# Lab2 Pulse Shaping and Matched Filtering

汪海玉 12011331           张旭东 12011923

## Introduction

In the last experience, we finished the QAM modulation and decode. And after symbol mapping and before decode we need to do pulse shaping and matched filtering. Now we are going to discuss them in detail.

### Pulse Shaping

In the real channel, there is inter-symbol interference except for the noise. So we define the Signal to Interference plus Noise Ratio (SINR) as:

We can't change the power of noise, so we need to minimalize the power of Interference. The best idea is to let the amplitude of interference at the sampling time to be zero, just like:

This is called Nyquist principle. But there is quite lot of functions that meet the requirement. So we want the function that consumes the least bandwidth. As a result, we choose the sinc function:

But if we want to improve the quality of the communication, we would want the damping be as sharp as possible, so we multiple another part, and get the raised-cosine function:

The damping speed is relevant with the filter parameter , when it equals 0, the whole function becomes normal sinc function, and when it equals to 1, the damping is quite fast. But on the hand, it will consume more bandwidth. We can see the following graph:

The smaller the filter parameter is, the wider the bandwidth will be. So if we want to have better quality we should use larger filter parameter and wider bandwidth, and if the requirement for quality is not that high, we can use smaller parameter. It is a typical kind of trade off in real engineering problem.

### Matched Filtering

Actually, we need the response function of the whole system to be raised-cosine function, and it consists of the following part:

Normally, the response function of channel is . So we have two options:

1. We choose the raised-cosine function as the pulse shaping function, then we should use delta function as the matched filtering function.
2. We use the square-root raised cosine function as the pulse shaping function, which satisfies . And use the same function as the matched filtering function. The square-root raised cosine function is:

In practice, option 2 is better. That is because it meets the best receiver theory, grx(t)=gtx\*(-t).

## Lab Results and Analysis

### Program diagram

Pulse shaping is in the transmitter.vi, here we can see the signal comes out of the source, and after MOD, it will enter the pulse shaping part. And the program diagram is shown as below:

The process of pulse shaping is actually quite simple. It is just the convolution of pulse shaping function and the signal. The thing that we should notice is that how to use the modulation parameters in and MT Generate Filter Coefficients VI. According to the help sheet.

If we want to get the pulse shaping filter coeffients we need to pass the corresponding parameters to that vi. So we should use Unbundle by name.vi to get those parameters from the modulation parameters in. And MT Generate Filter Coefficients VI can generate both pulse shaping filter coefficients and matched filter coefficients, we should notice the output that we use, do not use the wrong one. After that, we just need to use Convolution.vi to get the results.

Matched filtering is in the receiver.vi. Here we can see that, after the RX receiving the signal it will pass to the matched filter,and after down sampling and decode,we will get the information we want. The procedure is shown as below:

Similar to pulse shaping, it is just the convolution of waveform and matched filter coefficients we just notice that, this time we should use another output of MT Generate Filter Coefficients VI to do convolution.

### Result

We should notice that, in order to reduce the inter symbol interference we should make sure the whole response function of the system is raised cosine function. And the result of two different kind of condition is shown as below:

Received Constellation with raised-cosine pulse shaping function and matched filter function.

We can see that, the constellation is quite clear and SNR is over 250dB, so the result is quite good.

Received constellation with root square cosine pulse shaping function and root square cosine matched filtering function.

We can see that, in that case,the received symbol is not as stable as the previous one. And the SNR is about 44dB which is much smaller than the previous one. So the performance is not as good as the previous one.

USRP result

bandwidth with different SRRC

## Experience

1. I discovered how pulse shaping and matched filtering works.
2. I learnt who to reduce the inter symbol interference to improve SINR.
3. I learnt how to balance the performance and the consumption of resource.

### In class submission

汪海玉：

Week4:

Week5: