UCD School of Electrical and Electronic Engineering

EEEN40050 Laboratory Report

Receiver Design

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We declare that the work described in this report was done by the people named above, and that the description and comments in this report are our own work, except where otherwise acknowledged. We understand the definition of plagiarism. We have read and understand the consequences of plagiarism as discussed in the *School Policy on Plagiarism*, the *UCD Plagiarism Policy* and *A Briefing for Students on Academic Integrity and Plagiarism*.

Signed: . . . . **Date:** 02 / 12 / 2016

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Pulse Shaping

Power levels: @1831.5MHz : -110.03dBm @1833.5MHz : -110.03dBm

The notches are present because our graph represents the magnitude of the amplitude of our Fourier transform of a square wave (ie a sinc function) and the values below our zeroes are flipped. The values at which the amplitude flips (ie the notches) represent the value of our zeroes. They are 1MHz either side of the modulation frequency, 1832.5 MHz.

The root-raised-cosine pulse shape gives us no notches as our root-raised-cosine is a much tighter signal that spreads out much less than a rectangular pulse. This is a result of the Fourier transform of both shapes. Root-raised-cosine has less leakage into other frequency bands, resulting in better performance. The Fourier transform of a square range spreads to a larger range of frequencies.

This signal could be transmitted in a bandwidth of 2MHz.

Receiver Design

We chose to use a heterodyne receiver. We chose this design as it is relatively easy to build a high-spec filter at a fixed f_c.

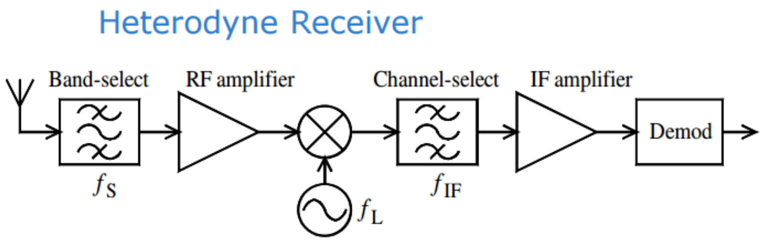
The design can also pick a relatively low frequency pass which we need, as our desired frequency will be set to 300MHz.

Often you can fix your band-select filter so that the frequency range does not change.

The demodulator is at a fixed frequency so it is easy to build. (We will use an ideal demodulator.)

As the demodulator is not at same frequency as our received frequencies there is no leakage from our inputs.

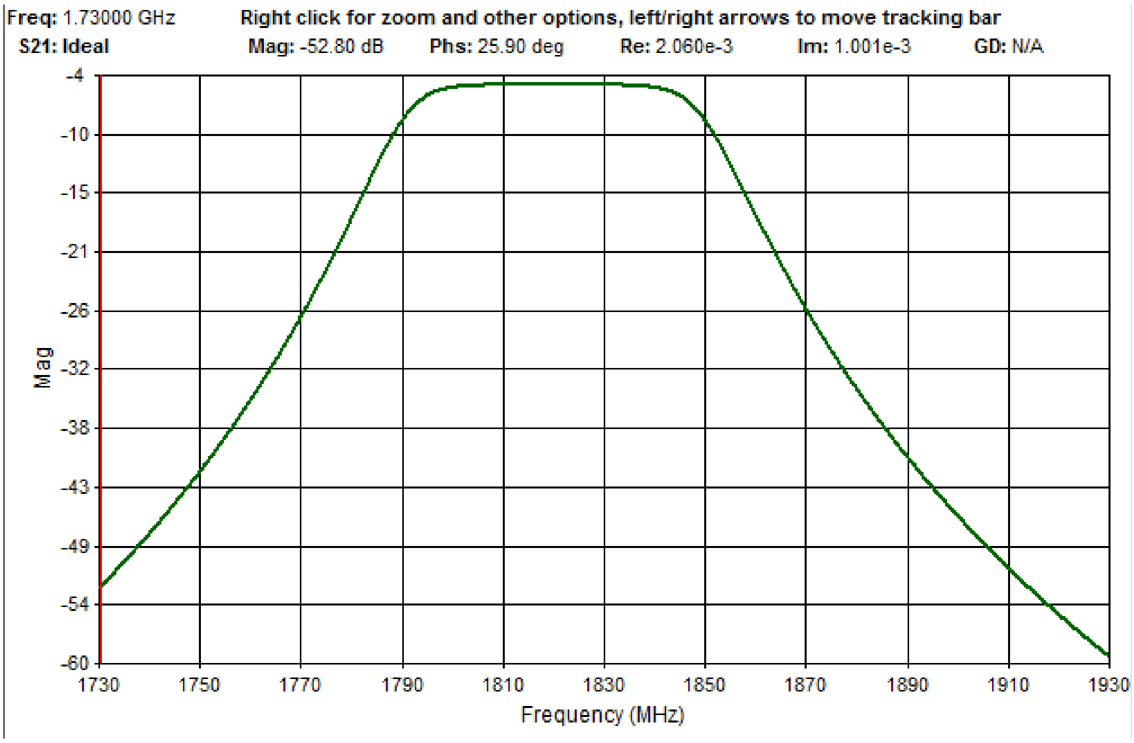
Our receiver block diagram is shown below:



