Custom Instrument and Audio Effects Processor Using NI MyRio

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***Abstract*—This paper presents a custom instrument and an audio effects processor consisting of master volume, 3 band equalization, echo, and left-right balance. These applications were implemented on two separate National Instruments MyRio boards using labView.**

***Index Terms*—3 band eq, echo, MyRio, labView, audio processing.**

I. Introduction

CURRENT Wi-Fi and LTE systems transmit and recieve on the same channel using half duplex; therefore a system cannot simultaneously transmit and recieve. A full duplex system would allow a cellular base station or Wi-Fi access point to achieve this simultaneous communication, ideally doubling the throughput and enabling the service of twice as many users in the same amount of time and using the same power as a half duplex system. This project considers circuit structures to passively maintain high transmit/recieve isolation in a full duplex 2x2 MIMO setup with a symmetrical 4 port antenna. Unlike other methods of achieving full duplex, this setup relies on the symmetry of the antenna and circuit setup to provide all the isolation.

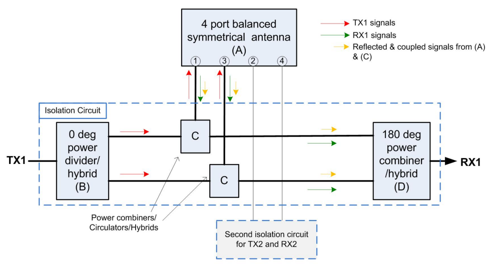

Fig. 1. Full Duplex 2x2 MIMO Antenna and Isolation Circuit Layout

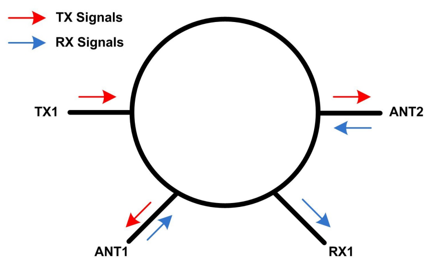

Fig. 2. 180° hybrid combiner properties for 2x2 full duplex MIMO use.

A. Full Duplex 2x2 MIMO Requirements

In order to sucessfully acheive full duplex MIMO communication, a few key requirements must be attained in order to ensure that the recieved signal is sufficiently unmodified to be reconstructed in the ADC. First, a high isolation between the transmit and recieve ports must be maintained at all times to avoid drowning out the recieved signal. Second, the isolation circuit must cancel signals coupled acoss the balanced 4 port antenna. As well, transmitted signals internally reflected by the antenna must be cancelled in the isolation circuit to avoid mixing with the recieved signal. Since each transmit signal is split to opposing ports of the 4 port antenna, the isolation circuit is also responsible for divding this signal.

II. Implementation of a Musical Instrument

A. Frquency Generation

B. Signal Generation and Processing

The instrument creates a tone quality for each note by generating the fundamental frequency signal and combining it with the four subsequent harmonics. Since the operations required for signal generation and processing require fast performance, the signal generation and processing logic is designed on the onboard FPGA of the NI MyRio. Fig.3 shows the implementation of signal generation in LabVIEW. Sine wave generator blocks are used to produce a sine wave at a calculated frequency. To produce four subsequent harmonics, the calculated frequency is multiplied by integer factors, two through five, and the resultant frequencies are used as input to separate sine wave generator blocks. An array of fixed point numbers contain the gain level of each harmonic are converted into a cluster, de-bundled, and then multiplied to the output of their respective sine waves before they are summed together. This allows for variable tone quality by changing the volume of each harmonic. Multiplication is carried out using fixed point arithmetic for increased precision.

Three instances of the signal generation code are used to generate three separate notes. Similar to the harmonic volume each note is multiplied by a fixed point number gain to control the volume of each note. Chords are enabled by a summation of the three separate notes.

Acceleration controlled volume level of the output signal is achieved through scaling the raw acceleration data from the native accelerometer to the NI MyRio, and multiplying the result with the output signal. Similar to signal generation,

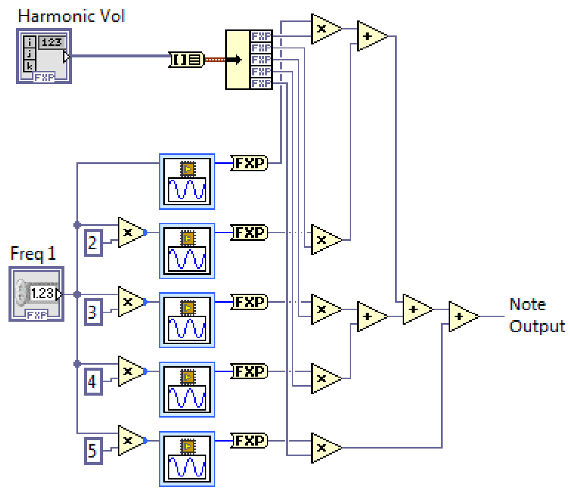

Fig. 3. LabVIEW code for generating the summation of a sine wave and four of its harmonics.

