Experiment-1

Amplitude Modulation (AM) and Demodulation

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Conventional AM technique

- message signal : $m(t) = A_m \cos(2\pi f_m t)$

  A_m - Amplitude , f_m - frequency of message signal

- Carrier signal : $c(t) = A_c \cos(2\pi f_c t)$

  A_c - Amplitude , f_c - frequency of carrier signal

- modulated signal : $m(t) \cdot c(t) + c(t)$

- product demodulator : $(m(t) \cdot c(t) + c(t))(2 * c(t))$

$$= (m(t)+1)\, 2 A_c^2 (\cos^2(2\pi f_c t))$$

$$= (m(t)+1) A_c^2 [1 + \cos(2\omega_c t)]$$

$$= (m(t)+1) A_c^2 + \underbrace{\cancel{(m(t)+1) A_c^2 \cos(2\omega_c t)}}_{[\text{Low Pass filter}] \to 0}$$

Butter worth LPF

$[num, den] = butter(N, \omega_n)$

ω_n: 0 — 1 → 0 — $fs/2$

0 — f_m — 1

$0/(fs/2)$, $(fs/2)/(fs/2)$

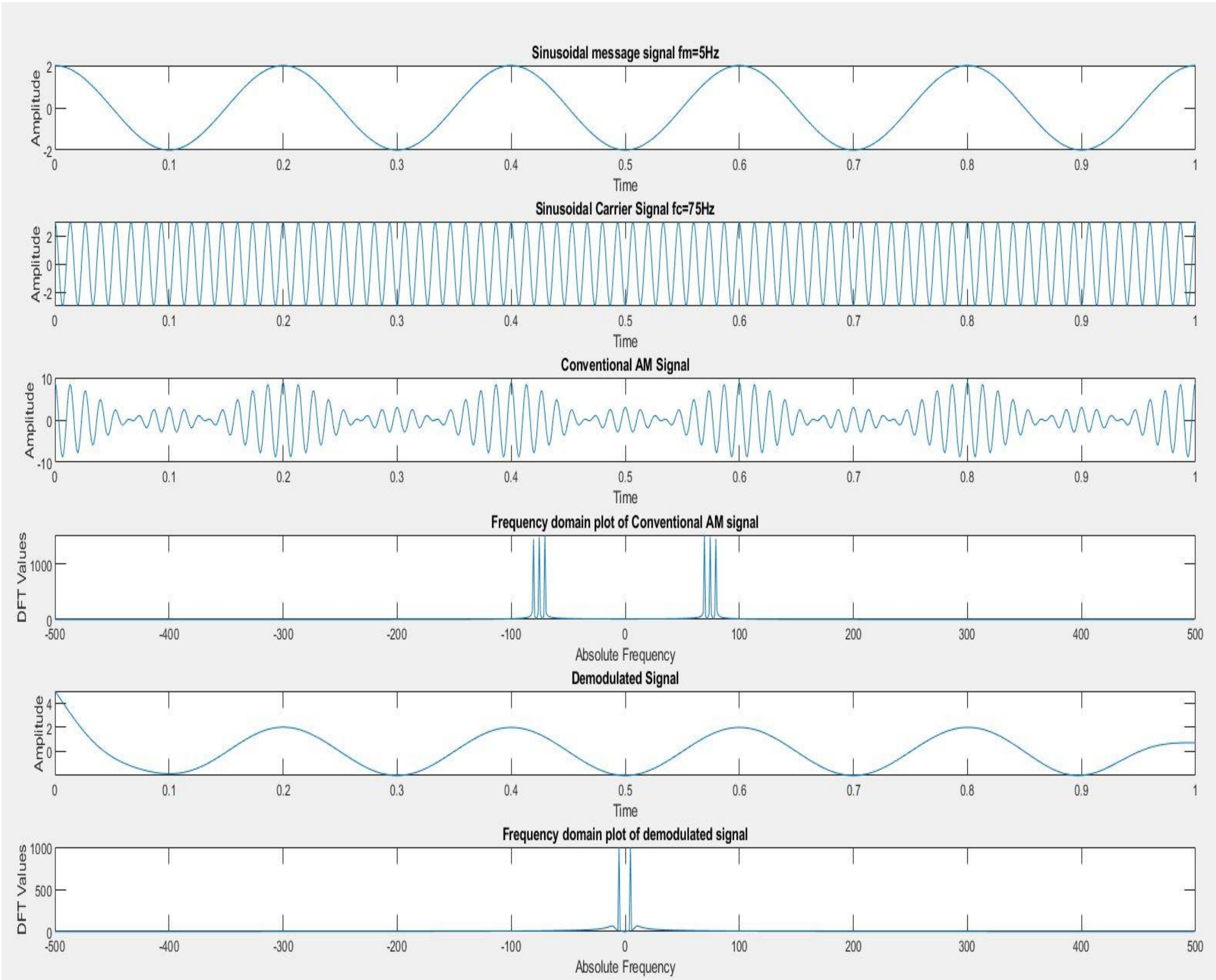
$\left\{\frac{2f_m}{f_s}\right\}$ → Lets take cutoff frequency as $2\left(\frac{2f_m}{f_s}\right)$

