Frequency Division Duplexing by Agile Waveform Cancellation

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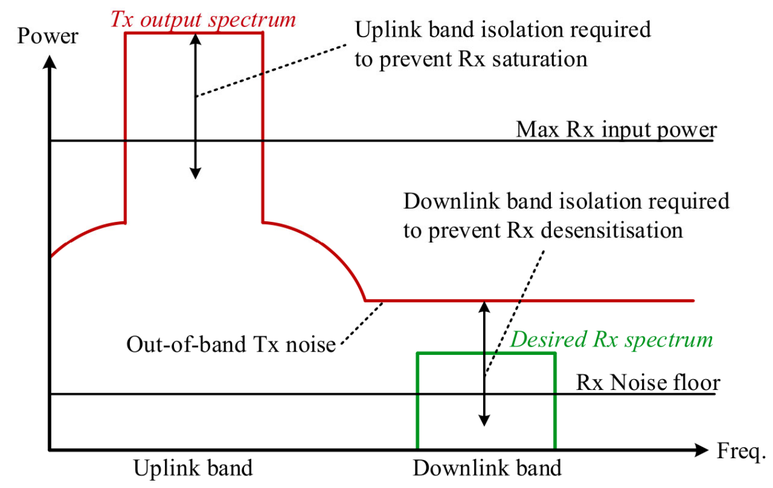
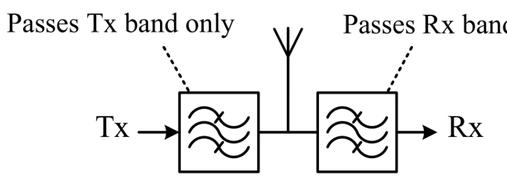
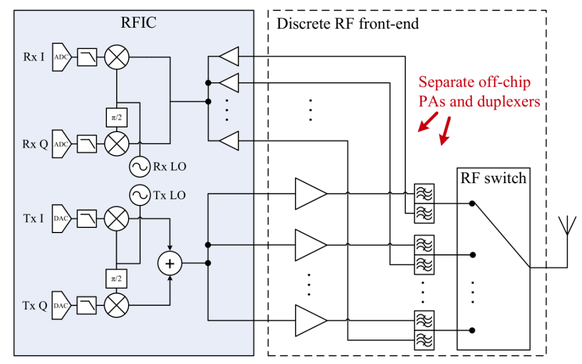
Aim: To replace the fixed-frequency acoustic duplexing filters for frequency division duplexing in mobile devices, with a tunable duplexer based on self-interference cancellation



Frequency Division Duplexing

In FDD, duplexing filters are used to connect the Tx and Rx to the same antenna but prevent the transmit signal from leaking into the receiver.





Acoustic filters (e.g. surface acoustic wave devices) are the only filters which can give the required performance, but these are difficult to tune, requiring multiple off-chip duplexers to support multiple bands. This increases cost, size and losses, and limits the number of bands which can be covered, restricting roaming.

Self-interference Cancellation Based Duplexer

Instead of filtering, this architecture cancels Tx signals leaking into the receiver.

Two cancellation methods are combined to simultaneously cancel signals in the Tx *and* Rx bands.

