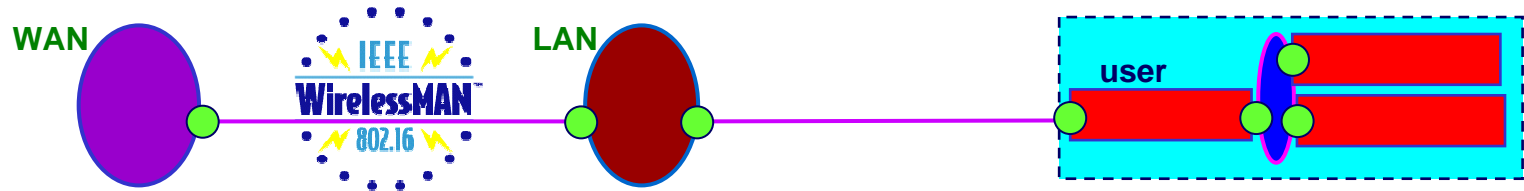# WIRELESS ACCESS SYSTEMS STANDARDS

WAN   **IEEE WirelessMAN 802.16**   **LAN**   **user**

	WAN	Access to WAN	LAN	Access to LAN	PAN
Distance					
Capacity					
Ad hoc					
QoS					
Freq band					
Access					
NLOS					
Mobility					

Access to WAN

IEEE 802.16

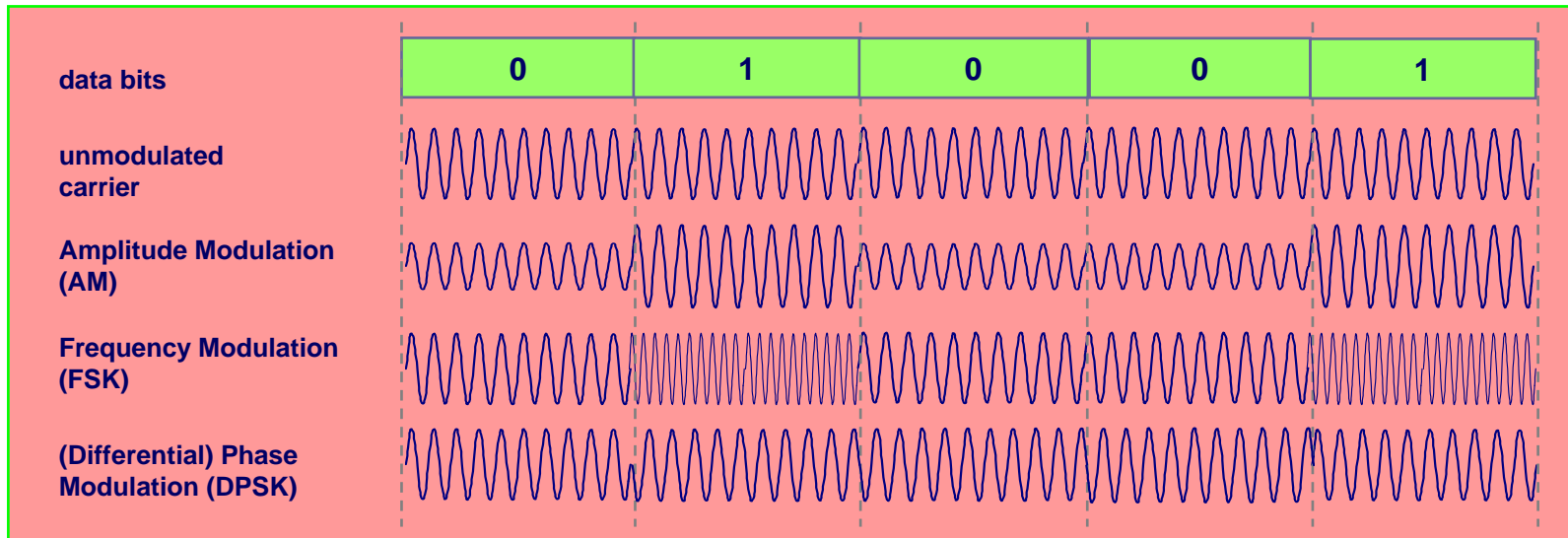- 802.16 - 10 - 66 GHz
  - 120 Mbps
  - 50 km
  - Single Carrier
  - LOS (high freq)

