Principles of Communication systems FINAL PROJECT -II

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Contents

1 Impact of jamming on AM and FM radios:-

Aim: To use the AM and FM radios designed before and jam the audio signal at a frequency band by transmitting either a white gaussian noise or AM/FM signal.By changing the power of the interferer w.r.t. the original signal, estimate the MOS for different ratios of power.

We are changing the **Interferer power to signal power ratio** and writing our observations on the audio quality of the received audio signal.if we have two quantities of power, P1 and P2, the ratio of these two values is represented by the equation:

$$dB = 10log_{10}(P2/P1) \tag{1}$$

So we change the amplitudes in this relation to transmit the signals at required Interferer power to signal power ratio such as 5dB,2dB,-5dB etc.

So here the P2 is the power of the interfering signal and P1 is the power of the original audio signal and we are computing this ratio using the above formula.

For transmitting the original signal and interferer in particular power ratio, we need to find the average powers of the two signals and then changing the amplitude(since power is dependent on amplitude of the signal) of the signals accordingly such that we can attain the required power ratio.

$$(P2/P1) = 10^{dB/10} \tag{2}$$

$$(amplitude2/amplitude1) = 10^{dB/20} \tag{3}$$

1.1 MOS table results and observations

These are my own MOS definitions and criteria:- Here , MOS score can vary from 1 to 6

Score 6:- original audio signal as if there is no noise /interferer
Score 5:- Minute amount of noise but the audio signal can be understood clearly

Score 4:- Audio is intelligible more than 60 percent of the time
Score 3:- Audio can be intelligible for less than 30 percent of the time
Score 2:- Audio is unintelligible(cant understand anything) bits and pieces
Score 1:- Complete garbage if interferer is noise, hearing interfering signal completely

MOS(1-6)				
Interferer power/signal power	AM	AM	FM	FM
interfering signal ⇒⇒	white noise	another AM signal	white noise	another FM signal
Ratio of -10dB	2.5	4	3	4
Ratio of -5dB	2	3.75	2.5	4
Ratio of -2dB	1.5	3.5	1.5	3
Ratio of 1dB	1	3	1	2
Ratio of 5dB	1	2.5	1	1
Ratio of 10dB	1	2	1	1

Observations:- From the table we can see that:-

interfering signal is noise:- If the power of the noise is more than signal power, we are listening complete noise i.e complete wash out of the original signal in both AM and FM radios . If the power of the interferer is less than the original signal power, then the signal can be heard in FM radio slightly better compared to AM radio.for example if the power ratio is -10dB , MOS score for FM radio is 3 while for AM radio is 2.5 which is a slight difference.

Interfering signal is AM/FM signal:- In case of AM ,If the power of interfering signal is more than the signal power(1dB, 5dB, 10dB), we can hear the interfering signal dominating the original signal but the original signal is not completely wiped out. But in case of FM, If the power of interfering signal is more than the signal power(1dB, 5dB, 10dB), the original signal is not at all audible. And at 5dB ratio, we are hearing completely the interfering signal as if it is the signal which is transmitted i.e the interfering signal is completely replacing the original signal.

1.2 Ability of AM and FM to resist jamming and conclusions

– a) From the above mentioned observations, we can clearly see that the ability to resist jamming is better in AM radio as compared to FM radio, because in AM, the interfering signal completely replaced the original signal is the power ratio taken to be greater than 25dB. Whereas in FM, The interfering signal completely replaced the original signal at 5dB only.i.e the interferer power required to jam the AM signal is more than than the interferer power required to jam the FM signal.

Effect of modulation index:- In FM, By decreasing the modulation index , we can see that more interfering signal power is required to jam the signal. so decreasing the modulation index helps.For example by changing the modulation index β from 1 to 0.5 the interfering signal to original signal power ratio required is increased to 10dB instead of 5dB before.

b) If I am a jammer, for AM radio , I would choose to transmit white noise as the interfering signal because if the noise power is more than signal power , then the original signal can't be heard. For FM radio, I would transmit an FM signal as the interferer because , we can replace the interfering signal with the original signal at a low interfer power/original signal power ratio.

2 Appendix

2.1 Matlab code

```
s1_f = 10 * 10^3; s2_f = 16 * 10^3;
[s1_data,fs] = audioread('m1_audio.wav');
[s2_data,fs] = audioread('m2_audio.wav');
[s3_data,fs] = audioread('m3_audio.wav');

s1_resample = resample(s1_data,60000,fs);
s2_resample = resample(s2_data,60000,fs);
s3_resample = resample(s3_data,60000,fs);

s1_filter = filter(b,a,s1_resample);
s2_filter = filter(b,a,s2_resample);
s3_filter = filter(b,a,s3_resample);


power_ratio = 10;%dB
p_ratio = 10^(power_ratio/10);


s1_mod = ammod(s1_filter,s1_f,60000,0,1);
s2_mod = ammod(s2_filter,s2_f,60000,0,1);
interferer_mod = ammod(s3_filter,s1_f,60000,0,1); % interferer ...
    at s1 frequency
pinitial_1 = bandpower(s1_mod)  % find power of s1_mod
pinitial_2 = bandpower(interferer_mod);  % find power of ...
    interferer_mod
pi_ratio = (pinitial_2/pinitial_1);
p_mul = (p_ratio*pinitial_1)/pinitial_2;
p_mul = p_mul^0.5;
interferer_mod = p_mul * ammod(s3_filter,s1_f,60000,0,1);
% changing the amplitude to attain required power ratio
p_1 = bandpower(s1_mod);
p_2 = bandpower(interferer_mod);  %checking power after changing ...
    the amplitude

interference_ratio = 10*log10(p_2/p_1)  % verifying if the ratio ...
    is correct

s_mod = s1_mod(1:300000) + s2_mod(1:300000)+ ...
    interferer_mod(1:300000);

%receiver
r_freq = s1_f;
passage = [r_freq-2000,r_freq+2000];

s_mod_rec = bandpass(s_mod,passage,60000);
s_out = amdemod(s_mod_rec,r_freq,60000,0,1);

soundsc(s_out,60000);

```

```
% similar code for FM radio with slight changes like ...
    fmmod,fmdemod etc..
```

```
interference_ratio =

   10.0000

>>
```

3 References

[1]Upamanyu Madhow,Introduction to Communication Systems,January 17 2014, University of California, Santa Barbara
[2] MATLAB Bandpower URL:https://in.mathworks.com/help/signal/ref/bandpower.html
[3] Decibel power gain. URL:https://www.electronics-tutorials.ws/filter/decibels.html