errors, and bytes can have anywhere from 1 to 8 bit errors within them, a significant amount of error correction can be accomplished in the VSB receiver. The output of the Reed-Solomon coder 11 is preferably 184 bytes (164 bytes from the original packet plus 20 parity bytes).

The VSB supplemental data processor 100 further includes the data interleaver 12, which interleaves the output data of the Reed-Solomon coder 11. The data interleaver 12 is for interleaving the coded supplemental data to enhance performance against burst noise. The data interleaver 12 may be omitted, if necessary.

The data interleaver 12 according to the preferred embodiment mixes the sequential order of the supplemental data packet and disperses or delays the supplemental data packet throughout time. The data interleaver 12 then reassembles new data packets incorporating small sections from many different supplemental data packets. Each one of the reassembled packets are 184 bytes long.

As described above, the purpose of the data interleaver 12 is to prevent losing of one or more packets due to noise or other harmful transmission environment. By interleaving data into many different packets, even if one packet is completely lost, the original packet may be recovered from information contained in other packets. However, there is a data interleaver in the ATSC 8T-VSB transmission system, the data interleaver for the supplemental data can be omitted if it is not required to enhance the burst noise performance of the supplemental data. For this reason, the data interleaver 12 may not be necessary for the VSB supplemental data processor 100.

The VSB supplemental data processor 100 also includes the null sequence inserter 13 for inserting a null sequence to an allocated region of the interleaved (if the data interleaver 12 was present) or Reed-Solomon coded supplemental data for generating the predefined sequence for the supplemental data at an input terminal of a Trellis coder (shown in Fig. 1). The null sequence is inserted so that the VSB reception system receives the supplemental data more reliably, even in a noisy multipath fading

channel. An example structure of the transmission data formed by the insertion of the null sequence will be explained below in detail with reference to Fig. 5.

Further referring to Fig. 2, the VSB supplemental data processor 100 includes the MPEG header inserter 14 for adding an MPEG header to the supplemental data having the null sequence inserted thereto, for backward-compatibility with the legacy VSB reception system. Because the MPEG-II data supplied to the VSB transmission system 16 is 187 bytes long, the MPEG header inserter 14 places, preferably, three headers in front of each packet (which was 184 bytes) to form a 187 byte long packet identical to the MPEG-II data packet.

The supplemental data having the MPEG header added thereto is provided to a multiplexer 15. The multiplexer 15 receives as inputs the processed supplemental data from the MPEG header inserter 14 and MPEG data packets. MPEG data packet, such as a broadcasting program (movie, sports, entertainment, or drama), coded through another path (output from MPEG encoder), is received together with the supplemental data at the multiplexer 15. Upon reception of the MPEG data and the supplemental data, the multiplexer 15 multiplexes the supplemental data and the MPEG data at a fixed ratio under the control of a controller defining a multiplexing ratio and unit and forwards the multiplexed data to the 8T-VSB transmission system 16.

The 8T-VSB transmission system 16, which is described in detail in reference to Fig. 1, processes the multiplexed data and transmits the processed data to the VSB reception system through the antenna 17.

For example, the Reed-Solomon coder 11 uses a code having a block size N=184, a payload K=164, and an error correction capability T=10. On the other hand, as a polynomial generator of the Galois Field and the Reed-Solomon coder 11, the same code as the Reed-Solomon coder 2 described with respect to Fig. 1 may be used. According to the preferred embodiment, other values of the block size N, the payload K, and the error correction capability T may be used in the Reed-Solomon coder 11 in Fig. 2. For an example, a code having N=184, K=154, and T=15 may be used, or a code having N=92, K=82, and T=5 may be used. Although the Reed-Solomon code is used

in the present invention, other code suitable for error correction known to one of ordinary skill in the art may be used therein.

Fig. 3 illustrates the structure of a VSB data field used in the VSB transmission system 100. As shown in Fig. 3, one data field has 313 segments: 312 data segments 124 and one field synchronizing segment 122. The 312 data segments have data segments of the supplemental data and the MPEG data segments. Each data segment 124A has 184 byte data, a 3 byte MPEG header, and the 20 byte ATSC Reed-Solomon parity. The 3 byte MPEG header will used by the MPEG decoder in the VSB reception system.

The use of the MPEG header is explained in more detail. ISO/IEC 13818-1 has a definition on an MPEG transport packet header. If a 0x47 synchronization byte is removed from the MPEG transport packet header, a 3 byte header is left. A PID (program identification) is defined by this 3 bytes. A transport part of the MPEG decoder discards a packet if the PID of the received packet received is not valid. For example, a null packet PID or other reserved PID can be used. Therefore, the MPEG header inserter 14 in Fig. 2 inserts the 3 byte header containing such a PID into the supplemental data packet. Therefore, the supplemental data can be discarded at the MPEG decoder of the legacy VSB receiver.

Fig. 4 illustrates a process for multiplexing the supplemental data and the MPEG data at the multiplexer 15 in Fig. 2. As shown in Fig. 4, the supplemental data is multiplexed with the MPEG data in segment units. The supplemental data is multiplexed with the MPEG data in synchronous to the field synchronizing signal used for synchronizing a data frame synchronization in the VSB transmission system.

Therefore, the VSB reception system determines the multiplexing locations of the MPEG data and the supplemental data in the field data received synchronous to the field synchronizing signal. The VSB reception system demultiplexes the MPEG data and the supplemental data based on the multiplexing locations. A multiplexing ratio and method for multiplexing the MPEG data and the supplemental data may vary with amounts of data thereof.

Information on the variable multiplexing method and ratio may be loaded on, for example, a reserved area of the 92 bits not used in the field synchronizing signal. By retrieving and decoding such information, the VSB reception system identifies the correct multiplexing ratio and method from the multiplexing information contained in the field synchronizing signal.

Alternatively, the multiplexing information may be inserted, not only in the reserved area of the field synchronizing signal, but also in the data segment of the supplemental data. As shown in Fig. 4, of the entire 312 multiplexed data segments, one half are occupied by the data segments representing the supplemental data inputted to the VSB supplemental data processor 100. One of the supplement data segment may be used to transmit the multiplexing information for use by the VSB reception system.

Fig. 5 illustrates an example of inserting the null sequence into the supplemental data by the null sequence inserter 13 according to the preferred embodiment of the present invention. The supplemental data having the null sequence inserted therein is transmitted to the VSB reception system. The predefined sequence has 1's and 0's arranged in a fixed order. The predefined sequence inserted in the supplemental data can be used for performance improvement in the reception system.

For example, the channel equalizer of the VSB reception system uses the sequence to enhance ghost cancellation performance of both the supplemental data and the MPEG data and the Trellis decoder can use the sequence to improve noise performance of supplemental data. As shown in Fig. 5, upon reception of one supplemental data byte, the null sequence inserter 13 for generating the predefined sequence inserts null bits, to provide two bytes.