Butterworth Filter (Band-Select)

The first block is a Butterworth band select filter. It is needed to get rid of any unwanted signals outside of our 1.79-1.85 GHz spectrum. As the centre frequency of our filter is 1.83GHz. We set the limits of our filter to those specified. We chose a 3rd order Butterworth filter. This is because it is a maximally flat filter and so it will meet the specifications. The order of this filter didn't have to be high as we will be filtering our signal later on in the system in our IF filter. We also don't want to spend a lot of money or power on this filter as we want to save these for our Channel-Select filter.

Channel Select Filter

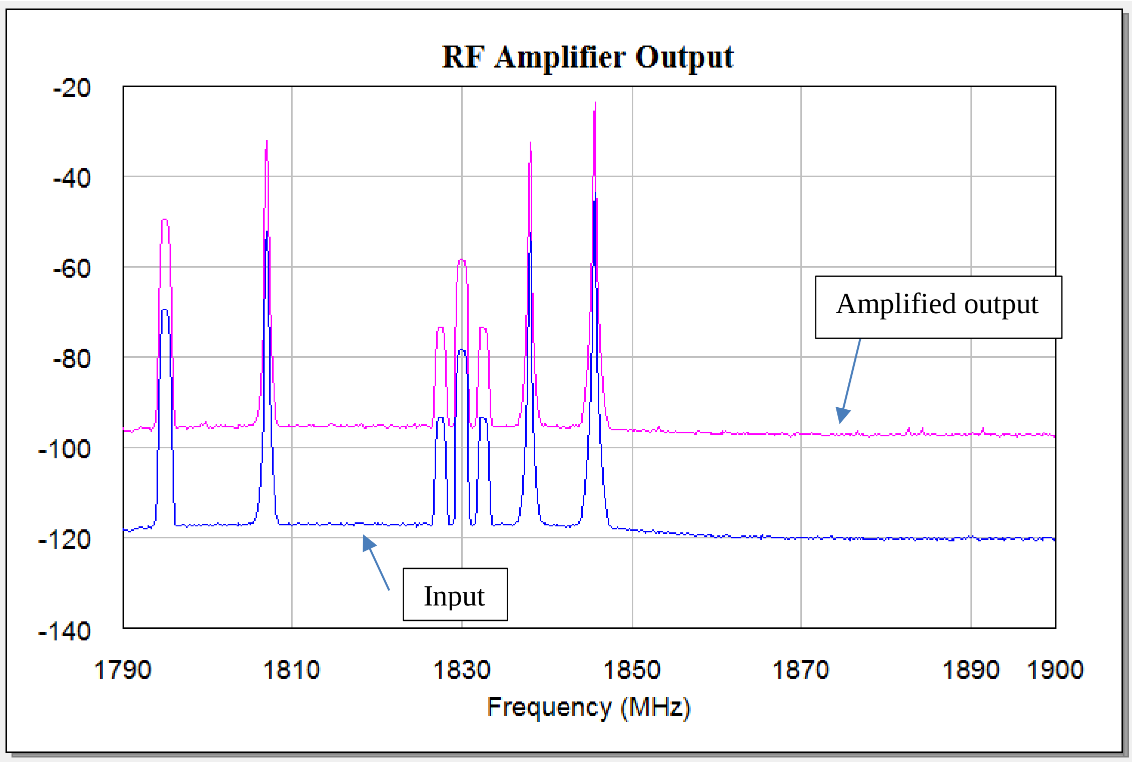


RF Amplifier