Final output : $(m(t)+1) A_c^2$

1) Divide by A_c^2
2) Subtract 1

=> $m(t)$ → Recovered signal

Plots:



Sinusoidal message signal fm=5Hz
Amplitude
Time
Sinusoidal Carrier Signal fc=75Hz
Amplitude
Time
Conventional AM Signal
Amplitude
Time
Frequency domain plot of Conventional AM signal
DFT Values
Absolute Frequency
Demodulated Signal
Amplitude
Time
Frequency domain plot of demodulated signal
DFT Values
Absolute Frequency

<u>Double Side band Suppressed Carrier (DSB SC)</u>

- modulated signal : $m(t) \cdot c(t)$
- product demodulator : $(m(t) \cdot c(t))(2 * c(t))$

$$= (m(t) A_c^2)(2\cos^2(2\pi f_c t))$$

$$= (m(t) A_c^2)[1 + \cos(2\omega_c t)]$$

$$= m(t) A_c^2 + \cancel{m(t) A_c^2 \cos(2\omega_c t)} \rightarrow 0$$

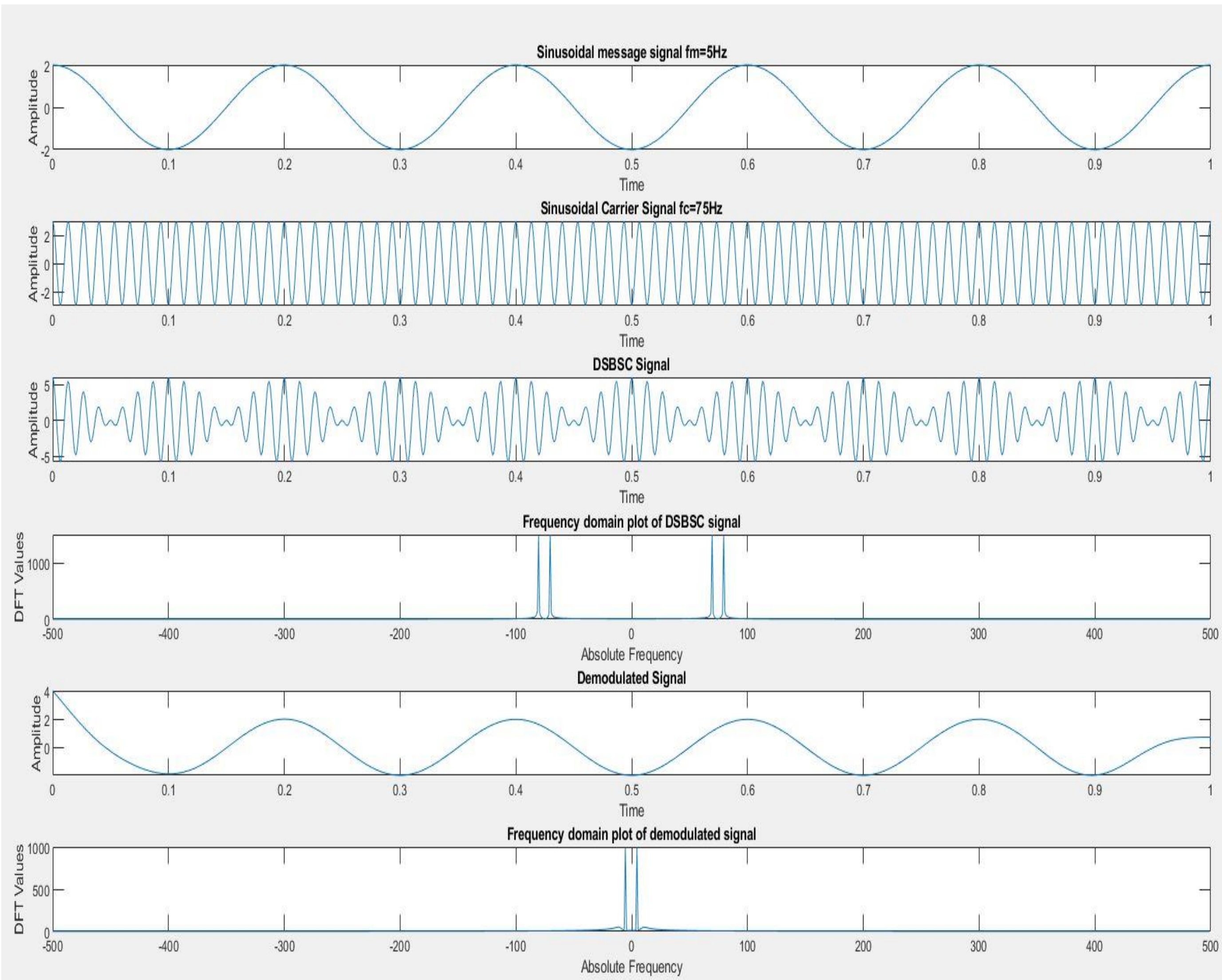
[Low pass filter]

