CVxxx Single- and Dual-Branch IF Amplifier Matching Circuit

Introduction

WJ Communications has developed a line of single- and dual-branch converters designed for mobile infrastructure applications (CV110-1, CV110-3, CV111-1, CV111-2, CV111-3, CV210-1, CV210-2, CV210-3, CV210-3, CV211-1, CV211-2, CV211-3, collectively referred to as CVxxx). The dual-branch converters provide two separate mixer and IF amplifier elements driven by a common LO amplifier and are intended to serve as the primary and diversity receive chain downconverters in single or multi-carrier transceiver cards. The single-branch converters contain similar LO amplifiers, IF amplifiers, and mixers while including an addition RF amplifier into the multi-chip module (MCM).

The IF amplifier are of the same type on all of the downconverters and are MESFET-based MMIC's that employ conventional resistive feedback. The IF amplifier requires input matching to obtain the high-dynamic range performance over the desired IF frequency band of interest.

Since IF bandwidths are typically on the order of 5 to 10%, a simple two element matching network, in the form of either a high-pass or low-pass filter structure, is sufficient to match the MMIC IF amps over these narrow bandwidths. The current WJ application board makes use of the low-pass structure for two reasons. The first reason is that a low-pass structure helps the CVxxx's L-I isolation, and second reason is that tests performed by WJ shows better NF when using the low-pass configuration.

Further testing revealed that as higher values of capacitance are placed in shunt at the input of the IF amplifier the stability circles encroach on the outer edge of the smith chart around 3.5 GHz. This phenomena is most apparent with IF frequencies of 70 MHz which require a shunt capacitance value of 22 pF. Therefore, in order to keep Rollett's stability factor (K) greater than one, a resistor is required to 'de-Q' the shunt capacitor.

In this paper, stability of the low-pass configuration is investigated. A conventional method, involving de-Q'ing the tuning capacitor with a series resistance is analyzed, and recommendations for the resistance value are determined.

Models

Figure 1 shows the model for the high-pass form of the matching circuit is shown for completeness. Figure 2 shows the model for the low-pass structure with a 2.2 Ω used in the WJ application circuits for the CVxxx product line. The IF amplifier models were created in AWR™'s Microwave Office™ linear simulator. S-parameters for the IF amplifier FET were measured on-wafer and imported into the simulator. The required matching elements (including the self resonance of the inductor) were added along with the bias structure, blocking capacitors, and via inductances. Three circuits were created, each with a different matching R1 resistor value. The first circuit used R1=0 Ω, the second: R1=1 Ω, and the third: R1=2.2 Ω.

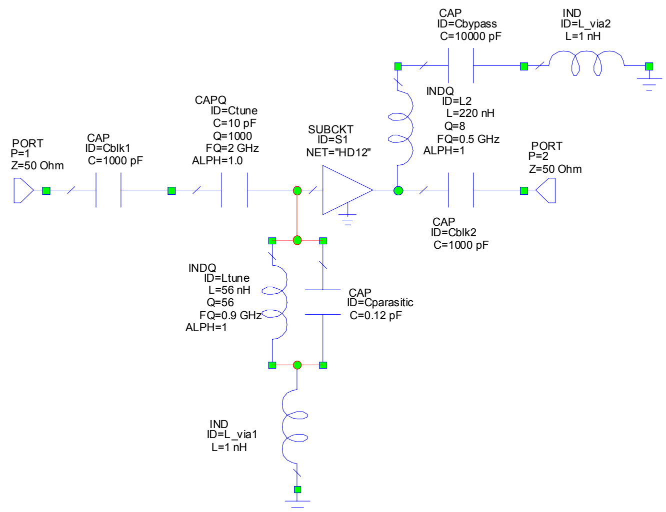

Figure 1: IF amplifier model matched for 240 MHz; using a high-pass structure.

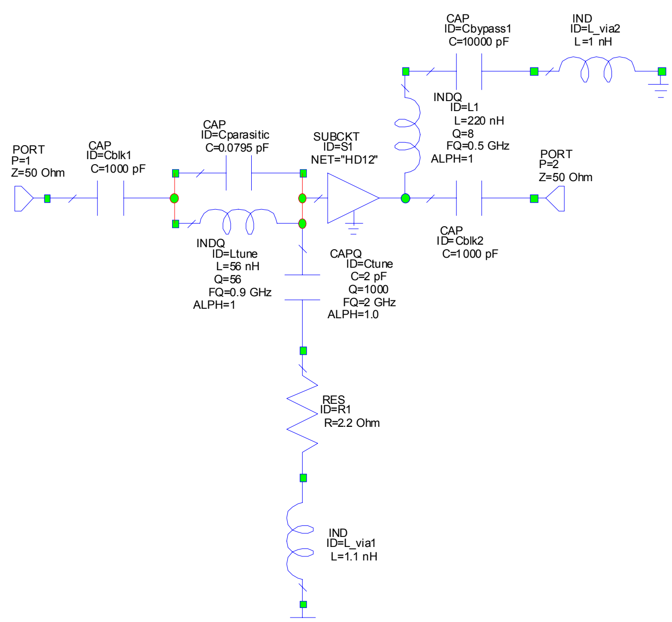

Figure 2: IF amplifier model matched for 240 MHz; using a low-pass structure and a 2.2 Ω resistor.