The second block is An RF amplifier. We were told to use the Amp_B amplifier in the design specs. We set the gain to be 20dB as it had to be less than 40dB but we wanted our final output to be above $10\mu W$. We can see here how our amplifier amplifies the signal. We also have unwanted signals that look large. They were attenuated by 2dB which isn't that large in comparison to their original power. This is why they still look quite big despite the fact that they have been attenuated.

We see here that the signal has been amplified.

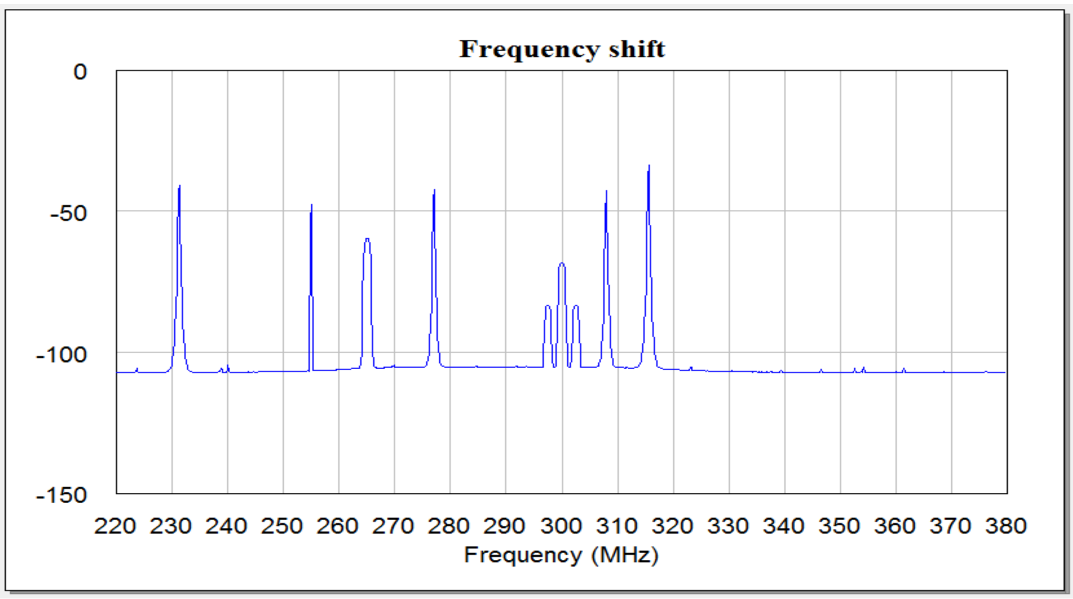
RF Amplifier Output



Mixer

The third block is a mixer that mixes our signals with a Local oscillator frequency of 1530MHz. This was to shift the passband to 300MHz, as our desired frequency is 1.83GHz. We had to set our mixer to DIFF so that we got the subtracted product.