- 802.16. a - 2 - 11 GHz
  - 120 Mbps
  - 50 km
  - Single Carrier, OFDM, OFDMA
  - NLOS (low freq)

- 802.16.e - mobility

WiMAX FORUM

IEEE 802.20

- MBWA (Mobile BWA)
- under 3.5 GHz
- 1 Mbps per user
- up to 250 km/h
- stopped its activities in June 2006

Access to LAN

IEEE 802.11

- 802.11 - 2.4 GHz
  - 1, 2 Mbps
  - 5 km
  - FHSS, DSSS, IR

- 802.11.a - 5.x GHz
  - 54 Mbps
  - 5 km
  - OFDM

- 802.11.b - 11 Mbps
  - 2 km
  - 2.4 GHz

Wi Fi

- 802.11.g - 2.4 GHz
  - 54 Mbps
  - OFDM

- 802.11.n - 150 Mbps over longer distances using MIMO (Multiple Input Multiple Output) antennas.
- 12,000 comments on the first draft - May 2006!

PAN

IEEE 802.15

- 802.15.1 - Bluetooth
  - 2.4 GHz
  - 720 kbps
  - 10 m
  - FHSS

- 802.15.3 - UWB (Ultra Wide-Band)
  - High rate WPAN
  - 480 Mbps

- 802.15.4 - Zig Bee
  - Low power consumption
  - Low rate
  - 200 kbps
  - 2.4 GHz; 915 MHz; 868 MHz

MODULATION TECHNIQUES
BASIC TECHNIQUES

- **Data bits modulate (modify) a carrier signal**
- **Basic modulation techniques**
  - **amplitude** • **frequency** • **phase**

carrier

message(t) → **modulator** → transmitted signal

| data bits | 0 | 1 | 0 | 0 | 1 |

unmodulated carrier

Amplitude Modulation (AM)

Frequency Modulation (FSK)