The inserted null sequence is processed in the VSB transmission system 16 in Fig. 2, and then transmitted to the VSB reception system. The null sequence is randomized by the data randomizer 1 of the VSB transmission system 16, and coded by the Reed-Solomon coder 2. Then, the null sequence is interleaved by the data interleaver 3, and provided to the Trellis coder 4 as an input signal D0. This converted sequence is the predefined sequence. The input signal D0 is a lower bit of the two input

bits to the Trellis coder 4. The Trellis coder is basically operative such that three bits are provided with two received bits.

The VSB reception system generates the sequence received as the input signal D0 from the Trellis coder in the 8T-VSB transmission system 16, i.e., the predefined sequence, and uses the generated sequence for improving its own performance. Alternatively, other sequences known to one of ordinary skill in the art may be used instead of the null sequence described above.

The VSB transmitter 110 of the present invention is required to have identical probabilities of occurrence of the 8 levels, for having backward-compatibility with the related art VSB transmission system. Therefore, the presence of the 0's and 1's in the sequence received as the input signal D0 at the Trellis coder are required to be almost the same.

Fig. 6 illustrates a block diagram of the data interleaver 12 for interleaving the supplemental data in Fig. 2. According to the preferred embodiment, a convolutional interleaver may be used as the data interleaver 12. However, other suitable interleaver, such as a block interleaver, known to one of ordinary skill in the art may also be used.

Referring to Fig. 6, the data interleaver 12 has 'B' (preferably 46) branches, and 'M' (preferably 4) bytes of unit memory. The data interleaver 12 may be operative synchronous to a field synchronization signal of the VSB transmission system 16. The 'B' branches, and the 'M' bytes of unit memory of the data interleaver 12 may be changed to other suitable value without deviating from the gist of the present invention.

Because the VSB transmission system 16 already includes a data interleaver 3, as shown in Fig. 1, the data interleaver 12 in the VSB supplemental data processor 100 of Fig. 2 may be omitted if no further burst noise performance improvement is required.

Fig. 7 illustrates a block diagram showing an example of supplemental data coding according to the preferred embodiment of the present invention. Referring to Fig. 7, the supplemental data has a block size of 164 bytes. Fig. 7 illustrates the process of coding the supplemental data packet until the supplemental data packet is provided to the multiplexer 15. This occurs after the supplemental data packet passes the Reed-

Solomon coder 11, the data interleaver 12, the null sequence inserter 13, and the MPEG header inserter 14 in Fig. 2 in succession.

The operation of the VSB supplemental data processor 100 according to the present invention will be described. According to Fig. 7, a Reed-Solomon 20 byte parity is inserted to the supplemental data that is 164 bytes long by the Reed-Solomon coder 11. This process changes the supplemental data into a 184 byte packet. A number of parity bytes may vary with a number of the supplemental data bytes. For example,, if the supplemental data has 154 bytes, the parity has 30 bytes. At the end, the number of the supplemental data bytes having the parity bytes added thereto is fixed to be 184 bytes in advance. The supplemental data having the parity added thereto is interleaved by the data interleaver 12 and provided to the null sequence inserter 13 92 bytes by 92 bytes. The null sequence inserter 13 inserts 92 bytes of the null data into each of the 92 bytes of supplemental data to provide two 184 byte packets for the 184 bytes of supplemental data, where the 20 parity bytes are included in only one of the two 184 byte packets.

Thereafter, the MPEG header inserter 14 inserts 3 bytes of MPEG header, preferably containing the PID, to the front part of each of the supplemental data packets for backward-compatibility with the related art ATSC 8T-VSB transmission system. The multiplexer 15 multiplexes each of the supplemental data packets from the MPEG header inserter 14 and the MPEG data received through another route, and transmits the multiplexed data to the VSB transmission system 16. The VSB transmission system 16 codes the multiplexed data and transmits the data to the VSB reception system.

Fig. 8 illustrates a diagram showing another example of coding the supplemental data. Referring to Fig. 8, 10 bytes of parity bits are inserted into the 82 extra bytes by the Reed-Solomon coder 11, to change the extra bytes into a 92 byte packet. The number of parity bytes varies with the number of the supplemental data bytes. That is, if the supplemental data has 72 bytes, then the parity has 20 bytes. At the end, the supplemental data having the parity added thereto is fixed to have 92 bytes in advance. The 92 bytes of supplemental data having the 10 bytes of parity added thereto is

interleaved by the interleaver 12, and provided to the null sequence inserter 13, and the null sequence inserter 13 inserts 92 bytes of null sequence into the 92 bytes of supplemental data, to provide a total 184 bytes of packet. Accordingly, each of the 184 bytes of packets includes 10 parity bytes.

Similar to Fig. 7, the MPEG header inserter 14 inserts 3 bytes of MPEG header to the front part of the 184 bytes of supplemental data packets for backward-compatibility with the related art ATSC 8T-VSB transmission system, for a total of 187 bytes of data. Finally, the multiplexer 15 multiplexes each of the supplemental data packets from the MPEG header inserter 14 and MPEG data received through another route, and transmits the multiplexed data to the VSB transmission system 16. The VSB transmission system 16 codes the multiplexed data, and transmits the data to the VSB reception system. At the end, FIGS. 7 and 8 are identical in that the total number of bytes of the supplemental data having the null sequence inserted thereto is 184, and the total number of bytes of the supplemental data having the MPEG header added thereto is 187.

As has been explained, the present invention has the following advantages. First, supplemental data can be transmitted on the same channel with MPEG data with the supplemental data multiplexed with the MPEG data.

Second, a backward-compatibility with the conventional ATSC 8T VSB system can be sustained. That is, the reception of the MPEG transport data at the ATSC 8T-VSB receiver is not affected. Third, reliable reception both of the MPEG data and the supplemental data at the reception system is facilitated by using the predefined sequence inserted in the supplemental data even on a channel with excessive ghost. Fourth, a noise immunity of the supplemental data is enhanced at the VSB reception system by using the predefined sequence inserted in the supplemental data. Fifth, transmission of other MPEG data through supplemental data path is permitted, which in turn permits reception of the MPEG data even in a poor channel state.

It will be apparent to those skilled in the art that various modifications and variations can be made in the VSB communication system, and the signal format for the

VSB communication system of the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

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CLAIMS:

1. A VSB transmitter for use with an MPEG data signal and a supplemental data signal, the VSB transmitter comprising:

a VSB supplemental data processor configured to preprocess the supplemental data signal, the VSB supplemental data processor comprising:

a forward error correction coder that codes the supplemental data signal;

a null bits inserter for inserting a plurality of null bits into the supplemental data signal subjected to the forward error correction coder;

a header inserter for inserting a header to the supplemental data signal having the null bits inserted therein; and

a multiplexer for multiplexing the MPEG data signal and the preprocessed supplemental data signal having the header inserted thereto in at least one of a predetermined multiplexing ratio and unit; and

a VSB transmission system connected to the VSB supplemental data processor for coding the multiplexed data signal for forward error correction, and for modulating the coded multiplexed signal to form at least one data field comprising a plurality of segments that includes at least one segment formed from the supplemental data signal and at least one segment formed from the MPEG data signal.

