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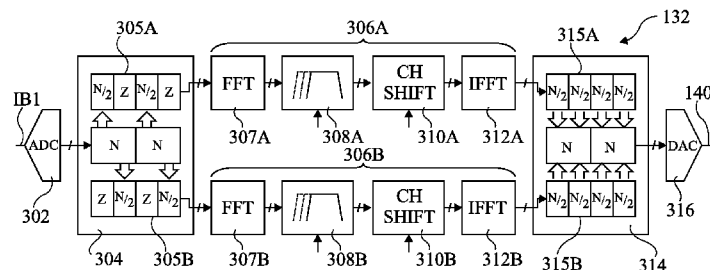


Fig 3

(57) Abstract: The invention concerns a satellite receive unit having an analog to digital converter (302) adapted to sample a satellite signal to generate a data stream; at least one digital channel multiplexer having at least one processing branch (307A, 307B) which includes: a Fourier transform block (307A, 307B); a channel shifter (310A, 310B); and an inverse Fourier transform block (312A, 312B); the satellite receiver comprising a digital to analog converter (316) adapted to convert the output data stream of the processing branch into an analog signal in a transmission band for transmission over a transmission channel to at least one satellite decoder.

RECEIVE UNIT FOR RECEPTION OF A SATELLITE SIGNAL

FIELD OF THE INVENTION

The present invention relates to the field of satellite signal reception, and in particular to a receive unit and method for reception of a satellite signal.

5 BACKGROUND OF THE INVENTION

A satellite receive unit, for example the unit often referred to as an outdoor unit, comprises one or multiple LNBS (low noise blocks), which amplify a satellite signal received via a parabolic satellite dish. The satellite signal for example
10 conveys sound and/or video data, such as television signals or radio signals. Each LNB is designed to introduce as little noise as possible, which is typically in the order of one decibel. Each LNB also performs some filtering, and initial down conversion of the satellite signal to a lower frequency band
15 that may be processed by the receive unit prior to being transmitted via one or more coaxial cables to one or more indoor satellite decoders, for example coupled to television displays.

The satellite signal as received by the LNB is modulated on a carrier frequency, for example in a frequency
20 band of 10.7-12.75 GHz. Within this frequency band there are a number of channels each corresponding to a particular data stream that may comprise video and/or audio data corresponding

to one or more television and/or radio broadcasts. The bandwidth of each channel is typically between 8 MHz and 30 MHz.

Multiple LNBs may be provided in the receive unit to allow satellite signals of different polarizations to be received, the polarizations being either linear (horizontal and vertical) or circular (clockwise and counter-clockwise). Furthermore, each satellite signal may comprise a low band signal and a high band signal, which may be separated by the receive unit and processed individually.

It is desirable to enable a single receive unit to provide satellite television signals to multiple users, each user being able to select the television or radio broadcasts that they wish to view via a satellite decoder. These television or radio broadcasts may be selected from channels of different satellite signals, for example from satellite signals having different polarizations and of high or low band.

However, a problem is that in existing solutions, the number of different users that are supported tends to be limited. Furthermore, existing solutions tend to be complex to implement.

SUMMARY OF THE INVENTION

It is an aim of embodiments of the present invention to at least partially address one or more problems in the prior art.

According to one aspect of the present invention, there is provided a satellite receive unit comprising: an analog to digital converter adapted to sample a satellite signal to generate a data stream of digital samples; at least one digital channel multiplexer comprising at least one processing branch comprising: a Fourier transform block adapted to perform a Fourier transform to convert the data stream into the frequency domain; a channel shifter adapted to re-order samples of the frequency domain data stream to shift at least one channel of said satellite signal to a new frequency band; and an inverse Fourier transform block adapted to convert the re-ordered frequency domain data stream into an output data stream in the

time domain; and a digital to analog converter adapted to convert said output data stream into an analog signal in a transmission band for transmission over a transmission channel to at least one satellite decoder.

5 According to an embodiment of the present invention, the digital channel multiplexer comprises a plurality of said processing branches arranged in parallel with each other.

 According to an embodiment of the present invention, the satellite receive unit further comprises a data interleaver
10 block adapted to split said data stream of digital samples into first and second data streams, and to provide said first data stream to a first of said plurality of processing branches and said second data stream to a second of said two processing branches; and a data stream combiner adapted to receive the
15 output data streams from said first and second processing branches and to add corresponding samples of the output data streams to generate said output data stream for conversion by said analog to digital converter.

 According to an embodiment of the present invention,
20 the data interleaver is arranged to receive blocks of data of said data stream of digital samples, and to output the samples of a first half of each of said blocks of data to the first branch and the samples of a second half of each of said blocks of data to the second branch.

25 According to an embodiment of the present invention, the satellite signal is provided by a mixer adapted to frequency shift an initial satellite signal to an intermediate frequency band.

 According to an embodiment of the present invention,
30 said transmission band has a bandwidth of less than or equal to the bandwidth of said intermediate frequency band.

 According to an embodiment of the present invention, transmission band has a lower frequency limit in the range 0-100 MHz and an upper frequency limit in the range 300-1100 MHz.

35 According to an embodiment of the present invention, the satellite receive unit comprises a plurality of said digital

channel multiplexers, each adapted to process a respective satellite signal, and the analog signal from each of said digital channel multiplexers is combined into a transmission band signal for transmission over said transmission channel.

5 According to an embodiment of the present invention, the channel shifter comprises a buffer into which samples of said frequency domain data stream are loaded, and circuitry for reordering the samples as they are output from said buffer in order to shift said at least one channel to a new frequency
10 band.

 According to an embodiment of the present invention, the processing branch further comprises a digital filter arranged to extract at least one selected channel from said frequency domain data stream.

15 According to an embodiment of the present invention, the satellite receive unit further comprises: at least one receive head for receiving one or more initial satellite signals; and at least one low noise block arranged to amplify and frequency shift said one or more initial satellite signals
20 to generate said satellite signal.

 According to another aspect of the present invention, there is provided a satellite receive system comprising the above satellite receive unit and a plurality of satellite decoders adapted to receive the analog signal in said
25 transmission band transmitted over the transmission channel.

 According to an embodiment of the present invention, the transmission channel comprises one or more of: a coaxial cable; a wired network connection; and a power line communication.

30 According to another aspect of the present invention, there is provided a method of receiving a satellite signal comprising: performing an analog to digital conversion on said satellite signal to generate a data stream of digital samples; processing said data stream digital samples by at least one
35 processing branch of at least one digital channel multiplexer, said processing comprising: performing a Fourier transform to

convert the data stream into the frequency domain; reordering samples of said frequency domain data stream to shift at least one channel of said satellite signal to a new frequency band; and performing an inverse Fourier transform block to convert the re-ordered frequency domain data stream into an output data stream in the time domain; and converting said output data stream into an analog signal in a transmission band, for transmission over a transmission channel to at least one satellite decoder.

According to an embodiment of the present invention, said step of reordering samples comprises loading said samples of said frequency domain data stream into a buffer, and reordering the samples as they are output from said buffer in order to shift the at least one channel to a new frequency band.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other purposes, features, aspects and advantages of the invention will become apparent from the following detailed description of embodiments, given by way of illustration and not limitation with reference to the accompanying drawings, in which:

Figure 1 illustrates a receive unit according to an embodiment of the present invention;

Figure 2 shows frequency diagrams illustrating spectrums of several signals of the receive unit of Figure 1 according to an embodiment of the present invention;

Figure 3 illustrates a digital channel multiplexer of the receive unit of Figure 1 in more detail according to an embodiment of the present invention;

Figure 4A illustrates data streams of the digital channel multiplexer of Figure 3 according to an embodiment of the present invention;

Figure 4B shows frequency diagrams illustrating an example of the form of a digital filter of the digital channel multiplexer of Figure 3 according to an embodiment of the present invention;

Figure 5 illustrates one branch of the digital channel multiplexer of Figure 3 in more detail according to an embodiment of the present invention;

Figure 6 illustrates a receive unit according to an
5 alternative embodiment of the present invention; and

Figure 7 illustrates a satellite receive system according to an embodiment of the present invention.

Throughout the figures, like references have been labelled with like reference numerals.

10 **DETAILED DESCRIPTION OF THE INVENTION**

For clarity, only the features that aid a comprehension of the invention are described herein in detail. In particular, the operation of the set-top boxes that demodulate and decode the selected channels for displaying a television or
15 radio broadcast on a television has not been described in detail, the embodiments herein being applicable to all types of satellite decoders, including those implemented in a set-top box or in a video card of a personal computer.

Figure 1 illustrates a receive unit 100 comprising an
20 antenna 102, which for example receives a satellite signal received via a parabolic satellite dish (not shown in Figure 1). In this example, a pair of receive heads 104, 105 are provided, receive head 104 for example being adapted to receive a horizontally polarized satellite signal, while receive head 105
25 is for example adapted to receive a vertically polarized satellite signal. In alternative embodiments, receive heads adapted to additionally or alternatively receive satellite signals of circular polarization could be provided.

The signals from receive heads 104, 105 are provided
30 to low noise blocks (LNBs) 106 and 107 respectively, and in particular to a respective low noise amplifier 108, 110 of each LNB. LNB 106 further comprises mixers 112, 114 coupled to the output of amplifier 108, while LNB 107 further comprises mixers 116 and 118 coupled to the output of amplifier 110. Mixers 112
35 to 118 also receive mixing frequencies from respective frequency synthesizers 120 to 126.

The mixers 112 to 118 provide a frequency translation of the received satellite signals from the received frequency bands, for example in the range 10.7-12.75 GHz, to an intermediate frequency band, for example each being the base-band 0-500 MHz. The mixers 112 and 116 are for example adapted to provide a frequency translation of part of a high band portion of the received satellite signal, for example part of the band 11.7-12.75 GHz, to the intermediate frequency band 0-500 MHz, while the mixers 114 and 118 are for example adapted to provide a frequency translation of part of a low band portion of the received satellite signal, for example part of the band 10.7-11.7, to the frequency band 0-500 MHz. In this example, the bandwidth of high and low frequency bands is larger than the bandwidth of the intermediate frequency band 0-500 MHz, and the mixing frequencies of blocks 120 to 126 provided to the mixers are thus for example programmable such that a required portion of the high and low frequency bands can be selected.

The signals from each of the four mixers 112 to 118, respectively labeled IB1 to IB4 in Figure 1, are provided to a digital multiplexer block 128, which provides selected "wanted" channels over a transmission channel 130. Transmission channel 130 is used to transmit satellite channels to indoor satellite decoders associated with respective users, and for example comprises a coaxial cable, a wired LAN connection, and/or a power line communication, according to which data signals are transmitted on a conductor usually used for transmission of mains power through a building.

The digital multiplexer block 128 in this example comprises four digital channel multiplexers (DCMs) 132, 134, 136, 138 coupled respectively to the outputs of the four mixers 112 to 118 via four variable amplifiers 131, 133, 135 and 137 respectively. The variable amplifiers are optionally provided for amplifying the output signal of the mixers to adapt the signals to appropriate levels for analog to digital conversion by each DCM 132, 134, 136, 138, as will be explained in more detail below.

The outputs from DCMs 132, 134, 136, 138 are for example analog signals that are combined by being coupled to a single line 140 provided to an output block 142. The output block 142 provides an interface for transmitting the satellite channels over the transmission channel 130, and may comprises an amplifier. The output block 142 is optional, as in some cases, depending on the transmission interface, no output block is used, and line 140 is coupled directly to the output line 130.

A control block 144 receives on a line 146 from the output block 142 a channel selection signal indicating the channels selected for viewing by one or more users. The control block 144 provides appropriate control signals to the DCMs 132, 134, 136, 138 such that the corresponding selected channels are provided on the output line 140. The channel selection signal is for example transmitted via the protocol known as DiSEqC2 (Digital Satellite Equipment Control 2). The channel selection signal is for example transmitted from each user satellite decoder (not shown in Figure 2) to the output block 142 via the interface 130. In alternative embodiments, the channel selection signal could be transmitted directly to the control block 144, for example via a wireless interface, or other alternative interface to the main interface 130 used for transmission of the satellite channels.

Operation of the digital multiplexer block 128 will now be described with reference to the frequency diagrams shown in Figure 2.

In Figure 2, the top four frequency diagrams show the respective frequency spectrums of the four signals IB1 to IB4 at the lower frequency band, which in this example is the band 30-500 MHz. As illustrated, among other channels, the signal IB1 includes channels CH1 and CH2, the signal IB2 includes a channel CH3, the signal IB3 includes a channel CH4, and the signal IB4 includes channels CH5 and CH6. Each channel for example has a bandwidth in the range 8-80 MHz, and contains a data stream corresponding to one or more television and/or radio broadcasts. For example, a channel of 8 MHz bandwidth may comprise just one

television broadcast, whereas a channel of a higher bandwidth may comprise multiple television broadcasts.