(Differential) Phase Modulation (DPSK)
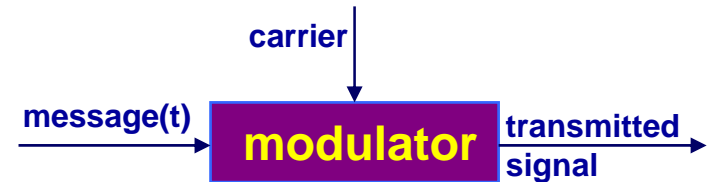
- **Data bits are represented over the transmission channel by SYMBOLS**
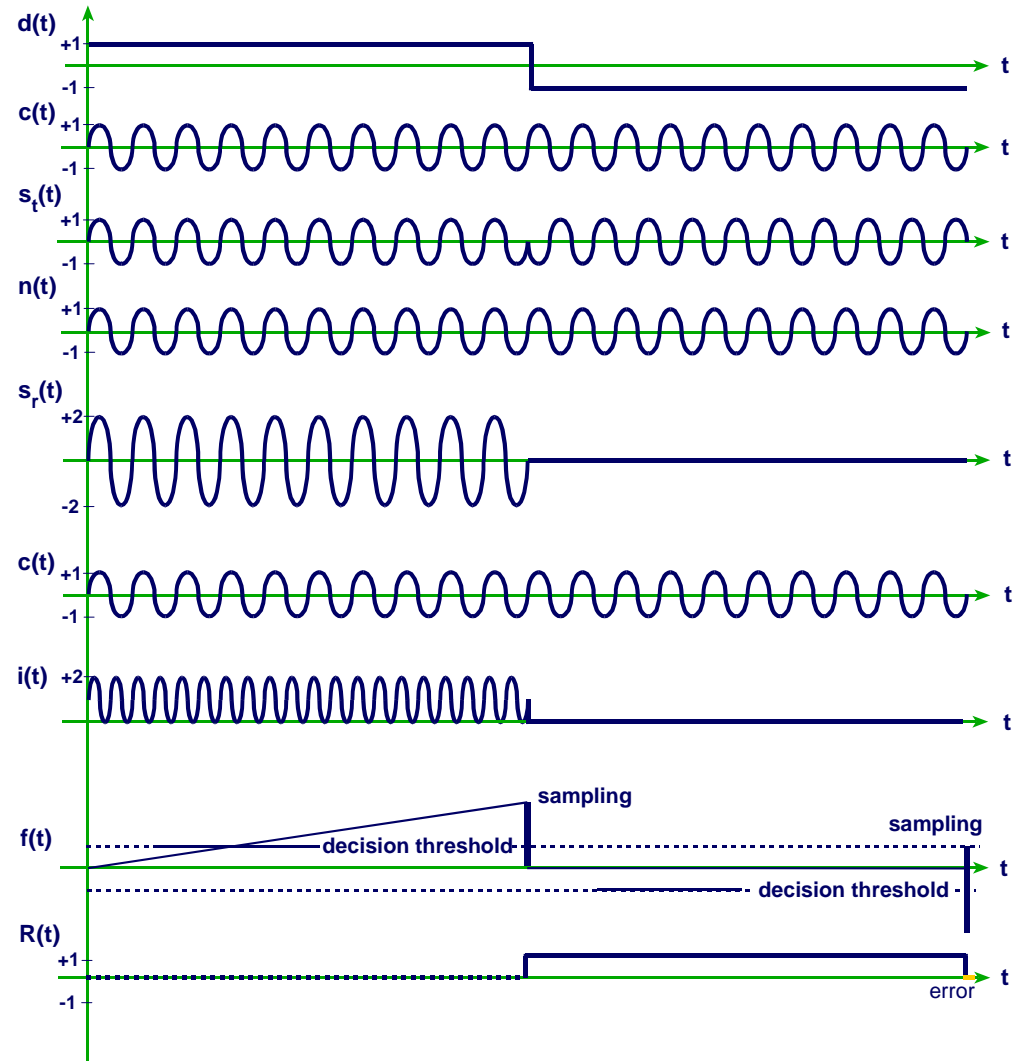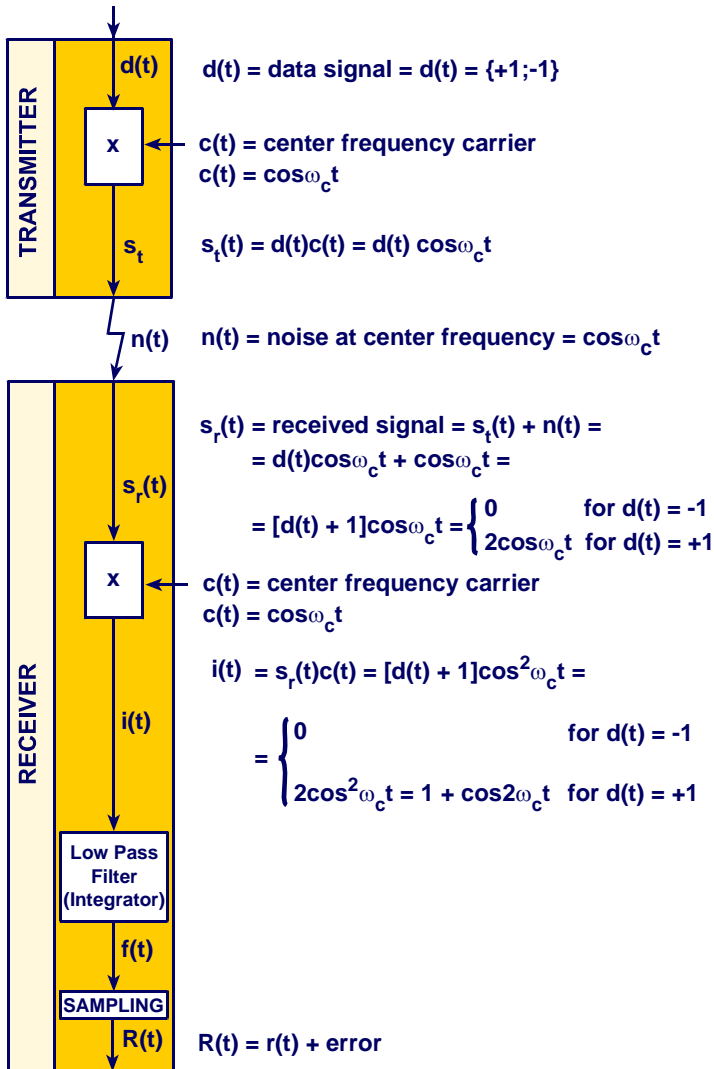- **Symbol rate is expressed in Baud**

