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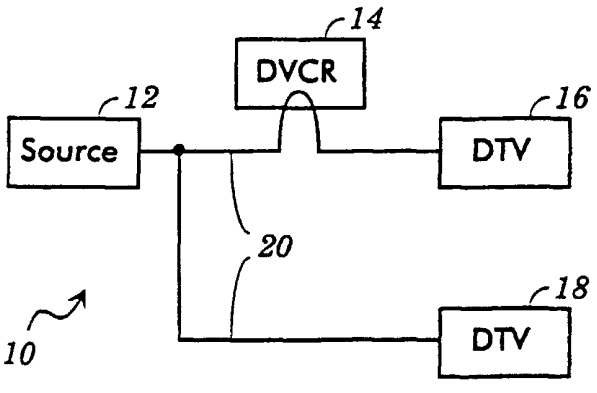
(54) Title: RF BACK CHANNEL FOR DTV



(57) Abstract: A communication system comprises a digital data source including a digital VSB remodulator, such as a VCR, and a downstream digital VSB device, such as a television. The digital VSB remodulator remodulates digital data from the data source received on one of a plurality of channels to digital VSB data on a downstream channel and transmits the digital VSB data to the downstream digital VSB device in the downstream channel at a symbol rate f_s. The downstream digital VSB device transmits information, such as its identification, to the digital VSB remodulator in an upstream channel corresponding to a carrier frequency $(N/M)f_s$. The plurality of channels and the downstream channel occupy a bandwidth above about 50 MHZ, and $(N/M)f_s$ is below this bandwidth.

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RF BACK CHANNEL FOR DTV

Technical Field of the Invention

The present invention relates to the transmission of digital VSB data in a downstream channel from an upstream digital VSB source to a downstream digital VSB device and to the transmission of information in an upstream channel (i.e., a back channel) from the downstream digital VSB device to the upstream digital VSB source.

Background of the Invention

In digital television communication systems, video and audio are transmitted to a digital television over respective 6 MHZ channels occupying a bandwidth of about 50 MHZ to 1 GHz. The digital video and audio are provided as symbols at a symbol rate f_S and are transmitted as digital vestigial sideband (VSB) data. The digital television receives the digital VSB data, tunes to a selected one of the channels, demodulates and decodes the digital VSB data in the selected channel using a symbol clock synchronized to the symbol rate f_S in order to recover the corresponding video and audio, and processes the recovered video and audio for supply to a monitor and one or more speakers.

Certain auxiliary receivers, such as VCRs and cable and satellite converters, also receive transmitted VSB data, tune to a first selected channel from among the plurality of channels, demodulate the VSB data in the first selected channel, remodulate the demodulated data

to a second selected channel (such as channel 3 or 4), and communicate the remodulated data over the second selected channel to a digital receiver such as a digital television. Such auxiliary receivers are also synchronized to the symbol clock. An auxiliary receiver, *inter alia*, may be referred to herein as an upstream source.

When an upstream source communicates digital VSB data over a downstream channel to a downstream device, such as another VCR, a digital television, or other downstream receiver, it may be necessary for the downstream device to communicate information back to the upstream source over an upstream channel. For example, some digital VSB data may be copy protected so that only an authorized downstream device can receive the digital VSB data and display the video and/or audio contained therein.

In the case of copy protection, and as described below, an upstream source of copy protected data transmits a message in a downstream channel to a downstream device which is to receive the copy protected data. The message requests the downstream device to identify itself. The downstream device in an upstream channel answers this request with its identification. The upstream source then transmits, in the downstream channel, a key to allow the downstream device to properly process the material that is to follow. The downstream device acknowledges receipt of the key by transmitting a

suitable acknowledgment in the upstream channel. Thereafter, the upstream source transmits the digital VSB data in the downstream channel to the downstream device.

The carrier frequency defining the upstream channel should preferably be different than the carrier frequency defining the downstream channel. The present invention is directed to an upstream channel defined by a carrier frequency which is different than the carrier frequency of the downstream channel and which is synchronized to the symbol rate at which downstream digital VSB data is transmitted. The present invention accordingly reduces the complexity required in defining the upstream channel.

Summary of the Invention

In accordance with one aspect of the present invention, a communication system comprises an upstream digital VSB source and a downstream digital VSB device. The upstream digital VSB source transmits digital VSB data to the downstream digital VSB device in a downstream channel at a symbol rate f_S, and the downstream digital VSB device transmits information to the upstream digital VSB source modulated on a carrier which is synchronized to $(N/M)f_S$.

In accordance with another aspect of the present invention, a digital VSB apparatus has a transmitter and a receiver. The receiver receives digital VSB data in a downstream channel at a symbol rate

f_S, and the transmitter transmits information in an upstream channel corresponding to a carrier frequency $(N/M)f_S$.

In accordance with yet another aspect of the present invention, a digital VSB apparatus comprises a transmitter and a receiver. The transmitter transmits digital VSB data in a downstream channel at a symbol rate f_S, and the receiver receives information in an upstream channel corresponding to a carrier frequency $(N/M)f_S$.

