

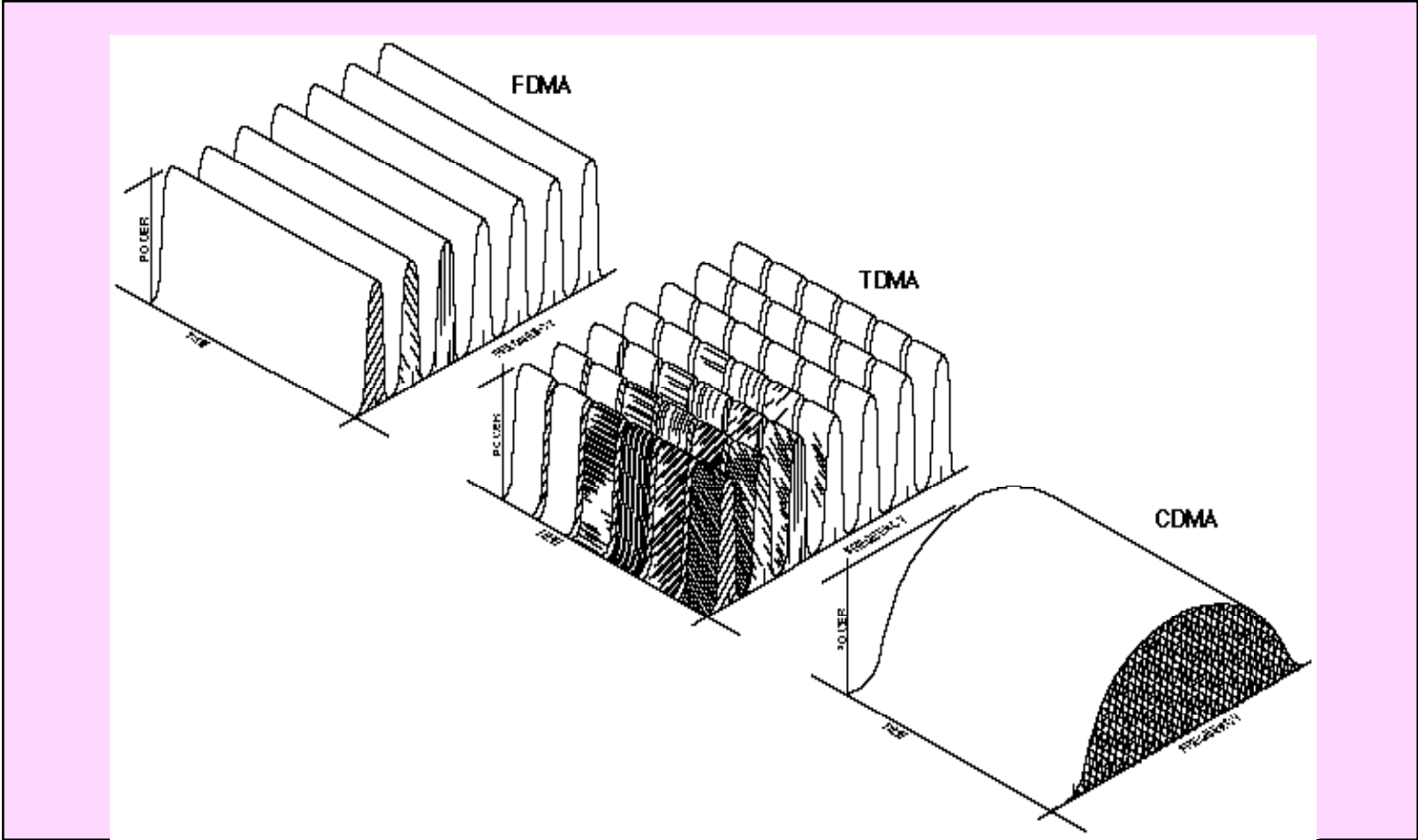
## Applications to DS-CDMA System

- System Basics
- Physical Layer of Forward and Reverse Links
- Use of Hadamard matrices for orthogonality
  - Forward: Orthogonal CDMA Channels
  - Reverse: Orthogonal Coding
- Use of cyclic Hadamard matrices (constructed from m-sequences) for 2-level auto-correlation function property
  - PN Long Code and Short Code
  - Unique Identification
  - Data Scrambling and Authentication
  - Spectrum Spreading

# The CDMA Cocktail Party

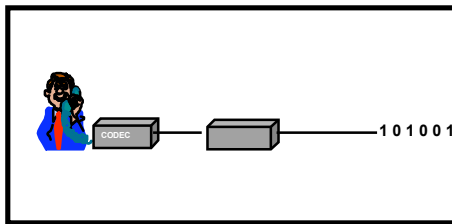


# Multiple Access Methods

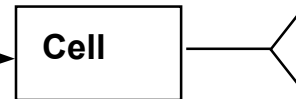
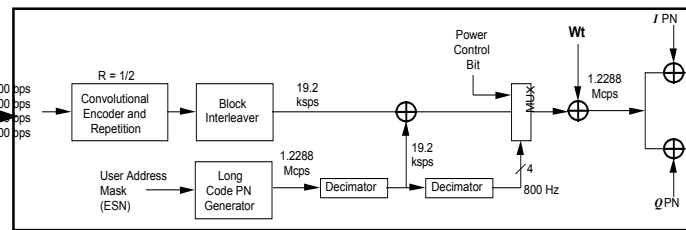


# CDMA System Design

## Voice Coding

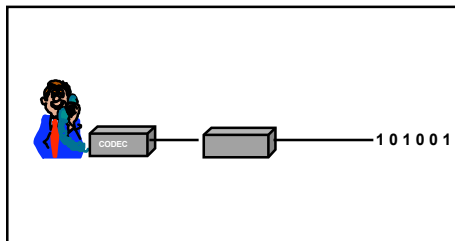


## Forward Link Generation

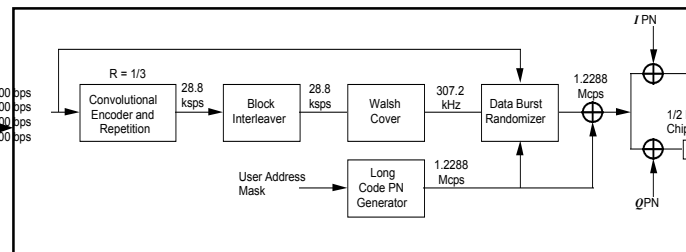


Power Control

## Voice Coding



## Reverse Link Generation

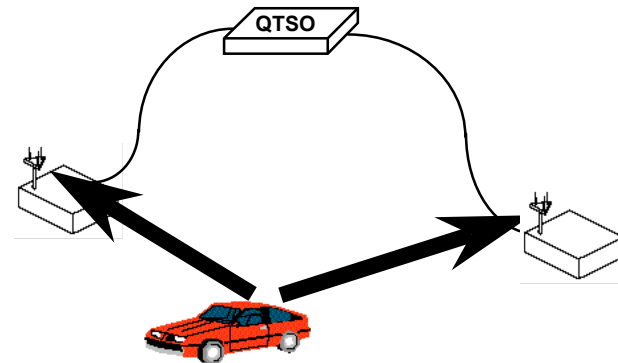
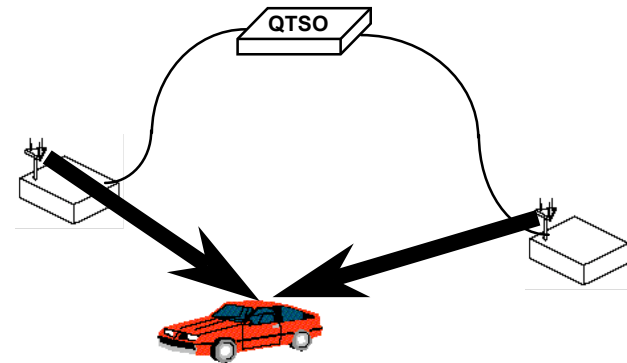


## The CDMA Rate Families

- IS-95 defines the 9600 bps family of rates (Rate Set 1)
  - 9600, 4800, 2400, and 1200 bps
  - Can select one of the four rates every 20 ms frame
- 14400 bps family of rates (Rate Set 2)
  - 14400, 7200, 3600, and 1800 bps
  - Can select one of the four rates every 20 ms frame
- Extended rates (extended Rate Set 1)
  - Adds 19200, 38400, and 76800 bps
  - At most four rates can be active
  - Can select one of the four active rates every 20 ms frame

# Link Waveform

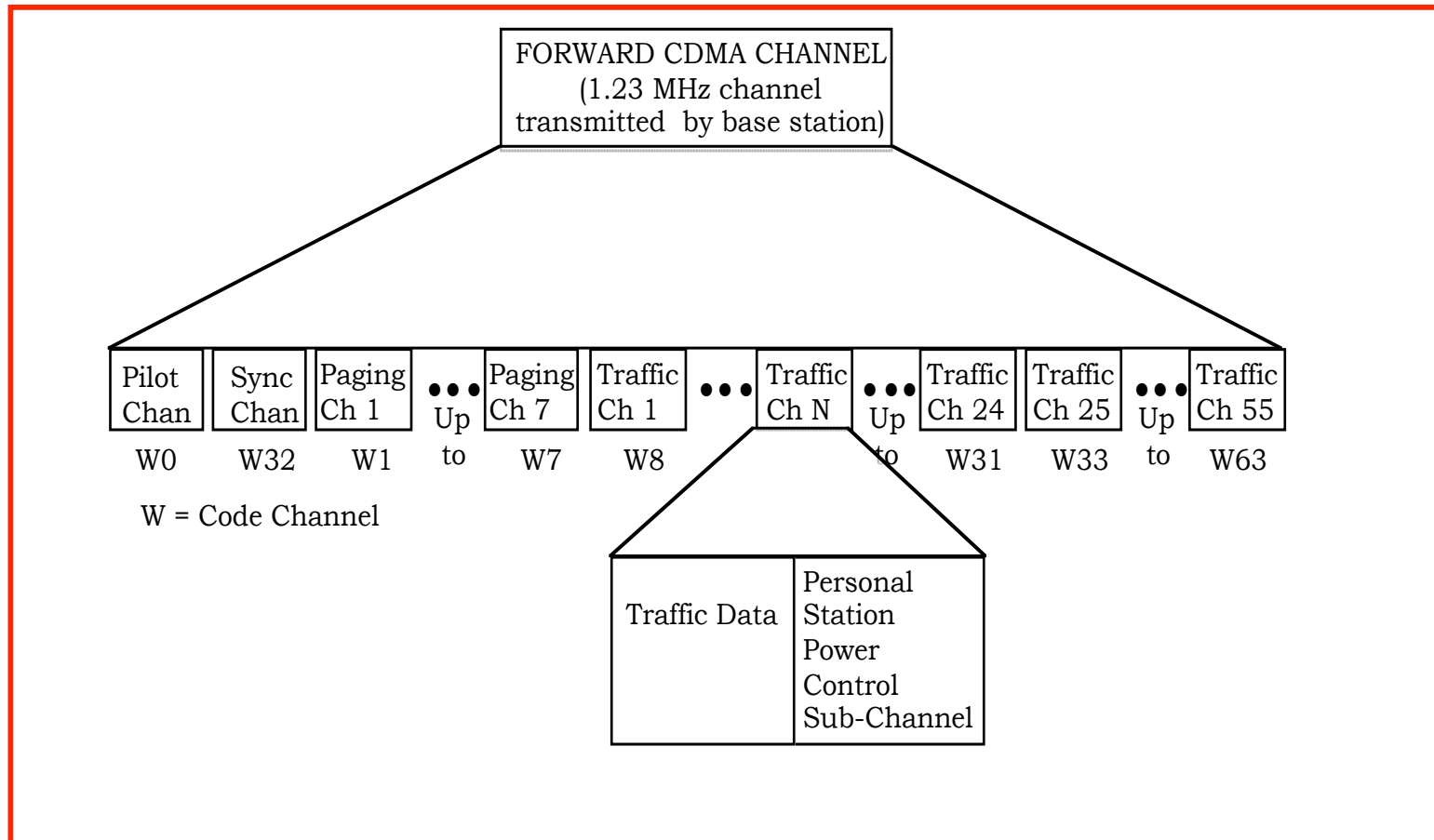
- CDMA Forward Link Waveform
  - Pilot Channel
  - Sync Channel
  - Paging Channel
  - Traffic Channel
- CDMA REVERSE Link Waveform
  - Access Channel
  - Traffic Channel



