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ULTRASONICS RESEARCH GROUP
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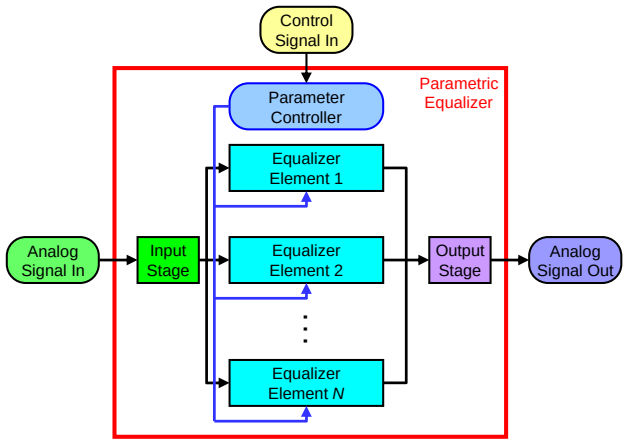
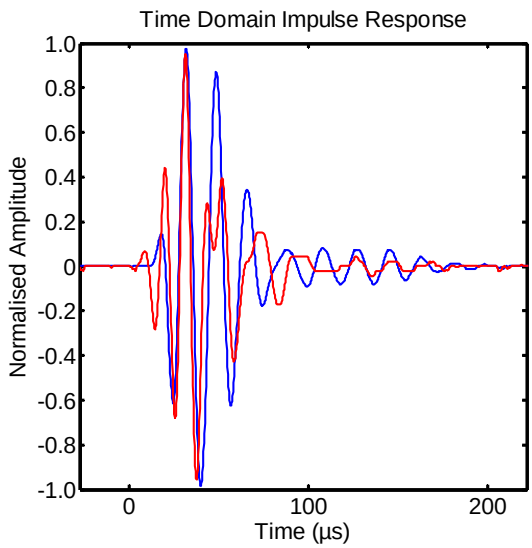
REAL-TIME PARAMETRIC EQUALIZER FOR ULTRASONIC APPLICATIONS

UCC has developed a parametric equalizer that can improve the output of an ultrasonic transducer using multiple equalizer elements connected in parallel. Each element contains an oscillator-controlled switched-capacitor bi-quadratic filter circuit, the parameters of which can be controlled in real time. An additional output stage containing sliding rail Antoniou equivalent inductor circuitry also allows the application of a large bias voltage to a capacitive ultrasonic transducer. Hence, the entire technology may be implemented in CMOS or BiCMOS and combined with a cMUT or other transducer in a single package.

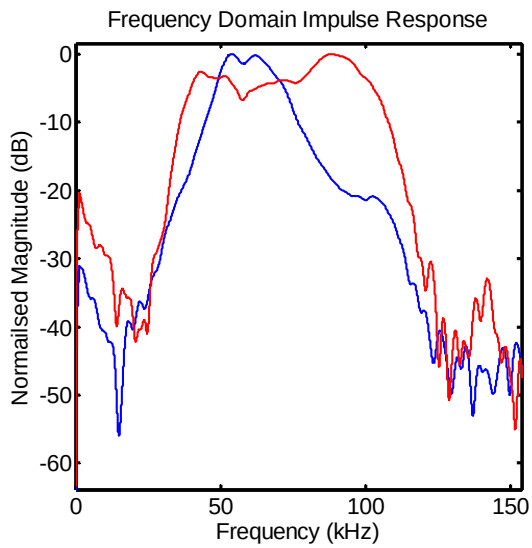


The parametric equalizer architecture

Frequency control: The parallel architecture greatly increases the flexibility of the equalizer and hence allows fine control of the frequency content of the transducer output. Undesired transducer resonances can be suppressed, bandwidth can be extended, and ripple in the pass band can be removed. In the example below, the impulse response of a transmitter has been modified using a 2-element parametric equalizer to increase the available bandwidth. Increasing up to *N*-elements gives even greater control and flexibility.



Pulse modification



Bandwidth extension

Real-time operation: In addition to using a fixed set of parameters to produce a constant equalizer response, the parallel architecture allows modification of individual equalizer elements to fine tune the output, and elements may also be switched on or off as required, resulting in a significant power saving. Using a suitable controller algorithm, a parametric equalizer that adapts to changing transmission conditions has been developed. A desired output response can be specified, which the equalizer then tracks in real time.

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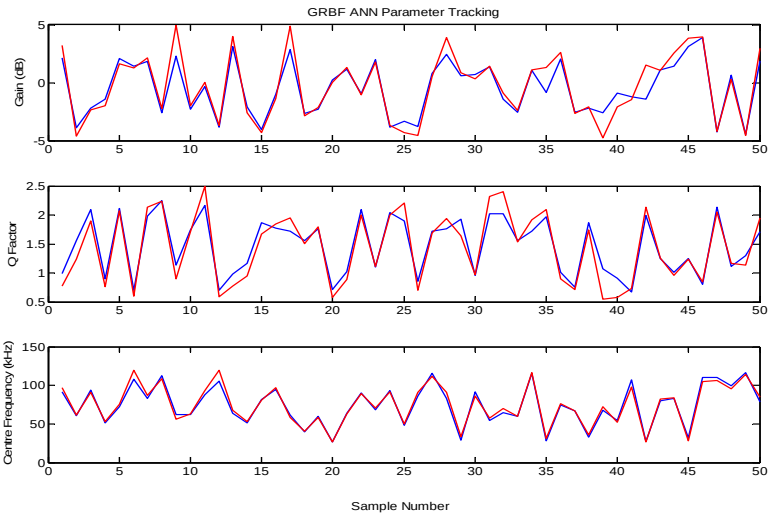

Real-time tracking of desired parameters

The Controller: The use of multiple parallel equalizer elements is extremely difficult, due to the large number of often conflicting parameters that must be selected. Choosing parameters to improve the frequency response may then, for example, simultaneously degrade the time domain response. Many parameters are indirectly coupled to each other, so the controller developed in UCC uses an adaptive neural network to select an optimized set of parameters to track the desired output in real time.

Applications: There are many potential NDT/NDE, medical, automotive and telecommunication applications, including:

Compensation for ***minor variations in transducer manufacture***, e.g. element thickness between batches, to produce an identical response from nominally similar transducers, allowing the use of cheaper devices or less stringent manufacturing processes.

Compensation for variations in output caused by ***transducer degradation*** over time, including output correction of individual transducer elements in an array.

Adaptive focusing of phased arrays, and real-time ***noise cancellation*** or suppression.

Compensation for ***variations in propagation path properties***, e.g. increasing attenuation due to a changing path length, localised variations in sound speed or temperature, or an increase in contaminants or scatterers in the medium, ***in real-time***.

Development Status: A working prototype consisting of two parallel equalizer elements has been implemented on a pSOC platform, using an independent neural network to update the switched capacitor equalizer parameters to track a desired output in real time. Experimental verification of the technology was achieved using commercially available 50kHz capacitive ultrasonic transducers. The frequency capabilities of the equalizer were determined by the capabilities of the switched-capacitor elements available on the enabling platform.

Commercial Status: UCC are currently seeking licensees for the technology.

Intellectual Property: European Patent application number EP08105496.7, and provisional US Patent Application number 61/102,946 initial filing date 30th October 2008, at PCT stage.

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