(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
9 September 2005 (09.09.2005)

PCT

(10) International Publication Number
WO 2005/084024 A1

(51) International Patent Classification[7]: H04N 7/173, 5/00

(21) International Application Number:
PCT/US2004/004826

(22) International Filing Date: 18 February 2004 (18.02.2004)

(25) Filing Language: English

(26) Publication Language: English

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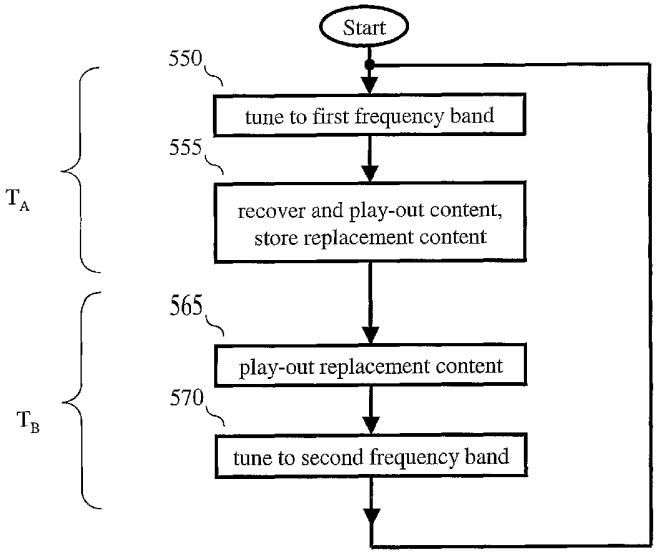
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *with amended claims and statement*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD AND APPARATUS FOR OPTIMIZING BANDWIDTH IN BROADCAST/MULTICAST VIDEO SYSTEMS



(57) Abstract: A video distribution system (e.g., a cable broadcast system) comprises an upstream distribution point (e.g., a cable head-end), a communications channel (e.g., a cable) and one, or more, endpoints (e.g., a set-top box). The cable head-end transmits a program channel downstream along with a redundant portion of the program channel to the set-top box in a first frequency band. The set-top box plays-out the content associated with the program channel and uses the redundant portion of the program channel for bridging a time duration during which the tuner of the set-top box is tuned to another frequency band, e.g., an out-of-band (OOB) channel.

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METHOD AND APPARATUS FOR OPTIMIZING BANDWIDTH IN BROADCAST/MULTICAST VIDEO SYSTEMS

BACKGROUND OF THE INVENTION

[0001] The present invention generally relates to communications systems and, more particularly, to multi-media communications systems, such as, e.g., a cable broadcast system.

[0002] In a multi-media communications system such as, e.g., a cable broadcast system, a cable provider (or system operator) transmits, or broadcasts, video programs (content) to subscribers. This transmission typically takes place from an upstream distribution point, e.g., a cable head-end, over a downstream channel on the transmission medium, e.g., cable, to an endpoint, e.g., a set-top box located at a subscriber's home. Some services, such as Pay-Per-View (PPV) or Video-on-Demand (VoD), also require upstream communications, e.g., from the set-top box to the cable head-end. As such, it is generally known that the multi-media communications system may also include a separate out-of-band (OOB) channel to transmit and/or receive command and control messages between, e.g., the cable head-end and the set-top box.

[0003] While the OOB channel could be conveyed over a different transmission medium, e.g., the public-switched-telephone-network (PSTN), the downstream channel and the OOB channel may be conveyed over the same transmission medium in different frequency bands. In this case, the set-top box includes at least two communications interfaces (also referred to herein as "tuners") — one tuned to the downstream channel and the other tuned to the OOB channel.

SUMMARY OF THE INVENTION

[0004] As described above, an endpoint, such as a set-top box, that includes two tuners is able to support simultaneous communications over multiple frequency bands in a multi-media communications system. As such, the presence of two tuners allows the set-top box to support an increased feature set such as PPV and VoD. Unfortunately, we have observed that requiring an endpoint, such as a set-top box, to incorporate multiple tuners may significantly add to the cost of the set-top box. Therefore, and in accordance with the principles of the invention, an endpoint of a multi-media communications system shares, e.g., time multiplexes, a tuner for providing communications over a first frequency band and a second frequency band.

[0005] In an embodiment of the invention, an endpoint (e.g., a set-top box) of a video distribution system (e.g., a cable broadcast system) comprises a tuner for communicating over

a first frequency band and a second frequency band. The set-top box switches the tuner between the first frequency band and the second frequency band. While tuned to the second frequency band, the set-top box transmits and/or receives data and while tuned to the first frequency band, the set-top box recovers content for play-out to a user in such a way that the play-out of the recovered content is not interrupted while the tuner is tuned to the second frequency band. Illustratively, the second frequency band corresponds to an out-of-band (OOB) signaling channel between the set-top box and an upstream distribution point (e.g., a cable head-end) of the video distribution system.

[0006] In another embodiment of the invention, a video distribution system (e.g., a cable broadcast system) comprises an upstream distribution point (e.g., a cable head-end), a communications channel (e.g., a cable) and one, or more, endpoints (e.g., a set-top box). The cable head-end transmits a program channel downstream along with a redundant portion of the program channel to the set-top box in a first frequency band. The set-top box plays-out the content associated with the program channel and uses the redundant portion of the program channel for bridging a time duration during which the tuner of the set-top box is tuned to another frequency band, e.g., an out-of-band (OOB) channel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 shows a portion of a prior art upstream distribution point;

[0008] FIG. 2 illustrates a prior art packetized data stream provided by the upstream distribution point of FIG. 1;

[0009] FIG. 3 illustrates recovery of content from the packetized data stream of FIG. 2;

[0010] FIG. 4 shows a portion of a video distribution system in accordance with the principles of the invention;

[0011] FIGs. 5 – 8 further illustrate the inventive concept;

[0012] FIG. 9 shows an illustrative embodiment of head-end 45 in accordance with the principles of the invention;

[0013] FIG. 10 shows an illustrative flow chart embodying the principles of the invention for use in head-end 45 of FIG. 9;

[0014] FIG. 11 shows an illustrative multi-media signal in accordance with the principles of the invention;

[0015] FIG. 12 shows an illustrative embodiment of STB 60 of FIG. 4 in accordance with the principles of the invention;

[0016] FIG. 13 shows an illustrative flow chart embodying the principles of the invention for use in STB 60 of FIG. 4; and

[0017] FIGs. 14 -15 show illustrative buffer arrangements for use in STB 60 of FIG. 4.

DETAILED DESCRIPTION

[0018] Other than the inventive concept, the elements shown in the figures are well known and will not be described in detail. As used herein the terms "multi-media communications system" and "video distribution system" are used interchangeably. Also, familiarity with video distribution systems, such as cable, satellite, terrestrial, etc., is assumed and is not described in detail herein. For example, other than the inventive concept, satellite transponders, cable head-ends, set-top boxes, downlink signals, symbol constellations, predistorters, a radio-frequency (rf) front-end, or receiver section, such as a low noise block, formatting and encoding methods (such as the Moving Picture Expert Group (MPEG)-2 Systems Standard (ISO/IEC 13818-1)) for generating transport bit streams and decoding methods such as log-likelihood ratios, soft-input-soft-output (SISO) decoders, Viterbi decoders and a master program guide (MPG) are well-known and not described herein. In addition, the inventive concept may be implemented using conventional programming techniques, which, as such, will not be described herein. Finally, like-numbers on the figures represent similar elements. It should also be noted that as used herein the term "downstream channel" simply refers to a particular frequency band from which content is recovered for use by a user, e.g., for viewing a TV show, and that the term "out-of-band (OOB) channel" simply refers to another frequency band that supports signaling between, e.g., a set-top box (STB) and a head-end, in one or both directions (upstream and/or downstream). However, nothing described herein prohibits the downstream channel from conveying signaling in either direction and the OOB channel from conveying content in either direction. Also, as used herein the term "tuner" is simply a communications interface, or a portion thereof, that is capable of being tuned to a particular frequency band for the reception and/or transmission of signals. As such, a tuner includes e.g., a transmitter and/or receiver, or portions thereof, along with associated circuitry. For example, a transmitter may be tuned, or set, to transmit signals in a particular frequency range. Therefore, in the context of this description, the aforementioned transmitter represents a tuner.

[0019] Before describing the inventive concept, a brief overview of a portion of a multi-media communications system is provided in conjunction with FIGs. 1, 2 and 3. In a multi-media communications system, an upstream distribution point transmits at least one data-

bearing signal to one, or more, endpoints. The data-bearing signal conveys video, audio and/or data (e.g., programs and/or files). Typically, the data-bearing signal is in the form of a packetized data stream.

[0020] The packetized data stream conforms to a known standard such as the Moving Picture Expert Group (MPEG)-2 Systems Standard (ISO/IEC 13818-1) ("MPEG standard"). This is illustrated in FIG. 1, which shows a portion of an upstream distribution point 5 (e.g., a cable head-end). Upstream distribution point 5 includes a packet formatter 10, which forms a packetized data stream, or multi-media signal, 11 from a number, *N*, of applied program channel signals as represented by input signals 9-1 to 9-N. The packetized data stream 11 includes a number of "physical transmission channels" (PTC) as represented by signals 11-1 through 11-K, each PTC having a center frequency (carrier frequency) and bandwidth, and each PTC conveying content (video, audio and/or data) for a number of the program channels, the content in packet form. For example, the packetized data stream may represent thirty-three PTCs (PTC(0) through PTC(32)), each PTC having a center frequency in the range of 119 - 406 MHz (Millions of Hertz) and a bandwidth of 6 MHz, and each PTC including content from *J* program channels, where *J* illustratively equals 6. It should be noted that the term "multi-media signal" is used herein to refer not only to the packetized data stream 11, i.e., the aggregate of signals 11-1 through 11-K, but also to each of the component parts of packetized data stream 11, e.g., signal 11-1 is a multi-media signal. Also, from the above description of multi-media signal 11, it should be observed that packet formatter 10 obviously includes other elements, e.g., a modulator, processor, memory etc., which are not shown and described herein for simplicity. It should be noted that the term "program channel" is used in the context of, e.g., signals 9-1 to 9-N, and their packetized form, e.g., as a part of multi-media signals 11-1 through 11-K.

[0021] Turning now to FIG. 2, an illustrative format for each of the multi-media signals, 11-1 through 11-K, is shown. A multi-media signal includes a stream of packets 70. The stream of packets includes at least one content (C) packet 80 and at least one MPG (G) packet 90. Each content packet 80 comprises a packet identifier (PID) and content (video, audio and/or data). For example, the content could relate to video and/or audio for a particular program channel, or even data representing an executable program being downloaded to the endpoint. As can be observed from FIG. 2, included within each PTC is a copy of a "Master Program Guide" (MPG), i.e., G packet 90, which includes a channel map associating particular programs (audio, video and/or data) with their respective PTCs, program channels

and packet identifiers (PIDs), which are used to identify the particular packets associated with content corresponding to a particular program.

