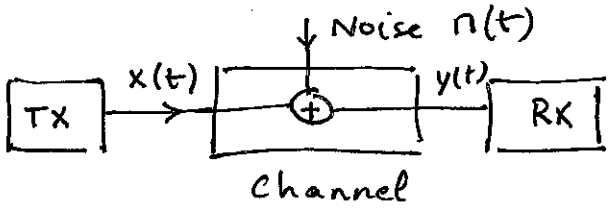
Lecture 18

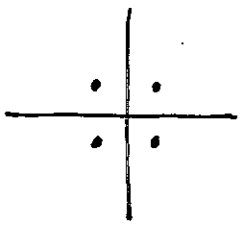
BER (Bit error rate analysis) is a way to analyze performance of different schemes (e.g. in the presence of noise such additive white Gaussian noise AWGN)

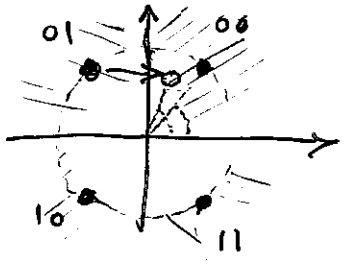


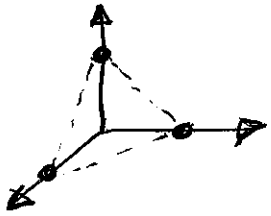
$$y(t) = x(t) + n(t)$$

BER → P(error)

P(error) = P(received decoded symbol ≠ transmitted symbol)







Spread spectrum communication

Initially developed for military to overcome susceptibility to jamming.

Basic idea : expand or spread the BW (broader spectrum)

By doing so, we make our signals more resistant to jamming.

There are two main types of SS comm:

1. Frequency Hopping SS (FHSS)
2. Direct Sequence SS (DSSS)

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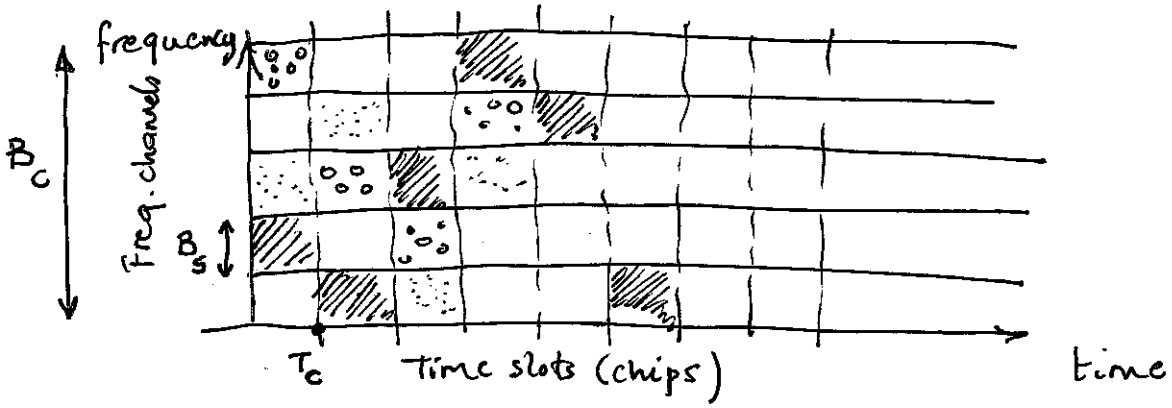
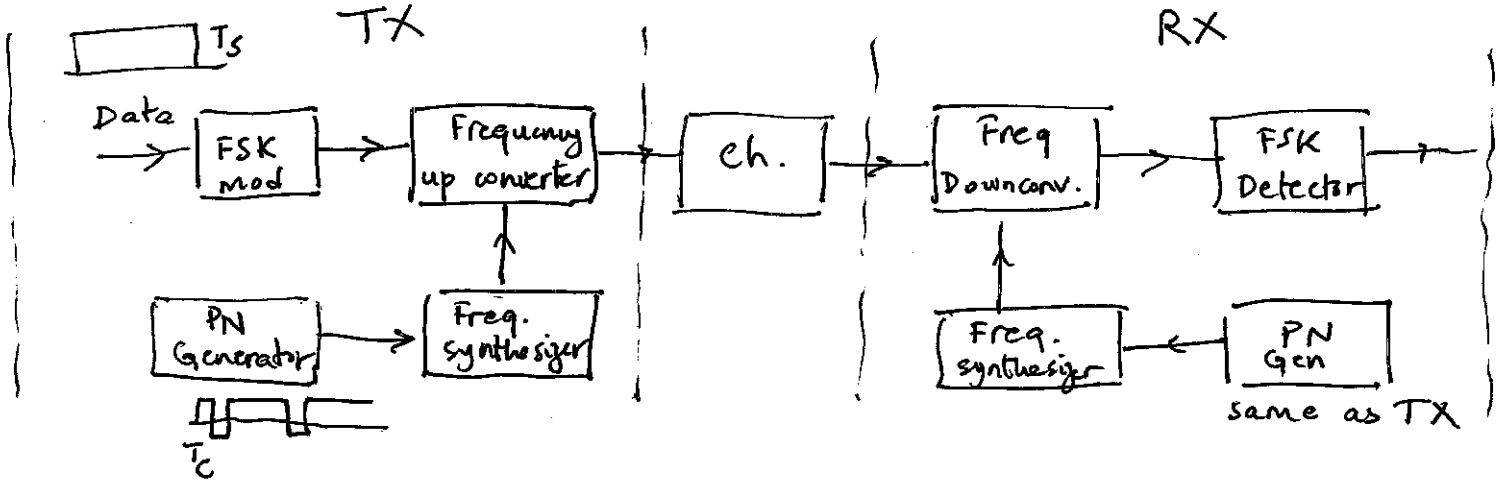
① FHSS change the carrier over time (for each user) according to a pseudorandom pattern. Effectively, the signal will occupy a broader spectrum and becomes harder to intercept.





If BW was B_s Hz, then FHSS will use (occupy)

a BW $B_c = LB$ L: spreading factor

T_s: symbol duration

T_c: Chip duration

$R_s = \frac{1}{T_s}$ symbol rate

$R_c = \frac{1}{T_c}$ Chip rate

If $T_c \gg T_s \rightarrow$ FH is slow hopping

If $T_c < T_s \rightarrow$ FH is fast hopping (multiple ~~symbols (hops)~~ hops over the duration of a symbol)

* Suppose a jamming source has level of jamming power P_J
* Narrow band (NB) signal BW = B_s, Jammer also has BW = B_s

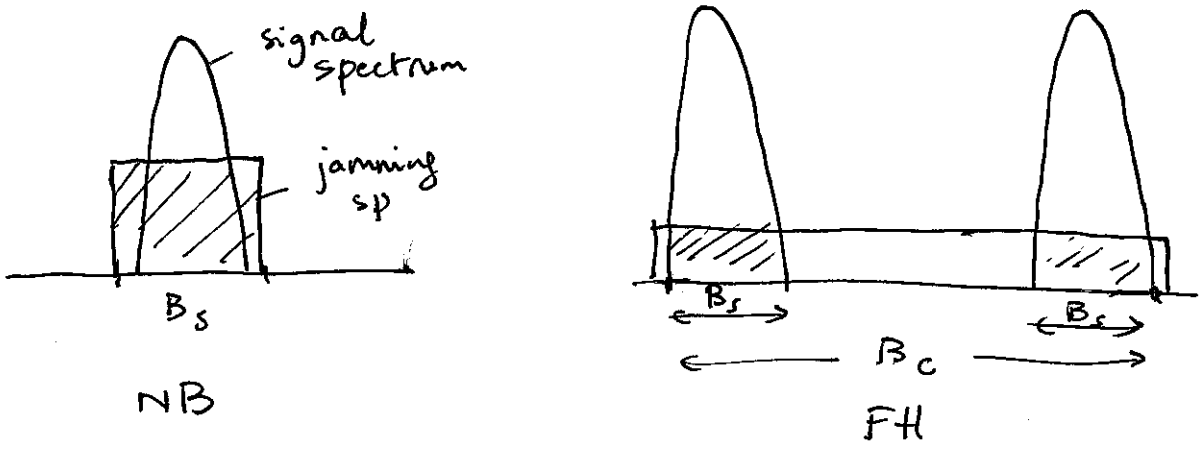
$$\text{Interference level} = \frac{P_J}{B_s} = I$$

$$\text{Signal-to-interference ratio} = SIR_{NB} = \left(\frac{E_b}{I}\right)_{NB} = \boxed{\frac{E_b B_s}{P_J}}$$