In accordance with still another aspect of the present invention, a downstream digital VSB device has a receiver and a transmitter. The receiver receives digital data having a frame sync transmitted by an upstream digital VSB source in a downstream digital VSB channel. The transmitter transmits information in a group of time slots to the upstream digital VSB source in an upstream channel. The transmitter synchronizes the group of time slots to the frame sync received by the receiver.

In accordance with a further aspect of the present invention, a downstream digital VSB device comprises a receiver and a transmitter. The receiver receives digital data transmitted by an upstream digital VSB source in a downstream digital VSB channel according to a symbol clock. The transmitter transmits upstream data to the upstream digital VSB source in an upstream channel. The transmitter synchronizes the upstream data to the symbol clock.

Brief Description of the Drawings

These and other features and advantages of the present invention will become more apparent from a detailed consideration of the invention when taken in conjunction with the drawings in which:

Figure 1 illustrates a communication system having an upstream source and one or more downstream devices wherein the upstream source communicates digital VSB data to the downstream devices in a downstream channel and wherein the downstream devices communicate information to the upstream source in an upstream channel in accordance with the present invention;

Figure 2 illustrates in additional detail a portion of the upstream source of Figure 1 that is relevant to the present invention;

Figure 3 illustrates in additional detail the receiver of the upstream source shown in Figure 2;

Figure 4 illustrates an exemplary time slot containing an upstream message; and,

Figure 5 illustrates a plurality of time slots in which the downstream devices may communicate; and,

Figure 6 illustrates in additional detail a portion of a representative one of the downstream devices of Figure 1 where the portion is relevant to the present invention.

Detailed Description

As shown in Figure 1, a communication system 10 includes an upstream source 12 and downstream devices 14, 16, and 18. The upstream source 12 and the downstream devices 14, 16, and 18 are interconnected by a communication medium 20 such that the upstream transmission path is the same as the downstream transmission path. Accordingly, the upstream source 12 communicates with the downstream devices 14, 16, and 18 downstream over the communication medium 20, and the downstream devices 14, 16, and 18 communicate with the upstream source 12 upstream over the communication medium 20. Although the communication system 10 is shown with three downstream devices, it should be understood that the communication system 10 may include any number of downstream devices. Moreover, although the communication medium 20 preferably comprises a cable interconnecting the upstream source 12 and the downstream devices 14, 16, and 18, the communication medium 20 alternatively may comprise a pair of wires, a wireless transmission channel, and/or the like.

The upstream source 12 and the downstream devices 14, 16, and 18 are preferably digital devices with the upstream source 12 transmitting digital VSB data to the downstream devices 14, 16, and 18. For example, in digital television, a transmitter transmits digital VSB data to receivers such as televisions and set top boxes using a standard symbol rate of about 10.76 MHZ. Accordingly, the transmitter compresses data, encodes the

compressed data as corresponding data symbols at the symbol rate f_S, and modulates the encoded symbols as a digital VSB modulated signal for transmission over a selected television channel to digital receivers. The transmitter includes a clock operating at the symbol rate f_S of about 10.76 MHZ so that the digital VSB data is transmitted at this rate. The receivers receive the digital VSB data, demodulate the digital VSB data to recover the symbol clock of about 10.76 MHZ and to recover the data symbols, and decode and decompress the data symbols in order to recover the original data for supply to displays and/or speakers.

In an exemplary digital television environment for the communication system 10, the upstream source 12 may be a digital VCR, a cable converter, or a satellite converter, the downstream device 14 may be a digital VCR, and the downstream devices 16 and 18 may be digital televisions. However, other digital equipment may be provided for the upstream source 12 and the downstream devices 14, 16, and 18.

As shown in Figure 2, the upstream source 12 may include, for example, a processor 30, a remodulator 32, a diplexer 34, a switch 36, and a receiver 38. Thus, in the case where the upstream source 12 is a digital converter or a digital VCR, the upstream source 12 receives a plurality of channels occupying the normal television bandwidth of about 50 MHZ to about 1 GHz and tunes to a selected one of these channels. Digital VSB

data in that selected channel are supplied downstream by the upstream source 12, for example to the downstream device 18, either in real time or for delayed viewing. In either case, the remodulator 32 remodulates the received digital VSB data in the selected tuned channel to a preselected downstream channel, such as channel 3 or channel 4, and supplies the remodulated digital VSB data to the communication medium 20 through the diplexer 34 and the switch 36 for communication to one or more of the downstream devices 14, 16, and 18. The remodulator 32 also recovers the symbol clock f_S from the VSB data that it remodulates.

In some cases, it is necessary for the upstream source 12 to receive information from the downstream devices 14, 16, and 18. Therefore, the upstream source 12 is provided with the receiver 38. The remodulator 32 supplies the recovered symbol clock f_S and an internally generated frame sync signal F_{SYNC} to the receiver 38. Also, the diplexer 34 couples the information that it receives from one or more of the downstream devices 14, 16, and/or 18 to the receiver 38. The receiver 38 demodulates the received information coupled to it by the diplexer 34 and uses the clock signal f_S to synchronize this demodulation function to the upstream channel.