[0022] At the endpoint, a receiver receives multi-media signal 11, i.e., the data-bearing signal, and recovers the appropriate content, e.g., a movie, from a particular one of the *J* program channels of a PTC. For example, when a user selects a program for viewing and/or listening, the receiver must identify the associated packets of the received data-bearing signal that convey the content for the selected program. In this regard, and as noted above, included within each PTC is a copy of a "Master Program Guide" (MPG) that includes a channel map associating particular programs (audio, video and/or data) with their respective PTCs, program channels and packet identifiers (PIDs), which are used to identify the particular packets associated with content corresponding to a particular program. As such, when a user selects, e.g., a program for viewing, the receiver accesses the locally stored version of the MPG to determine the PTC, program channel and PIDs for recovering the respective content for the selected program.

[0023] The recovery of content for a selected program channel is further illustrated in FIG. 3. As noted above, the receiver determines the PTC of the selected program channel, e.g., a PTC associated with a frequency band F1, and then tunes to this frequency band to receive the associated packetized data stream 21, which conveys the content for six program channels. From packetized data stream 21, the receiver selects those packets having a PID value associated with the selected program channel (again, the PID value is available from the MPG) and after a time delay T_D (associated with decoding, etc.) provides content 22 to the user. Also shown in FIG. 3 is the operation of another tuner (23) of the receiver. Illustratively, the receiver is simultaneously tuned to frequency band F2, which corresponds to an OOB channel for communicating with the upstream distribution point while simultaneously recovering content 22.

[0024] As described above, an endpoint, such as a set-top box, that includes two tuners is able to support simultaneous communications over multiple frequency bands in a multi-media communications system. As such, the presence of two, or more, tuners allows the set-top box to support an increased feature set such as PPV and VoD. However, requiring an endpoint, such as a set-top box, to incorporate multiple tuners may significantly add to the cost of the set-top box. Therefore, and in accordance with the principles of the invention, an endpoint of a multi-media communications system shares, e.g., time multiplexes, a tuner for providing communications over a first frequency band and a second frequency band.

[0025] Attention should now be directed to FIG. 4, which shows a portion of an illustrative video distribution system 50 in accordance with the principles of the invention. Video distribution system 50 includes an upstream distribution point 45, a communications channel 55, at least one downstream receiver, or endpoint, as represented by set-top box (STB) 60 and a multi-media endpoint as represented by television (TV) 65. Although described in more detail below, the following is a brief overview of video distribution system 50. Illustratively, video distribution system 50 is a cable broadcast system. In this context, upstream distribution point 45 is, e.g., a cable-head-end 45 (hereafter head-end 45). Head-end 45 is a stored-program-processor based system and includes at least one processor (e.g., a microprocessor) with associated memory as represented by processor 25 and memory 30, along with a transmitter and receiver as represented by transceiver 20. Head-end 45 receives a number of data streams as represented by signals 9-1 through 9-N. Illustratively, each of these N data streams represents a program channel for conveying content, e.g., video, audio and/or data. It should be noted that although shown as N separate data streams, head-end 45 may receive one or more data streams that represent aggregations of program channels. Some of the N program channels may represent Pay-Per-View (PPV) and/or Video-on-Demand (VoD) channels and others of the N program channels may represent program channels associated with basic service packages or program channels associated with different pricing structures, e.g., premium service channels. In this regard, head-end 45 distributes the programming to a number of receivers, as represented by STB 60, via communications channel 55, e.g., a coaxial cable, fiber-optic cable, etc. Communications channel 55 supports a downstream channel 56, for conveying program channels (content) from head-end 45 to STB 60, and an OOB channel 57, for conveying data from STB 60 to head-end 45. The downstream channel 56 is associated with a first frequency band and the OOB channel 57 is associated with a second frequency band. As known in the art, and other than the inventive concept, the downstream channel represents the earlier described multi-media signal 11 and the OOB channel is also known as a reverse channel or back channel. Turning now to STB 60, STB 60 provides programming to TV 65 via signal path 61. In particular, STB 60 also includes a selector, e.g., a remote control (not shown) that enables a user to select a program for viewing on TV 65. When the user indicates selection of a particular program channel via the remote control, STB 60 identifies the related PTC and tunes thereto for selection of the packets with the appropriate PID values for the selected program channel to provide the respective content to TV 65 via signal path 61 for viewing thereon. It should be noted that whether a program channel is a pay-per-view channel and/or a scrambled channel, etc., is

irrelevant to the inventive concept. In accordance with the principles of the invention, STB 60 includes a transceiver that first recovers content from one frequency band and then switches to another frequency band for the transmission and/or reception of data while still providing the content to the user. Thus, an endpoint requiring only one tuner may be constructed at a reduced cost.

[0026] An illustration of the inventive concept is further shown in FIG. 5. Time axis 101 represents STB 60 sharing, or time multiplexing, a tuner between two different frequency bands, F1 and F2, over a period of time. Illustratively, the first frequency band, F1, is associated with the PTC corresponding to the user's selected program channel; while the second frequency band, F2, is associated with an OOB channel. As shown in FIG. 5, STB 60 is tuned to the first frequency band for a first period of time, T_A, and is tuned to the second frequency band for a second period of time, T_B, where $T_A > T_B$ (although the inventive concept is not so limited). Illustratively, a switching cycle period is equal to T_T, where $T_T = T_A + T_B$. While tuned to the first frequency band, STB 60 recovers, after a processing delay (T_D) content A therefrom as illustrated on time axis 102. However, as can be observed from FIG. 5, during those time periods on time axis 101 when STB 60 switches over to the second frequency band, F2, there is a gap in time, T_B, during which the tuner of STB 60 no longer provides data representing content A but, instead, transmits and/or receives data from the second frequency band. Therefore, and in accordance with the principles of the invention, STB fills this gap with replacement content R as illustrated on time axis 102 such that the user does not perceive an interruption in the program.

[0027] One example of replacement content in accordance with the principles of the invention is further shown in FIG. 6, which shows an illustrative PTC comprising six (i.e., $J = 6$) program channels, 201-1 through 201-6. As conceptually illustrated in FIG. 6, the six program channels are formed into a packetized data stream 202, each of the packets identified by different PID values, each PID value associated with one of the program channels as detailed in an MPG. However, and in accordance with the principles of the invention, at least one of the program channels, e.g., 201-6, is simply a delayed version of another one of the program channels as illustrated by program channel 201-5. The amount of time delay, T_X, is represented by time delay element 205. The actual value of T_X can be determined experimentally and is preferably greater than the value of T_B used by the endpoint. Thus, in effect, at least one of the program channels of the PTC is allocated to redundantly broadcast another one of the program channels of the PTC.

[0028] The temporal relationship between a program channel and its delayed version is further shown in FIG. 7. Again, assuming that 201-5 is the selected program channel, program channel 201-6 then represents a delayed version of the selected program channel. In particular, content conveyed on program channel 201-6 is delayed by a time duration T_X as compared to the content conveyed on program channel 201-5. Thus, as shown in FIG. 7, content conveyed in time interval 152 of the delayed program channel has already been received by the endpoint in previous time interval 151. As described above, and in the context of FIG. 5, further assume that the endpoint switches the tuner from the selected program channel (frequency F1) to the OOB (frequency F2) during the time interval 152. Therefore, and in accordance with the principles of the invention, if the duration of time interval 151 (and, therefore 152) is greater than, or equal to, the time duration T_B and $T_B \leq T_X$, then the content conveyed in time interval 151 will already have arrived at the endpoint before the tuner is retuned to frequency F2. In addition, the endpoint can bridge the gap T_B by using the actual program channel (represented by program channel 201-5) as a source of replacement content and the delayed version (represented by program channel 201-6) as the primary source of content for the user. In other words, in this example, when switching the tuner the endpoint (a) uses the delayed program channel as the source of content for play-out to the user and (b) uses the actual program channel as a source of replacement content for bridging the gap T_B during those time intervals when the tuner is tuned to the OOB channel. In view of the above, and in accordance with a feature of the invention, at least one program channel of a PTC is allocated to convey a delayed version of, e.g., a selected program channel. The identification of the delayed program channel is, e.g., predefined and conveyed via the above-mentioned MPG.

[0029] The inventive concept is further illustrated in FIG. 8. Portion 141 of FIG. 8 illustrates the switching of the tuner between the two different frequency bands F1 and F2 with reference to time axis 142. Initially, during a time duration T_A, the tuner is tuned to frequency band F1. During this time, and as illustrated in the upper portion of FIG. 8, STB 60 recovers content 111 for the current selected program for play-out to the user and also recovers replacement content 112, which is stored in a buffer (not shown) of STB 60. Illustratively, the content 111 is recovered from the delayed version of the selected program channel, while the replacement content 112 is recovered from the selected program channel. The replacement content 112 illustratively spans a time interval equal to T_B. At a time T_1, the tuner is retuned to frequency F2 for a time duration T_B. Illustratively, the frequency F2 is associated with an OOB signaling channel. In accordance with the principles of the invention,

STB 60 plays-out replacement content 112 from the buffer to a user during time duration T_B – thus, the user should perceive no interruption in, e.g., watching a movie, since replacement content 112 spans, or bridges, the gap T_B during which the tuner is not tuned to frequency F1 and replacement content 112 represents the same content that the user would have seen but for the change in tuner frequencies. At a time T_2, the tuner is retuned to frequency F1 for recovery of content 111 and also recovers replacement content 113 for storage in the buffer in preparation for the next retuning time interval.

[0030] Turning now to FIG. 9, an illustrative embodiment of head-end 45 in accordance with the principles of the invention is shown. Head-end 45 comprises a number of transmitters: 20-1 through 20-K, a memory 30 and a processor 25. The latter is representative of one or more microprocessors and/or digital signal processors (DSPs) and may include additional memory (not shown) for executing programs and storing data. In this regard, memory 30 is representative of any memory in head-end 45 and includes, e.g., memory of processor 25 and or transmitters 20-1 through 20-K. Reference at this time should also be made to FIG. 10, which shows an illustrative flowchart in accordance with the principles of the invention for use in head-end 45. Illustratively, head-end 45 forms a PTC comprising at least one program channel and at least one delayed version of the program channel. In particular, and in step 505, head-end 45 receives a number of program channels, e.g., the earlier-described *N* program channels (9-1 through 9-N). As shown on FIG. 9, of these *N* program channels, each transmitter receives a number of *J* program channels, 19-1 through 19-K, where $J > 0$ for each transmitter (and values of *J* for each transmitter may be different). Illustratively, *J* equals three. In step 510, head-end 45 updates an MPG with respect to additionally identifying for each PTC not only the associated program channel and PIDs but also which program channels of the PTC convey redundant or delayed data for a particular program channel. In particular, processor 25 receives data related to each of the PTCs, PTC(0) through PTC(K-1), where $K > 0$, via signal 24, and forms a "Master Program Guide" (MPG or G) 3 for storage in memory 30. Other than the inventive concept, processor 25 forms the MPG as known in the art (and, as such, is not described herein). As can be observed from FIG. 9, the MPG includes data, or information, for each of the PTCs as illustrated by the MPG data associated with PTC (K-1). The data associated with each PTC includes modulation format, coding format and data related to each of the *J* programs channels that are a part of a particular PTC (e.g., program data and PID data). In forming the MPG, and in accordance with the principles of the invention, processor 25 adds redundant channel data (also referred to as delayed channel data) as indicated in FIG. 9 by dashed arrow

1. The redundant channel data associated with each PTC is assumed to be predefined and available for use by processor 25. It should also be noted that the MPG can be formed in other ways, e.g., data representing an MPG can be received by processor 25, which then adds the delayed channel data to the received MPG to yield a new MPG in accordance with the inventive concept. In step 515, processor 25 provides MPG 3 to each of the transmitters 20-1 through 20-K, via signal 26. In addition, in step 515, and as noted above, each transmitter also receives a data stream associated with one of the PTCs and provides therefrom a multi-media signal 11′ for transmission that includes MPG 3. For example, transmitter 20-1 receives MPG 3 and a data stream 19-1 conveying J program channels associated with PTC(0). Transmitter 20-1 then forms a multi-media signal 11-1′ representative of PTC(0) at the appropriate carrier frequency. In accordance with the principles of the invention, head-end 45 forms at least one PTC such that the PTC includes a program channel and a delayed (or duplicate) version of the program channel. Step 515 is further illustrated in FIG. 11, for multi-media signal 11-1′. As shown in FIG. 11, multi-media signal 11-1′ comprises three program channels: 201-1, 201-3 and 201-5 and delayed versions thereof (201-2, 201-4 and 201-6, respectively) such that the packetized data stream conveys a total of six program channels. Illustratively, the time delays, as represented by time delay 205 for program channels 201-1, 201-3 and 201-5, are substantially identical although this is not required.

[0031] Referring now to FIG. 12, an illustrative embodiment of STB 60 shown. It should be noted that only those elements of STB 60 relevant to the principles of the invention are shown. STB 60 includes transceiver 490, transport processor 450, controller 455 and memory 460. Transceiver 490 includes both a transmitter and a receiver for receiving signals from downstream channel 56 and transmitting signals to OOB channel 57, respectively. Both transport processor 450 and controller 455 are each representative of one or more microprocessors and/or digital signal processors (DSPs) and may include memory for executing programs and storing data. In this regard, memory 460 is representative of memory in STB 60 and includes, e.g., any memory of transport processor 450 and/or controller 455. An illustrative bidirectional data and control bus 401 couples various ones of the elements of STB 60 together as shown in FIG. 12. Bus 401 is merely representative, e.g., individual signals (in a parallel and/or serial form) may be used, etc., for conveying data and control signaling between the elements of STB 60. Controller 455 sets the frequency band, or tunes, transceiver 490 via bus 401 as represented by dashed arrow 406. As described further below, when tuned to a first frequency channel transceiver 490 demodulates and decodes the signal conveyed on downstream channel 56 to provide a decoded signal 491 to transport processor

490, which distributes video, audio and data bits as represented by content signal 451 to appropriate subsequent circuitry (not shown) and is eventually provided, via signal 61, to TV 65 of FIG. 4. It should be noted that STB 60 may receive commands, e.g., program selection, via a remote control (not shown).

[0032] Reference should now be made to FIG. 13, which shows an illustrative flow chart in accordance with the principles of the invention for use in STB 60. STB 60 switches a tuner, e.g., transceiver 490 of FIG. 12, between a first frequency band, F1, and a second frequency band, F2. Steps 550 and 555 are associated with STB 60 tuning to the first frequency band during a time interval T_A, and steps 565 and 570 are associated with STB 60 tuning to the second frequency band during at time interval T_B. Illustratively, the first frequency band is associated with a selected program channel conveyed on the downstream channel 56 and the second frequency band is associated with OOB channel 57. In step 550, STB 60, e.g., controller 455, tunes transceiver 490 to the first frequency band of the selected program channel. As known in the art, and other than the inventive concept, a program channel can be selected, e.g., during initialization of STB 60 (e.g., when STB 60 is first "turned on") or by the user via the above-mentioned remote control. Further, and as noted earlier, the requisite information associated with the selected program channel such as PTC, frequency setting, PID values, and, in accordance with the inventive concept, the delayed version of the selected program channel, is determined from a copy of an MPG already stored in STB 60, e.g., in memory 460. In step 555, STB 60 recovers and plays out content from those packets having PID values associated with the delayed version of the selected program channel. As known in the art, transport processor 450 recovers the appropriate packets from decoded signal 491 via the identified PID value and, e.g., utilizes a buffer 461 of memory 460 for use in providing the content to the user (also referred to as content buffer 461). Also in step 555, STB 60, e.g., transport processor 450, recovers replacement content from those packets having PID values associated with the selected program channel and stores the replacement content in a buffer 462 of memory 460 (also referred to as replacement buffer 462). It should be noted that acquiring content associated with two different types of packets (as identified by different PID values) from a packetized stream for a selected PTC is within current filtering abilities for a transport processor. Turning briefly to FIG. 14, the illustrative buffers 461 and 462 of memory 460 are shown. At the expiration of time interval T_A, STB 60, e.g., transport processor 450, executes step 565 and begins to play-out the stored replacement content to the user and then in step 570 STB 60, e.g., controller 455, tunes to the

second frequency band. At the expiration of time interval T_B, STB 60 returns to step 550 and switches back to the first frequency band.

[0033] The above-described play-out process is further illustrated in FIG. 15. In particular, STB 60 further comprises a selector 410. STB 60 selects content for play-out to a user from either content buffer 461 or replacement buffer 462 via control signal 409 of selector 410. The selected content is provided via signal 411. In addition, the content stored in replacement buffer 462 is delayed by time delay element 405, which is illustratively equal to the earlier described time delay value associated with time delay element 205 to, in effect, synchronize the content in the different buffers. It should be noted that the elements of FIG. 15 may be implemented in hardware and/or software.

[0034] As described above, STB 60 recovers content from one frequency band and then switches to another frequency band for communications over a signaling channel while still providing the content to the user. Thus, an endpoint requiring only one tuner may be constructed at a reduced cost.

[0035] It should be noted that for simplicity it was assumed that the replacement content is of enough size to at least cover the time interval, T_B, in which STB 60 is tuned to the second frequency band. The time period T_B is preferably of sufficient time duration to perform all necessary out-of-band command and control operations. Alternatively, an aggregation of L time periods of length T_B within a time interval T_W may be of sufficient time duration, LT_B, to perform all necessary out-of-band command and control operations. However, it should be observed that at the instant STB 60 retunes to the first frequency band it is desirable to provide for a seamless transition such that the user does not perceive an interruption in the play-out of the content. As such, the replacement content may have to include enough content to cover any additional time delay required to account for reacquisition and processing of the received multi-media signal on downstream channel 56. Therefore, it may be preferable to store enough replacement content in buffer 462 of memory 460 such that play-out of the stored replacement content spans a time interval greater that T_B and the user is presented with a substantially seamless transition. In this regard, it may be preferable for replacement buffer 462 to be of a size that allows storage of the last $T_x + T_A$ seconds of content.

[0036] It should be observed that the cost of the additional memory necessary to provide a replacement buffer may offset some of the cost benefit from removing additional tuners. However, in many cases adequate memory may already exist in a given STB design since some STBs include additional memory for infrequent operations such as software upgrades.

For example, assume that a value for T_B is 10 seconds. Therefore at least 10 seconds of replacement content must be transmitted, acquired and buffered. Assuming a typical data rate of 3.2 Mbps (millions of bits per second) for a packetized data stream, the resultant buffering needed is 32 million bits, or 4 million bytes (Mbytes). Since it is unlikely that the replacement content would need to survive a power loss, the memory buffer would comprise RAM (random access memory). Further, it should also be noted that it may be preferable to immediately cease any OOB operations if the selected program channel is changed by, e.g., the user.

[0037] As described above, STB 60 periodically switches transceiver 490 between two different frequency bands. However, the inventive concept is not so limited and other variations in accordance with the principles of the invention are possible. For example, synchronization between the selected program channel and the delayed version of the selected program channel may be achieved by use of time stamp information, or equivalents thereof, in the respective contents packets 80. As another alternative, STB 60 can monitor the amount of replacement content accumulating in replacement buffer 462 such that once a sufficient amount of replacement data has been accumulated STB 60 then switches to the second frequency band. As such, and in accordance with the principles of the invention, the switching between frequency bands can occur synchronously, asynchronously (a periodically) or isochronously. For example, STB 60 may switch to the second frequency channel only when necessary. Similarly, STB 60 may switch to the second frequency channel under the control of head-end 45, e.g., since conditional access and program guide data (e.g., the above-described MPG) is sent in the same frequency band as the program content, an EMM (Entitlement Management Message) or similar command could be used to direct STB 60 to acquire the replacement content at particular times and/or switch to the second frequency channel.

[0038] Also, it can be observed that, in effect, the above-described embodiment reduces by one half the capacity of a PTC. However, replacement content may be limited to only those portions required to bridge the time period during which the tuner is tuned to the OOB channel. This may require significantly less then an entire program. In addition, a redundant channel may be limited to a particular one of the program channels of a PTC. Further, specific replacement content may be transmitted by the upstream distribution point targeted to a specific one of each of the endpoints. In this regard, information representing the selected program channel is sent upstream from each endpoint. The upstream distribution point then provides specific replacement content as a function of the selected program channel

information to each endpoint such that the particular endpoint can switch a tuner between at least two different frequency bands and still provide content is a substantially seamless fashion to a user.

[0039] It should also be noted that the timing as to the use of the second frequency band by a particular set-top box can further be controlled by the upstream endpoint. For example, synchronization as to use of the second frequency band can be controlled by suitable signaling from an upstream distribution point to each endpoint such that, e.g., the time interval T_B for some endpoints occurs at a different point in time than for other endpoints. Thus, the upstream distribution point can provide a form of load balancing on the use of the second frequency band by the endpoints.

[0040] It should be further noted that although described in the context of a cable-based video system, the inventive concept is not so limited and applies to terrestrial broadcast, satellite broadcast (Digital Broadcast Satellite (DBS), e.g., Direct TV), etc. In addition, although described in the context of switching between two frequency bands, the inventive concept applies to sharing a tuner over more than two frequency bands. Also, although described in the context of an STB having a single tuner and, thus, reducing the cost of the STB, the inventive concept is applicable to endpoints having more than one tuner, where one, or more, tuners are shared in accordance with the principles of the invention. Further, it should also be noted that groupings of components for particular elements described and shown herein are merely illustrative. For example, head-end 45 may be located further upstream in a distribution system such that other distribution points, or routers, are located between head-end 45 and STB 60. Also, although described in the context of video programming, it should be realized that the inventive concept applies to programming be it video, audio and/or data (e.g., executable code). In this regard, the term "program" may also encompass video, audio and/or data and the term "viewed" simply refers to the currently tuned program of the receiver regardless of whether the program represents video, audio and/or data.

[0041] As such, the foregoing merely illustrates the principles of the invention and it will thus be appreciated that those skilled in the art will be able to devise numerous alternative arrangements which, although not explicitly described herein, embody the principles of the invention and are within its spirit and scope. For example, although illustrated in the context of separate functional elements, these functional elements may be embodied on one or more integrated circuits (ICs). Similarly, although shown as separate elements, any or all of the elements may be implemented in a stored-program-controlled processor, e.g., a digital signal processor (DSP) or microprocessor that executes associated software, e.g., corresponding to

one or more of the steps shown in FIGs. 10 and 13. Further, although shown as separate elements, the elements therein may be distributed in different units in any combination thereof. For example, STB 60 may be a part of TV 65. It is therefore to be understood that numerous modifications may be made to the illustrative embodiments and that other arrangements may be devised without departing from the spirit and scope of the present invention as defined by the appended claims.

