# Analogue Communication Theory

# Final Lab Project


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## DSB Modulation

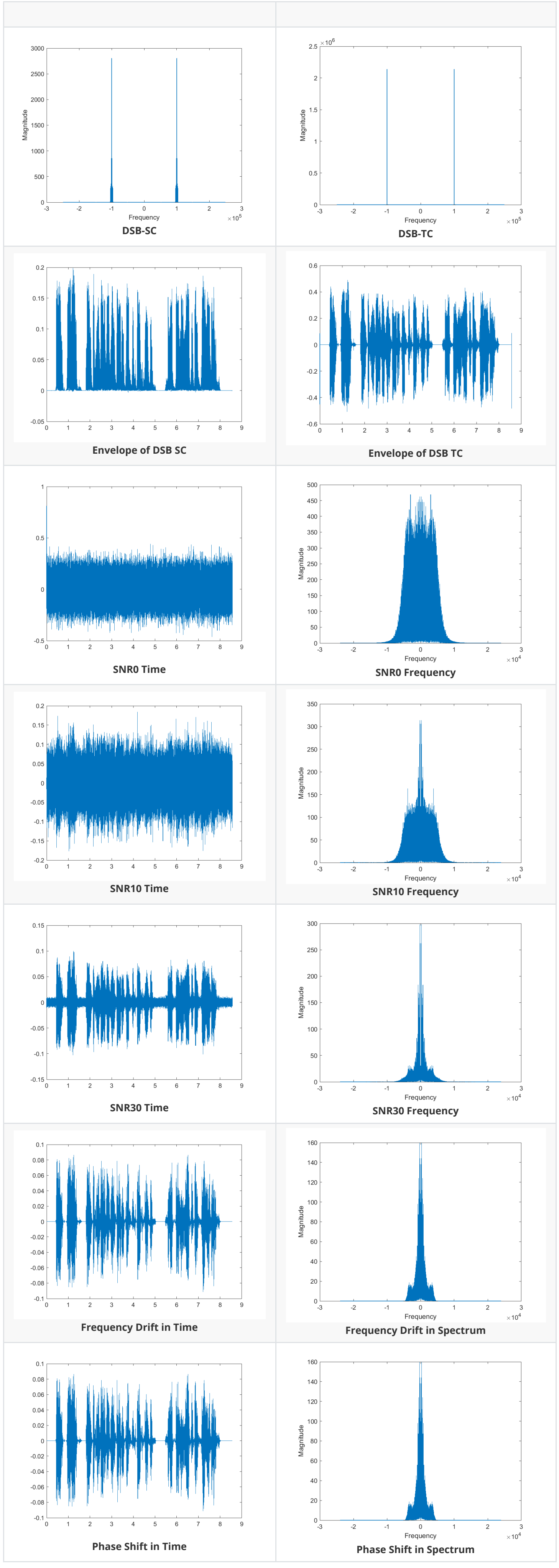
Modulation

```
classdef dsbmod
    properties
        fs_original
        resampled_msg
        carrier
    end
    methods
        function obj = dsbmod(msgsig,fc,fs_original,Xnyquist)
            obj.fs_original = fs_original;
            new_fs = fc*Xnyquist;
            [p,q] = rat(new_fs/fs_original);
            obj.resampled_msg = resample(msgsig,p,q);
            msg_len = length(obj.resampled_msg);
            obj.carrier = commonspectrum.gen_carrier(fc,0,msg_len/new_fs,msg_len);
        end
        function sc = suppressed_carrier(obj,Ac)
            sc = (Ac .* obj.carrier) .* obj.resampled_msg;
        end
        function tc = transmitted_carrier(obj,Mu,Ac)
            tc = Ac*(1 + Mu * obj.resampled_msg/max(obj.resampled_msg)) .* obj.carrier;
        end
    end
end
```