The receiver 38 is shown in more detail in Figure 3 and includes a demodulator 40 and a carrier recovery module 42. The carrier recovery module 42 receives the clock signal f_S from the remodulator 32 and

applies a multiplier of N/M to it in order to recover the carrier frequency which is used by the downstream devices 14, 16, and 18 to transmit data into the upstream channel. The carrier recovery module 42 also receives the upstream data in order to recover the phase of the upstream carrier. Thus, the carrier recovery module 42 supplies a synchronizing clock signal to the demodulator 40 so that the demodulator 40 is synchronized to the upstream carrier in frequency and phase.

As shown in Figure 5, the downstream devices 14, 16, and 18 transmit their information in corresponding time slots, where the start of each group of time slots is synchronized to the frame sync (F_{SYNC}) that is recovered from the downstream data, i.e., the digital television data transmitted downstream by the upstream source 12. The number of time slots in a group is dependent upon the amount of time allocated to each time slot. Moreover, the time slots in a group may be divided between fixed time slots and contention time slots. The contention time slots may be used by downstream devices in order to reserve a fixed time slot in which to transmit a message to the upstream source 12. Accordingly, when a downstream device has a message to transmit, it randomly selects one of the contention time slots. Each of the other downstream devices does the same. If the reservation request is received by the upstream source 12 without contention from reservation requests from the other downstream devices, the upstream

source 12 assigns a fixed time slot to the downstream device which then transmits its message in the assigned fixed time slot. If the downstream device is not assigned a fixed time slot, it knows that its reservation request was not received by the upstream source 12 without contention and it will, therefore, try again in a randomly selected contention time slot. However, the time slots need not be divided between fixed time slots and contention slots in this manner and, instead, each downstream device may be pre-assigned one or more time slots from each group of time slots.

The data transmitted in a time slot by the downstream devices 14, 16, and 18 is transmitted as a data message having the form shown in Figure 4. Each message has a clock portion (a series of logical "1" bits which modulate the RF carrier to provide a constant CW signal), a preamble portion, a data portion, and a CRC error checking portion.

The data received by the demodulator 40 is in analog form. A sampler 44 of the receiver 38 samples the demodulated data at the output of the demodulator 40 in order to convert the demodulated data to digital form. The sampler 44 is supplied with a sampling clock signal by a clock phasing circuit 46. The sampling clock signal is divided by a divider 43 to provide a frequency that matches the data clock that is used by the downstream devices 14, 16, and 18 when transmitting data upstream. A preamble correlator 48 uses the preamble in the

upstream data message in order to synchronize the phase of the sampling clock signal supplied by the clock phasing circuit 46 to the data clock of the downstream devices 14, 16, and 18. A time slot generator 45 is responsive to the frame sync signal F_{SYNC} to generate a signal representing the received time slots which are used by the clock phasing circuit 46 as a window to facilitate the identification of the preamble in each received message.

Accordingly, the sampler 44 samples the data in the upstream data message and supplies the sampled data to the processor 30. The processor 30 is responsive to the preamble in each received message for locating the data in the respective message. Also, the sampler 44 supplies the sampled data to a CRC checker 50 which uses the CRC portion of the upstream data message in order to determine the presence of transmission errors.

A portion of a downstream device 60 is shown in Figure 6. The downstream device 60 is representative of each of the downstream devices 14, 16, and 18 such that each of the downstream devices 14, 16, and 18 may be constructed similarly to the downstream device 60. The portion of the downstream device 60 shown in Figure 6 is the portion involved in the upstream transmission of information to the upstream source 12. The downstream device 60 includes a diplexer 62, a tuner 64, a VSB demodulator 66, a downstream processor 68, an upstream

control processor 70, a phase locked loop 72, and a transmitter 74.

The diplexer 62 receives digital VSB data that is transmitted by the upstream source 12 in the downstream channel. The diplexer 62 couples this digital VSB data to the tuner 64 which is tuned to the downstream channel and which supplies the digital VSB data at IF to the VSB demodulator 66. The VSB demodulator 66 recovers the symbol clock f_S and frame sync F_{SYNC} from the received digital VSB data. The VSB demodulator 66 supplies the symbol clock f_S to the upstream control processor 70 and to the phase locked loop 72, and supplies the frame sync F_{SYNC} to the upstream control processor 70. The VSB demodulator 66 also demodulates the received digital VSB data in order to recover data symbols, and supplies these data symbols to the downstream processor 68.

The upstream control processor 70 decodes any control information that might be contained in the downstream data which is demodulated by the VSB demodulator 66. Such control information, for example, can be used to set the data rate at which the upstream control processor 70 supplies data to the transmitter 74, to set the time slot in which the downstream device 60 is to transmit upstream data, if any, and/or to set the value of N/M which is described below.

