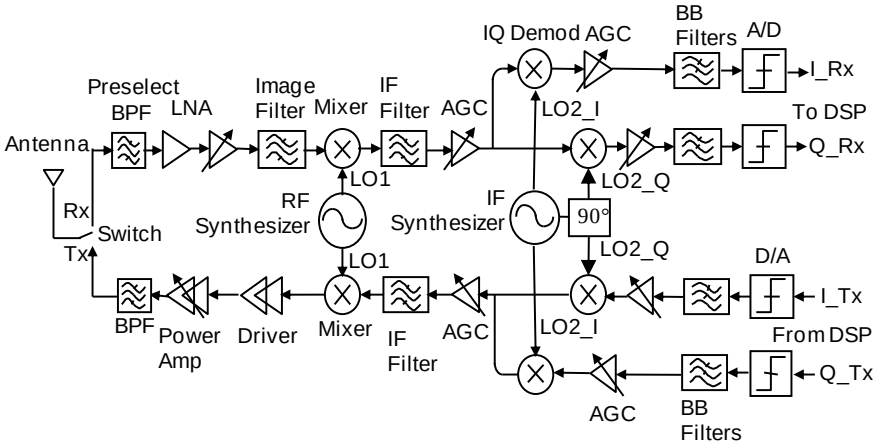
ELEC 5705 RF Systems Design: Assignment #1

Due March 7th, 2012

The goal of this course will be to come up with a complete architecture for a radio. This first assignment will be to specify the block diagram and specifications for the receiver. Reports will be in the form of a 15 page report on your radio plus problem set solutions. For this assignment you must pick a radio standard to work on. A rough guide for what a completed assignment should include is:

- Gain, linearity and noise specs for all active receive chain circuits.
- Tuning range, phase noise, spurious performance, step size, and phase matching of any LOs.
- A detailed description of any filters required.
- If a superhertodyne architecture is chosen, a frequency plan should be analyzed in detail.
- ADC specifications should be given.
- Some detail on AGC should be given.
- Specify what BER and sensitivity you are going to aim for. Do not spend a lot of time on research, but try and make it realistic if possible.



There are four radio standards to choose from:

1) A 2.4-2.5GHz radio with a transmit power of 23dBm. The channels will be 25MHz wide and the radio will need to operate as a full duplex system. Two in band interferers with a power level as high as -30dBm may be close by, and you can expect at least one out of band interferer with a power level of -15dBm at any frequency which is most troubling.

2) A 5.1-5.3GHz half duplex radio with a transmit power of 18dBm. The channels will be 25MHz wide and the radio will need to operate as a half duplex system. Two in band interferers with a power level as high as -36dBm may be close by, and you can expect at least one out of band interferer with a power level of -15dBm at any frequency which is most troubling.

3) A 60-64GHz radio with a transmit power of 10dBm. The channels will be 1GHz wide and the radio will need to operate as a half duplex system. Two in band interferers with a power level as high as -45dBm may be close by, and you can expect at least one out of band interferer with a power level of -35dBm at any frequency which is most troubling.

4) A 1000MHz to 1960MHz cable system. Receive power is to be +15dBmV into 75Ω across 5 miles of cable. The channels will be 8MHz wide. Since this is a cable no unwanted signals will be present.

In addition:

1) Determining transmit power and modulation preference:

Recently ABC ran a series set in 2050 in which a group of space explorers are loaded on a ship called the Antaries which travels to Venus. Even though the show attempted to be true to science fact there were a number of plot holes that you could drive a space ship through. The Antaries enjoyed real time broad band communications with Earth from a distance of 300,000km. This included telemetry on all ship's systems, video communications, audio communications, as well as biological monitoring of all ship personal.

a) State the glaring flaw the idiot writers have overlooked in this communication system.
b) What type of PSK modulation would you choose for this communications link and why?
c) If the link requires a data rate of 1Gb/s and the receiver requires a SNR of 5dB and the transmit frequency is 100GHz and the antennas have a gain of 25dBi what is the required transmit power? Assume the noise temperature is 100K.

