Praktikum VII

Modulation & Demodulation

1. Modulasi Amplitudo

Modulasi Amplitudo (AM) merupakan modulasi yang paling sederhana dan dipakai pada awal perkembangan siaran radio dan televisi.

1. Ketik command line dibawah ini dan save sebagai function.

function X = am\_spectrum(x)

% AM\_SPECTRUM Calculates the spectrum of a signal

% X = am\_spectrum(x)

%

% x: signal

% X: spectrum of signal x

X = abs(fftshift(fft(x)));

1. Ketik command line dibawah ini dan save sebagai function

function am\_plot(idx,m,c,u,rng)

% AM\_PLOT Plots the three modulation signals

% am\_plot(m,c,u,rng)

%

% idx: x index (it can represent time or frequency)

% m: modulating signal

% c: carrier signal

% u: modulated signal

% rng: range of x axis to plot (optional)

if nargin < 5; rng = 1; end % default value for rng

figure; % create a new figure so we don't overwrite an existing one

subplot(311); % split the figure in three subplots

plot(idx,m); grid on;

axis([rng\*min(idx) rng\*max(idx) min(m)-0.1 max(m)+0.1]);

subplot(312);

plot(idx,c); grid on;

axis([rng\*min(idx) rng\*max(idx) min(c)-0.1 max(c)+0.1]);

subplot(313);

plot(idx,u); grid on;

axis([rng\*min(idx) rng\*max(idx) min(u)-0.1 max(u)+0.1]);

1. Ketik command line berikut

fs = 2000; % Define the sampling frequency in Hz

len = 1; % length of signals in seconds

t = (-len/2):1/fs:(len/2); % time index

% Make our first modulating (message) signal m(t)

fm = 0.5; % modulator frequency (Hz)

m = cos(2\*pi\*fm\*t) - 0.25;

% Now make the carrier c(t)

fc = 20; % carrier frequency

c = cos(2\*pi\*fc\*t);

% Modulate the signal

u = m.\*c;

% Let's plot them in time to see how they look like

am\_plot(t,m,c,u,1.1);

% Calculate the spectra

M = am\_spectrum(m);

C = am\_spectrum(c);

U = am\_spectrum(u);

% Make the frequency index for plotting

f = (-fs/2):(1/len):(fs/2);

% Now let's plot them in frequency

am\_plot(f,M,C,U,0.1);

1. Apa yang dimaksud nrg. Dengan merubah parameter nrg pada langkah ke-2, apa pengaruh panjang-pendek nrg ?
2. Dengan merubah frekuensi pembawa (*carrier*), menjadi lebih besar dan lebih kecil dari nilai semula; Tunjukkan dengan plot dan jelaskan perbedaan hasil yang diperoleh.
3. Sisipkan command berikut pada source code langkah ke-3

% Now make the second message signal

pw = 0.1; % pulse width

m = rectpuls(t,pw);

% Now make a new carrier

fc = 60; % carrier frequency

c = cos(2\*pi\*fc\*t);

% Modulate the signal

u = m.\*c;

1. Apa yang dimaksud dengan pulse width? Apa yang terjadi pada spektrum pulsa jika nilai variabel pw diganti 0.01, 0.2, 0.5 dan 0.75 ? Jelaskan apa itu upper sidebands dan lower sidebands dengan hasil percobaan ini.
2. Ganti pw = 0.05 dan fc = 15, apakah sinyal tersebut dapat di-demodulasi sempurna ? Desainkan filter (dalam source code baru) untuk men-demodulasi-nya.

II. Modulasi Frekuensi

Prosedur :

1. Ketik command line dibawah ini.

clc; clear all; close all;  
t = 0:0.001:1; %upto 1000 samples  
vm = input('Enter Amplitude (Message) = ');  
vc = input('Enter Amplitude (Carrier) = ');  
fM = input('Enter Message frequency = ');  
fc = input('Enter Carrier frequency = ');  
m = input('Enter Modulation Index = ');  
msg = vm\*sin(2\*pi\*fM\*t);

subplot(3,1,1); %plotting message signal  
plot(t,msg);  
xlabel('Time');  
ylabel('Amplitude');  
title('Message ');  
  
carrier = vc\*sin(2\*pi\*fc\*t);  
subplot(3,1,2); %plotting carrier signal  
plot(t,carrier);  
xlabel('Time');  
ylabel('Amplitude');  
title('Carrier Signal');  
  
y = vc\*sin(2\*pi\*fc\*t+m.\*cos(2\*pi\*fM\*t));  
subplot(3,1,3);%plotting FM (Frequency Modulated) signal  
plot(t,y);  
xlabel('Time');  
ylabel('Amplitude');  
title('FM Signal');

1. Apakah yang dimaksud dengan modulation index ? Jelaskan dan tunjukkan dengan plot pengaruh besar-kecil modulation index.
2. Tentukan periode modulasi !
3. Plot masing-masing spektrum frekuensi carrier dan frekuensi message, dan desain filter yang dapat memisahkan keduanya !

