Application Note
In-band Combiner

Due to the increasing restriction on Tower infrastructure deployments by local municipal policies and the physical limitations of towers, operators are facing difficulties in adding new antenna systems to their existing sites. Network equipment sharing between multiple operators or multiple technologies can be seen as a cost-effective solution to the deployment of current and next generation base stations. By network sharing, the operators can benefit from massive Capex and Opex savings and faster time to market for overlaying the new technologies.
Multiple frequency bands or multiple channels within the same band can be combined and fed to one antenna element. This allows multiple operators to share the infrastructure equipment or allows one operator to share its existing equipment amongst legacy, current and future technologies.
Filtronic's combiner product range enables the transmission of two or more RF signals through a single antenna. By providing a very narrow guard band, low loss and low PIM, the In-band combiner enables the combination of multiple continuous or in-continuous channels within the same frequency band.
This application note discusses the performance details of the In-band combiner and its application.

In-band Combiners

The in-band combiner consists of a combination of filters which are used to allow two or more base stations / node B's to be connected to a single antenna with minimal spectral loss and insertion loss.
The most important parameters that need to be considered when choosing the In-band combiner are the guard band, insertion loss and the isolation between the input ports.

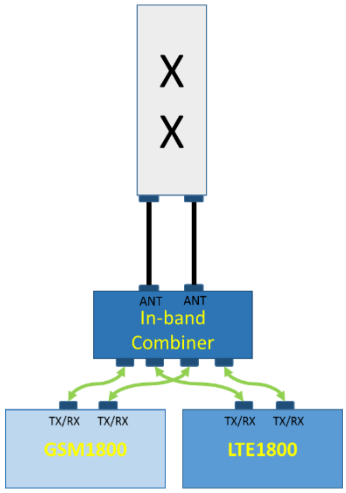

Figure 1. The in-band combiner used to combine two signals within the same frequency band

Cavity resonator filters are used to achieve a very narrow guard band. In designing the filters there is always a trade-off between the selectivity, insertion loss, group delay, size and cost of the filter. Depending on the required performance, the combiner filters can be designed using air or ceramic cavity resonators. In comparison with air cavity filters, ceramic filters are smaller in size and can provide a narrower guard band at the expense of higher cost and higher weight.

Group delay is another factor which needs to be considered in the selection of combiners. Depending on the carrier technology, group delay can play an important role in the filter performance. For example if the combiner is used for a WCDMA carrier, group delay is an important factor to be considered. While it is less important for narrow band GSM signals or LTE carriers. During the design process of the combiner filters for CDMA or WCDMA carriers, additional equalization techniques might be used in order to provide the best EVM and ρ (Rho) factor. While used for combining the GSM signals, the combiners should provide very low loss in order to avoid the loss of signal at the band edge.

Figure.2 shows an insertion loss plot of the filter designed to combine the GSM with WCDAM signals. In this example the filter is designed to aim for the minimum insertion loss for the GSM signal (0.25dB typical) and low EVM for WCDAM signal. The filter has symmetrical ultra-narrow guard band for no loss of spectrum. The channel spacing (centre-to-centre) in this particular example is 2.4MHz from WCDMA to GSM. Channel spacing can be reduced to 2.2MHz at the expense of a slight increase in EVM over the WCDMA channel.

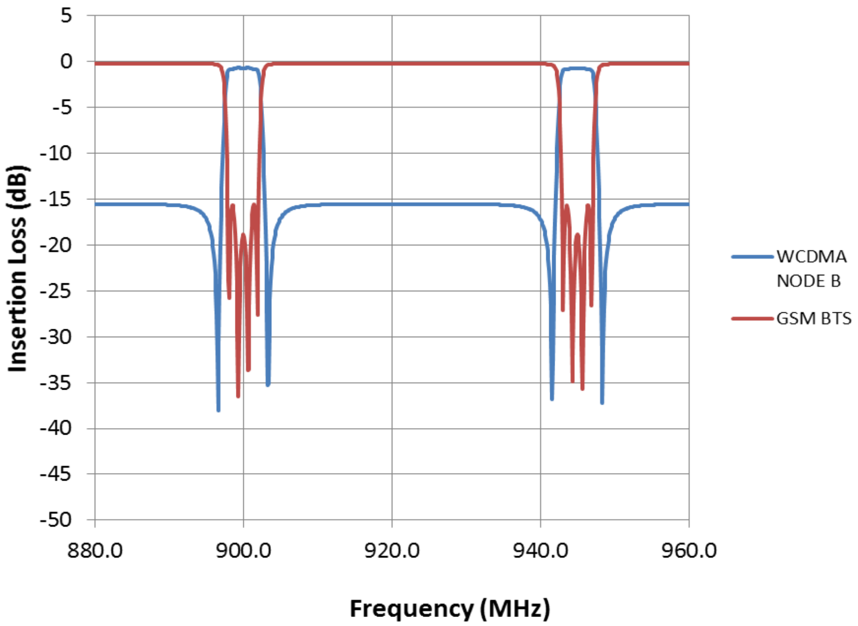

Figure 2. The WCDMA and GSM signals combined with very narrow symmetrical guard bands

Figure.3 shows another example of the In-band combiner designed for combining the LTE and CDMA signals. Bandwidth for the CDMA signal can be up to 20MHz i.e A+D or F+C block and it is electrically tuneable within the PCS band. The filter is designed for an ultra-narrow guard band of less than 625KHz at one side. The insertion loss for the CDMA signal is less than 0.5dB with ρ (Rho) factor of above 0.997.

