October 31, 2023, Deadline: Nov 03, 2023

L01-03, SLIDE 18

1. Packet switching may be used for WhatsApp calls but not WhatsApp message. Is this assertion correct? Justify.

Issue with Packet switching: *Packets may arrive in incorrect order or, some packets may be lost in transit. Packets at the transmitter end must be stitched at the receiver end before the information is presented to the user.* $\therefore$ *is not perfect.*

Human limitations: *Humans are quite tolerant to data losses or even some amount of mis-ordered data while interpreting speech data; i.e., will yet be able to interpret the data. However, that is not so in the case of text.*

Conclusions: $\therefore$ *packet switching may be used for WhatsApp calls but not messages.*

L01-03, SLIDE 26

2. UHF propagation is limited by line-of-sight (LOS). Calculate the minimum height of a hill at which the receiver must be stationed in order to receiver a signal 80 km away. Assume that UHF signals suffer a 0.4 dB attenuation/km. Transmitted power is 20 dB and minimum power at receiver required for acceptable reception is –20 dB.

As we go higher up, LOS possibility increases.

However, even if there is LOS, signal cannot be received if dB at receiver is less than min required. Thus, let us check this first.

dB at receiver at 80 km is $20 - 0.4 * 80 = -12\ dB$. *As* $-12\ dB > -20\ dB$, *signal attenuation is not a concern.*

Assume the min height the receiver must be above the ground is h. $\therefore d = \sqrt{15(h)}$.

$\therefore 80 = \sqrt{15(h)}\ \ \therefore 6400 = 15(h1)\ \therefore h = 426.67m.$

3. In Q2., Calculate the minimum height of a hill at which the receiver must be stationed in order to receiver a signal 80 km away if signal attenuation increased by 50%.

Calculate impact of 50% rise in attenuation on dB at receiver: *dB at receiver at 80 km if attenuation* $\uparrow$ *by 50% is* $20 - 0.4 * (150\%) * 80 = -28\ dB$.

Compare with requirement: *This is* $< -20\ dB$, *the minimum needed by the receiver.*

Physical Logic: *Raising the height of the antenna will not improve the dB. It only takes care of LOS issues.*

Conclusion: $\therefore$ *changing the antenna height is of no use in this case.*

L01-03, SLIDE 31

4. In AM frequency of received signal is the same as carrier frequency. True/False? Justify.

True.

Justification

What AM does: *In AM, only the amplitude of the carrier is modulated (reveal your understanding).*

What AM does: *Neither the phase nor the amplitude of the carrier is modulated (show that your understanding is sound).*

Argue its impact on the carrier: *amplitude modulation does NOT impact carrier frequency.*

Conclude: $\therefore$ *the frequency of the received signal is the same as that of the carrier.*

5. In FM amplitude of received signal is same as message signal amplitude. True/False? Justify.

False.

Write the equation: $A_c \cos\left(2\pi f_c t + \beta_f \int_{-\infty}^{t} m(t)dt\right)$.

Infer from the equation: *The equation shows that the amplitude at the receiver will be same as that of the carrier.*

Other argument you may make: *Channel losses of* L_c *where* $0 \leq L_c \leq 1$, *will cause equation to become* $L_c A_c \cos\left(2\pi f_c t + \beta_f \int_{-\infty}^{t} m(t)dt\right)$. *This again justifies the same claim.*

L07-09, SLIDE 03

6. Compute the power of the signal $[\cos(t^2)]^2$ over $\frac{\pi}{2}$.

Power over 1 cycle is $\frac{1}{T}\int_0^T |m(t)|^2 dt = \frac{1}{T}\int_0^T |[cos(t^2)]^2|^2 dt$ *... (1)*

Let $t^2 = p$. $\therefore 2tdt = dp$ *& when* $t = 0, p = 0$ *& when* $t = T, p = T^2$ *... (2)*

Using (2) in (1), we have power $= \frac{1}{\sqrt{P}}\int_0^{\sqrt{P}} |[cosp]^2|^2 dt = \frac{1}{\sqrt{P}}\int_0^{\sqrt{P}} cos^4 p dp$ *.... (3)*

$2cos^4 p - 1 = cos^2(2p)$ $\therefore cos^4 p = \frac{1+cos^2(2p)}{2} = \frac{1+\frac{1+cos(4p)}{2}}{2} = 0.5 + 0.25 + 0.25\, cos(4p)$ $= 0.75 + 0.25\, cos(4p)$ *... (4)*

