Real Time Packet reception using STR

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March 8, 2017

1 FM modulation and demodulation

1.1 Introduction

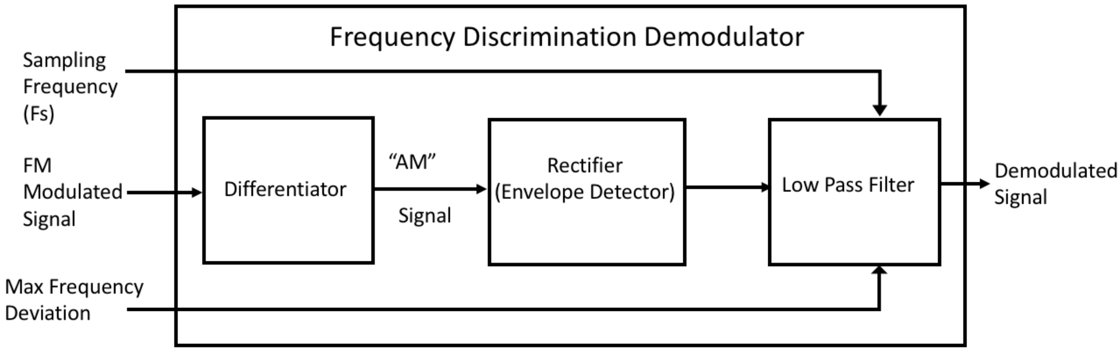

Figure 1: Block diagram of FM Demodulation

As shown in figure 1, the FM demodulator consists of the differentiator, following by the envelope detector and the low pass filter. In this case the rectifier is used as a rectifier. The low pass filter is able to remove the noises outside the frequency deviation. Undersampling can be implemented after the demodulator for music output.

1.2 Importing of SDR Data into Matlab

The RTL-SDR has a pre-defined function to recive data samples.The following is the code to recive raw I/Q data from the radio.

```
userInput = helperFMUserInput;
[fmRxParams,sigSrc] = helperFMConfig(userInput);
radioTime = 0;
while radioTime < userInput.Duration
  % Receive baseband samples (Signal Source)
  if fmRxParams.isSourceRadio
    [rcv,~,lost,late] = sigSrc();
  else
    rcv = sigSrc();
    lost = 0;
    late = 1;
  end

  % Update radio time. If there were lost samples, add those too.
  radioTime = radioTime + fmRxParams.FrontEndFrameTime + ...
```

```
    double(lost)/fmRxParams.FrontEndSampleRate;
end
a=length(rcv);
rv=[];
iv=[];
for i= 1:a
    am=abs(rcv(i));
    ag=angle(rcv(i));
    rv(i)=am*cos(ag);
    iv(i)=am*sin(ag);
end
figure(1)
plot(rv)
figure(2)
plot(iv)
figure(3)
plot(real(rcv))
figure(4)
plot(imag(rcv))


% Release the audio and the signal source
release(sigSrc)
```

The raw IQ data is of complex form.I is the current momentary amplitude of the signal (i.e. the Real signal) Q is the momentary amplitude of the signal phase shifted 90Âř. For a simple function such as sine, the phase shift is what the signal was earlier in time, but for a signal with more than one sine component, Q reflects a 90Âř shift of the individual components, and not the composite signal as such. To convert a Real Signal to a I/Q Data Signal, discrete Fourier transformation is required (Hilberts transform). The FM modulation in IQ can visualized from the figure 2.