CLAIMS

1. A method for use in an endpoint of a video distribution system, the method comprising:

sharing a tuner between at least a first frequency band and a second frequency band for providing communications over the first frequency band and the second frequency band at different times.

2. The method of claim 1, wherein the sharing step time multiplexes the tuner between the first frequency band and the second frequency band.

3. The method of claim 1, wherein the first frequency band is for receiving content for a program channel and the second frequency band is for communicating over an out-of-band signaling channel.

4. The method of claim 1, wherein the sharing step comprises:

tuning the tuner to the first frequency band;

providing content from the first frequency band to a user;

storing replacement content that is associated with the program channel;

tuning the tuner to the second frequency band; and

providing at least a portion of the replacement content to the user while the tuner is tuned to the second frequency band.

5. The method of claim 4, wherein the steps of tuning the tuner to the first frequency band and tuning the tuner to the second frequency band are repeated.

6. The method of claim 5, wherein the steps of tuning the tuner to the first frequency band and tuning the tuner to the second frequency band are repeated every T_T seconds.

7. The method of claim 4, wherein the steps of tuning the tuner to the first frequency band and tuning the tuner to the second frequency band are a periodic.

8. The method of claim 4, wherein the steps of providing and storing occur simultaneously.

9. The method of claim 4, wherein a time interval during which the tuner is tuned to the first frequency band is greater than a time interval during which the tuner is tuned to the second frequency band.

10. The method of claim 4, wherein the step of storing the replacement content includes the step of determining an identifier associated with the replacement content.

11. The method of claim 10, wherein the identifier is a packet identifier (PID).

12. The method of claim 10, further including the step of accessing a master program guide (MPG) to determine the PID.

13. The method of claim 10, further comprising the step of receiving a master program guide (MPG) that includes the PID.

14. The method of claim 1, wherein the video distribution system is a cable broadcast system.

15. The method of claim 1, wherein the video distribution system is a satellite broadcast system.

16. A method for use in an upstream distribution point of a multi-media communications system, the method comprising:

providing content to an endpoint; and

providing replacement content to the endpoint, wherein the replacement content is a duplicate of at least a portion of the content.

17. The method of claim 16, wherein the content is a delayed version of a selected program channel.

18. The method of claim 16, wherein the replacement content is a selected program channel.

19. The method of claim 16, further comprising the step of providing a master program guide (MPG) that provides data associating the replacement content with the content.

20. The method of claim 19, wherein the data is a packet identifier (PID).

21. The method of claim 16, wherein the multi-media communications system is a cable broadcast system.

22. The method of claim 16, wherein the multi-media communications system is a satellite broadcast system.

23. A method for use in an endpoint of a video distribution system, the method comprising:

receiving content for a program channel;

receiving replacement content for the program channel; and

using the replacement content to bridge a time period during which a tuner of the endpoint is tuned to a frequency band different than that used to receive the content.

24. The method of claim 23, further comprising the step of playing out the received content to a user.

25. The method of claim 23, wherein the step of using includes the step of playing out at least a portion of the replacement content to the user during the time period.

26. The method of claim 23, wherein the steps of receiving content and receiving replacement content occur simultaneously.

27. The method of claim 23, wherein the steps of receiving content and receiving replacement content occur a periodically.

28. Apparatus for use in an endpoint of a multi-media communications system, the apparatus comprising:

a tuner;

a processor for controlling the tuner, such that during a first time interval the tuner is set to a first frequency band for recovering content for a program channel and during a second time interval the tuner is set to a second frequency band; and

a memory for storing replacement content for use during the second time interval, wherein the replacement content is associated with the program channel.

29. The apparatus of claim 28, wherein the second frequency band is for communicating over an out-of-band signaling channel.

30. The apparatus of claim 28, wherein the processor time multiplexes the tuner between the first frequency band and the second frequency band.

31. The apparatus of claim 28, wherein the processor periodically switches the tuner between the first frequency band and the second frequency band.

32. The apparatus of claim 28, wherein the first time interval is greater than the second time interval.

33. The apparatus of claim 28, wherein the processor provides at least a portion of the replacement content to a user while the tuner is tuned to the second frequency band.

34. The apparatus of claim 28, wherein the processor a periodically switches the tuner from the first frequency band to the second frequency band.

35. The apparatus of claim 28, wherein the processor determines an identifier associated with the replacement content.

36. The apparatus of claim 35, wherein the identifier is a packet identifier (PID).

37. The apparatus of claim 36, wherein the processor accesses a master program guide (MPG) to determine the PID.

38. The apparatus of claim 28, wherein the multi-media communications system is a cable broadcast system.

39. The apparatus of claim 28, wherein the multi-media communications system is a satellite broadcast system.

AMENDED CLAIMS
[received by the International Bureau on 13 May 2003 (13.05.2003);
original claims 1-39 replaced by amended claims 1-31 (4 pages)]

CLAIMS

1. A method for use in an endpoint of a video distribution system, the method comprising:

sharing a tuner between at least a first frequency band and a second frequency band for providing communications over the first frequency band and the second frequency band at different times;

wherein the first frequency band is for receiving content for a program channel and the second frequency band is for communicating over an out-of-band signaling channel.

2. The method of claim 1, wherein the sharing step time multiplexes the tuner between the first frequency band and the second frequency band.

3. The method of claim 1, wherein the sharing step comprises:

tuning the tuner to the first frequency band;

providing content from the first frequency band to a user;

storing replacement content that is associated with the program channel;

tuning the tuner to the second frequency band; and

providing at least a portion of the replacement content to the user while the tuner is tuned to the second frequency band.

4. The method of claim 3, wherein the steps of tuning the tuner to the first frequency band and tuning the tuner to the second frequency band are repeated.

5. The method of claim 4, wherein the steps of tuning the tuner to the first frequency band and tuning the tuner to the second frequency band are repeated every T_T seconds.

6. The method of claim 3, wherein the steps of tuning the tuner to the first frequency band and tuning the tuner to the second frequency band are a periodic.

7. The method of claim 3, wherein the steps of providing and storing occur simultaneously.

AMENDED SHEET (ARTICLE 19)

8. The method of claim 3, wherein a time interval during which the tuner is tuned to the first frequency band is greater than a time interval during which the tuner is tuned to the second frequency band.

9. The method of claim 3, wherein the step of storing the replacement content includes the step of determining an identifier associated with the replacement content.

10. The method of claim 9, wherein the identifier is a packet identifier (PID).

11. The method of claim 9, further including the step of accessing a master program guide (MPG) to determine the PID.

12. The method of claim 9, further comprising the step of receiving a master program guide (MPG) that includes the PID.

13. The method of claim 1, wherein the video distribution system is a cable broadcast system.

14. The method of claim 1, wherein the video distribution system is a satellite broadcast system.

15. A method for use in an endpoint of a video distribution system, the method comprising:

receiving content for a program channel;

receiving replacement content for the program channel; and

using the replacement content to bridge a time period during which a tuner of the endpoint is tuned to a frequency band different than that used to receive the content.

16. The method of claim 15, further comprising the step of playing out the received content to a user.

17. The method of claim 15, wherein the step of using includes the step of playing out at least a portion of the replacement content to the user during the time period.

18. The method of claim 15, wherein the steps of receiving content and receiving replacement content occur simultaneously.

19. The method of claim 15, wherein the steps of receiving content and receiving replacement content occur a periodically.

20. Apparatus for use in an endpoint of a multi-media communications system, the apparatus comprising:

a tuner;

a processor for controlling the tuner, such that during a first time interval the tuner is set to a first frequency band for recovering content for a program channel and during a second time interval the tuner is set to a second frequency band; and

a memory for storing replacement content for use during the second time interval, wherein the replacement content is associated with the program channel.

21. The apparatus of claim 20, wherein the second frequency band is for communicating over an out-of-band signaling channel.

22. The apparatus of claim 20, wherein the processor time multiplexes the tuner between the first frequency band and the second frequency band.

23. The apparatus of claim 20, wherein the processor periodically switches the tuner between the first frequency band and the second frequency band.

24. The apparatus of claim 20, wherein the first time interval is greater than the second time interval.

25. The apparatus of claim 20, wherein the processor provides at least a portion of the replacement content to a user while the tuner is tuned to the second frequency band.

26. The apparatus of claim 20, wherein the processor a periodically switches the tuner from the first frequency band to the second frequency band.

AMENDED SHEET (ARTICLE 19)

27. The apparatus of claim 20, wherein the processor determines an identifier associated with the replacement content.

28. The apparatus of claim 27, wherein the identifier is a packet identifier (PID).

29. The apparatus of claim 28, wherein the processor accesses a master program guide (MPG) to determine the PID.

30. The apparatus of claim 20, wherein the multi-media communications system is a cable broadcast system.

31. The apparatus of claim 20, wherein the multi-media communications system is a satellite broadcast system.

STATEMENT

The abstract has not been amended and now appears on page 20.

With respect to the original claims, claim 1 has been amended and claims 3 and 16-22 have been canceled. Where necessary, the claims have been renumbered. In particular, on the attached substitute sheets:

- Claim 1 has been amended to include the requirement of original dependent claim 3; and
- Claims 2, 3-14 and 15-31 correspond to original claims 2, 4-15 and 23-37, respectively.