The bottom frequency diagram in Figure 2 shows the frequency spectrum of the transmission band signal TB on the output line 140 of the DCMs 132, 134, 136, 138 or Figure 1. In this example the transmission band is divided into ten sub-bands each dedicated to a specific user. The transmission band is for example the same as the lower frequency band 0-500 MHz, although other frequency bands are possible. In the example of Figure 2, the user sub-bands each have a bandwidth of approximately 45 MHz, and ten neighbouring sub-bands are provided between 40 MHz and 490 MHz, corresponding from left to right to ten users U1 to U10. For example, channels CH1 to CH5 are inserted into the sub-bands corresponding to users U9, U1, U3, U7 and U2 respectively, while the channel CH6 is inserted into the sub-bands corresponding to users U4, U5 and U6. Furthermore, users U8 and U10 are not watching any satellite channel, and thus the corresponding sub-bands are not used.

In alternative embodiments to that of Figure 2, the user sub-bands could have a bandwidth of anything between 8 and 80 MHz. Assuming a relatively low bandwidth, for example of approximately 8 MHz, there could be up to 50 or more users sharing the transmission bandwidth TB.

The user sub-bands are for example permanently programmed, meaning that a certain sub-band is always associated with a given user's satellite decoder, and each satellite decoder is also permanently programmed to extract its respective sub-band from the transmission band signal.

Alternatively, the user sub-bands could be assigned to users on the fly, based on the users that wish to view a satellite channel. In other words, the sub-bands could be dynamically allocated. For example, it may be likely that not all the set-top boxes will be active at the same moment, and thus in this case there may be more set-top boxes than the maximum number of active users supported by the system, allowing the use of resources to be optimized. In one example, upon

activation, each satellite decoder requests from the control block 144 a sub-band, and in response, the control block 144 transmits a reply to the decoder indicating its assigned sub-band. The satellite decoders then adapt their receive circuitry to extract the corresponding assigned sub-band.

Figure 3 illustrates the DCM 132 of Figure 1 in more detail. The other DCMs 134, 136 and 138 of Figure 1 for example have an identical structure to that of DCM 132.

The DCM 132 comprises an analogue to digital converter (ADC) 302, which receives the signal IB1 from mixer 112 via variable amplifier 131, and samples this signal, for example at a sampling rate of 1 GHz, to generate a data stream of samples.

The output of the ADC 302 is coupled to a data interleaver block 304, which separates the incoming data stream into two paths. For example, interleaver 304 passes blocks of samples from the incoming data stream alternately to two different buffers 305A and 305B, which output these samples to generate two parallel data streams, each padded with blocks of zeros. For example, each block of N samples of the incoming stream is divided in two, to generate a pair of blocks of N/2 samples, one of which is written to buffer 305A, and the other of which is written to buffer 305B. The blocks of N/2 samples in each buffer are for example separated by memory blocks containing N/2 zeros, such that when the data from these buffers 305A, 305B is output, the N/2 data samples are interspaced by N/2 zeros. Alternatively, the zero padding in each branch can be implemented by a bit-level multiplication of the N data samples in each block with a binary signal equal to logic 1 for the N/2 samples to be included in each branch, and equal to logic 0 for the N/2 zero samples that are to be generated.

Parallel data streams output from buffers 305A and 305B are provided to parallel processing branches A and B of DCM 132, each branch comprising a respective Fast Fourier Transform (FFT) block 307A, 307B, a respective variable band-pass filter 308A, 308B, a respective channel shifter 310A, 310B, and a

respective Inverse Fast Fourier Transform (IFFT) block 312A, 312B.

The FFT blocks 307A, 307B perform an FFT operation on the respective data streams, to convert these samples from the time domain to the frequency domain.

The variable band-pass filters 308A, 308B extract one or more frequency bands from the respective data streams corresponding to one or more desired channels. The frequency bands are selected based on a control input to each of the variable filters 308A, 308B, and the same frequency bands are selected by each of the filters 308A, 308B.

The channel shifters 310A, 310B shift the channels contained within the frequency band extracted by the respective variable filters 308A, 308B to frequency bands associated with given users.

The IFFT blocks 312A, 312B then perform an inverse fast Fourier Transform operation on the channel shifted frequency streams from the respective channel shifters 310A, 310B, to convert these streams back into data streams in the time domain, which are provided to a combiner block 314.

The combiner block 314 recombines the data streams from the IFFT blocks 312A, 312B into a single data stream, by performing an addition of corresponding samples of corresponding blocks. For example, the data streams are provided to respective buffers 315A, 315B, and corresponding samples of corresponding blocks of $N/2$ samples in each stream are added.

The resulting stream is provided by the combiner block 314 to a digital to analog converter (DAC) 316, which provides the signal TB on line 140 in the transmission band.

Operation of the digital channel multiplexer 132 of Figure 3 will now be described in more detail with reference to the data streams illustrated in Figure 4.

Figure 4A shows an example of a data stream 402 at the output of the ADC 302. Data stream 402 comprises samples that may be grouped in fixed length blocks B, to provide a series of blocks of samples B0, B1, B2,... etc. Each block B comprises $N/2$

samples, with N for example equal to 2048 samples, although other values are possible.

The interleaver 304 divides the data stream 402 into two separate data streams 404, 406, each respectively comprising alternate blocks B of the data stream 402. The interleaver 304 also performs zero padding, inserting $N/2$ zero samples between each block. For example, data stream 404 comprises odd blocks $B_1, B_3, B_5, \dots$ etc. of data stream 402, interspaced by blocks of zeros, while data stream 406 comprises even blocks $B_0, B_2, B_4, B_6, \dots$ etc. of data stream 402, interspaced by blocks of zeros.

The data streams 408 to 416 of Figure 4A illustrate the result of processing of the data stream 402 in branch 306A, which is the branch comprising FFT 307A, filter 308A, channel shifter 310A and IFFT 312A. The data stream 404 is processed in a similar fashion in branch 306B.

A fast Fourier transform is first performed on the zero padded data stream 404 by the FFT block 307A, based on a Fourier transformation with T points, where T is for example equal to the number of samples N , for example 2048. The FFT block thus generates frequency samples $\text{FFT}[B_1], \text{FFT}[B_3], \dots$ etc. as shown by the data stream 408 of Figure 4, each of these blocks for example comprising N samples, for example 2048 samples.

The frequency domain signal resulting from the fast Fourier transform operation is filtered by the digital filter 308A based on a series of L filter coefficients C , where L is for example also equal to N . The L filter coefficients are determined based on the impulse response $H(f)$ in the frequency domain of the desired filter, generated for example by applying the FFT to the desired impulse response $h(n)$ of the filter in the time domain. The result of the filtering of data stream 408 is a data stream 412 of blocks $F_1, F_3, \dots$ etc., each for example of N values, corresponding to the filtered values of the blocks B_1, B_3 etc. in the frequency domain.

