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Efficient Frequency Band Reallocation Using Transmultiplexers In Radio Receiver

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Abstract:
Multirate filter banks have become excellent solution for future wireless communication system. Filter bank based multicarrier system provides high spectral efficiency through removal of redundant information resulting in efficient use of available spectrum. In multicarrier communication system, filter bank based transmultiplexer (TMUX) having same analysis and synthesis filter bank is employed. Efficient utilization of the available limited frequency spectrum, calls for on-board signal processing to perform flexible frequency-band reallocation (FFBR).This paper introduces a uniform TMUX which is the uniform band structure in which all the incoming data signals are assumed to have the same sampling rates and are upsampled at the same integer factor and thus, achieves nearly perfect reconstruction.

Key words: *Multimode communication, Transmultiplexer, Flexible Frequency-Band Reallocation*

1.Introduction

Multicarrier modulation is default choice for high data rate wireless communication. In multicarrier modulation system available channel bandwidth is efficiently subdivided into several sub- channels; each has its associated subcarrier present scenario, most commonly used multicarrier modulation technique is orthogonal frequency division multiplexing (OFDM). Even though OFDM has numerous advantages it has certain shortcomings. It uses cyclic prefix (CP) which consumes certain amount of available bandwidth (critical in cognitive radio networks) and it uses rectangular prototype filter and IFFT/FFT blocks which results in less frequency selective sub channel.

Filter bank based multicarrier system (FBMC) is widely used in present communication technology (e.g. cognitive radio) because of its inherent frequency selectivity and spectral efficiency. FBMC system provides certain advantages over conventional OFDM like improved frequency selectivity through use of longer and spectrally well shaped prototype filter and efficient use of available spectral bandwidth (spectral efficiency) by removal of CP. Basic FBMC system consists of TMUX structure. A general TMUX consist of synthesis filter bank (SFB) at transmitter, analysis filter bank (AFB) at receiver. Corresponding filters in AFB and SFB are tuned so as to get desired response.

2.General TMUX Structure

Multirate filter banks can be used not only to realize subband (analysis/synthesis) systems but also transmultiplexers (synthesis/analysis systems). The complementary nature of subband systems and transmultiplexers are interpreted through network duality. A transmultiplexer which is illustrated in Figure.1 is a multi-input, multi-output system well suited for simultaneous transmission of many data signals across a single channel.

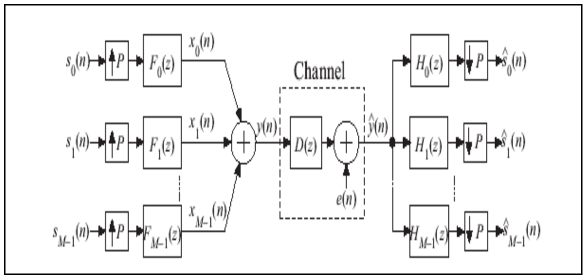

Figure 1: General TMUX structure

At the transmitter the multiplexing is performed by interpolating and filtering, where combining (multicarrier modulating) filter bank serves to allocate different portions of the channel bandwidth to the various input signals. At the receiver the composite signal is passed through a structure of separation (multicarrier demodulating) filter bank and decimators to yield the output signal. The demodulation stage should ensure that the output signals depend only on their corresponding inputs.

Transmultiplexers find wide applications in multimedia signal processing and communication systems due to the fact that they allow several signals to be transmitted through a single channel.

Generally, in a dynamic communication system, we can have different bandwidths allocated to different users and users can demand any bandwidth at any time. As an example, to transmit video, one needs a wide bandwidth whereas texts can be transmitted in a narrower channel.

3.Frequency Band Reallocation

A main aim for future digital communication systems is to support various wideband services accessible to everybody everywhere. Although the large theoretical bandwidth provided by optical fibers could make terrestrial networks capable of supporting such services; this bandwidth is hardly available today. Furthermore, there is a gap between the local exchange and the customer which needs to be filled. Thus, it has been concluded that satellites with high-gain spot beam antennas, onboard processing and switching will be a major part of future digital communication systems. The reason is that satellites provide global coverage, and if a satellite is in orbit, customers only need to install a satellite terminal and subscribe to the service.