Thus we have from (3) & (4): power is $\frac{1}{\sqrt{P}}\int_0^{\sqrt{P}} [0.75 + 0.25\, cos(4p)]dp$

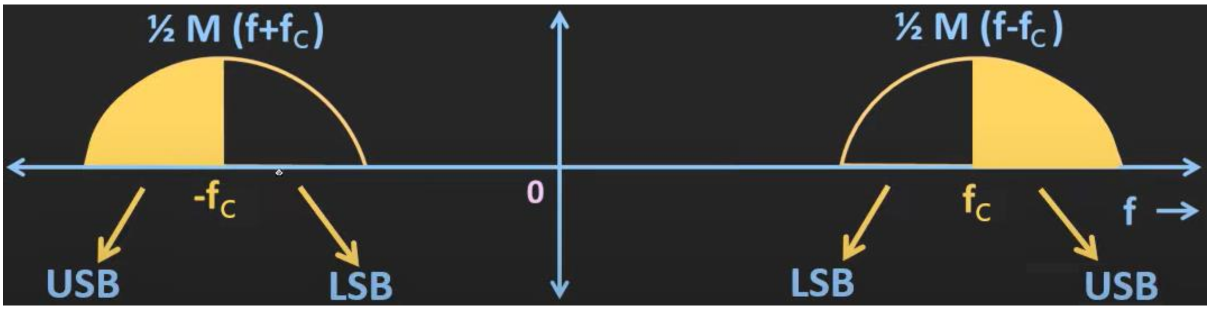
$= \frac{1}{\sqrt{P}}\left[0.75p + \frac{0.25\, sin(4p)}{4}\right]_0^{\sqrt{P}} = 0.75 + \frac{0.0625\, sin(4\sqrt{P})}{\sqrt{P}}$ *... as* $\sqrt{P} = T = \frac{\pi}{2}$, *the power is* $0.75 + \frac{0.0625\, sin\left(4\cdot\frac{\pi}{2}\right)}{\frac{\pi}{2}} = 0.75$.

L07-09, SLIDE 04

7. Show that frequency spectrum of DSB-SC AM is $\mathfrak{I}[u(t)] = \frac{A_c}{2}[M(f - f_c) + M(f + f_c)]$.

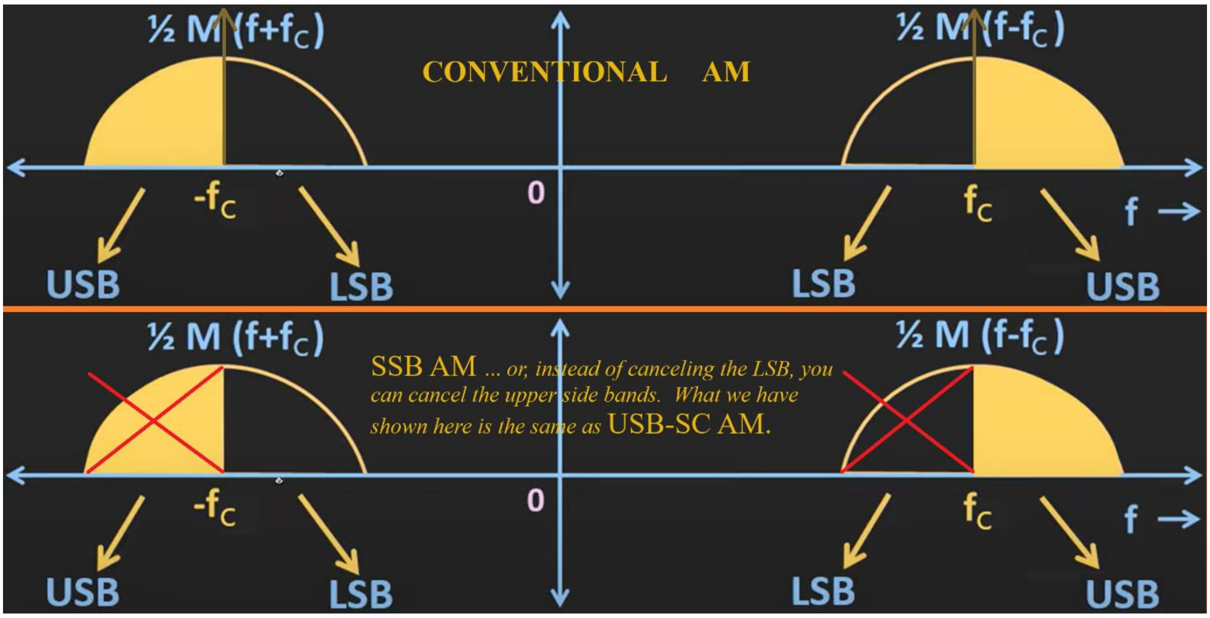
Same as on the slide.