FIG. 1

Prior Art

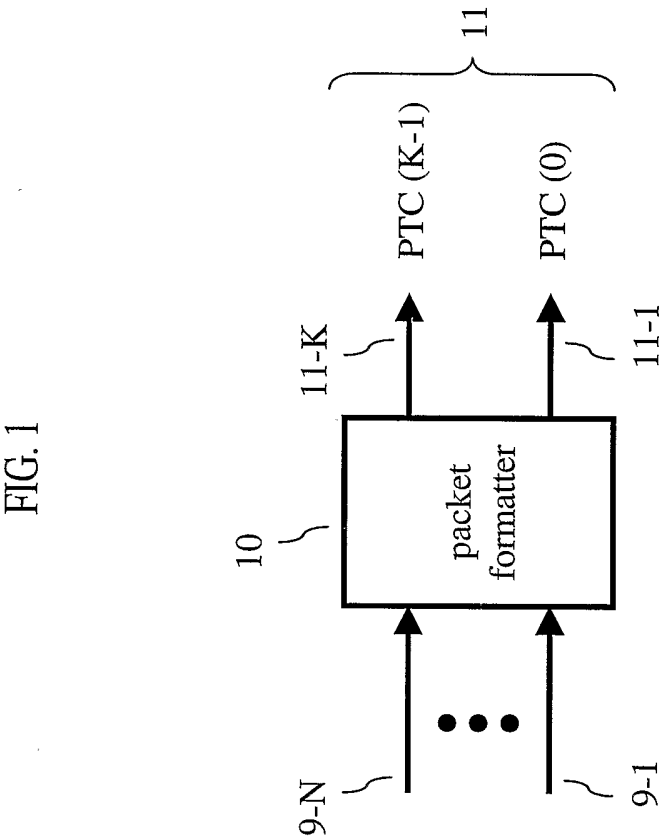
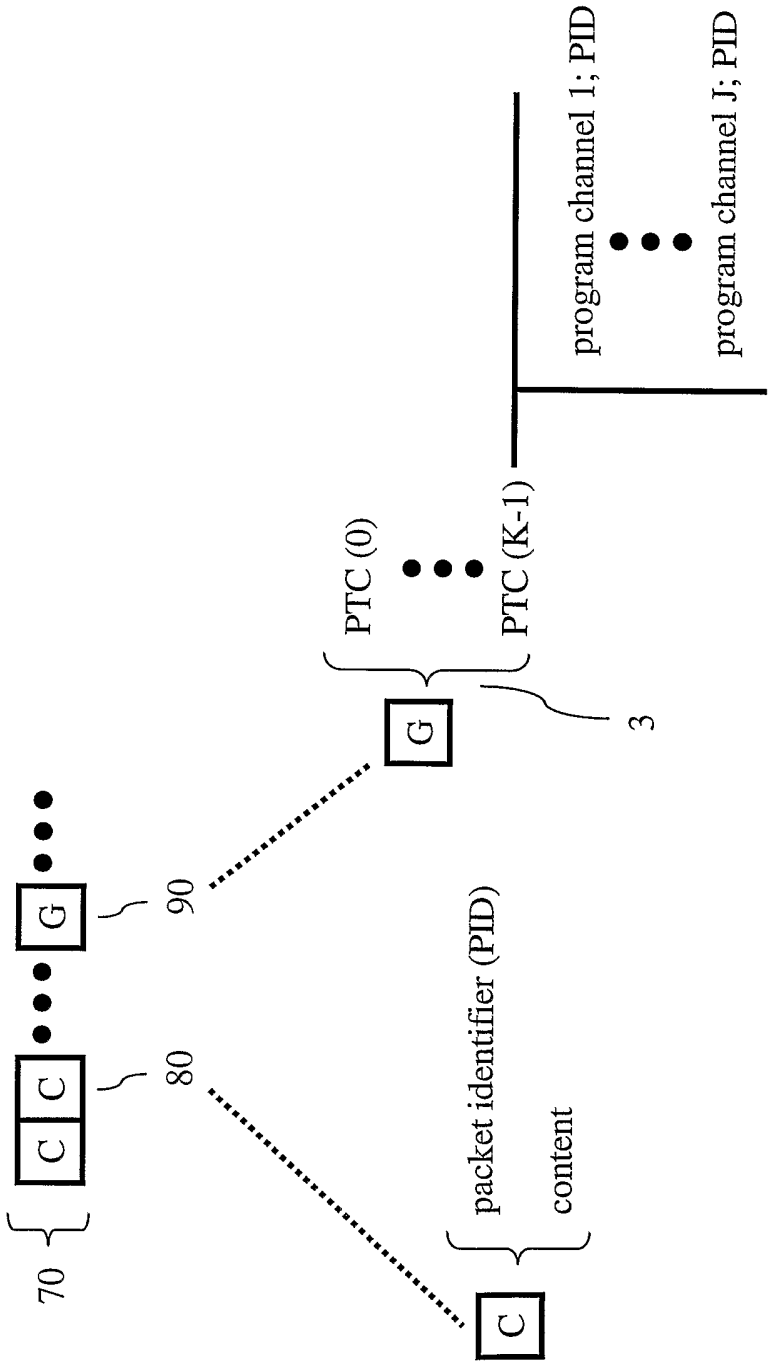


FIG. 2

Prior Art



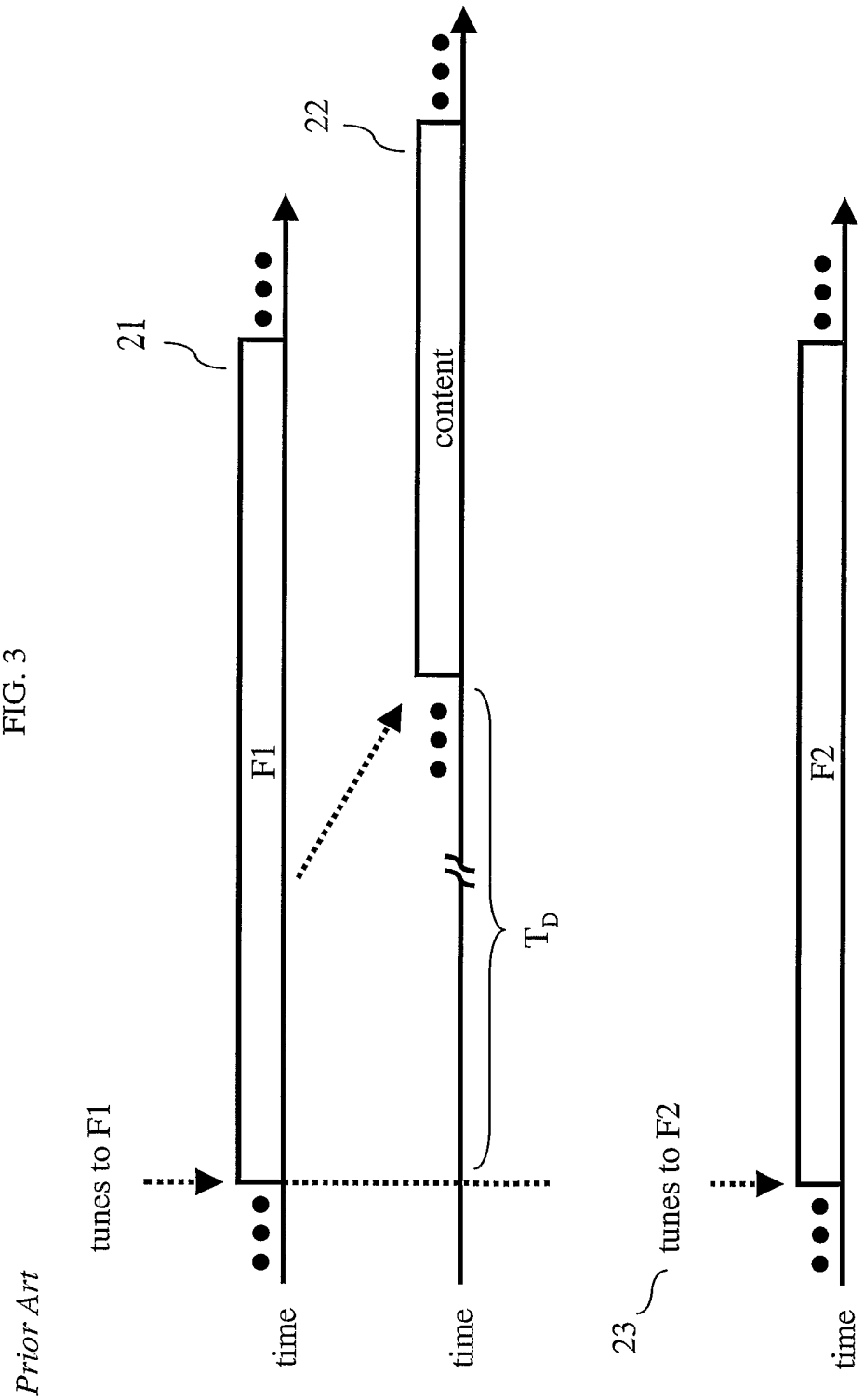

Prior Art
tunes to F1
21
F1
time
22
content
time
T_D
23
tunes to F2
F2
time

FIG. 3

FIG. 4

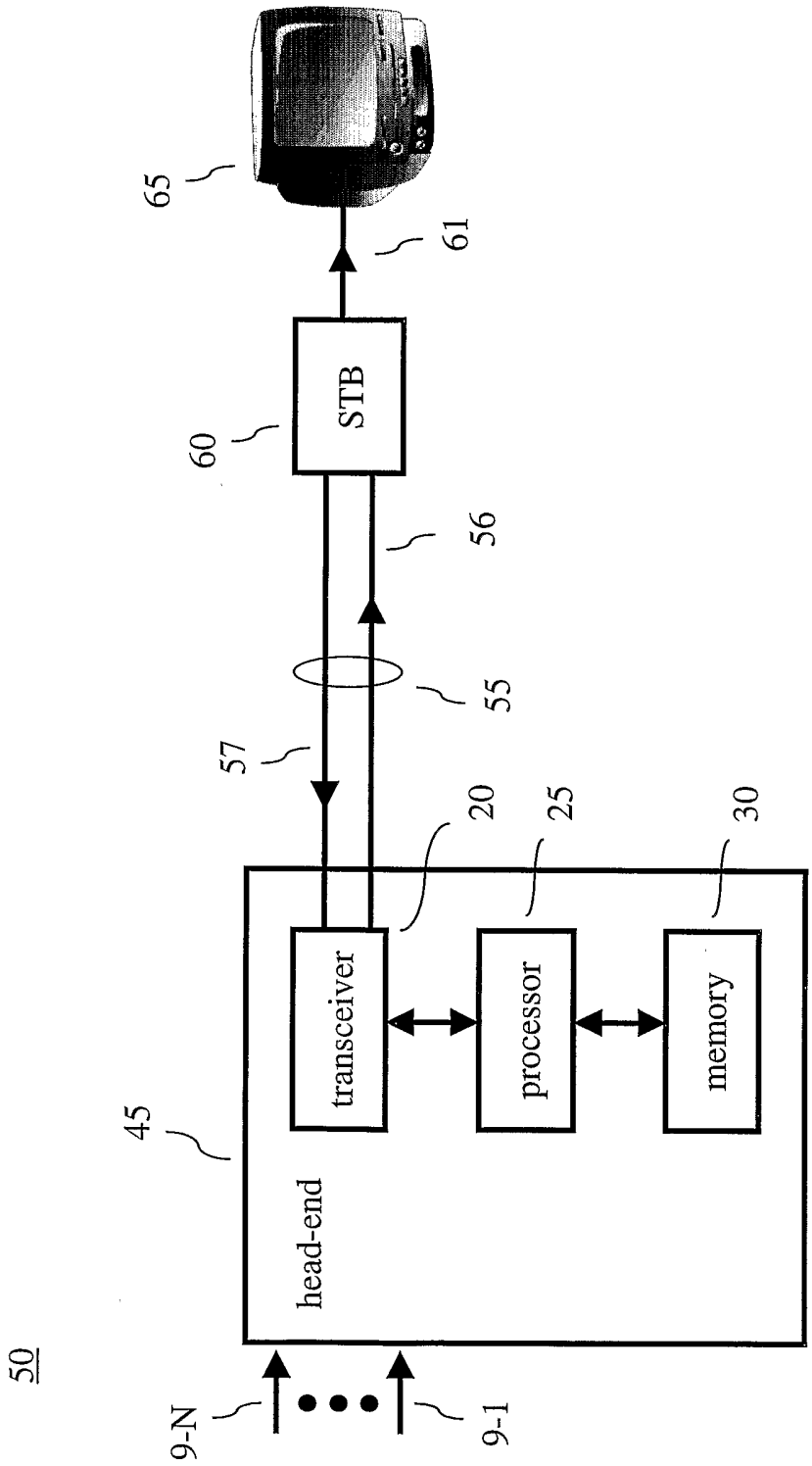

50
9-N
9-1
45
head-end
transceiver
processor
memory
20
25
30
57
55
56
60
STB
61
65