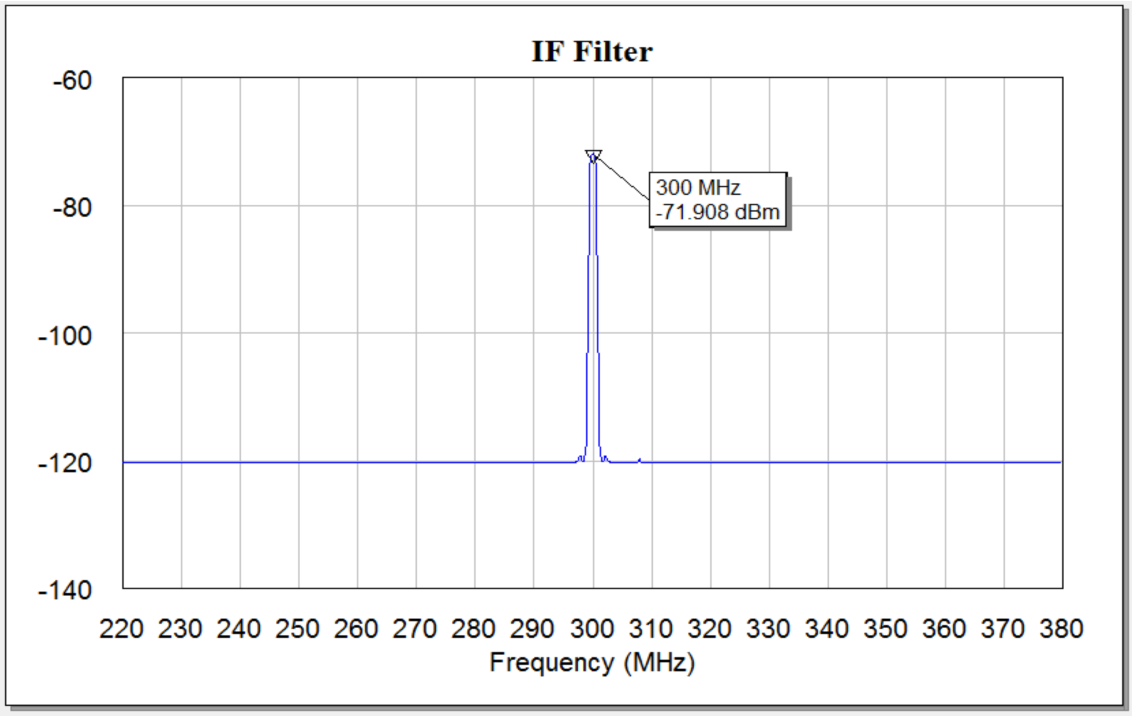
We see the shifted signal here:



Channel Select Butterworth filter

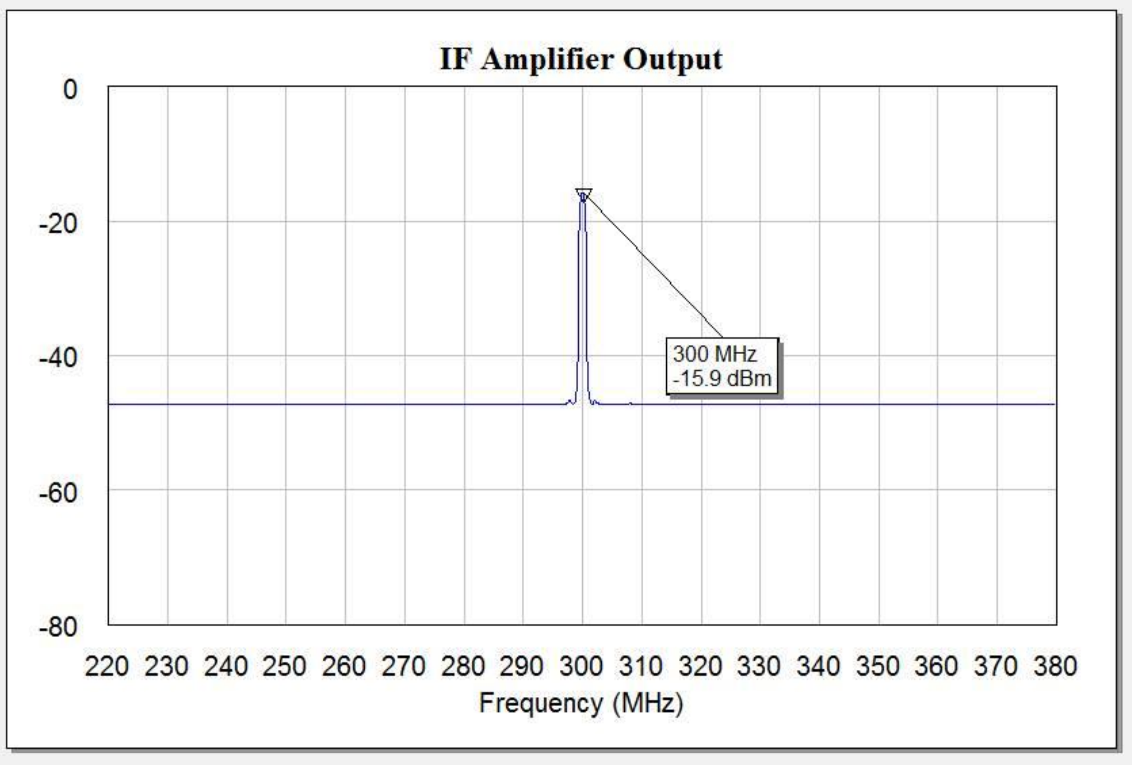
Again we chose a Butterworth filter here but seeing as we had to choose a very small passband and to attenuate the signal a lot we chose a high order. We chose a fourth order Butterworth with a very narrow passband from 229.3-300.7MHz as our desired signal is now centred at 300MHz. This filter gave us the desired output and attenuated all unwanted frequencies sufficiently. It also filtered out all distortion which a passband of 229-301MHz (2MHz), the original passband we thought would work, could not.