8. Redraw this for



A. conventional AM
B. SSB-SC AM
C. LSB-SC AM

See below.



L07-09, SLIDE 7

9. Find fourier transform of $u_t = A \cdot cos(2\pi f_c t)$.

Same as on the slide.

L07-09, SLIDE 8

10. $u(t) = A_c[1 + a\,cos(2\pi f_m t)]\,cos(2\pi f_c t)$ is a conventional AM signal. Find the power of the signal.

Same as on the slide but show all steps. On the slides previously obtained results have been used. You need to show it all here.

L07-09, SLIDE 11

11. Show that if the receiver is $\frac{\pi}{2}$ out of sync with the transmitter then irrespective of how much powerful the transmitter is, the DSB-SC AM signal cannot be demodulated by a receiver is based on lowpass filtering.

Write the Eqn: *The output of an ideal DSB-SC AM lowpass filter is* $\frac{1}{2}A_c m(t)\,cos(\varphi)$ *where* φ *is the phase angle between the Tx & the Rx.*

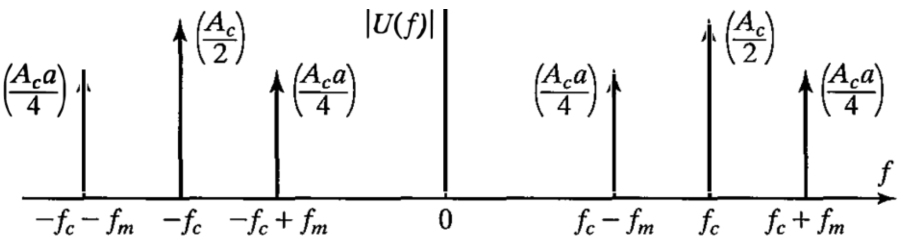
Make your argument:

(1) *If transmitter & the receiver are out-of-sync by* $\frac{\pi}{2}$ *then,* $\frac{1}{2}A_c m(t)\,cos(\varphi) = \frac{1}{2}A_c m(t)\,cos(0)\,\frac{1}{2}A_c m(t)\cdot 0 = 0.$

(2) *The result above remains unchanged, irrespective of the transmitted power (*A_c*).*

Conclusion: *∴ the DSB-SC AM signal cannot be demodulated by* ***ANY*** *receiver, not just a lowpass filtering-based receiver in case the receiver is* $\frac{\pi}{2}$ *out of sync with the transmitter.*

L07-09, SLIDE 16



12. From the figure,

A. infer whether it represents DSB-SC AM, USB-SC AM, DSB AM, USB AM?

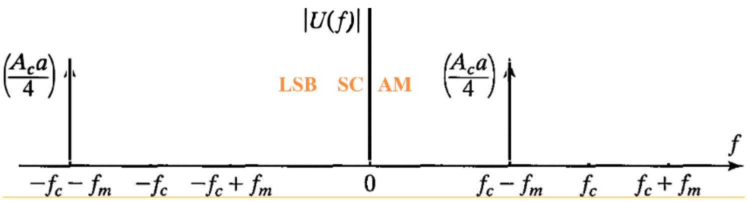
Write what you see in the graph which you will use to build your conclusions:

We see impulse at the carrier **(1).**

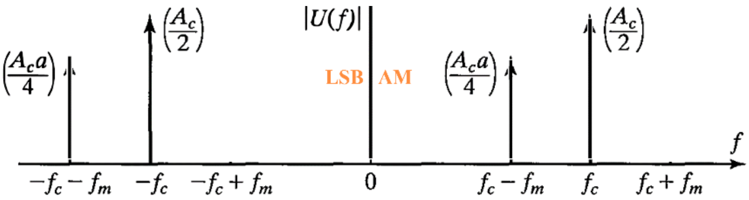
We see impulses at the LSB & USB positions **(2).**

Conclude: *∴ it is a DSB AM signal.*

B. Redraw to show LSB SC AM.



C. Redraw to show LSB AM.



D. The message signal is of the form $m(t)$ where $m(t)$ is NOT a sine/cosine function? Justify.

False.