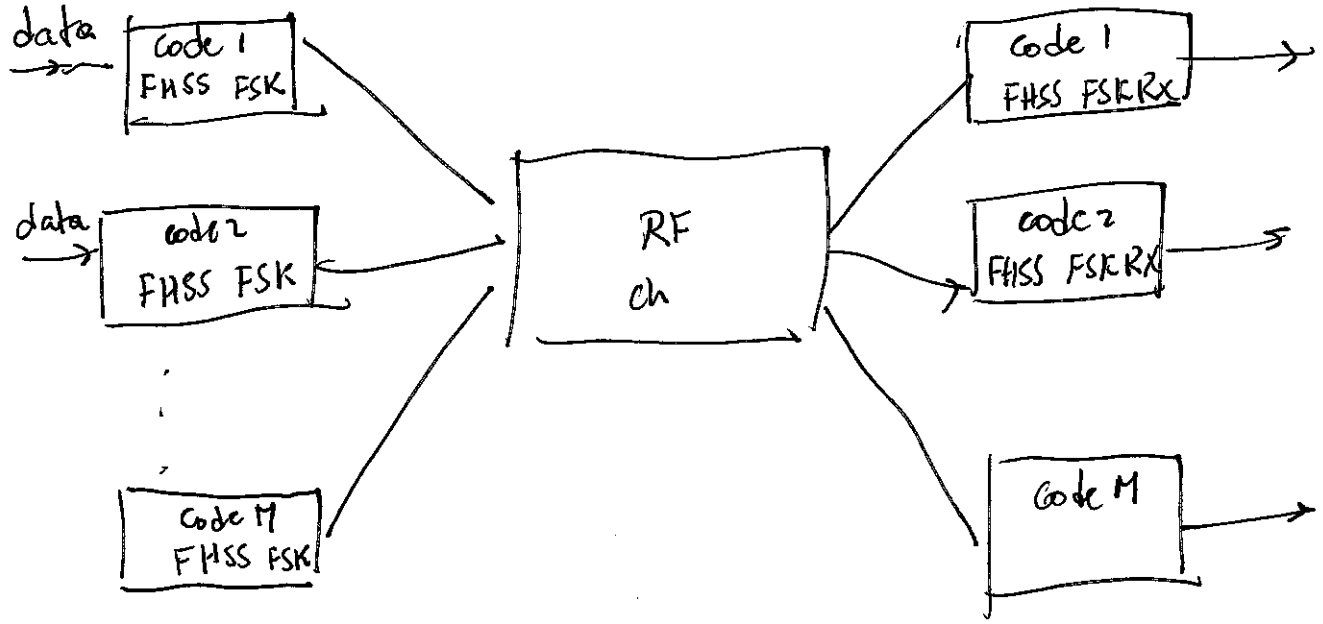
* FHSS has BW = $B_c = LB_s$. Jamming source will divide its power $\Rightarrow$ $I = \frac{P_J}{B_c} = \frac{P_J}{LB_s} \Rightarrow \boxed{SIR_{FH} = \frac{E_b LB_s}{P_J}}$

$$SIR_{FH} = L\, SIR_{NB}$$

Hence, with a spreading factor L, an FH signal is L time more resistant to a jamming source with finite power than a narrowband transmission.



If FHSS is used by 1 TX then it's too wasteful. Instead we can have multiple users.



Codes can be designed to avoid collision.

PN code controls the hopping pattern for each user.

⇒ CDMA (Code Division Multiple Access)