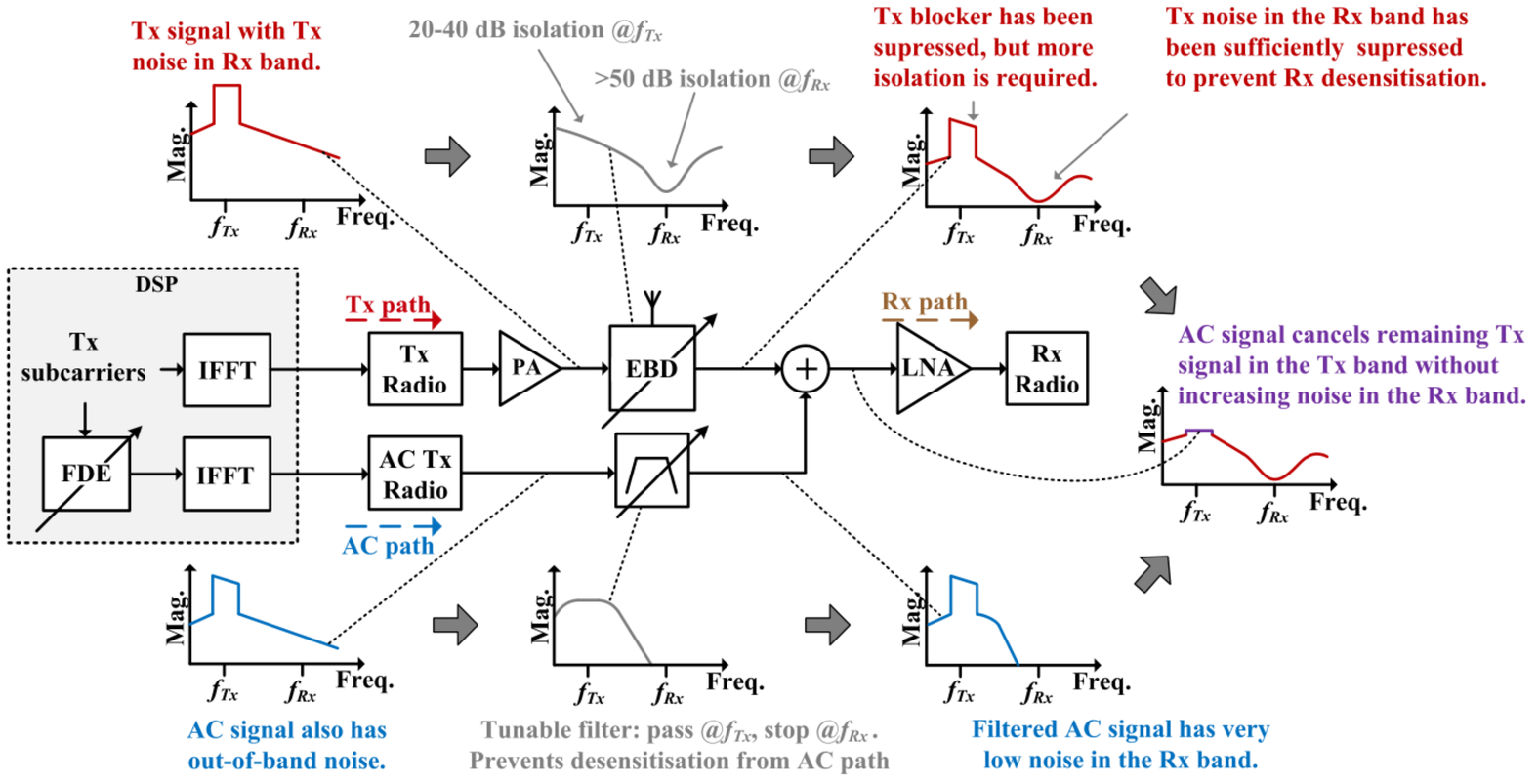
An electrical balance duplexer (EBD) implements passive feed-forward RF cancellation. This is used to cancel the Tx noise in the Rx band.

However, the isolation bandwidth of the EBD is not wide enough to provide isolation in both bands.

A second stage of active cancellation (AC) is therefore used to provide extra cancellation in the Tx band.

Both cancellation loops are adaptively tuned.

All of these technologies are suitable for implementation within a radio frequency integrated circuit.

