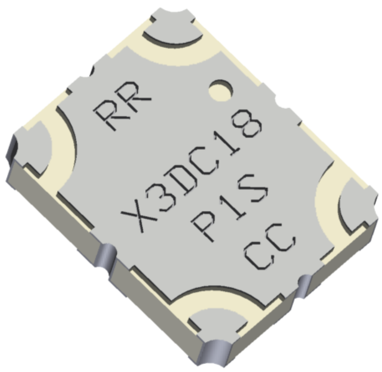
Tuning procedures for out of band operation of RF&S SMT Doherty Combiners



Introduction

TTM Doherty combiners are designed for symmetrical two-way Doherty power amplifier architectures that have even power slitting ratio between main and peaking power amplifiers. A typical Doherty combining circuit consisting of two quarter-wave-length transmission lines of 50 Ohm and 35 Ohm are packaged in the combiner as shown in Figure 1.

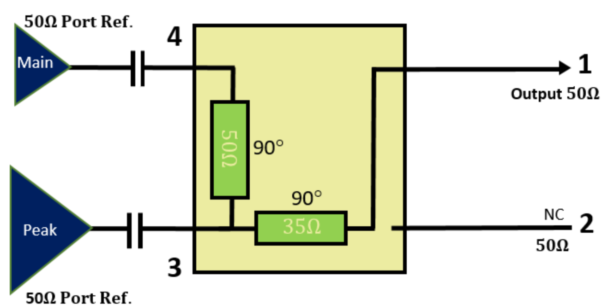


Figure 1: Doherty combiner transmission line impedances

As a transmission line of fixed physical length is of quarter-wave length only at a single frequency, this type of Doherty combiners are considered narrow band. Typically ± 5% of bandwidth are achieved in this type of Doherty amplifiers. With several models, the TTM Doherty combiner product line covers major communication bands ranging from 700 MHz to 2700 MHz. Each model is optimized for the center frequency of targeted frequency band. However, as new spectrum is being released worldwide to meet urgent capacity demands, the pre-designed standard models may find themselves slightly off band for these applications.

This document is to provide a guideline to use these standard models for off-band applications.

Analysis

The schematic above in Figure 1 serves two functions for required Doherty operation.

At the maximum mode when the main and peaking amplifiers deliver equal amount of output power, the combining circuit functions as a 1:1 combiner. The 50 Ohm quarter-wave-length transmission line provides required phase delay and amplitude division. The 35 Ohm quarter-wave-length transmission line serves as an impedance transformer transforming 25 Ohm to 50 Ohm.

At the backoff mode or low power condition where the peaking amplifier is turned off and presents high output impedance, the combining circuit functions as a 1:2 impedance transformer, providing the required load pulling-up for the main amplifier. The 35 Ohm quarter-wave-length transmission line still serves as a 1:2 impedance transformer transforming 25 Ohm to 50 Ohm. The 50 Ohm quarter-wave-length transmission line severs as a 1:4 impedance transformer transforming 25 Ohm to 100 Ohm.

The bandwidth of the Doherty combiner is actually limited to ± 5% by this 1:4 impedance transforming function of the 50 Ohm line, while as a 1:2 impedance transformer, the 35 Ohm line provides much wider bandwidth and it typically can cover more than ± 15% bandwidth.

Ideally if a pre-designed standard model is to be tuned outside its designated frequency band, both the 50 Ohm line and 35 Ohm line need to be adjusted to the center of the new band. However, if the application band is not too far away from the original targeted band center, it is possible that the 35 Ohm line without length adjustment can still cover the new band and provide good enough impedance transforming. In this case, both the 50 Ohm and 25 Ohm lines need their lengths adjusted. And even more conveniently, the increase or reduction of the 50 Ohm line can be easily absorbed in the offset phasing line of Doherty amplifier design. Once it is tuned to new center frequency, the impedance transforming function as well as the phase delay requirement can be re-satisfied in the new band. Amplifier designers are encouraged to take the s-parameter of TTM Doherty combiner into the amplifier simulation to verify the performance.

Tuning X3DC18P1S

This example demonstrates how X3DC18P1S can be used outside its designated frequency.

X3DC18P1S is originally optimized at 1862.5 MHz with a band of 1805-1920MHz. There are inevitably short lines associated with input ports in some high frequency band parts, known as Port Extension. For X3DC18P1S, this length is 10° at 1862.5 MHz. The designer should take this length into consideration to optimize the offset line length for the band of 1805-1920MHz.