The blocks $F_1, F_3, \dots$ etc. are provided to the channel shifter 310A, which reorders frequency bands of the channels in

each block based on the desired frequency band of each channel, and generates a data stream 414 of channel shifted blocks $F1'$, $F3'$, ... etc. As an example, with reference again to Figure 2, assuming the signal being processed is IB4, the samples in the
5 frequency bands corresponding to channels CH5 and CH6 should be ordered such that they correspond to the frequency bands assigned to users U2, U4, U5 and U6.

The frequency shifted signals $F1'$, $F3'$,... etc. are reconverted into the time domain by IFFT block 312A, to generate
10 a data stream 416 comprising blocks $B1'$, $B3'$,... etc. each of N samples. A similar data stream 418 of blocks $B0'$, $B2'$, $B4'$,... etc. is generated in the parallel branch 306B of the DCM 132.

The data streams 416, 418 are provided to the combiner block 314, which performs an addition of corresponding samples
15 in each block, to generate the recombined stream 420. In particular, there is a 50 percent overlap between odd blocks $B1'$, $B3'$, ... etc. and even blocks $B0'$, $B2'$,... etc. Thus, the last $N/2$ samples of blocks $B0'$ are added to the first $N/2$ samples of block $B1'$, the last $N/2$ samples of block $B1'$ are added to the
20 first $N/2$ sample of block $B2'$, and so on and so forth.

Figure 4B shows frequency diagrams illustrating an example of the form of a digital filter of the digital channel multiplexer of Figure 3, assuming the signal processed is the signal IB1, containing two wanted channels CH1 and CH2. As
25 illustrated, the form BPF1 of the band-pass filter 308A is adapted to comprise pass bands corresponding to the positions of the channels CH1 and CH2, whereas other parts of the signal are filtered out. To achieve such a filtering, filter coefficients corresponding to a filter for each desired pass band are for
30 example combined.

In one embodiment, the digital filters 308A, 308B of each DCM for example receive an indication of the width of the pass bands to be applied, for example illustrated $w1$ and $w2$ in Figure 4B and the gradients of rising and falling edges at the
35 edges of the pass-bands, for example $g1$ and $g2$ in Figure 4B. The

digital filters for example comprise a look-up table enabling filter coefficients to be generated based on these parameters.

Figure 5 illustrates branch 306A of the DCM 132 of Figure 3 in more detail according to one embodiment.

5 The band-pass filter 308A comprises a multiplier 502, which receives the data stream of frequency samples from FFT 307A, and performs a multiplication with the filter coefficients $C[1]$ to $C[L]$, received on a second input line 504 of the multiplier. In fact, at bit level this multiplication can be
10 implemented by an adder, adding the corresponding bits of the samples and filter coefficients. The filter 308A also for example comprises an FFT block 505, which generates the filter coefficients C by performing a fast Fourier transform on samples of the impulse response of the desired filter. The samples
15 provided to FFT blocks 307A and 505 are for example synchronized with each other by timing stages 506, 507 positioned on their respective input lines, such that the addition of the streams is performed on the corresponding bits of each stream.

 The channel shifter 310A comprises a buffer 508, which
20 is filled by the filtered samples from multiplier 502, respecting their order. Frequency shifting is performed upon output of the frequency samples from the buffer 508, using a variable pointer 509. In particular, assuming that a block N of samples corresponds to the transmission band, for example 0-
25 500 MHz, then the positioning of the samples within each block N will determine their corresponding frequency. Thus groups of samples of each channel are output in turn at a position corresponding to their desired frequency band in the transmission band signal.

30 The pointer is controlled based on the known previous positions (frequency bands) of desired channels within a block of N samples and the desired new positions (frequency bands) of the desired channels. This information is for example provided by the control block 144 of Figure 1. Addresses for the pointer
35 are for example generated by a buffer address block (not shown in Figure 5), which determines the order of addresses from which

the samples are to be output, and controls the buffer 508 accordingly. For example, a block of N samples covers the entire bandwidth of the transmission band signal, and thus for a given set of desired channels, the addresses provided by the buffer
5 address block are valid for each block of N samples, each of which is for example output from the buffer in the same new order.

In one example, assuming that a particular channel is to be transmitted to a plurality of users, this channel is not
10 over-written in the buffer until it has been output at each of the positions corresponding to the sub-bands assigned to said users.

The values from buffer 508 are provided directly to IFFT block 312A, for conversion into the time domain.

15 As will be appreciated by those skilled in the art, the FFT and IFFT operations introduce a reversing of the bit order in the data stream. In some embodiments, rather than correcting the bit reverse order after the FFT and IFFT operations, the processing of samples between these blocks is
20 performed based on the samples in the bit reverse order.

Figure 6 illustrates a receive unit 600 according to an embodiment in which the DCM comprises four branches. Receive unit 600 comprises an antenna 601, for example being part of a satellite dish, which receives a satellite signal and provides
25 this to an LNB 602, comprising a low noise amplifier 604 and a mixer 606. Mixer 606 performs an initial frequency shift of the satellite signal to an intermediate frequency band based on a mixing frequency received from a block 608.

The output of the mixer 606 is provided to digital
30 multiplexer block 610, which in this example comprises a single digital channel multiplexer. Block 610 comprises an optional variable amplifier 611, which receives the output from LNB 602, and if needed applies an amplification to bring the signal to an appropriate level for the input of an ADC 612. The output of ADC
35 612 is provided to a data interleaver block 614, which splits the data stream from the ADC 612 into four zero-padded data

streams provided to four branches 616A, 616B, 616C and 616D respectively. Each of these branches comprises an FFT block, variable digital filter, channel shifter and IFFT block, which operate in a similar fashion to the branch 306A described above.

5 The output of the branches 616A to 616D are merged by a combiner block 618, before being provided to a DAC 620, which generates an analog signal for output on an output line 622, for example to output circuitry similar to block 142 of Figure 1 (not shown in Figure 6). This analog signal can be transmitted
10 to indoor satellite decoders, as described above.

 An advantage of splitting the input stream into two data streams in the case of the DCM of Figure 3, or into four data streams in the case of the DCM of Figure 6, is that the number of samples to be processed by each branch becomes
15 considerably reduced, by a factor of 2 or 4 respectively. This allows a reduced complexity of the DCM, and/or the sampling frequency of the ADC at the input of the DCM can for example be increased, and thus also the bandwidth of the satellite signal processed by the ADC. In particular, in the example of Figure 6,
20 the ADC for example samples at a rate of 2.2 GHz, and the bandwidth of the input signal is for example up to 1.1 GHz. It will be apparent to those skilled in the art that there will be a trade-off between the sampling frequency of the analog to digital converter at the input of the DCM, which determines the
25 largest input bandwidth, and the complexity of the DCM.