The upstream control processor 70 receives from the downstream processor 68 the data that is to be transmitted in the upstream channel and causes this

upstream data to be transmitted in a selected time slot. Accordingly, each of the downstream devices 14, 16, and 18 transmits message in a different time slot. Alternately, the upstream messages may be transmitted in contention slots. In order to determine the start of each time slot group, the upstream control processor 70 receives F_{SYNC} from the VSB demodulator 66 and synchronizes the beginning of each group with F_{SYNC}.

Moreover, the data clock that the upstream control processor 70 uses to insert upstream data into a time slot may be set equal to or may be a fraction of the symbol clock f_S. This fraction, for example, may be 3/50, 1/50 or 1/100 of the symbol clock f_S. If a fraction of the symbol clock f_S is to be used, the symbol clock f_S is divided by a divider 71 and the divided symbol clock is used by the upstream control processor 70 in order to generate the data clock for the upstream messages.

The phase locked loop 72 produces a carrier signal having a desired frequency $(N/M)f_S$, where N/M is a value that is supplied to the phase locked loop 72 by the upstream control processor 70. Alternatively, one or more values for N/M may be preset in the phase locked loop 72 and may be selectively used to generate a carrier frequency. The phase locked loop 72 supplies this carrier signal to the transmitter 74 to be used as the carrier for the upstream channel.

When the upstream control processor 70 determines the presence of the time slot allocated to the downstream device 60, the upstream control processor 70 supplies upstream data to the transmitter 74, and at the same time turns on the transmitter 74. The transmitter 74 then modulates the upstream data onto the carrier supplied by the phase locked loop 72 so that the upstream data is transmitted in the upstream channel defined by the carrier frequency $(N/M)f_S$. The upstream control processor 70 otherwise maintains the transmitter 74 off so that the transmitter 74 does not produce babble on the upstream channel.

As discussed above, the carrier frequency of the upstream channel is defined by a value related to the symbol clock f_S. This value depends upon the ratio N/M, where N and M are preferably integers. For example, the ratio N/M may be 1/3, ½, 1, 3/2, 2, and the like. The value of N/M may be chosen so that $(N/M)f_S$ is below the normal television bandwidth of about 50 MHZ to about 1 GHz. In this manner the upstream channel is tied to the symbol clock f_S.

The processors 30 and 68 determine, at least in part, the information that is transmitted between the upstream source 12 and the downstream devices 14, 16, and 18. The processors 30 and 68, for example, may be arranged to provide copy protection in accordance with the so-called 5C copy protection protocol. According to this protocol, the processor 30 in the upstream source 12

causes the upstream source 12 to transmit to a downstream device, such as the downstream device 16 which is to receive copy protected data, a message requesting the downstream device 16 to identify itself. The downstream processor 68 of the downstream device 16 recognizes this message and, accordingly, causes the transmitter 74 to transmit the identification of the downstream device 16 in the upstream channel defined by the carrier frequency $(N/M)f_S$. The receiver 38 receives this message and passes this message to the processor 30 of the upstream source 12. If the processor 30 recognizes the identification of the downstream device 16, the processor 30 causes the upstream source 12 to transmit in the downstream channel a key which allows the downstream device 16 to properly decrypt the copy protected material that is to follow.

The downstream processor 68 of the downstream device 16 acknowledges receipt of the key by causing the transmitter 74 to transmit a suitable acknowledgment in the upstream channel assigned to the downstream device 16. The acknowledgment is received by the receiver 38 which passes the acknowledgment to the processor 30. Thereafter, the processor 30 causes the upstream source 12 to transmit the copy protected digital VSB data in the downstream channel to the downstream device 16. The downstream processor 68 decrypts the copy protected digital VSB data and supplies this decrypted copy protected digital VSB data to appropriate video and audio

processing modules. Accordingly, only an authorized downstream device may receive and properly display the video and/or audio contained in the copy protected digital VSB data.

As described above, the upstream source 12 transmits VSB modulated data to the downstream devices 14, 16, and 18. The downstream devices 14, 16, and 18 may use a different modulation type, however, when transmitting information in the upstream channels to the upstream source 12. For example, as indicated by the drawings, the transmitters 74 of the downstream devices 14, 16, and 18 may be BPSK transmitters which use BPSK modulation in the transmission of upstream information on a carrier having a frequency equal to $(N/M)f_S$. If the transmitters 74 of the downstream devices 14, 16, and 18 are BPSK transmitters, then the receiver 38 of the upstream source 12 is a BPSK receiver.

The switch 36 is provided so that an external source, such as an antenna, may be connected directly to the downstream devices 14, 16, and 18.

Certain modifications and alternatives of the present invention have been discussed above. Other modifications and alternatives will occur to those practicing in the art of the present invention. For example, the transmitters 74 of the downstream devices 14, 16, and 18 are described above as BPSK transmitters and the receiver 38 of the upstream source 12 is described above as a BPSK receiver. However, the

transmitters 74 of the downstream devices 14, 16, and 18 and the receiver 38 of the upstream source 12 may implement other types of modulation such as QAM, QPSK, or PSK.