Channel Select Filter



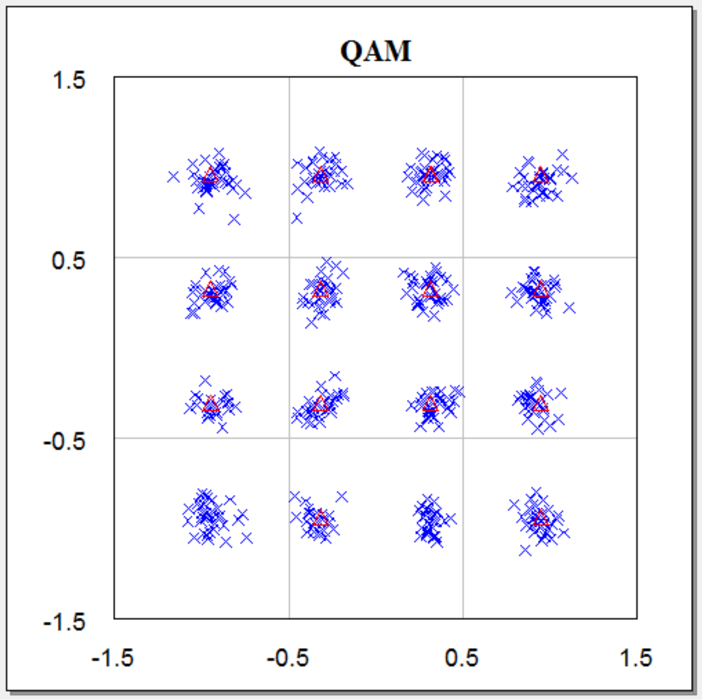
IF Amplifier

We then added two amplifiers to raise the power of our signal over a value of -20dBm ($10\mu W$). To do this we added two Amp_B amplifiers with gain of 35dB each. Our signal was now at a value of -15.9dBm, centred at 300MHz, which is our desired output.