2. The VSB transmitter of claim 1, wherein the forward error correction coder is a Reed-Solomon coder.

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3. The VSB transmitter of claim 2, wherein the supplemental data signal includes at least one data packet having X bytes and the Reed-Solomon coder provides parity bytes of Y bytes, wherein a total of X and Y bytes is 184 bytes.

4. The VSB transmitter of claim 3, wherein the header inserter adds three bytes of header information to the data packet, wherein the header information contains program identification.

5. The VSB transmitter of claim 3, wherein the null bits inserter divides the one data packet of the supplemental data signal into a plurality of data packets.

6. The VSB transmitter of claim 5, wherein the plurality of null bits has substantially the same occurrence of bits "1" and "0".

7. The VSB transmitter of claim 1, further comprising an interleaver receiving data from the forward error correction coder and outputting to the null bits inserter, wherein the interleaver interleaves the supplemental data signal coded by the forward error correction coder.

8. The VSB transmitter of claim 7, wherein the forward error correction coder is a Reed-Solomon coder.

9. The VSB transmitter of claim 8, wherein the supplemental data signal includes at least one data packet having X bytes and the Reed-Solomon coder provides parity bytes of Y bytes, wherein a total of X and Y bytes is 184 bytes.

10. The VSB transmitter of claim 9, wherein the header inserter adds three bytes of header information to the data

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packet, wherein the header information contains program identification.

11. The VSB transmitter of claim 9, wherein the null bits inserter divides the one data packet of the supplemental data signal into a plurality of data packets.

12. The VSB transmitter of claim 11, wherein the plurality of null bits has substantially the same occurrence of bits "1" and "0".

13. The VSB transmitter of claim 1, wherein the multiplexing unit is a segment, and the multiplexing ratio varies with amounts of MPEG data packets representing the MPEG data signal and supplemental data packets representing the supplemental data signal.

14. The VSB transmitter of claim 13, wherein the multiplexing ratio of the supplemental data packets and the MPEG data packets in the multiplexer is one segment to one segment.

15. The VSB transmitter of claim 13, wherein the multiplexing ratio of the supplemental data packets and the MPEG data packets in the multiplexer is one segment to three segments.

16. The VSB transmitter of claim 1, wherein the multiplexer is responsive to a field synchronizing signal used for synchronizing a data frame of the VSB transmission system.

17. The VSB transmitter of claim 1, wherein the data field has 312 data segments and one field synchronizing segment.

18. A VSB supplemental data processor for use with a VSB transmission system to provide a supplemental data signal and an MPEG data signal thereto, wherein the VSB transmission system modulates at least one data field comprising a plurality of segments that includes at least one segment formed from the supplemental data signal and at least one segment formed from the MPEG data signal, the VSB supplemental data processor being configured to preprocess the supplemental data signal, the VSB supplemental data processor comprising:

a forward error correction coder that codes the supplemental data signal;

a null bits inserter for inserting a plurality of null bits to the supplemental data signal subjected to the forward error correction coder;

a header inserter for inserting a header to the supplemental data signal having the null bits inserted therein; and

a multiplexer for multiplexing the MPEG data signal and the supplemental data signal having the header inserted thereto in at least one of a predetermined multiplexing ratio and unit.

19. The VSB supplemental data processor of claim 18, wherein the forward error correction coder is a Reed-Solomon coder.

20. The VSB supplemental data processor of claim 19, wherein the supplemental data signal includes at least one data packet having X bytes and the Reed-Solomon coder provides parity bytes of Y bytes, wherein a total of X and Y bytes is 184 bytes.

21. The VSB supplemental data processor of claim 20, wherein the header inserter adds three bytes of header information to the data packet, wherein the header information contains program identification.

22. The VSB supplemental data processor of claim 20, wherein the null bits inserter divides the one data packet of the supplemental data signal into a plurality of data packets.

23. The VSB supplemental data processor of claim 22, wherein the plurality of null bits has substantially the same occurrence of bits "1" and "0".

24. The VSB supplemental data processor of claim 18, further comprising an interleaver receiving data from the forward error correction coder and outputting to the null bits inserter, wherein the interleaver interleaves the supplemental data signal coded by the forward error correction coder.

25. The VSB supplemental data processor of claim 24, wherein the forward error correction coder is a Reed-Solomon coder.

26. The VSB supplemental data processor of claim 25, wherein the supplemental data signal includes at least one data packet having X bytes and the Reed-Solomon coder provides parity bytes of Y bytes, wherein a total of X and Y bytes is 184 bytes.

27. The VSB supplemental data processor of claim 26, wherein the header inserter adds three bytes of header information to the data packet, wherein the header information contains program identification.

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28. The VSB supplemental data processor of claim 26, wherein the null bits inserter divides the one data packet of the supplemental data signal into a plurality of data packets.

29. The VSB supplemental data processor of claim 28, wherein the plurality of null bits has substantially the same occurrence of bits "1" and "0".

30. The VSB supplemental data processor of claim 18, wherein the multiplexing unit is a segment, and the multiplexing ratio varies with amounts of MPEG data packets representing the MPEG data signal and supplemental data packets representing the supplemental data signal.

31. The VSB supplemental data processor of claim 30, wherein the multiplexing ratio of the supplemental data packets and the MPEG data packets in the multiplexer is one segment to one segment.

32. The VSB supplemental data processor of claim 30, wherein the multiplexing ratio of the supplemental data packets and the MPEG data packets in the multiplexer is one segment to three segments.

33. A method for a supplemental data packet and an MPEG data packet in a VSB transmitter comprising a VSB supplemental data processor and a VSB transmission system, the method comprising the steps of:

preprocessing the supplemental data packet, the preprocessing step comprising:

subjecting the supplemental data packet comprising a first preset number of bytes to a Reed-Solomon coding and adding a Reed-Solomon parity data comprising a second preset number of bytes to the supplemental data packet;

interleaving the coded supplemental data packet;

inserting null bits into the interleaved supplemental data packet for producing at least one supplemental data packet comprising a third preset number of bytes; and

adding an MPEG header comprising a fourth preset number of bytes to each one of the supplemental data packets;

multiplexing the MPEG data packet with the preprocessed supplemental data packet at a preset multiplexing ratio; and

modulating the data multiplexed at the preset multiplexing ratio through the VSB transmission system.

34. The method of claim 33, wherein the Reed-Solomon parity data is included to only one of the supplemental data packets.

35. The method of claim 33, wherein the step of inserting null bits comprises;

dividing the supplemental data packet into two supplemental data packets having the same numbers of bytes; and

inserting a plurality of null bits having the same bytes with the supplemental data packet into each one of the supplemental data packets to provide two supplemental data packets each having the null bits inserted therein.

36. The method of claim 35, wherein each one of the supplemental data packets has 184 bytes comprising 92 bytes of supplemental data and 92 bytes of the null bits.

37. The method of claim 33, wherein the MPEG header is an identification code for identifying whether the multiplexed data is the supplemental data packet or the MPEG data packet.

38. A method of processing a digital television (DTV) signal in a DTV receiver, the method comprising:

receiving a DTV signal including a data frame, the data frame including normal data and robust data multiplexed with the normal data, wherein the normal data result from performing interleaving operation once and the robust data result from pre-processing original robust data before multiplexing with the normal data by coding the original robust data for first forward error correction (FEC), by interleaving the FEC-coded robust data, and by periodically inserting predefined sequences into the interleaved robust data, coding the pre-processed robust data for second FEC, and interleaving the robust data coded for second FEC; and

performing channel equalization on the robust data in the data frame using the predefined sequences in order to enhance ghost cancellation performance of the robust data.

39. The method of claim 38, wherein the normal data are MPEG data.

40. The method of claim 38, wherein the normal data and the robust data are multiplexed in the data frame at a multiplexing ratio of 1:N.

41. A transmission system for processing AV data, the transmission comprising:

a first interleaver configured to interleave first AV data having first attribute for first burst error correction, the first AV data including at least one of

audio and video data and being input to the first interleaver through a first path, the first interleaver dispersing the first AV data;

a multiplexer configured to multiplex the interleaved first AV data with second AV data having second attribute different from the first attribute, the second AV data including at least one of audio and video data and being input to the multiplexer through a second path different from the first path; and

a second interleaver configured to interleave the multiplexed first and second AV data for second burst error correction, the second interleaver dispersing the multiplexed first and second AV data.

42. The transmission system of claim 41, further comprising a pilot inserter configured to insert pilot signals into the interleaved first and second AV data.

43. The transmission system of claim 41, further comprising a trellis coder configured to convert the interleaved first and second AV data into corresponding symbols.

44. The transmission system of claim 41, wherein the first and second AV data are multiplexed based on multiplexing information which comprises multiplexing ratio and locations.

45. A method of processing AV data in a transmission system, the method comprising:

interleaving in a first interleaver first AV data having first attribute in for first burst error correction, the first AV data including at least one of audio and video data and being input to the first interleaver through a

first path, wherein interleaving first AV data comprises dispersing the first AV data;

multiplexing in a multiplexer the interleaved first AV data with second AV data having second attribute different from the first attribute, the second AV data including at least one of audio and video data and being input to the multiplexer through a second path different from the first path; and

interleaving in a second interleaver the multiplexed first and second AV data for second burst error correction, wherein interleaving the multiplexed first and second AV data comprises dispersing the multiplexed first and second AV data.

46. The method of claim 45, further comprising inserting pilot signals into the interleaved first and second AV data.

47. The method of claim 45, further comprising converting the interleaved first and second AV data into corresponding symbols.

48. The method of claim 45, wherein the first and second AV data are multiplexed based on multiplexing information which comprises multiplexing ratio and locations.