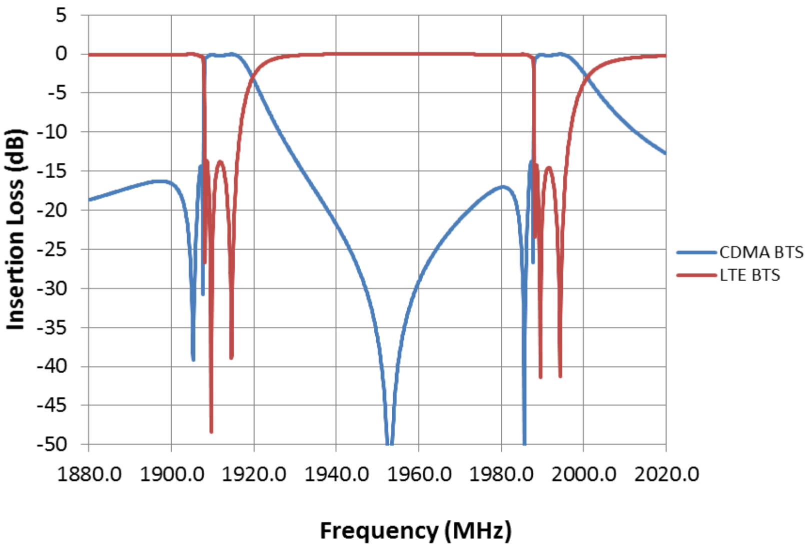

Figure 3. The CDMA and LTE signals combined with very narrow guard band

In Figure.4, there is another example of an in-band combiner designed for combining the LTE and GSM signals. In this case, a symmetrical ultra-narrow guard band filter is used to site a 10MHz LTE block in the middle of 20MHz wide GSM band.

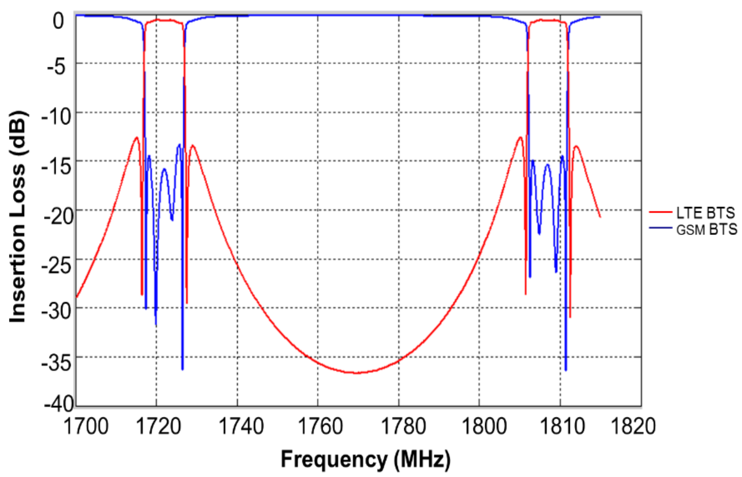

Figure 4. The LTE and GSM signals combined with ultra-narrow symmetrical guard bands

The filter has 5.5MHz channel spacing from GSM carrier centre to LTE carrier centre with very low insertion loss for both GSM and LTE signals. In this particular example the channel spacing can be reduced to 5.3MHz to further minimize the loss of GSM channels at the expense of extra loss at the LTE bandedge. This would not affect the LTE EVM and would add 0.07dB to the LTE average loss.

In-band Combiner Architecture

The in-band combiner can be designed to have both TX and RX filters as shown in Figure 5.a. This architecture is used when no TMA (tower Mounted Amplifier) is used before the filter. The RX filter is to provide very low loss and therefore low noise figure at the RX path.
In some scenarios where a TMA is used before the In-band combiner, the architecture similar to Figure 5.b is used. In this case, the carriers are filtered in the TX path and are split in the RX path. This results in a wideband passive RX on all ports. The structure offers a lower size and lower cost variant of the product. Using this architecture, the overall size of the combiner can be reduced by half compared with the combiners with RX filtering.