Jean Maurice Emile BAUDOT (1845 - 1903)

- 1874 - Baudot code - 5 bits - for use with telegraphs (more economical than Morse code)

- 1894 - Telegraph multiplexer

DIRECT SEQUENCE SPREAD SPECTRUM (DSSS)

Effect of single tone interference (on center frequency) when no chipping is used (narrow band)

TRANSMITTER

d(t)

x

s_t

$d(t)$ = data signal = $d(t)$ = {+1; -1}

$c(t)$ = center frequency carrier
$c(t) = \cos\omega_c t$

$s_t(t) = d(t)c(t) = d(t)\cos\omega_c t$

$n(t)$ $n(t)$ = noise at center frequency = $\cos\omega_c t$

RECEIVER

$s_r(t)$

x

$c(t)$ = center frequency carrier
$c(t) = \cos\omega_c t$

i(t)

$s_r(t)$ = received signal = $s_t(t) + n(t)$ =

$= d(t)\cos\omega_c t + \cos\omega_c t =$

$= [d(t) + 1]\cos\omega_c t = \begin{cases} 0 & \text{for } d(t) = -1 \\ 2\cos\omega_c t & \text{for } d(t) = +1 \end{cases}$

$i(t) = s_r(t)c(t) = [d(t) + 1]\cos^2\omega_c t =$

$= \begin{cases} 0 & \text{for } d(t) = -1 \\ 2\cos^2\omega_c t = 1 + \cos 2\omega_c t & \text{for } d(t) = +1 \end{cases}$

Low Pass
Filter
(Integrator)

f(t)

SAMPLING

R(t) $R(t) = r(t) + error$

d(t) +1 -1 t

c(t) +1 -1 t

$s_t(t)$ +1 -1 t

n(t) +1 -1 t

$s_r(t)$ +2 -2 t

c(t) +1 -1 t

i(t) +2 t

f(t) sampling   decision threshold   sampling   decision threshold   t

R(t) +1 -1 t   error

FREQUENCY HOPPING SPREAD SPECTRUM (FHSS)
Transmission / reception without interference

TRANSMITTER

d(t)