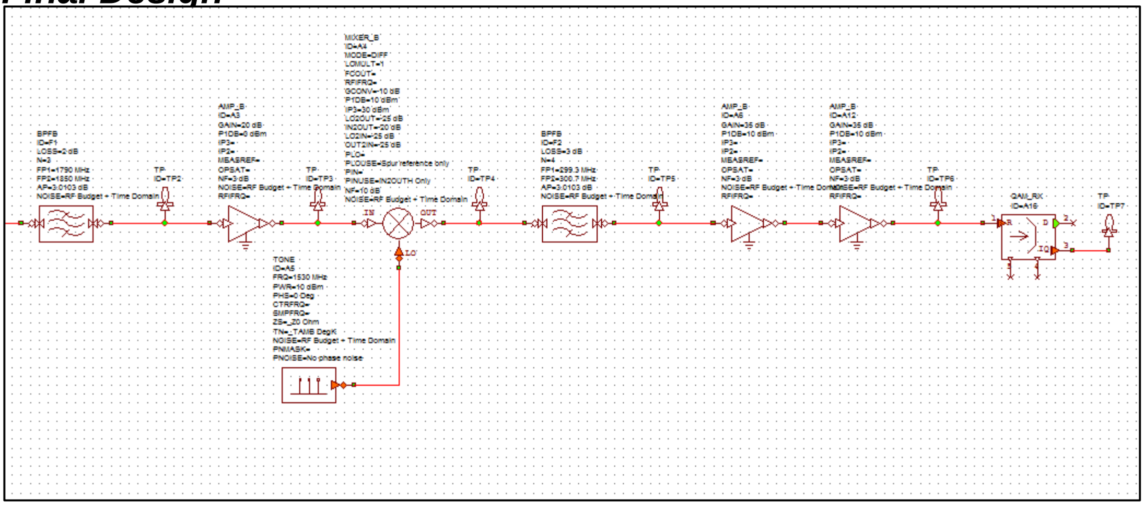


Demodulator

We then used the ideal demodulator to demodulate our output signal. At the original power of our desired input signal of -84dBm we can see from the following graph that our design works.

