UHF Frequency Converter and Power Amplifier

Degree programme: BSc in Electrical Engineering and Information Technology
Specialisation: Communication Technologies
Thesis advisor: Prof. Dr. Rolf Vogt
Expert: Hugo Ziegler (CSA Engineering AG)

Wireless telecommunications increasingly use higher frequencies to meet growing data rate and bandwidth demands. Lower-frequency systems are upgraded often by shifting to higher frequencies. To maximize data rates, complex modulations requiring high signal-to-noise ratios are used, necessitating powerful transmit-side amplifiers.

Introduction

Frequencies at 1.2 GHz are widely used, and output powers of up to 10 watts have been available at reasonable prices for a long time. However, this threshold is rarely exceeded. The objective of this thesis is to develop a frequency converter to mix signals from 430 MHz to 1.296 GHz, while substantially amplifying the output to an average power of 43 dBm (20 watts). This research aims to explore and analyse this 10 watt phenomenon in greater detail.

Methods

An upconverter system is developed, consisting of a bandpass filter on its input to prevent undesired signals from entering the system. This is followed by the mixer creating the desired output frequency using its quadratic characteristic in combination with the oscillator signal. The mixer generates signals on the frequencies $f_{RF} = |f_{LO} \pm f_{IF}|$. A bandpass filter is then deployed to remove the unwanted generated signals. This new signal on 1.296 GHz is then sent through a series of amplifiers to reach the desired output power. A modular approach is adopted for the implementation of this architecture, so that the characteristics given by the S-Parameters of the circuits can be observed and altered to ensure good interaction between them.

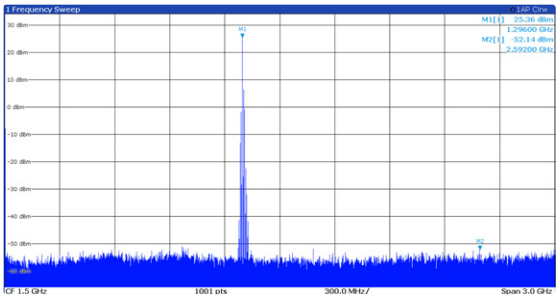
Results

Four boards were developed. The first one for the mixer also contains a bandpass filter on the input and output, followed by the first amplifier.

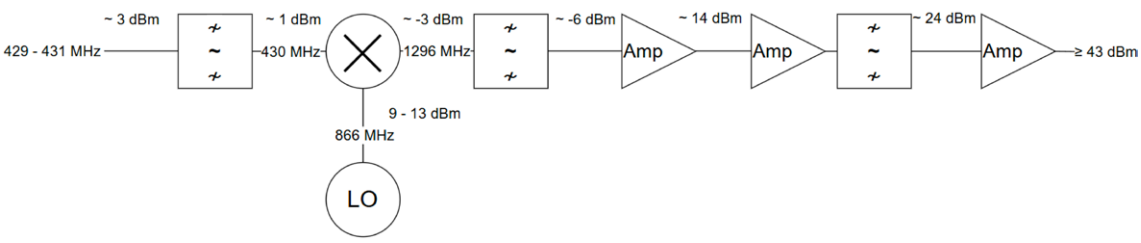
The second board contains the first power amplifier, which amplifies the 1.296 GHz signal up to 24 – 27 dBm to drive the final stage. The third board includes various filters designed to attenuate spurious signals, ensuring compliance with OFCOM regulations and therefore prepares the output for the final stage. The fourth board is the final stage power amplifier with 35.5 watts output power and a rated gain of 20 dB assumingly reaching the 43 dBm and more. On this last board, high power dissipation emerges, and therefore cooling is an essential part and requires using a sufficient heat sink.

Conclusion

All boards were designed and manufactured and are in the characterization phase. Regarding the question of the 10 watts limit, it became apparent that an increase in output power of 3 dB translates in our implementation into costs five times higher. This is based on the combined factors of component costs at this small market, power handling, and cooling needs.



Spectrum of Poweramplifier Input, from -60 dBm to +30 dBm and 2 Hz - 3 GHz



System Overview

Nico Tobias Sieber