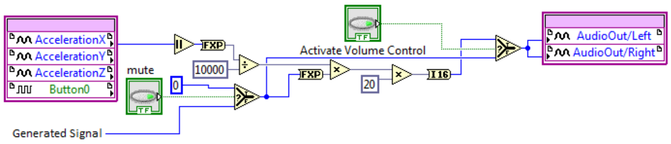

Fig. 4. LabVIEW code for changing the gain on the output signal using accelerometer data and controls.

multiplication is carried out using fixed point numbers for precision. Fig.4 shows the implementation of signal volume control in LabVIEW. A select block controlled by a control is used to switch between the signal at acceleration controlled volume and at maximum volume. Mute functionality is implemented similarly with a select block switching between the generated signal and no signal.

III. Audio Effects Processing Unit

The audio effects processing unit was required to have four functions: Left-right balance, 3-band equalization, echo, and master volume. These functions were implemented on a second myRIO board from the instrument. The overall block diagram of the system can be seen in Figure X.

A. Left-Right Balance

B. 3-Band Equalizer

The next step in the signal path was the 3-band equalizer, which can be seen in Figure Y. Each channel was fed into three parallel filters which were either low-pass or high-pass filters. The cutoff frequency of each filter was controlled from the front panel of the microcontroller, where it was fed into a Butterworth Filter Coefficient subvi, and passed into the FPGA as a fixed point number. As well, the gain for each band is taken from the front panel of the microcontroller, converted to fixed point, and fed into the FPGA. The bass-band filter was implemented as a low-pass filter, as was the upper-limit of the mid-band. The lower-limit of the mid-band and the treble were implemented as high-pass filters. After each filter, the signals are converted back to 16-bit integers. At the end of the equalizer stage. the split-signals of each channel are recombined into one and fed into the echo stage.

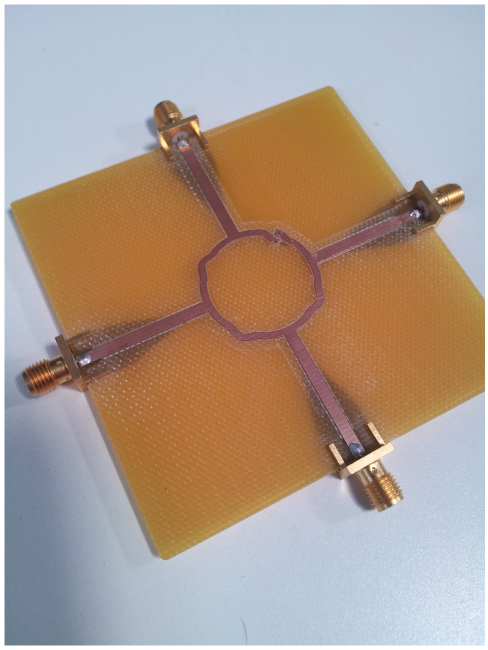

Fig. 5. Final fabricated circuit structure with included phase inverter, balun taper and path length correction.

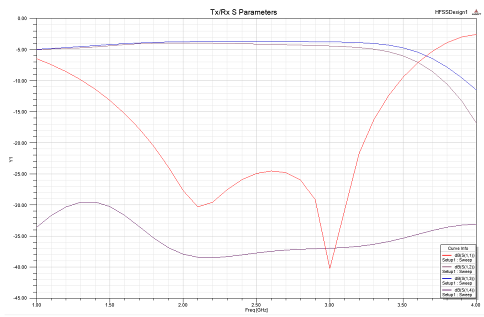

Fig. 6. Simulation results from final optimized structure

IV. Conclusion and Future Improvements

A modified 180° hybrid combiner for use in broadband 2x2 MIMO applications was presented and developed as an isolation circuit to be used with a symmetrical 4 port antenna. The structure proposed in (reference) was improved upon and applied to full duplex applications. While this circuit structure is effective and extremely inexpensive to manufacture, with a TX/RX isolation of only -38dB it still needs improvement before it can be sucessfully applied to long range communications. With more time to develop and simulate this circuit structure, this isolation level could be improved and tested with the 4 port antenna.

Acknowledgment

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