X

c(t) = carrier

g(t) = controls the frequency of the carrier

f_c carrier central frequency

f_{79}
f_{78}
f_{77}
f_5
f_4
f_3
f_2
f_1

t_1 dwell time t_2 t_3 t_4 t_5 t_6 t

Unmodulated Carrier

Data
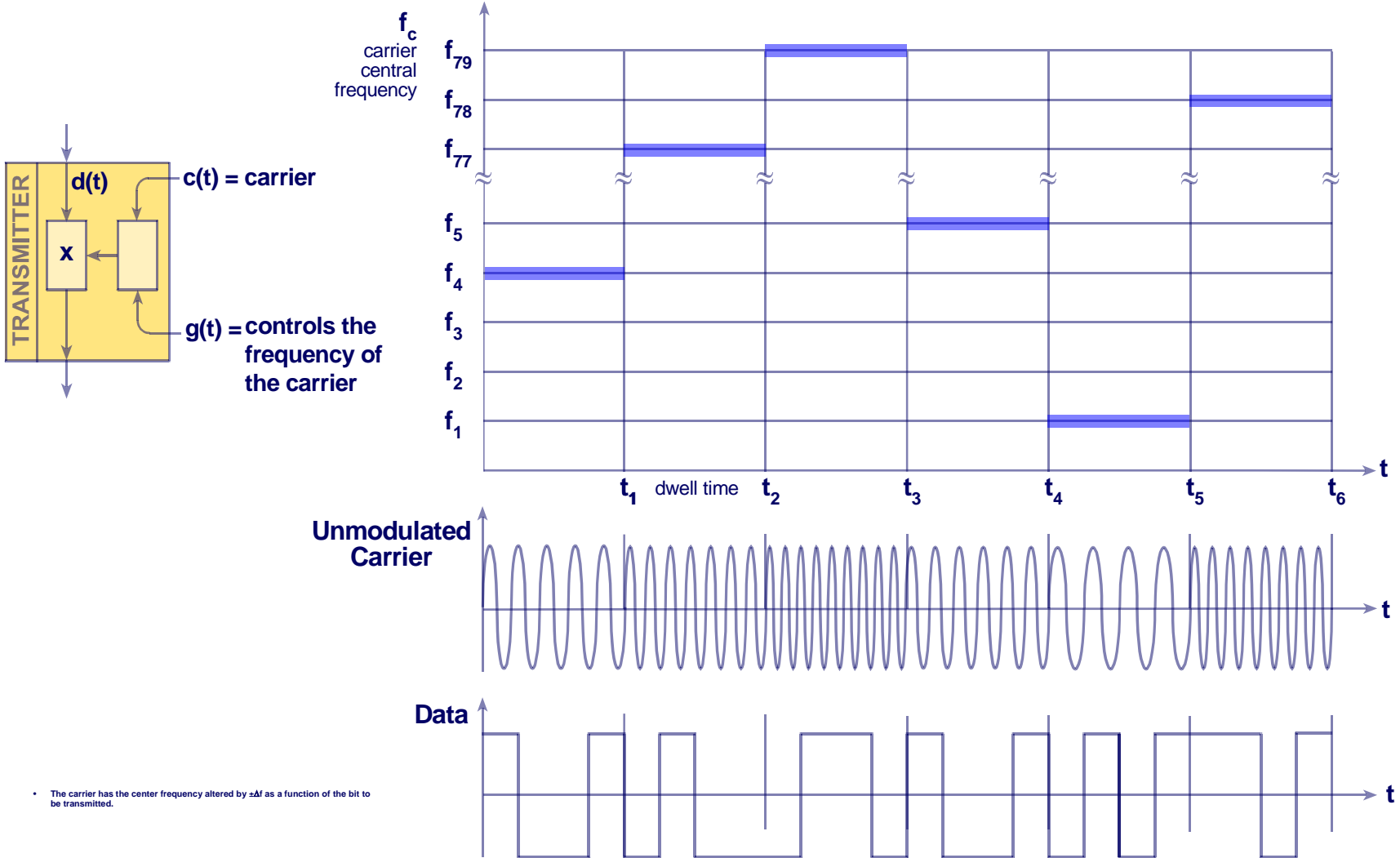
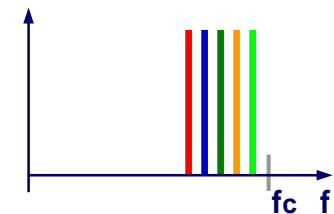- The carrier has the center frequency altered by ±Δf as a function of the bit to be transmitted.

OFDM - THE MODULATION PROCESS (for 16 QAM)
GENERATING THE HIGH FREQUENCY (HF) SIGNAL

• *option #2 - single sided (oppressed side) modulation*

fsc1	fsc2	. . .	fsc64
1	1	. . .	0
1	0	. . .	0

IFT

$\Sigma cos(\omega sci t)$

$cos(\omega sc1-\omega c)t+ cos(\omega sc1+\omega c)t+$
$cos(\omega sc2-\omega c)t+ cos(\omega sc2+\omega c)t+$
...

$\Sigma sin(\omega sci t)$

$\frac{\pi}{2}$

$cos(\omega ct)$

$cos(\omega sc1-\omega c)t- cos(\omega sc1+\omega c)t+$
$cos(\omega sc2-\omega c)t- cos(\omega sc2+\omega c)t+$
...

