Design of Digital Wireless Transmission for 64 Channel Array using IEEE 802.11n

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Introduction:

Recently, several proposals of using wireless transmission for MRI have been reported to avoid the RF baluns and interference among array channels [1-6]. However, the limitation of array channels and data transfer for fast imaging is still a major challenge [6]. In this work we investigate how to use WLAN 802.11n (draft) with advantages of Multiple Input Multiple Output (MIMO) [7] and Orthogonal Frequency Division Multiplexing (OFDM) technology [8] for parallel imaging application up to 64 channel array.

Method:

The block diagram of the digital wireless MRI transmission system is shown in Fig. 1. Digital signal processing (DSP) board controls direct digital synthesizer (DDS) and Mixer to converts RF signal down to the low carry frequency. Using frequency division multiplexing (FDM) method, each down loaded RF signal is multiplexed and assigned to its own frequency band with 400 KHz bandwidth.

Then all these FDM signals are combined together and sent to the A/D to be digitized and later transformed to Ethernet configuration, then sent to the 802.11n access port to be transmitted. In Wireless-N router (WRT300N, Linksys, Cisco. Inc.) the digitized data are modulated again using OFDM in both the time and frequency domains. In frequency domain, it consists of 52 separate carrier frequencies. The data is modulated on each carrier by varying the phase and amplitude. In addition, an error-corrected code is applied to provide the highest possible throughput (150 Mbps). In time domain, using FFT the transmitted waveform can be seen as the sum of many sinusoids with different frequencies, and each modulated in phase and amplitude to convey the data. MIMO method is also used in 802.11n access point to do multiple inputs and outputs between transmitter and receiver by multiple antennae for better range and faster speed.

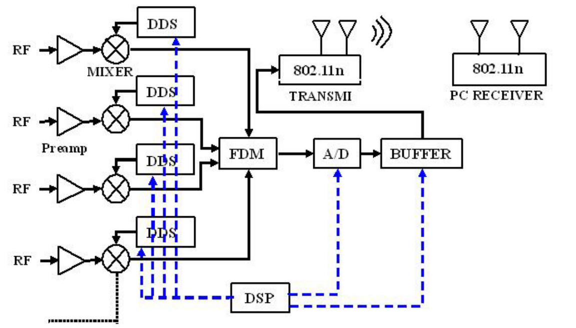

Fig1. Block diagram of the digital wireless using 802.11n

Results and Discussion:

The DSP with DDS, ADC, controlled pre-processing circuit and Ethernet is shown in Fig. 2. The performance of the pre-processing circuit was evaluated by bench test with HP 8595E Spectrum Analyzer and HP 8647A Signal Generator. The linearity and frequency response of the signal pre-processing device are tested respectively. The measured data show that the dynamic range for transmission could be up to 112 dB and the flat frequency response is about 10 MHz for input -21dBm to -66 dBm. Because for most MRI applications the dynamic range of MRI signal is about 72-96 dB it requires 12-16 bit ADC. In this study, 16 bit ADC is chosen to guarantee a wider dynamic range. This wireless system was designed to transmit Ultra-fast EPI imaging (20 images/s) with pixel size of 128x128, and each pixel contains 4 bytes (Siemens Trio 3T), then data rate is required about 20Mbps. However, in order to accommodate framing, overhead, checksum and efficiency of throughput (70-75%) 30 Mbps data rate should be enough for this wireless transmit design. Using frequency division modulation (FDM) pre-processing circuit each channel MRI signal can be down converted with the bandwidth of 400 KHz, then 10 MHz of flat frequency response can cover at least 25 channels of MR signals which are closely modulated at different frequency bands. Therefore, three non-overlapping channels with each of 22 MHz bandwidth in 802.11n access port can transmit 75 RF channels, theoretically.

Fig2. DSP with DDS, ADC, controlled pre-processing circuit and Ethernet

Conclusion:

Design of using digital wireless transmission based on 802.11n draft (up to 300 Mbps data rate) Broadband Router and Receiver for ultra-fast EPI imaging application has been proposed. The imaging transmission rate, bandwidth, sampling rate of AD and related pre-processing have been analyzed. The primary tests of DSP, DDS, dynamic range of input signal (120dB), linearity and frequency response show that this system has very fast transmit data rate and wide bandwidth which can be applied for EPI with 64 channel RF array and 20 images/ per second rate.

Reference:

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