## Forward CDMA Channel

- A 64 x 64 Hadamard matrix is used to produce 64 orthogonal channels.
- Each row of a Hadamard matrix is used to uniquely identify channels from 0 to 63.
- This is possible since each row (as a binary vector of length 64) of the 64 x 64 Hadamard matrix is orthogonal to any other row.
- If we call 64 row vectors as  $W_0, W_1, \dots, W_{63}$ , then the waveform for Channel #k is obtained by multiplying  $W_k$  to the input signal.

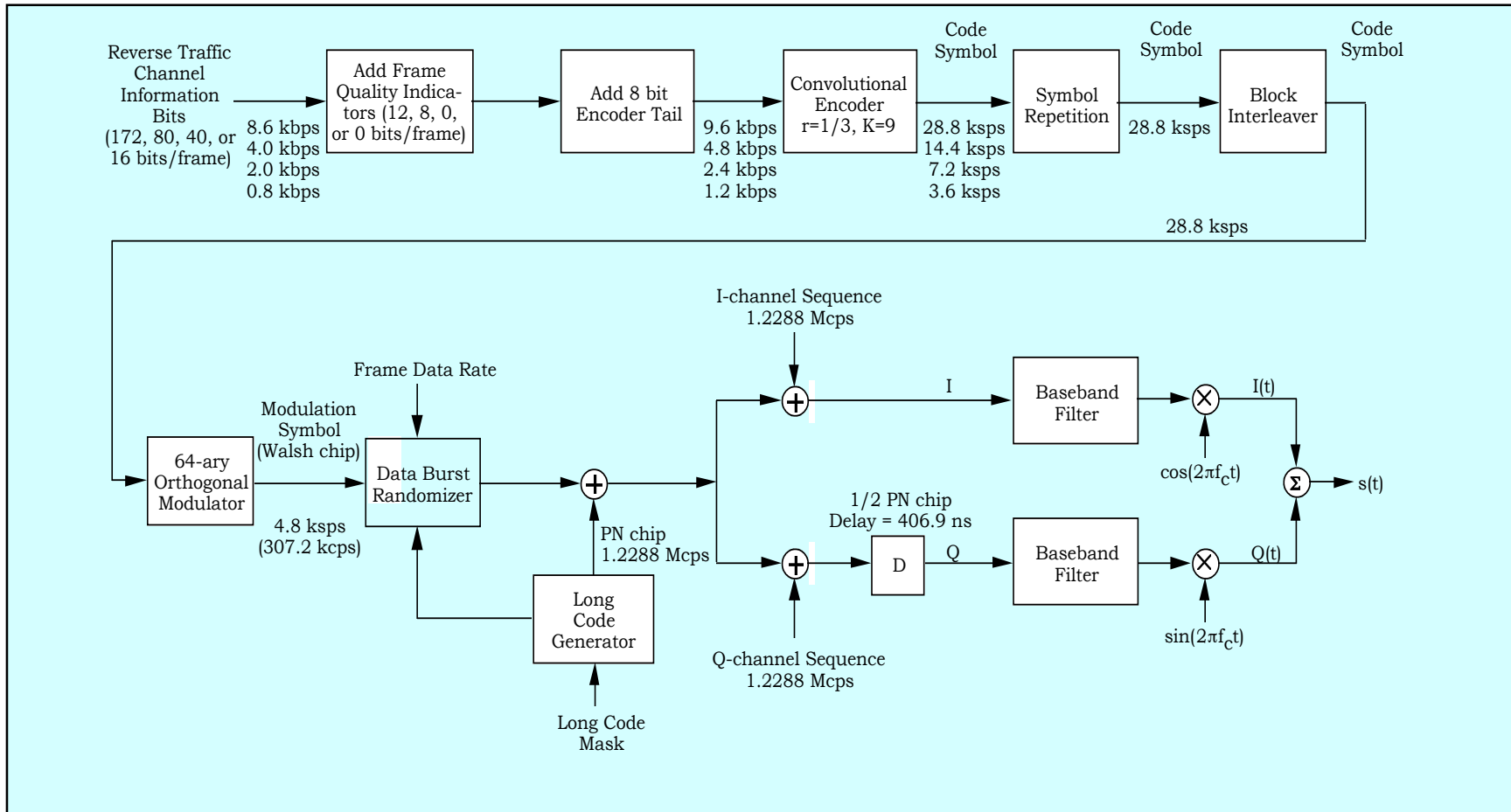
# Forward CDMA Channel



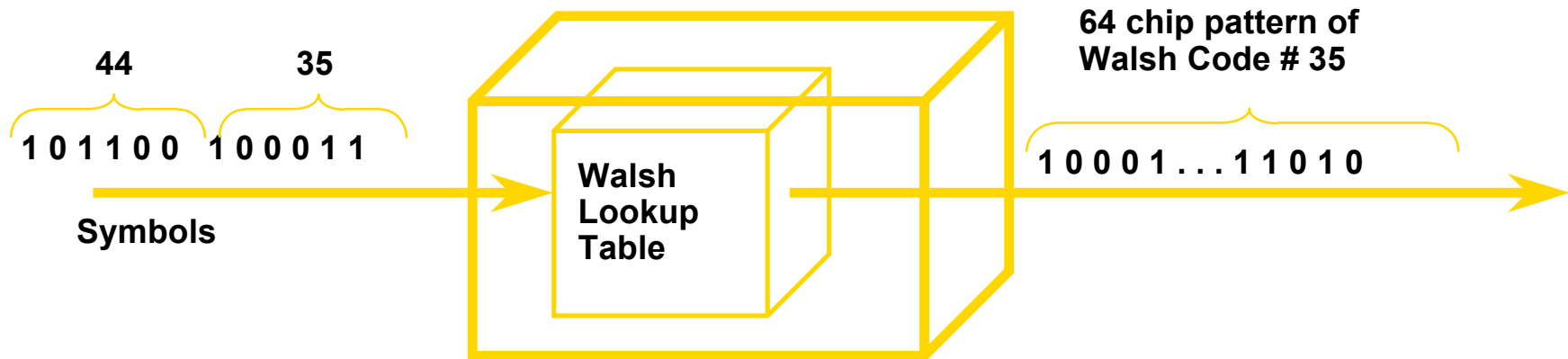
## Reverse CDMA Channel

- A Reverse Channel is uniquely identified by an initial phase of a binary PN sequence (so called, the long code) of length  $2^{42}-1$ .
- Different initial phases correspond to different shift of the PN sequence, hence they are orthogonal.
- Only 1/256 positions of the length are used to address all the users in the system.