Σ
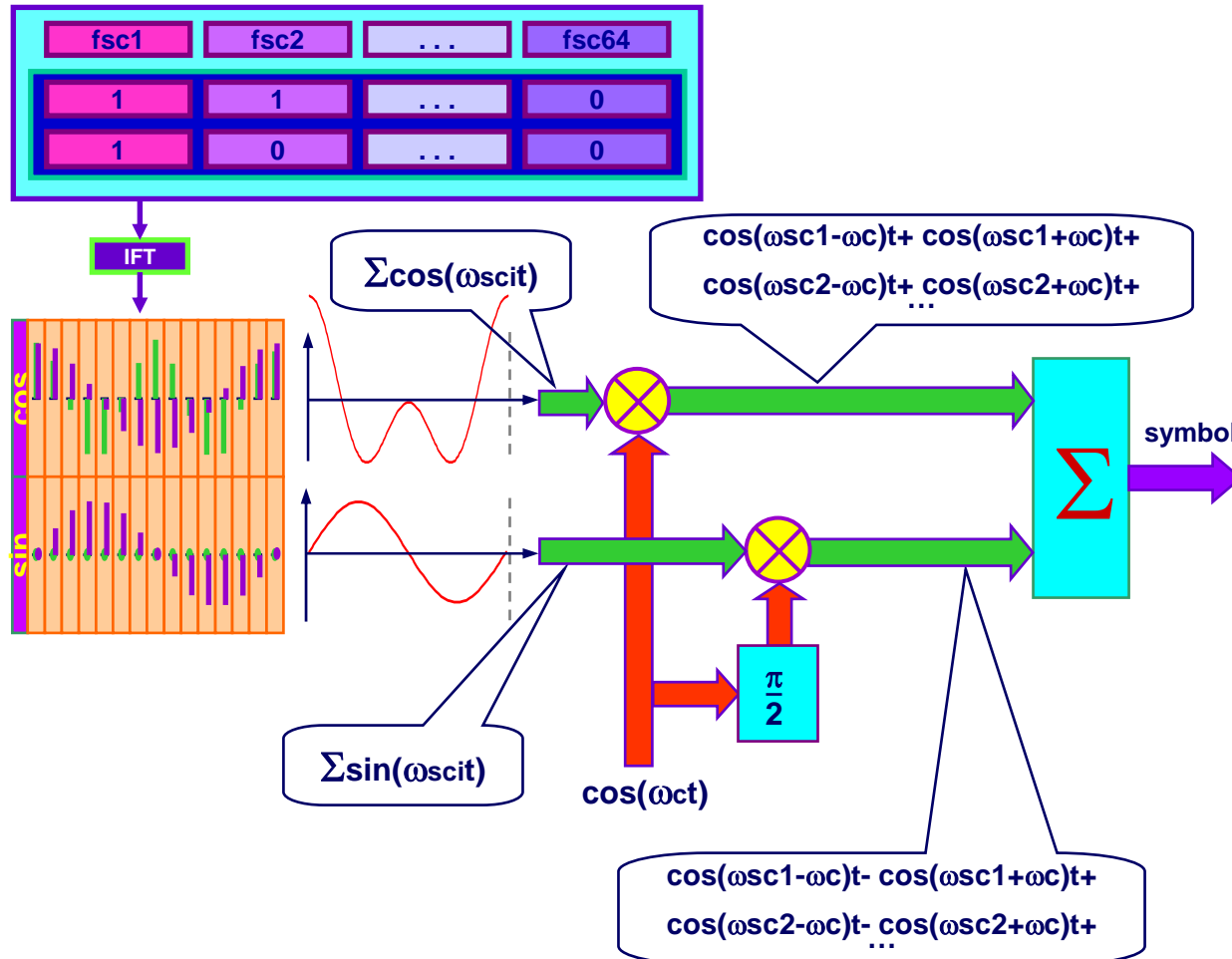
symbol

Resulting symbol has components:

• $cos(\omega c- \omega sc1)$

• $cos(\omega c- \omega sc2)$

• …

• $cos(\omega c- \omega sc64)$

fc f

For the resultant signal to be centered on fc, the carrier to be modulated should be selected as fc+ (channel b/w)/2

(e.g. for a 4 MHz channel, the actual carrier to be modulated should be fc+ 2MHz)

MEDIA ACCESS CONTROL (MAC)

Overview
Frame format

- **Power Management**   = 0 - Active mode
                           = 1 - Power Save mode

- **More Data**
  - **Indicates to a STA in Power Save mode that more frames destined to it are buffered in the AP (for both directed and broadcast frames).**

- **WEP** = 1 - Frame Body data is encrypted

- **Order** = 1 - If the frame is to be transmitted using Strictly Ordered Service (not to be buffered)

		1	2	3	4	5	6	7	8
FRAME CONTROL	(2)	Protocol Version		Type		Subtype			
		To DS	From DS	More Frag.	Retry	PWR Mgmt.	More Data	WEP	Order
DURATION / ID	(2)								
ADDRESS 1	(6)								
ADDRESS 2	(6)								
ADDRESS 3	(6)								
SEQUENCE CONTROL	(2)	Fragment Number			Sequence Number				
		Sequence Number (cont'd)							
ADDRESS 4	(6)								
FRAME BODY (payload)	(0 - 2312)								
FRAME CHECK SEQUENCE	(4)								