 Figure 7 illustrates a satellite receiving system 700 for receiving a satellite signal. The system 700 comprises a receive unit 702, which is for example mounted at the focal point of a satellite dish and comprises the unit 100 of Figure 1
30 or the unit 600 of Figure 6. The receive unit 702 receives one or more satellite signals and generates and transmits a transmission band signal comprising channels extracted from one or more of the satellite signals, the channels being positioned in desired frequency bands of the transmission band.

35 The transmission band signal is transmitted over a wired communication path 704, which is for example a coaxial

cable, to a splitter box 706, which provides the transmission band signal to each of a number of satellite decoders 708, 710, 712 for demodulation and decoding. The satellite decoders 708 and 710 for example correspond to set-top boxes, and are coupled to respective displays 714, 716 for displaying video images received via the satellite system to corresponding users. The satellite decoder 712 is for example a personal computer arranged to decode the satellite signal, and display the received video on a display 718.

An advantage of embodiments described herein is that, by providing a receive unit that processes a satellite signal in the frequency domain, channel selection can be performed with high precision, allowing a high number of channels to be transmitted simultaneously over a limited transmission band. In particular, the frequency band of the signal transmitted from the satellite receive unit to satellite decoders for example has a bandwidth of approximately 500 MHz, and up to 50 users may be supported within this bandwidth.

A further advantage of embodiments described herein is that, by performing channel shifting using a buffer with a variable output pointer, samples may be shifted in the frequency domain in a simple and precise fashion, using a minimum amount of resources.

Having thus described at least one illustrative embodiment of the invention, various alterations, modifications and improvements will readily occur to those skilled in the art.

For example, while Figure 1 shows an example of a receive unit receiving two satellite signals, further satellite signals may be received by the receive unit 100. Furthermore, while four DCMs 132, 134, 136 and 138 are provided, fewer or more DCMs could be provided, in general, one DCM being provided for each satellite signal received.

Furthermore, while an example of a transmission band signal in the frequency band 0-500 MHz has been described, alternatively the transmission band could have an alternative frequency band, of a higher or lower bandwidth. The transmission

band can have the same bandwidth as the bandwidth of the satellite input to each DCM, or alternatively these bandwidths may be different. The sampling rate of the ADC 302 of each DCM can be adapted based on the desired band of the input signal, to
5 respect the Nyquist frequency.

Furthermore, while it has been disclosed that in the embodiment of Figure 1 the signals from the DCMs 132, 134, 136 and 138 are combined on a signal line 140 by connecting the outputs of the DCMs together, alternatively the signal could be
10 combined prior to the digital to analog conversion. In particular, the output of each DCM could comprise the digital samples directly from the IFFT blocks, and the output block 142 could sum these digital samples, prior to converting them into an analog signal by a single DAC for transmission on the output
15 line 130.

While certain features have been described in relation to certain embodiments, in alternative embodiments, such features could be combined in any combination with each other.

CLAIMS

1. A satellite receive unit comprising:
 - an analog to digital converter (302) adapted to sample a satellite signal to generate a data stream of digital samples;
 - at least one digital channel multiplexer (132-138)
 - 5 comprising at least one processing branch (307A, 307B) comprising:
 - a Fourier transform block (307A, 307B) adapted to perform a Fourier transform to convert the data stream into the frequency domain;
 - 10 a channel shifter (310A, 310B) adapted to re-order samples of the frequency domain data stream to shift at least one channel of said satellite signal to a new frequency band; and
 - an inverse Fourier transform block (312A, 312B)
 - 15 adapted to convert the re-ordered frequency domain data stream into an output data stream in the time domain; and
 - a digital to analog converter (316) adapted to convert said output data stream into an analog signal in a transmission band for transmission over a transmission channel to at least
 - 20 one satellite decoder.
2. The satellite receive unit of claim 1, wherein said digital channel multiplexer comprises a plurality of said processing branches arranged in parallel with each other.
3. The satellite receive unit of claim 2, further
- 25 comprising:
 - a data interleaver block (304) adapted to split said data stream of digital samples into first and second data streams, and to provide said first data stream to a first of said plurality of processing branches and said second data
 - 30 stream to a second of said two processing branches; and
 - a data stream combiner (314) adapted to receive the output data streams from said first and second processing branches and to add corresponding samples of the output data

streams to generate said output data stream for conversion by said analog to digital converter.

4. The satellite receive unit of claim 3, wherein said data interleaver is arranged to receive blocks of data (N) of
5 said data stream of digital samples, and to output the samples of a first half ($N/2$) of each of said blocks of data to the first branch (305A) and the samples of a second half of each of said blocks of data to the second branch (305B).

5. The satellite receive unit of any of claims 1 to 3,
10 wherein said satellite signal is provided by a mixer (112-118) adapted to frequency shift an initial satellite signal to an intermediate frequency band.

6. The satellite receive unit of claim 5, wherein said transmission band has a bandwidth of less than or equal to the
15 bandwidth of said intermediate frequency band.

7. The satellite receive unit of claim 5 or 6, wherein said transmission band has a lower frequency limit in the range 0-100 MHz and an upper frequency limit in the range 300-1100 MHz.

8. The satellite receive unit of any of claims 1 to 7,
20 comprising a plurality of said digital channel multiplexers (132-138), each adapted to process a respective satellite signal, wherein the analog signal from each of said digital channel multiplexers is combined into a transmission band signal
25 for transmission over said transmission channel.

9. The satellite receive unit of any of claims 1 to 8,
wherein said channel shifter comprises a buffer (508) into which samples of said frequency domain data stream are loaded, and circuitry for reordering the samples as they are output from
30 said buffer in order to shift said at least one channel to a new frequency band.

10. The satellite receive unit of any of claims 1 to 9,
wherein said processing branch further comprises a digital filter (308A, 308B) arranged to extract at least one selected
35 channel from said frequency domain data stream.

11. The satellite receive unit of any of claims 1 to 10, further comprising:

at least one receive head for receiving one or more initial satellite signals; and

5 at least one low noise block (106, 107) arranged to amplify and frequency shift said one or more initial satellite signals to generate said satellite signal.

12. A satellite receive system comprising the satellite receive unit of any of claims 1 to 11 and a plurality of
10 satellite decoders (710-714) adapted to receive the analog signal in said transmission band transmitted over the transmission channel.

13. The satellite receive system of claim 12, wherein said transmission channel comprises one or more of:

15 a coaxial cable;
a wired network connection; and
a power line communication.