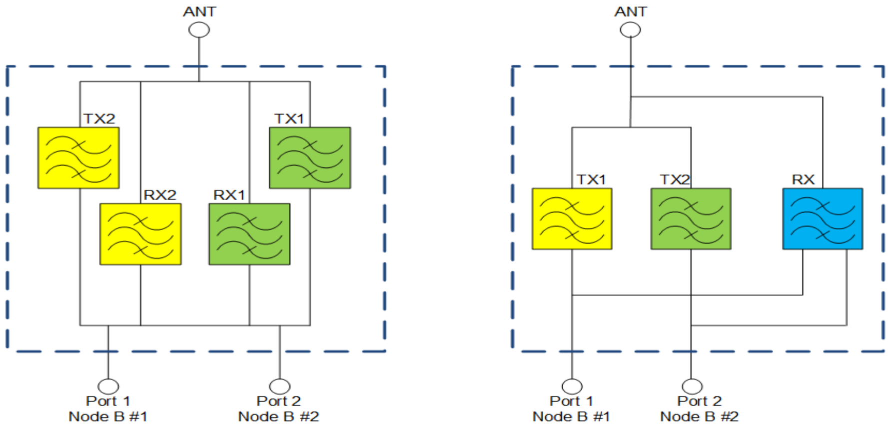

Figure 5. (a) The in-band combiner with TX and RX filters (b) The in-band combiner with TX filters and passive split RX

In-band Combiners with diversity feature

In the applications where the RF or baseband diversity is required, the combiner can be designed to provide the appropriate diversity signals. Figure.6 shows the dual in-band combiner which allows two basestations to share the same antenna and preserve the recieve and transmit diversity with minimum loss. ANTA and ANTB are the main and diversity ports of the antenna and in both uplink and downlink directions the main and diversity signals of both basestations are combined and connected to the relevant antenna port.

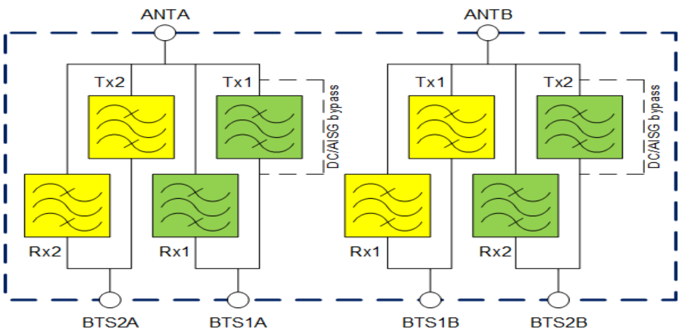

Figure 6. Dual MIMO In-band combiner

In-band Combiner Examples

Filtronic offers a wide range of In-band combiners for different scenarios in the infrastructure sharing market. The filters are designed for 800, 900, 1200, 1800, 2100 and 2600MHz frequency bands. The pass-band of the combiners are factory tuneable within the band and the guard band can be designed to be as low as 600KHz.

As an example of Filtronic In-band combiners, PCC055 is a Dual MIMO combiner which combines two continuous blocks within 800MHz band with no loss of spectrum. The filter's guard band is 1MHz. Therefore when used for LTE carriers, the centre-to-centre distance for two adjacent 5MHz LTE blocks is 5.5MHz and for 10MHz LTE blocks is 10MHz. As shown in Figure.7, this is due to the fact that the occupied bandwidth for 5MHz and 10MHz LTE carriers are 4.5MHz and 9MHz respectively.

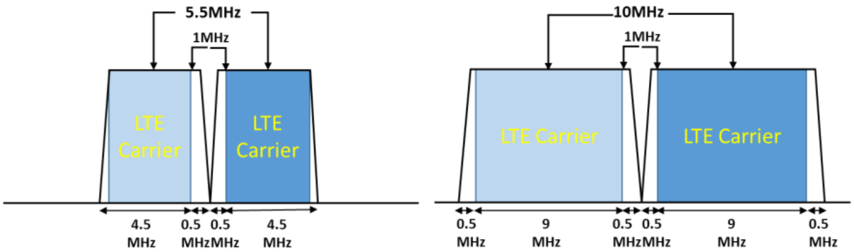

Figure 7. Two continuous 5MHz and 10MHz LTE blocks combined with an In-band combiner with 1MHz guard band with no loss of spectrum

The filter is designed with Filtronic proprietary architecture to achieve significantly reduced overall size, weight and cost.

Another example is PCD019 which is a Dual MIMO combiner with symmetrical ultra-narrow guard bands (700KHz). The combiner can be used to insert a 10MHz LTE block within two GSM blocks in 1800MHz band with minimum loss of GSM signals.
PCC049 is another product in the In-band combiner range which combines two blocks within the 1800MHz band with wider guard band (min 40MHz). The filter is smaller, lighter and lower in cost than PCD015 due to the relaxed guard band requirement.
Similarly there are wide range of In-band combiners for different frequency bands to fulfil the requirements for different scenarios. For more information please review our product portfolio.

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General Features of In-band Combiners

- Covers wide range of wireless frequency bands; 800, 900, 1200, 1800, 2100 and 2600MHz
- Supports different technologies; GSM, UMTS, CDMA, WCDMA and LTE
- Minimal RF insertion loss over all frequency bands
- Very high isolation and return loss
- Lowest PIM (<-160dBc, 2 x +43dBm tones)
- Excellent power handling at all input ports
- AISG and DC pass-through
- N x 7/16 DIN female connectors

Conclusion

Filtronic offers a wide range of In-band combiners which covers different scenarios of equipment and technology sharing. The combiner can be designed with a very narrow guard band with no loss of spectrum, very low insertion loss and high isolation between input ports.

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