SMART & BIGGAR

OTTAWA, CANADA

PATENT AGENTS

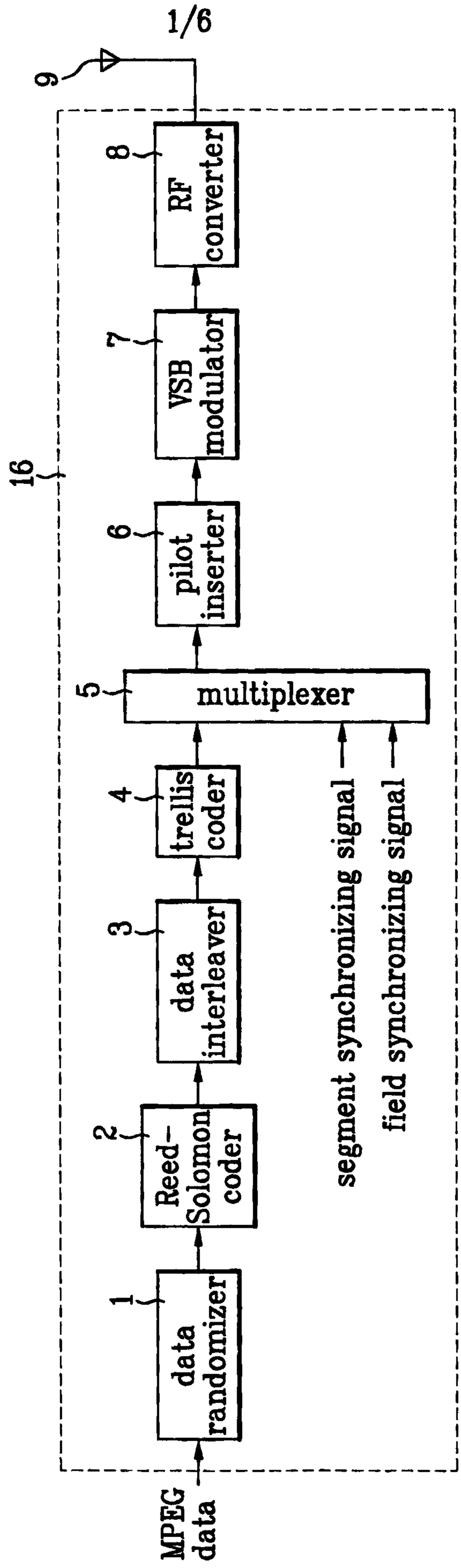


FIG. 1
Prior Art

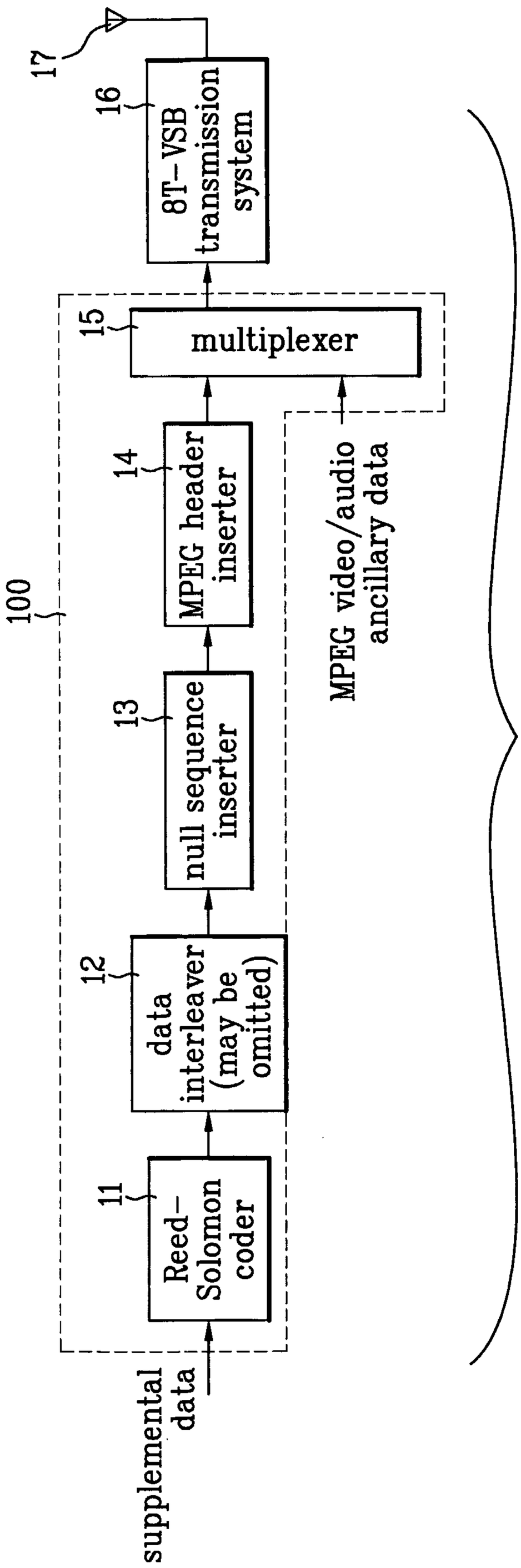
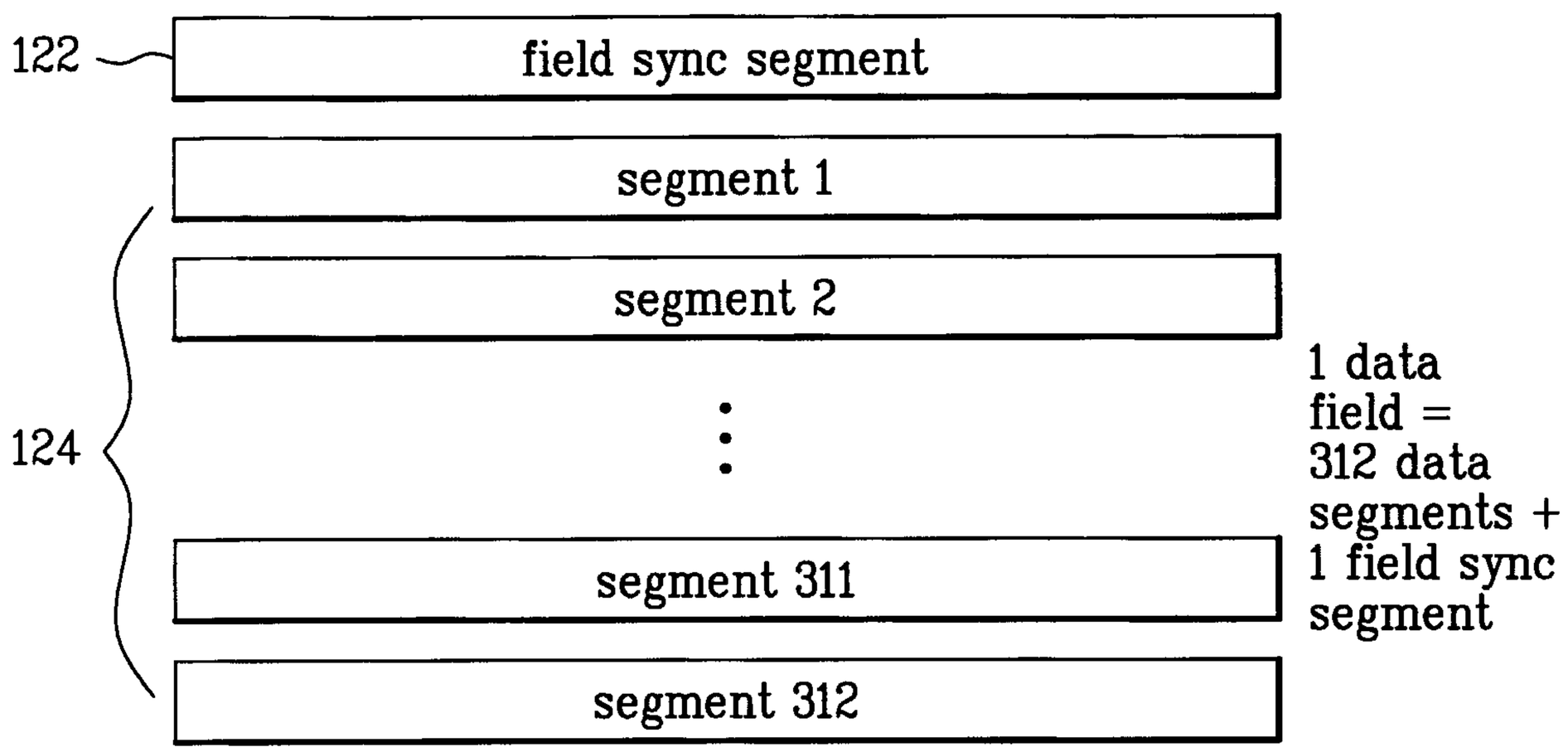

17
16
8T-VSB transmission system
15
multiplexer
14
MPEG header inserter
13
null sequence inserter
12
data interleaver (may be omitted)
11
Reed-Solomon coder
100
supplemental data
MPEG video/audio ancillary data
110

FIG. 2

FIG. 3


122
field sync segment
segment 1
segment 2
124
segment 311
segment 312
1 data field = 312 data segments + 1 field sync segment