FIG. 5

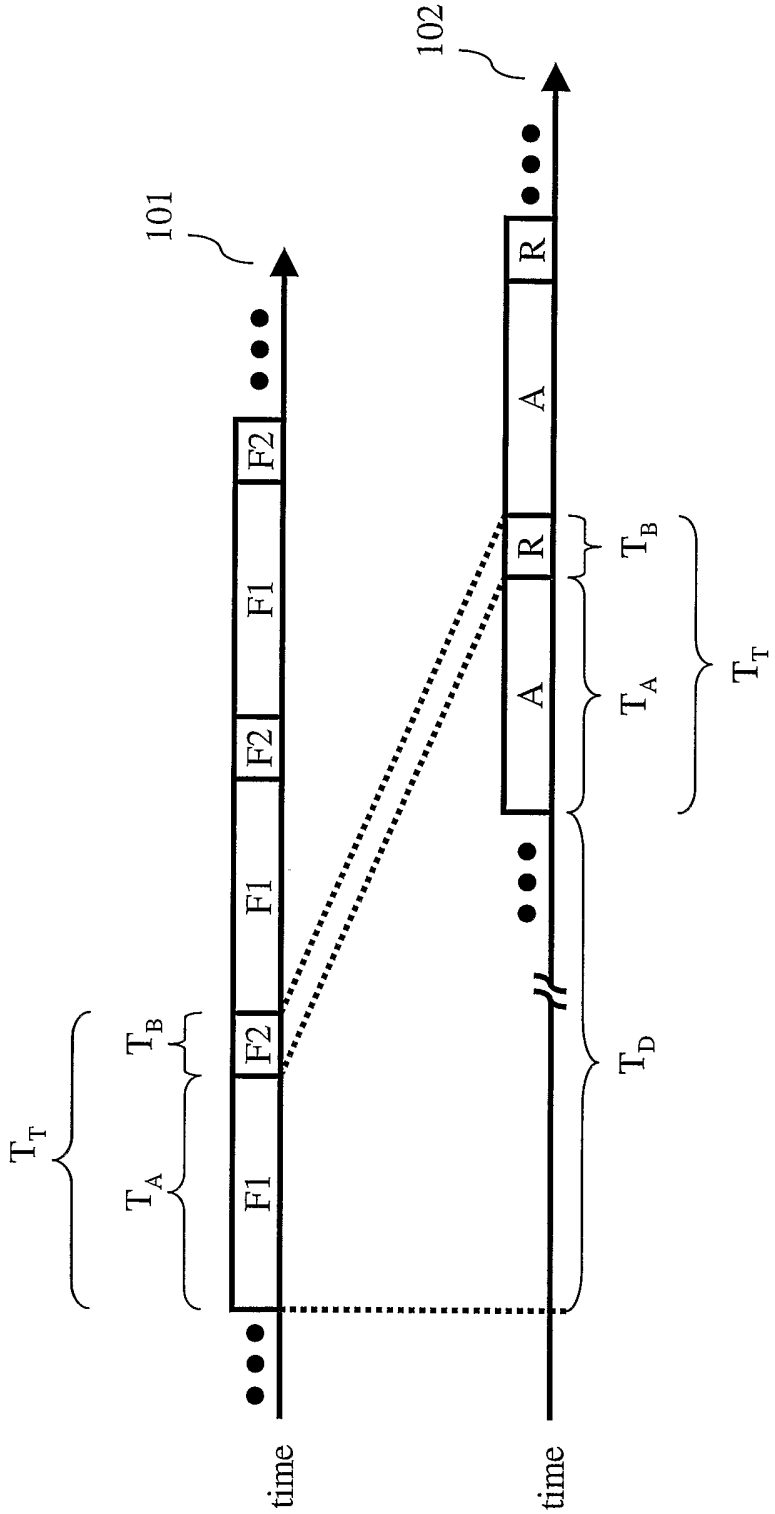


FIG. 6

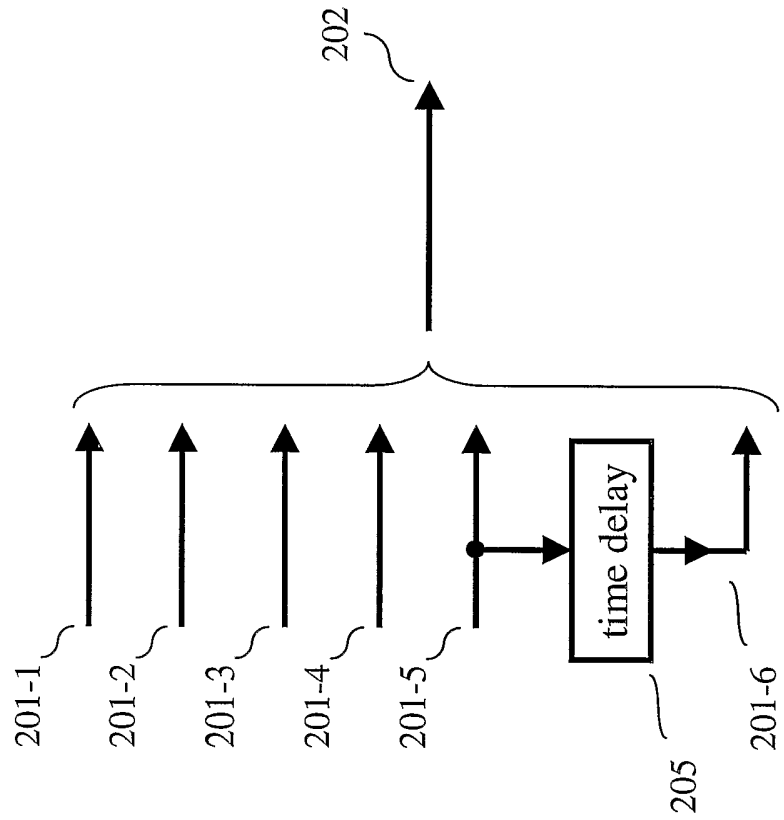
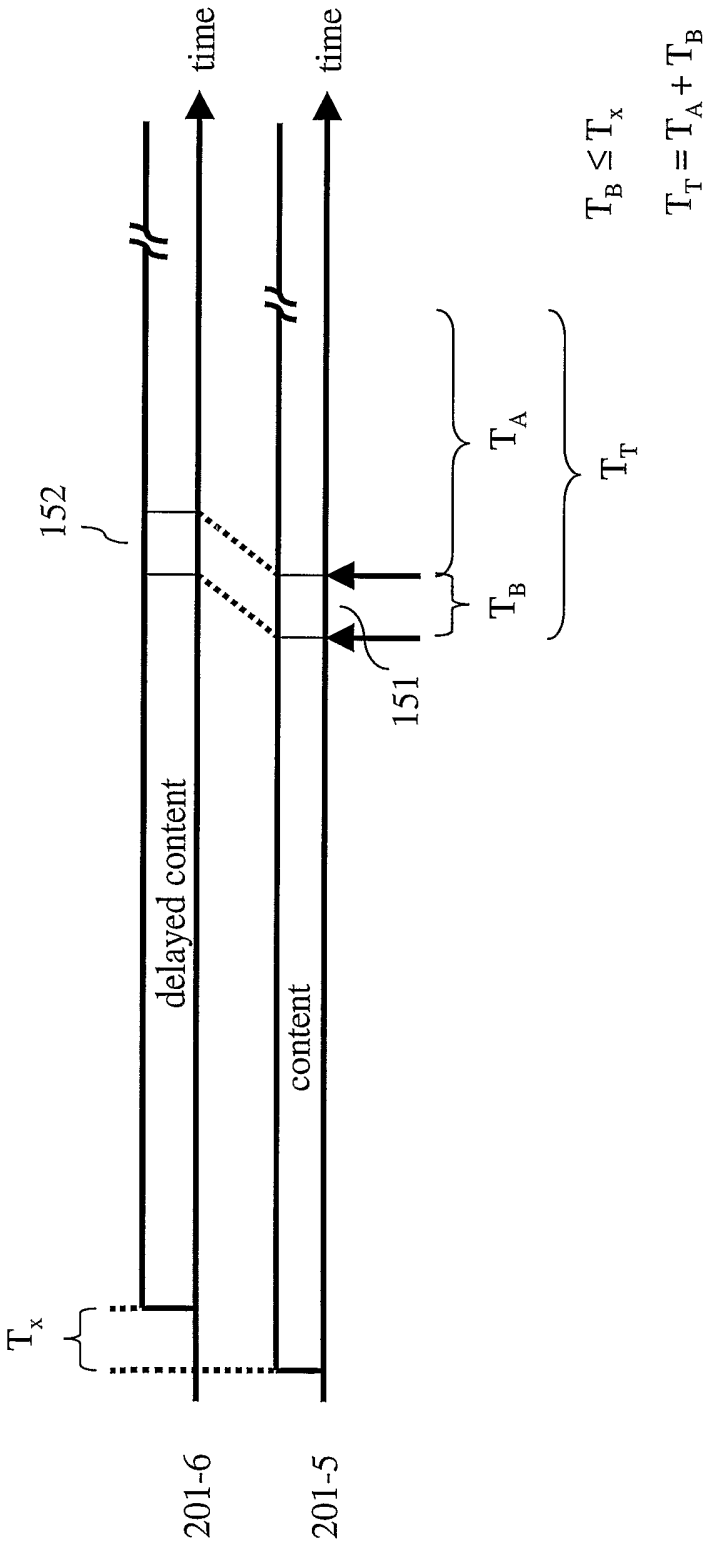


FIG. 7


time
time
152
delayed content
content
151
T_x
T_B
T_A
T_T
$T_B \leq T_x$
$T_T = T_A + T_B$
201-6
201-5