Demodulation

```
classdef dsbdemod
    methods (Static)
    function demodulated=envelope(modulated,fcut,fs)
       temp= abs(hilbert(modulated));
       filtered=lowpass(temp,fcut,fs,'ImpulseResponse','iir');
       %HardCoded
       [p,q]=rat(48/500);
       demodulated=resample(filtered,p,q);
    end
    function demodulated=coherent(modulated,fc,fs,phase,fcut)
        len=length(modulated);
        demod= modulated.*commonspectrum.gen_carrier(fc,phase,len/fs,len);
        filtered=lowpass(demod,fcut,fs,'ImpulseResponse','iir');
        %HardCoded
       [p,q]=rat(48/500);
       demodulated=resample(filtered,p,q);
    end
    end
end
```

### Figures



DSB-SC | DSB-TC | Envelope of DSB SC | Envelope of DSB TC | SNR0 Time | SNR0 Frequency | SNR10 Time | SNR10 Frequency | SNR30 Time | SNR30 Frequency | Frequency Drift in Time | Frequency Drift in Spectrum | Phase Shift in Time | Phase Shift in Spectrum

### Conclusions for DSB Modulation:

- Envelope Detector should only be used for transmitted carrier only
- Frequency Error is called Frequency Drift

## SSB Modulation

Modulation:

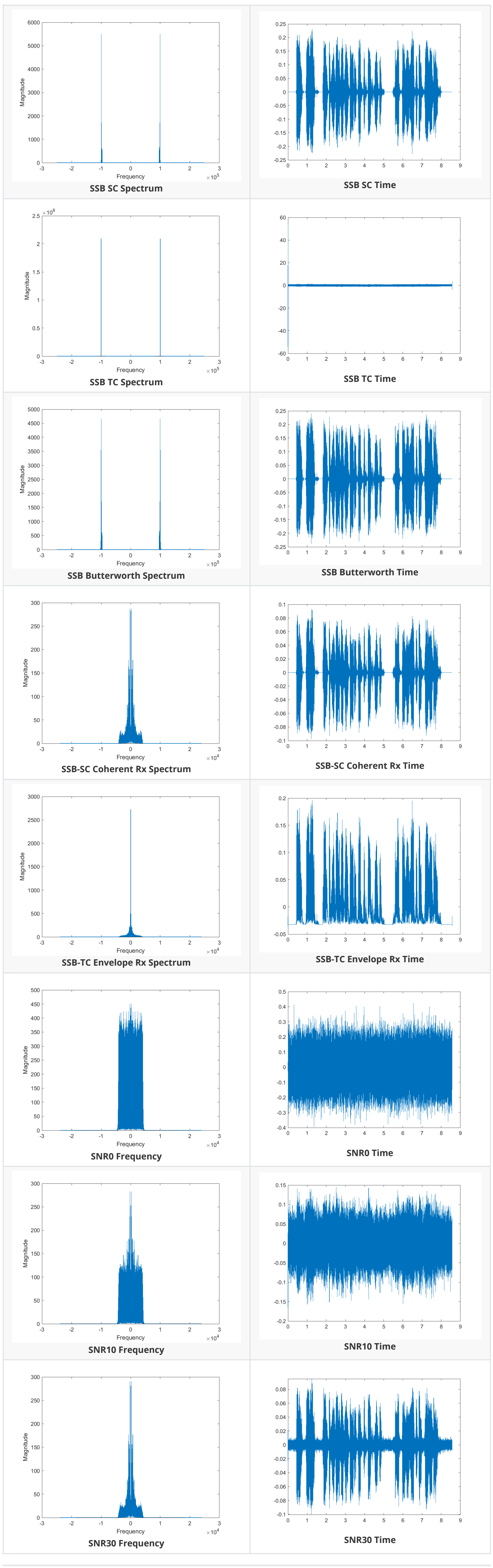
```
classdef ssbmod
    methods (Static)
        function ideal = idealSC(dsbsc,fc)
            fs = fc * 5;
            ideal = bandpass(dsbsc,[1e5-4e3
1e5],fs,'ImpulseResponse','iir','Steepness',0.999,'StopbandAttenuation',90);
        end

        function practical = practicalSC(dsbsc,fc)
            fs = fc * 5;
            flow = (fc-4e3)/ (fs/2);
            fhigh = fc/ (fs/2);
            fcut = [flow, fhigh];
            [b, a] = butter(4,fcut);
            practical = filter(b, a, dsbsc);
        end
        function tc = transmitted_carrier(dsbtc,fc)
            fs = fc * 5;
            tc = bandpass(dsbtc,[1e5-4e3
1e5],fs,'ImpulseResponse','iir','Steepness',0.999,'StopbandAttenuation',90);
        end
    end
end
```