14. A method of receiving a satellite signal comprising:

20 performing an analog to digital conversion on said satellite signal to generate a data stream of digital samples;

processing said data stream digital samples by at least one processing branch (307A, 307B) of at least one digital channel multiplexer (132-138), said processing comprising:

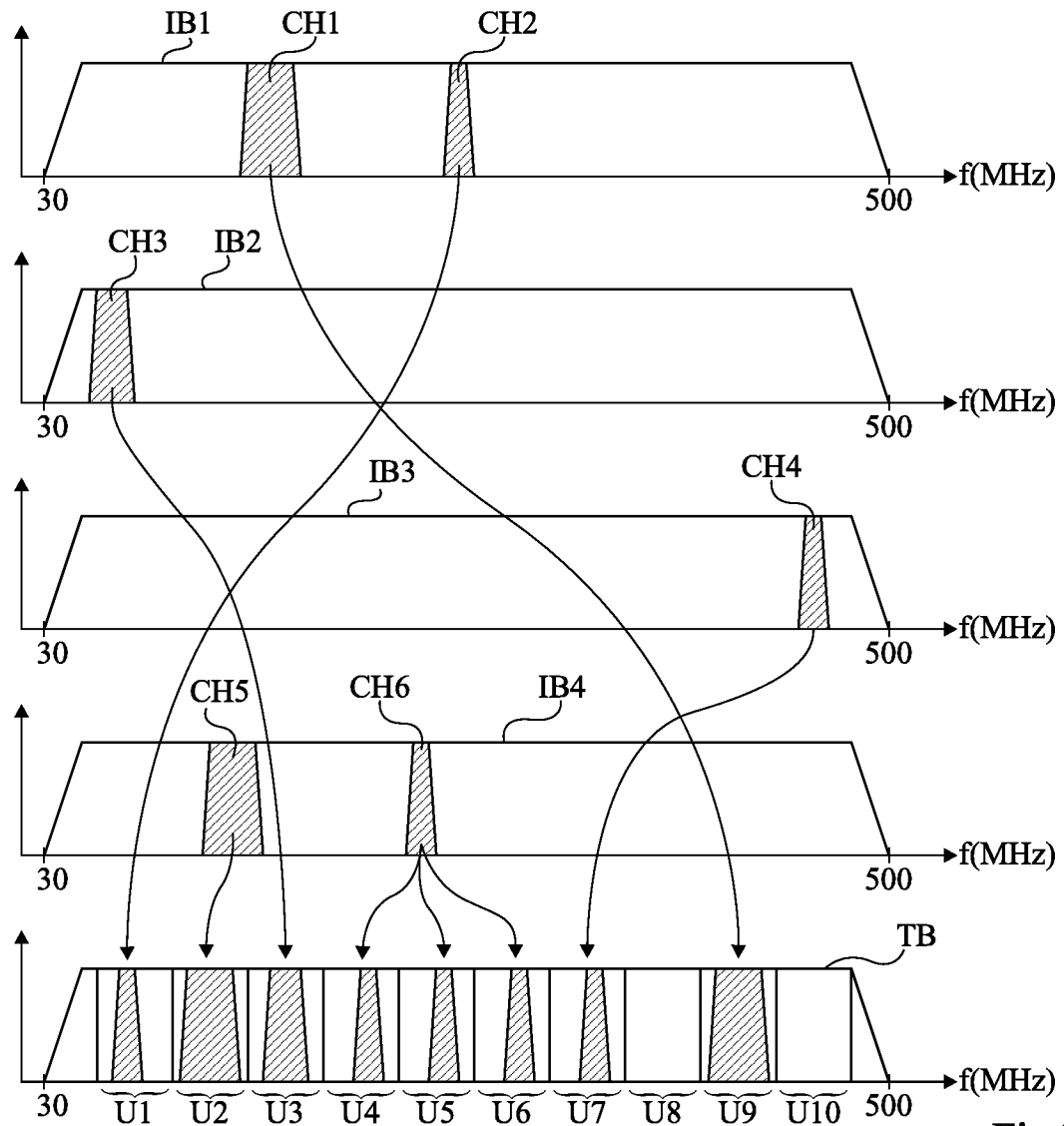
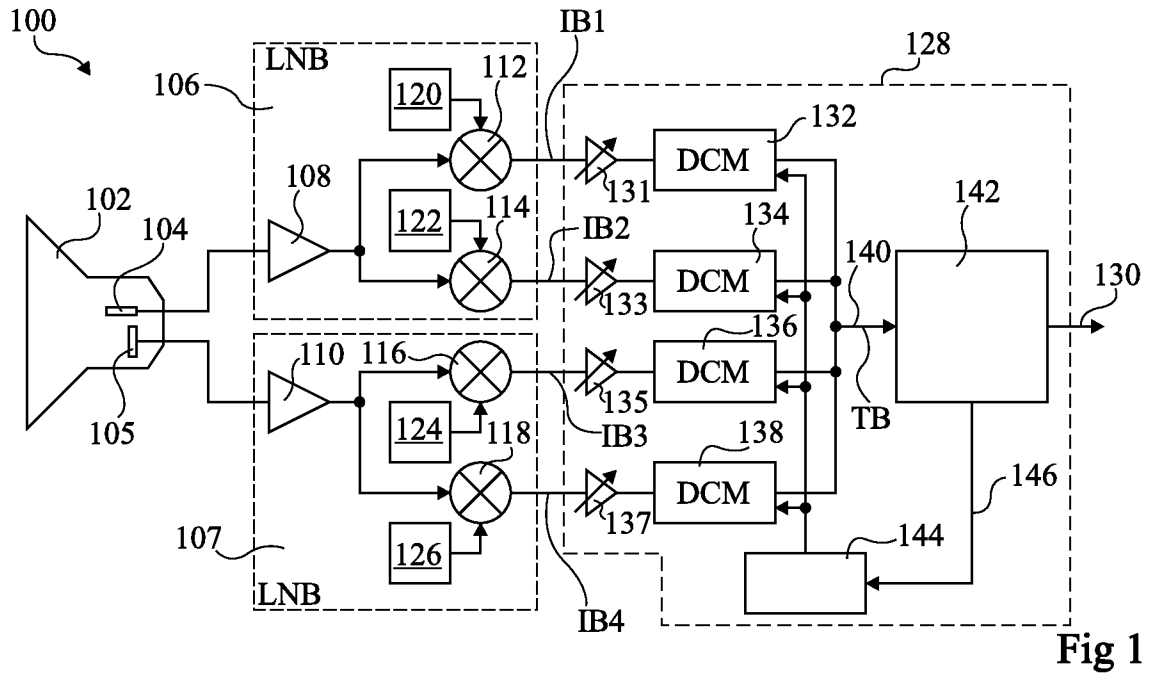
25 performing a Fourier transform to convert the data stream into the frequency domain;

reordering samples of said frequency domain data stream to shift at least one channel of said satellite signal to a new frequency band; and

30 performing an inverse Fourier transform block to convert the re-ordered frequency domain data stream into an output data stream in the time domain; and

converting said output data stream into an analog signal in a transmission band, for transmission over a
35 transmission channel to at least one satellite decoder.