- Cutoff frequency : $\frac{4 f_m}{f_s}$
- <u>Final output</u> : $m(t) A_c^2$

  $\rightarrow$ Divide by A_c^2

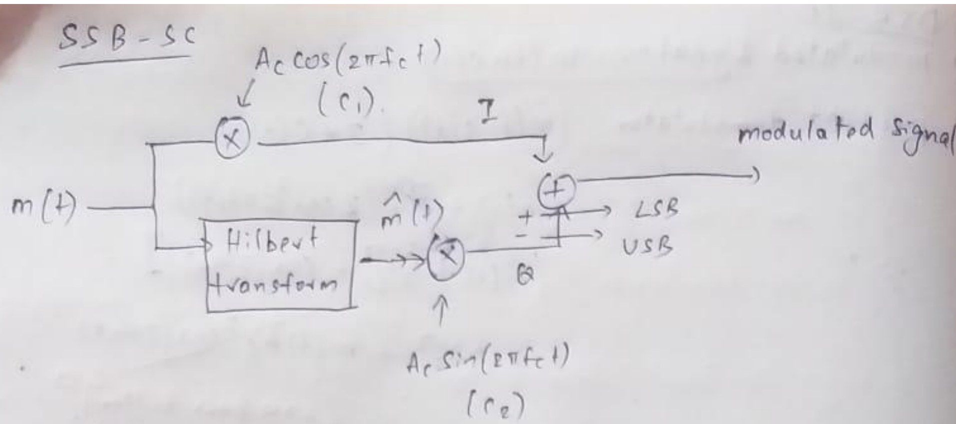
$\Rightarrow m(t) \rightarrow$ Recovered signal

Plots:


Sinusoidal message signal fm=5Hz
Amplitude
Time
Sinusoidal Carrier Signal fc=75Hz
Amplitude
Time
DSBSC Signal
Amplitude
Time
Frequency domain plot of DSBSC signal
DFT Values
Absolute Frequency
Demodulated Signal
Amplitude
Time
Frequency domain plot of demodulated signal
DFT Values
Absolute Frequency

Single Side band Suppressed Carrier (SSB SC)

SSB - SC



Hilbert transform

$m(t) = A_m \cos(2\pi f_m t)$

$\hat{m}(t) = A_m \cos(\omega_m t - \pi/2) = A_m \sin(\omega_m t)$

↓

Hilbert transform of $m(t)$

$\Rightarrow$ modulated signal $= I \pm Q$ {Quadrature components}

$= m(t) A_c \cos(\omega_c t) \pm \hat{m}(t) A_c \sin(\omega_c t)$

$+ \rightarrow$ LSB

$- \rightarrow$ USB

- Product demodulator : (modulated signal)$(2\, c_1(t))$

$\Rightarrow 2\, m(t) A_c^2 \cos^2(\omega_c t) + 2\, \hat{m}(t) A_c^2 \sin(\omega_c t) \cos(\omega_c t)$

$\Rightarrow m(t) \cdot A_c^2 [1 + \cos(2\omega_c t)] + \hat{m}(t) A_c^2 [\sin(2\omega_c t)]$

$= m(t) A_c^2 + \underbrace{m(t) A_c^2 \cos(2\omega_c t)}_{\rightarrow 0} + \underbrace{\hat{m}(t) A_c^2 \sin(2\omega_c t)}_{\rightarrow 0}$ $\boxed{\text{LPF}}$