Demodulation:

```
classdef ssbdemod
    methods (Static)
    function demodulated = envelope(modulated,fcut,fs)
       temp= abs(hilbert(modulated));
       demod = temp - mean(temp);

filtered=lowpass(demod,fcut,fs,'ImpulseResponse','iir','Steepness',0.999,'StopbandAttenuation',90);
       %HardCoded
       [p,q]=rat(48/500);
       demodulated=resample(filtered,p,q);
    end
    function demodulated = coherent(modulated,fc,fs,phase,fcut)
        len = length(modulated);
        demod = modulated.*commonspectrum.gen_carrier(fc,phase,len/fs,len);
        filtered =
lowpass(demod,fcut,fs,'ImpulseResponse','iir','Steepness',0.999,'StopbandAttenuation',90);
        %HardCoded
       [p,q] = rat(48/500);
       demodulated = resample(filtered,p,q);
    end
    end
end
```



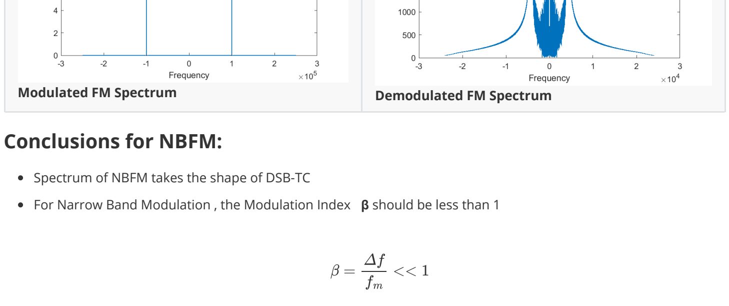
SSB SC Spectrum | SSB SC Time | SSB TC Spectrum | SSB TC Time | SSB Butterworth Spectrum | SSB Butterworth Time | SSB-SC Coherent Rx Spectrum | SSB-SC Coherent Rx Time | SSB-TC Envelope Rx Spectrum | SSB-TC Envelope Rx Time | SNR0 Frequency | SNR0 Time | SNR10 Frequency | SNR10 Time | SNR30 Frequency | SNR30 Time

## NBFM Modulation

Modulation and Demodulation:

```
classdef NBFM
    methods(Static)
        function modulated = modFM(audio,fc,fs,kf)
            dsbobj = dsbmod(audio.filtered_data,1e5,audio.fs,5);
            % Integration of Msg
            int_M = cumsum(dsbobj.resampled_msg);
            t=linspace(0,length(int_M)/fs,length(int_M));
            % Generating FM Modded Msg
            modulated = cos(2*pi*fc*t' + kf.*int_M);
        end
        function demodulated = demodFM(moddedFM,fs)
            [p,q] = rat(48/500);
            % Discriminator to Convert to AM
            differentiated = diff(moddedFM);
            % Envelope Detection
            envelop=abs(hilbert(differentiated));
            % Remove DC
            demod = envelop - mean(envelop);
            % Remove High Freqs
            demod = lowpass(demod,4000,fs,'ImpulseResponse','iir');
            % Downsample Again
            demodulated=resample(demod,p,q);
        end
    end
end
```

### Figures



Modulated FM Spectrum | Demodulated FM Spectrum

### Conclusions for NBFM:

- Spectrum of NBFM takes the shape of DSB-TC
- For Narrow Band Modulation , the Modulation Index **β** should be less than 1

$$\beta = \frac{\Delta f}{f_m} << 1$$