III. ASK

Prosedur :

1. Ketik command line berikut ini.

clc %for clearing the command window  
close all %for closing all the window except command window  
clear all %for deleting all the variables from the memory  
fc=input('Enter the freq of Sine Wave carrier:');  
fp=input('Enter the freq of Periodic Binary pulse (Message):');  
amp=input('Enter the amplitude (For Carrier & Binary Pulse Message):');

t=0:0.001:1; % For setting the sampling interval  
c=amp.\*sin(2\*pi\*fc\*t);% For Generating Carrier Sine wave

subplot(3,1,1) %For Plotting The Carrier wave  
plot(t,c)  
xlabel('Time')  
ylabel('Amplitude')  
title('Carrier Wave')  
m=amp/2.\*square(2\*pi\*fp\*t)+(amp/2);

%For Generating Square wave message

subplot(3,1,2) %For Plotting The Square Binary Pulse (Message)  
plot(t,m)  
xlabel('Time')  
ylabel('Amplitude')  
title('Binary Message Pulses')  
w=c.\*m; % The Shift Keyed Wave

subplot(3,1,3) %For Plotting The Amplitude Shift Keyed Wave  
plot(t,w)  
xlabel('Time')  
ylabel('Amplitude')  
title('Amplitude Shift Keyed Signal')

1. Jelaskan yang membedakan AM dengan ASK !
2. Lakukan percobaan dengan merubah bervariasi antara frekuensi pembawa dan frekuensi informasi, apa yang dapat anda simpulkan ?

IV. FSK

Prosedur :

1. Ketik command line dibawah ini.

clc %for clearing the command window  
close all %for closing all the window except command window  
clear all %for deleting all the variables from the memory  
fc1=input('Enter the freq of 1st Sine Wave carrier:');  
fc2=input('Enter the freq of 2nd Sine Wave carrier:');  
fp=input('Enter the freq of Periodic Binary pulse (Message):');  
amp=input('Enter the amplitude (For Both Carrier & Binary Pulse Message):');

amp=amp/2;  
t=0:0.001:1; % For setting the sampling interval  
c1=amp.\*sin(2\*pi\*fc1\*t);% For Generating 1st Carrier Sine wave  
c2=amp.\*sin(2\*pi\*fc2\*t);% For Generating 2nd Carrier Sine wave

subplot(4,1,1); %For Plotting The Carrier wave  
plot(t,c1)  
xlabel('Time')  
ylabel('Amplitude')  
title('Carrier 1 Wave')

subplot(4,1,2) %For Plotting The Carrier wave  
plot(t,c2)  
xlabel('Time')  
ylabel('Amplitude')  
title('Carrier 2 Wave')  
m=amp.\*square(2\*pi\*fp\*t)+amp;%For Generating Square wave message

subplot(4,1,3) %For Plotting The Square Binary Pulse (Message)  
plot(t,m)  
xlabel('Time')  
ylabel('Amplitude')  
title('Binary Message Pulses')  
for i=0:1000 %here we are generating the modulated wave  
    if m(i+1)==0  
        mm(i+1)=c2(i+1);  
        else  
        mm(i+1)=c1(i+1);  
    end  
end  
subplot(4,1,4) %For Plotting The Modulated wave  
plot(t,mm)  
xlabel('Time')  
ylabel('Amplitude')  
title('Modulated Wave')

1. Tunjukkan perbedaan FM dengan FSK !
2. Dengan merubah banyak pesan (message) yang dikirim, tunjukkan batas maksimum berapa pesan yang dapat dikirim dan mengapa ?
3. Kesimpulan apa yang anda peroleh ?