15. The method of claim 14, wherein said step of reordering samples comprises loading said samples of said frequency domain data stream into a buffer (508), and reordering the samples as they are output from said buffer in order to
5 shift said at least one channel to a new frequency band.



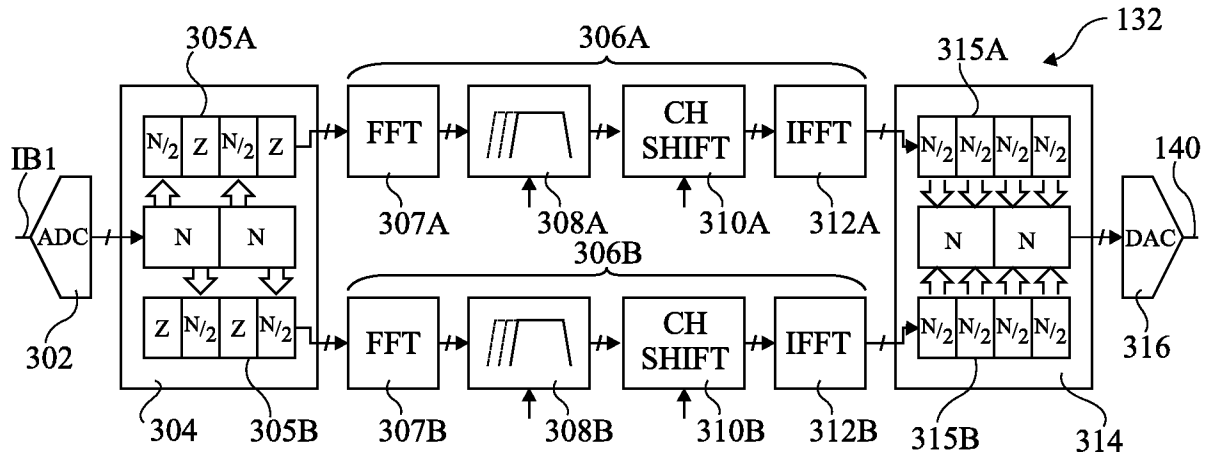


Fig 3

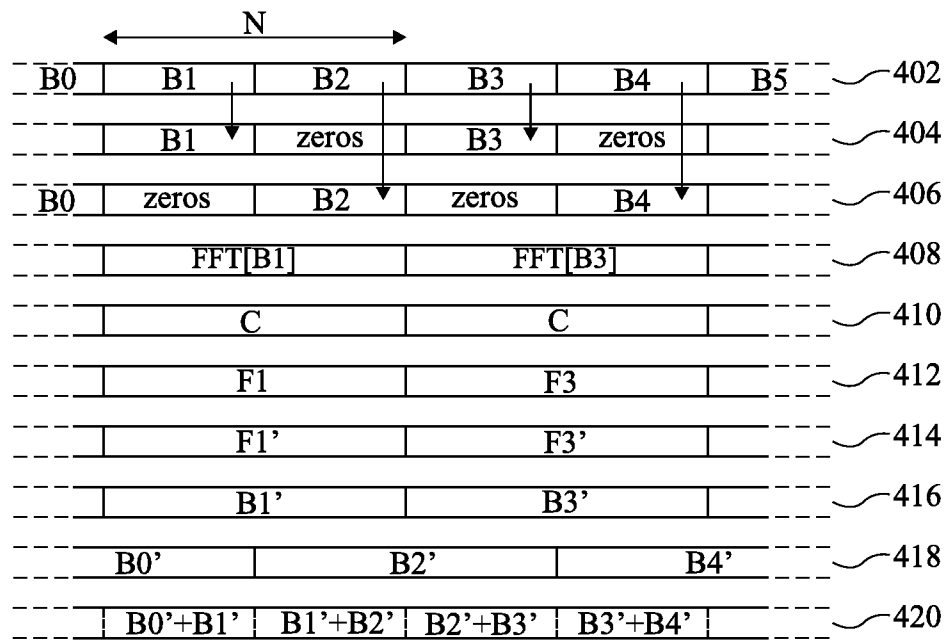


Fig 4A

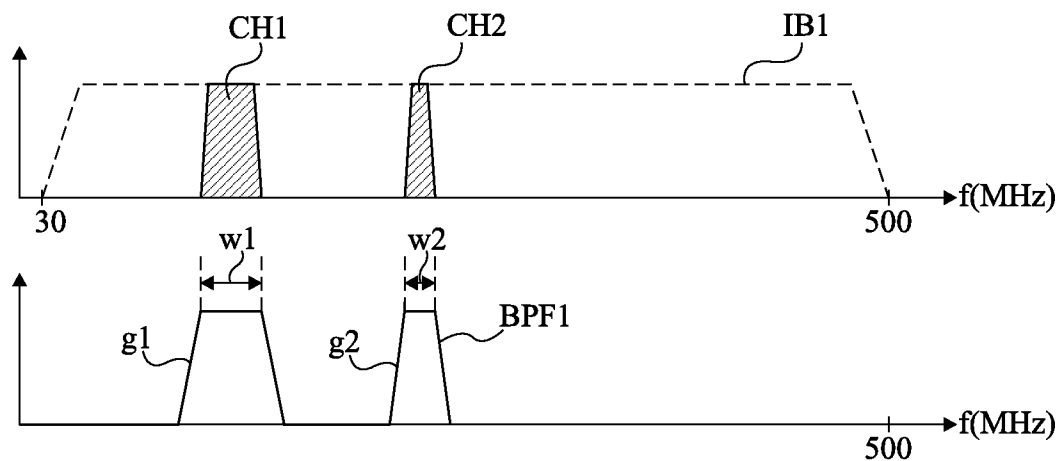


Fig 4B

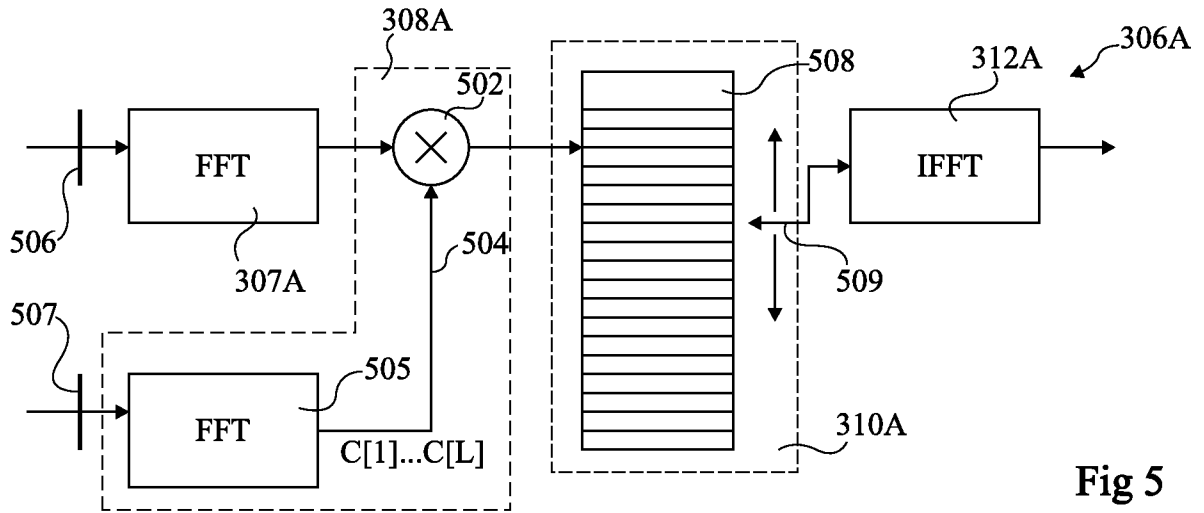


Fig 5

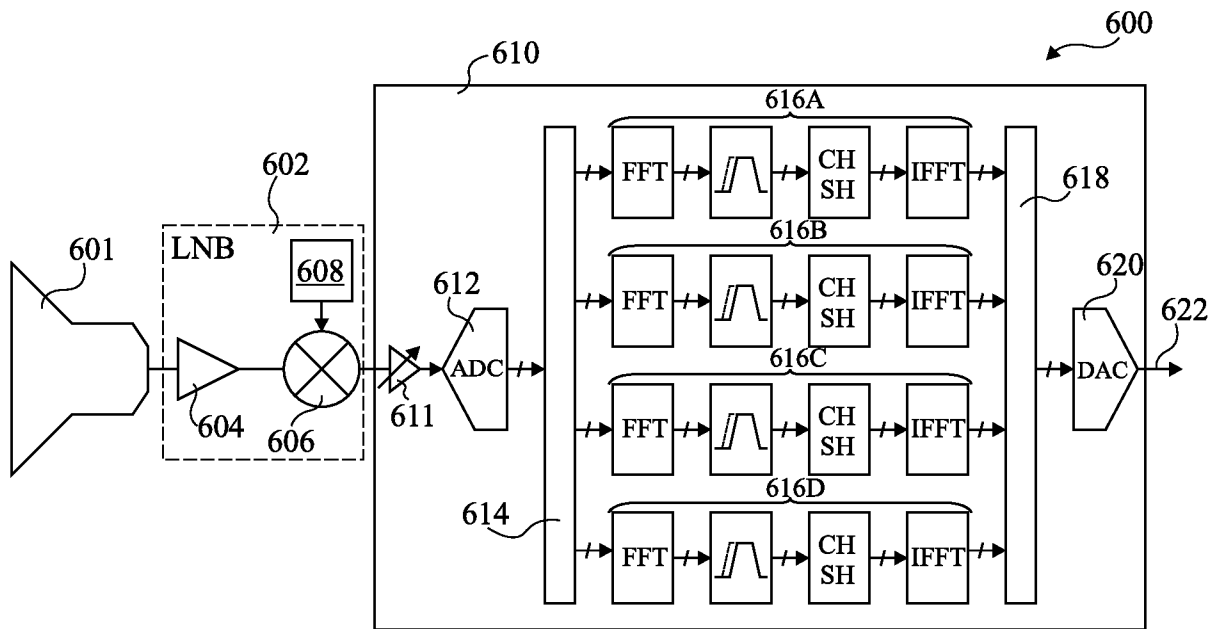


Fig 6

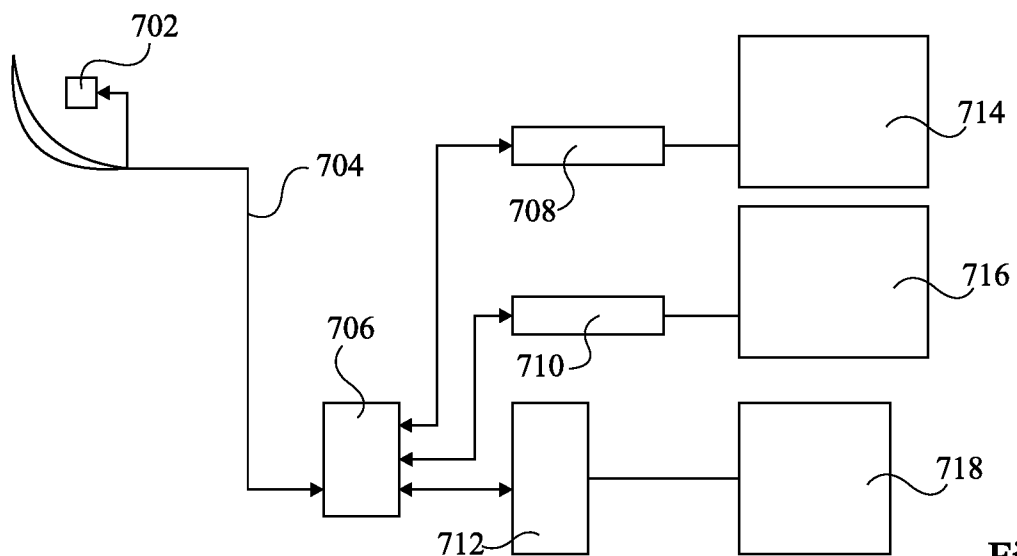


Fig 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2009/055093

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04H40/90

ADD. H04H20/63

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)

H04H

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 7 130 576 B1 (GURANTZ ITZHAK [US] ET AL) 31 October 2006 (2006-10-31) column 4, line 29 - column 5, line 54; claims 1,5; figures 3,5,8 -----	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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Date of the actual completion of the international search

9 June 2010

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2009/055093

Patent document cited in search report	Publication date	Patent family member(s)	Publication date	
US 7130576	B1	31-10-2006	US 7542715 B1	02-06-2009