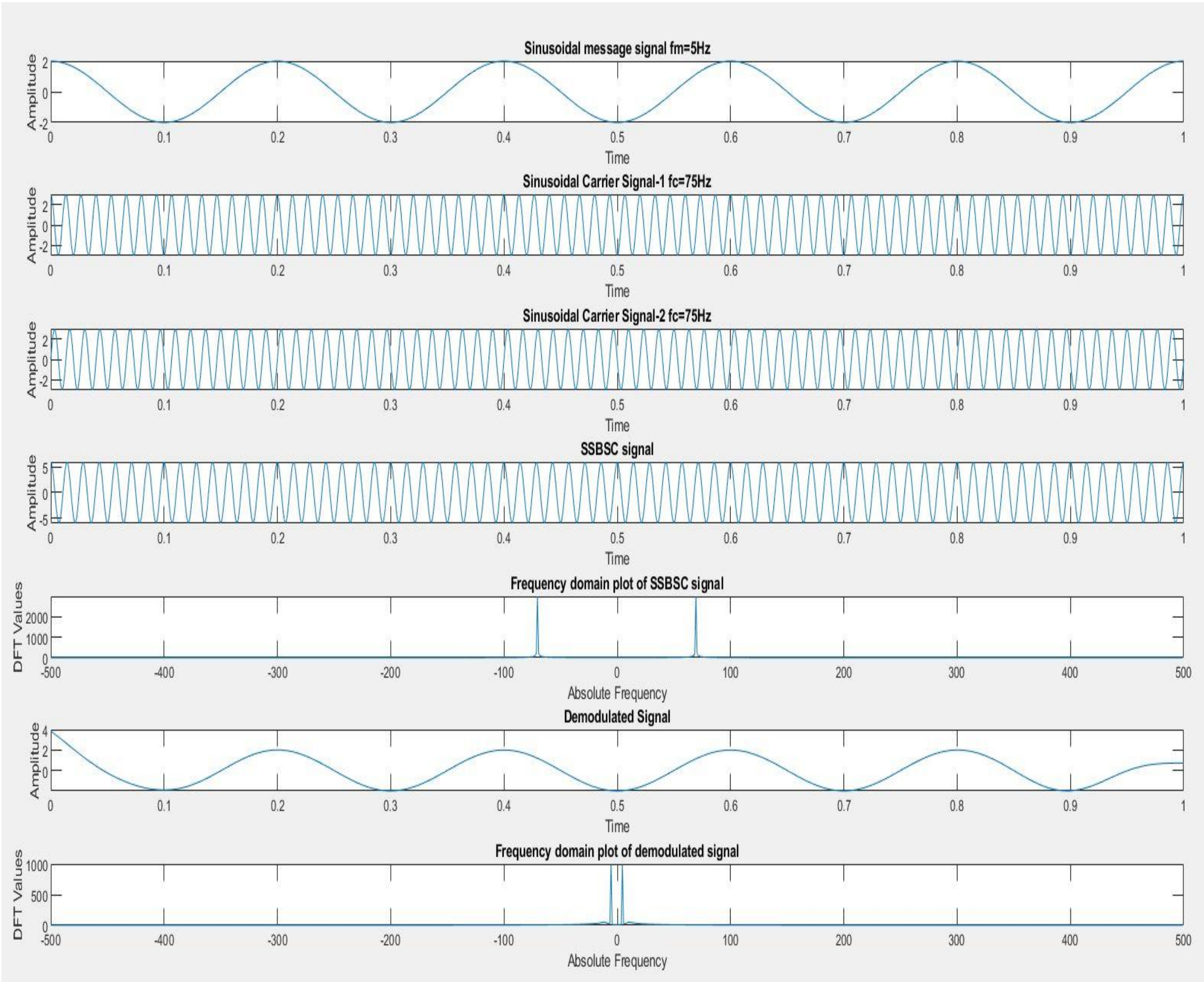
- Cutoff frequency $= \dfrac{4 f_m}{f_s}$

Final output : $m(t) A_c^2$

$\rightarrow$ Divide by A_c^2

$\Rightarrow m(t)$ - Recovered signal

Plots:



Sinusoidal message signal fm=5Hz
Amplitude
Time
Sinusoidal Carrier Signal-1 fc=75Hz
Amplitude
Time
Sinusoidal Carrier Signal-2 fc=75Hz
Amplitude
Time
SSBSC signal
Amplitude
Time
Frequency domain plot of SSBSC signal
DFT Values
Absolute Frequency
Demodulated Signal
Amplitude
Time
Frequency domain plot of demodulated signal
DFT Values
Absolute Frequency