The European Space Agency (ESA) has proposed three major network structures for broadband satellite-based systems in which satellites communicate with users through multiple spot beams and therefore, there is a need for efficient reuse of the limited available frequency spectrum by satellite on-board signal processing. In technical terms, this calls for digital flexible frequency band reallocation (FFBR) networks which are shown in Figure.2 and the process is also referred to as frequency multiplexing and demultiplexing.

The digital part of the satellite on-board processor is a multi-input multi-output (MIMO) system. The number of input signals can in general, differ from the number of output signals and the input/output signals can have different bandwidths and data rates, e.g., users from different telecommunication standards.

A main role of the on-board processor is to reallocate all subbands to different prespecified output signals and positions in the frequency spectrum. Furthermore, the system must support bandwidth-on-demand, which means that the bandwidths of different subbands may vary with time. This is handled by dividing the input beam into a number of granularity bands, where at any time any user can occupy any number of granularity bands.

Hence we can achieve flexible frequency band reallocation by using filter banks in transmultiplexers.

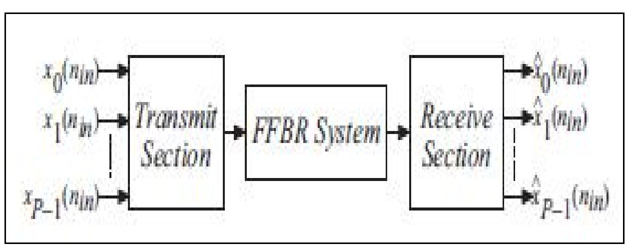

Figure 2: Block Diagram Of FFBR Network

4.Lab View Implementation Of Uniform TMUX

This section presents the LabVIEW software implementation of uniform TMUX. LabVIEW is a graphical programming environment which allows one to design complex DSP systems in a relatively time efficient manner as compared to textual programming.

A LabVIEW program consists of two major components: Front Panel (FP) and Block Diagram (BD). A Front Panel provides a graphical user interface while a Block Diagram contains building blocks of a system resembling a flowchart. LabVIEW blocks are called Virtual Instruments or VIs.

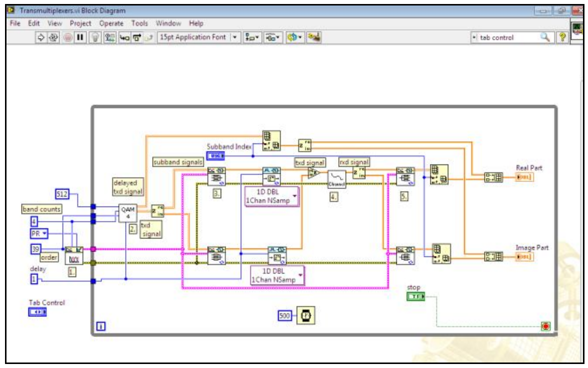

Figure 3: Block diagram of uniform TMUX using LABVIEW

The above block diagram shows the uniform TMUX. It can convert TDM signals into FDM signals where, M-band cosine modulated perfect reconstruction filter bank is created then QAM signal is generated as a transmitted signal and that transmitted signal is converted into a frequency multiplexed (FDM) signal.The synthesis bank converts the input QAM signal into an FDM signal.The analysis bank converts the transmitted FDM signal back to a QAM signal.The received QAM signal is almost the same as the input QAM signal.

Analysis and synthesis filters are uniformly shifted version of prototype filter in frequency domain and integer delay delays a signal continuously by a specified number of integer intervals.

The TMUX, with analysis filters $H_k(z)$ and synthesis filters $Z^{\wedge}J\ F_k(z)$ has perfect reconstruction if L+J is a multiple of M, where L is the order, J is the delay and M is the band counts. L=39; J=1; M=4 and signal reconstruction is perfect reconstruction, order must equal 2*band counts*k-1, where k is a positive integer.

FDM signal is transmitted through the channel and the received FDM signal is converted back into a QAM signal.

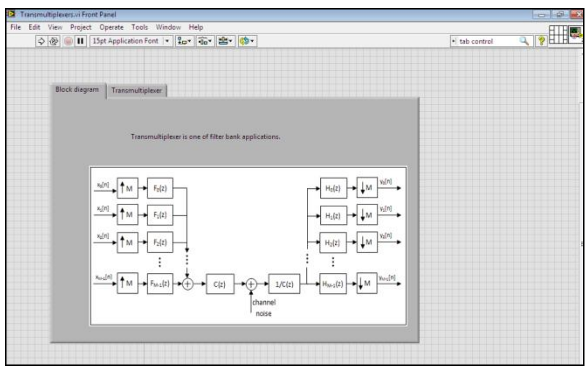

Figure 4: Front panel of uniform TMUX

The simulation results gives the time domain representation of 4 subbands of subband 0 in Figure.5, subband 1 in Figure.6, subband 2 in Figure.7 and subband 3 in Figure.8 are shown which includes delayed transmitted and received signal for real part as well as for imaginary part.