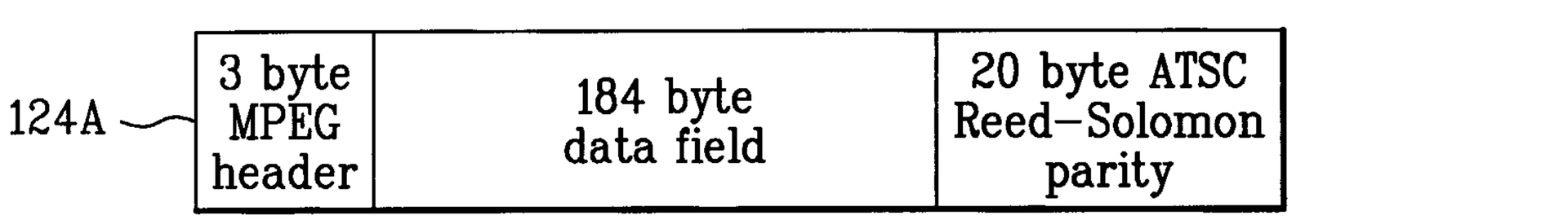

124A
3 byte MPEG header
184 byte data field
20 byte ATSC Reed-Solomon parity

FIG. 4

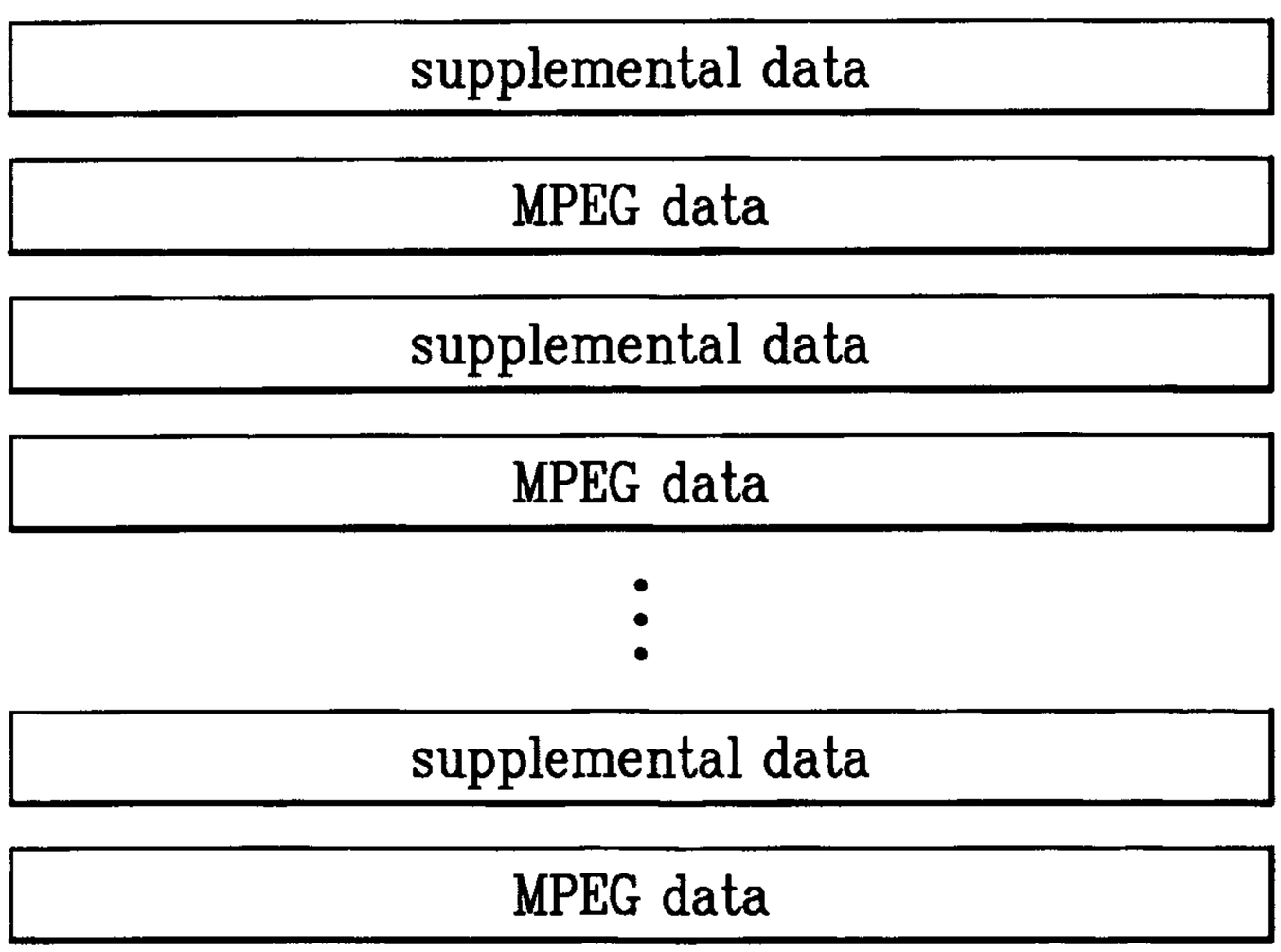

supplemental data
MPEG data
supplemental data
MPEG data
supplemental data
MPEG data

FIG. 5

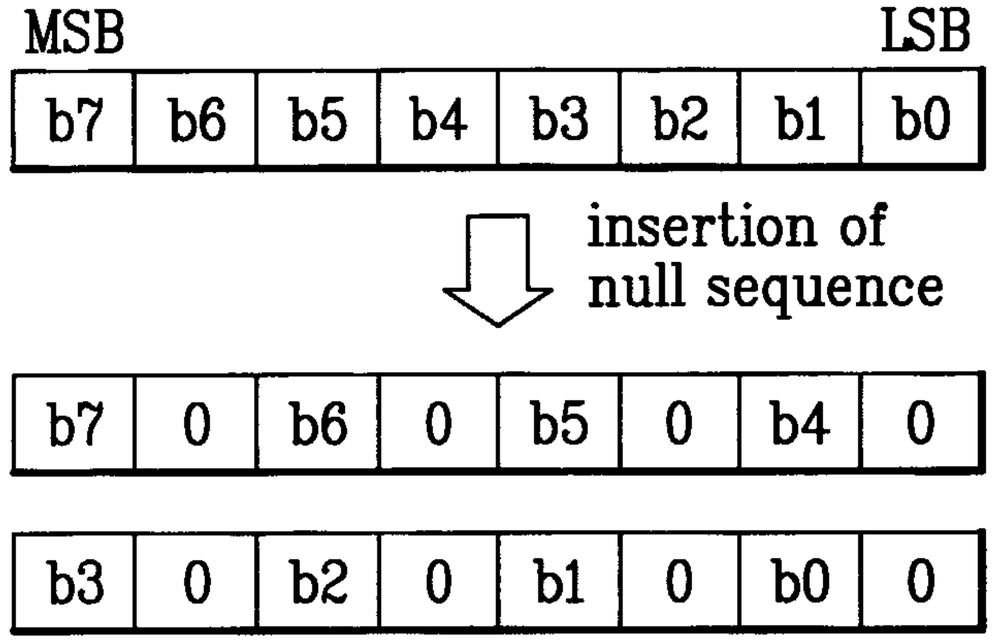

MSB
LSB
b7 b6 b5 b4 b3 b2 b1 b0
insertion of
null sequence
b7 0 b6 0 b5 0 b4 0
b3 0 b2 0 b1 0 b0 0