V. PSK

Prosedur :

1. Ketik command line dibawah ini.

clc %for clearing the command window  
close all %for closing all the window except command window  
clear all %for deleting all the variables from the memory

t=0:.001:1; % For setting the sampling interval  
fc=input('Enter frequency of Carrier Sine wave: ');  
fm=input('Enter Message frequency : ');  
amp=input('Enter Carrier & Message Amplitude(Assuming Both Equal):');  
c=amp.\*sin(2\*pi\*fc\*t);% Generating Carrier Sine

subplot(3,1,1) %For Plotting The Carrier wave  
plot(t,c)  
xlabel('Time')

ylabel('Amplitude')  
title('Carrier')  
m=square(2\*pi\*fm\*t);% For Plotting Message signal

subplot(3,1,2)  
plot(t,m)  
xlabel('time')  
ylabel('amplitude')  
title('Message Signal')% Sine wave multiplied with square wave in order to generate PSK  
x=c.\*m;

subplot(3,1,3) % For Plotting PSK (Phase Shift Keyed) signal  
plot(t,x)

xlabel('t')  
ylabel('y')  
title('PSK')

1. Jelaskan perbedaan ASK, FSK dan PSK !
2. Tunjukkan aplikasi PSK pada telekomunikasi data.
3. Buktikan secara eksperimen apakah ada batas maksimum data yang masih dapat dikirim, dan mengapa ?

VI. Double Sideband (DSB)

Prosedur :

1. Ketik command line berikut :

clear all, close

clc

%DSB Monotone

N = 1024; %N point FFT N>fc to avoid freq domain aliasing

fs = 4096; % sample frequency

t = (0:N-1)/fs;

fc = 500; %Carrier Frequency

fm1 = 10; %message signal frequency

Ec = 20; %Carrier Amplitude

Em1 = 10; %message signal amplitudes

%---------Double SideBand Full Carrier Modulation (DSB-FC(AM))

A = Ec + Em1\*sin(2\*pi\*fm1\*t);

m = A.\*[sin(2\*pi\*fc\*t)];

Mf = 2/N\*abs(fft(m,N));

f = fs \* (0 : N/2) / N; %Since the fft result is symmetrical, only the positive half is sufficient for spectral representation

close all;

figure('Name','Time/Fequency domain representations of DSB-AM signals');

subplot(2,1,1); %Time domain plot

plot(t,m)

title('Time Domain Representation');

xlabel('Time'); ylabel('Modulated signal');

subplot(2,1,2);

plot(f,Mf(1:N/2+1));

title('Frequency Domain Representation');

xlabel('frequency'); ylabel('Modulated signal');

1. Ketik pada file yang lain :

%dsb multitone

% Try changing the message and carrier amplitudes to see the effect in

% DSB-AM modulation

N = 1024; %N point FFT N>fc to avoid freq domain aliasing

fs = 4096; % sample frequency

t = (0:N-1)/fs;

fc = 500; %Carrier Frequency

fm1 = 80; %Three message signal frequencies

fm2 = 150;

fm3 = 200;

Ec = 20; %Carrier Amplitude

Em1 = 10; %Three message signal amplitudes

Em2 = 5;

Em3 = 10;

%---------Double SideBand Full Carrier Modulation (DSB-FC(AM))

A = Ec + Em1\*sin(2\*pi\*fm1\*t) + Em2\*sin(2\*pi\*fm2\*t) + Em3\*sin(2\*pi\*fm3\*t); %Envelope/eliminate the carrier amplitude

m = A.\*[sin(2\*pi\*fc\*t)]; %to convert DSB-AM to DSB-SC

Mf = 2/N\*abs(fft(m,N));

f = fs \* (0 : N/2) / N; %Since the fft result is symmetrical, only the positive half is sufficient for spectral representation

close all;

figure('Name','Time/Fequency domain representations of DSB-AM signals');

subplot(2,1,1); %Time domain plot

plot(t,m)

title('Time Domain Representation');

xlabel('Time'); ylabel('Modulated signal');

subplot(2,1,2);

plot(f,Mf(1:N/2+1));

title('Frequency Domain Representation');

xlabel('frequency'); ylabel('Modulated signal');

1. Ketik command line berikut :

close all, clear

clc

%----------Double SideBand Suppressed Carrier DSB-SC----------

%

%% Try changing the message and carrier amplitudes to see the effect in

% DSB-AM modulation

N = 1024; %N point FFT N>fc to avoid freq domain aliasing

fs = 4096; % sample frequency

t = (0:N-1)/fs;

fc = 500; %Carrier Frequency

fm1 = 80; %Three message signal frequencies

fm2 = 150;

fm3 = 200;

Ec = 20; %Carrier Amplitude

Em1 = 10; %Three message signal amplitudes

Em2 = 5;

Em3 = 10;

%

A = Em1\*sin(2\*pi\*fm1\*t) + Em2\*sin(2\*pi\*fm2\*t) + Em3\*sin(2\*pi\*fm3\*t); %Envelope/eliminate the carrier amplitude

m = A.\*[sin(2\*pi\*fc\*t)]; %to convert DSB-AM to DSB-SC

Mf = 2/N\*abs(fft(m,N));

f = fs \* (0 : N/2) / N;

figure('Name','Time/Fequency domain representations of DSB-SC signals');

subplot(2,1,1); %Time domain plot

plot(t,m);