# Reverse Traffic Channel Structure for Rate Set 1

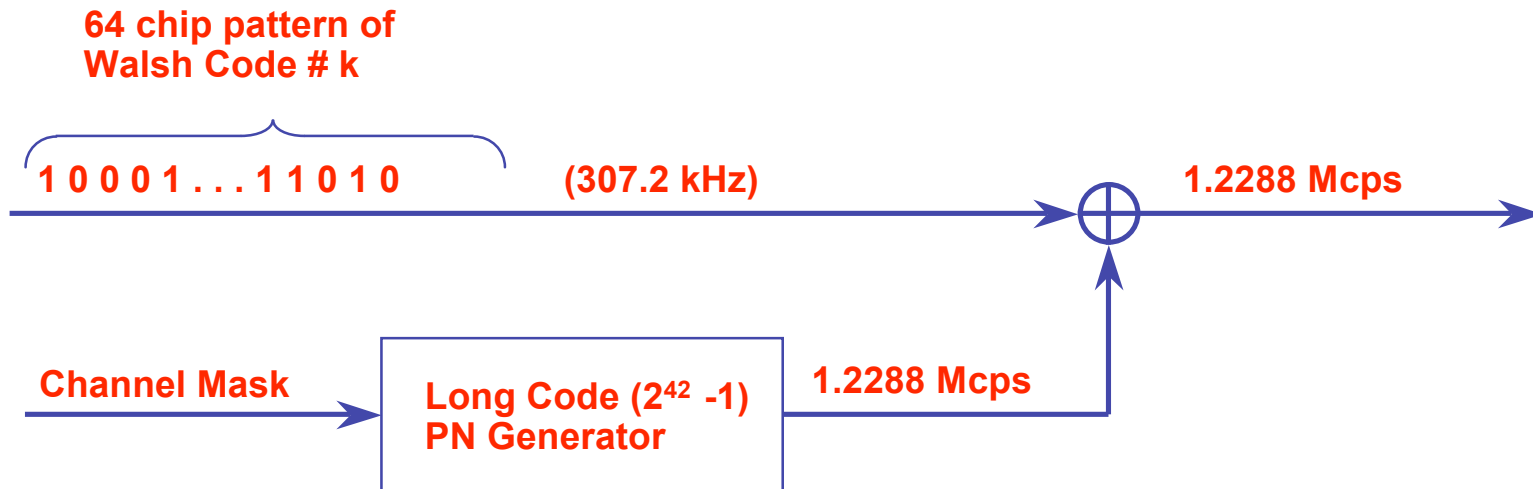


## Orthogonal Modulation (R. Link)



- For every 6 symbols in, 64 Walsh chips are out.
- Here, 64 Walsh chips are 64 components of a row of the 64 x 64 Hadamard matrix.
- Note the different role of the same 64 x 64 Hadamard matrix in Reverse Link.

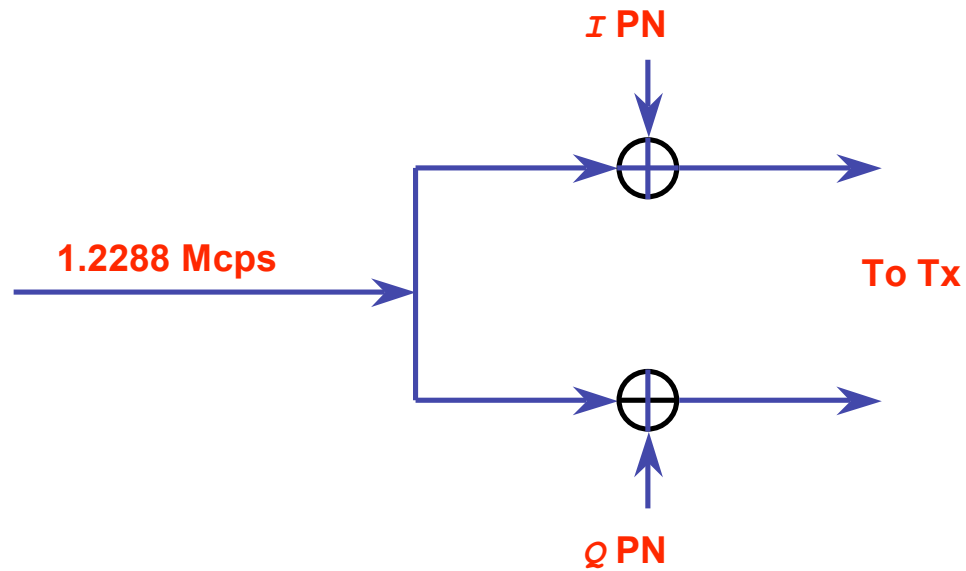
# PN Long Code Spreading



# PN Long Code

- Long Code
  - Maximal Linear Feedback Shift Register Sequence
  - Length (Period) is  $2^{42}-1$
- Unique identifier for:
  - Access and Traffic Channel (R. Link)
  - Paging and Traffic Channel (F. Link)
- Functions
  - Access, Paging, Traffic Channel spreading
  - DBR on the Reverse Traffic Channel
  - Power Control Bit randomization
  - Data Scrambling (encryption) and Authentication

## PN Short Codes of length $2^{15}$



## Short Code

- Short Code ( $2^{15}$ )
  - Unique identifier for a Cell or a Sector
  - Repeats every 26.67 ms
  - Consists of I and Q codes (different polynomials)
- It is called a Modified Maximal Length Sequence or de Bruijn sequence or span- $n$  sequence.
- It is obtained by adjoining one extra bit “1” after the unique run of 1 of length 14 in the PN sequence of length  $2^{15}-1$ .

# Summary of Application to DS-CDMA systems

- Orthogonality -- Channelizing and Coding
  - ✓ Scrambling and Authentication
  - ✓ Spectrum Spreading