FIG. 6

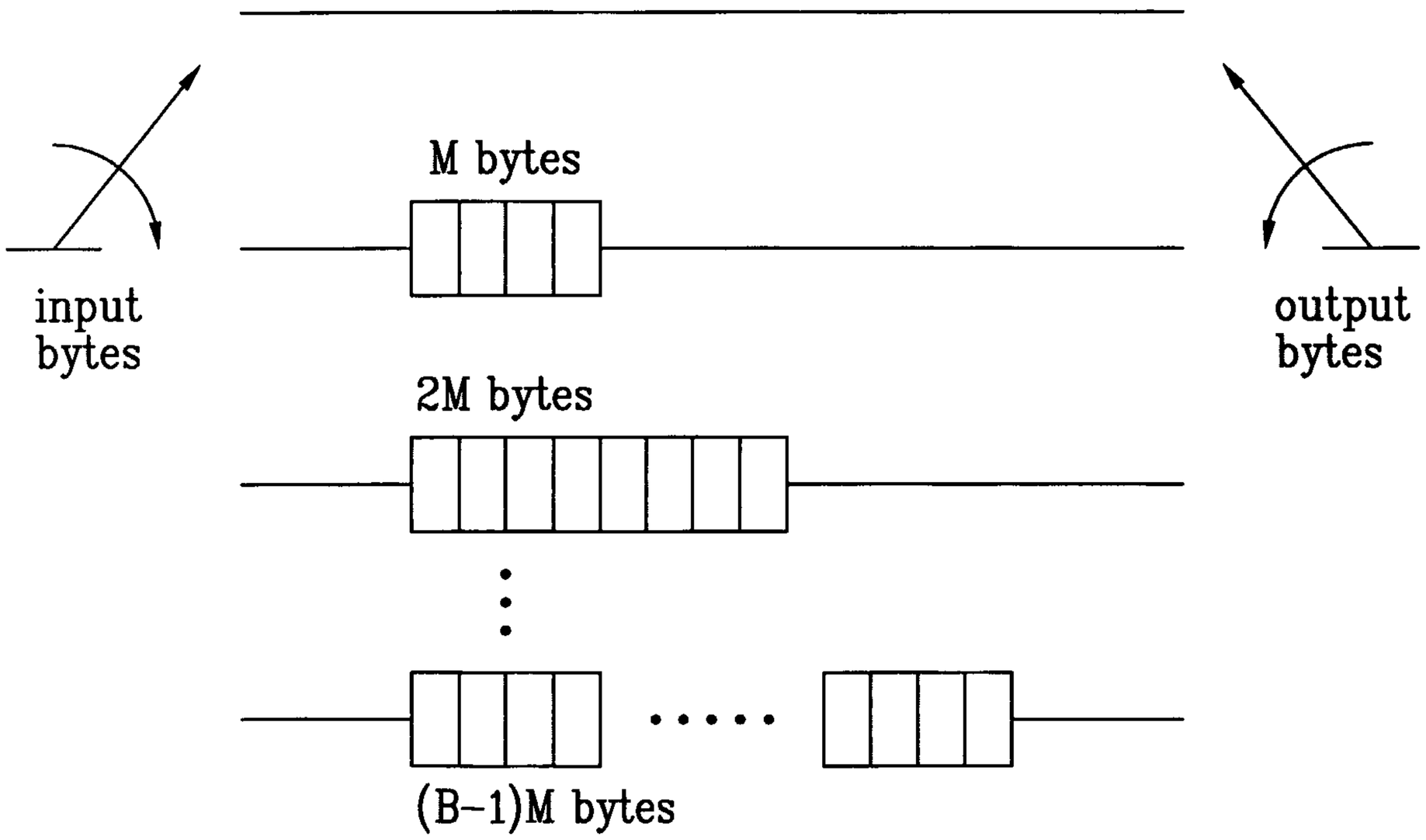

M bytes
input
bytes
output
bytes
2M bytes
(B-1)M bytes

FIG. 7

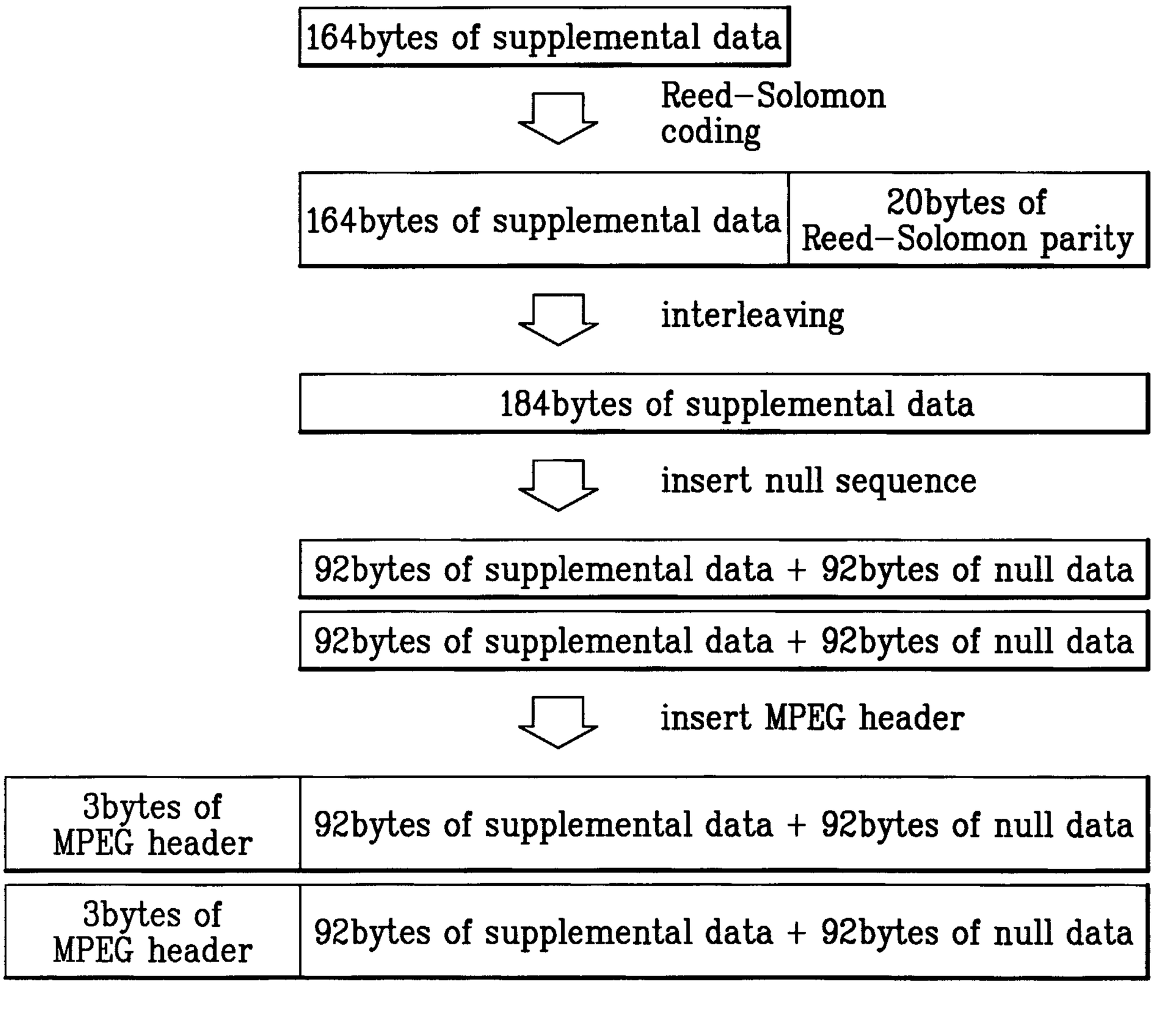
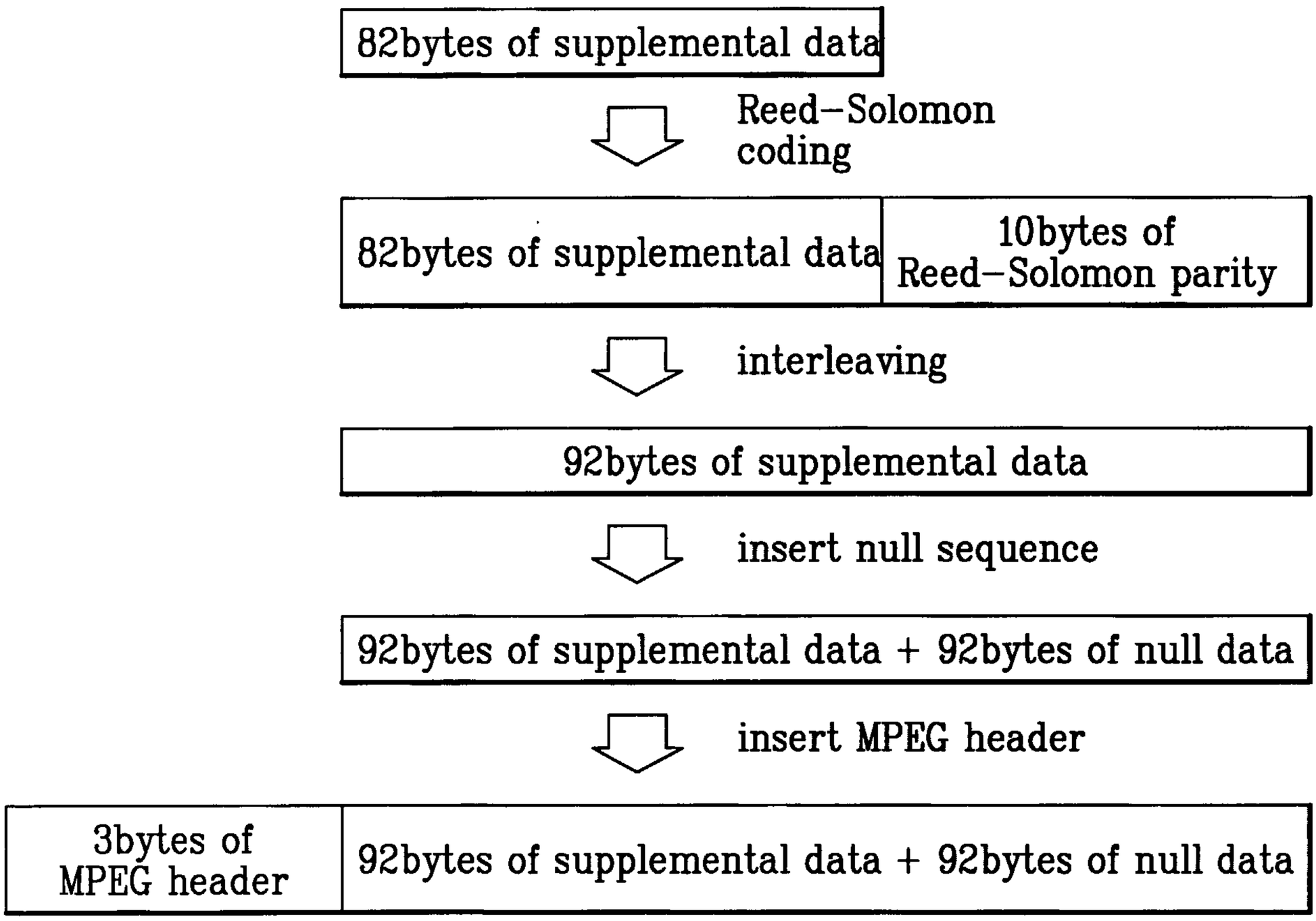
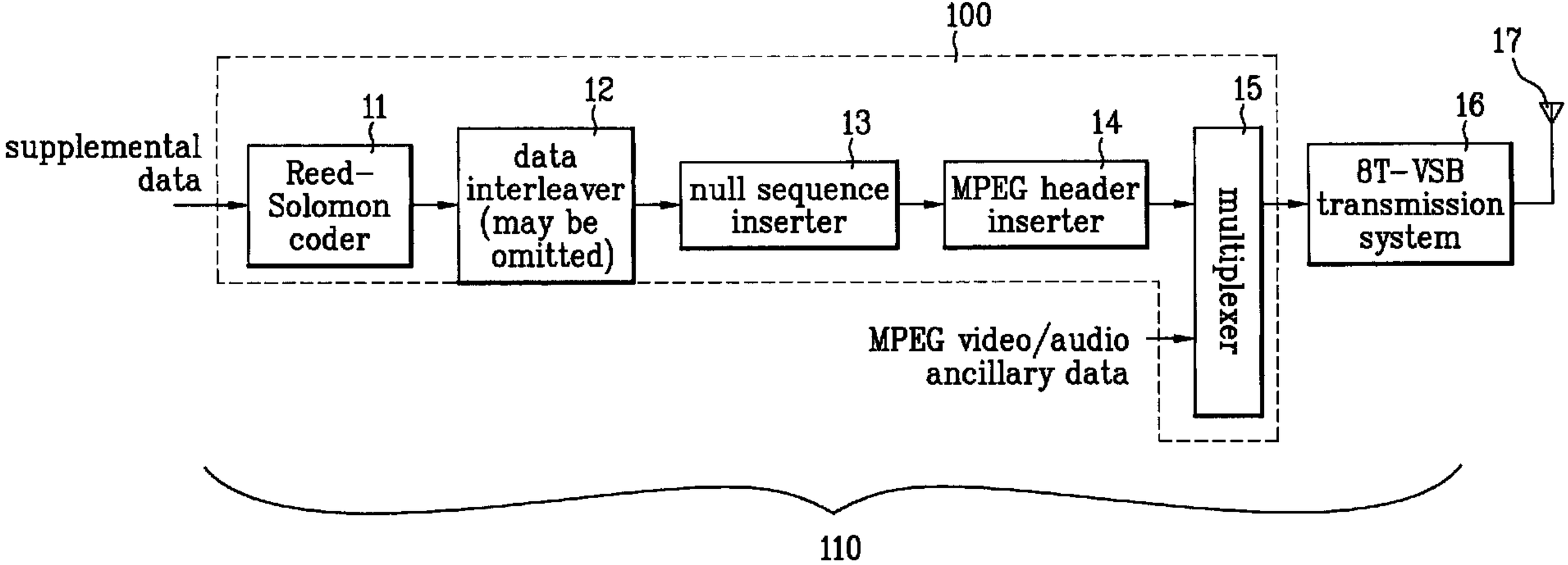

164bytes of supplemental data
Reed-Solomon coding
164bytes of supplemental data
20bytes of Reed-Solomon parity
interleaving
184bytes of supplemental data
insert null sequence
92bytes of supplemental data + 92bytes of null data
92bytes of supplemental data + 92bytes of null data
insert MPEG header
3bytes of MPEG header
92bytes of supplemental data + 92bytes of null data
3bytes of MPEG header
92bytes of supplemental data + 92bytes of null data

FIG. 8


82bytes of supplemental data
Reed-Solomon coding
82bytes of supplemental data
10bytes of Reed-Solomon parity
interleaving
92bytes of supplemental data
insert null sequence
92bytes of supplemental data + 92bytes of null data
insert MPEG header
3bytes of MPEG header
92bytes of supplemental data + 92bytes of null data


100
17
supplemental data
11
Reed–Solomon coder
12
data interleaver (may be omitted)
13
null sequence inserter
14
MPEG header inserter
15
multiplexer
16
8T–VSB transmission system
MPEG video/audio ancillary data
110