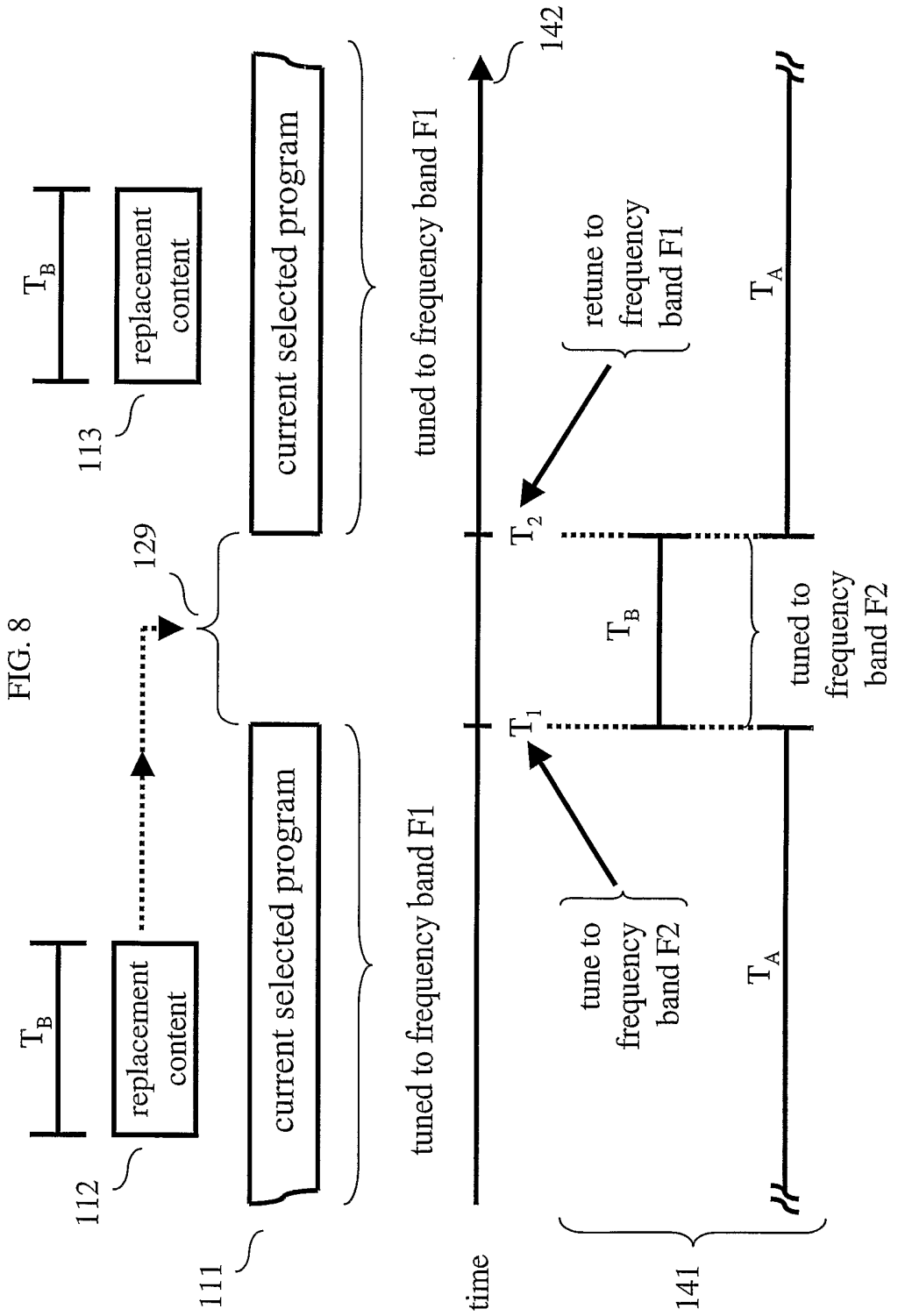

T_B
replacement content
112
current selected program
111
129
T_B
replacement content
113
current selected program
tuned to frequency band F1
tuned to frequency band F1
142
time
T_1
T_2
tune to frequency band F2
retune to frequency band F1
T_B
tuned to frequency band F2
T_A
T_A
141

FIG. 8

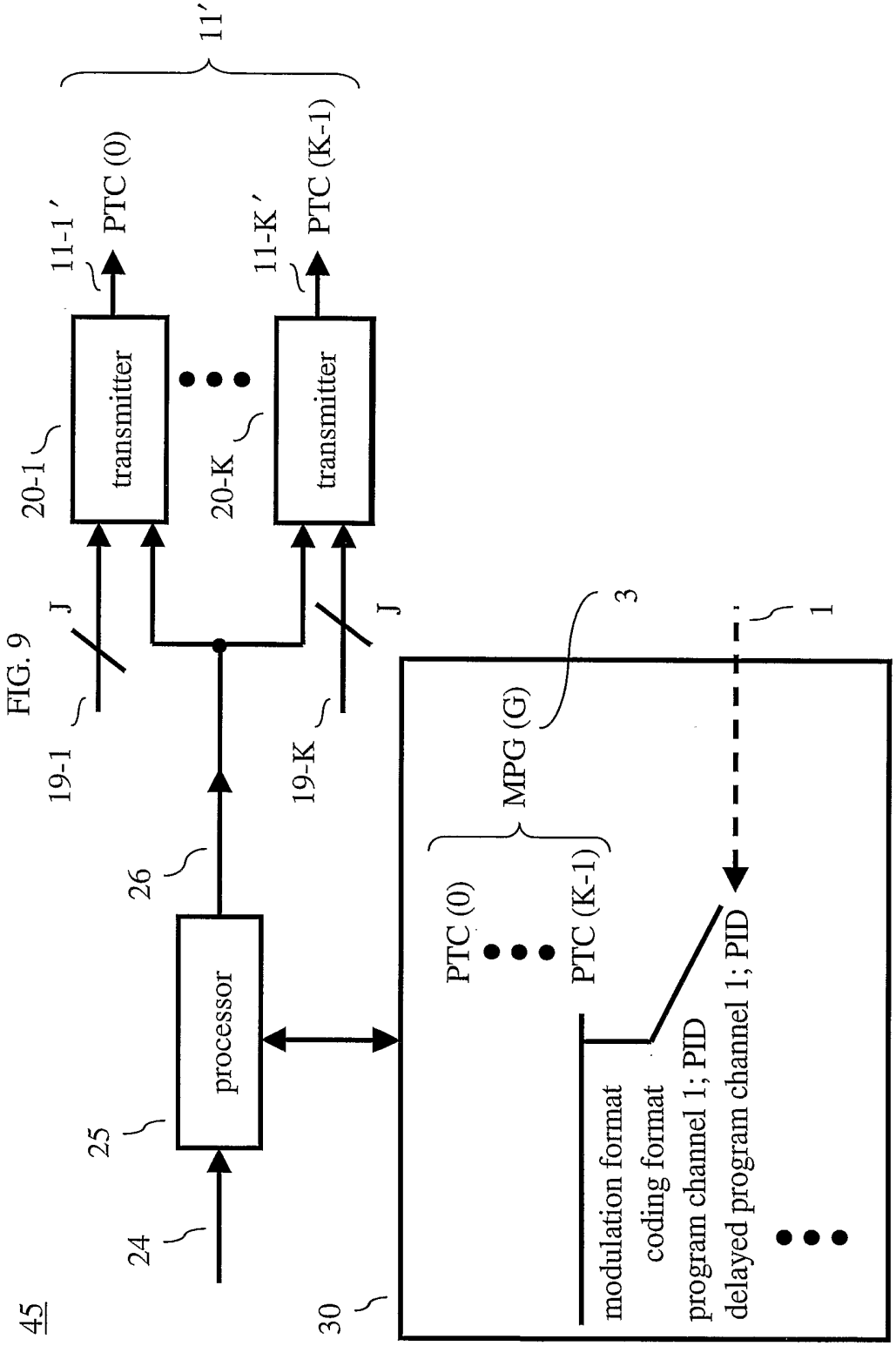

45
24
25
processor
26
30
19-1
19-K
J
J
20-1
20-K
transmitter
transmitter
11-1'
11-K'
PTC (0)
PTC (K-1)
11'
3
MPG (G)
PTC (0)
PTC (K-1)
1
modulation format
coding format
program channel 1; PID
delayed program channel 1; PID

FIG. 9

FIG. 10

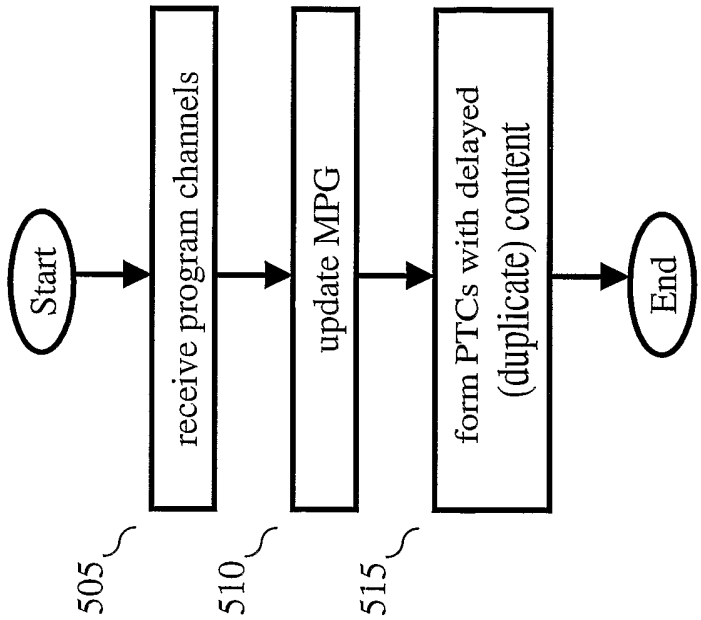

Start
receive program channels
update MPG
form PTCs with delayed (duplicate) content
End
505
510
515

FIG. 11

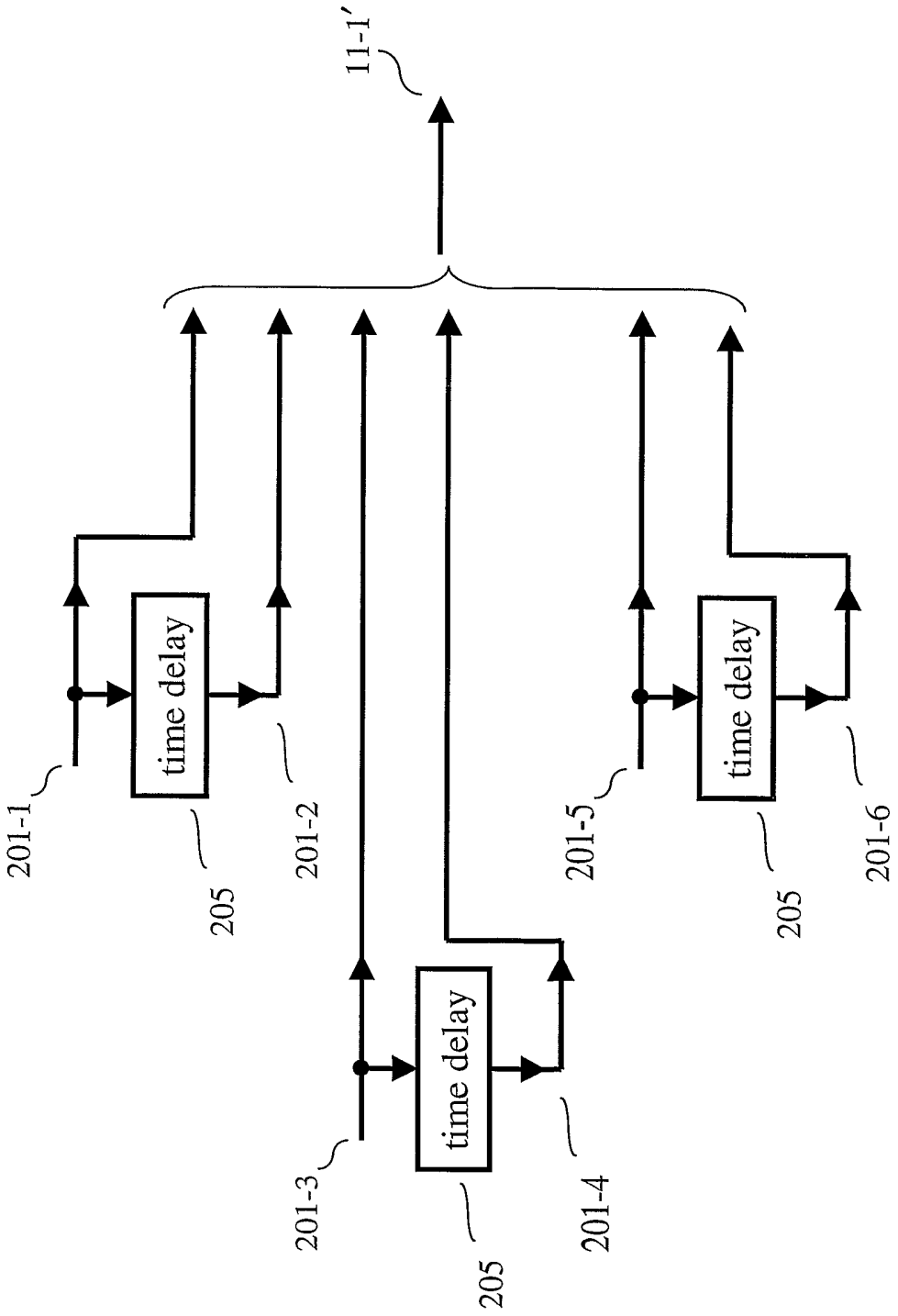

11-1'
time delay
time delay
time delay
201-1
201-2
201-3
201-4
201-5
201-6
205
205
205