To support the band at 1600-1700 MHz for X3DC18P1S, the offset lines on the main amplifier path and output path have to be tuned, as shown in figure 2. In addition, the designer no longer has to take the Port Extension length into account for this frequency band, since the extra lines associated with input ports help push the frequency band lower, reflected by 0° Port Extension in Table 1. The required offset line length adjustments and corresponding electrical specifications are also shown in Table 1. Typical RF performances with tunings are shown in Table 2.

Similarly, using the same principle, the X3DC18P1S can be tuned for lower frequencies by adding/subtracting the offset line on the main amplifier path.

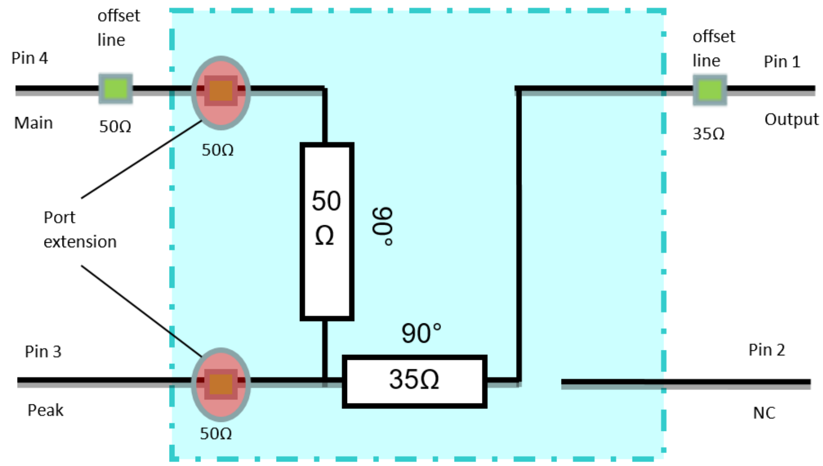


Figure 2: Tuning schematic for Doherty Combiner

Frequency	**Port Extension**	**Phase Adjustment at main amplifier path (pin 4) (50 ohm)**	**Phase Adjustment at output path (pin 1) (35 ohm)**	**Return Loss (Max Power Condition)**	**Insertion Loss (Max Power Condition)**
MHz	*Degrees @ 1862.5 MHz*	*Degrees @ 1862.5 MHz*	*Degrees @ 1862.5 MHz*	*dB Min*	*dB Max*
1805-1920	10	0	0	22	0.2
1600-1700	0	10	2	22	0.2
Frequency		**Mean Phase Imbalance (Max Power Condition)**	**Amplitude Imbalance (Max Power Condition)**	**Return Loss (Low Power Condition)**	**Insertion Loss (Low Power Condition)**
MHz		*Degrees*	*dB Max*	*dB Min*	*dB Max*
1805-1920		90±3	±0.2	20	0.3
1600-1700		90±3	±0.2	20	0.3

Table 1: Electrical specifications of X3DC18P1S with transmission line adjustments