%plot(t(1:N/2),m(1:N/2),t(1:N/2),A(1:N/2),'r',t(1:N/2),-A(1:N/2),'r');

title('Time Domain Representation');

xlabel('Time'); ylabel('Modulated signal');

subplot(2,1,2); %Frequency Domain Plot

plot(f(1:256),Mf(1:256));

title('Frequency Domain Representation');

xlabel('Frequency (Hz)'); ylabel('Spectral Magnitude');

1. Ketik command line berikut :

%exercise on SSB using MATLAB

N = 1024;

fs = 2048;

t = (0:N-1)/fs;

fc = 600; %Carrier frequency !! Limit fc<800 to avoid freq domain aliasing

fm1 = 200;

fm2 = 100;

Em1 = 2;

Em2 = 2;

m = Em1\*cos(2\*pi\*fm1\*t)+Em2\*cos(2\*pi\*fm2\*t); %Message

mh = imag(hilbert(m)); %Hilbert transform of the message signal

sbu = m.\*2.\*cos(2\*pi\*fc\*t) - mh.\*2.\*sin(2\*pi\*fc\*t);

%Expression for USB SSB

sbl = m.\*2.\*cos(2\*pi\*fc\*t) + mh.\*2.\*sin(2\*pi\*fc\*t);

%Expression for LSB SSB

SBU = 2/N\*abs(fft(sbu));

SBL = 2/N\*abs(fft(sbl));

freq = fs \* (0 : N/2) / N;

clc;

display('Single SideBand Modulation');

sprintf('Carrier frequency: %d Hz',fc)

sprintf('Message frequency: %d Hz and %d Hz',fm1,fm2)

sprintf('USB spectra at: %d Hz and %d Hz',fc+fm1,fc+fm2)

sprintf('LSB spectra at: %d Hz and %d Hz',fc-fm1,fc-fm2)

close all;

subplot(211);

plot(10\*t(1:200),sbu(1:200),'b'); %Time Domain Plot

title('Time Domain Representation');

xlabel('Time'); ylabel('Modulated Signal');

subplot(212);

%plot showing both side of side bands

plot(freq,SBU(1:N/2+1),freq,SBL(1:N/2+1)); %Frequency domain plot

%

%to see only one side band, whether upper side band, or lower side band, use:

%plot(freq,SBU(1:N/2+1)); or

%plot(freq,SBL(1:N/2+1));

title('Frequency Domain Representation');

xlabel('Frequency(Hz)'); ylabel('Spectral Magnitude');

legend('USB','LSB');

1. Jelaskan masing-masing perbedaan berbagai skema modulasi double sideband, dan apa gunanya ?
2. Tunjukkan cara (sertai dengan source code) demodulasi pesan dengan double sideband !

PELAPORAN

1. Masing-masing individu melakukan praktikum untuk topik 1-6. Buat laporan secara individu. Kumpulkan softcopy laporan anda ke [erna.septya@yahoo.com](mailto:erna.septya@yahoo.com) paling lambat Minggu 17 November 2019 pukul 23.59.

Jadikan satu dengan ketentuan setiap mahasiswa satu folder yang diberi nama NRP SAJA.

Silakan kreatif, semakin kreatif akan mendapat bonus nilai; tulis semua modifikasi source code dan plot grafik yang dikerjakan sesuai langkah/algoritma.

1. Buat kelompok sebanyak 4 orang, siapkan presentasi untuk dipresentasikan hari Selasa,19 November 2019, durasi presentasi max 15 menit. Dengan pembagian topik tiap kelompok sebagai berikut:

Kelompok 1-2 : Topik 1 – Modulasi Amplitudo

Kelompok 3-4 : Topik 2 – Modulasi Frekuensi

Kelompok 5-6 : Topik 3 – ASK

Kelompok 7-8 : Topik 4 – FSK

Kelompok 9-10 : Topik 5 – PSK

Kelompok 11-12 : Topik 6 – SDB Modulation

PPT dikumpulkan pada hari Selasa, 19 November 2019 pukul 06.00 ke email [erna.septya@yahoo.com](mailto:erna.septya@yahoo.com)

Bila terlambat, tidak perlu dikumpulkan.

Jangan mengkopi/plagiat, yang terlibat akan diberi nilai E !

Jangan lupa memberikan nama, nrp dan nama\_file.wav yang anda peroleh.

Have fun !

Instruktur :

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