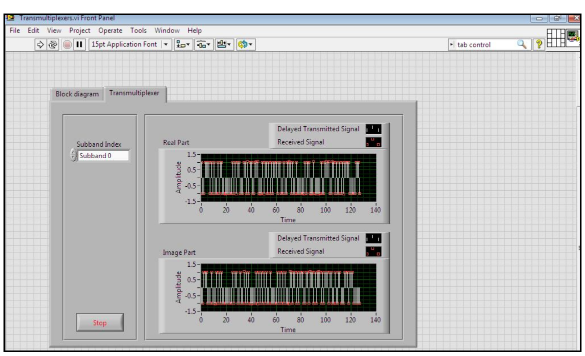

Figure 5: Time Domain Representation Of Subband 0

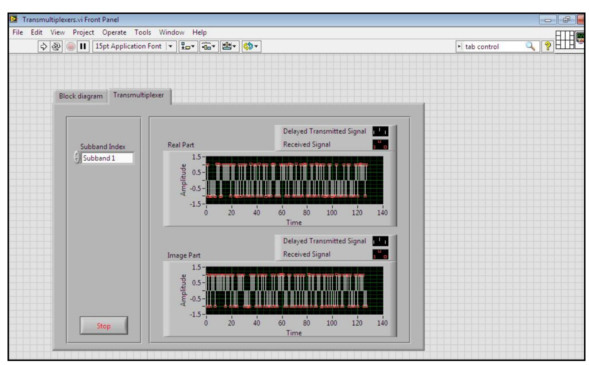

Figure 6: Time Domain Representation Of Subband 1

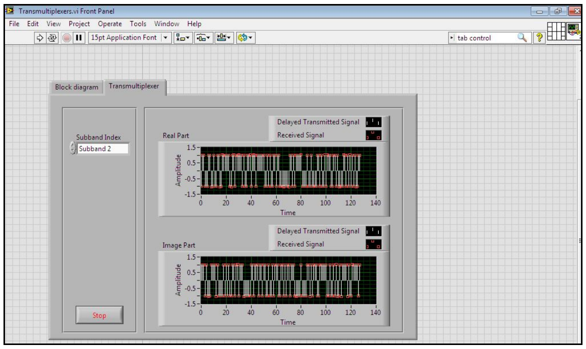

Figure 7: Time Domain Representation Of Subband 2

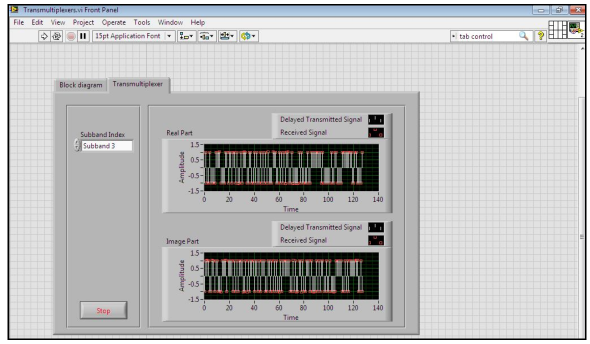

Figure 8: Time Domain Representation Of Subband 3

Further the frequency response at the real part is designed for uniform TMUX and it is computed based on input signals.

5.Conclusion

In this paper uniform TMUX is introduced and frequency response is determined. Therefore, it is vital to develop low complexity TMUXs which dynamically support different communication scenarios with reasonable implementation complexity and design effort. Eventhough the structure is simple; it does not achieve efficient frequency band reallocation due to aliasing distortion. Our aim is to introduce TMUXs which allow different number of users having different bandwidths to share the whole frequency spectrum in a time varying manner.

6.Future Work

To introduce a nonuniform TMUX which have different sampling rates. We can achieve perfect reconstruction as well as efficient frequency band reallocation without aliasing distortion by varying sampling rates and filter coefficients at the receiver (analysis filter bank) by using the same software labview and hardware used is FPGA kit.

7.References

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