Accordingly, the description of the present invention is to be construed as illustrative only and is for the purpose of teaching those skilled in the art the best mode of carrying out the invention. The details may be varied substantially without departing from the spirit of the invention, and the exclusive use of all modifications which are within the scope of the appended claims is reserved.

WHAT IS CLAIMED IS:

1. A digital VSB apparatus (14) having a receiver (62, 64, 66, 68, and/or 72), wherein the receiver (62, 64, 66, 68, and/or 72) receives digital data in a downstream digital VSB channel at a symbol rate f_S, the digital VSB apparatus being CHARACTERIZED in that:

the digital VAB apparatus further has a transmitter (70 and/or 74), wherein the transmitter (70 and/or 74) transmits information in an upstream channel corresponding to a carrier frequency $(N/M)f_S$.

2. The digital VSB apparatus of claim 1 wherein the transmitter (70 and/or 74) is a BPSK transmitter (74).

3. The digital VSB apparatus of claim 1 wherein the transmitter (70 and/or 74) is a based upon a different modulation type than is the receiver (62, 64, 66, 68, and/or 72).

4. The digital VSB apparatus of claim 1 wherein the receiver (62, 64, 66, 68, and/or 72)comprises a VSB demodulator (66) and a phase locked loop (72), wherein the VSB demodulator (66) recovers the symbol rate f_S, and wherein the phase locked loop (72) outputs the carrier $(N/M)f_S$ to the transmitter (70 and/or 74) in

response to the symbol rate f_S recovered by the VSB demodulator (66).

5. The digital VSB apparatus of claim 1 wherein the downstream digital VSB channel corresponds to a carrier frequency of at least 50 MHZ, and wherein $(N/M)f_S < 50$ MHZ.

6. The digital VSB apparatus of claim 5 wherein the receiver (62, 64, 66, 68, and/or 72) includes a VSB demodulator (66) and a phase locked loop (72), wherein the VSB demodulator (66) recovers the symbol rate f_S, and wherein the phase locked loop (72) outputs the carrier $(N/M)f_S$ to the transmitter (70 and/or 74) in response to the symbol rate f_S recovered by the VSB demodulator (66).

7. The digital VSB apparatus of claim 5 wherein the transmitter (70 and/or 74) is a BPSK transmitter (74).

8. The digital VSB apparatus of claim 1 wherein the transmitter (70 and/or 74) transmits an identification of the digital VSB apparatus in the upstream channel, and wherein the receiver (62, 64, 66, 68, and/or 72) receives a copy protection key in the downstream digital VSB channel.

9. The digital VSB apparatus of claim 1 wherein the receiver (62, 64, 66, 68, and/or 72) receives a frame sync, wherein the transmitter (70 and/or 74) transmits the information in a group of time slots, and wherein the transmitter (70 and/or 74) synchronizes the group of time slots to the received frame sync.

10. The digital VSB apparatus of claim 1 wherein the transmitter (70 and/or 74) transmits information according to a clock signal synchronized to kf_S.

11. The digital VSB apparatus of claim 10 wherein k is less than one.

12. The digital VSB apparatus of claim 1 wherein the digital VSB apparatus is a downstream digital VSB apparatus (14), wherein the downstream digital VSB apparatus is coupled to an upstream digital VSB source (12) through the downstream digital VSB channel and the upstream channel, wherein the upstream digital VSB source (12) transmits digital data to the downstream digital VSB apparatus (14) in the downstream digital VSB channel at the symbol rate f_S, and wherein the downstream digital VSB apparatus (140 transmits information to the upstream digital VSB source (12) modulated on a carrier which is synchronized to $(N/M)f_S$.

13. The digital VSB apparatus of claim 12 wherein $N/M < 4$.

14. The digital VSB apparatus of claim 12 wherein N and M are integers.

15. The digital VSB apparatus of claim 12 wherein N/M is set by the upstream digital VSB source (12).

16. The digital VSB apparatus of claim 12 wherein the downstream digital VSB apparatus (14) includes a BPSK transmitter (74) that transmits the information to the upstream digital VSB source (12) in the upstream channel on the carrier, wherein the upstream digital VSB source (12) includes a BPSK receiver (38) that receives the information from the downstream digital VSB apparatus (14) in the upstream channel, and wherein the BPSK receiver (38) includes a BPSK demodulator (40) and a carrier recovery module (42), wherein the BPSK demodulator (40) demodulates the information received from the downstream digital VSB apparatus (14) in the upstream channel, and wherein the carrier recovery module (42) recovers the $(N/M)f_S$ carrier.

17. The digital VSB apparatus of claim 12 wherein the upstream digital VSB source (12) includes a demodulator (40) and a carrier recovery module (42),

wherein the demodulator (40) demodulates the information received from the downstream digital VSB apparatus (14) in the upstream channel, and wherein the carrier recovery module (42) recovers the $(N/M)f_S$ carrier.

18. The digital VSB apparatus of claim 12 wherein the upstream digital VSB source (12) modulates the digital data onto a carrier frequency f_c, and wherein $(N/M)f_S < f_c$.