Measurements

Measurements of the IF amplifier were performed on the WJ application circuit card assembly shown in Figure 3. Again the measurements were performed with a 0 Ω, a 1 Ω, and a 2.2 Ω. The measurements were stored to disk and imported into the simulator.

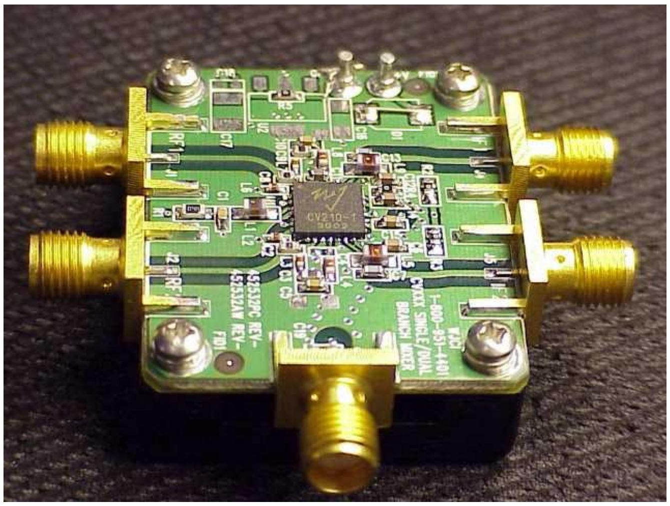

Figure 3: Current revision of the dual branch converter CCA.

Comparision of Modeled vs. Measured results

Once the models were created using the resistor values of interest, other components, and PWB parasitics, they were compared to the imported measured data. Figures 4 and Figure 5 show the results for a 0 Ω resistor. One can see that for both the modeled and measured data that at around 3.5 GHz the stability factor, K, is less than one indicating the possibility of an instability at that frequency.

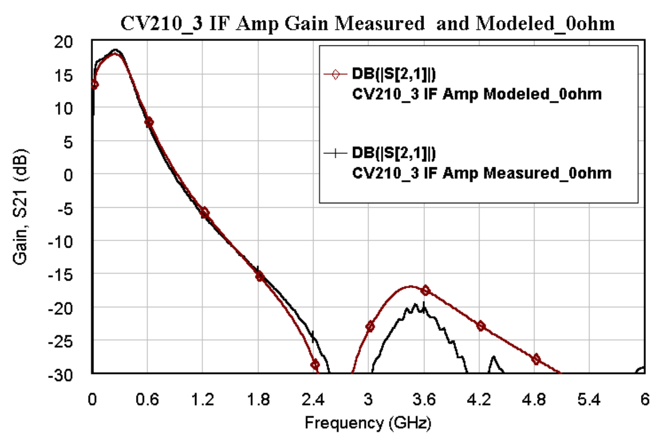

Figure 4: Measured and modeled data for S21 using R1=0Ω.

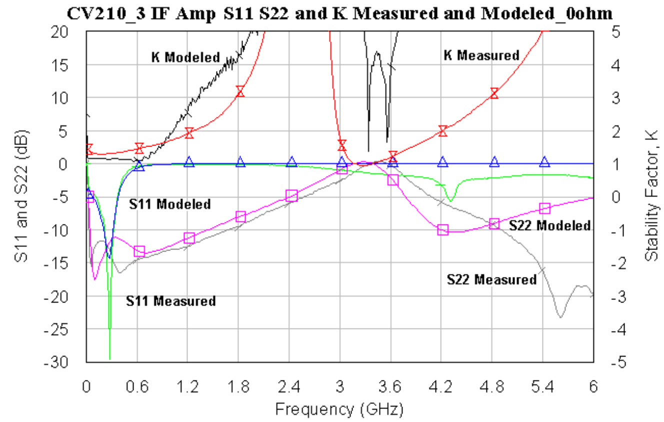

Figure 5: Measured and modeled data for S11, S22, and K using R1=0Ω.

Similarly, from Figures 6 and 7, the results for the 1 Ω matching resistor show that the stability factor is hovering close to one. To ensure plenty of margin, a resistor value of 2.2 Ω is installed in both the model, the test circuit, and then the final design.