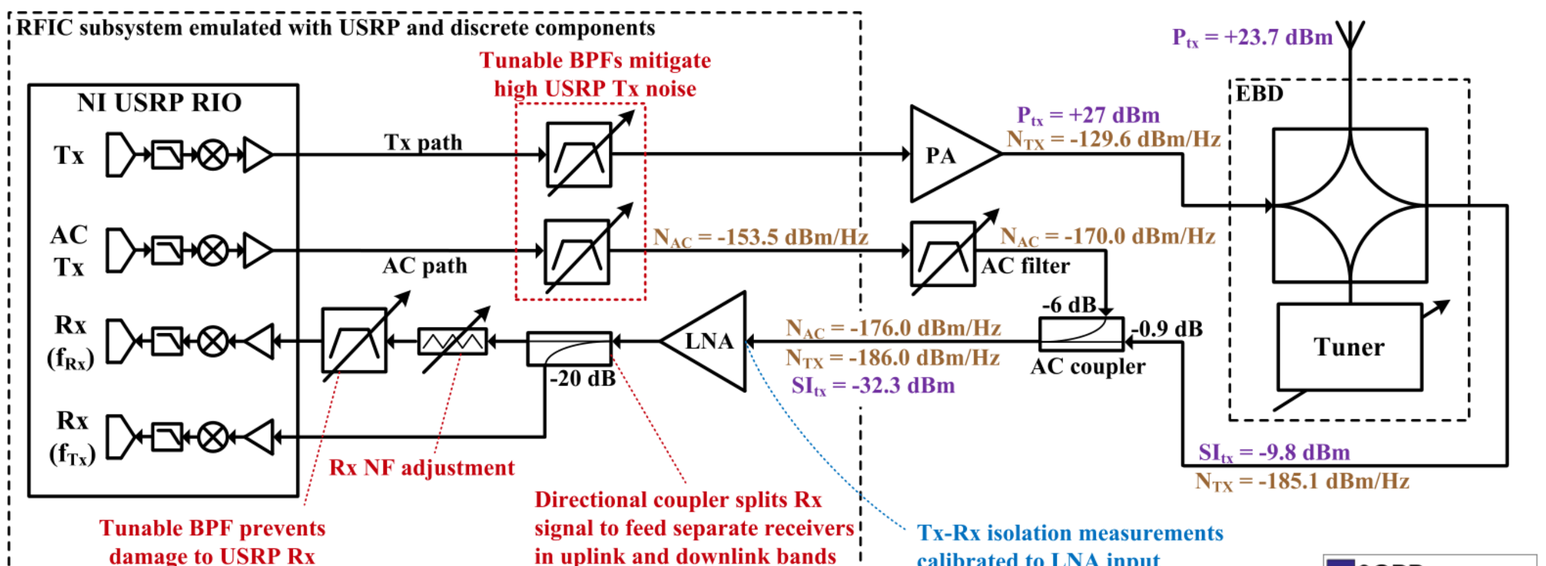


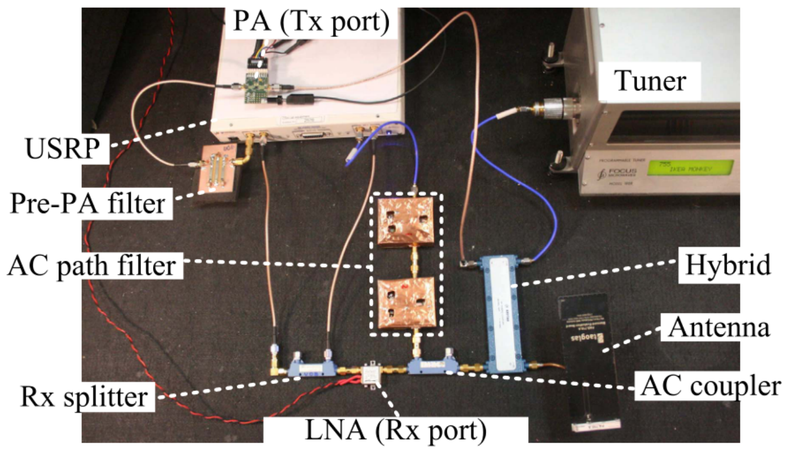
Hardware Prototype

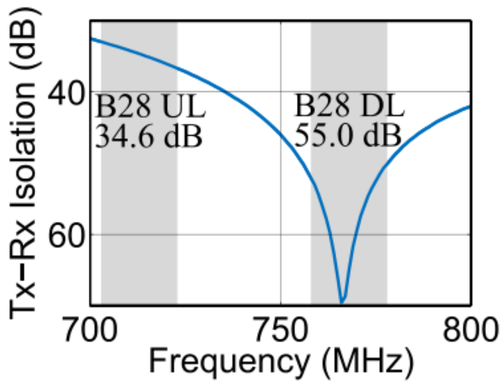
A discrete prototype has been implemented using off-the-shelf components representative of a cellular handset.

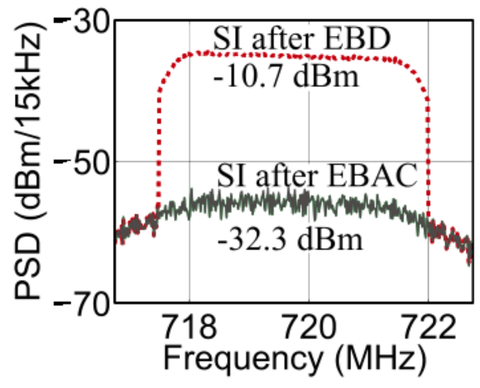
The prototype has achieved >50dB isolation in Tx and Rx bands and an acceptable noise figure across a range of frequencies.

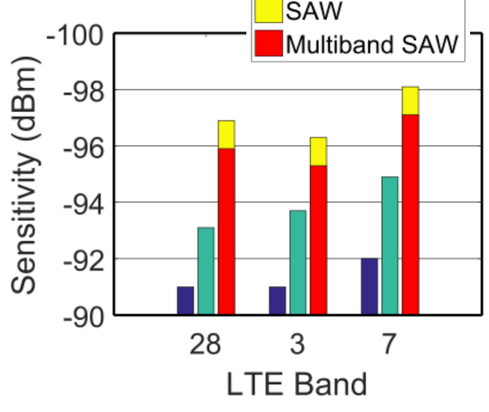
It has been tested according to the 3GPP LTE specification and achieves specification compliant sensitivity at full Tx power.











L. Laughlin et al., *Tunable Frequency-Division Duplex RF Front End Using Electrical Balance and Active Cancellation*, IEEE Trans MTT, 2018, 10.1109/TMTT.2018.2851990

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