Justification:

The graph shows frequency response (we have frequencies on the x-axis!).

The frequency response is only in the form of impulses.

We know that for frequency response to be only in the form of impulses, the time-domain signal must comprises discrete sinusoidal frequencies only.

E. How many frequencies are in the message? Justify.

Just one.

In a DSB AM signal, one will see only 6 impulse functions. Two for the carrier. One each for the two LSBs and one each for the two USBs.

L07-09, SLIDE 17

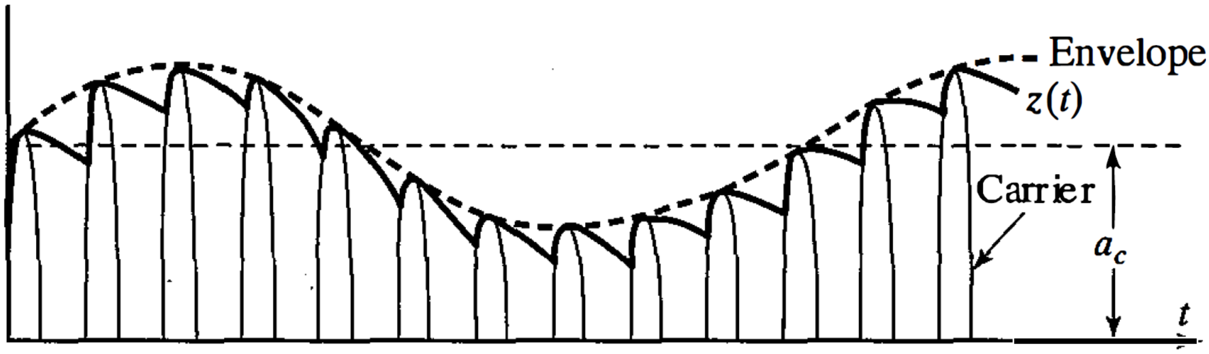
13. Message signal $m(t) = 3\,cos(200\pi t) + sin(1000\pi t)$.
Carrier signal $c(t) = cos(2 \times 10^7 t)$. Modulation index $a = 0.45$.
Determine the power of sidebands & carrier components of the modulated signal.

Same way as in the slides.

L07-09, SLIDE 19

14. Write all steps needed to perform envelope detection of a DSB SC AM signal.

Step 1: *Pass the signal through a diode. This will remove one of the sidebands, resulting in the signal shown*



Step 2: *Pass through a low-frequency bandpass filter. This will strip off the high-frequency carrier but will still leave small ripples (the 'sawtooth' you see just below the envelope).*

__Step 3:__ Pass it through another low-frequency bandpass filter. This will remove the ripples. The reason we do the high frequency removal of the sawtooth artefact separately from the removal of the carrier is to allow for optimal performance as the amplitudes of what is being removed are very different.

__Step 4:__ What we know have left is the message signal but shifted above, i.e., a DC component plus a message wave. Strip off the DC component using a DC block notch filter.

L07-09, SLIDE 22

15. Is QCM an AM, FM, or a PM modulation technique, or, a combination of two or more of these? Justify.

It is a phase modulation technique.

Justification: The modulated signal is $u(t) = A_c m_1(t)cos(2\pi f_c t) + A_c m_2(t)sin(2\pi f_c t)$.

This is achieved by:

multiplying the carrier wave by the 1st message followed by

phase-shifting the same carrier wave by $\frac{\pi}{2}$ *and then*

multiplying the phase-shifted carrier by the 2nd message signal

But, also, the amplitude of the message signal, A_c *in both cases is changed by the signals* $m_1(t)$ *&* $m_2(t)$.

We see that there is no change to the frequency of the carrier in this process.

∴ QCM is a combination of phase and amplitude modulation.

16. Write the steps in recovering the two message signals in a QCM using a balanced demodulator.

Same way as in the slides.