19. The digital VSB apparatus of claim 12 wherein the downstream digital VSB apparatus (14) includes a VSB demodulator (66) and a phase locked loop (72), wherein the VSB demodulator (66) recovers the symbol rate f_S, and wherein the phase locked loop (72) outputs the carrier $(N/M)f_S$ in response to the symbol rate f_S recovered by the VSB demodulator (66).

20. The digital VSB apparatus of claim 19 wherein the upstream digital VSB source (12) includes a non-VSB demodulator (40) and a carrier recovery module (42), wherein the non-VSB demodulator (40) demodulates the information received from the downstream digital VSB apparatus (14) in the upstream channel, and wherein the carrier recovery module (42) recovers the $(N/M)f_S$ carrier.

21. The digital VSB apparatus of claim 12 wherein the upstream digital VSB source (12) comprises a VSB remodulator (32), wherein the VSB remodulator (32) receives the digital data, wherein the VSB remodulator (23) remodulates the received digital data onto one of a plurality the downstream digital VSB channels, and wherein the VSB remodulator (32) transmits the remodulated digital data to the downstream digital VSB apparatus (14) in the downstream digital VSB channel at the symbol rate f_S.

22. The digital VSB apparatus of claim 21 wherein the upstream digital VSB source (12) includes a demodulator (40) and a carrier recovery module (42), wherein the demodulator (40) demodulates the information received from the downstream digital VSB apparatus (14) in the upstream channel, and wherein the carrier recovery module (42) recovers the $(N/M)f_S$ carrier.

23. The digital VSB apparatus of claim 21 wherein each of the plurality of downstream digital VSB channels has a carrier frequency, and wherein $(N/M)f_S$ is less than the carrier frequency of each of the plurality of downstream digital VSB channels.

24. The digital VSB apparatus of claim 21 wherein the plurality of downstream digital VSB channels

each occupy a bandwidth above about 50 MHZ, and wherein $(N/M)f_S$ is below the bandwidth.

25. The digital VSB apparatus of claim 21 wherein the downstream digital VSB apparatus (14) includes a VSB demodulator (66) and a phase locked loop (72), wherein the VSB demodulator (66) recovers the symbol rate f_S, and wherein the phase locked loop (72) outputs the carrier $(N/M)f_S$ in response to the symbol rate f_S recovered by the VSB demodulator (66).

26. The digital VSB apparatus of claim 12 wherein the downstream digital VSB apparatus (14) has an identification, wherein the downstream digital VSB apparatus (14) transmits its identification in the upstream channel, wherein the upstream digital VSB source (12) comprises a VSB remodulator (32), wherein the VSB remodulator (32) receives the digital data, wherein the VSB remodulator (32) remodulates the received digital data onto the downstream digital VSB channel, wherein the VSB remodulator (32) transmits a copy protection key to the downstream digital VSB apparatus (14) in the downstream digital VSB channel, and wherein the VSB remodulator (32) transmits the remodulated digital data to the downstream digital VSB apparatus (14) in the downstream digital VSB channel at the symbol rate f_S.

27. The digital VSB apparatus of claim 26 wherein the VSB remodulator (32) includes a demodulator (40) and a carrier recovery module (42), wherein the demodulator (40) demodulates the information received from the downstream digital VSB apparatus (14) in the upstream channel, and wherein the carrier recovery module (42) recovers the $(N/M)f_S$ carrier.

28. The digital VSB apparatus of claim 26 wherein each of the plurality of downstream channels has a carrier frequency, and wherein $(N/M)f_S$ is less than the carrier frequency of each downstream channel.

29. The digital VSB apparatus of claim 26 wherein each of the plurality of downstream channels occupy a bandwidth above about 50 MHZ, and wherein $(N/M)f_S$ is below the bandwidth.

30. The digital VSB apparatus of claim 26 wherein the downstream digital VSB apparatus (14) includes a VSB demodulator (66) and a phase locked loop (72), wherein the VSB demodulator (66) recovers the symbol rate f_S, and wherein the phase locked loop (72) outputs the carrier $(N/M)f_S$ in response to the symbol rate f_S recovered by the VSB demodulator (66).

31. The digital VSB apparatus of claim 12 wherein the upstream digital VSB source (12) receives the

digital data, wherein the upstream digital VSB source (12) transmits the digital data to the downstream digital VSB apparatus (14) in one of a plurality of downstream digital VSB channels at the symbol rate f_S, wherein the plurality of channels occupy a bandwidth above about 50 MHZ, and wherein $(N/M)f_S$ is below the bandwidth.

32. The digital VSB apparatus of claim 12 wherein the upstream digital VSB source (12) includes a modulator (32) implementing a first modulation type for downstream communication, wherein the downstream digital VSB apparatus (14) includes a modulator (70 and/or 74) implementing a second modulation type for upstream communication, and wherein the first and second modulation types are different.

