Modulation

Channel Sharing

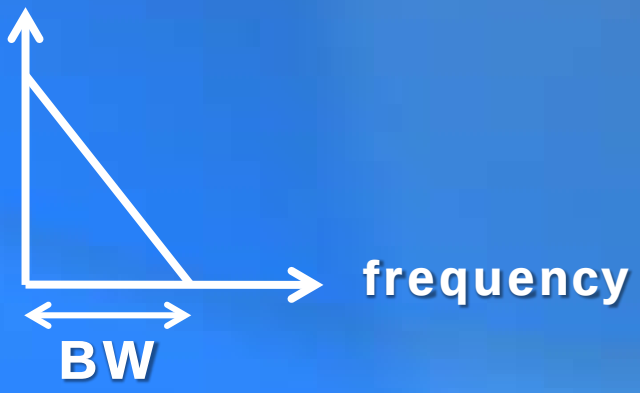
- Frequency Division Multiplexing (FDM): sharing a channel by allocating every user a separate band of frequencies.
- Problem: The signals we want to transmit (e.g. voice) generally do not lie in the allocated frequencies.
- Solution: Translate (move) them to the desired frequency band by modulation.

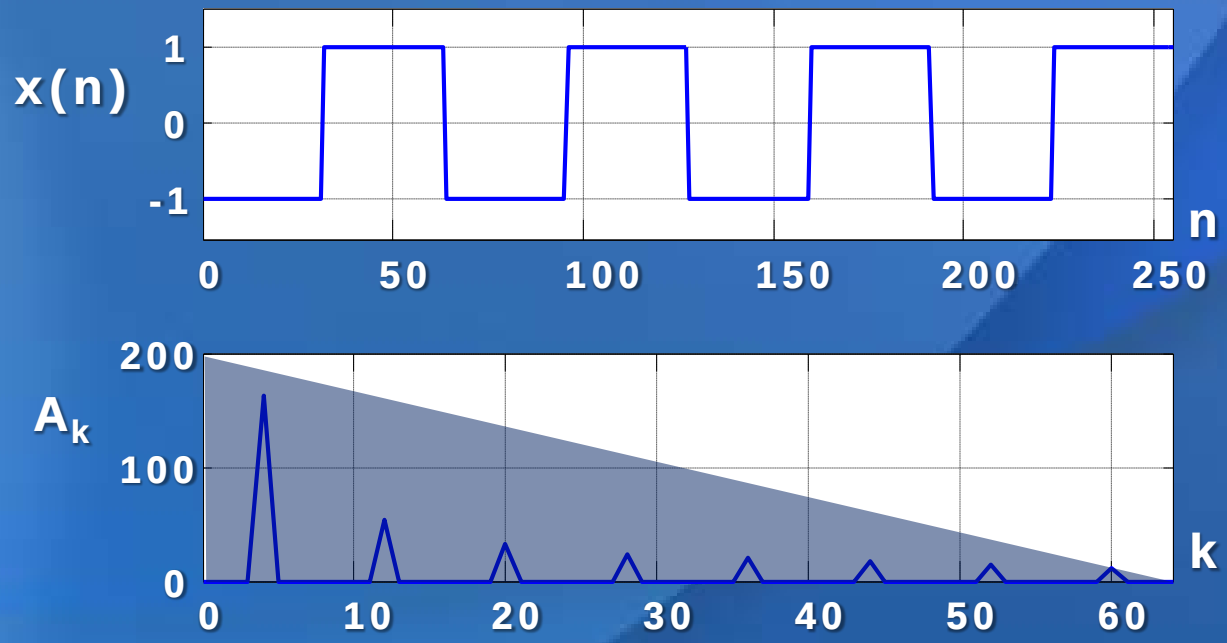
Baseband Signals

We usually refer to the signals and messages we want to transmit as “baseband signals”

- digital data (001100..)
- voice
- video

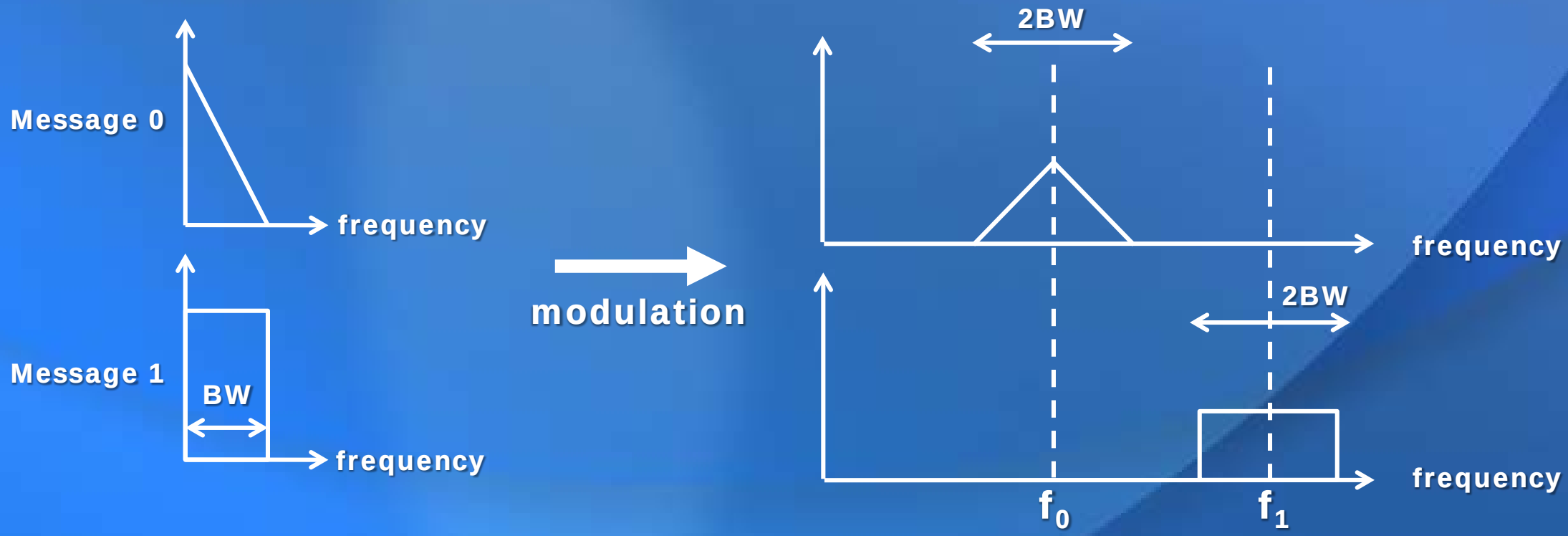
Typical baseband signal:





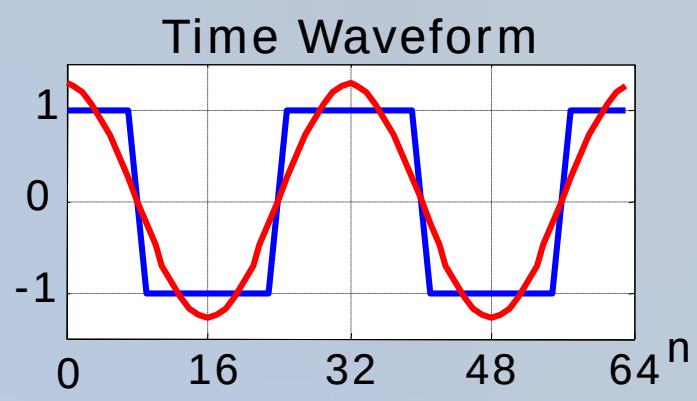
Frequency Division Multiplexing

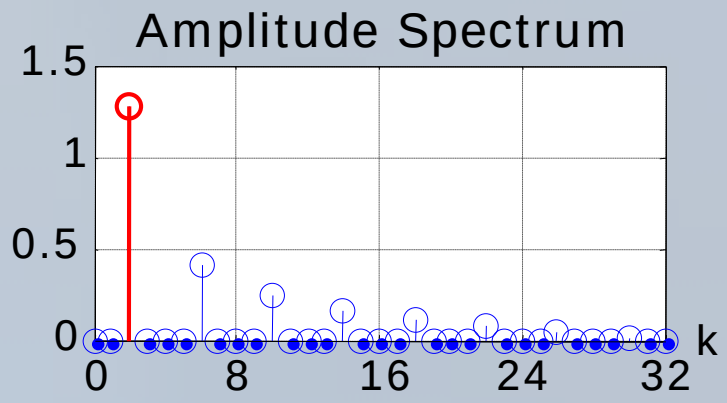
Translate two baseband messages to frequency bands centered at f_0 and f_1



Baseband Signals

We often simplify our analysis of baseband signals by assuming that they just have one frequency component.





$x(n)$

$A_2\cos(2\pi f_2 n + f_2)$

Understanding modulation

Modulation multiplies a baseband signal with a sinusoidal carrier signal.
The effect of modulation concept can understood using trigonometry.

$$\cos(A+B) = \cos(A)\cos(B) - \sin(A)\sin(B)$$
$$\cos(A-B) = \cos(A)\cos(B) + \sin(A)\sin(B)$$
$$\downarrow$$
$$\cos(A+B) + \cos(A-B) = 2\cos(A)\cos(B)$$

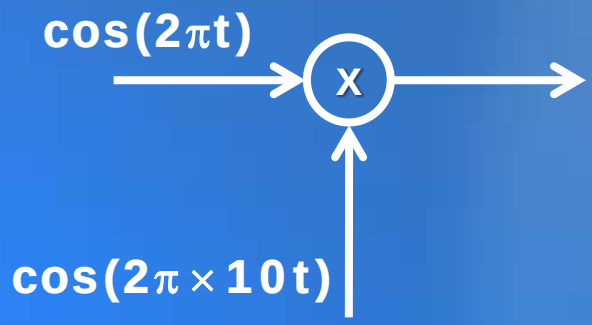
If a baseband signal at f_s is modulated by a carrier with frequency f_0,

$$\cos(2\pi f_s t)\cos(2\pi f_0 t) = \tfrac{1}{2}\cos(2\pi(f_0 - f_s)t) + \tfrac{1}{2}\cos(2\pi(f_0 + f_s)t)$$

signal — carrier — difference — sum

A simple example

Consider modulating a 1 Hz sinusoidal signal by a carrier frequency at 10 Hz



$$\cos(2\pi t)\cos(2\pi \times 10t) = \frac{1}{2}\cos(2\pi \times 9t) + \frac{1}{2}\cos(2\pi \times 11t)$$