2) Choosing an IF frequency:

A full duplex superheterdyne transceiver requires a SNR of 10dB. The transmit band is from 10GHz to 10.050GHz and the receive band is from 10.090GHz to 10.140GHz. The minimum detectable signal is to be -80dBm. Anywhere between 5GHz and 10GHz tones can be expected at a power level as high as -20dBm and between 10.2GHz and 15GHz tones can be as high as -40dBm. Choose an IF frequency for the RX of this radio, the LO frequency, and determine the order of the required image filter.

3) Linearity:

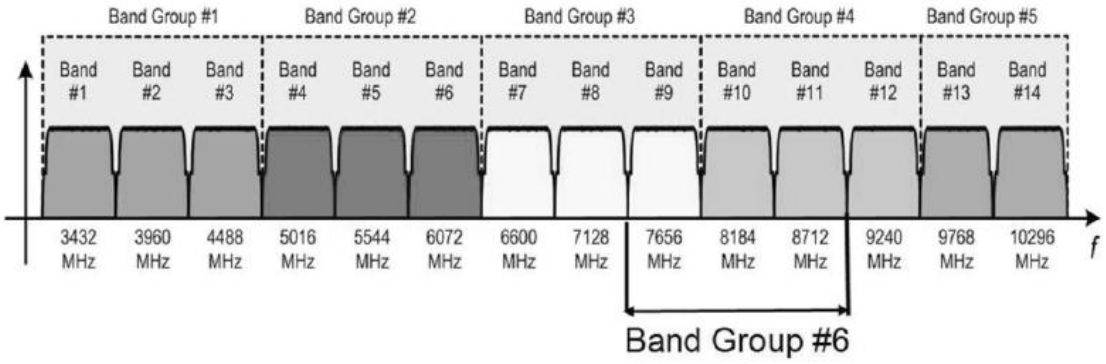
A direct down conversion radio requires a SNR of 15dB. Interfering signals can be as strong as -10dBm and the radio must detect signals at a power level of -90dBm. Estimate the IIP3 and IIP2 required in this front end.

4) A Simulation Exercise

Simulate 64 QAM in simulink. Add phase noise and thermal noise to the simulation. Compare the simulated and theoretical BER performance for a few conditions.

5) LO Generation

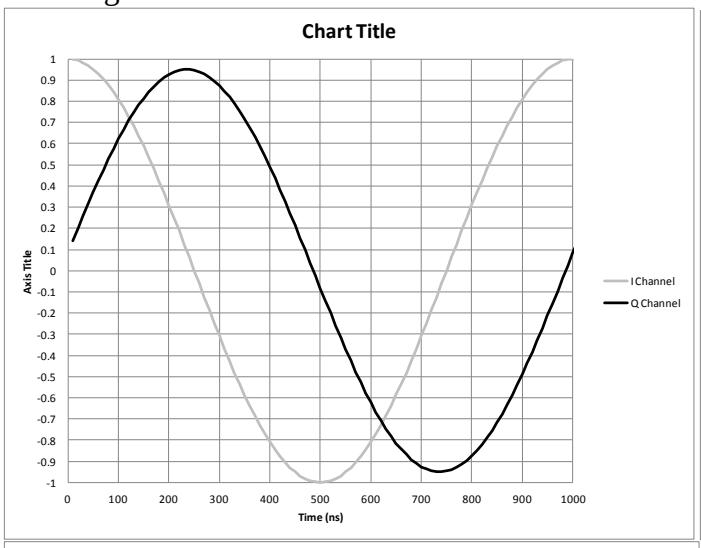
A UWB radio has channels centered on the following frequencies:

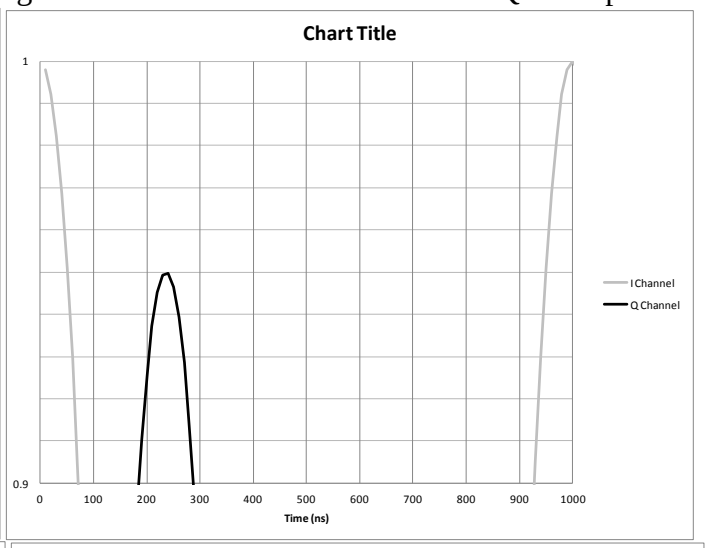


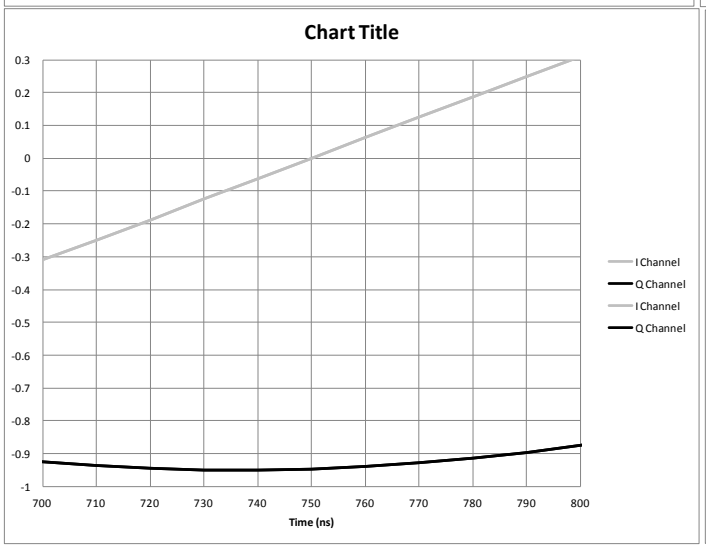
Design a LO network that takes a signal at 16896MHz and with SSB mixers, MUXs, and dividers generates all these frequencies.

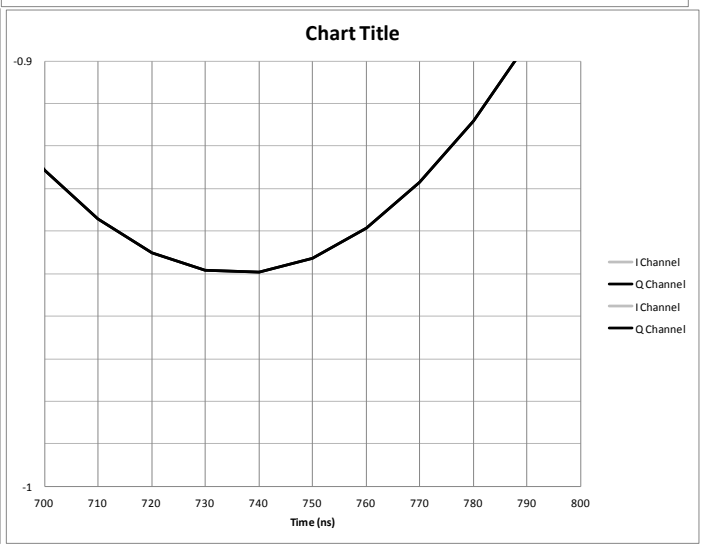
6) IQ Correction

A test signal is fed into a low IF receiver. The following waveforms can be seen at the I and Q IF outputs.









Determine values for α and β to fully correct any IQ path mismatches.