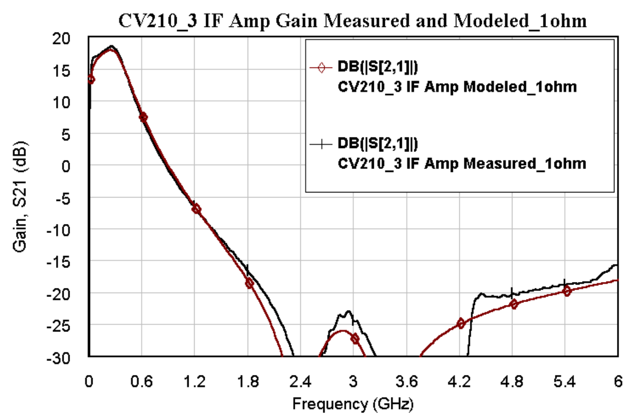

Figure 6: Measured and modeled data for S21 using R1=1Ω

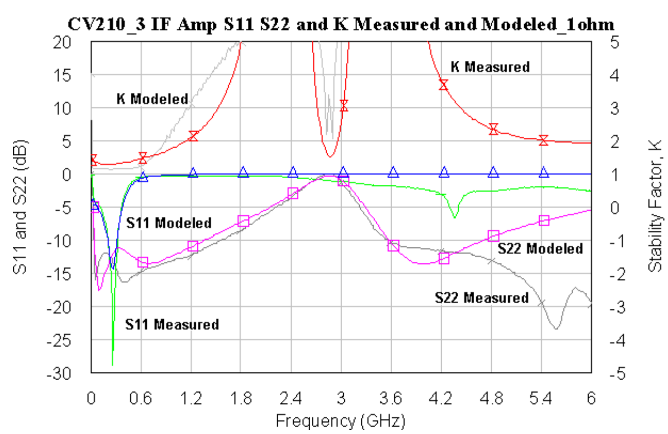

Figure 7: Measured and modeled data for S11, S22, and K using R1=0Ω

Figures 8 and 9 show the results for the 2.2 Ω matching resistor. The results indicate that the model matches the measured data quite nicely with plenty of margin in this design.

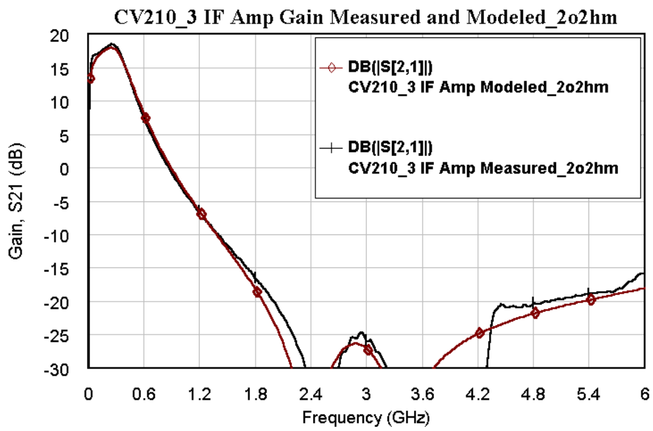

Figure 8: Measured and modeled data for Gain, S21, with 2.2Ω in the matching circuit.

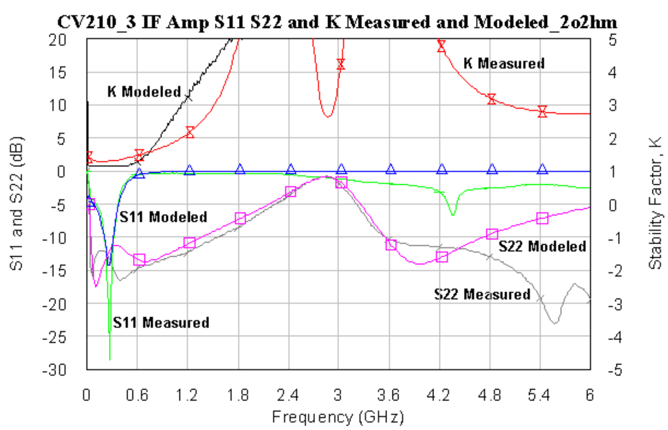

Figure 9: Measured and modeled data for S11,S22, and K with 0 Ω in the matching circuit.

Conclusion

When using the low-pass structure to match the IF amplifiers in the WJ dual branch converter product line, it is necessary to add a de-Q'ing resistor the matching circuit. The value of the resistor is dependent on the value of the shunt matching capacitor. Results indicate for IF frequencies above 100 MHz a 2.2 Ω matching resistor is more than sufficient. As the IF frequencies go below 100 MHz a 2.7 Ω resistor is recommended. One may use a 3.3 Ω for extra margin but at the expense of insertion loss and increase of NF.