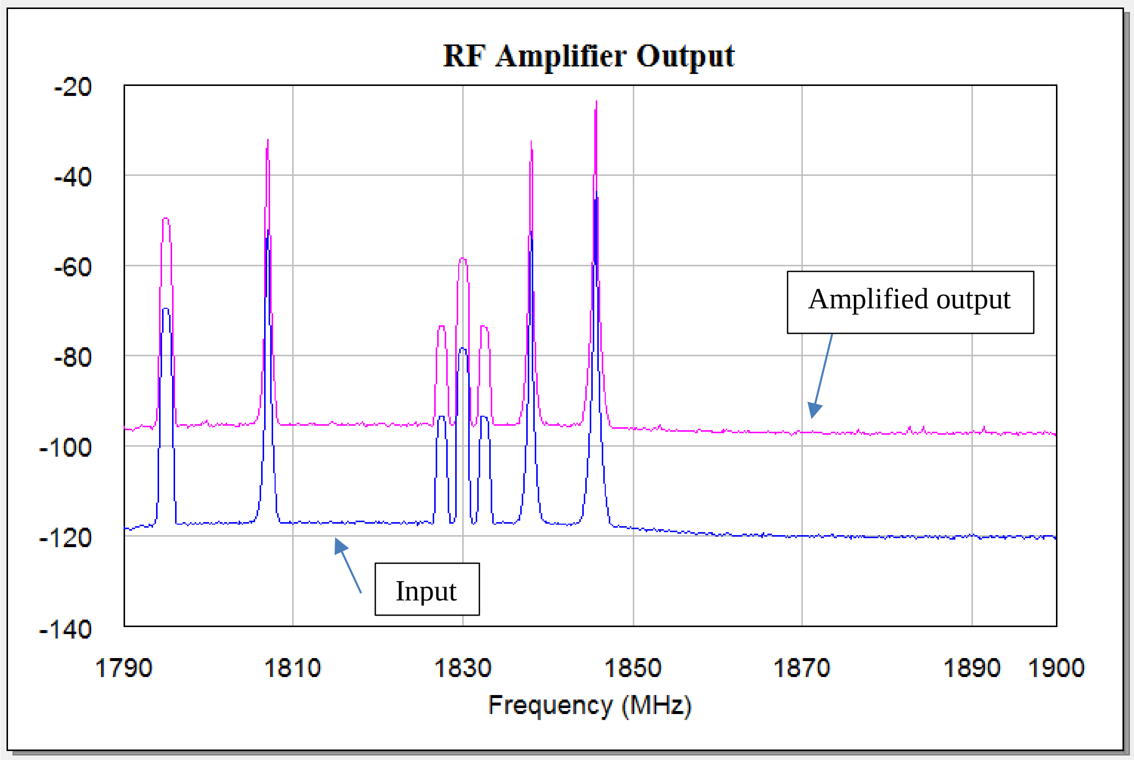


Final Design

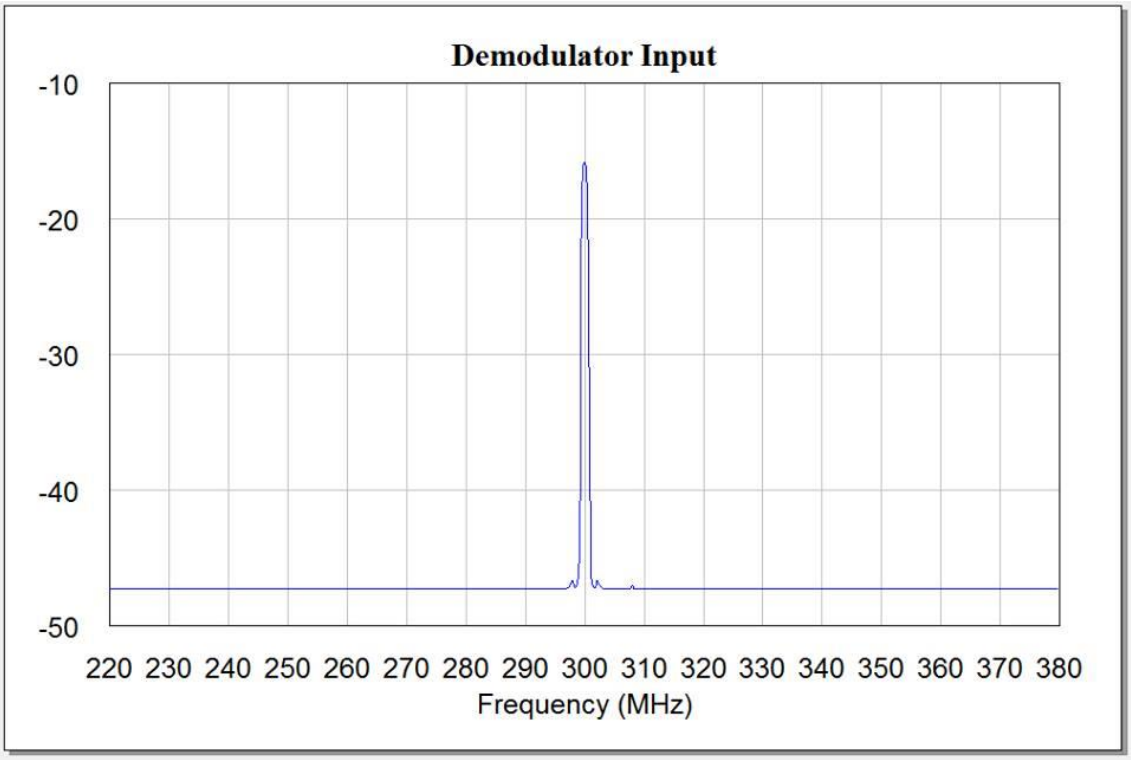


Simulation Results

The frequency spectrum at the output of the first amplifier is shown below. It shows that our unwanted input signals have been filtered by 2dB and then the filtered output is amplified by 20dB.



The frequency spectrum at the demodulator input is shown below. It shows that our second filter works and that we have the desired output we designed for. ie an output power of more than $10\mu W$ @ 300MHz