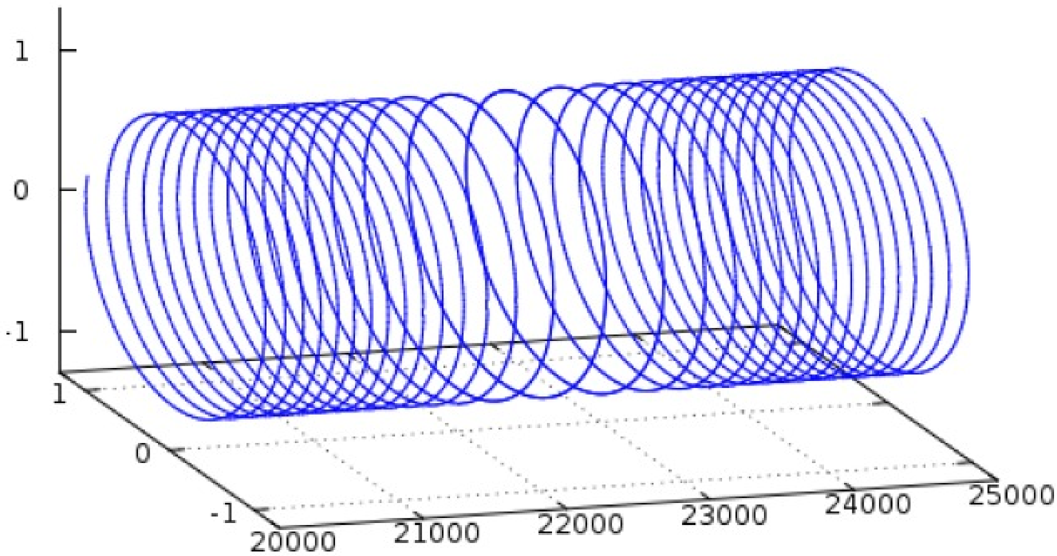

Figure 2: Representation of IQ Data representation

1.3 Demodulation on FM signal using Matlab

The code for fm demodulation is given below :

```
fs = 240000; % Front End sample rate
```

```
ts = 1/fs; % sampling interval


load rcv.mat;

t = 0:ts:(length(rcv)-1)*ts;

%% Draw the periodgram

fftpoints= 2^ceil(log2(length(rcv)));
f_rcv = fft(rcv,fftpoints);
PSD_rcv = fftshift(fft(rcv,fftpoints));
freq_rcv=(-fftpoints/2:fftpoints/2-1)/(fftpoints*ts)/1000;

% figure(1)
% plot(freq_rcv,abs(PSD_rcv))
% axis([-120 120 0 300]) % set x-axis and y-axis limits
% xlabel('{\it f}(kHz)'); ylabel('{\it S}_{\rm FM}({\it f})')
% title('FM Amplitude Spectrum of modulated signal')

axisset = [-120 120 0 300];
freqset = freq_rcv;
periodgramdraw(PSD_rcv,axisset,freqset)

%% Demodulation and Rectifier

diff_rc = diff(rcv); % Take Derivative of FM signal
diff_rcv = [0, diff_rc']';
abs_rcv = abs(diff_rcv);

figure(2)
subplot(211); fp1=plot(t,diff_rcv)
%axis(Trange) % set x-axis and y-axis limits
xlabel('{\it t}(sec)'); ylabel('{\it d s}_{\rm FM}({\it t})')
title('FM Derivative')

subplot(212); fp2=plot(t,abs_rcv)
%axis(Trange) % set x-axis and y-axis limits
xlabel('{\it t}(sec)'); %ylabel('{\it d}_{\rm PM}({\it t})')
title('rectified FM Derivative')

% PSD_absrcv = fftshift(fft(abs_rcv,fftpoints));
% axisset = [-120 120 0 300];
% freqset = freq_rcv;
% periodgramdraw(PSD_absrcv,axisset,freqset)

%% Low pass filter

N = 1;
cutoff = 75000;
[b,a]=butter(N,cutoff/(fs/2),'low');
lpf_rcv = filter(b,a,abs_rcv);

% PSD_lpfrcv = fftshift(fft(lpf_rcv,fftpoints));
% axisset = [-120 120 0 300];
% freqset = freq_rcv;
% periodgramdraw(PSD_lpfrcv,axisset,freqset)
```

```
%% Downsampling

audio_rcv = downsample(lpf_rcv, fs/48000);
sound(audio_rcv,48000);
```

1.4 Observations made on SDR console version 2.3

In order to get a better view of how the SDR radio works in real time and to play around with the vaious parametersof the radio, we downloaded SDR Console v2.3. This provided us with a graphical interace and we could see the available FM bands and analyse the spectrum of the signals.The figure 3 shows the SDR Console window.

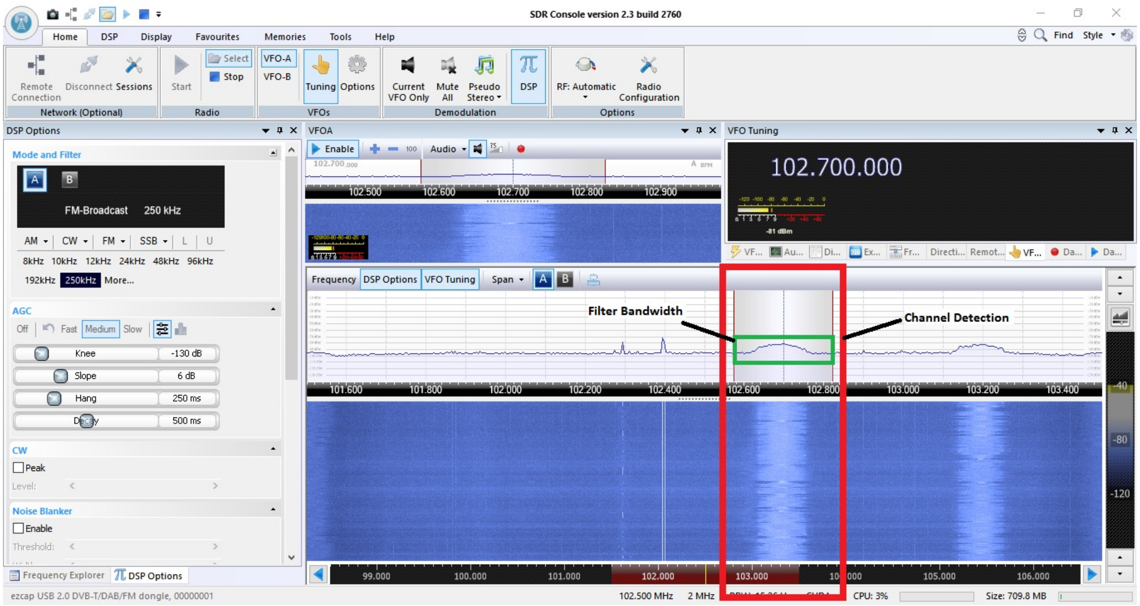

Figure 3: Console view of SDR

1. While running the demodulation module, the filter applied had a value of 250KHz. This could be seen as the frequency deviation from the center frequency as we reduce this value we experience a loss of information.
2. The FM receiver with noise filter and de emphasis is important as it suppresses the noise and spurious gains of the input signal. Without the de emphasis filter the output becomes loud and there is a large amount of noise present.
3. The SDR seems to have difficulty picking up signals in concrete buildings as the signals recieved were not very clear.