33. The digital VSB apparatus of claim 12 wherein the downstream digital VSB apparatus (14) receives a frame sync transmitted by the upstream digital VSB source, wherein the downstream digital VSB apparatus (14) transmits the information in a group of time slots to the upstream digital VSB source (12), and wherein the downstream digital VSB apparatus (14) synchronizes the group of time slots to the frame sync transmitted by the upstream digital VSB source (12).

34. The digital VSB apparatus of claim 12 wherein the downstream digital VSB apparatus (14)

transmits information to the upstream digital VSB source in response to a clock signal synchronized to kf_S.

35. The digital VSB apparatus of claim 34 wherein k is less than one.

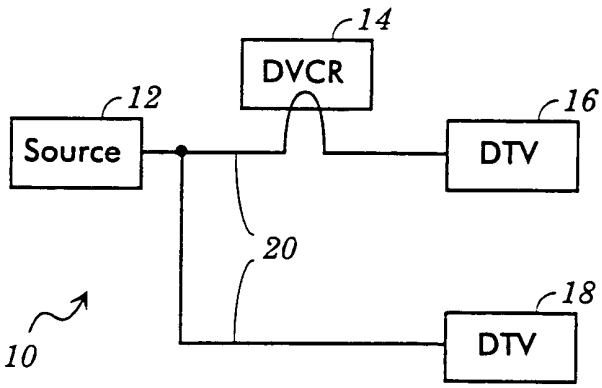

Figure 1

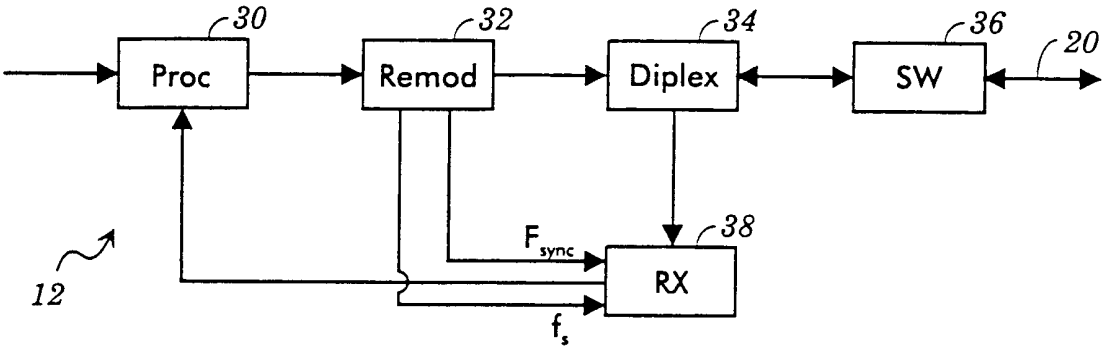

Figure 2

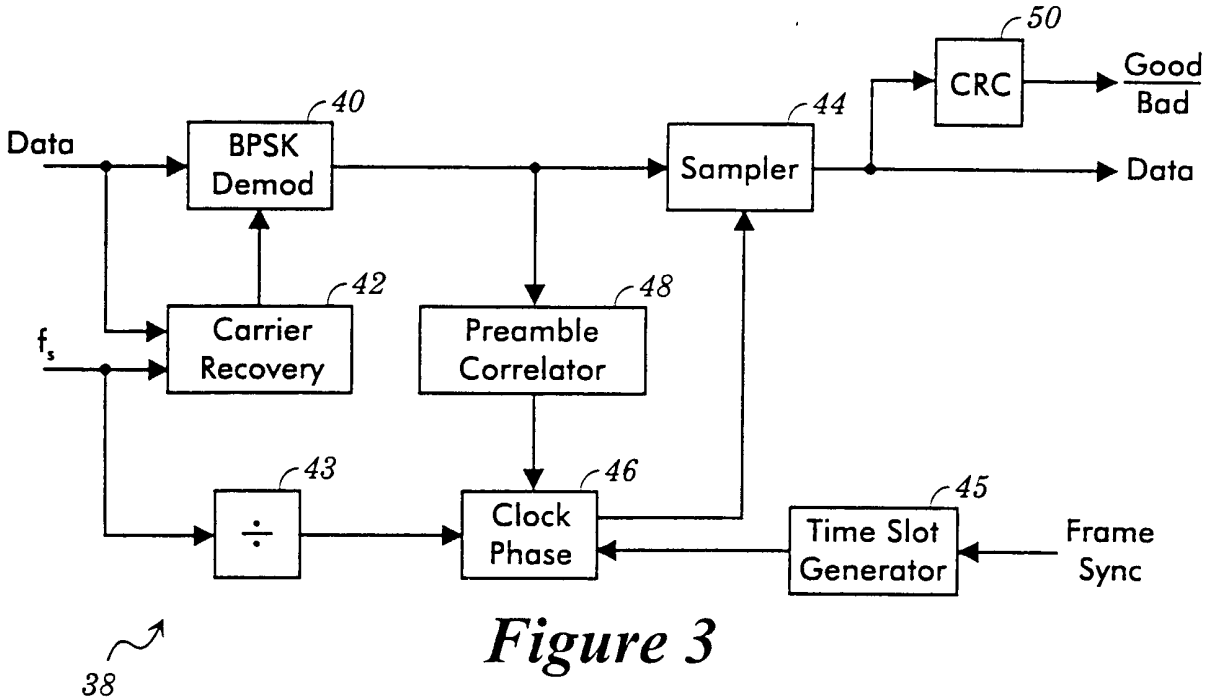

Figure 3

Figure 4

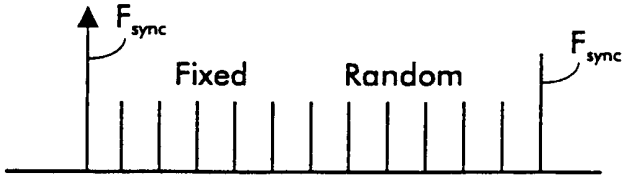

Figure 5

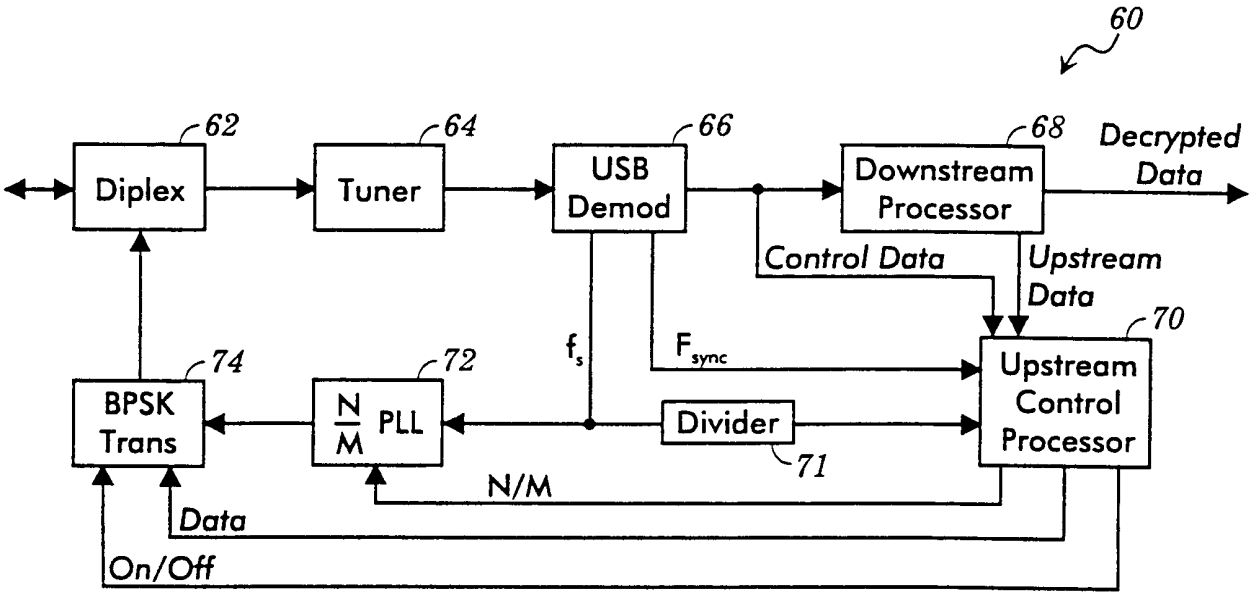

Figure 6

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/32268

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04N7/173

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 H04L

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 5 889 765 A (GIBBS GRAEME) 30 March 1999 (1999-03-30) column 5 -column 11 figures 1,3	1,5
X	NAIR A N: "INTERACTIVE TELEVISION SETTOP TERMINAL ARCHITECTURES" , DIGEST OF PAPERS OF THE COMPUTER SOCIETY COMPUTER CONFERENCE COMPCON,US,LOS ALAMITOS, IEEE COMP. SOC. PRESS, VOL. CONF. 41, PAGE(S) 233-238 XP000628482 ISBN: 0-8186-7414-8 the whole document	1,5
A	US 5 535 206 A (BESTLER CAITLIN B ET AL) 9 July 1996 (1996-07-09) the whole document	1-35

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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
22 March 2001	28/03/2001

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	Tito Martins, J

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

national Application No
PCT/US 00/32268

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	WILSON E J: "INTRODUCTORY SCENARIOS FOR INTERACTIVE TELEVISION" , EBU REVIEW-TECHNICAL,BE,EUROPEAN BROADCASTING UNION. BRUSSELS, NR. 275, PAGE(S) 28-41 XP000767497 ISSN: 0251-0936 the whole document	1-35
A	HOPKINS R: "DIGITAL TERRESTRIAL HDTV FOR NORTH AMERICA: THE GRAND ALLIANCE HDTVSYSTEM" , IEEE TRANSACTIONS ON CONSUMER ELECTRONICS,IEEE INC. NEW YORK,US, VOL. 40, NR. 3, PAGE(S) 185-198 XP000471174 ISSN: 0098-3063 the whole document	1-35
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 00/32268

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