FIG. 12

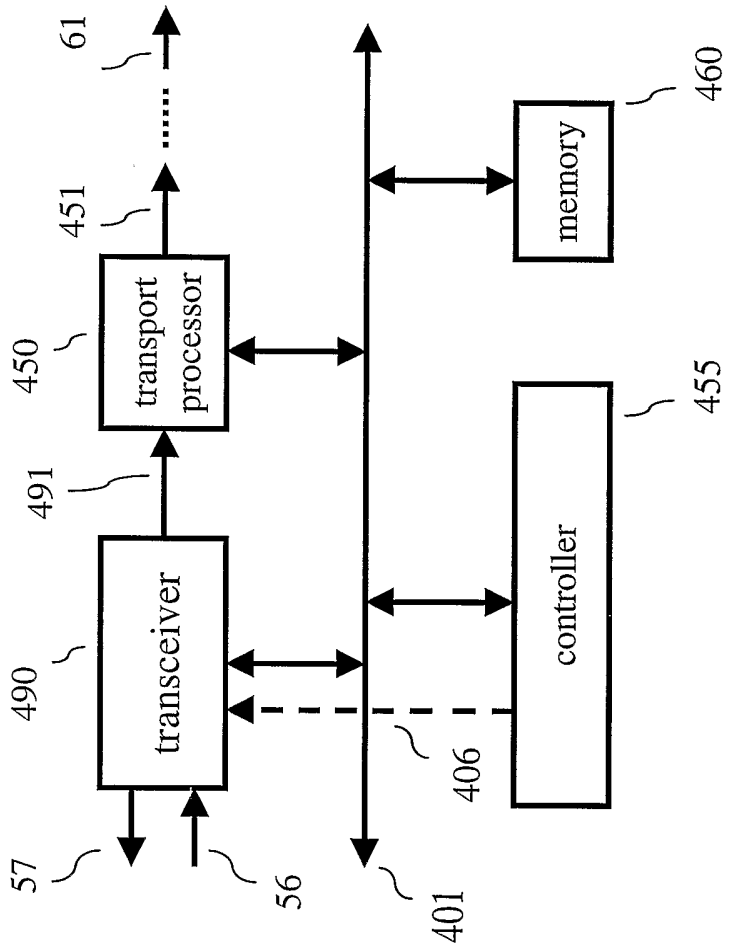

60
61
451
450
491
490
57
56
401
406
transport processor
transceiver
memory
controller
460
455

FIG. 13

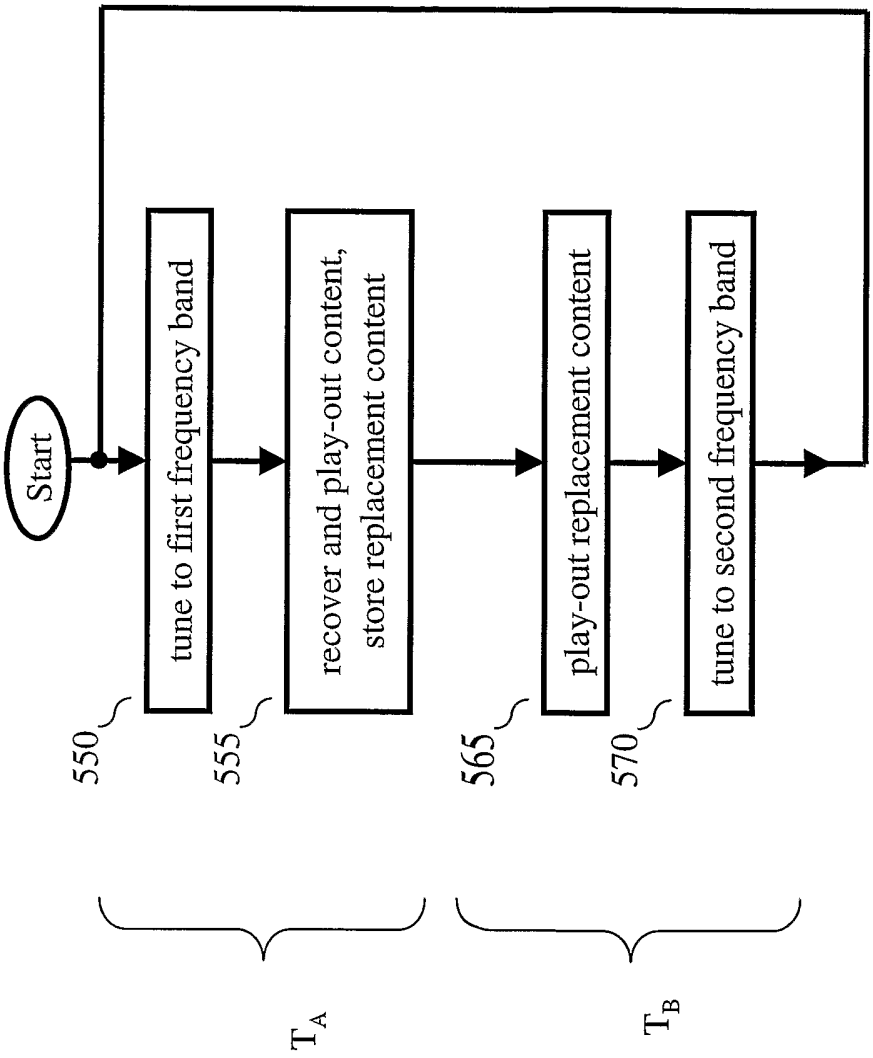
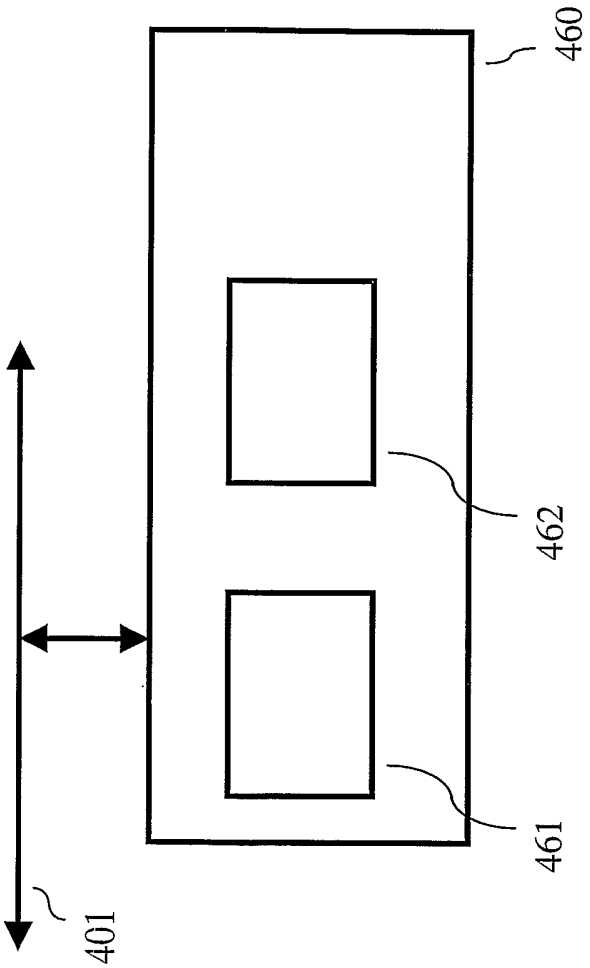

Start
tune to first frequency band
recover and play-out content, store replacement content
play-out replacement content
tune to second frequency band
550
555
565
570
T_A
T_B

FIG. 14



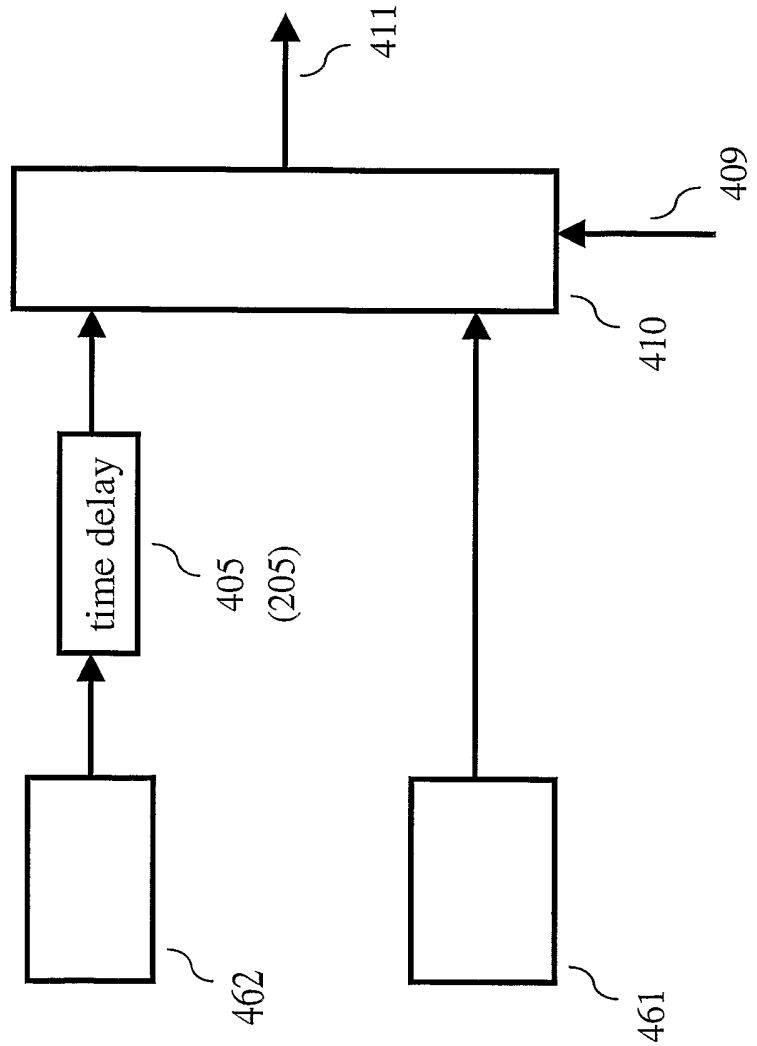


FIG. 15

INTERNATIONAL SEARCH REPORT

PCT/US2004/004826

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N7/173 H04N5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 622 305 B1 (WILLARD PIERRE) 16 September 2003 (2003-09-16)	1,2,4-8, 14-18, 21-28, 30,31, 33,34, 38,39
Y	column 3, line 46 - column 5, line 7	10-13, 19,20, 35-37
A		3,9,29, 32
Y	US 6 366 326 B1 (STEWART JOHN SIDNEY ET AL) 2 April 2002 (2002-04-02) column 6, line 20 - line 52	10-13, 19,20, 35-37

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
1 November 2004	15/11/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Blais, D

INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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