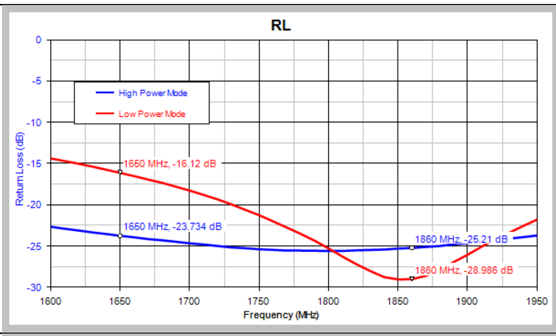
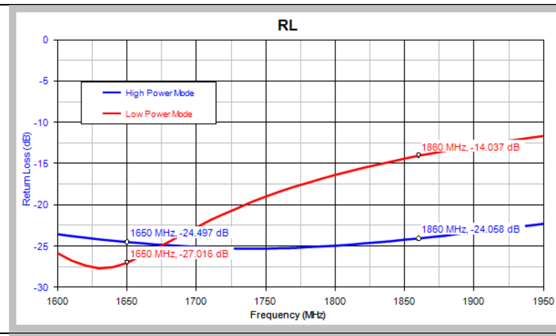
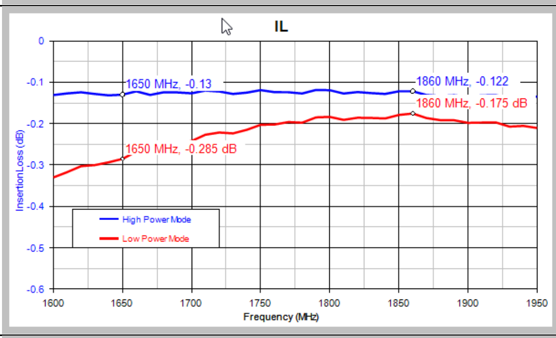
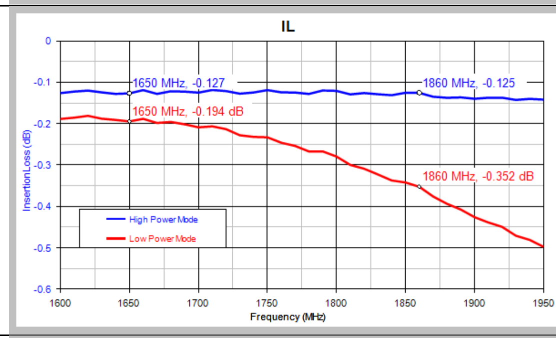
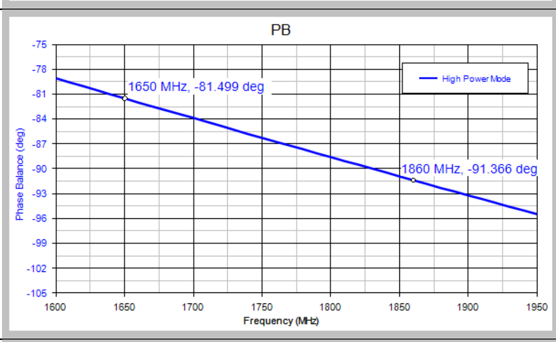
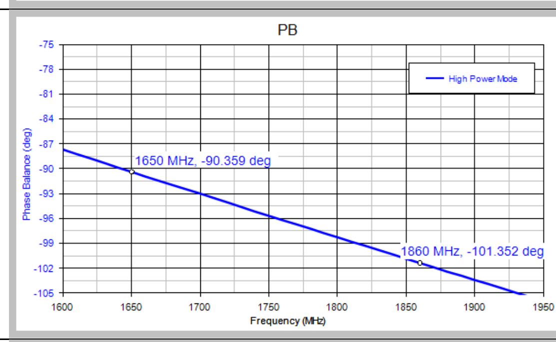
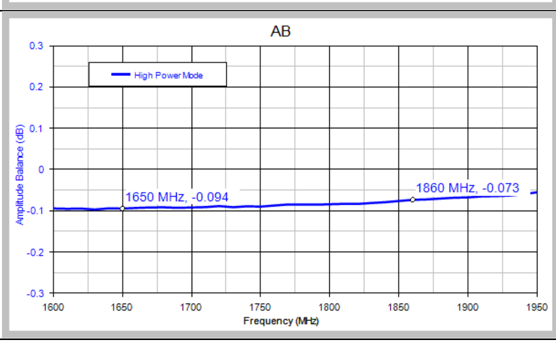
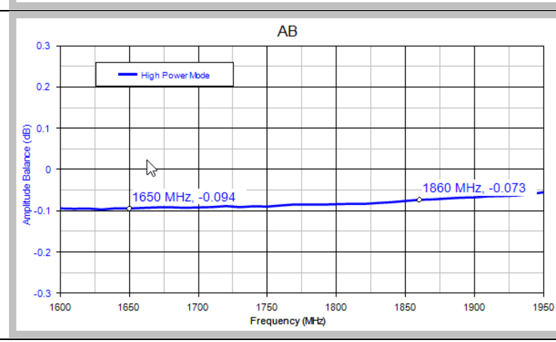
Typical Performance: 1600-1950 MHz X3DC18P1S	Adjusted electrical lengths: 1600-1950 MHz X3DC18P1S
	
	
	
	

Table 2: Comparison of nominal and tuned performance for a typical part.

Conclusion

TTM Doherty Combiners are versatile for today's amplifier architectures. For more information on tuning TTM Doherty Combiners, please contact TTM Technologies Inc. RF&S BU, Richardson, or RFMW.