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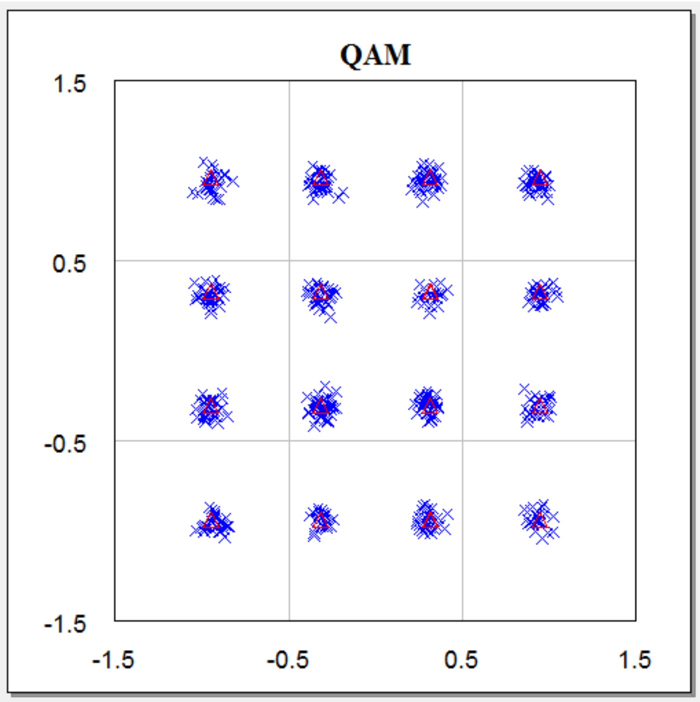
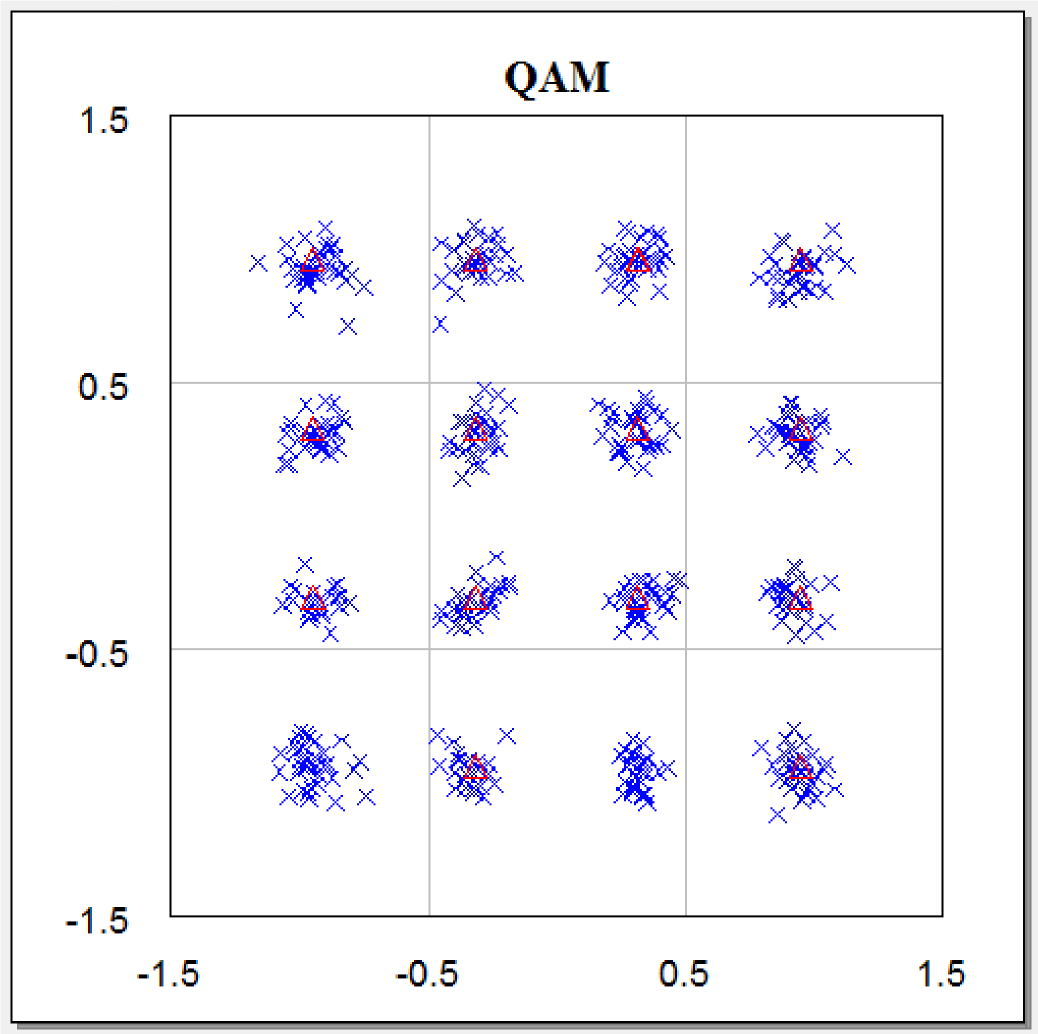
The constellation at the demodulator output is shown below, with the transmit power at its normal value. The transmit signal points are marked with X's.

Transmit power of -70dBm



Transmit power of -84dBm.



This diagram shows the constellation with a transmit power of -87 dBm, which we thought was the minimum value that would still allow you to distinguish each signal component clearly without it becoming distorted.

Transmit power at -87dBm.